SUBMISSION TO THE AUSTRALIAN SENATE

ANTHROPOGENIC NOISE (ACOUSTIC POLLUTION) FROM SHIPPING ON THE GREAT BARRIER REEF.

OMISSION OF REFERENCE IN MANAGEMENT PLANS DESPITE AGREED INTERNATIONAL CONVENTIONS ON REDUCTION OF SHIPPING NOISE IMPACTS.

Geoff McPherson

Marine Acoustic Biodiversity Solutions.
Phone 0421 198085

Adjunct Principal Research Fellow,
Engineering & Physical Sciences, James Cook University
geoff.mcpherson@jcu.edu.au

INTRODUCTION

The UN Commission for the Law Of the Sea (UNCLOS) in 1982 recognised that underwater noise was a marine pollutant. UNCLOS 1982 recognised that a human introduction, directly or indirectly, of substances or energy into the marine environment was in fact pollution and noise being energy, is marine pollution. That situation, or interpretration, has not changed.

The International Maritime Organisation (IMO) is the UN's specialised agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships. The IMO recognised the Great Barrier Reef as the first Particularly Sensitive Sea Area (PSSA) in 1990 (Lefebvre-Chalain 2007[1]) at the request of Australia where PSSA's (and subsequent iterations) were areas with "ecological, socio-economic, or scientific" importance needing special protection.

Lefebvre-Chalain (2007[1]) explained that the IMO Marine Environment Protection Committee (IMO MEPC) resolutions re-iterated that pollutants included 'oil and oily mixtures, noxious liquid substances, sewage, garbage, noxious solid substances, anti-fouling systems, harmful aquatic organisms and pathogens, and even noise'.

- The IMO therefore made it clear that marine ecosystems including the highest concern PSSA's could be impacted by shipping not simply based on physical vessel grounding but by pollutants during individual vessel transits as previously outlined namely *oil and oily mixtures, noxious liquid substances, sewage, garbage, noxious solid substances, anti-fouling systems, harmful aquatic organisms and pathogens, and even noise*.
- There is no question that pollution from underwater noise would be the most sustained though perhaps not as toxic as ships both transiting and at anchor make noise, the most from the former caused by propeller cavitation.

Marine ecosystems experience natural and anthropogenic levels of underwater noise well documented by acoustics and naval systems engineers. The rate at which ambient noise levels in oceans has been increasing by anthropogenic noise sources, and its impact, is also well documented at the United Nations level which includes UNESCO. It is not accidental that UNESCO currently considering the status of our Great Barrier Reef World Heritage Area (GBRWHA) are developing a Quiet Oceans Experiment 'with the objective of coordinating the international research community to both quantify the ocean soundscape and examine the functional relationship between sound and the viability of key marine organisms' (Boyd *et al*. 2011[2]).

[1]

1. Lefebvre-Chalain, H. (2007). Fifteen years of particularly sensitive sea areas: a concept in development. *Ocean & Coastal LJ*, *13*, 47.
2. Boyd IL, Frisk G, Urban E, Tyack P, Ausubel J, Seeyave S, Cato D, Southall B, Weise M, Andrew R, Akamatsu T, Dekeling R, Erbe C, Farmer R, Gentry R, Gross T, Hawkins A, Li F, Metcalf K, Miller JH, Moretti D, Rodrigo C & Shinke T. (2011) An International Quiet Ocean Experiment. *Oceanography* **24**(2):174–181.

Ambient noise levels are composed of natural (biotic and abiotic sources) and anthropogenic noise. Ambient noise may vary considerably on a diurnal and seasonal basis.

- Abiotic noise sources include sources such as wind, wave and rain movements, natural seismic events and lightning strikes.
- Biotic noise sources include marine animal communication and choruses of crustaceans and fish on coral and rock reef systems extending own to deep oceanic regions.
    - Most marine mammals communicate and/or hunt acoustically.
    - Almost every crustacean and fish species examined has been shown to utilise underwater sounds in some way as part of social and reproductive communication, predation and predator avoidance.
- Anthropogenic noises are from human impact.

Anthropogenic noise in the marine ecosystems such as the GBRWHA, called a soundscape, includes noise generated by mobile sources such as shipping involved with the commercial trade (general cargo, container vessels, car/livestock carriers, tankers), resources industry (bulk carriers), transportation and tourism (cruise liners, local high speed ferries), commercial fishing and smaller usually outboard powered recreational vessels. Anthropogenic noise may also be from stationary sources such as pile driving, marine pumps etc.

Anthropogenic noise sources also include from port construction and maintenance in the form of pile driving, noise resonance through operating belts and machinery and dredging that are more generally stationary noise sources. It includes noise from ships at anchor in standoff anchorages outside immediate port areas and inside the harbours as once a vessel transit stops the underwater noise generation does not.

There is an extensive literature of underwater noise in oceans and nearshore areas including the GBRWHA. There are many reviews that more than adequately address this with reference to seismic survey, sonar systems, port construction and the far more ubiquitous shipping for crustaceans, fish and marine mammals (Popper & Hastings 2009[3]; Slabbekoon *et al*. 2010[4] and Radford *et al*. 2014[5]). Particular attention should be attributed to the UN Environment Programme review on underwater noise of shipping on marine ecosystems (UNEP 2012[6]).

3. Popper AN & Hastings MC. (2009). The effects of anthropogenic sources of sound on fish. *Journal of Fish Biology*, **75**: 455 – 489.
4. Slabbekorn H, Bouton N, van Opzeeland I, Coers A, ten Cate C & Popper AN. (2010). A noisy spring: the impact of globally rising underwater sound levels on fishes. *Trends in Ecology and Evolution* **25**(7): 419-427.
5. Radford AN, Kerridge E and Simpson SD. (2014). Acoustic communication in a noisy world: can fish compete with anthropogenic noise? Behavioral Ecology (2014), 00(00), 1–9. doi:10.1093/beheco/aru029
6. United Nations Environment Programme (2012), Scientific synthesis on the impacts of underwater noise on marine and coastal biodiversity and habitats, in *Proceedings of the 16th meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, 30 April - 5 May 2012, Montreal, Canada*, eds. UNEP, UNEP, Nairobi, pp.1-93.

Specific mention should be made at this stage about the deleterious impacts of sub bottom profile sonars euphemistically called Multi Beam Echo Sounders (MBES) often used for high grade sonar mapping, oil & gas rig stabilisation and to map the GBRWHA that International Whaling Commission found directly responsible for a mass stranding of melon headed whales. (Southall *et al*. 2013[7]; Zykov 2013[8]).

- Many high resolution mapping projects using 12 and 3.5 kHz sonar, MBES, should not be exempted as possible extremely high noise sources readily detectable by dolphins and dugongs respectively for the GBRWHA based on known or assumed hearing sensitivities.
- These sonar systems should not be considered acoustically benign simply as they generate pretty bottom bathymetry.

Documentation of naval sonar systems are not included in this review as they are managed appropriately between Navy and SEWPaC for GBRWHA. Documentation of seismic impact on marine life and recommended practice to assess the impact (marine mammal centric) while not appropriate for GBRWHA is best summarised by Nowacek *et al*. (2014)[9].

7. Southall BL, Rowles T, Gulland F, Baird, RW & Jepson PD. (2013). Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melon---headed whales (*Peponocephala electra*) in Antsohihy, Madagascar. 5p.
8. Zykov M. (2012). *Multibeam Operations off the Coast of Madagascar: Post-Survey Modeling of Underwater Sound*. JASCO Document 00432, Version 1.1. Technical report by JASCO Applied Sciences. 27pp.
9. Nowacek DP, Bröker K, Donovan G, Gailey G, Racca R, Reeves RR, Vedenev AI, Weller DW & Southall BL. (2014). Responsible Practices for Minimizing and Monitoring Environmental Impacts of Marine Seismic Surveys with an Emphasis on Marine Mammals. *Aquatic Mammals* ***39***(4): 356-377.

This submission

The scope for this submission is not to review the extensive literature of underwater noise in oceans and nearshore areas including the GBRWHA. Particular attention should be attributed to the UN Environment Programme review on underwater noise of shipping on marine ecosystems (UNEP 2012[6]).

I will contend in this submission that international research, readily available scientific literature and legal marine policy documentation and United Nations agreements to which Australia is a signatory all acknowledge underwater noise from shipping and port development and make defensible concerns for impact of anthropogenic noise impacting the GBRWHA well-founded.

- Direct mortality from noise exposure is not likely to generate general significant impact.
- Most likely impact is anticipated to impact on an ecosystem basis in terms of masking of communication and generation of stress effects.

However, there would appear to be a 'strong reluctance' of responsible authorities associated with GBRWHA in Australia to introduce marine underwater noise as a marine pollutant impacting the GBRWHA despite its international acknowledgement.

- Queensland basically ignores it.
- GBRMPA makes scant reference to it.
    - More data are omitted than referenced.
    - Low hierarchy recommendations are made about noise that rarely achieve high level recommendations.
- While the Australian Maritime Safety Authority (AMSA) ratified IMO Guidelines to reduce the impact of underwater noise including within GBRWHA it would appear that AMSA through its North East Shipping Management Plan has actively downgraded references to noise impact on the environment, albeit a suppression of information considering shipping noise as a marine pollutant.
    - If AMSA follows its own international agreements within Australia, shipping could be considered to make alternate routing and scheduling arrangements that may impact on resource export economics irrespective of the impact on the GBRWHA.
    - Simply omitting most references to noise, terminating all official attempts at shipping data sourcing diverts attention of UNESCO away from Australia's international obligations.

Terms of Reference of this Review in relation this submission

The points relevant to underwater noise that I will discuss are highlighted (in bold).

The adequacy of the Australian and Queensland Governments' efforts to stop the rapid decline of the Great Barrier Reef, including but not limited to:

- *a. management of the impacts of industrialisation of the reef coastline, including dredging, offshore dumping, and* ***industrial shipping****, in particular, but not limited to, current and proposed development in the following regions or locations:*
  - *i. Gladstone Harbour and Curtis Island,*
  - ***ii. Abbot Point,***
  - *iii. Fitzroy Delta, and*
  - *iv. Cape Melville and Bathurst Bay;*
- *b. management of the impacts of agricultural runoff;*
- *c. management of non-agricultural activities within reef catchments impacting on the reef, including legacy mines, current mining activities and practices, residential and tourism developments, and industrial operations including Yabulu;*
- *d. ensuring the Great Barrier Reef Marine Park Authority has the independence, resourcing and capacity to act in the best interest of the long-term health of the reef;*
- ***e. the adequacy, timeliness and transparency of independent scientific work undertaken to support government decisions impacting the reef;***
- ***f. whether government decision processes impacting the reef are consistent with the precautionary principle;***
- ***g. whether the strategic assessments currently underway are likely to protect the reef from further decline;***
- ***h. the identification and protection of off-limits areas on the reef coastline to help protect the health of the reef;***
- *i. consistency of efforts with the World Heritage Committee's recommendations on what is required to protect the reef;*
- *j.* ***the extent to which government decisions impacting the reef, including development of the strategic assessments and Reef 2050 Plan, involve genuine, open and transparent consultation with the Australian community, affected industries and relevant scientific experts****, and genuine consideration of the broader community's views in final decisions; and*
- ***k. any other related matters.***

My submission will be presented in the following general order,

1. What is known internationally (outside Queensland) about underwater noise impacts from shipping.
2. Shortfalls in admission, possibly deliberate, of GBRWHA's Strategic Assessment and AMSA's North East Shipping Management Plan about underwater noise compared to Australia's agreed international obligations.
3. A generally positive outlook for mitigation of underwater noise impacts with minimal disruption of shipping.

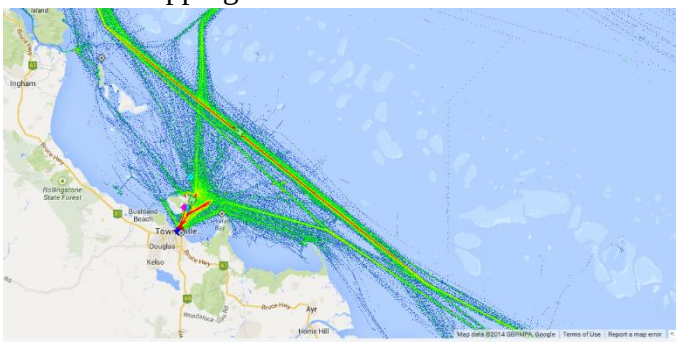
Personal qualification for providing this submission

To qualify for providing science based data for this submission I wish to indicate,

1. I functioned as Fisheries Biologist with Fisheries Queensland Government 38 years primarily on life history and stock assessment of mostly coastal, reef and oceanic fish species.
2. For twenty six years of that period I increasingly worked on the role of underwater acoustical physics and psychoacoustics in marine mammal interactions with fishing gear.
3. I am now Principal Adjunct Research Fellow, Engineering & Physical Sciences, James Cook University specialising on the impacts of underwater noise and marine and freshwater ecosystems.
4. Acoustic aspects of fisheries with commercial fisheries and government research agencies of Japan (Japan Fisheries Research Agency, Far Seas Tuna Lab Shimizu Japan) and the USA (acoustic specialist as Member Marine Mammal Advisory Committee Western Pacific Fishery Management Council) each for 8 years.
5. I was a Member of the Bioacoustics Technical Committee of the American Acoustical Society for two years.
6. Since departing Fisheries Queensland I have been engaged on fish and marine mammal acoustic interactions with fishing gear as well as the impacts of noise mainly from shipping activities on marine ecosystems.

I am currently engaged on three projects involving acoustic impact on marine animals in marine ecosystem soundscapes or on marine animals (humpback whales) that are representative of the GBR.

