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North West Shoals to Shore Research Program

Design and implementation of a real-world experiment to investigate the effect of marine seismic survey on fish and pearl oysters

Mark Meekan

September 2020

Acknowledgements

*AIMS acknowledges the **Jaburrara, Ngarluma/Yindjibarndi, Kariyarra, Naymal, Ngarla, Nyangumarda, Karajarri, Yawuru, Jukun** and **Ngumbarl** People as Traditional Owners of Country adjacent to the areas where the Theme 1 North West Shoals to Shore Research Program work was undertaken. We recognise these People's ongoing spiritual and physical connection to Country and pay our respects to their Aboriginal Elders past, present and emerging.*

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Acknowledgements

This work was conducted as part of the North West Shoals to Shore Research Program which was proudly sponsored by Santos as part of the company's commitment to better understand WA's marine environment.

Additional funding was provided by Woodside Energy Ltd.

Santos

Curtin University

Department of Primary Industries and Regional Development
Government of Western Australia

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CNOOC BGP

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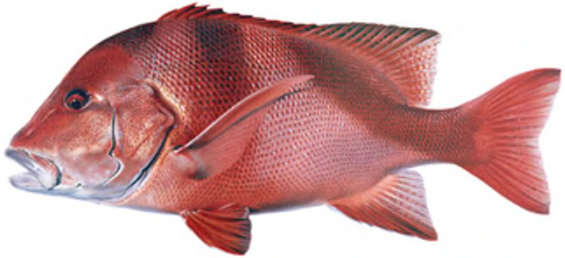
Theme 1: Marine Noise Monitoring and Impacts

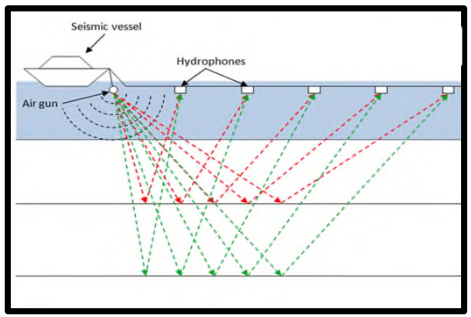
- Determine the impact of a “real-world” seismic survey on tropical fish assemblages and pearl oysters
- $6M project
- May 2017 to June 2020
- This presentation: Experimental design and set up of
  - Fish exposure experiment
  - Pearl oyster exposure experiment

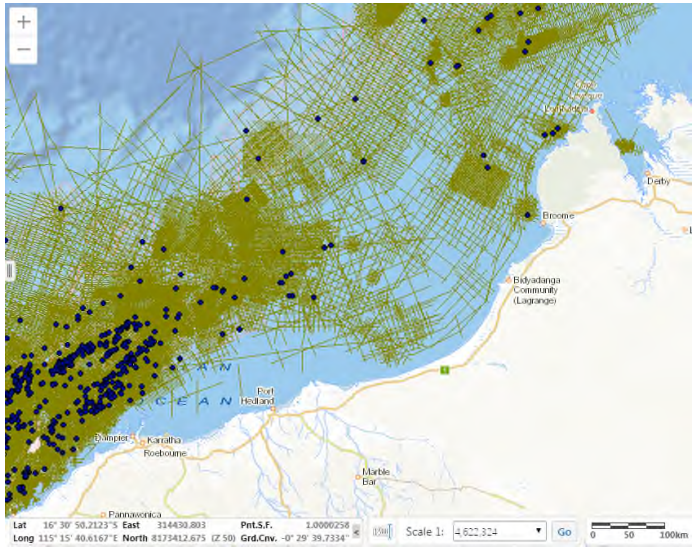


Background

Assessing the potential effects of petroleum exploration activities require field experiments that occur in real-world situations over scales of time and space relevant to the activities of industry and the life cycles of the organisms concerned

Santos Good Standing Agreement
May 2017 – May 2020





Location of petroleum activities that have occurred in the NWSSRP study area

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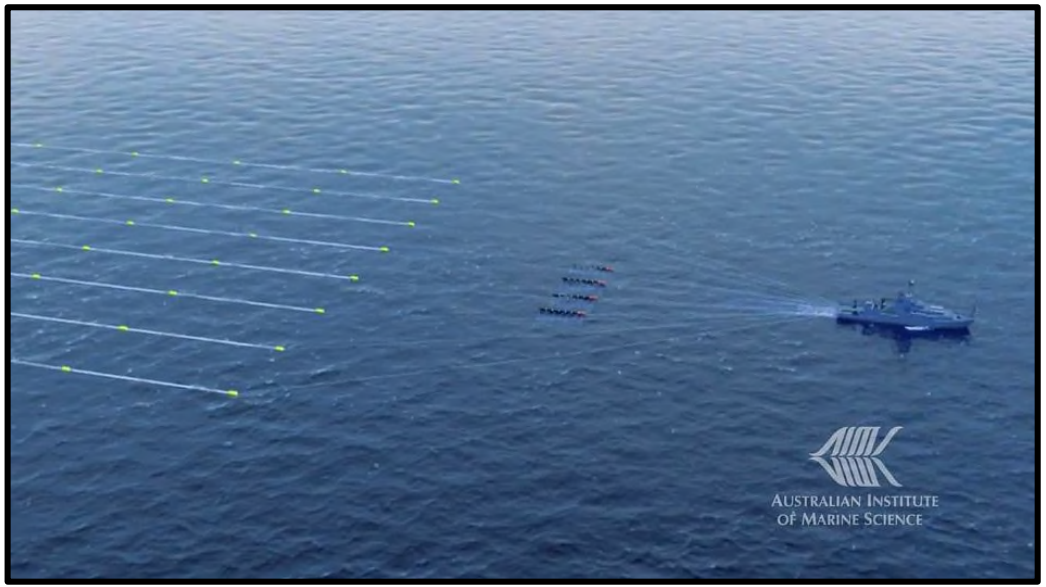
Demersal fish experiment:
Determine the impact of a “real-world” seismic survey on fish assemblages

Do the fish move away in the area of a seismic survey?

For a tropical fish assemblage, is there an impact of seismic survey activity on the:

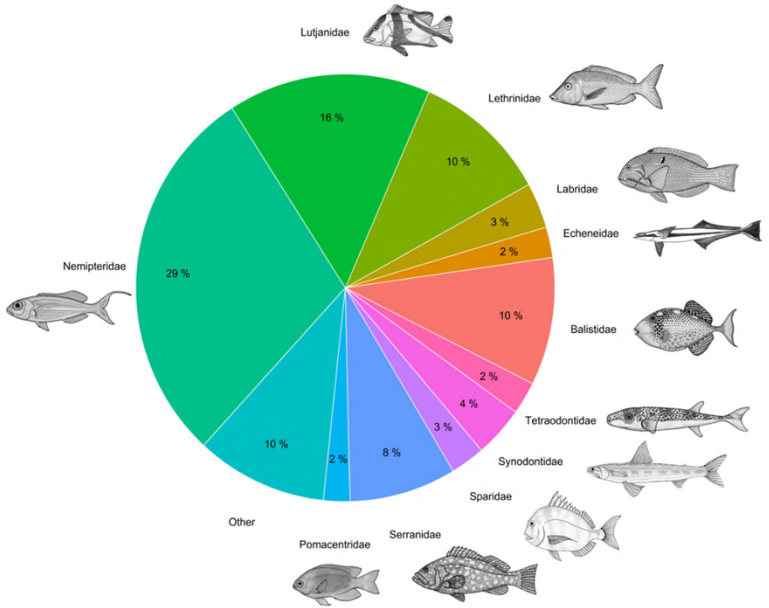
- abundance, distribution and community structure;
- behaviour; or
- movement?



