NORTH WEST SHOALS TO SHORE RESEARCH PROGRAM

THEME 1: Experiment Implementation

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Acknowledgements

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Collaboration Agencies include:

- Paspaley Pearling Company: Dave Mills, Dave Parker
- Curtin University: Rob McCauley, Iain Parnum
- Brown Dog Fishing Co.: Doug Gibson
- Department Primary Industries and Regional Development: Steve Newman, Cecille Dang
- University Tasmania: Jason Semmens
- Pearl Producers Association: Aaron Irving
- Crew *RV Solander*
- WA Fishing Industry Council: Mannie Shea

"The best laid plans" Robert Burns

"No plan survives first contact with the enemy." Helmuth van Moltke.

"Never work with children or animals (~~or scientists~~)" Fields

Adaptability is key!

Contingencies: Layout, data streams, equipment

Study sampling designs

Before-after-control-impact (BACI)

Samples in High Exposure, Control and Vessel Control conditions collected before and after the seismic exposure

Dose-Response

A selection of samples that experience a range of sound exposure levels from high to minimal, producing a decay curve in response to the sounds

Study sampling designs

Fish:

Multiple data streams to determine whether fish are at a certain location

Pearl oysters:

Multiple tests, to detect a specific response that has a mechanistic relationship with exposure to an acoustic source

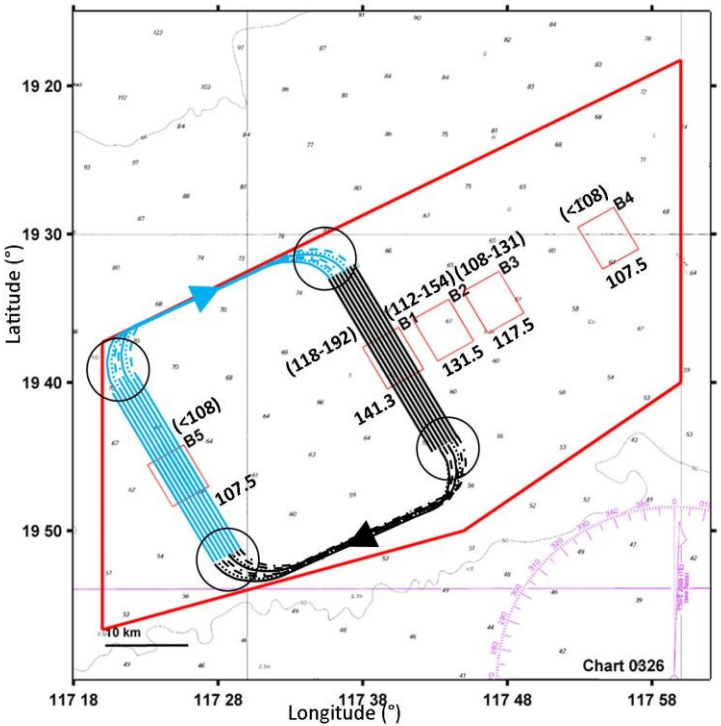
Data collection: Fish and oyster sampling

Method	Information gathered
Multi-beam mapping	Bathymetry and substrate type
Towed video	Benthic cover
Sediment sampling	Grain size
Passive acoustic monitoring (PAM)	Characteristics of seismic signals propagating to sampling locations
	Characteristics of local soundscapes
Acoustic tagging	Movement patterns of red emperor
BRUVS	Presence, length distribution, relative abundance, and behaviour of fish assemblage and red emperor
Echosounder (fish)	Presence, distribution of fish targets in the water column
Sediment sampling	Infauna composition and mortality
eDNA	Species presence
Laboratory sampling	Mortality and condition: physiology, immunology, histopathology, gene expression
Commercial audit	Mortality and condition (growth, mantle retraction, byssal attachment)
Audit after two years	Number, size, shape, weight, quality of pearl oysters

Timeline: Fieldwork

Fish		Pearl oysters	
April	Mapping study, Long-term PAM	April	Mapping study, Long-term PAM
June/July	Tag fish, Lay out acoustic tag receivers, BRUVs, Sediment grabs	July/August	Lay out oysters (industry)
August	Retrieve, download, redeploy receivers, Tag fish, BRUVs, Sediment, eDNA, echosounder		
September	BRUVS, echosounder (Pre exposure)	September	
	Seismic Exposure		**Seismic Exposure**
	PAM, echosounder transects		PAM, Laboratory sampling Trip 1
October	BRUVs, echosounder transects, Sediment grabs, eDNA	October	Laboratory sampling Trip 2
December	Retrieve Tag Receivers, BRUVs, echosounder	December	Laboratory sampling Trip 3
		April	Laboratory sampling Trip 4
		On-going	Pearl Industry monitoring and harvest (2 years)

Confirming Initial sampling locations – Fish (April mapping trip)



Constraints/needs Within ≈2700 km^2

Find three main areas (for the BACI design):

1. Vessel Control (VC)
2. High Exposure (HE)
3. Control (Cont)

plus Medium and Low Exposure (Dose Response)

Site:

Similar habitat

Similar fish assemblage (BRUVs)

Distances (depending on orientation of seismic lines):