1. Mitigating humpback whale entanglements on West Australian rock lobster gear.
    - Assessing most appropriate bycatch mitigation acoustic alarms (federally funded).
2. Mitigating dolphin interactions with South Australian shark nets.
    - Using sonar interference techniques to maintain playful dolphins from the immediate vicinity of nets.
3. Examining shipping noise impacts on Great Barrier Reef marine soundscape.
    - Using available use densities of ships transiting Great Barrier Reef waters off Townsville (Live Ships AIS shipping densities for May 2014 shown in Figure below) and generating cumulative noise densities based on known and validated shipping sound Source Levels.



IMPACT OF UNDERWATER NOISE ON THE MARINE ENVIRONMENT

1. Available knowledge on underwater noise from shipping

Marine ecosystems experience natural and anthropogenic levels of underwater noise well documented by acoustics and naval systems engineers. The rate at which ambient noise levels in oceans has been increasing by anthropogenic noise sources, and its impact, is also well documented at the United Nations level which holds for GBRWHA.

Studies of noise impact from shipping are steadily increasing with the 'bandwidth' of science journals widening. Accepted publications now include examining masking of communication (social and reproductive) in organisms from invertebrates (crabs, shrimp, bivalves), fish and marine mammals expanding from applied physics/acoustics and taxon based journals to broader ecological journals such as marine pollution, conservation, veterinary and aquaculture, marine policy and law to indicate a few.

Individual studies have demonstrated underwater noise impacts generate stress impacts on marine mammals and fish as measured by conventional hormonal based techniques leaving no doubt that a relationship existed between noise and biological stress. The most prominent example of shipping generating stress was established almost accidentally when right whales migrating past New York with dramatically reduced shipping noise as a result of the September 2011 terrorist attacks on the US, particularly New York, demonstrated significant reduced hormonal stress levels in adaptively sampled faeces. (Rolland *et al* 2012[10]).

Growth rate changes were determined in standardised seismic impacts studies in fish and bivalves. Playback of various forms of vessel noise at realistic 'in the wild' received levels generated classic growth rate and classical blood and hormonal stress indicators in fish equivalent to southern Australian pink snapper (Filiciotto *et al.* 2013[11]).

Behavioural ecologists and acousticians have long documented the Lombard Effect in natural populations where animals were forced to 'shout' or change communication strategies to allow for rising anthropogenic noise sources. Having to alter communication strategies under the constant bombardment of anthropogenic noise have been shown to reduce transmission distances, increased risk of predation/parasitism, altered energy budgets and loss of vital information (Read *et al.* 2014[11]). Specific examples included for dolphins in open water situations, including now for West Australian waters where bottlenose dolphin whistles are forced to vocalise louder than in other areas as background noise including from shipping was higher.

10. Rolland, RM, Parks, SE, Hunt, KE, Castellote, M, Corkeron, PJ, Nowacek, DP, Wasser SK & Kraus SD. (2012). Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society B* **279**, 2363–2368.
11. Filiciotto F, Giacalone VM, Fazio F, Buffa G, Piccione G, Maccarrone V, Di Stefano V, Mazzola S, Buscaino G. (2013). Effect of acoustic environment on gilthead sea bream (*Sparus aurata*): Sea and onshore aquaculture background noise. *Aquaculture* **414–415**, 36–45.
12. Read et al. (2014). Fitness costs as well as benefits are important when considering responses to anthropogenic noise. *Behavioral Ecology*, **25**(1), 4–7.

Now, fish in experimental situations to date have been shown to have to 'raise their voices' to be heard with appropriate energy expenditure concerns, likely reductions in communication range and reduced reproductive success.

2. International initiatives to reduce the impact of shipping noise

European Union

In June 2008 the EU established a Marine Strategy Framework Directive as a non-binding law to make a significant contribution to the preservation, protection and restoration of EU marine ecosystems, including pollution reduction and minimization. The Directive aimed at achieving *good environmental status* in the EU marine waters by 2020 at the latest. According to the Directive, EU Member States should undertake a series of steps to progressively achieve this *good environmental status* which should ensure the maintenance of ecologically healthy, clean and productive seas as well as reduce adverse human impacts on marine ecosystems.

To ensure that human induced pressures are kept within reasonable levels while enabling the sustainable use of marine goods and services by present and future generations, 11 qualitative descriptors were developed with no priority (Van der Graaf *et al*. 2012[13]). Those descriptors that mirror much of the priorities for the GBRWEA are below. Underwater noise is included as an energy introduction, as is electromagnetic radiation, and mirrors the 1982 UN Commission for the Law Of the Sea.

- Descriptor 1: Biological diversity
- Descriptor 2: Non-indigenous species
- Descriptor 3: Population of commercial fish / shell fish
- Descriptor 4: Elements of marine food webs
- Descriptor 5: Eutrophication
- Descriptor 6: Sea floor integrity
- Descriptor 7: Alteration of hydrographical conditions
- Descriptor 8: Contaminants
- [5]Descriptor 9: Contaminants in fish and seafood for human consumption
- Descriptor 10: Marine litter
- Descriptor 11: Introduction of energy, including underwater noise

It should be noted that within the EU came the first recognition that Marine Protected Areas were in no way protected from impact of underwater noise from shipping due to the nature of propagation of underwater noise. The EU states' waters are restricted and expanding the sizes of MPA area offered absolutely no protection from the impact of underwater noise pollution. The most appropriate way to reduce marine acoustic pollution was to reduce the sound from shipping which is under way through EU and International Maritime Organisation initiatives.

13. Van der Graaf AJ, Ainslie MA, André M, Brensing K, Dalen J, Dekeling RPA, Robinson S, Tasker ML, Thomsen F, Werner S. (2012). European Marine Strategy Framework Directive - Good Environmental Status (MSFD GES): Report of the Technical Subgroup on Underwater noise and other forms of energy. 75pp.

By way of general example for the Danish/Swedish Baltic area little information existed for the effect of ship traffic on the most numerous marine mammal in the region, a porpoise. Simultaneous monitoring of ship traffic (AIS), measurements of shipping noise and noise loggers in shipping lanes and recordings of porpoise acoustic activity are underway to study habitat exclusion caused by shipping noise in order to generate **noise-sensitivity maps** for the species.

United States of America

It would be reasonable to say that the impact of noise from shipping on marine ecosystems has been driven by the United States. Their impact on initiating activities for shipping noise mitigation, with the support of Australia as the records demonstrate, have been recently rewarded with the IMO ratifying Guidelines for the reduction of noise from ships.

The approach of NOAA Fisheries alone to impacts of shipping noise as distinct from noise generated by energy exploitation is best summarised in http://www.nmfs.noaa.gov/pr/acoustics/shipnoise.htm.

International ocean basins.

International maps of shipping routes shipping density demonstrate the extent of shipping routes (Fig. 1). The ships are noise generators and cumulative noise maps can, and have, been generated.

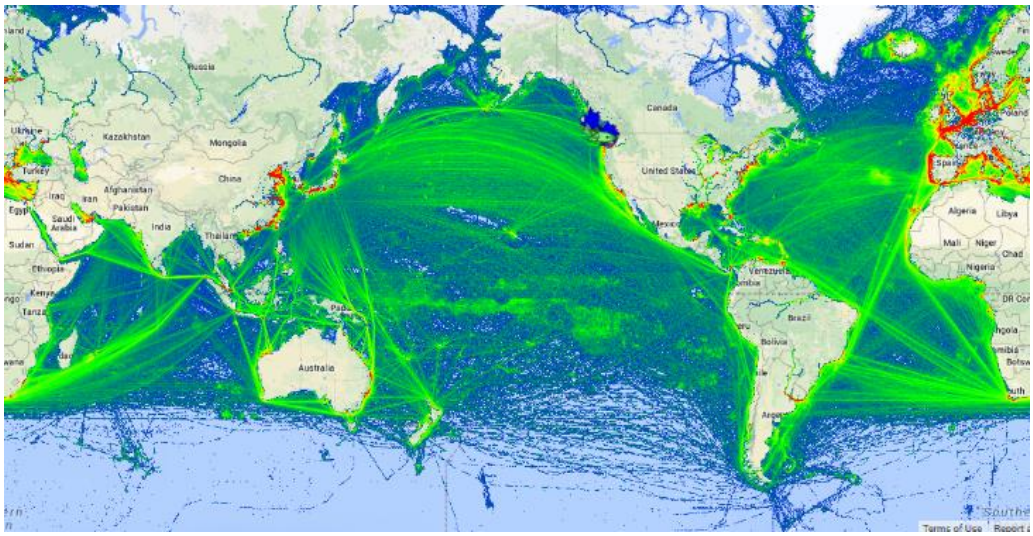


Fig. 1. Marine Traffic shipping density using Automatic Identification System data.

Parks *et al.* (2013)[14] assessed the general underwater noise impact across ocean basins and determined where natural baseline sound could be determined by extracting shipping noise that each marine area had its own unique noise level and acoustic diversity. The noise for each area could be assigned an Entropy Index that provided an indication of the complexity (or signal organisation) of the underwater noise. The noise compensated entropy index was viewed as being reflective of the regions biological patterns. Parks *et al*. (2013)[14] considered that underwater Entropy Indices (or lack thereof) held promise for its use as a rapid acoustic biodiversity and health indicator in the marine environment.

It would be reasonable to say that where shipping noise would mask biological activity no biodiversity using acoustic indices could be determined which in turn would indicated that acoustic biodiversity would be challenged.
It is also reasonable to conclude that the health of Marine Protected Areas could be assessed on the basis of remoteness of major shipping routes distant from acoustic pollution.

- The concentrated nature of shipping through narrow channels of the GBRWHA is clearly of concern.
- The figure above demonstrating major shipping routes clearly indicates major shipping routes through the once proposed Coral Sea Marine Park which clearly questions some of the rationales behind the Marine Park.
    - With major shipping routes through the middle of the once proposed MPA it would seem that the intention of the MPA was to protect shipping.
    - With shipping routes hence noise exposure lower at the margins of the Park it would also suggest that biodiversity in open waters away from the shipping and at the MPA margins would be less challenged.
    - Foreign fishing interests in adjacent countries would be the major beneficiaries of the Marine Park as they would be fishing adjacent to the edges of the Marine Park where noise impact from shipping would be least.
    - Noting that the US had signed fishing deals with adjacent countries and noting the commercial fishing interests associated with corporation portfolios of at least one environmental group the question remains…..*was the Coral Sea Marine Park established to facilitate US fishing interests with Australia providing the MPA?*

14. Parks, S.E., *et a*l. (2013). Assessing marine ecosystem acoustic diversity across ocean basins, *Ecological Informatics*, http://dx.doi.org/10.1016/j.ecoinf.2013.11.003

SHORTFALLS OF THE GBRWHA STRATEGIC ASSESSMENT:

UNDERWATER ANTHROPOGENIC NOISE POLLUTION FROM SHIPPING POORLY ASSESSED IN GBRWHA STRATEGIC ASSESSMENT

The GBRWHA Strategic Assessment (GBRWHA SA) consideration of underwater noise is essentially limited to two paragraphs in a >600 page report. The limited text and references dealing with noise pollution are copied and the pages that address noise from shipping are also provided and shown in Fig. 2. A general comparison is warranted between the way the GBRWHA SA and prior GBR Ports and Shipping documentation handled the topic of shipping impact.

The 600+ page GBWHA SA document mentions underwater noise in general terms numerous times but expansion of the topic is restricted to two pages copied as Figure 2.

- Richardson *et al*. (1995) (referenced in Fig. 2).
    - Still a classic textbook standard for underwater noise although the publication has been surpassed many times over since 1995.
    - The literature pertaining to Source Levels of noise sources for all classes of shipping, by angle of approach to each vessel type that transits the GBRWHA are now well documented and would be far more relevant for the GBRWHA SA to consider.
- United Nations Environment Programme as UNEP (2012)[5] (referenced in Fig. 2).
    - An excellent review of underwater noise prepared by the United Nations Environment Programme and used extensively by the International Maritime Organisation.

The reference of United Nations Environment Programme (UNEP)[5] is basically restricted in its use to the text represented in Fig. 2. Throughout the course of this submission it will be made clear that this reference UNEP (2012)[5] is not only the most current and expansive underwater noise anthropogenic review available it is also a United Nations Environment Programme document well known to its subsidiaries UNESCO and the UN IMO (in Australia the Australian Marine Safety Authority AMSA).

UNEP (2012)[5] may well be the *most non referenced* or *ignored* scientific publication on the impacts of shipping noise of marine ecosystems as far as the GBRWHA SA or particularly any AMSA document is concerned.

7

Main references to anthropogenic shipping noise in GBRWHA SA

Noise pollution

Greater shipping and boating activity, the use of sonar, activities associated with coastal development including pile driving, and defence activities all contribute to increased underwater noise on a local scale. Sound is extremely important to many marine animals, playing a role in communication, navigation, feeding, orientation and the detection of predators.[236] Concerns about the impacts of man-made sound on marine animals has grown over recent decades and is now considered a significant stressor on marine life worldwide.[237] Sounds can have a range of effects, depending on the acoustic frequency animals are able to detect and produce (Figure 6.24) and their proximity to the source. Effects to marine life range from detection with no adverse impacts, to significant behavioural changes, to hearing loss, physical injury and mortality.[236]

While there is a national policy addressing the acoustic impacts of seismic surveys on whales [238], there are no specific standards for the range of noise pollution affecting Great Barrier Reef species. Given the increases in man-made underwater noise and the observed effects on marine life around the world[237], there is an urgent need for a greater understanding of the ecological impacts of noise within the Region and for guidance on measures to avoid or mitigate these impacts

References

236. Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson, D.H. 1995, Marine mammals and noise, Academic Press, San Diego.
237. United Nations Environment Programme 2012, Scientific synthesis on the impacts of underwater noise on marine and coastal biodiversity and habitats, in *Proceedings of the 16th meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, 30 April - 5 May 2012, Montreal, Canada,* eds. UNEP, UNEP, Nairobi, pp.1-93.