What to study?

Target species

- Previous studies focus on a single species
- Demersal species – Assemblage
- Target species - Northwest Australia predominantly trawl and trap fisheries of demersal fish



Focal species

- Red emperor - commercially and recreationally important across tropical Australia
- Abundant
- Resilient to capture from depth and tagging
- Site-attached with a limited home range
- Potential to use sound as a cue for life functions

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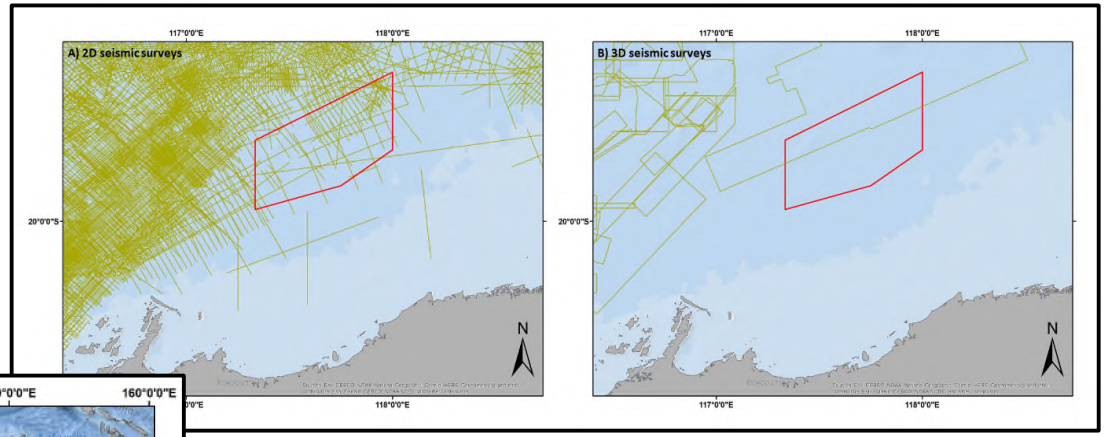
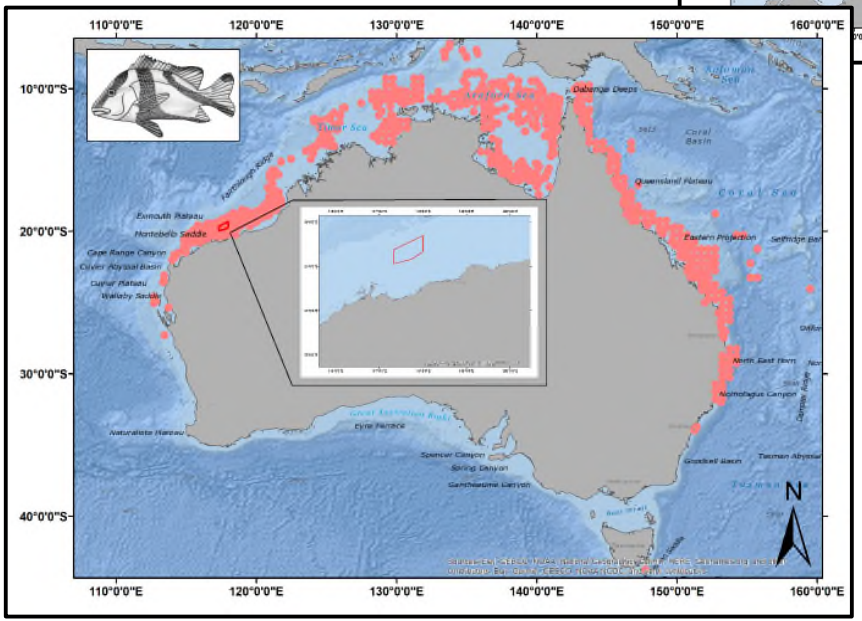
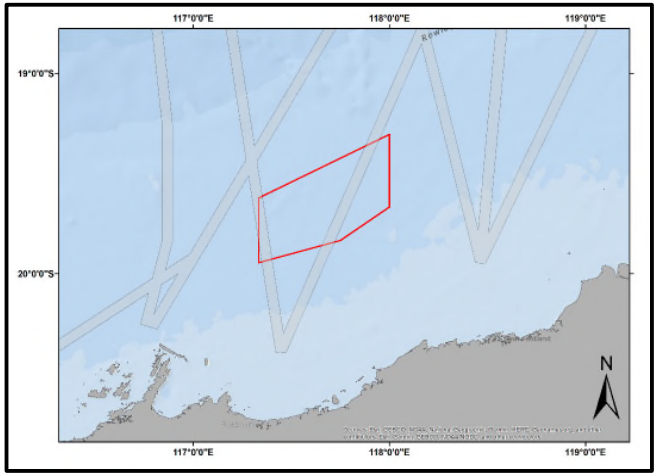
Where to study it?

Area 3:

- Closed to commercial fishing
- Target species abundant
- Little seismic activity
- Shipping fairways







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Sampling design

Seismic vessel operations (Racetrack style) with:

8 Active (airguns firing, black lines) and

8 Inactive (airguns not operating, blue lines) sail lines

Before-after-control-impact (MBACI):

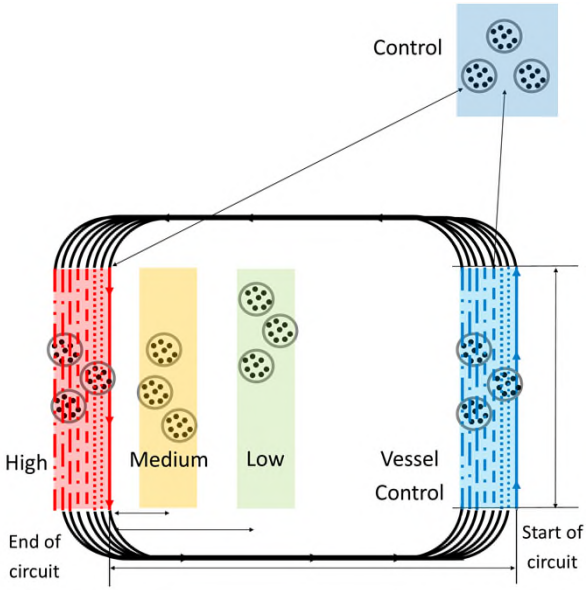
High Exposure, Control and ***Vessel Control*** zones sampled:

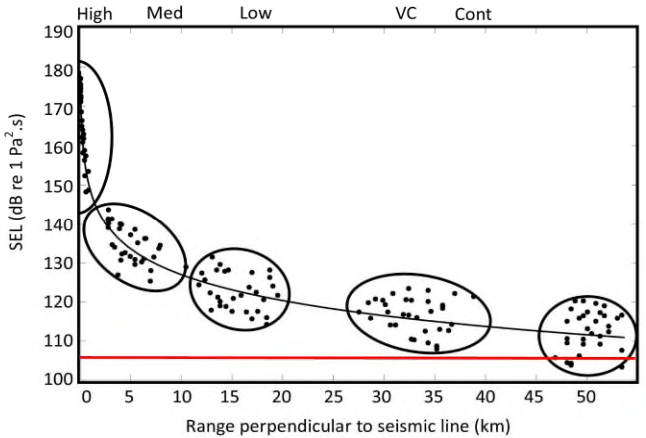
Before (three times, from five months)

After (twice, to three months) seismic exposure

Dose-Response:

Samples experience a range of sound exposure levels: a decay curve in response to the sounds.





