# Demonstrating an acceptable level of impact: an assessment of noise impacts to fishes from a seismic survey in an Australian Marine Park

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# Acknowledgements

Santos

The authors wish to thank Santos Ltd for their permission to present material derived from the Bethany 3D MSS Environment Plan and publish the paper in the APPEA journal.

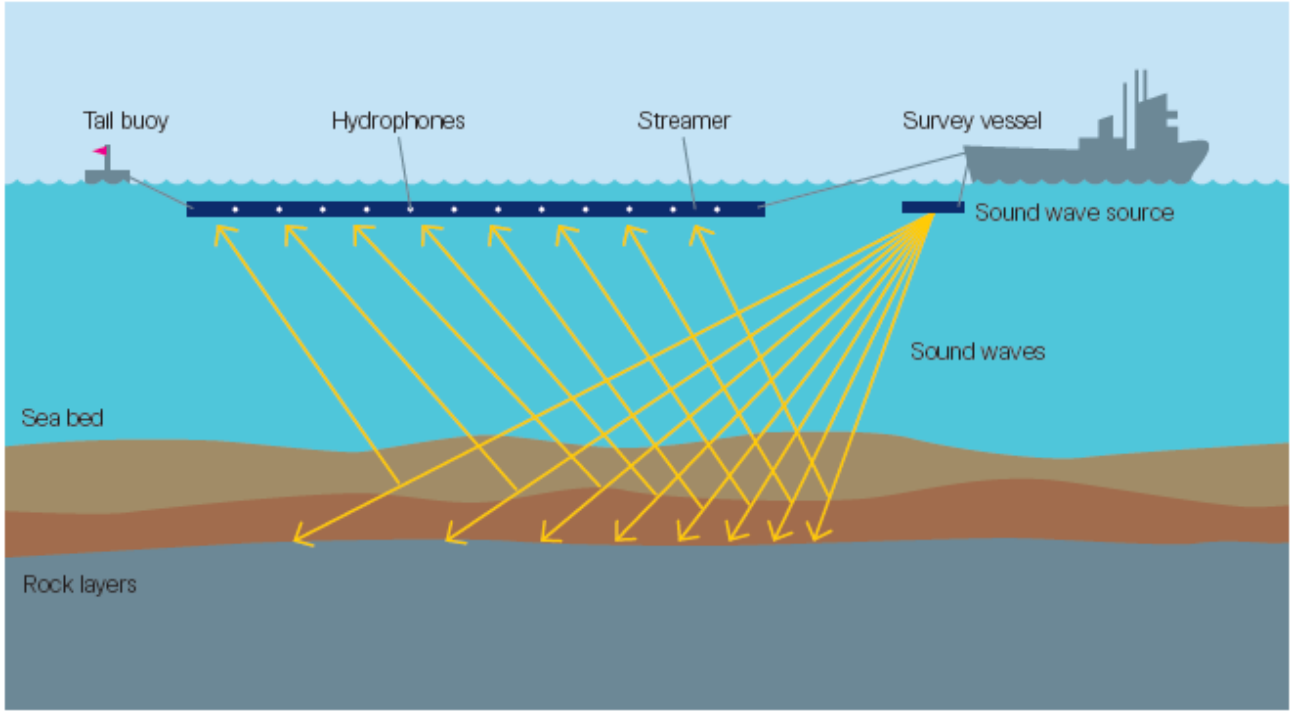
We also wish to extend our appreciation to:

JASCO Applied Sciences, for their input regarding acoustic modelling and sound source verification measurements.

Jacobs, for their work on benthic habitat modelling

# Presentation Overview

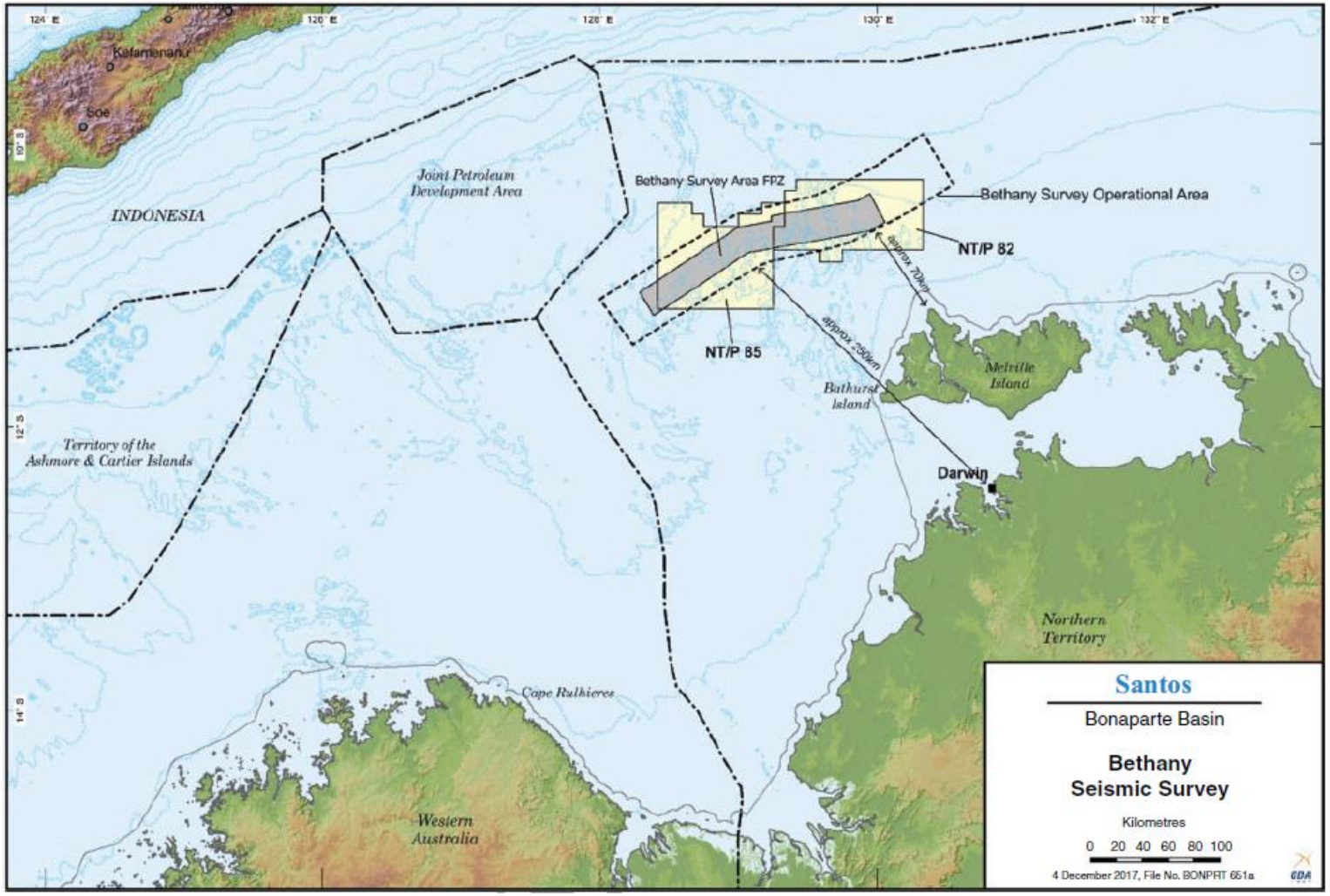
- Overview of the Bethany 3D MSS
- Environmental values and sensitivities of the survey location
- Process for demonstrating an acceptable level of impact in a complex environment – using assessment of noise impacts to fishes as an example
- Stakeholder engagement with fisheries