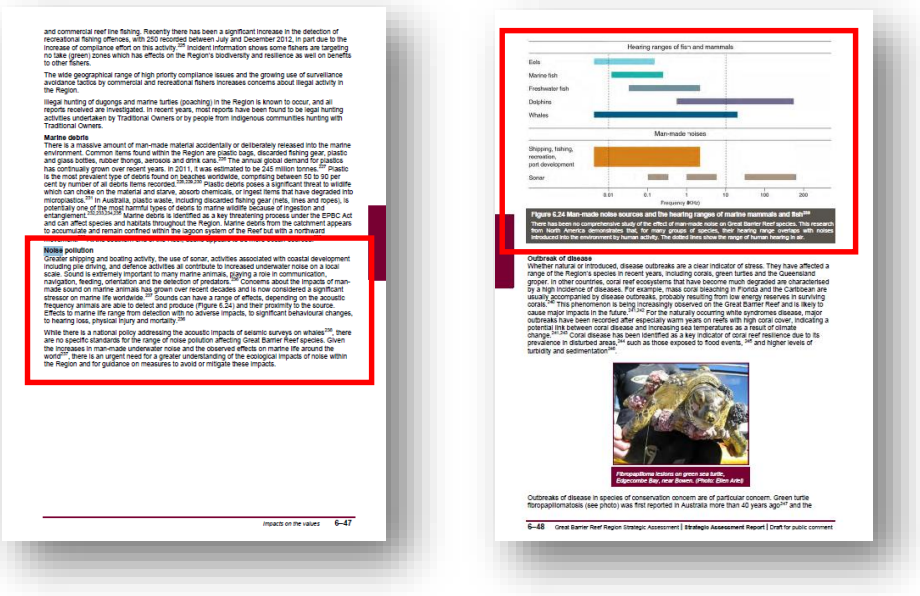


Fig. 2. Main two paragraphs addressing anthropogenic shipping noise, with references utilised, in the GBRWHA Strategic Assessment

The differential in consideration of UN endorsed underwater noise from shipping between the 600+ page GBRWHA SA with its limited references and the 17 page GBRMPA Ports and Shipping Information Sheets GBRMPA (2012)[15] and GBRMPA (2013)[16] (in May 2013)) published well before the GBRMPWHA SA are noteworthy. The succinct GBRMPA Ports and Shipping Information Sheets GBRMPA (2012)[15] and GBRMPA (2013)[16] included McKenna *et al*. (2012)[17] and Ellison *et al*. (2011)[18].while GBRWHA SA did not.

- McKenna *et al*. (2012)[17] discuss noise radiation from aspects of container and bulk carrier vessels common in GBRWHA waters.
    - Allen *et al*. (2010)[19] would have been appropriate for noise radiation as they also included noise from high speed ferries so common in GBRWHA waters.

- Ellison *et al.* (2011)[18] recognised that increases in human activity and background noise can alter habitats of marine animals and potentially mask communications for species that rely on sound to mate, feed, avoid predators, and navigate.
    - They provided a context based approach to assess marine mammal behavioural responses to anthropogenic sounds and specifically including shipping.
    - The simple fact that a context based approach was suggested to examine impact was a clear indication that impact did in fact exist and required attention.

- UNEP (2012)[5] was not cited in GBRMPA (2013)[15, 16].
    - However, the references McKenna *et al*. (2012)[17] and Ellison *et al.* (2011)[18] were integral to UNEP (2012)[5] anyway.

Arguably the most salient publication of the past decade directly implicating marine mammals and noise was that of Rolland *et al*. (2012)[20] who in a reverse methodical biological acoustic study clearly determined that endangered North Atlantic right whales migrating past the noisy shipping area of New York were demonstrating hormonal stress effects. Stress levels had not been noticed in this dramatically dwindling population until the *September 11* events in New York terminated shipping impact and non acoustically stressed levels of hormones could be determined.

15. Great Barrier Reef Marine Park Authority (2012). *Ports and shipping information sheet*, GBRMPA, Townsville.
16. Great Barrier Reef Marine Park Authority (2013). *Ports and shipping information sheet*, GBRMPA, Townsville.
17. McKenna MF, Ross D, Wiggins, SM & Hildebrand JA. (2012). Underwater radiated noise from modern commercial ships. *The Journal of the Acoustical Society of America*, **131**(1): 92-103.
18. Ellison WT, Southall BL, Clark CW & Frankel AS. *(2011). Conservation Biology*, Volume 26, No. 1, 21–28.
19. Allen JK, Peterson ML, Sharrard GV, Wright DL & Todd SK, (2010). Radiated noise from commercial ships in the Gulf of Maine: Implications for whale/vessel collisions. *Journal of the Acoustical Society of America* **132**(3), September 2012 EL231 [http://dx.doi.org/10.1121/1.4739251].
20. Rolland, RM, Parks, SE, Hunt, KE, Castellote, M, Corkeron, PJ, Nowacek, DP, Wasser SK & Kraus SD. (2012). Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society B* **279**, 2363–2368.

The GBRWHA SA correctly noted that few Australian acoustic based standards exist for regulating shipping noise pollution in GBRWHA waters. Erbe (2012)[21] provides an assessment of international noise regulations including what does currently exist for Australia. Internationally, outside Queensland at least, ethical user practice is to follow National Oceanic & Atmospheric Administration regulations or As Low As Reasonably Practical (ALARP) observance, the latter almost being the equivalent to a Precautionary Principle approach.

It was significant that the GBRWHA SA has accepted (copied text in Fig. 1) that underwater noise is a marine pollutant (*noise pollution affecting Great Barrier Reef species)*. Anthropogenic sound as a marine pollutant can be readily traced back to the UN Commission for the Law Of the Sea (UNCLOS 1982). (McCarthy (2004)[22].

Marine pollution journals have accepted publications dealing with acoustic impact on marine and freshwater animals for some time however Merchant *et al.* (2012)[23] was perhaps the most recent to refer to acoustic impact as a marine pollutant and publish in a mainstream marine pollution journal.

- A post analysis supplementary video of acoustic pollution monitoring of shipping movements by a later publication presumably not available for use (or omission) by GBRWHA SA in Marine Pollution Journal is included[24].
- Comparable post processing is now available for the GBRWHA [25] with real time acoustic monitoring for the GBRWHA discussed later in this submission.

21. Erbe C. (2012). International regulation of underwater noise. *Acoustics Australia* **41**(1): 12-19.
22. E. McCarthy, *International Regulation of Underwater Sound: Establishing Rules and Standards to Address Ocean Noise. Pollution*, Kluwer Academic Publishers, Boston, 2004.
23. Merchant ND, Witt MJ, Blondel P, Godley BJ & Smith GH. (2012). Assessing sound exposure from shipping in coastal waters using a single hydrophone and Automatic Identification System (AIS) data. *Marine Pollution Bulletin* **64**: 1320–1329.
24. http://www.youtube.com/watch?v=IqY7G7-fUmc.
25. (http://www.theaustralian.com.au/technology/great-barrier-reef-becomes-a-sounding-board-for-science/story-fn4htb9o-1226665210256#).

The GBRWHA SA (in Fig. 2) also noted that there was an urgent need to investigate the likely impacts of noise and further indicated that there was *'a need… for guidance'* to mitigate the impacts.

- The above statements are **a)** probably correct and **b)** do require action.

With respect to '*need … guidance*' as noted above perhaps accepting what data and capability was already available in the GBRWHA would have been a preliminary step. The Precautionary Principle has often been incorporated into issues relating to anthropogenic activities regarding marine mammals so perhaps the Precautionary Principle would have been a self-guiding early step to appropriate acoustic assessment by simply following the underwater soundscape noise mitigation initiatives so readily accessible for Europe and North America with a shipping perspective. While refinements are underway for the specific metrics for Sound Level Exposure for ecosystem components there are clear understandings of the nature and impact of the noise generators.

It should be accepted that reference to anthropogenic impact of shipping on ecosystems, namely the soundscape, refers to marine animals and is not restricted to a minor but conveniently limited sub ecosystem component of marine mammals or specifically listed fish Protected Species. Simply put if an ecosystem is not healthy the various protected species, for whatever reason, would be at greater risk anyway.

The simple fact that the UNEP process involving agencies such as UNESCO and IMO has prepared UNEP (2012)[5] in May 2012, arguably the most comprehensive review of underwater noise on international marine ecosystems including for the GBRWHA, it means UNESCO is in a far better position to comment on the underwater soundscape of the GBRWHA than the GBR can or has done to date.

- The GBRWHA SA makes scant reference to UNEP (2012)[5] apparently preferring to rely more heavily on cut-and-paste shipping studies from within Australia that could well be described as deliberately ineffective, uninformative and totally out of date.
- As the GBRWHA SA had indicated it *required guidance* on underwater acoustics it would have seemed appropriate that UNEP (2012)[5] had in fact provided *guidance* yet the GBRWHA SA did not take heed of the guidance.

AUSTRALIAN / INTERNATIONAL UNSTANDING OF SHIPPING NOISE IMPACT ON THE GBRWHA ECOSYSTEM: NOT ASSESSED IN GBRWHA STRATEGIC ASSESSMENT

Three areas are briefly considered where documented government anecdotal data and clear peer reviewed data indicate a deleterious impact of shipping noise that have not been addressed in the GBRWHA SA.

a. ***Anecdotal information from Queensland commercial fishermen on shipping noise impact of GBRWHA***.

Cairns based Queensland commercial fishermen first introduced the concept of shipping noise impacting tuna like fish aggregations (narrow barred Spanish mackerel Fig. 3) as early as 1980. Commercial fishermen indicated to Fisheries Queensland, and later to GBRMPA when it was established, that the change in ferry technology from displacement hulls to hovercraft and later high speed catamarans was associated with a discernable rise in underwater noise as perceived through the hulls of fishing vessels and to fishermen and divers nearby in the water.

A dramatic decline in standing stock of gold spot herring in island anchorages in the Cairns region visited by tourist vessels was assessed, pre and post exposure, over a number of surveys by South Pacific Commission Tuna and Baitfish Programme staff. The likely reasons for the change was high intensity low frequency noise.

Cairns-Port Douglas based Spanish mackerel fishermen since 1980 have complained over the dramatic decline of the apparent stocks of aggregating and spawning fish on recognised spawning reefs available in the published literature (McPherson personal observation[26]). Fisheries Queensland refused to believe the claims of commercial fishermen and refused to permit the analysis of historical Departmental logbooks from the era for comparison to contemporary catch rates. Fisheries Queensland certainly noted how catches declined in the Port Douglas to Cairns Spanish mackerel spawning reefs and noted how fishing effort concentrated to spawning grounds off Townsville and catch data in GBRWHA SA certainly demonstrate that for recent years. No investigation of the change was permitted.

Fig. 3. Narrow barred Spanish mackerel surrounded by semi pelagic baitfish.

26. McPherson, Geoff. Personal Observation with Fisheries Queensland 1974-2010. (File copies of reports retained for reference purposes).

Sara *et al*. (2007)[27] observed that high speed ferries and speedboats vessels with broadband acoustic signatures comparable to the high speed ferries and outboards that carry tourist through the Cairns Spanish mackerel (a tuna-like fish of the family Scombridae) spawning aggregation area waters profoundly disrupted the schooling behaviour on an Atlantic tuna species (family Scombridae). The work of Sara *et al.* (2007)[27] was supportive of the claims made by 1980 commercial fishermen that high speed vessels with broadband acoustic signatures disrupted spawning aggregations.

Allen & Demer (2003)[28] observed that a North Pacific tuna species generate a schooling associated sound matched to a clear physical behaviour. The sound would have assisted schooling behaviour prior to spawning given spawning occurs in the hours of darkness. As the same physical behaviour described by Allen & Demer (2003)[28] is recognised for narrow barred Spanish mackerel in Great Barrier Reef waters a proposal was generated that Spanish mackerel used the same acoustic signalling after dark to facilitate spawning in GBRWHA waters. The frequency of the signal and the Sound Pressure Level based on fish length was modelled compared to tonal levels of passing shipping.

- The model indicated masking by shipping would occur conservatively within 6,000 m and occur for the duration of the ship transit.
- The model indicated that the masking of signal directional capability would be even greater.
- Masking was considered to be a factor of shipping densities.
- Validation of masking for this and other Great Barrier Reef fish species such as coral trout is required.
- Arguably this was the first indication of masking of fish communication in the GBRWHA.

27. Sarà G, Dean JM, D'Amato D, Buscaino G, Oliveri A, Genovese S, Ferro S, Buffa G, Lo Martire M & Mazzola S. (2007). Effect of boat noise on the behaviour of bluefin tuna *Thunnus thynnus* in the Mediterranean Sea. *Marine Ecology Progress Series* **331**: 243-253.
28. Allen S & Demer DA. (2003). Detection and characterization of yellowfin and bluefin tuna using passive-acoustical techniques. *Fisheries Research* **63;** 393–403.

b. Shipping impact on masking humpback whale mother-calf communication in the GBRWHA.

Baleen whales – Australian waters

In mid 2013 Craig McPherson of JASCO Applied Sciences (Australia) made a presentation to a Cairns GBRMPA LMAC convened meeting in Cairns (*Underwater Acoustics and the Great Barrier Reef – An outline of a current monitoring project, along with broader applications for environmental management*).