HE → VC >25 km

HE → Cont >25 km

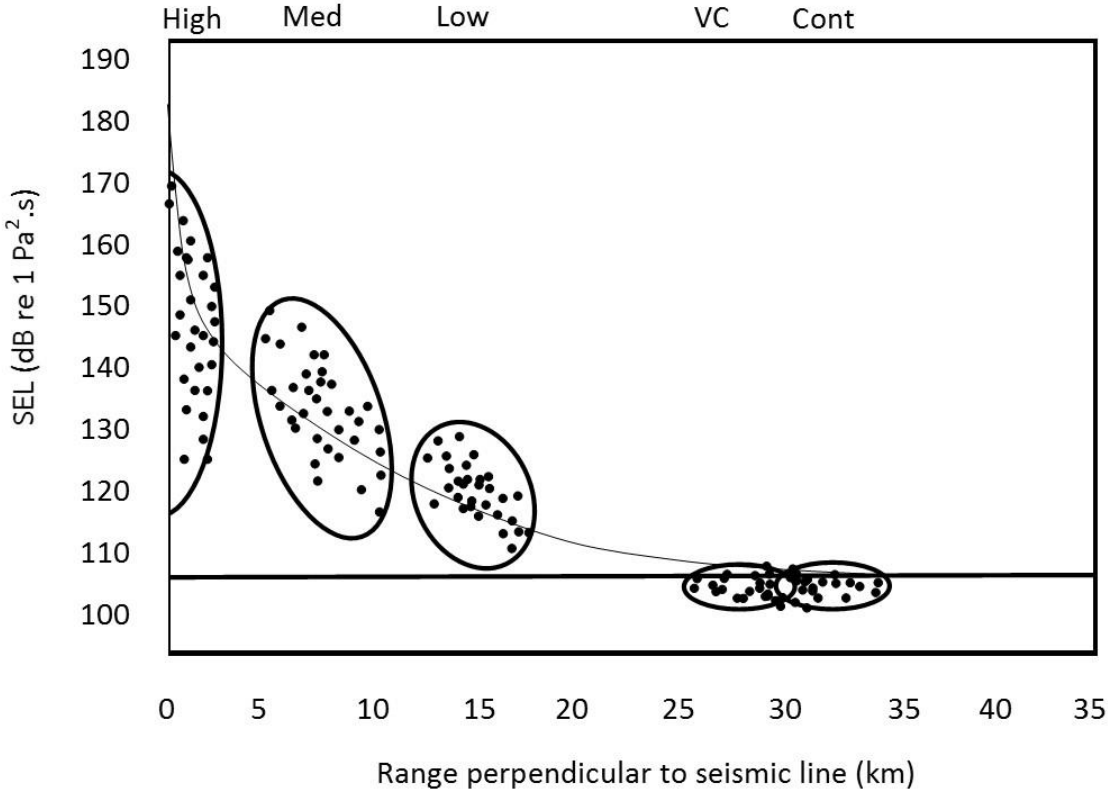
VC → Cont >10 km

HE, VC, Cont > 5 km for edge of Area 3

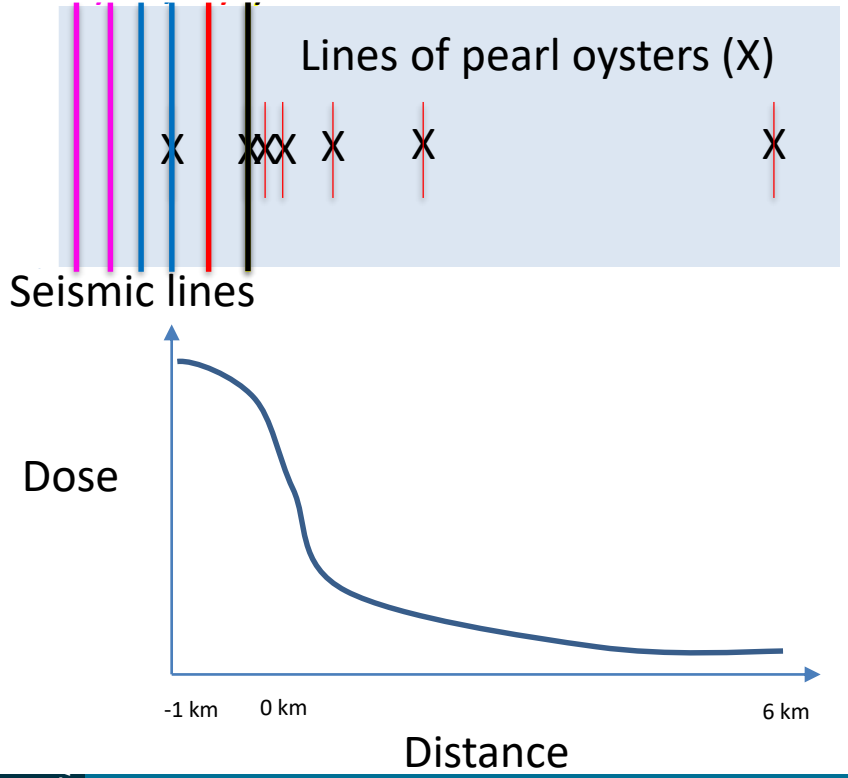
HE → VC <38 km (Seismic vessel)

Keep HE and VC as shallow as possible (barotrauma)

Dose Response Concept



Confirming Initial sampling locations-Oysters (April mapping trip)



Constraints/needs

Far from currently operated farms/leases (>? km)

Habitat:

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

Site needs to hold:

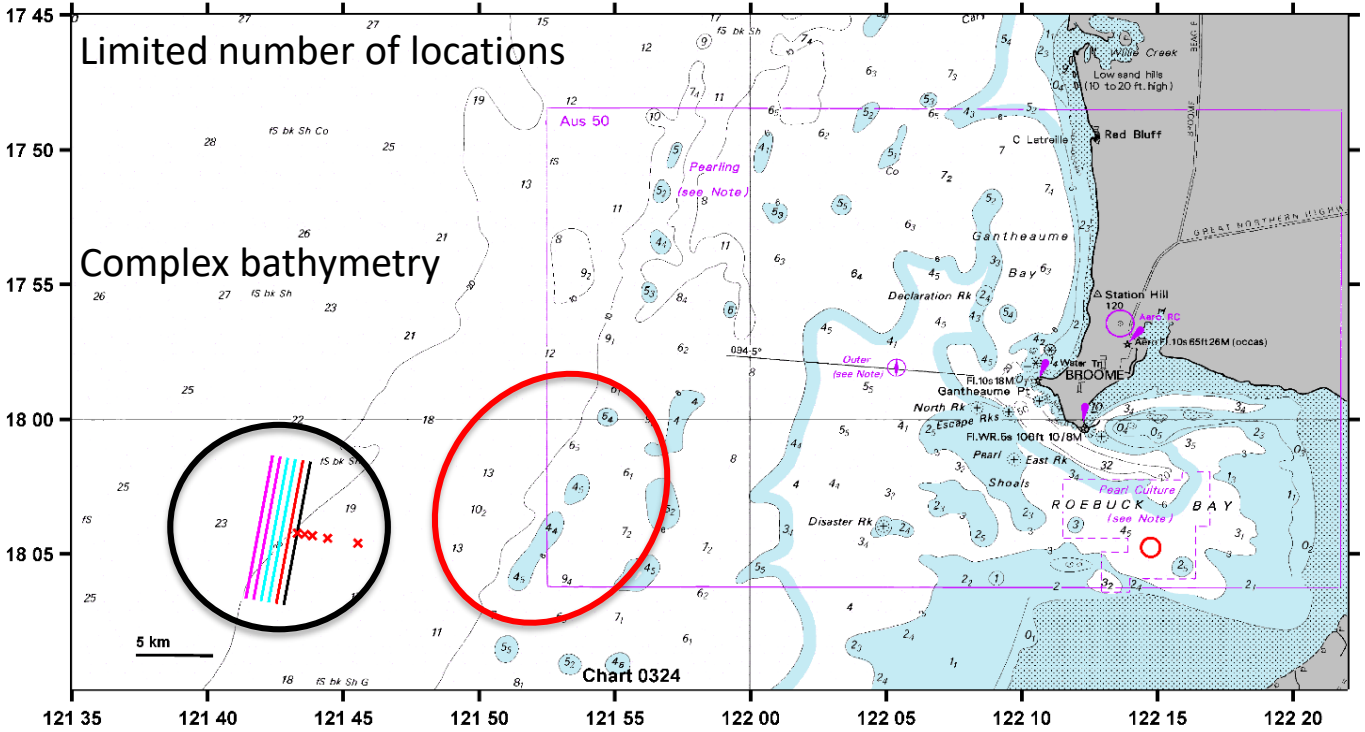
- Seven lines of pearl oysters (100s metres long)
- Distance apart (oyster lines): unknown up to 10 km