# Introduction

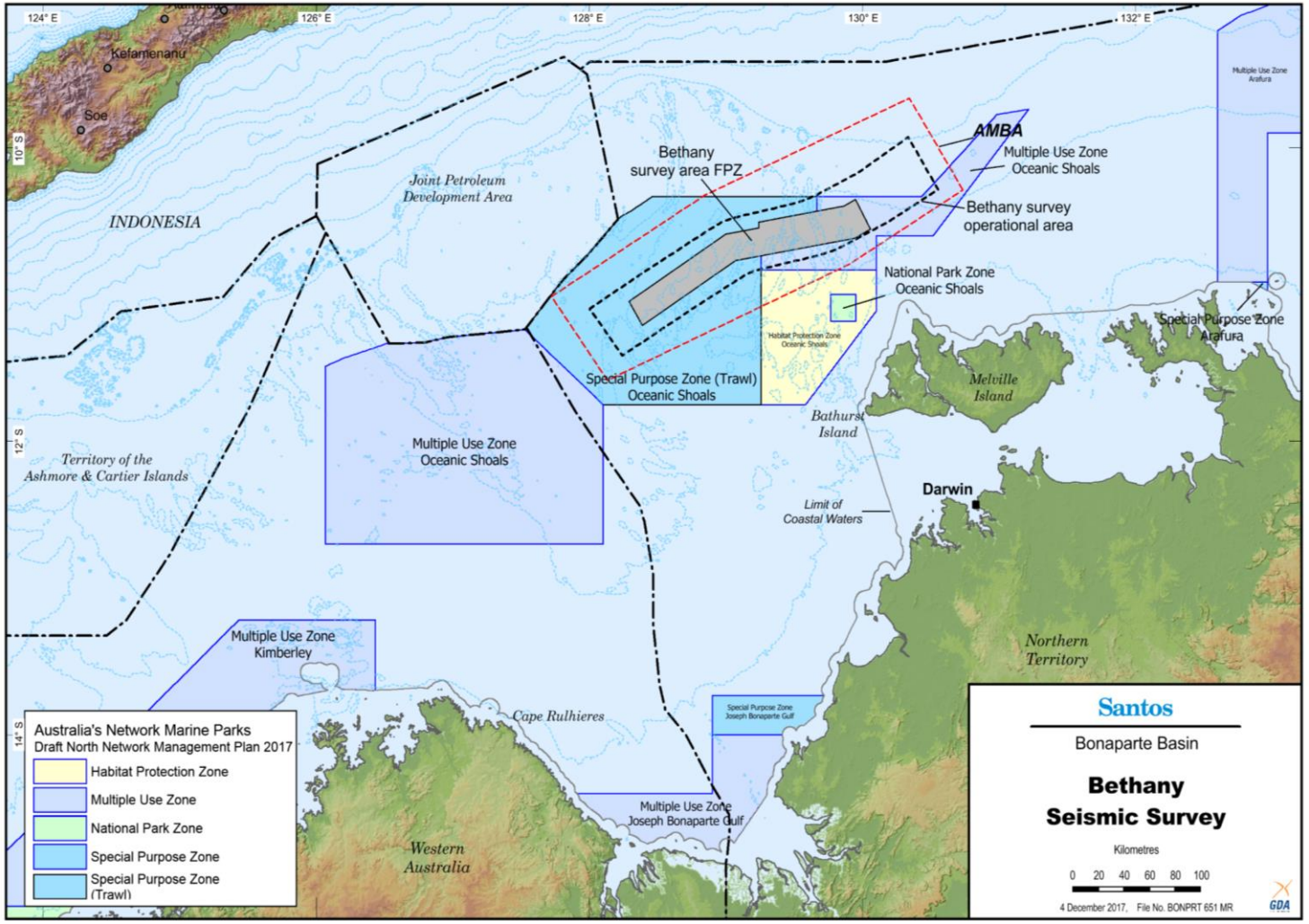
Bethany 3D Marine Seismic Survey

- Bonaparte Basin
- ~250 km NW from Darwin
- 4,565 km$^2$ ‘full power zone’ (FPZ)
- 2,380 in$^3$ array
- Undertaken by Santos in 2018