Spatial constraints

Sampling site:

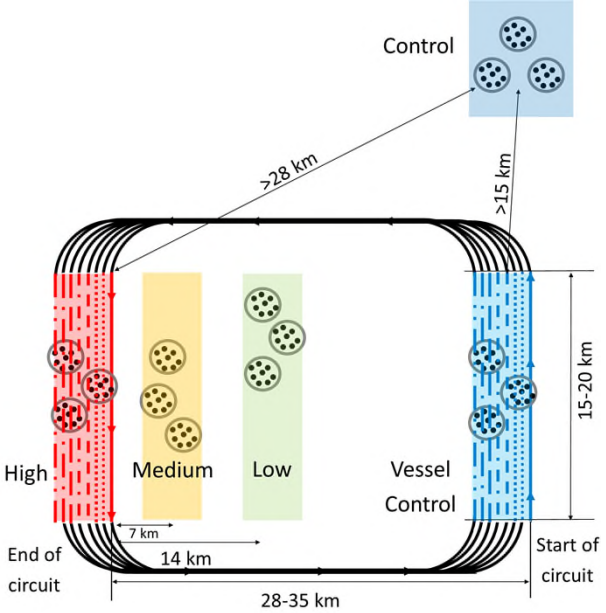
- Similar habitat
- Similar fish assemblage (confirm with BRUVs)

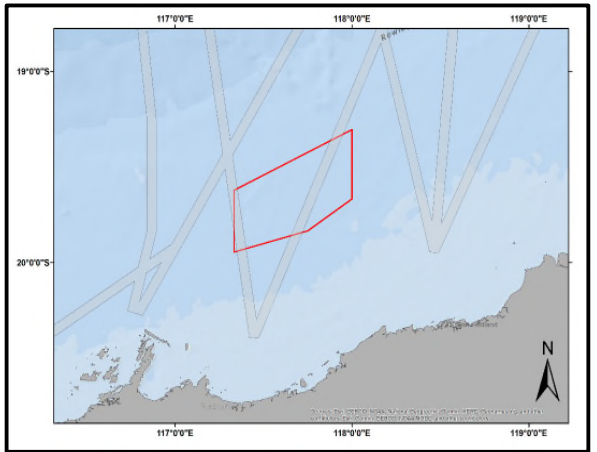
Distances (depending on orientation of seismic lines):

- HE → VC >28 km (Separation to remain a control)
- HE → VC <38 km (Seismic vessel speed)
- HE → Control >28 km
- VC → Control >10-15 km
- HE, VC, Control > 5 km for edge of Area 3

Keep HE and VC as shallow as possible (barotrauma)

All within Area 3





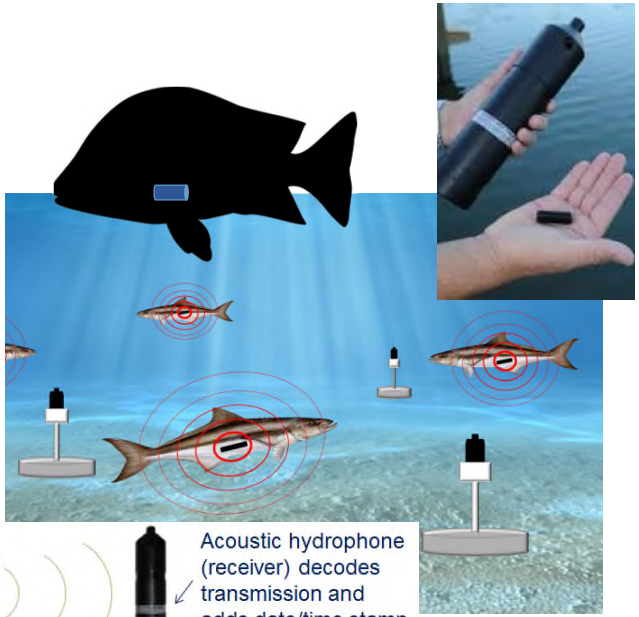
How to study it? (Multiple data streams)

Baited remote underwater video systems (demersal fish assemblage)

- Abundance (relative) and distribution, size,
- Behaviour: likelihood of feeding, time taken to approach bait, distance from bait

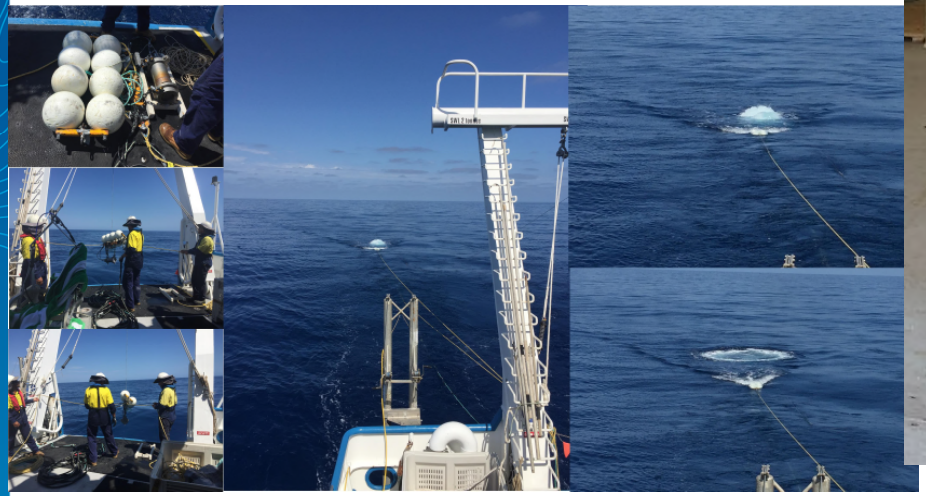
Acoustic telemetry tagging (target species)

- Movement patterns (displacement)



Fish: Mapping experimental site acoustic propagation

Single air-gun operations

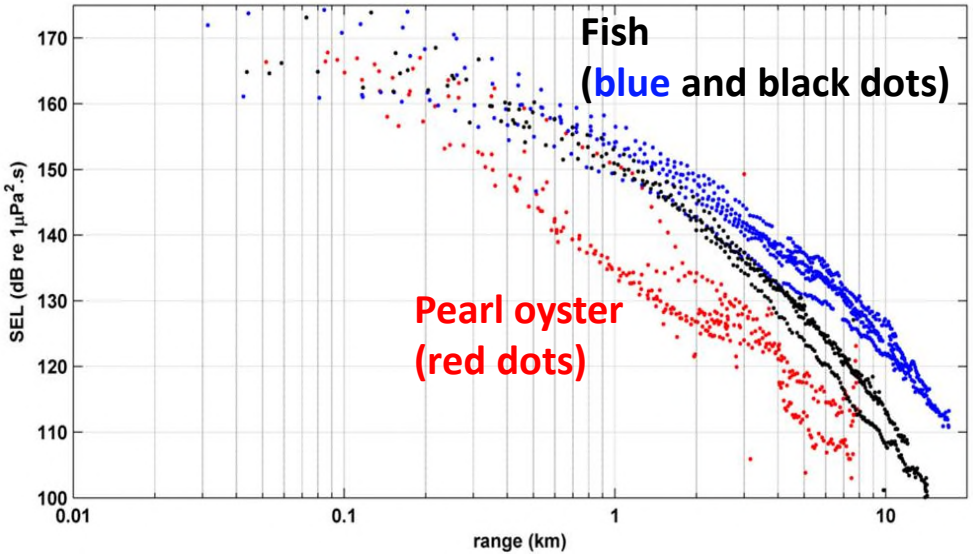


Recording airgun signal at multiple ranges

Pressure:	Curtin University, Underwater Sound Recorders (USRs)
Particle motion :	Geospectrum M20 particle motion sensor, JASCO AMAR logger
Ground motion:	Curtin University, USR with 3 axis accelerometer

Fish: Mapping experimental site acoustic propagation and habitat

Propagation losses: both fish and pearl oyster sites



Propagation loss plot: McCauley, Curtin University

Fish:
Confirmed ranges of **BRUVS** from seismic lines and design of **acoustic telemetry receivers** to experience the required exposure levels

Just needed to locate the habitat!!!!