The presentation included modelling of the masking of humpback whale mother-calf communication utilising data on migrating humpback whale sound Source Levels for GBR waters (Dunlop *et al*. 2013[29] – published well before GBRWHA SA so no excuses for its non utilisation by GBRWHA SA), and sound models and propagation using Critical Ratio hearing detection algorithms utilised for whales (McPherson, Cato & Gribble 1999[30]; Clarke *et al*. 2009[31]; Erbe, McPherson & Craven 2011[32]). The techniques were originally suggested by Chris Clarke of Cornell Uni to McPherson, Cato and Gribble *et al*. (1999)[30] for use at the International Whaling Commission meeting Grenada 1999 and later as Clarke *et al*. (2009)[31].

Mother-calf whale concentrations in the Cairns region had been established weeks before the presentation to GBRMPA by passive acoustic survey (Curt Jenner, *pers. comm*. and [33]) so the models were developed for the whale locations off Cairns in relation to passing ships with estimated sound Source Levels (Dunlop *et al*. 2013[23]). The models demonstrated that the shipping blade tones masked the locally recorded mother-calf communication frequencies to <<1000 m for significant periods during individual vessel transits.

- The masking radii extended to known humpback whale calving areas on either side of the main shipping routes particularly north of Townsville where the width of the shipping channel significantly reduces and at times to less than a few kilometres.
- The more frequent the vessel traffic, particularly in confined waters of the northern GBRWHA the longer the duration of the masking.

In January 2014 Craig McPherson further explained the masking concept reinforcing that whales were detected acoustically over at least 30 k in waters off Townsville[34].

29. Dunlop RD, Cato DH, Noad MJ & Stokes DM. (2013). Source levels of social sounds in migrating humpback whales (*Megaptera novaeangliae*). *Journal of the Acoustical Society of America* **134**(1): 706-714.
30. McPherson GR, Cato DH & Gribble NA (1999). Acoustic properties of low cost alarms developed to reduce marine mammal bycatch in shallow coastal waters of Queensland., Australia. Paper SC/51/SM36 presented to the IWC Scientific Committee, May 1999 16pp.
31. Clark CW, Ellison WT, Southall BL, Hatch LT, Van Parijs SM, Frankel A & Ponirakis D. (2009). Acoustic masking in marine ecosystems: intuitions, analysis, and implications. *Marine Ecology Progress Series* **395:**201–222.
32. Erbe C, McPherson C & Craven A. (2011). *Acoustic Investigation of Bycatch Mitigation Pingers,* Project Report 10/21 to Australian Marine Mammal Centre. JASCO Applied Sciences, Brisbane.
33. http://theconversation.com/too-much-noise-in-the-ocean-for-whales-sensitive-ears-17933
34. http://www.abc.net.au/news/2014-01-17/claims-shipping-on-reef-upsets-whale-migration/5206250?section=qld.

Braithwaite *et al*. (2012)[35] had described an acoustically mediated spacing behaviour of humpback mothers with calves off Western Australia essentially to keep calves from social contact with other whales. A spacing of 1,800 m was estimated that helped reduce unnecessary calf stimulation with resultant energy loss immediately prior to their upcoming 4,000 k swim to Antarctica. While the ships generated unfortunate stimulation of young whales, the ship noise reduced the accuracy of the adult whales to acoustically mediate appropriate spacing permitting unwitting and energetically taxing inter whale stimulation.

- Although the research was conducted in Western Australia (Latitudes equivalent to Rockhampton to Bowen) it should be noted that the late 2012 paper was not considered by GBRWHA SA.
- The Longitudinal variation to the GBRWHA should not be any reason for its notable omission. A more likely reason is that Braithwaite *et al*. (2012)[35] documented underwater acoustic behaviour highlighting the potential for communication masking.

The Centre for Whale Research's Curt Jenner indicated in 2013 that the Great Barrier Reef had become a very noisy place underwater as a result of increased shipping traffic. Through a project that involved plotting whale vocalisations at 30 k intervals around the Australia coastline and assessing shipping traffic along the length of the Great Barrier Reef he also noted in particular how the northern Great Barrier Reef with its narrowing lagoon and more constrained noise channels how become particularly noisy (Curt Jenner, *pers. comm*.)[33]. Curt Jenner noted,

> *The Great Barrier Reef may already be too noisy in some places to allow whales to rest. Identifying where the natural resting places are in relation to our own uses should become a priority if that population is to reach its full potential.*

35. Braithwaite JE, Meeuwig JJ, Jenner KCS. (2012). Estimating Cetacean Carrying Capacity Based on Spacing Behaviour. *PLoS ONE* **7**(12): e51347. doi:10.1371/journal.pone.0051347

Baleen whales – US waters

For comparative purposes on baleen whale communication masking there are substantial data for shipping impacting on communication range of North Atlantic right whales. Fig. 4 below demonstrates the shipping routes out of the Port of Boston past which an endangered population of right whales migrates each year. Note the white lined rectangular area the Stellewagen marine reserve that has an east-west dimension of 35 kilometres compared to the width of the NW-SE oriented shipping channel near Abbott Point of about 40 kilometres

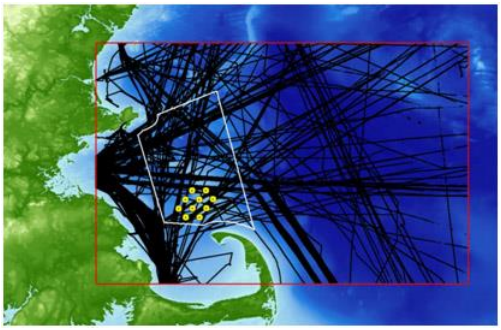


Fig. 4. Stellewegen marine reserve (white border), acoustic data loggers (yellow dots) and major shipping tracks from the Port of Boston (http://www.noaanews.noaa.gov/stories2012/20120815_rightwhale.html).

An expanded view of the Stellewegen Reserve is given in Fig. 5 below. The figure on the left shows noise of a single significant vessel with the noise isopleth that would mask right whale communication, with acoustically localised right whale positions shown as black dots. The figure on the right shows noise from a number of vessels with 3 significant vessels with Source Levels equivalent to tankers or container vessels. The light red margins to the recorded/modeled sound isopleths shows Sound Levels at an arbitrary 120 dB isopleth.

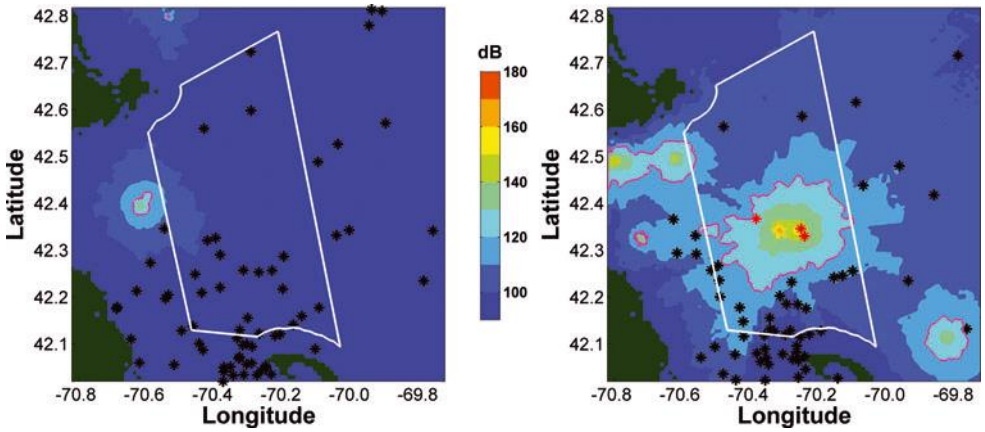


Fig. 5. Stellewagen marine reserve (white border), major shipping tracks from the Port of Boston. (http://www.noaanews.noaa.gov/stories2012/20120815_rightwhale.html)

36. Hatch LT, Clark CW, Van Parijs SM, Frankel AS & Ponirakis DW (2012), Quantifying loss of acoustic communication space for right whales in and around a U.S. National Marine Sanctuary. *Conservation Biology* **26**(6): 983–994.

Using known hearing capability of whales the authors estimated that effective communication of right whales was reduced by shipping during the migration period of the whales by 65%.

The GBRWHA SA acknowledged there was emerging evidence of additional impacts from ship operations worldwide (Hatch *et al*. 2012[36]) including and loss of 'communication space' for marine animals as a result of vessel noise, provided a reference number but little else. This expansion of the loss of communication space places the whales' loss of communication space into perspective and quantifies the result at 65%.
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Baleen whales – Canadian waters
Increases in shipping density off Canada's British Columbia coastline over recent years due in part to an increase in resources based shipping resulted in JASCO Applied Sciences providing the calculations to generate shipping density (left figure Fig. 6) from AISA shipping data into cumulative noise levels (right figure Fig. 6).

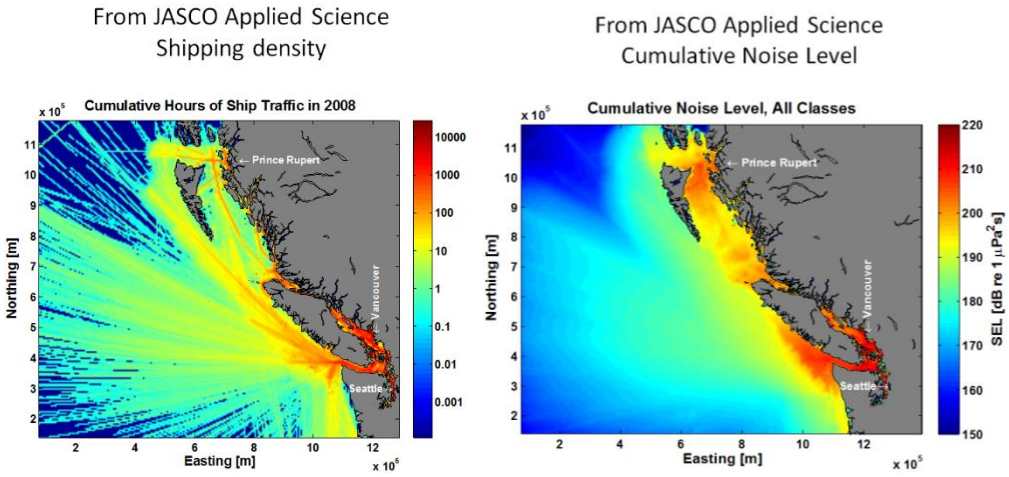


Fig. 6. Shipping density and cumulative noise levels for British Columbia. Data provided by JASCO Applied Science.

A result of the increased noise levels off British Columbia was the masking of whale communications. Fig. 7 taken from Williams *et al*. (2013)[37] demonstrates how shipping has reduced the communication range of humpbacks at specific sites where humpback whales are represented by pale red circles, where the reduced size of the circle represents the reduced communication range.

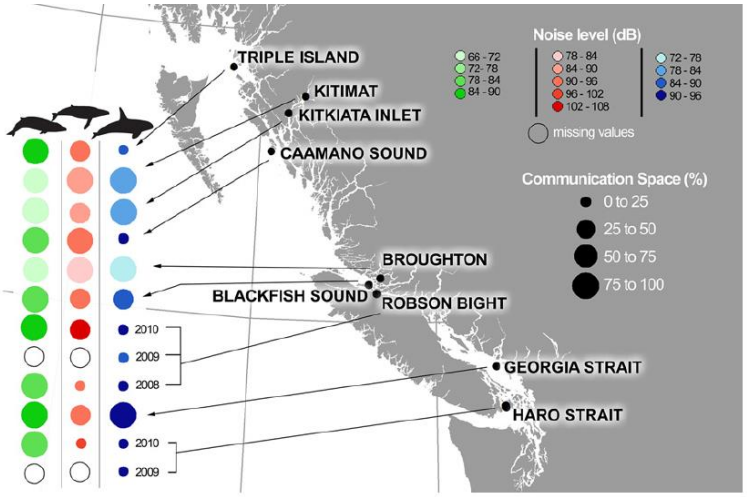


Figure 1 Map of study region and 12 sites along the British Columbia coast at which underwater recordings were collected in 2008, 2009 and 2010. The colour tone of the coloured circles in left hand columns indicates the median ambient deployment noise level (in dB re: 1 μPa, see colour key in upper right) at each site for frequency bands in which fin whales *Balaenoptera physalus* (17–28 Hz, green), humpback whales *Megaptera novaeangliae* (71–708 Hz, red) and killer whales *Orcinus orca* (1.5–3.5 kHz, blue) produce communication signals (see Table 1 for deployment details). The size of a coloured circle indicates the percentage of expected communication space available to the species at that site throughout the recording period under median ambient deployment noise conditions, relative to the communication space available under median quietest deployment noise conditions (see circle size key in middle right).

Fig. 7. Fig. 1 from Williams *et al*. (2013)[37].

37. Williams R, Clark CW, Ponirakis D & Ashe E. Acoustic quality of critical habitats for three threatened whale populations. *Animal Conservation* 1469-1795 http://dx.doi.org/10.1111/acv.12076

Ocean Networks Canada has incorporated time logged and real time baleen and toothed whale detection capability over the Strait of Georgia and Saanich Sea (British Columbia) where an increasing number of ships are transiting notably with increase in LNG resource materials shipping (Fig. 8). Given concerns over impact of increased shipping on communication of marine mammals and in order to examine interactions between marine mammals and transiting ships the interaction between shipping noise and marine mammal movemsnt is being investigated. Shipping movements are determined via the Automatic Identification System (AIS, also available for the Great Barrier Reef) and a demersal mounted JASCO Applied Sciences range and bearing localisation array[38].