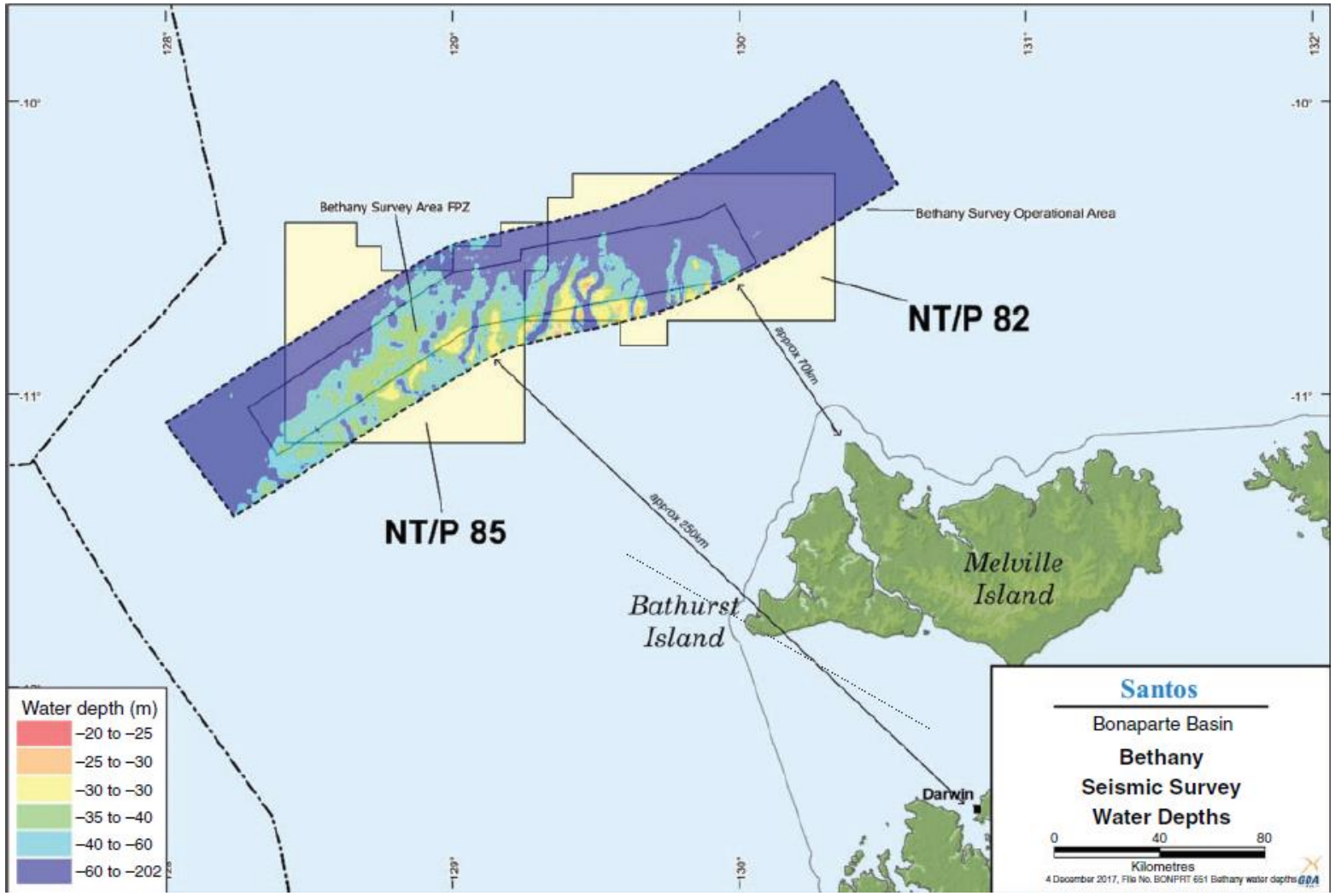
# Key sensitivities

- Oceanic Shoals Marine Park (IUCN IV Zones)
- Shallow banks <40 m water depth – diverse epibenthic assemblages of sponges, octocorals and hard corals, along with smaller colonies of bryozoan and ascidians
- Support site-attached fish assemblages