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

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

Minimise potential movement of pearls of deployment

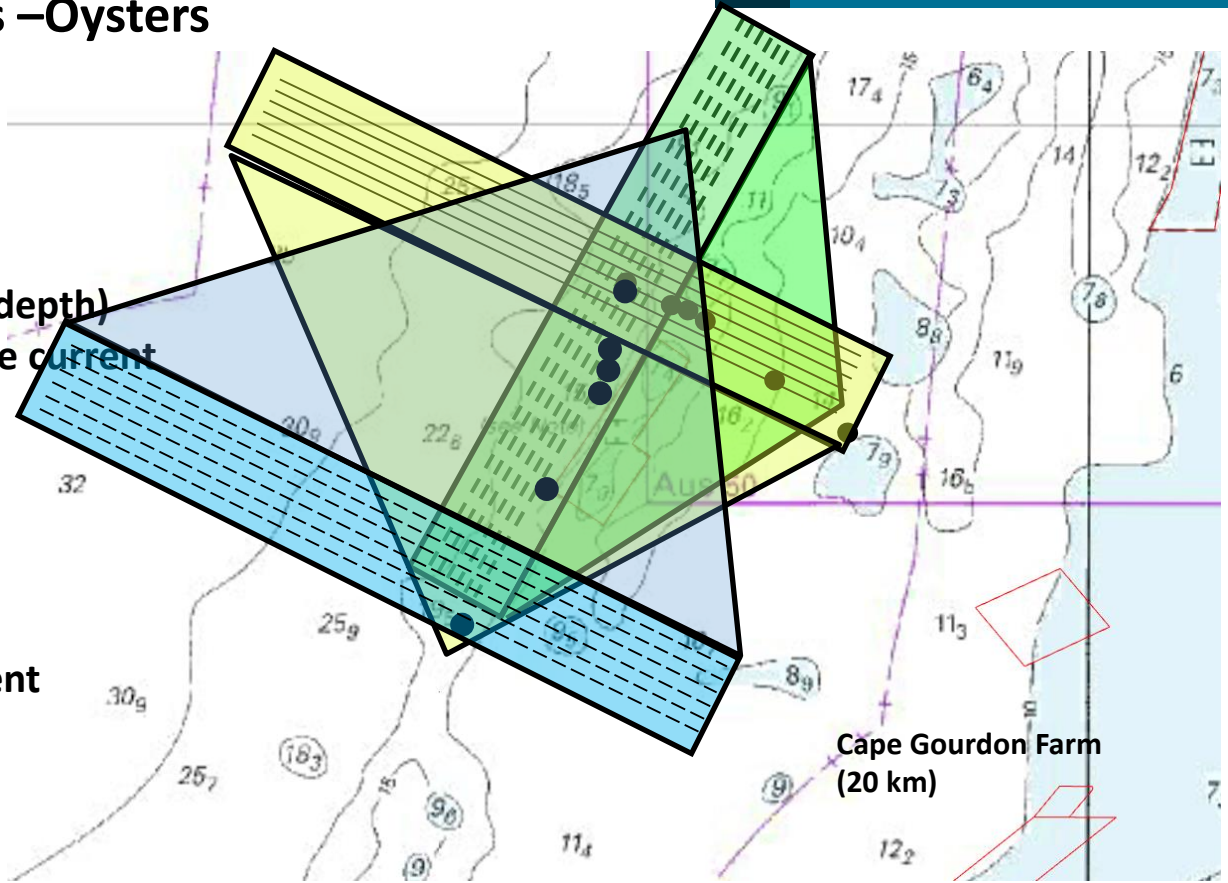
Confirming Initial sampling locations- Oysters (April mapping Trip)



Initial sampling locations –Oysters

Seismic lines: North-south
- **Seismic lines – same depth**
- **Oyster lines – over shoals (varies depth)**
- **Oyster lines – perpendicular to the current**

Seismic lines: East-west
- **Oyster lines– same depth**
- **Seismic lines – shallow water?**
- **Oyster lines – parallel to the current**



April Mapping Study

Chicken and the egg – Can't select sites until identified transmission losses, can't accurately test the transmission losses until you know the sites.

And we don't know where the best bottom is!

Compromise: Do everything at the same time!

Propagation – air-gun signals (April)

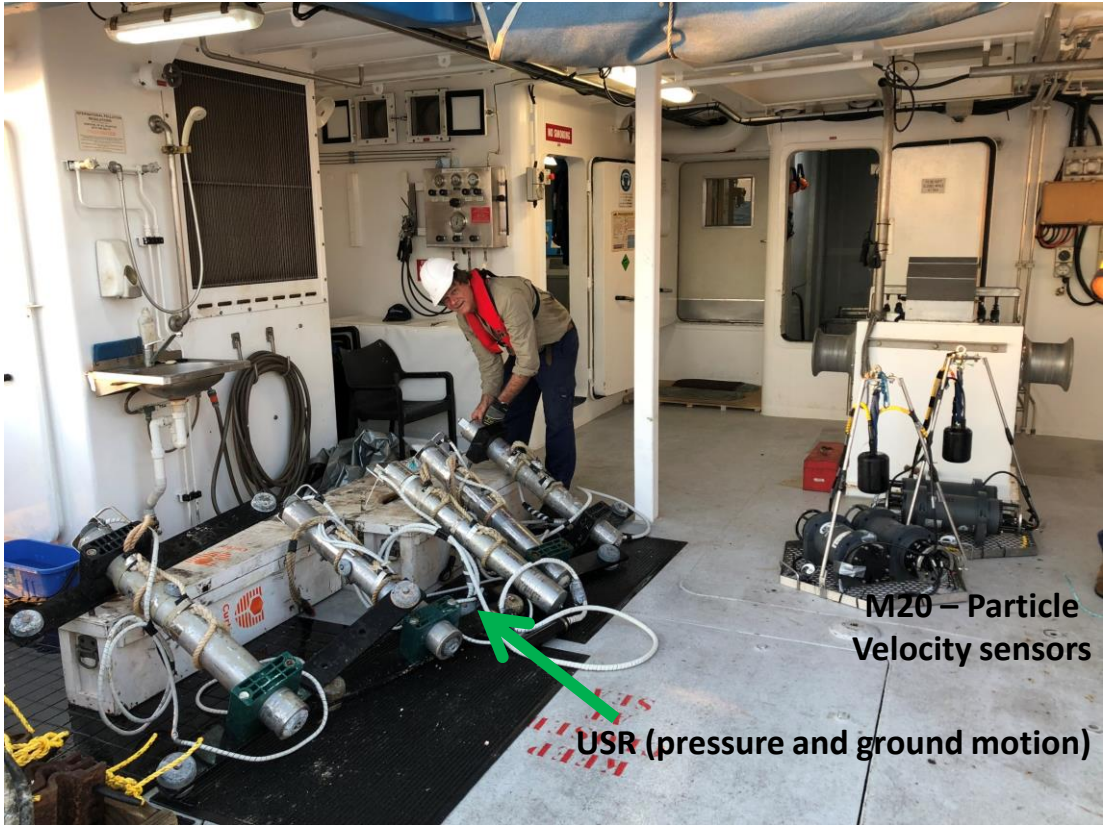
Passive acoustic monitoring (April)

Three components of seismic acoustic signal:

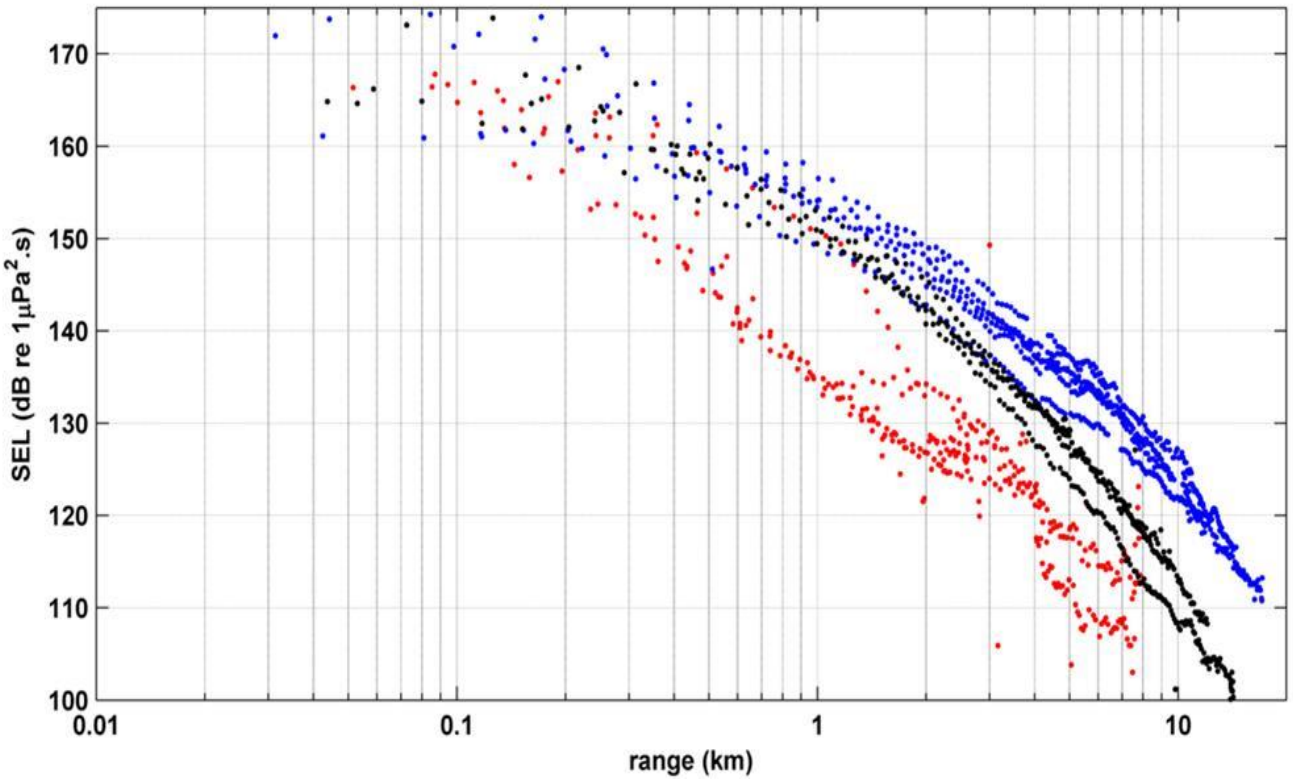
Pressure

Particle velocity (Fish)

Ground motion (Pearl oysters)



Acoustic propagation



Propagation plot: McCauley, Curtin University

Measured transmission losses shown by the received sound exposure levels of single 150 cui airgun shots against range at the pearl site (red dots) and fish site (blue and black dots).

These confirmed the ranges at which:

Pearl oyster lines
BRUVS
Acoustic tag receivers

should all be located to experience the required sound exposure levels

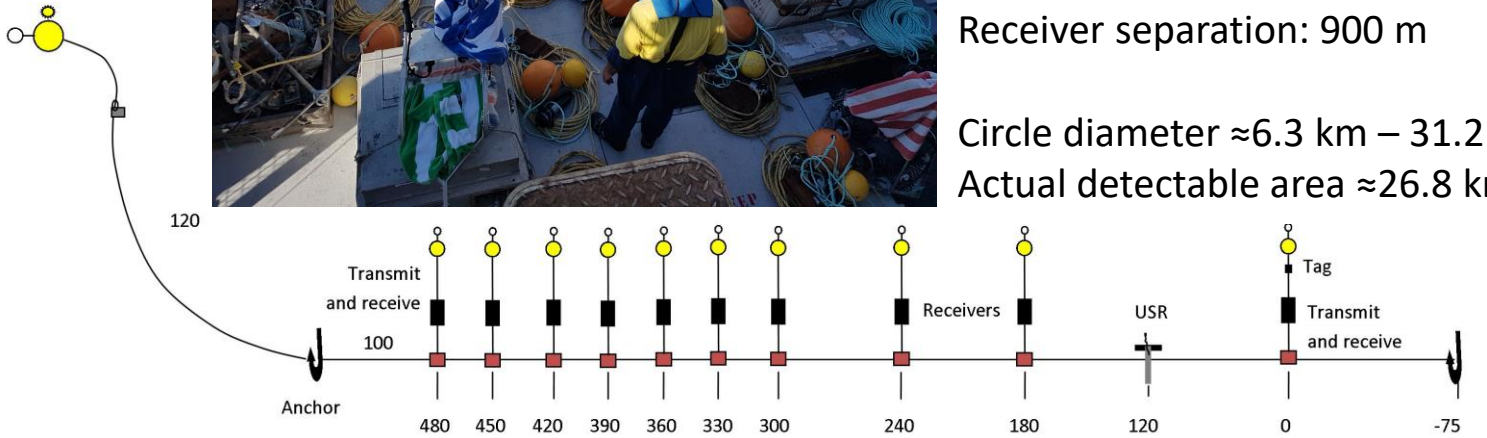
Fish Site: Acoustic Telemetry Range Test

A test tag deployed and receivers positioned at increasing ranges, up to 480 m

PAM mooring - background noise levels that may reduce performance (e.g. shrimp clicks)

Receivers set out in 2 hexagonal ‘circle’ arrays
Receiver separation: 900 m

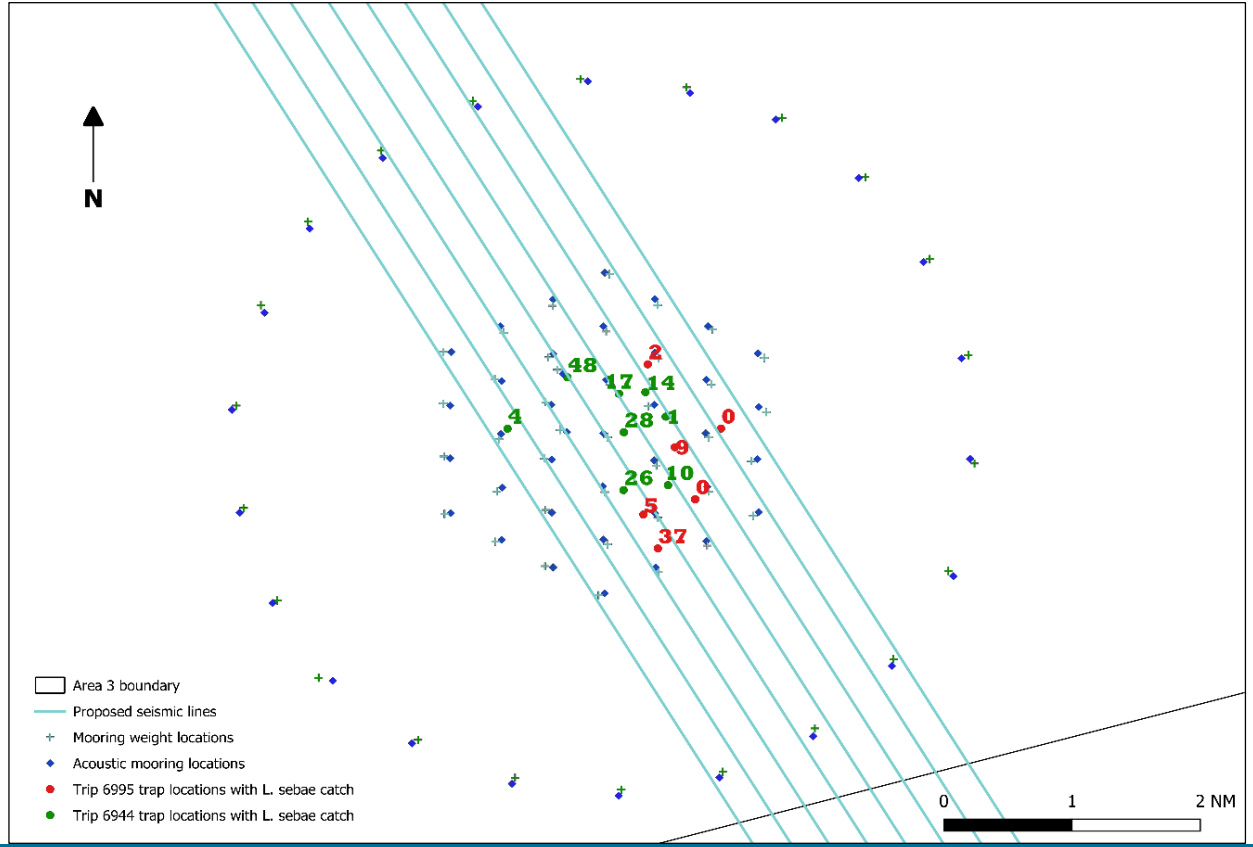
Circle diameter ≈6.3 km – 31.2 km^2
Actual detectable area ≈26.8 km^2 (~86% circle)