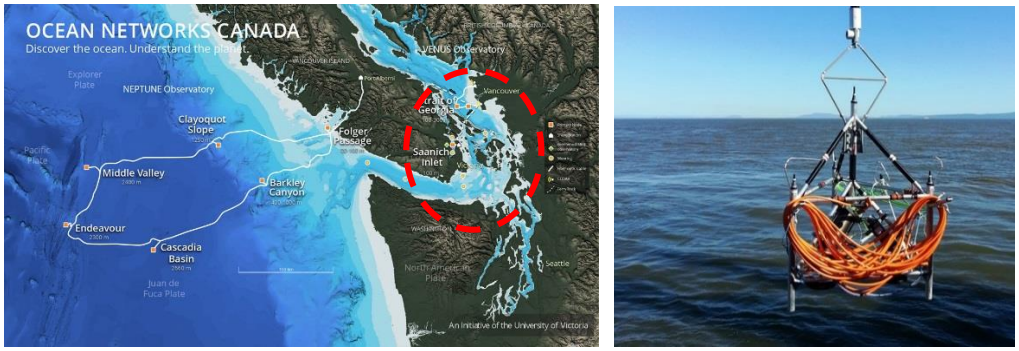


Fig. 8. Map of Ocean Networks Canada real time monitoring cabled and isolated sensor network. Red marker denotes baleen whale, toothed whale and shipping realtime tracking and localisation region. JASCO Applied Sciences realtime sound source tracking array.

The demonstration of shipping density and cumulative noise reducing the masking communication range of marine mammals off British Columbia is also relevant to GBRWHA. Earlier data presented clearly suggest that fish communication in GBRWHA are also likely to be routinely masked by shipping noise.

The methodology used in the Ocean Networks Canada project is the basis of acoustic data logging in GBRWHA waters being conducted by JASCO Applied Sciences and Engineering & Physical Sciences JCU for the transiting ships that generate anthropogenic noise through the GBRWHA off Townsville. An estimation of the cumulative ship noise exposure to mid GBRWHA areas as a three month time lapse exposure in preparation for presentation at INTERNOISE 2014 in Melbourne November 2014 (McGillivray *et. al.* 2014)[39].

17

38. http://www.jasco.com/news/2014/5/27/amar-mission-to-venus
39. MacGillivray A, McPherson C, McPherson G, Hannay D & Li Z. (2014). Modelling underwater shipping noise in the Great Barrier Reef Marine Park using AIS vessel track data

Fig. 9 (next page) provides a broad comparison on the shipping density between British Columbia and GBRWHA on a comparable scale for the same shipping period. A subsequent expansion of the GBRWHA area demonstrates higher shipping densities (shown in red) within the constrained shipping channels of the GBRWHA.

On an indicative basis an estimated masking radius for narrow Barred Spanish mackerel is shown. Masking radii would be in the same general order of magnitude such as shown in Fig. 7 for British Columbia.

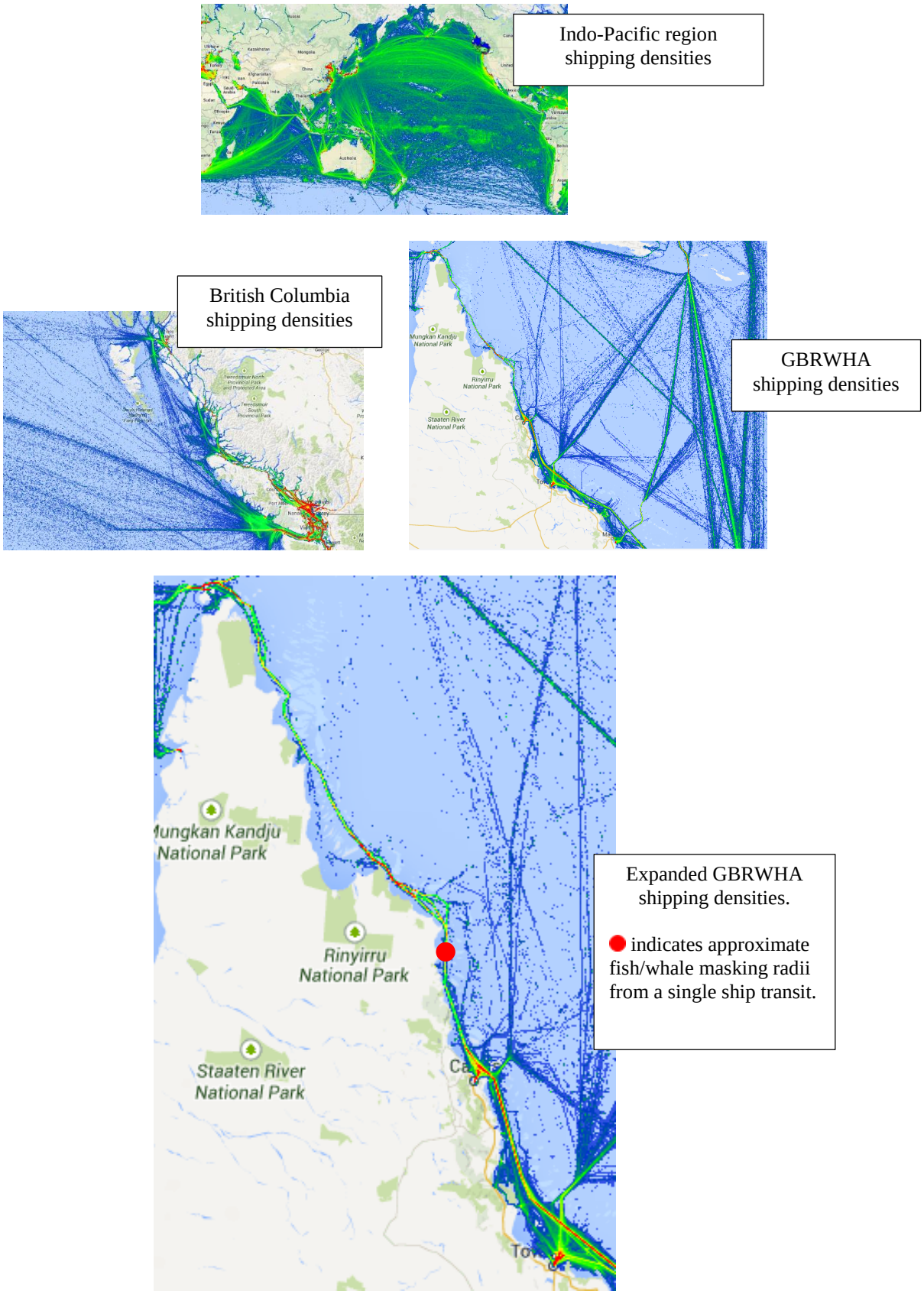


Fig. 9. Relative (comparative scale) shipping densities comparing British Columbia with an expanded GBRWHA to highlight shipping densities through the restricted northern GBRWHA waters. Higher shipping densities are in red.

Australian shipping industry view of whale response to shipping

It should be noted that Polglaze *et al*. (2012)[40], the Abbot Point ports and shipping industry 'voluntary' *Great Barrier Reef Shipping: Review of environmental implications* report, has become the default summary of shipping impact on the GBRWHA.

Unfortunately Polglaze *et al*. (2012)[40] do not get around to discussing the transiting of ships through the GBRWHA, particularly the Great North East Shipping Channel, in much detail. Mush is said of the possibility of ship noise being detected at ranges of 500 to 1000 kilometres with a comment that ship noise would not travel far in GBRWHA waters.

- A scant 2.5 pages of a report of 226 apparently attempting reporting on the environmental implications of shipping.
- No shipping noise reference on radiated ship noise was mentioned more recent that 1998 while two more recent examples were provided from two ships off Western Australia.

Of most significance of what Polglaze *et al*. (2012)[40] wrote with respect to impact on marine soundscapes,

- no biological reference was used for shipping noise impact even if vaguely associated, more recent than 2000.
- That while ship noise may not radiate 500 to 1000 kilometres as in ocean waters, the actual distance to reef habitat in the North East Shipping Channel varied from a maximum 30 kilometres to a minimum of 2-5 kilometres hence close enough for noise to have a profound impact on local soundscapes and of no issue at all for detailed models – loud would be loud with little need to model it.

In an apparent attempt to marginalise the impact of shipping on humpback whales to and from Abbot Point Polglaze *et al* (2012)[40] indicated,

> *It is conceivable that increasing numbers of ships in the GBR region at some time hypothetically pose some form of acoustic interference to humpback whales migrating through and aggregating within the reef. This is only possibly of local and hence intermittent and transitory concern, however due to physical, acoustic propagation conditions within the GBR region.*

The report of Polglaze *et al*. (2012)[40] for Abbott Point Voluntary Cumulative Impact Assessment for the Abbott Point Working Group makes reference to underwater radiated noise from ships pages 95-98. Included is,

> *Low frequency broadband noise from shipping is of potential concern as it may impede use of portions of the acoustic spectrum by sensitive or vulnerable marine fauna, particularly whales. This concern centres upon the possibility that such noise may mask echolocation vocalisations or communication, acoustically mask predators or prey, lead to separation of calves from mothers, or if intense and localised, alienate the animals from preferred aggregation areas or migration pathways.*

40. Polglaze, Griffin, Miller and Associates (2012), *Great Barrier Reef Shipping: Review of environmental implications*, PGM Environment, Safety Bay, Western Australia. 226pp.

Underwater acoustic science has not remained static since 2000 that Polglaze *et al*. (2012)[40] seems to base their science on. Unfortunately the assessment of Polglaze *et al*. (2012)[40] is used as the defacto confirmation that underwater shipping noise has no impact on GBRWHA ecosystems. Polglaze *et al*. (2012)[40] should be at least questioned and probably best ignored because of its extreme deficiencies.

- Accidental unlikely.
- Convenient and deliberate most likely.
- Sufficient to justify lack of biological impact from ships in the NESMP region, definitely not.

Dolphins

References appear in GBRWHA SA describing the biology of dolphins. They also cursorily mention vessel traffic, speed boats in the reference provided. However, in the context of shipping noise impacts on dolphins for instance references would appear not to have been very limited compared to what is available. Van Paris & Corkeron (2001)[41] had no trouble linking small boat traffic in Moreton Bay Queensland (undefined but apparently outboard powered based on water depth) while no reference was made to shipping transits nearby.

Sims *et al*. (2012)[42] related the potential communication masking impact of the noise of high speed ferries in Hong Kong, similar to those that operate in the GBRWHA area, on the same inshore species of dolphins present in GBRWHA waters and discussed by Van Paris & Corkeron (2001)[41]. The GBRWHA SA did not utilise this relevant paper.

Research papers linking vessel noise (outboard powered sped boats to commercial shipping) that could have been utilised to demonstrate impact of noise on dolphins include Nowacek *et al*. (2001)[43], Papale *et al*. (2012)[44], Rako *et al.* (2013a)[45], Rako *et al.* (2013b)[46] . The titles are self-explanatory.

41. Sims PQ, Hung SK & Wursig B. (2012). "High-speed vessel noise in West Hong Kong waters and their contributions relative to Indo-Pacific humpback dolphins (*Sousa chinensis*)," *Journal Marine Biology* **2012**: Article ID 169103, 11 pages. http://dx.doi.org/10.1155/2012/169103.
42. van Parijs SM & Corkeron PJ (2001). "Boat traffic affects the acoustic behaviour of Pacific humpback dolphins, *Sousa chinensis*." *Journal of the Marine Biological Association UK* **81**, 533–538.
43. Nowacek SM, Wells RS & Solow AR (2001). "Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay Florida," *Marine Mammal Science* **17**: 673–688.
44. Papale E, Azzolin M & Giacoma C. (2012). "Vessel traffic affects bottlenose dolphin (*Tursiops truncatus*) behavior in waters surrounding Lampedusa Island, south Italy," *Journal of the Marine Biological Association UK*. **92**, 1877–1885.
45. Rako, N., Fortuna, C. M., Holcer, D., Mackelworth, P., Nimak-Wood, M., Pleslic, G., Sebastianutto, L., Vilibi_ac, I., Wiemann, A., and Picciulin, M. (2013a). "Leisure boating noise as a trigger for the displacement of the bottlenose dolphins of the Cres-Lo^ısinj archipelago (northern Adriatic Sea, Croatia)," *Marine Pollution Bulletin* **68**: 77–84.
46. Rako N, Vilibi_ac L & Mihanovi_ac H. (2013b). "Mapping underwater sound noise and assessing its sources by using a self-organizing maps method," *Journal of the Acoustical Society of America* **133**: 1368–1376.

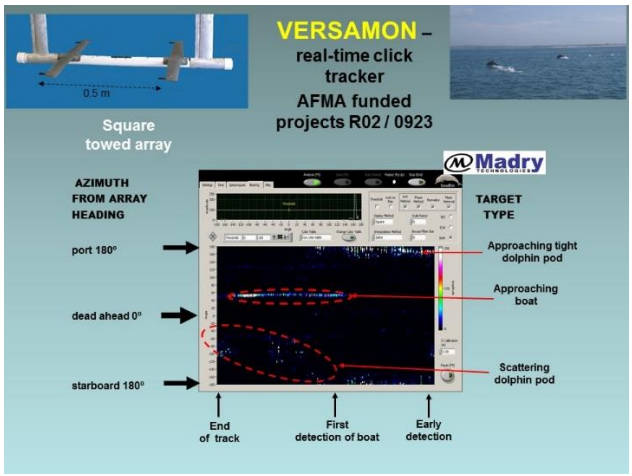
Recent publications include May-Collado & Qui~nones-Lebr_on (2014)[47] and Frankel *et al.* (2014)[48] the latter being relevant in that it discusses why dolphins in Western Australia were forced to whistle louder to be heard over the noise coming from a nearby shipping port.