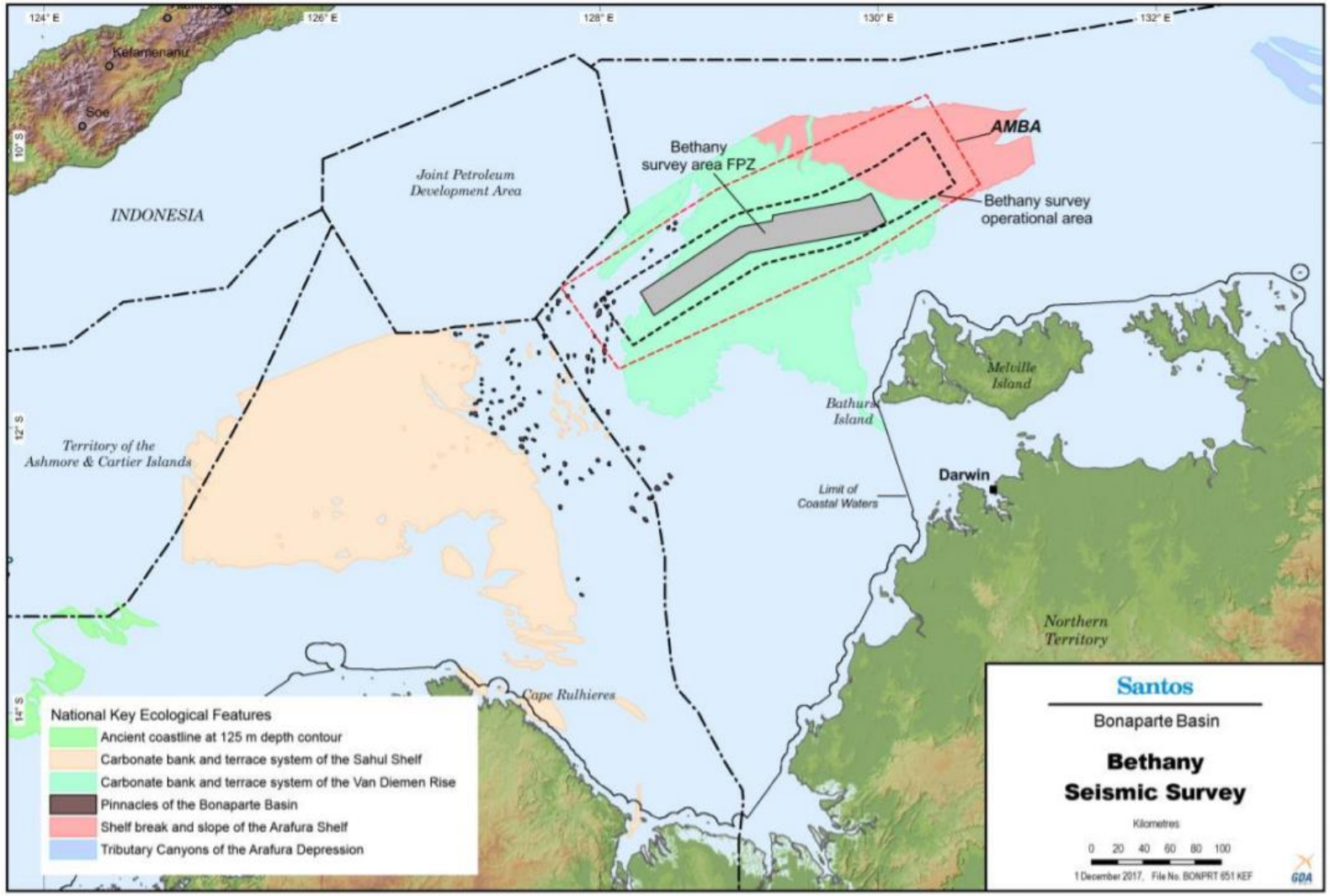
# Key sensitivities

- Water depths in the FPZ ranged from 20 m to 200 m



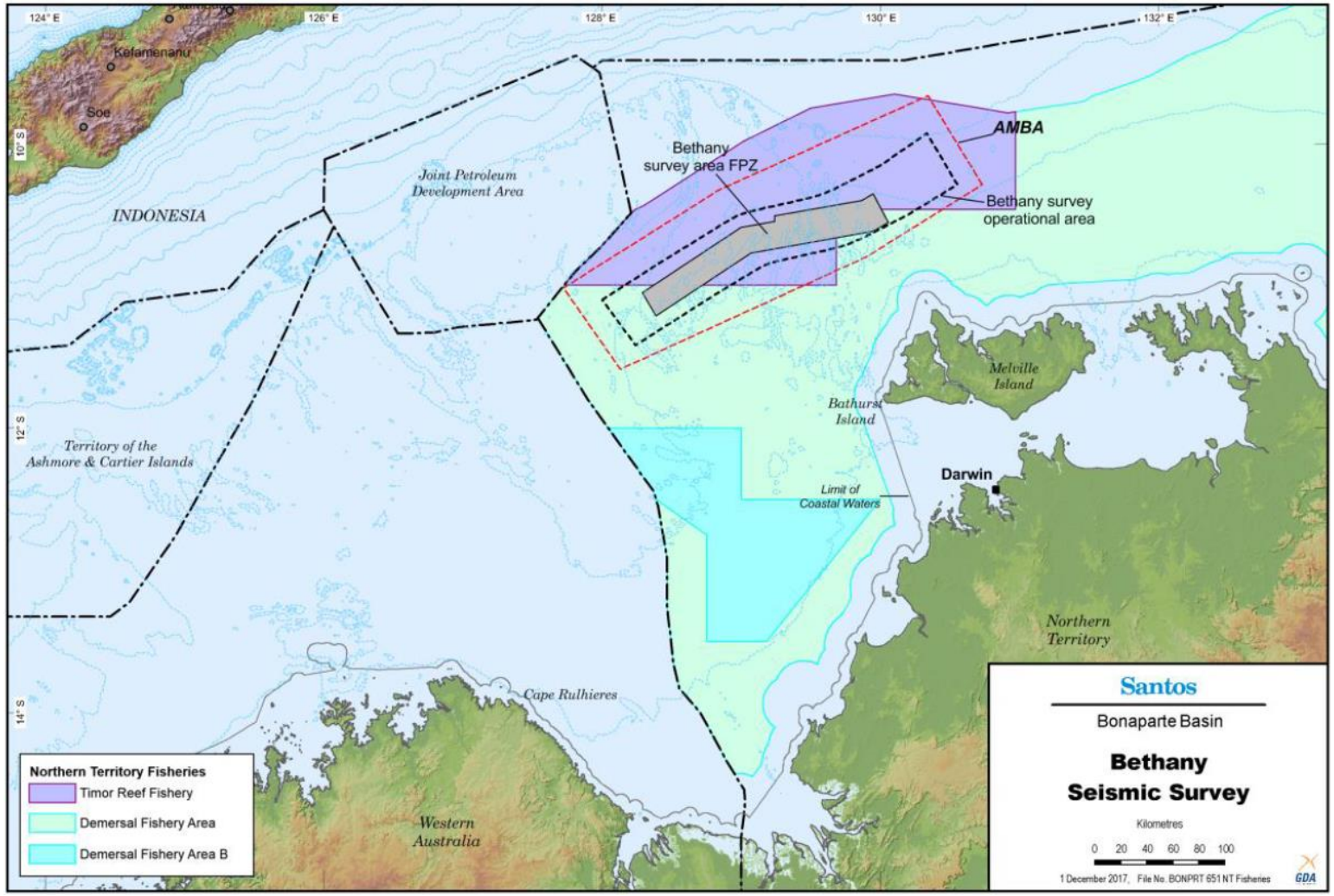
# Key sensitivities

- ‘Carbonate bank and terrace system of the Van Diemen Rise’ Key Ecological Feature (KEF)



# Key sensitivities

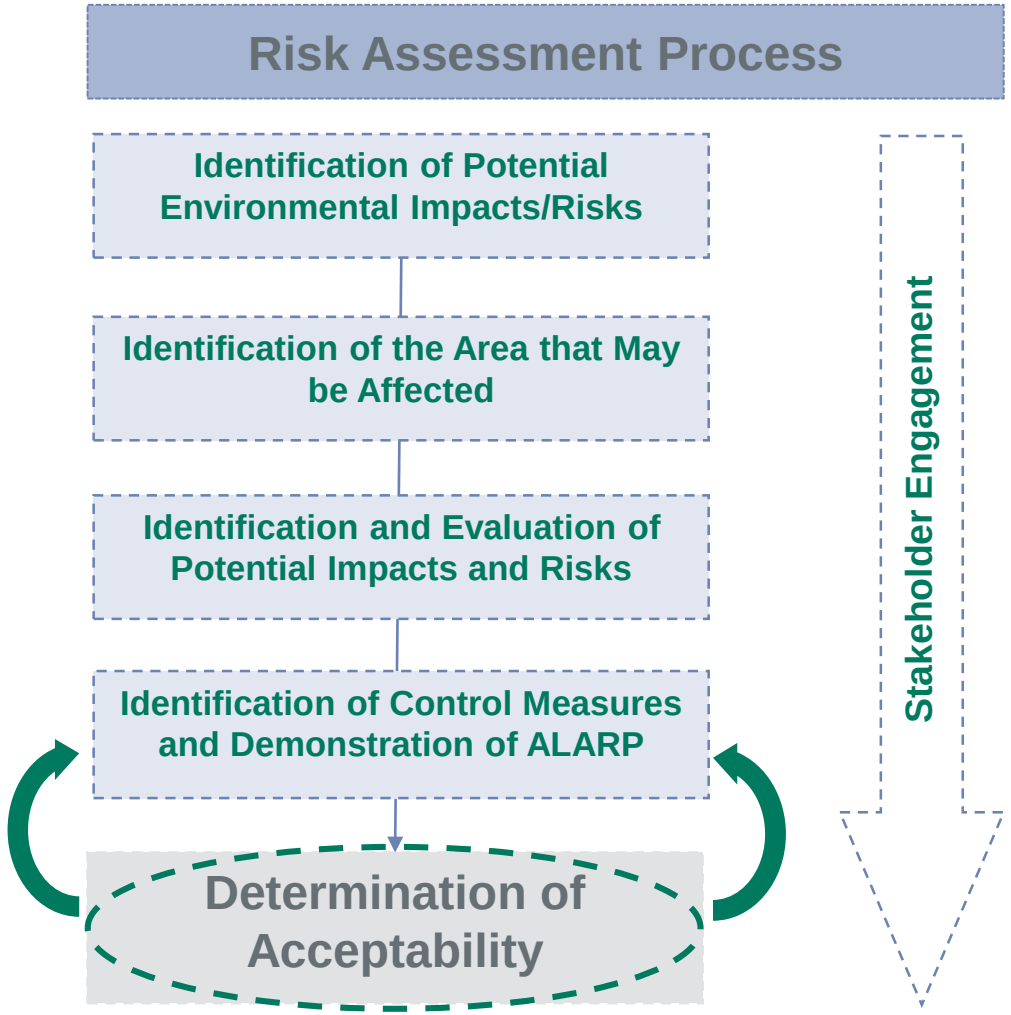
- Timor Reef Fishery and NT Demersal Fishery (trap and line)



# Demonstrating an ‘acceptable level’ of impact

- An Environment Plan (EP) is required under the Offshore Petroleum and GHG Storage (Environment) Regulations
- OPGGS (Environment) Regulations are objective-based and performance-based rather than prescriptive.
- Titleholders must demonstrate that risks are ALARP and reduced to an ‘acceptable level’.

An ‘***acceptable level***’ is the specified amount of environmental impact and risk that an activity may have which is tolerable, is consistent with all relevant principles, and does not compromise the management/conservation/protection objectives of the environment.