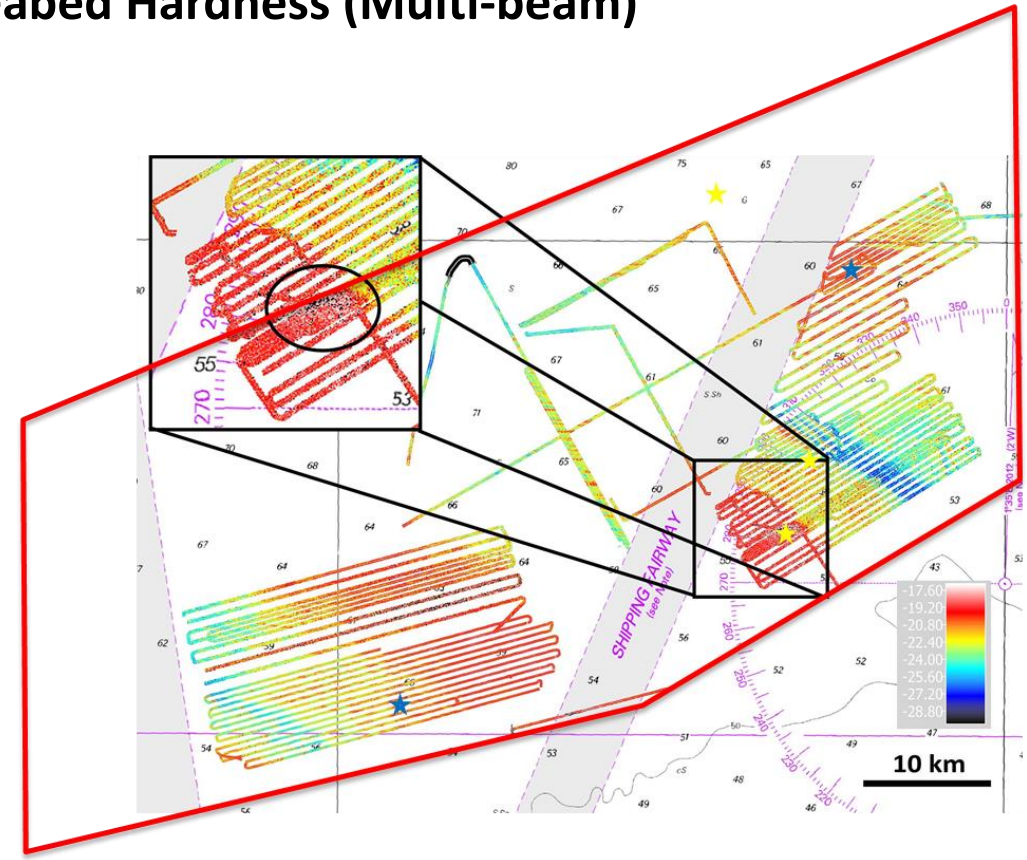
Fish Site: Acoustic telemetry Range test

High exposure acoustic receiver mooring array

- Internal receiver array
- Outer ring array



Seabed Hardness (Multi-beam)



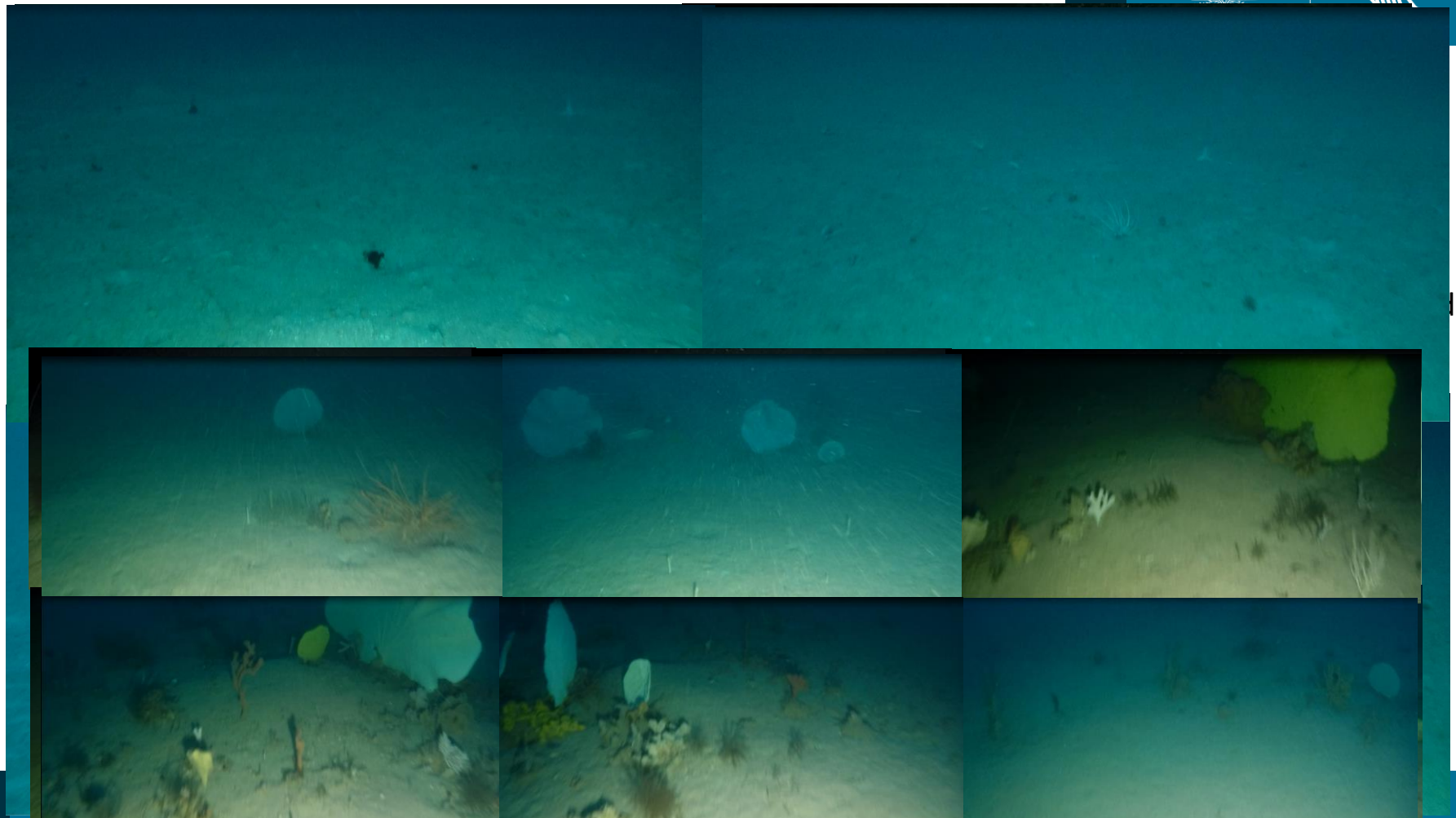
Backscatter Map: Parnum, Curtin University

Blue/green – definitely sand
Orange/yellow – nearly all sand
Red – Mostly sand
Black – Good (thin veneer of sand)