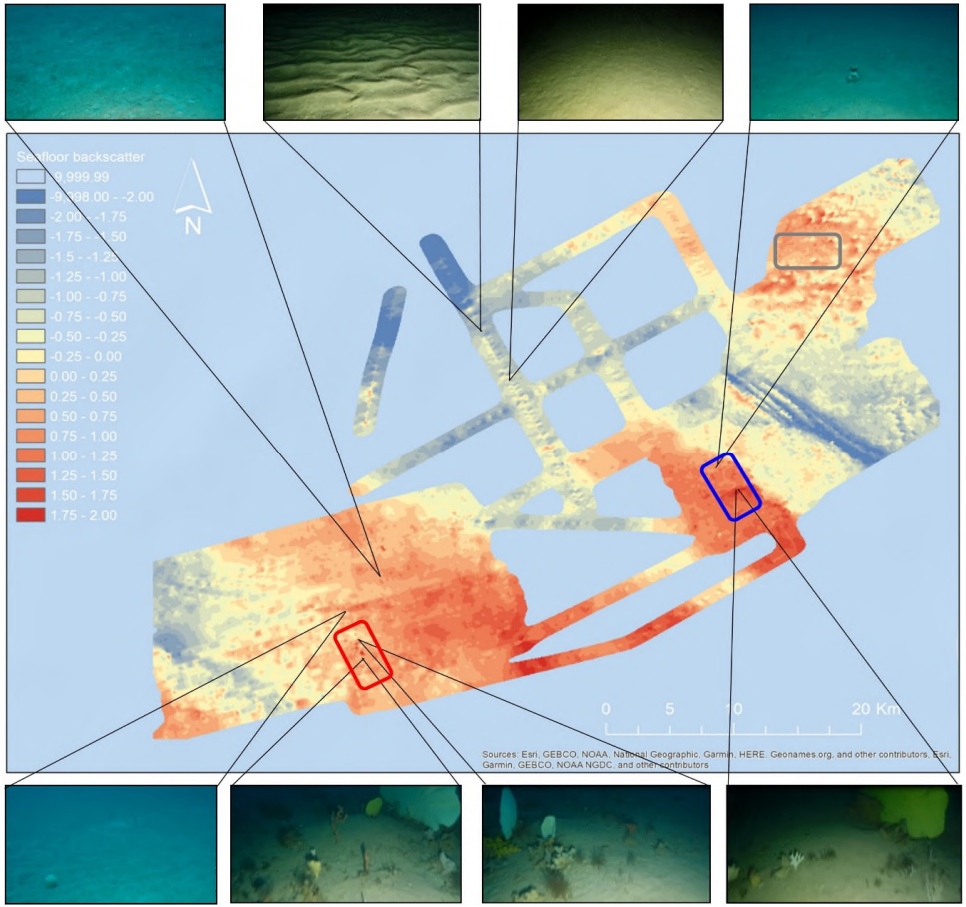
Fish: Mapping experimental site acoustic propagation and habitat

Multi-beam survey (R2Sonic 2026)
100, 200, 400 kHz

Thickness of sediment layer - 100 kHz
Fishers use lower frequencies - 'hard' bottom

Habitat (sponge community - 100 kHz)
Blue – definitely sand
Orange/yellow – nearly all sand
Red – Mostly sand (odd sponge)
Dark red – Good (thin veneer of sand)

Validation – 14 x 1500 m towed vid



Seafloor backscatter: Parnum, Curtin University

Fish: Mapping experimental site habitats

Preferred habitat was:

Patchy

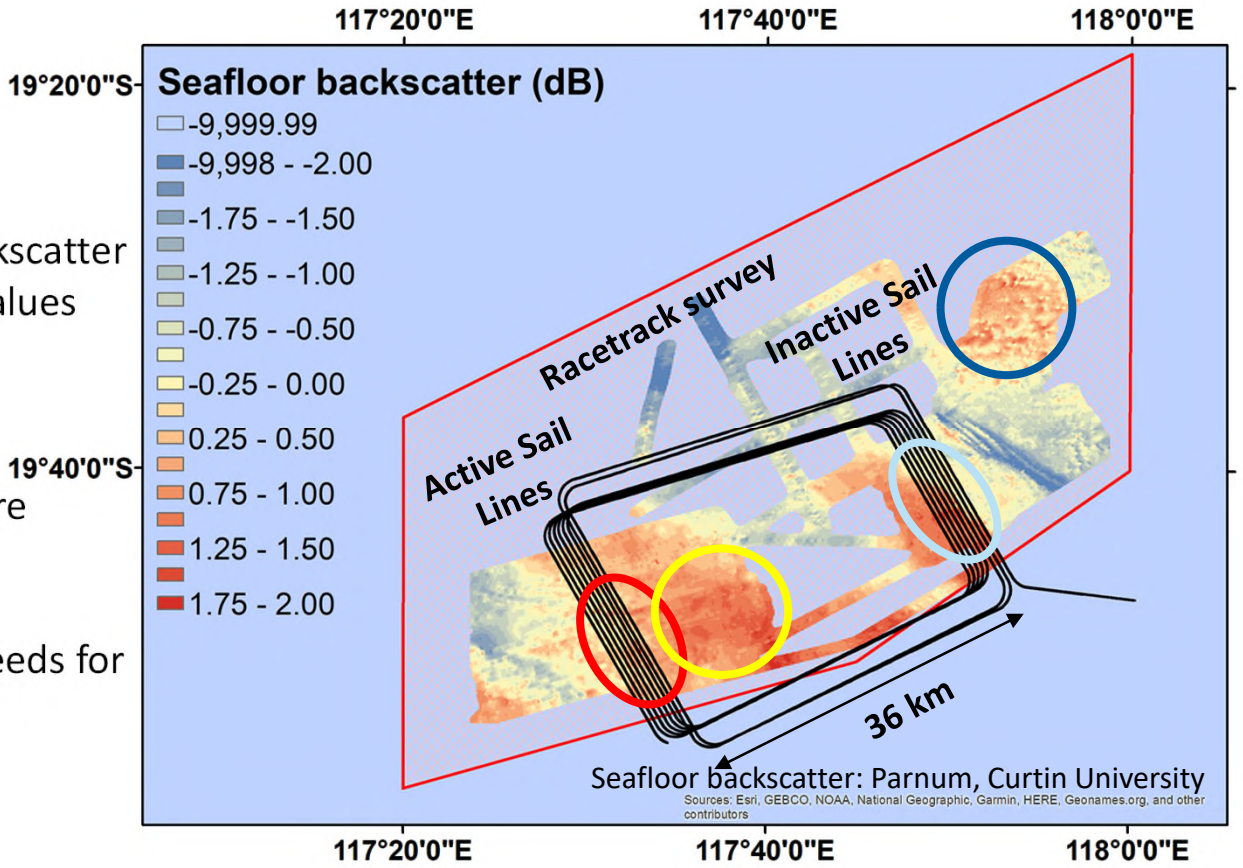
Not always reflected in backscatter

Present at the highest dB values

Enough areas for:

- High Exposure
- Medium-Low Exposure
- Vessel Control
- Control

that met spatial and model needs for the experiment



Fish: BRUVS sampling sites

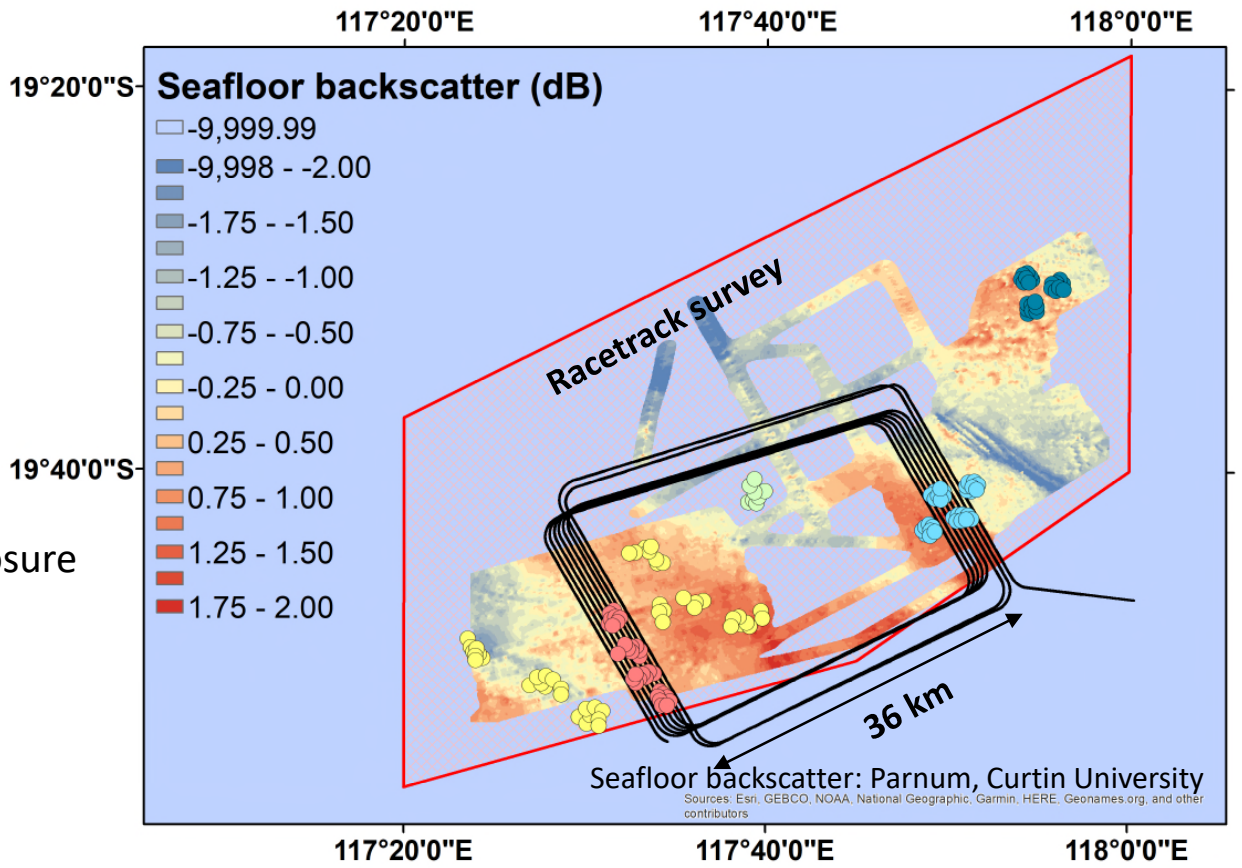
Exposure

- High
- Medium
- Low
- Vessel Control
- Control

All (almost) sites sampled:

Three times pre exposure

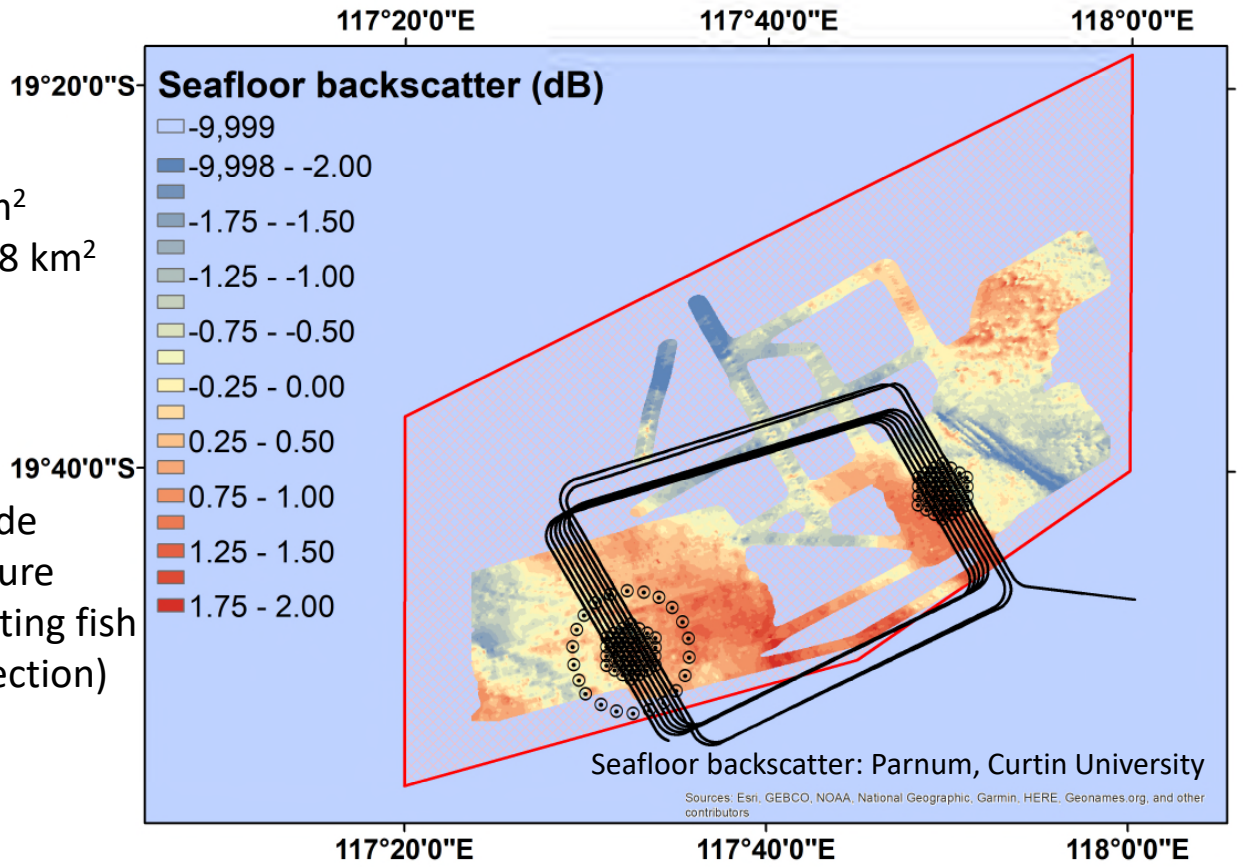
Twice post exposure



Fish: Acoustic telemetry sites

Two hexagonal arrays:
- Between receivers: 900 m
- Diameter ≈6.3 km – 31.2 km^2
- Actual detectable area ≈26.8 km^2
- Coverage ≈ 86% of circle

Further support from Woodside
- Circular array at High Exposure
- Broadscale detection departing fish
- Diameter ≈12 km (60% detection)



Pearl oyster experiment:
Determine the impact of a “real-world” seismic survey on the health and productivity of pearl oysters (*Pinctada maxima*)

What is the nature and extent, if any, of the impact of seismic surveys on mortality, physiology, growth and production of market quality pearls by pearl oysters, *P. maxima*?