It should be mentioned at this point that while a case could be made for shipping interest not wishing to have underwater noise impacts on marine ecosystems being mentioned there is a class perhaps of marine mammal biologists in Australia, not necessarily working in GBRWHA waters, who simply will not mention underwater noise with respect to marine mammals. Why these research biologists do not mention noise is not clear although not understanding the topic may be the reason. If these biologists have any involvement in any kind of management plans relating to dolphins then it may explain why some management plans appear to go out of the way to avoid mentioning underwater noise form shipping. Examples include research projects associated with dolphin watching in Port Stephens NSW and general dolphin work in South Australia.

Example 1. Dolphin watching in Port Stephens NSW.

In 2002 a 2D realtime passive acoustic tracking system for dolphins was under development for fisheries applications as part of an Australian Fisheries Management project to the author.

a. The gear was field tested in Port Stephens NSW and while tracking dolphins monitored the behavioural result of the onset of some dolphin watch vessels.
b. This 2014 PowerPoint slide used by the author in a current South Australian dolphin fishery application, describing 2002 events, demonstrates how dolphins were immediately impacted by the approach of one specific dolphin watch vessel.
    i. The relative bearings of dolphins to the array are shown over time.
    ii. Of prime interest are the escape reactions of dolphins to one incoming vessel (upper right below). The relative bearings of those 'fleeing' dolphins were tracked in real time.



47. May-Collado & Qui~nones-Lebr_on (2014) Dolphin changes in whistle structure with watercraft activity depends on their behavioral state. *Journal of the Acoustical Society of America Express Letters* [http://dx.doi.org/10.1121/1.4869255]
48. Frankel AS, Zeddies D, Simard P & Mann D. (2014) Whistle source levels of free-ranging bottlenose dolphins and Atlantic spotted dolphins in the Gulf of Mexico. *Journal of the Acoustical Society of America* **135**(3): 1624-1631.

Steckenreuter *et al.* (2012)[49] responded to increasing concerns over the impact of dolphin watch vessels in Port Stephens making numerous recommendations for impact reduction.

a. Somewhat incredulously no mention was made of the impact of underwater noise.
b. Impact of noise of dolphin and whale watching vessels is a regular agenda item at International Whaling Commission meetings.

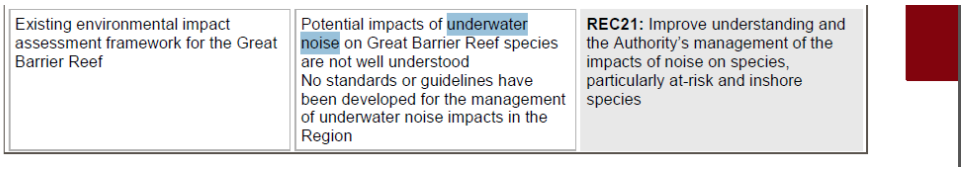
Example 2. Dolphin stress impacts in South Australian waters.

Seuront & Cribb (2011)[50] examined the impact of vessels causing stress in South Australian dolphins. Using a surface observation technique stress indices of dolphins generated by a kayaks, a motorised inflatable boat, a powerboat and a fishing boat stress indices were observed. Not surprisingly the dolphins swam in the water surrounded by the noise generated by the vessels.

a. Incredulously no mention was made of the impact of underwater noise generating the stress.
b. No mention was made of other vessel parameters such as wetted waterline length etc but it is hard to imagine how noise was not considered yet the researchers clearly managed to do so.

49. Steckenreuter A., Moller L & Harcourt R (2012). "How does Australia's largest dolphin-watching industry affect the behaviour of a small and resident population of Indo-Pacific bottlenose dolphins?," *Journal of Environmental Management* **97**, 14–21.
50. Seuront L & Cribb N. (2011). Fractal analysis reveals pernicious stress levels related to boat presence and type in the Indo–Pacific bottlenose dolphin, *Tursiops aduncus*. *Physica A* **390**; 2333–2339.

The GBRWHA SA made a brief reference to the impact of underwater noise noting enhanced work in this area as a *Recommended change to management*. Potential impacts were canvassed although the lack of standards for impact were noted. However, for as long as Australian marine mammal researchers conduct research on dolphins totally ignoring the fact that dolphins are obligate acoustic communicators and while shipping impact references are continually omitted in reviews no understanding of dolphins at comparable to the rest of the world will ever be obtained. Section 12-7 *Recommended changes to management.* *G*BRMPA had been informed of all US standards of noise impact on dolphins and Erbe (2013)[21] that discussed likely Australian standards.



Existing environmental impact assessment framework for the Great Barrier Reef	Potential impacts of underwater noise on Great Barrier Reef species are not well understood No standards or guidelines have been developed for the management of underwater noise impacts in the Region	**REC21:** Improve understanding and the Authority's management of the impacts of noise on species, particularly at-risk and inshore species

From GBRWHA SA Section 12-7 *Recommended changes to management*

c. Likely shipping impact on the function of acoustics in coral, invertebrate and fish larvae settlement on coral reefs.

Research has been conducted by north Queensland based, Australian and international, scientists on the role of the sound generated by reefs in attracting settlement of coral, crab and fish larvae. The work has been conducted since 2003 and mirrors work on coral reefs elsewhere. It has been demonstrated that many larvae are attracted, or repulsed if that be their life habit, to the noise made by reefs which in reality is a major factor dictating settlement behaviour. Olfaction is also a factor in reef settlement.

Research papers from coral reef areas are summarised by larval taxon and year of publication. The location of the work, the research permitting authority (if GBRMPA in Townsville) and the funding agency (if Australian funding included) are provided.

Ecosystem wide studies have never been funded to assess the impact of shipping noise on the GBRWHA ecosystem. Without funded research the direct links must be assumed from laboratory or small scale experiment. Those experiments do indicated strong causal links and under a precautionary principle those links appear valid.

Corals

Vermeij MJA, Marhaver KL, Huijbers CM, Nagelkerken I, & Simpson SD. (2010).
Coral Larvae Move toward Reef Sounds.
PLoS ONE 5(5): e10660. doi:10.1371/journal.pone.0010660

- Netherlands Antilles. A significant experimental paper relevant to coral decolonisation to noisy reefs, if in fact reefs were healthy and noisy.

Crustaceans – temperate waters.

Stanley JA, Radford CA. & Jeffs AG. (2009).
Induction of settlement in crab megalopae by ambient underwater reef sound.
Behavioral Ecology **21**: 113-120.

- New Zealand. This paper is a single representative from NZ and UK waters.

Fish – mostly from coral reefs

Leis J, Carson-Ewart BM, Hay AC & Cato DH. (2003).
Coral-reef sounds enable nocturnal navigation by some reef-fish larvae in some places and at some times.
Journal of Fish Biology **63**, 724–737.

- GBRWHA. GBRMPA Research Permit. Includes Australian funding

Simpson SD, Meekan MG, McCauley RD & Jeffs A. (2004).
Attraction of settlement-stage coral reef fishes to reef noise.
Marine Ecology Progress Series **276**: 263–268.

- GBRWHA. GBRMPA Research Permit. Includes Australian funding

Wright KJ, Higgs DM, Belanger AJ & Leis JM. (2008).
Auditory and olfactory abilities of larvae of the Indo-Pacific coral trout *Plectropomus leopardus* (Lacepe`de) at settlement.
Journal of Fish Biology **72**, 2543–2556.

- GBRWHA. GBRMPA Research Permit. Includes Australian funding

Gagliano M, Depczynsk M. Simpson SD & Moore JAY. (2008).
Dispersal without errors: symmetrical ears tune into the right frequency for survival.
Proceedings of the Royal Society B **275**, 527-534.

- GBRWHA. GBRMPA Research Permit. Includes Australian funding

Simpson, SD, Jeffs, A, Montgomery, JC, McCauley, RD & Meekan, MG. (2008).
Nocturnal relocation of adult and juvenile coral reef fishes in response to reef noise
Coral Reefs **27**:97–104.

- GBRWHA. GBRMPA Research Permit. Includes Australian funding

Simpson SD, Meekan MG, Larsen NJ, McCauley RD & Jeffs A. (2010).
Behavioral plasticity in larval reef fish: orientation is influenced by recent acoustic experiences
Behavioral Ecology doi:10.1093/beheco/arq117

- GBRWHA. GBRMPA Research Permit. Includes Australian funding

Simpson SD, Radford AN, Tickle EJ, Meekan MG & Jeffs AG. (2011).
Adaptive Avoidance of Reef Noise.
PLoS ONE **6**(2), 1-5.

- GBRWHA. GBRMPA Research Permit. Includes Australian funding

Radford CA, Stanley JA, Simpson SD & Jeffs AG. (2011).
Juvenile coral reef fish use sound to locate habitats.
Coral Reefs **30**:295–305.

- GBRWHA. GBRMPA Research Permit. Includes Australian funding

Leis JM, Siebeck U & Dixson DL. (2011).
How Nemo Finds Home: The Neuroecology of Dispersal and of Population Connectivity in Larvae of Marine Fishes
Integrative and Comparative Biology **51**, 826–843.

- GBRWHA. GBRMPA Research Permit. Includes Australian funding.

Stanley JA, Radford CA & Jeffs AG. (2012).
Location, location, location: finding a suitable home among the noise.
Proc. R. Soc. B **279**, 3622–3631.

- GBRWHA. GBRMPA Research Permit. Includes Australian funding

Holles S. Simpson SD, Radford AN, Berten L & Lecchini D. (2013).
Boat noise disrupts orientation behaviour in a coral reef fish.
*Marine Ecology Progress Series**, 485, 295-300.***

- French Polynesia. A coral reef fish family common in GBRWHA.

Jung CA & Swearer SE. (2011).
Reactions of temperate reef fish larvae to boat sound.
Aquatic Conservation: Marine and Freshwater Ecosystems **21**: 389–396.

- Rocky reefs including pylon structures in Port Phillip Bay show the same boats noise impact.

Given the relatively poor hearing capability of most larvae and the relatively moderate attraction range of the sounds made by reefs to these larvae within a dynamic water stream passing between, around and over reefs, the similarity of the acoustic signature of shipping and the peak hearing sensitivity of the larvae then anthropogenic noise from shipping would all have the capacity to mask the reef attraction effect. Conclusions of most of the above papers specifically acknowledge future problems of anthropogenic shipping noise and masking effects.

Masking the attraction capability would therefore seriously compromise the capability of reefs to attract annual larval recruitment levels. This would be especially important at periods when coral cover was low due to Crown of Thorns infestations (note, algal reefs have a low sound source level) or past cyclones.

What is striking about the acoustically mediated larval 'attraction' papers listed above is that **1)** they received levels of Australian funding, **2)** they received GBRMPA Research Permits to conduct the work yet **3)** they were generally conducted by researchers outside the immediate Townsville region. Given that GBRPMA provided so much input into the projects and would be more than aware of their implications for coral reef dynamics and indeed the impact of shipping, one can only wonder why virtually none of these papers were mentioned in the GBRWHA SA pertaining to the impacts of shipping.

The first baseline study of acoustics soundscape on a GBR reef was conducted by a collaboration between JASCO Applied Sciences and JCU Sustainable fishing over a four month period in 2013[11]. Baseline monitoring means acoustically recording in an ecosystem soundscape for a sufficient period of time to assess variability over diurnal and seasonal periods with sufficient caveats to clearly delimit the capability of extrapolation from the monitoring that would rarely consider inter-annual variation. The extreme to this type of quality monitoring is best exemplified by the totally inappropriate and non-representative technique referred to as hydrophone dipping utilised by consultants to document bits of Gladstone Harbour underwater activity and shipping movement. The Gladstone examples are too poor to even reference.

JASCO was interested in ambient noise levels that may impact crustacean and fish communication and the long range detection of distant shipping[11] and is directing a project on shipping densities and cumulative Sound Exposure Levels modelling through an Engineering & Physical Sciences James Cook University project. JCU Sustainable Fishing was interested in the deleterious impact of high frequency snapping shrimp signals on detection of active acoustic tags (multiple short duration tones around 70 kHz) placed in fish for population monitoring and residence studies.

A considerable level of funding has been attributed to anthropogenic effects and masking effects in northern Queensland waters with direct relevance to the current Abbott Point

terminals and particularly the ships approaching and leaving it through GBR waters. By not considering any references after 2000 Polglaze *et al*. (2012)[40] effectively negates the contribution of close range shipping masking the capability of reef noise attraction of coral, crustacean and fish larvae to reefs and masking of communication of adult fish such as tuna species and myriads of reef fish.

SHORTFALLS OF THE NORTH-EAST SHIPPING MANAGEMENT PLAN

a. Australia's international obligations to International Maritime Organisation on mitigating the impact of shipping noise on ecosystems.

The UN Commission for the Law Of the Sea (UNCLOS) in 1982 recognised that underwater noise was a marine pollutant and that situation has not legally changed in any way. Universal acceptance, indeed recognition probably as it seems to be increasingly convenient not to maintain this recognition. UNCLOS 1982 defined marine pollution as,

> *the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities. (*McCarthy 2004)[22]

The International Maritime Organisation (IMO) is the UN's specialised agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships. With the UN's IMO recognition of the Great Barrier Reef as the first Particularly Sensitive Sea Area (PSSA) in 1990 at the request of Australia where PSSA's (and subsequent iterations) are areas with "ecological, socio-economic, or scientific" importance needing special protection, noise was accepted as a one of many potential pollution sources that would impact a PSSA.