# Demonstrating an ‘acceptable level’ of noise impact to Fish

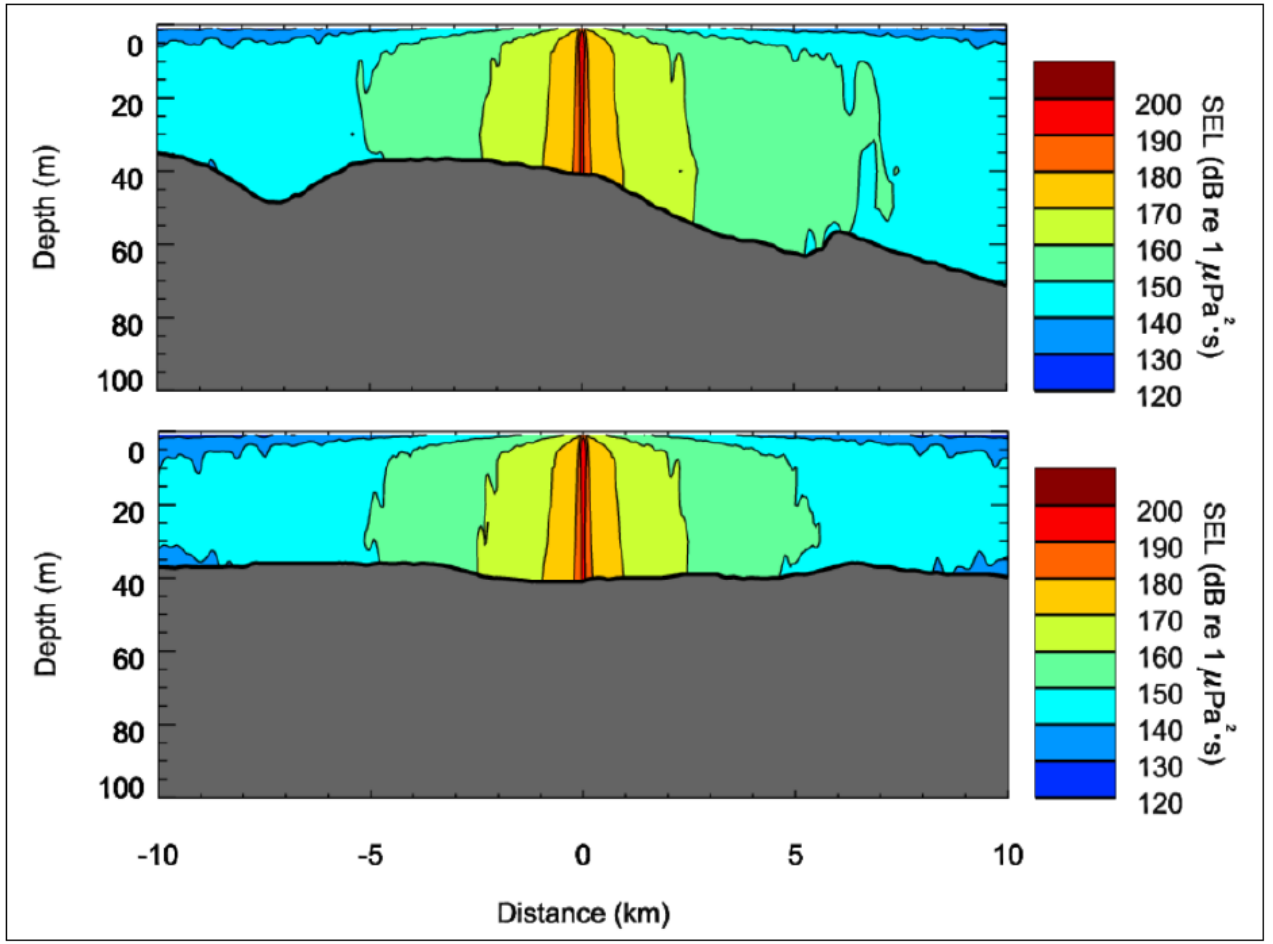
- Key potential impacts for the Bethany 3D MSS:
  - Potential mortality/physical injury to site-attached fish
  - Potential impairment/disturbance of commercial fish species
- The method adopted by Santos provides an example of the level of detail and rigour that is sometimes required to demonstrate an acceptable level of impact in a complex environmental setting

Bethany 3D MSS demonstration of acceptable levels comprised seven key elements:

1. acoustic modelling;
2. application of sound exposure guidelines;
3. quantitative risk assessment, involving benthic habitat predictive modelling and spatial analysis
4. definition of an acceptable level of impact;
5. sound source verification process;
6. engagement with key fishery stakeholders; and
7. independent, expert peer review process.

# 1. Acoustic modelling

- Common approach used in the assessment of impacts from seismic surveys.
- Included single pulse metrics (PK, SPL and SEL), and cumulative (multiple pulse) metrics ($SEL_{24hr}$).
- A number of locations within the FPZ were modelled with depths ranging from 41 m to 84 m
- Used to assess the ranges at which physical injury, hearing impairment and behavioural effects may occur.




Source: McPherson and Zi (2017). JASCO Applied Sciences.