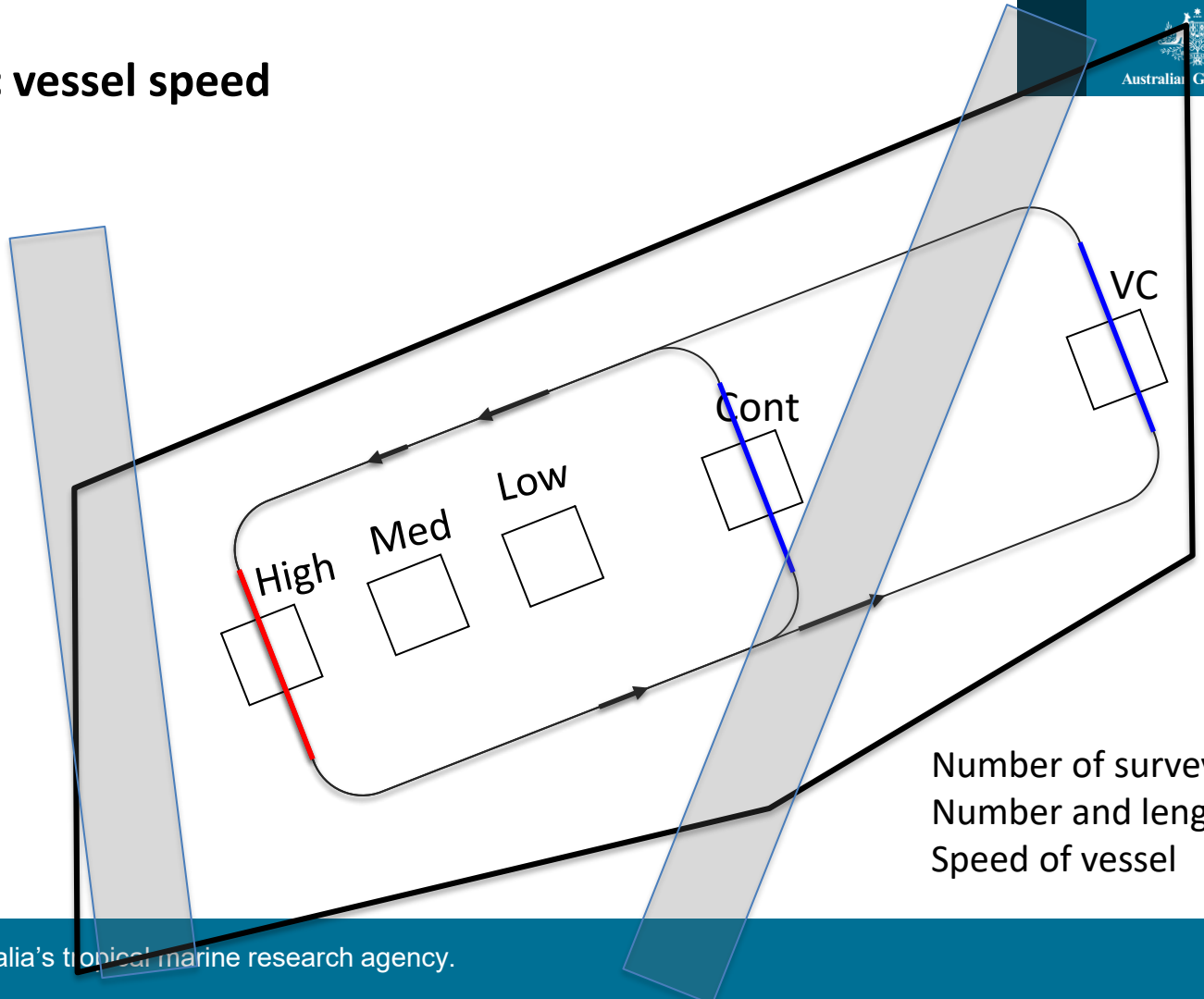
Validation – 14 x 1500 m towed vid

Multi-beam:
100, 200, 400 kHz

400 kHz – grain size
100 kHz – thickness of sediment layer