At what distances/exposure levels do these impacts occur?

Over what duration are these impacts present?

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Pearl oysters: Key Constraints

No harm to commercial stakeholders or the surrounding ecosystem

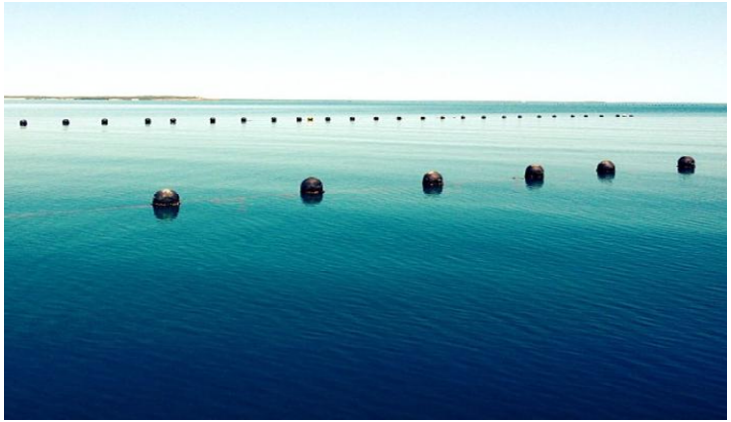
Weather

- Cyclone season ~ December to March
- Rough seas ~ May to October

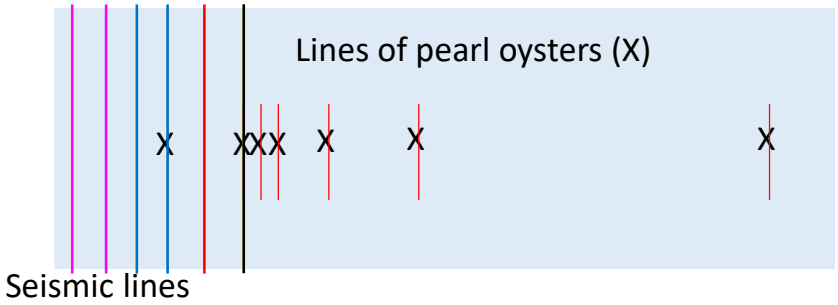
Whales

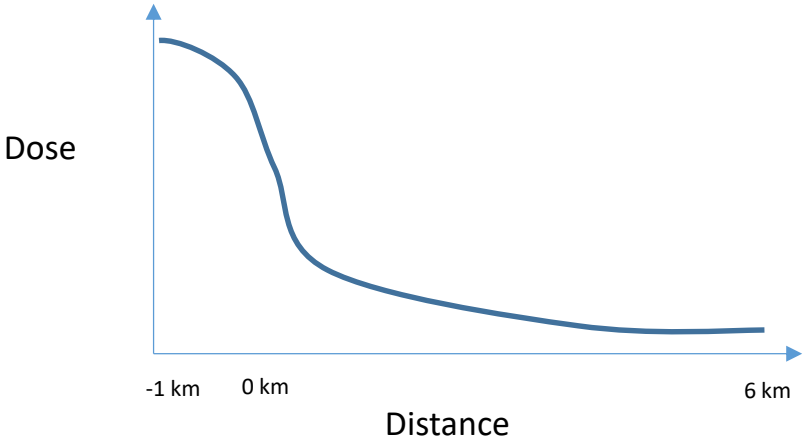
- Abundant May/June through to August

Proximity to holding and laboratory facilities



Pearl oysters: Seismic operations and exposure



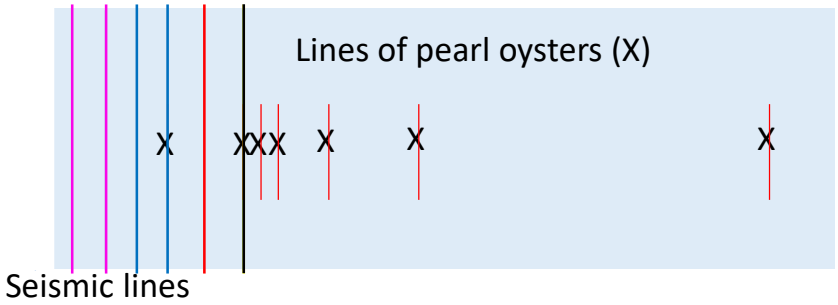


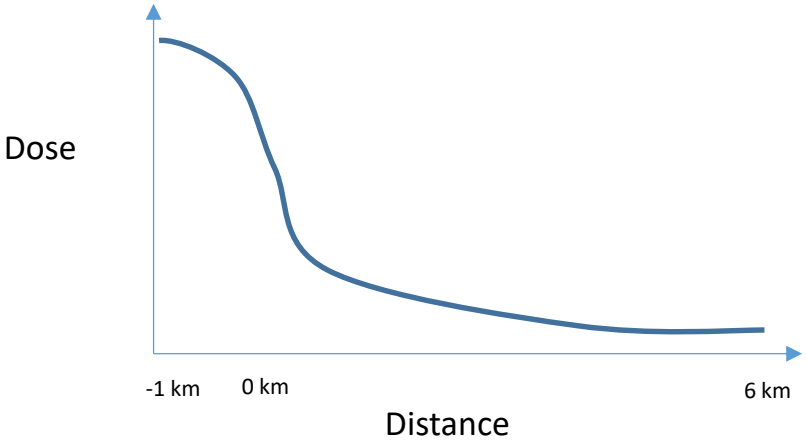
Lines of pearl oysters on the seafloor
Parallel to seismic sail lines

Seismic sail lines	6
Line spacing (m)	500
Line spacing (hrs)	24/12
Line length (km)	20

Day 1 – Vessel control (no firing air-guns)
Day 2 – Single seismic line (1200 hrs)
Day 3 – Single seismic line (1200 hrs)
Day 4 – Two seismic lines (1200 then 0000 hrs)
Day 5 – Two seismic lines (1200 then 0000 hrs)

Pearl oysters: Seismic operations and constraints





Far from currently operated farms/leases

Habitat:

- Not to soft (covered in sediment)
- Not too hard (entangled lines)

Site needed to hold:

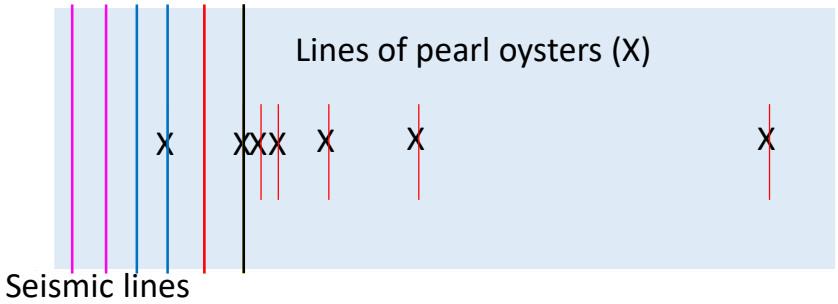
- Seven lines of pearl oysters (100s m long)
- Up to 10 km apart