# 2. Identifying impact thresholds for sound exposure

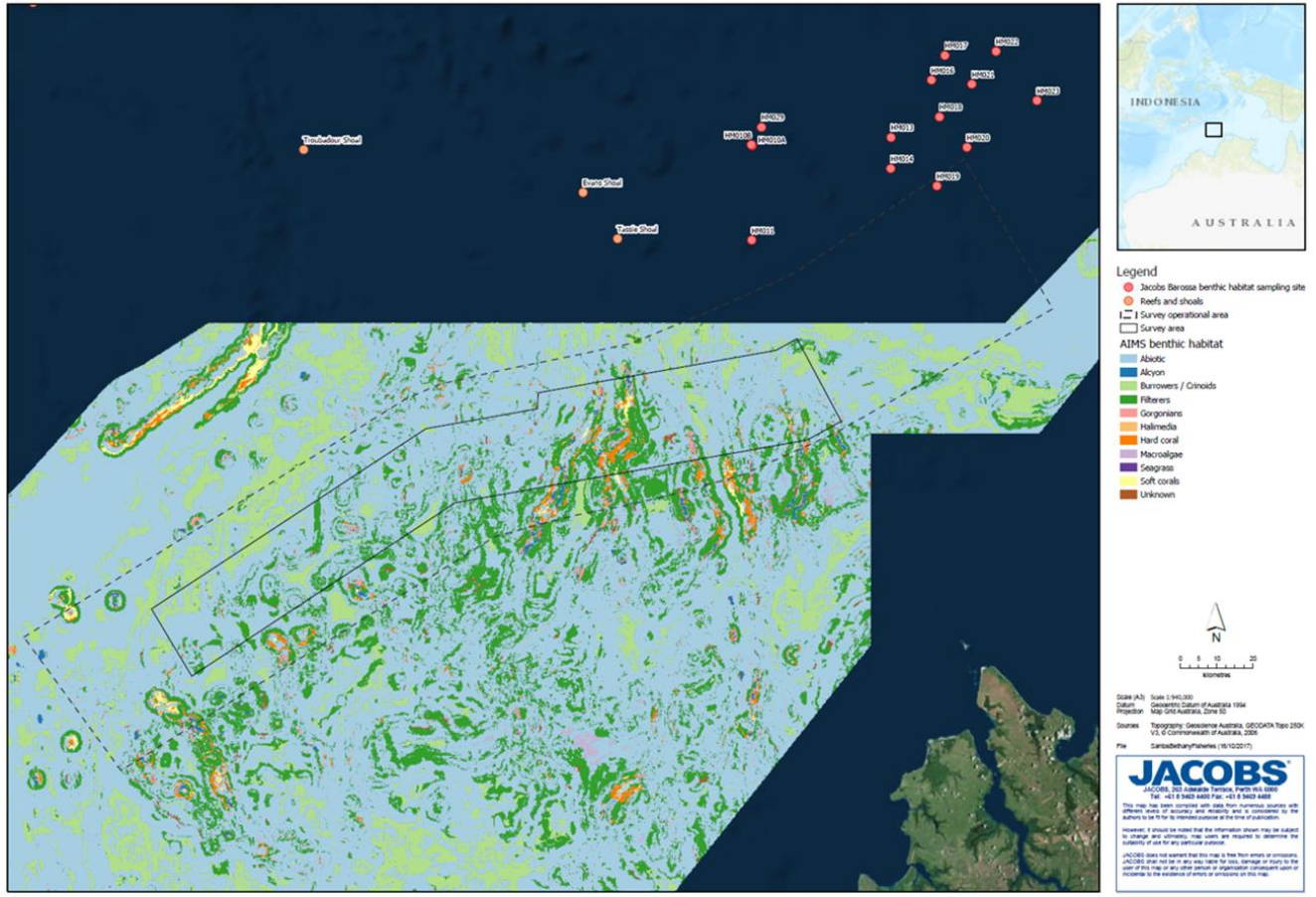
- Working Group on the Effects of Sound on Fish and Turtles (ANSI accredited) (Popper et al. 2014).
- Threshold for mortality/potential mortal injury: 207 to 213 dB re 1 µPa PK
- But based on pile driving.
- ERM (2017) – Literature review of potential fish mortality and physical injury as a result of exposure to seismic sources.
- 28 papers reviewed: 3 = mortality (< 2 m); 9 = injury but no post exposure mortality (3 – 4 m), 16 = no mortality or damage.
- Mortality: 220 – 241 dB re 1 µPa PK

ERM (2017) sound exposure guidelines for mortality and physical damage effects in fishes exposed to seismic source emissions

| Effect type | ERM sound exposure guidelines (PK; $L_{pk}$ dB re 1 µPa) |
|---|---|
| Mortality and potential mortal injury | >215 |
| Recoverable injury (excl. hair cell damage) | >207 |
| Hearing epithelia (hair cell) damage | >203 |

# Quantitative risk assessment and spatial analysis

- Predictive benthic habitat modelling undertaken by ***Jacobs*** based on the ***AIMS*** habitat model for the Oceanic Shoals Marine Park.
- Classes of benthos were grouped into two broad categories based on the likelihood of supporting site-attached fishes:
- Identified % of habitat in the Oceanic Shoals Marine Park and the KEF that may support site-attached fishes.
- Spatial analysis of potential footprint where sound emissions may cause mortality or mortal injury.
- ~23% of the FPZ predicted to overlap habitat that may support site-attached fish assemblages.




| Mortality / Mortal Injury Threshold | $R_{max}$ Distance (m) | Area (km²) | Overlap with Marine Park (%) | Overlap with KEF (%) |
|---|---|---|---|---|
| 215 dB PK | 58 | 205 | 0.29 | 0.66 |
| 207 dB PK | 165 | 585 | 0.81 | 1.87 |

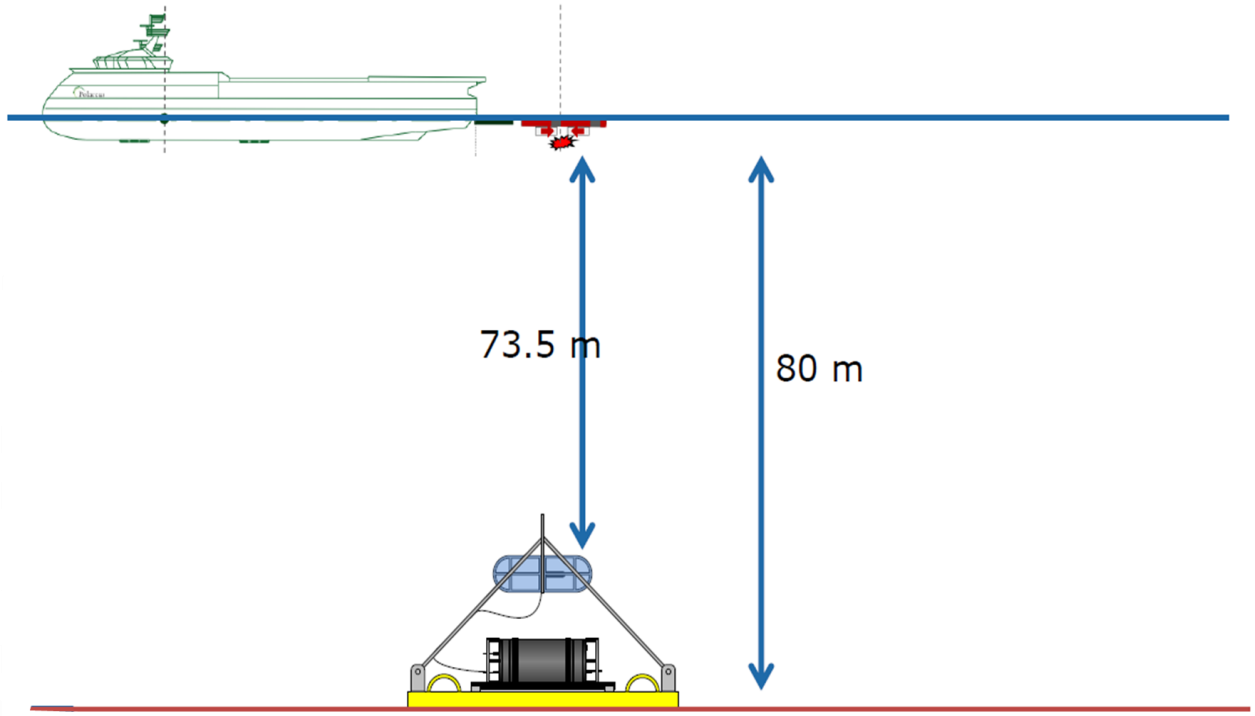
# Defining an acceptable level of impact for site-attached fish

- Process of defining an acceptable level of impact considered:
  - natural rates of mortality in site-attached fish populations; and
  - resilience and recovery to a range of significant natural and anthropogenic disturbances.
- The criterion for an acceptable level of impact was set at <5% mortality in the site-attached fish assemblages in the marine park and KEF.
- <2% of site-attached fish habitat in the marine park and the KEF were predicted to be effected by sound levels with the potential to cause mortality or mortal injury in fishes.