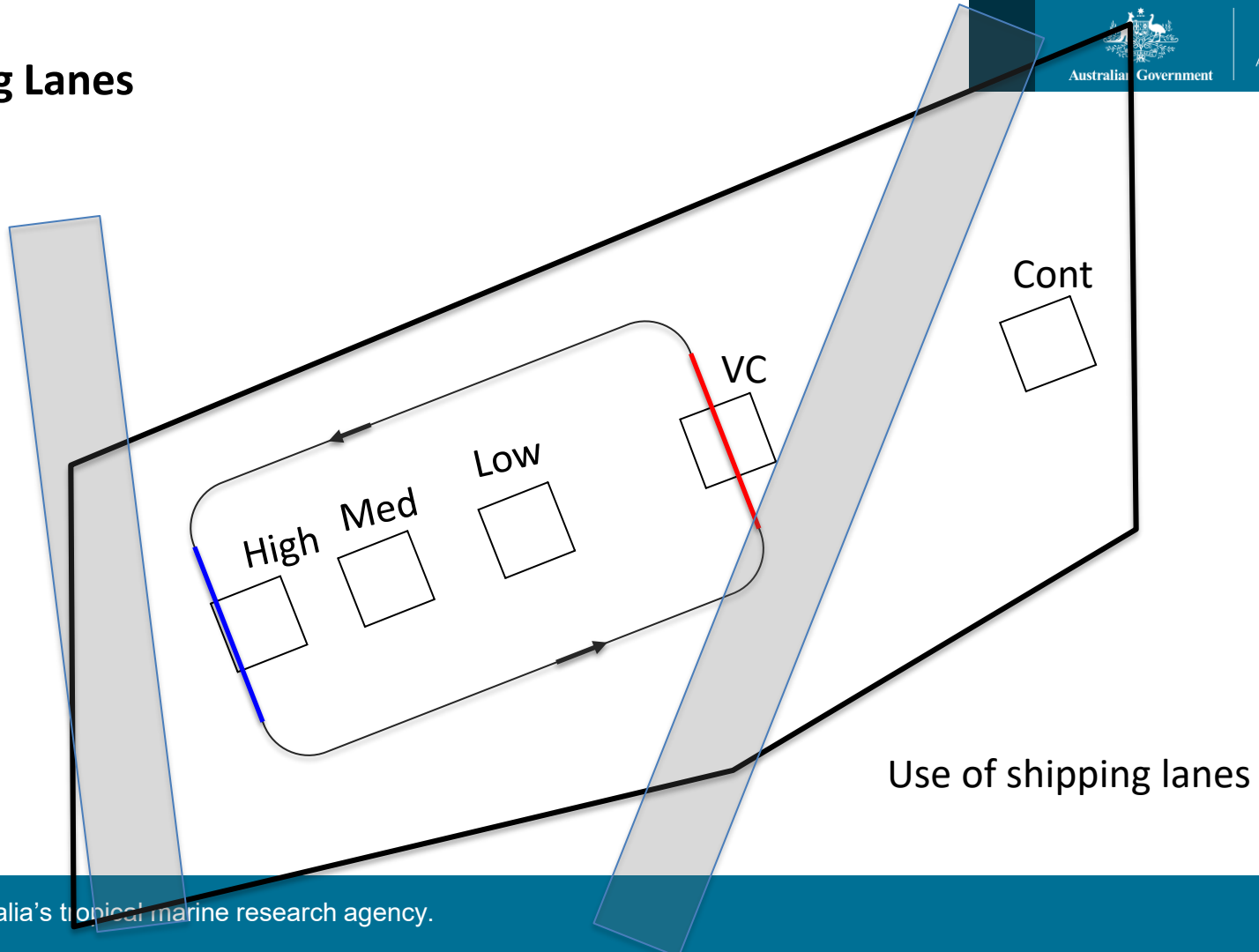


Seismic vessel speed



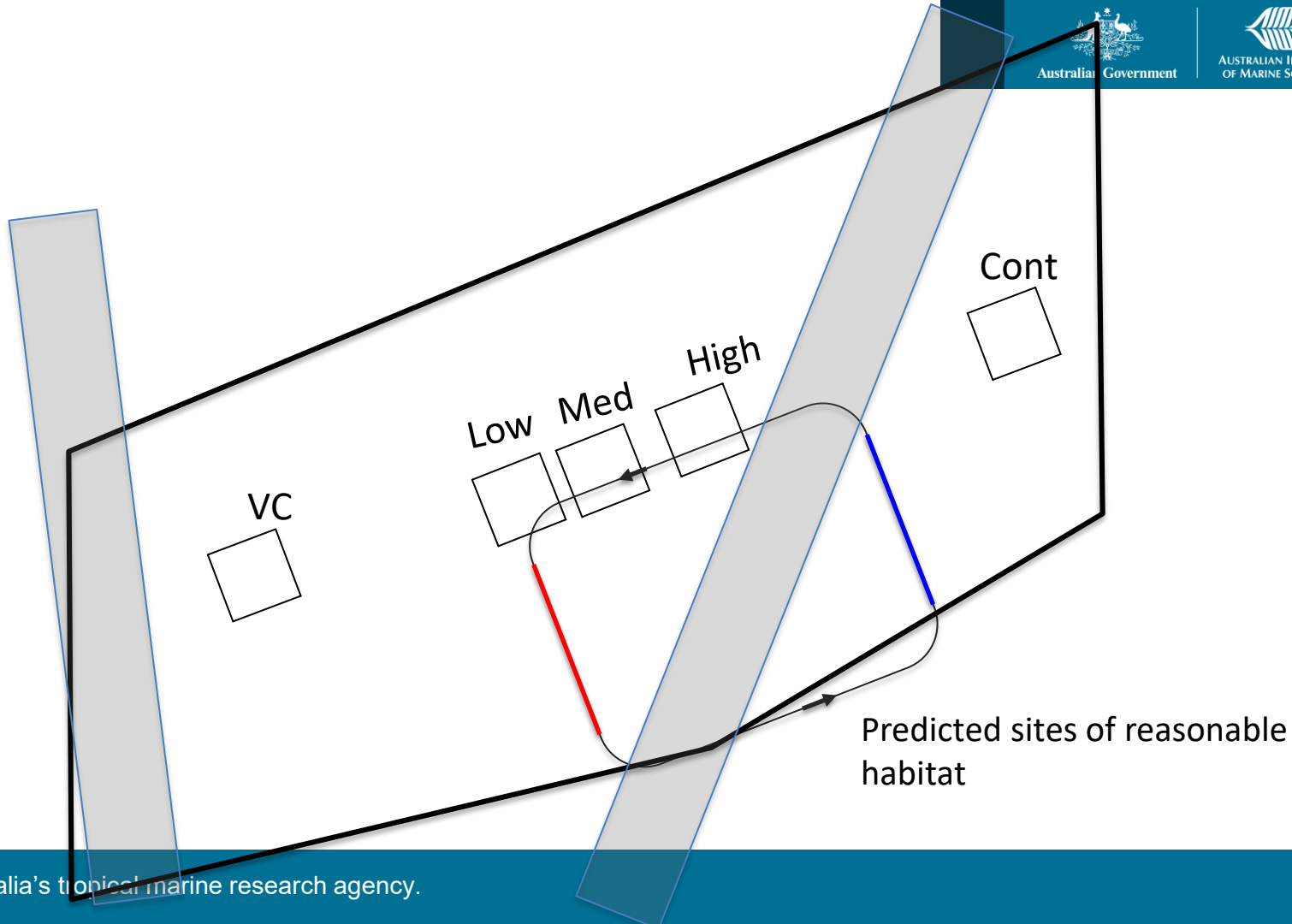
Number of survey days
Number and length of lines
Speed of vessel