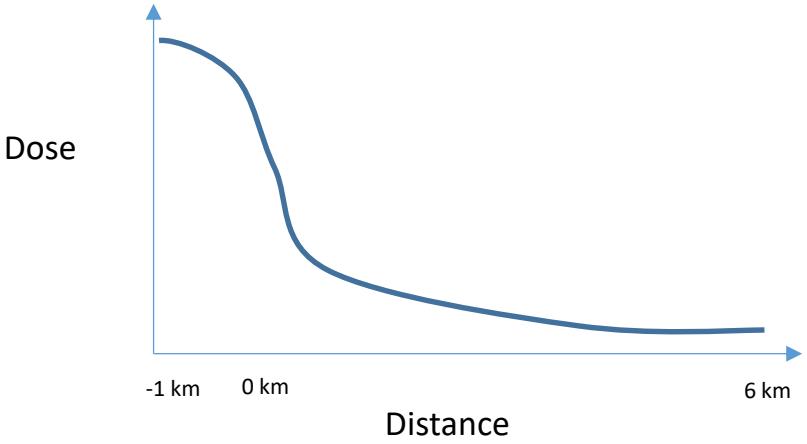
All oysters at the same depth (15<d<30 m)

Draft seismic vessel at all times (air-guns - 6 m)

Minimise potential movement of pearls after deployment

Pearl oysters: Sampling design





Combines of MBACI and dose response design

Controls: Farm, site, vessel

Treatments: After each day of exposure and 7 distances (35 treatments)

Laboratory sampling

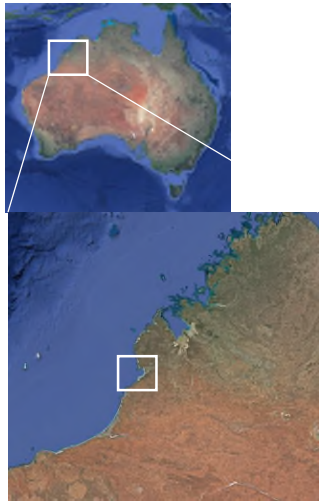
Through time: Immediate, 1, 2, and 6 months.

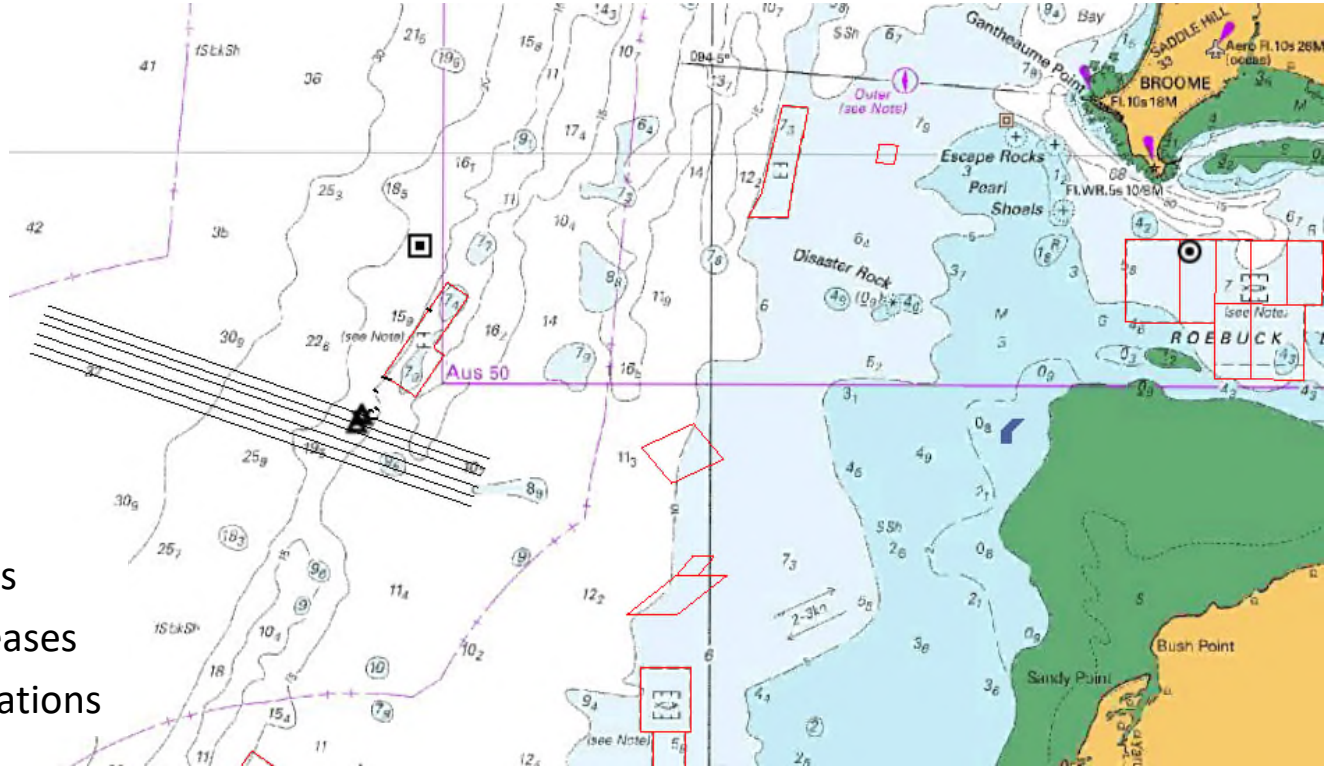
Pearl productivity

Seeded and grown to harvest (two-year period)

Control and highest exposure (7000 oysters)

Pearl oysters: Experimental Site





Seismic sail lines

Existing pearl leases

△ ○ □ PAM sensor locations

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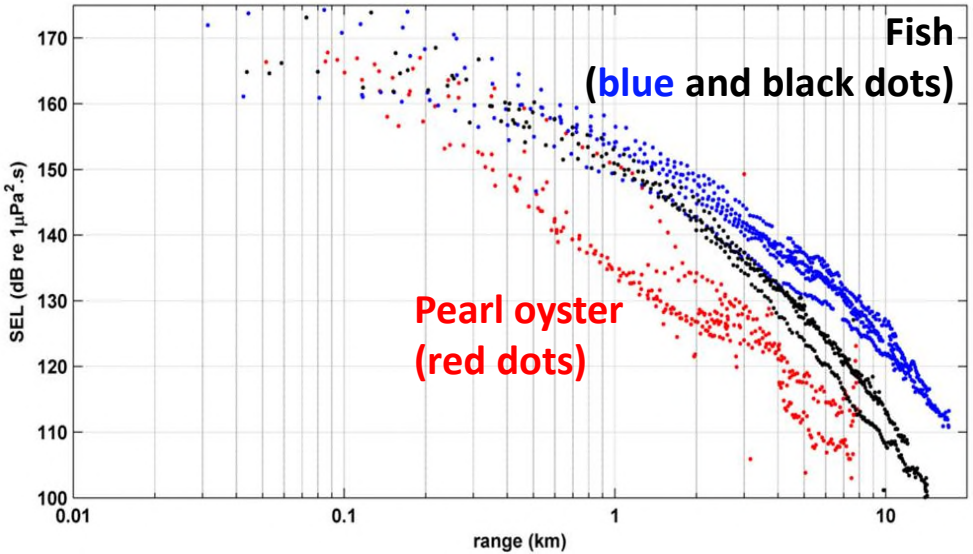
Pearl oysters: Single air-gun measures for acoustic propagation