| Mortality / Mortal Injury Threshold | $R_{max}$ Distance (m) | Area ($km^2$) | Overlap with Marine Park (%) | Overlap with KEF (%) |
|---|---|---|---|---|
| **215 dB PK** | 58 | 205 | 0.29 | 0.66 |
| **207 dB PK** | 165 | 585 | 0.81 | 1.87 |

# Sound source verification

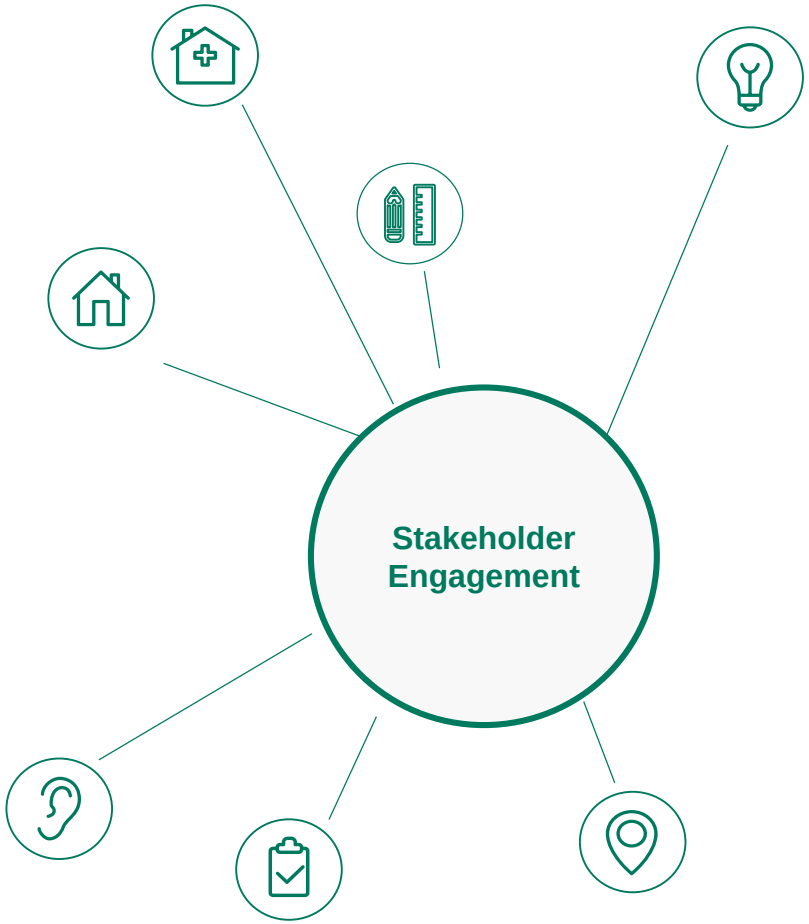
- Basis of the assessment of impacts and the acceptable level relied heavily on the accuracy of the acoustic modelling.
- JASCO Applied Sciences undertook *in-situ* sound source verification measurements prior to the survey commencing.
- Measurements taken as seismic source passed directly over an autonomous recorder on the seabed and along lines offset at various distances from the recorder.
- Results showed good agreement with the predictive modelling results.
- Confidence in the assessment.




McPherson and MacGillivray (2018). JASCO Applied Sciences.

# Engagement with fishery stakeholders

- Timor Reef Fishery – raised concerns regarding impacts to target demersal fish species.
- Consultation was extensive (36 months).
- Concerns raised included hearing impairment – temporary threshold shift (TTS) and behavioural disturbance.
- Following extensive consultation and attempts to answer these queries and concerns, Santos commissioned an independent, expert peer review of aspects relating to the concerns raised.



# Independent expert peer review

- Professor Arthur Popper. Over 50 years' experience and over 250 peer-reviewed publications.
- Direct line of contact between the stakeholder and Popper (for transparency and independence).
- Popper (2018) peer review is publicly available as part of the EP Summary on the NOPSEMA website.
- Referred to by NOPSEMA in their published Statement of Reasons on why the EP was accepted.

**Potential for Impact of Cumulative Sound Exposure on Fishes During a Seismic Survey**

Arthur N. Popper
Environmental BioAcoustics, LLC
Silver Spring, Maryland, USA
February 24, 2018

Environmental BioAcoustics LLC was commissioned by Environmental Resources Management (ERM) to conduct an independent, expert peer review of aspects relating to concerns raised by stakeholders regarding impacts of cumulative seismic noise from the proposed Santos Bethany 3D seismic survey on fish, including TTS effects, and length of time for recovery and the applicability of an $SEL_{24h}$ metric.

Inputs:

- seismic noise and fish impact assessment section from the Bethany Environment Plan;
- underwater noise modeling report and additional data extraction/analysis from JASCO; and
- the findings of relevant peer-reviewed scientific literature.

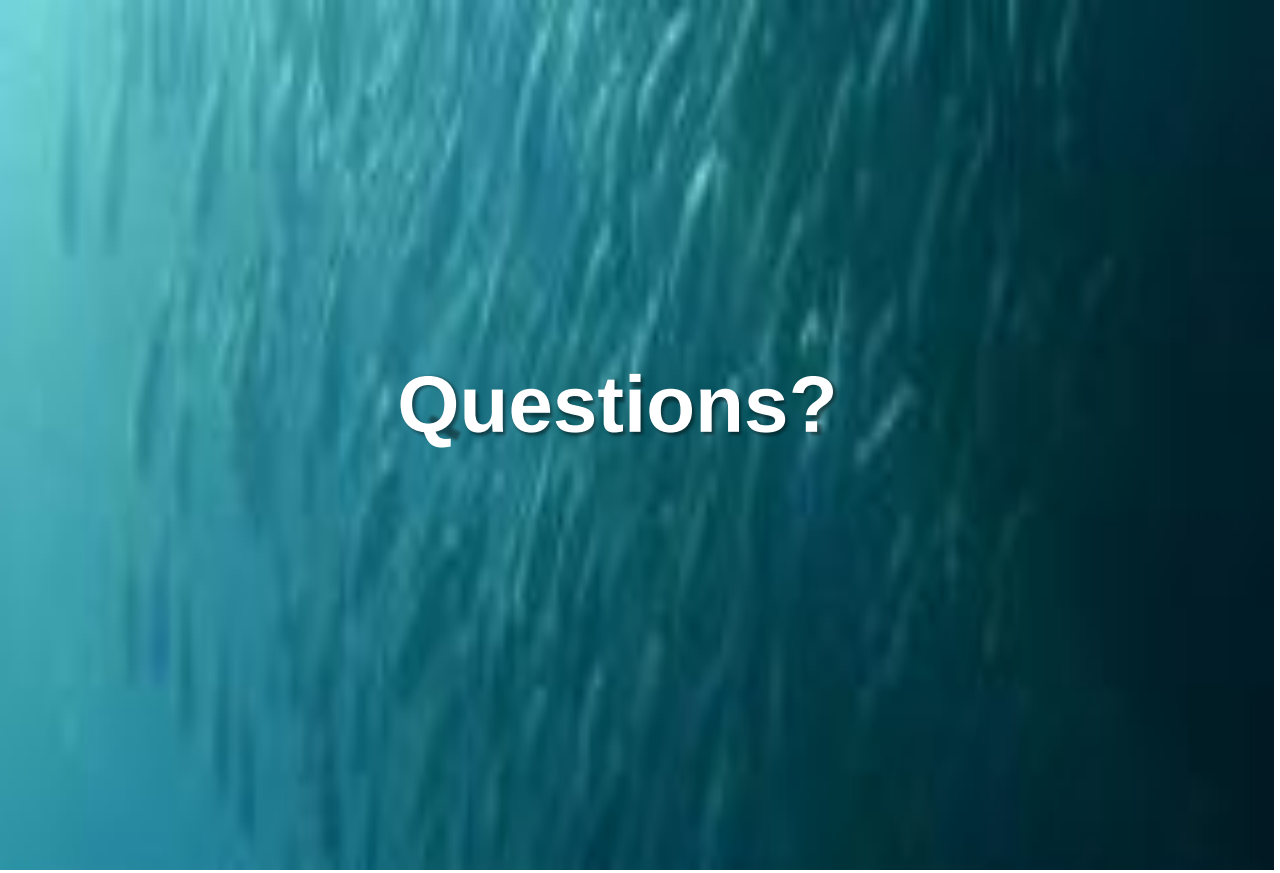
The review is based upon the best available science, with a focus on peer-reviewed scientific literature.[1]