Lefebvre-Chalain (2007)[1] explained that the IMO Marine Environment Protection Committee (MEPC) resolutions considered pollutants to include 'oil and oily mixtures, noxious liquid substances, sewage, garbage, noxious solid substances, anti-fouling systems, harmful aquatic organisms and pathogens, and even noise'. The IMO therefore made it clear that PSSA's could be impacted by shipping during individual vessel transits and not simply based on physical vessel grounding.

- The IMO therefore made it clear that marine ecosystems including the highest concern PSSA's could be impacted by shipping not simply based on physical vessel grounding but by pollutants during individual vessel transits as previously outlined namely *oil and oily mixtures, noxious liquid substances, sewage, garbage, noxious solid substances, anti-fouling systems, harmful aquatic organisms and pathogens, and even noise.*
- There is no question that pollution from underwater noise would be the most sustained pollutant from shipping as ships both transiting and at anchor make noise, the most from the former caused by propeller cavitation.

Shipping in Australia is regulated by the Australian Maritime Safety Authority (AMSA), the Australian shipping representative on the International Maritime Organisation (IMO). Australia was one of the founding members of the IMO and is currently one of 40 IMO members.

A potted history of the role of consideration of the impacts of shipping in Australian seas underwater acoustics may be readily assessed through the website of AMSA[35] and in more detail that of the IMO.

- Essentially in 2008 Australia introduced a proposal to IMO for a new work programme on minimizing the introduction of incidental noise from commercial shipping operations into the marine environment to reduce potential adverse impacts on marine life. Examples for Australian waters were provided.
    - Note the initiative for recognising underwater noise impacts on ecosystems was Australia's, and that of the USA.
- The July 2009 59th session of International Maritime Organisation's Marine Environment Protection Committee (MEPC 59) approved the inclusion of a new item "Noise from commercial shipping and its adverse impacts on marine life".
- At the July 2011 62nd session of MEPC (MERC 62), the Committee instructed the Sub-Committee on Ship Design and Equipment (DE 55) to address the issue of noise from commercial shipping as an extension to considerations of noise onboard vessels.
- In November 2011 the UN Environment Programme in its Convention on Migratory Species in its *Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species* noted the steps being made to reduce underwater noise by shipping on marine animals by other UN organisations International Whaling Commission and IMO decided, with the vote of Australia,

    > *Reaffirms that there is a need for ongoing and further internationally coordinated research on the impact of underwater noise (including inter alia from offshore wind farms and associated shipping) on cetaceans and other migratory species and their migratory routes and ecological coherence in order to give adequate protection to cetaceans and other marine migratory species;*
- In the February 2012 Design and Equipment Subcommittee (DE 56) it was agreed to develop non-mandatory draft guidelines for reducing underwater noise from commercial ships.
    - Australia participated in this Correspondence Group under the Coordination of AMSA and in consultation with representatives from SEWPaC.
    - Non-mandatory draft guidelines for reducing underwater noise from commercial ships, for potential underwater noise reduction (propulsion, hull design, outboard machinery and operational modifications), and to examine the available options for ship-quieting technologies and operational practices were established.

- In March 2012 in Montreal the UNEP subsidiary the Convention on Biological Diversity Subsidiary Body on Scientific Technical and Technological Advice (CBD SBSTTA) developed and ratified *Scientific Synthesis on the impacts of underwater noise on marine and coastal biodiversity and habitats*
    - It was released in May 2012 as UNEP (2012)[5].
    - Investigation has confirmed that Australia was represented at this meeting including the Australian Government as SEWPaC and AMSA
    - Key points included:-

- *The underwater world is subject to a wide array of human-made noise from activities such as commercial shipping, oil and gas exploration and the use of various types of sonar.*
- *Anthropogenic noise in the marine environment has increased markedly over the last 100 or so years as the human use of the oceans has grown and diversified.*
- *Anthropogenic noise has gained recognition as an important stressor for marine life and is now acknowledged as a global issue that needs addressing.*
- *Sound is extremely important to many marine animals and plays a key role in communication, navigation, orientation, feeding and the detection of predators.*
- *A variety of marine animals are known to be affected by anthropogenic noise. Negative impacts for at least 55 marine species (cetaceans, teleost fish, marine turtles and invertebrates) have been reported in scientific studies to date.*
- *A wide range of increased levels of sound on marine fauna have been documented.*
- *There are increasing concerns about the long-term and cumulative effects of noise on marine biodiversity.*

The document clearly establishes Australia commitments to addressing the impacts of underwater sound from shipping on marine life. Despite its significance to Australia, and indeed UNESCO bodies, UNEP (2012)[5] is mentioned essentially only a single time once is referenced in the GBRMPA SA as shown earlier in Fig. 1.

- In March 2013 the draft DE 57 Guidelines *Noise from commercial shipping and its adverse impacts on marine life*, based on UNEP (2012)[5] were finalised by a drafting group in session.
- In November 2013 the IMO MEPC acting on UNEP May 2012 finalised draft Guidelines to reduce noise from commercial shipping.
- The Guidelines *Noise from commercial shipping and its adverse impacts on marine life* were presented to MEPC 66 for consideration in March 2014.

In early April 2014 the IMO MEPC approved a wide range of environmental issues including reduction of shipping noise from commercial ships on the environment[51].

- IMO MEPC approved the guidelines for noise reduction in order to address acknowledged adverse impacts on marine life.
- This was a recognition that underwater noise radiating from commercial ships has both short- and long-term negative consequences on marine life.

The new IMO shipping noise reduction Guidelines,

1. call for measurement of shipping noise using pre existing ISO standards for measuring shipping noise, which are themselves on the verge of adoption by UN's IMO.

- Of relevance to GBRMPA is that the ISO standard quoted is for measuring ship noise in deep oceanic water only which would have differences to measurement in shallow water as in the GBR lagoon.

2. identify computational models for determining effective quieting measures;
3. provide guidance for designing quieter ships and for reducing noise from existing ships, especially from propeller cavitation; and
4. advise owners and operators on how to minimize noise through ship operations and maintenance, such as by polishing ship propellers to remove fouling and sea surface state.

These UN IMO Guidelines are voluntary. However, they highlight IMO's acceptance that underwater noise generated by heavy ship traffic is an issue of concern in waters navigated by IMO vessels and that includes Great Barrier Reef waters.

It should be noted that shipping noise is universally recognised as being indicative of a vessels fuel inefficiency including by Australians Defence Department. Most shipping noise is generated from hydrodynamic turbulence around propellers. Therefore,

- Development of quieter vessels would have significant economic advantages for shipping.
- At least 4 international shipping conferences focused on vessel noise reduction in 2013.

In an initial effort to address shortfalls in knowledge of the shipping impact in GBRWHA waters and acting on the recommendations provided by JASCO Applied Sciences regarding estimations of shipping densities being expressed as cumulative shipping noise densities Geoff McPherson Adjunct Principal Research fellow (E&PS) at JCU and an Adjunct Senior Lecturer (Marine Biology) JCU sought advice from AMSA staff about obtaining shipping movement's data to match the JASCO Applied Sciences and JCU Sustainable Fisheries baseline acoustic data logging using a AMAR at Wheeler Reef.

Given the abovementioned, internationally agreed, role of AMSA in addressing the impacts of shipping noise on the marine environment our natural assumption was that as AMSA was the responsible agency for shipping administration and the appropriate agency to apply for the raw data with which to generate shipping densities. Part way through discussions with GBRMPA and AMSA staff we found that all communication was abruptly terminated. Despite repeated attempts no response was ever evoked from AMSA or GBRMPA.

- This change was so abrupt it could not have been coincidental.
- The data required was obtained elsewhere.

50. (http://www.imo.org/MediaCentre/PressBriefings/Pages/10-MEPC-66-ends.aspx#.U2FN-4XQ8rh

b. Commenting on the omission of obligations to mitigate shipping noise impacts in North East Shipping Management Plan 2013.

The North-East Shipping Management Plan(2013)[52] (AMSA 2013[52]) establishes a **designated shipping area** for the Marine Park (Fig. 5) so coastal and international shipping traffic follow lower risk routes through the Great Barrier Reef the Torres Strait and the Coral Sea (within Australia's Exclusive Economic Zone). The significant restriction of the width of the shipping lanes north or Cairns should be considered with respect to inevitable higher anthropogenic noise exposure to marine life in northern waters.

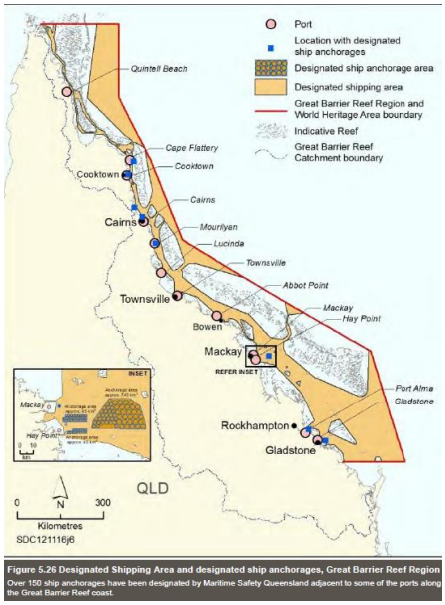


Fig. 5. GBRWHA SA Fig 5.26 showing width of the shipping lanes in the GBRWHA.

The draft North-East Shipping Management Plan was released in August 2013. The Plan claims that its role was to identify protective measures for the shipping area and to address them, and indicates that it is a collaborative plan developed with the Australian Maritime Safety Authority. An explanatory note from AMSA 2013[52] is given.

> [23]*To ensure protection of the environment has the highest priority, including preservation of the OUV of the World Heritage property, cooperation between government agencies and industry in the planning and implementation of safety control measures for shipping is essential. To achieve this, the North-East Shipping Management Group (NESMG) has been formed to develop and oversee implementation of an integrated approach to shipping management in the region.*

The North East Shipping Management Plan (AMSA 2013[52]) featured two general aggregated comment blocks relating to shipping noise. They are summarised below and acoustic comments are reprinted in Figure 6. The document clearly establishes Australia commitments to addressing the impacts of underwater sound from shipping on marine life. Despite its significance to Australia, and indeed UNESCO bodies, UNEP (2012)[5] is mentioned essentially only a single time once is referenced in the GBRMPA

51. AMSA 2013. Australian Maritime Safety Authority 2013, *North-East Shipping Management Plan (Draft for consultation)*, AMSA, Canberra.

Excerpts from North-East Shipping Management Plan

Section 5. Known and potential environmental impacts of shipping
5.6 Interference with species behaviour

Noise pollution from shipping may modify the behaviour of cetaceans and turtles through attraction or avoidance, or cause temporary or permanent injury. It should be noted that there is a lack of information on the impacts of shipping noise on these species including the cumulative impact of increased shipping.

As many marine animals, including dolphins, whales and dugongs, rely on sounds for communication, an examination of underwater noise is important in determining any impacts. Several types of baleen whales (humpback, Minke and Bryd's whales) are important within the GBR region. Whilst the GBR region is a relatively shallow water body in which sound will propagate differently to open ocean conditions, researchers have yet to examine the effect of shipping noise on communication within these species in the region.

Physiological or behavioural thresholds also influence the cumulative impact of threats. Baleen whale responses to underwater noise are known to include ceasing communication when loud noise sources are present, vocalising louder to overcome increases in ambient noise, and changing the pitch of their vocalisations to avoid masking. There will be limits to which these strategies can be adopted, after which the whale will switch to an avoidance strategy.

Section 9. Protective measures – environment protection.
9.6 Interference with species behaviour and cumulative impacts

Actual impacts on species behaviour from underwater noise in the region are not clearly understood and further information is needed. Physiological or behavioural thresholds also influence the cumulative impact of
threats. Baleen whale responses to underwater noise are known to include ceasing communication when loud noise sources are present, vocalising louder to overcome increases in ambient noise, and changing the pitch of their vocalisations to avoid masking. There will be limits to which these strategies can be adopted, after which the whale will switch to an avoidance strategy.

- *ambient and shipping noise in the GBR region: assessment of reduced scope for communication amongst GBR whales, and collision risk and collision rates where high density shipping movements co-occur with high density whales movements*

Action:
• SEWPaC and GBRMPA to undertake further research into cumulative impacts from shipping in the GBR.

Fig. 6. Excerpts from North East Shipping Management Plan.

Specific reference is made to the highly restrictive comments made about underwater noise, namely Section 5 and Section 9 with the included headings.

- **Section 5. Known and potential environmental impacts of shipping.**
    - 5.6 interference with species behaviour.

Given the AMSA (2013)[52] has no indicative references it is hard to know what the Report is claiming although the Plan suggests a *lack of information on the impacts of shipping noise on these species* (cetaceans and turtles presumably) *including the cumulative impact of increased shipping.*

- A 'lack of information' claim is a totally baseless claim by AMSA.
- A brief summary of some available data of shipping impact through masking of communication and stress impacts has been provided in this submission.
- The AMSA (2013)[52] may be using the review of Polglaze *et al*. (2012)[40] as its reference point but as Polglaze *et al*. (2012)[40] devotes so little effort to underwater noise and as no relevant reference to biological impact on the marine soundscape more recent than 2000 the ASMA (2013)[52] baseline is utter rubbish!
- More information would always be usable yet this would never happen while AMSA continues to take steps to deny that underwater noise actually exists.

AMSA (2013)[52] notes that *whilst the GBR region is a relatively shallow water body in which sound will propagate differently to open ocean conditions, researchers have yet to examine the effect of shipping noise on communication within these species in the region.*

- This claim is also baseless.
- In some cases water depth may be <5 m and in some vessels with 19 m draught steaming through passes with a recorded 40 m depth the distance of a 300 m bulk carrier to a receiver animal will be in the order of 20 m requiring little or no modelling. A suite of shallow water models have been already tested in shallow seas underlain by limestone formations. More could be used however, for propagation of ranges appropriate to the steadily narrowing shipping lanes of the GBRWHA claims for non adherence to any appropriate modelling based on a lack of knowledge are fanciful.
- Anecdotal experience for shipping transits at up to 30 k have been known since the early 1990s at least.
- Shipping detection at ranges to 30 k have been conformed over recent times.
- Data are available for while more advanced model suites have been provided for assessment.