Propagation losses: both fish and pearl oyster sites



Propagation loss plot: McCauley, Curtin University

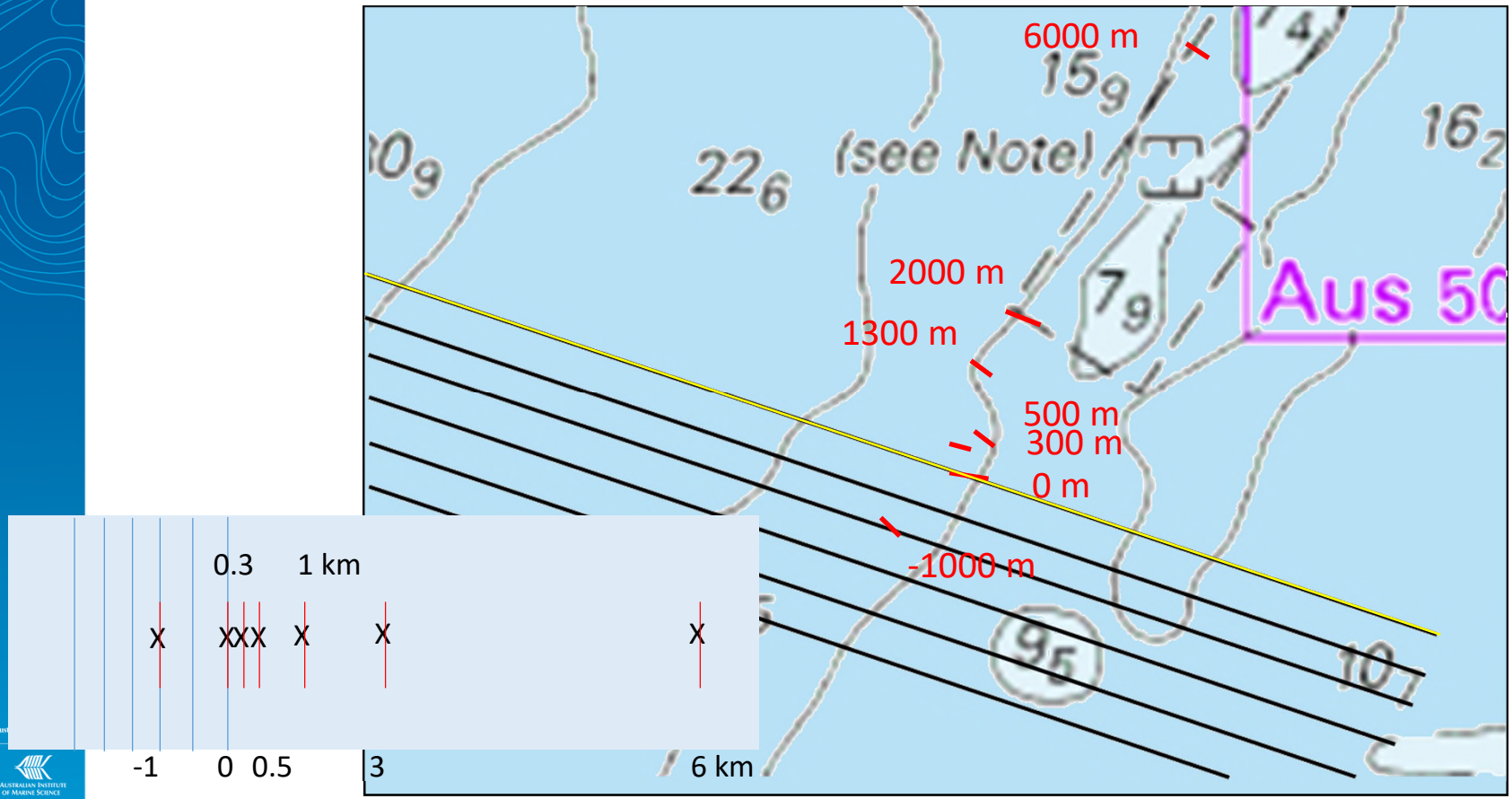
Pearl oyster site propagation losses greater than expected

These confirmed the ranges at which:

Pearl oyster lines

should all be located to experience the required sound exposure levels

Pearl oysters: Oyster line location



Pearl oysters: Measures

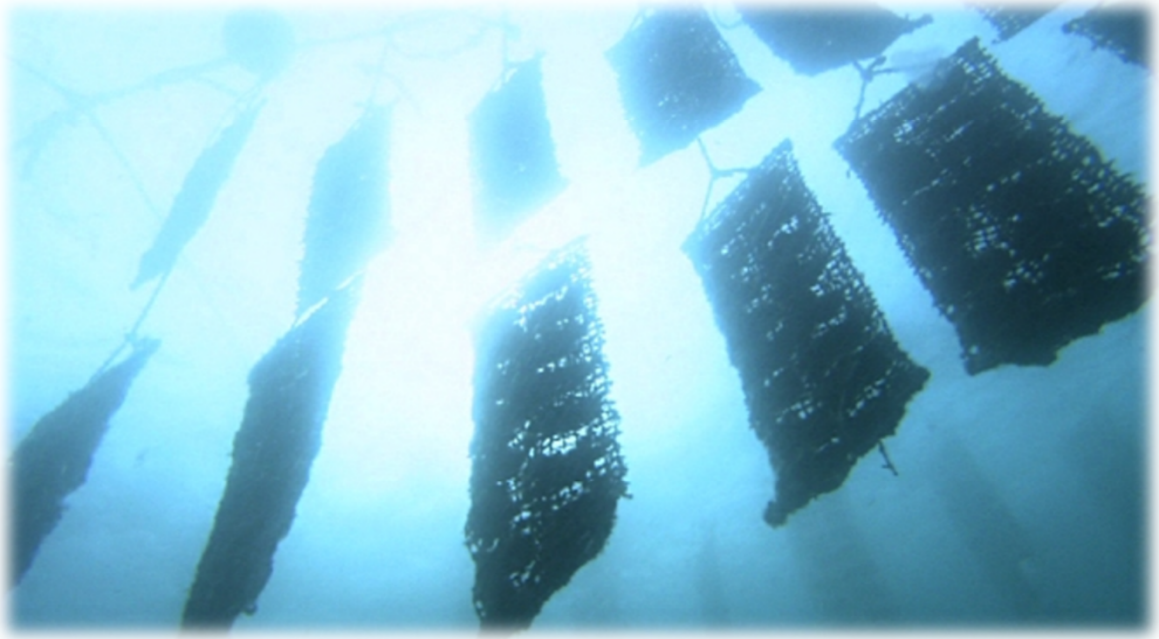
1. **Cellular functions** (immunity, enzyme activity)
2. **Molecular functions** (transcriptomics)
3. **Histology** (general health status and reproduction)
4. **Physiology** (mortality, growth, condition index, proximal analyses, etc.)
5. **Ability of oysters to produce market quality pearls**

Pearl oysters: Why no results today?

Oysters seeded with pearls

Grown out for 2 years – approx. 7,000 oysters

Later this year!



Conclusions

- The most detailed information on the impacts of seismic surveys on fish and oysters
- Definitive answers to the question do seismic surveys impact adult fishes and oysters
- Basis for impact assessment for industry
- Basis for regulation by management agencies
- Pearl oyster results due for release 2021
- See website: www.aims.gov.au/nw-shoals-to-shore

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AIMS: Australia's tropical marine research agency.

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