As background, I (the author) have been working on various aspects of fish hearing and bioacoustics for over 50 years, (over 250 peer-reviewed publications) and has been investigating the effects of man-made sound on fishes and other aquatic life since the early 1990's. My laboratory at the University of Maryland (College Park, MD, USA - www.popperlab.umd.edu) has done a number of formative studies on effects of various sounds on fishes, including several studies on effects of seismic air guns (e.g., Popper et al. 2005; Popper et al. 2016b) and another loud impulsive source, pile driving (e.g., Halvorsen et al. 2012b; Halvorsen et al. 2012a; Casper et al. 2013a; Casper et al. 2017). I have also been involved in developing current guidelines for effects of man-made sound on fishes and turtles (Popper et al. 2014) and I am co-founder and organizer of a series of international meetings on effects of man-made sound on aquatic life (see www.an-2019.org) (Popper and Hawkins 2012; Popper and Hawkins 2016). I have consulted in the US and internationally on various aspects of sound and fishes. I am co-founder and editor of the Springer Handbook of Auditory Research (SHAR), a series of books (now close to 70) on various aspects of hearing. Finally, I am editor of *Acoustics Today* (www.acousticstoday.org), a scientific magazine of the Acoustical Society of America, the foremost scholarly group in the world for the study of all aspects of acoustics.

[1] Focus is on peer reviewed material since, as pointed out clearly by Popper and Hastings (2009), much of the non-peer reviewed literature on effects of sound on fishes lacks appropriate statistical analysis and/or controls. Thus, all such information needs to be carefully evaluated before use in any review or analysis.

# Summary

- The Bethany 3D MSS was proposed within a complex environmental setting of an Australian Marine Park and KEF.
- Demonstration that potential impacts would be of an acceptable level required a rigorous and quantitative assessment of impacts including:
  - A quantitative assessment of predicted impacts to compare against a defined acceptable level of impact (including acoustic and benthic habitat modelling, and identification of appropriate sound exposure thresholds)
  - Sound source verification
  - Engagement with stakeholders including an independent, expert peer review of aspects relating to the concerns raised.

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# Thank you

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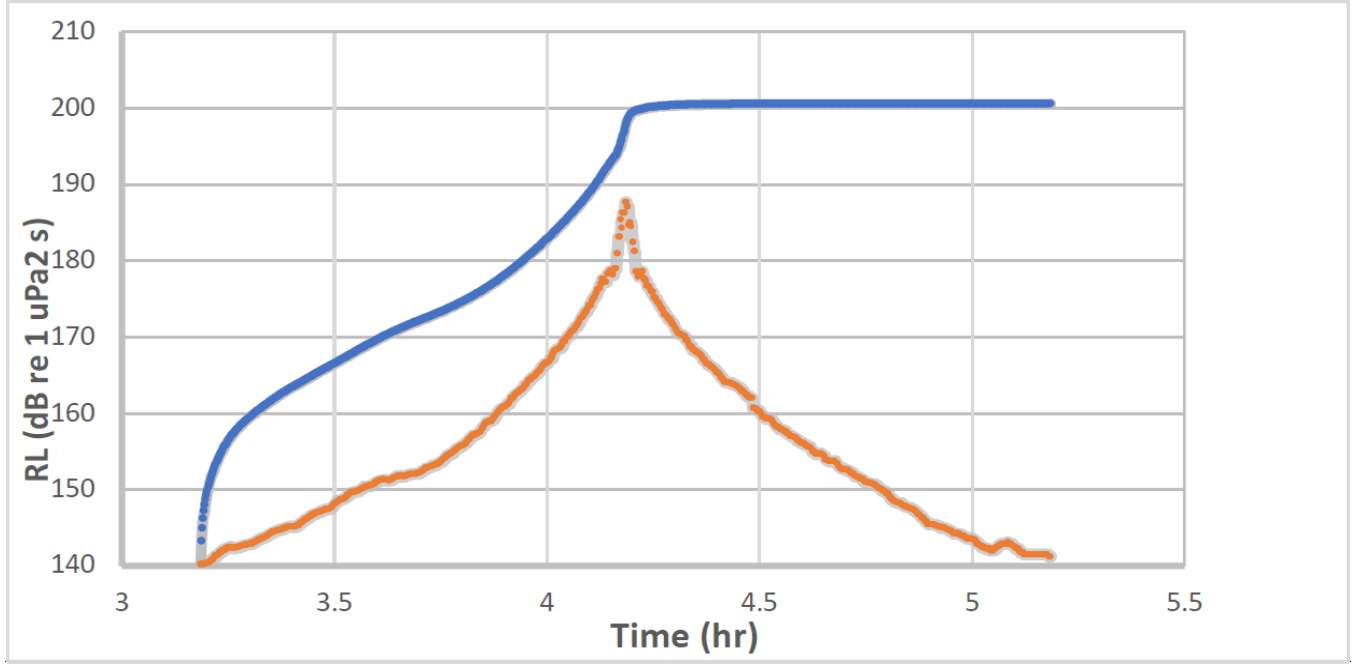
# Independent expert peer review

- Most commercially targeted demersal fishes in the region do not have hearing specialisations.
- The duration of exposure to the most intense sounds that fishes may hear and that could result in TTS will be over a few hours. Thus accumulation over longer periods (i.e. 24 hours) is likely to be conservative.
- If TTS takes place, recovery will occur soon after.




Popper (2018). Data provided by JASCO Applied Sciences.