The AMSA (2013)[52] provides words suggesting a sophisticated understanding of marine mammal hearing systems that display some skills in the cut-and paste departments, no more.

- I would suggest many readers would wait on an explanation from the AMSA (2013)[52] authors as to how marine mammals generally switch from a masking beating strategy to an avoidance strategy where avoidance may be impossible or a form of habitat exclusion specially for humpback whale calves.

- **Section 9. Protective measures – environment protection.**
    - 9.6 Interference with species behaviour and cumulative effects.

It was pleasing to read the suggestion that many aspects of underwater noise are not clearly understood and that research to example cumulative research should be instigated to include ambient noise estimation and a correlation of shipping density, cumulative shipping noise density and whale movements.

- I find that comment implausible which so much apparent effort is being made to omit references to underwater noise impact.

JASCO Applied Sciences has developed even more refined modelling software to integrate real time shipping density and noise cumulative noise levels with whale density changes given this is effectively mainstream in some states other than Queensland.

- In a voluntary proactive sense JASCO Applied Sciences and Engineering & Physical Sciences have already commenced research into cumulative impacts from shipping.

Perhaps not surprisingly Polglaze *et al*. (2012)[40] did not reference UNEP (2012)[5] at all with respect to shipping impacts through GBRWHA waters. Further, in order to minimise the perception of the impact of shipping through the GBRWHA the Queensland Resources Council, that is funnily enough the user of IMO shipping that have signed Guideline to reduce the impact of noise on marine ecosystems such as GBRWHA, outlined the main shipping and exit routes for the Great Barrier Reef in https://www.qrc.org.au/_dbase_upl/6230%20QRC%20GBR%20Fold%20Out%20Brochure%20V9_web.pdf.

It should be noted in the main map (included below as Fig. 7) that 'the QRC utilised 'reef' ends about Cairns yet an examination of the insert map shows the shipping extends to Torres Strait through ever progressively narrowing channels. Reduced shipping channel width means noise exposure on reefs that would progressively increase between Townsville and Cairns and even more so north of Cairns.

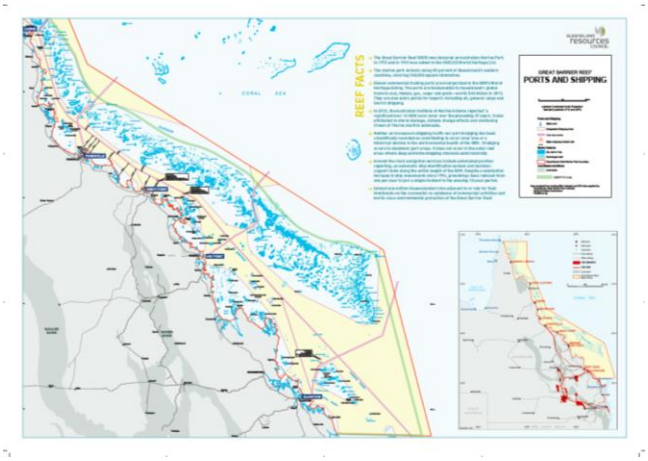


Fig. 7. Queensland Resources Council Ports and shipping routes.

From a noise exposure to reef ecosystem perspective the QRC document is at best diversionary at worst highly deceptive.

SHORTFALLS OF THE AMSA MANAGING RISK PROCESS; ASSESSING RISK FROM VESSEL GROUNDINGS BUT NOT FOR REQUIRED VESSEL NOISE IMPACT ON ECOSYSTEMS.

Managing risk and noise from shipping

In 2010, well before GBRWHA SA was released, Det Norske Veritas (DNV a shipping classification agency) developed a specific notation class of DNV – SILENT vessels[53], a multi category of vessels appropriate for cargo, fishing research vessels all with design features to mitigate the impact of shipping noise on the environment.

To assist in developing the AMSA (2013)[52], AMSA engaged Det Norske Veritas Australia Pty. Ltd (DNV) to estimate risk of shipping incidents, mainly due to collisions and groundings. The DNV review determined that there was a low risk of shipping accidents provided specific caveats for pilotage and ReefVTS vessel monitoring systems.

It is appropriate to note that AMSA as the Australian signatory to the IMO and therefore being well aware of international yet non-binding obligations to work to reduce the risk of anthropogenic noise from shipping, did not engage DNV to investigate the applicability of the DNV – SILENT notation class to reduce the impact of underwater noise on marine ecosystems when they engaged DNV to investigate vessel noise risk.

Kellett *et al*. (2013)[54] not only described the DNV – SILENT class but outlined design features appropriate for design of a vessel in that class. In short DNV-SILENT Class is a functional vessel class system intended to reduce environmental impact from shipping and has been functional since 2010.

In its 2011 *Underwater noise - The invisible pollution* document (http://www.dnvusa.com/Binaries/UnderwaterNoise_tcm153-525715.pdf) DNV Maritime took a proactive approach by establishing DNV SILENT as a safeguard against excessive noise radiation.

There would be no conceivable way that AMSA would not be aware of its international obligations to mitigate underwater noise from shipping and also not being aware of the DNV-SILENT notation class. To further highlight that AMSA would have been well aware of the DNV-SILENT class it is well established that the new 93.9 m CSIRO research vessel RV Investigator has a DNV-SILENT R classification (http://www.marinelink.com/news/month-boat-the365321.aspx).

52. http://www.dnv.com
53. Kellett P, Turan O & Incecik A. (2013). A study of numerical ship underwater noise prediction *Ocean Engineering* **66**:13–120.

CONCLUSIONS

Shipping noise is an internationally recognised marine pollutant. There is an ISO Standard for it. Yet shipping noise is not toxic in a long half-life chemical sense and it may be mitigated by improved propulsion system redesigns and by more appropriate scheduling of shipping through the GBR on a seasonal and locational basis.

UN instrumentalities, United Nations Environment Programme, UNESCO, UN International Maritime Organisation have recognised the impact of underwater noise from shipping on marine ecosystems including coral reef areas such as GBRWHA. Impact includes all animals in ecosystems and is not restricted to marine mammals, impact to marine animals is therefore the most appropriate terminology. Impacts likely to occur in GBRWHA area relate primarily to masking of communication and stress impacts.

The International Maritime Organisation (IMO), Australian Maritime Safety Authority is the Australian based agency, has acknowledged the impact of noise on marine ecosystems. AMSA as the Australian signatory on the IMO Committee Of Partners has signed a non binding agreement to mitigate noise from shipping on the marine environment on behalf of the Australian Government. However,

- there is scant reference to Australian non binding obligations to mitigation of underwater noise impacts in the GBRWHA Strategic Assessment.
- I would contend that this could not have occurred on a random basis, the omission must be orchestrated.

a. UNESCO would be more than aware of the discrepancy between Australian international agreements on underwater noise and what it is not happening for the GBRWHA.

The GBRWHA Strategic Assessment did not effectively address the impacts of underwater noise which it has not attempted in any reasonable way. Why that is the case is simply not understood.

What is far more profound is that the Australian Maritime Safety Authority, as the Australian representative at the IMO has almost gone out of its way to marginalise or minimise any reference to the impacts on under water through its North East Shipping Management Plan. This is clearly at odds to its international, admittedly non-binding, agreements. Why that is the case is simply not understood although the most parsimonious explanation would be to marginalise or minimise any perceived threat to unfitted shipping transits through the GBRWHA on behalf of what is represented to be a significant increase in shipping activity associated with resource development along the Queensland coast.

The above is speculation of course. However, it is based on consistent perceived omissions of reference to noise impact in Australia (specifically Queensland as ethical and responsible conduct associated with vessel noise mutation can be demonstrated in some other states), regulatory documents and institutional arrangements over many years. Near instantaneous, time coordinated and inexplicable personal isolation from any contact with GBRMPA Ports and Shipping in Townsville and particularly AMSA were the more than subtle disconnections

of communication that suggested a lack of interest by Australian Government agencies in investigating the issue of noise from shipping impacting on the GBRWHA ecosystem.

The Queensland Resources Council from its FAST FACTS website clearly indicates that shipping has not been responsible for any aspect of decline of the GBRWHA. (https://www.qrc.org.au/01_cms/details.asp?ID=3284)

> *Neither an increase in shipping traffic nor port dredging has been scientifically recorded as contributing to coral cover loss or a historical decline in the environmental health of the GBR. Dredging occurs in shallower port areas. It does not occur in the outer reef areas where deep and wide shipping channels exist naturally.*

That may well be so with respect to vessels striking reefs. That may not be so where current reef users (personal observation) may readily observe ship wakes generating long mud trains in northern waters. If an observer is unlucky enough to be near ship transects in the Lizard Island area they may see bottom material thrown up in wakes as ships transit shallow water irrespective of what keel depth regulations demand.

The Queensland Resources Council may well be in a position to claim that shipping has not impacted the GBRWHA primarily as they rely on data from last century to support their claim with respect to animal impact. Any claim that ships may have no impact is clearly eroded by the UNEP (2012)[5] review of the impact of underwater noise on marine ecosystems and the April 2014 ratification of Guidelines by the IMO ships that the TRC uses to reduce noise impact.

The level of noise in open and more restricted waters between narrowing reef passes will be variable. To date the only baseline acoustic monitoring of GBRWHA waters is using a JASCO Applied Sciences acoustic recorder on a reef off Townsville admittedly remote from shipping lanes but clearly detecting transit at up to 50 kilometres distance. It is clear from the data presented that international research bodies are in fact linking shipping noise to masked communication and stress impacts on marine animals with at least localised impact. Shipping impact over the GBRWHA by increasing numbers of ships and ships also carrying resource materials from areas outside the GBRWHA is also due to increase exacerbating likely reef impact. Perhaps the Queensland Resources Council is aware of something the rest of the world is not aware of?

There should be no reason that acoustic noise pollution, the only pollution with a near instantaneous half-life period, should be ignored. In fact reduction of shipping noise impact offers one of the most readily documented and readily achievable pollution mitigation schemes worth considering for the GBREWHA. The IMO has offered Guidelines for reduction of shipping noise and shipping noise is regarded as an economic disadvantage to shipping operation by IMO so it is likely there will be general support for the Guidelines especially for new ships. There should be support for noise reduction but clearly there is not.

1. AMSA as Australians shipping regulator may see shipping noise reduction within the narrow channels of the GBRWHA as an unwanted regulatory or environmental mitigation burden. With due deference to AMSA, their employees at IMO level have been observed to be supportive of initiatives to reduce shipping noise.
2. The only organisation that has flatly denied any impact from shipping on GBRWHA is the Queensland Resources Council on the basis of their use of research data from last century.
3. Underwater noise is not readily understood by many scientists associated with the GBRWHA and a modified focus to include shipping noise may be a technology threat and funding source threat.

Noise from shipping currently has been currently shown to be of a patchy exposure characteristic on more open reef areas (JASCO Applied Sciences preliminary assessment of 4 months of ambient data in the Wheeler Reef are 30 k from shipping lanes). However, impact of coral reef areas may only be part of the overall picture as not all animals are directly associated with coral reefs just as many GBRWHA animals are not associated with coral or seagrass areas with pelagic fish, large demersal fish species being outstanding examples and subject to most threat when development activities such as dredge spoil dumping are rationalised as not being on seagrass when the activity is clearly directed at non-seagrass supporting species that have even more recreational and commercial value.

Localised impacts from individual vessels on specific reef areas have been observed to be dramatic involving uprooted coral, extended mud trails and reports from reef divers of very loud and painful underwater noise from nearby transiting ships let alone passing speedboats. However, the expected rise in shipping levels, irrespective of what data are used to express increase levels, suggest that cumulative Sound Pressure Levels will increase dramatically as both ship numbers and ship size increase. In the early 1990's ships of moderate size could be detected by hydrophone up to 30 k away in the Cairns region depending on ship orientation yet as ship lengths increase Sound Pressure Level cumulative exposure will further increase.

The intention for this submission is not to suggest that all sections of the GBRWHA are impacted by constant and inordinate levels of underwater noise from shipping. Far from it.

The International Maritime Organisation is looking to set a goal for oceanic noise reduction by a specified level that includes quieter and more propulsion efficient shipping which is great for marine soundscapes and their operating costs. The IMO initiatives should be encouraged and we wish them every success in getting to and from our ports with the least amount of noise impact. It is for the Australian IMO agency AMSA to support the Guidelines for shipping noise reduction that has been (voluntarily) agreed to by Australia as shipping noise is projected to increase. That could be achieved through ship noise generation reduction or by appropriate ship rescheduling to minimise impact at specific periods.

The basis for this submission is to highlight the near total omission of consideration of potential impacts of underwater noise from shipping transiting through the GBRWHA.

> *The bulk carriers etc now exceeding 300m in length do not tiptoe through GBRWHA waters to get to ports with no impact, they roar through the water at known Sound Pressure Levels currently predicted by vessel hull length often occupying most of the vertical water column at extremely close range to the nearest inter-reef structure.*

Geoff McPherson
Marine Acoustic Biodiversity Solutions.
mcpherson.geoff@gmail.com
Adjunct Principal Research Fellow,
Engineering & Physical Sciences, James Cook University
geoff.mcpherson@jcu.edu.au
Cairns. Queensland Australia. Mobile 0421 198 085
http://au.linkedin.com/pub/geoff-mcpherson/17/882/831