Shipping Lanes

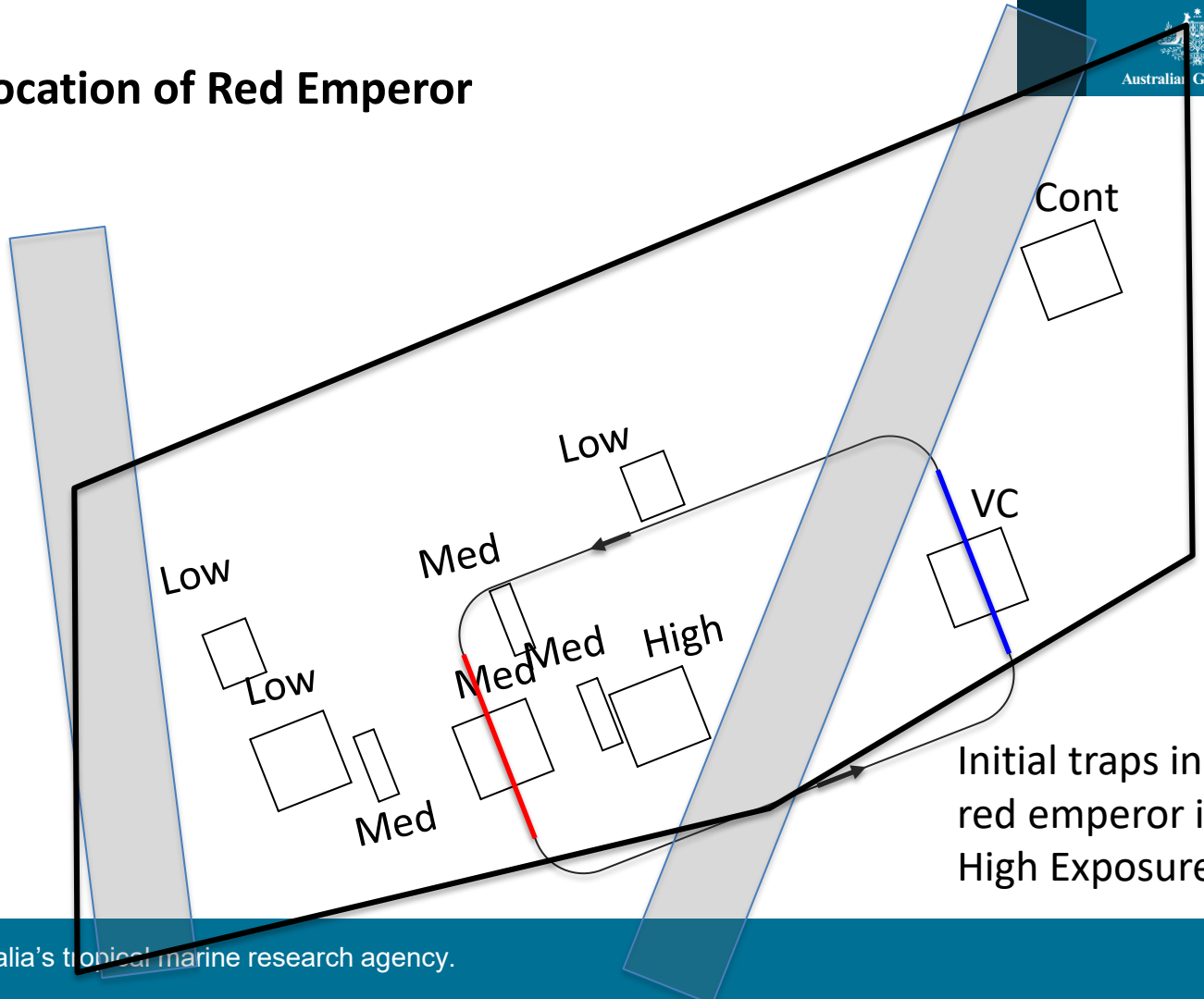


Use of shipping lanes

Habitat



Actual Location of Red Emperor



Initial traps indicated few red emperor in the planned High Exposure site

Observation techniques

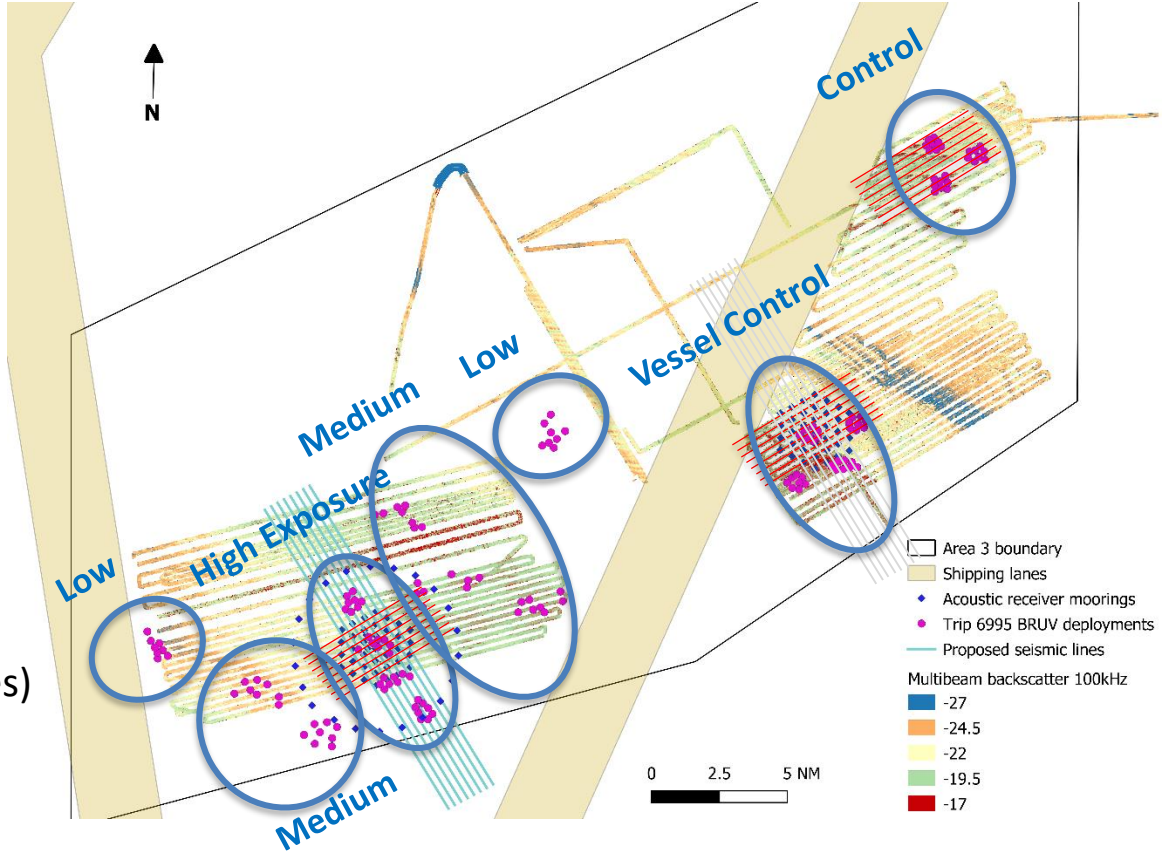
5 Zones each sampled:

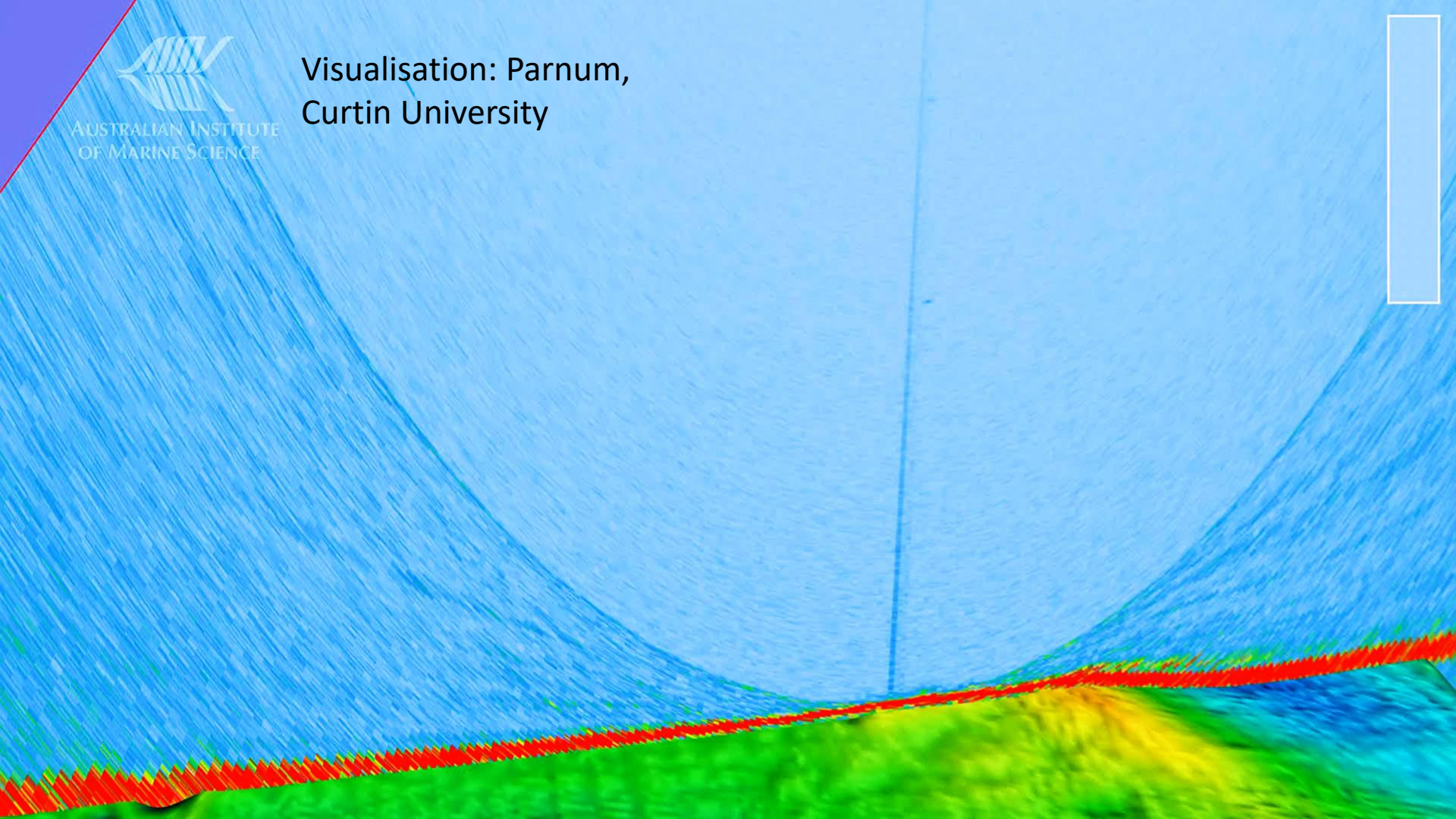
Three times pre exposure

Twice post exposure

Map of area 3

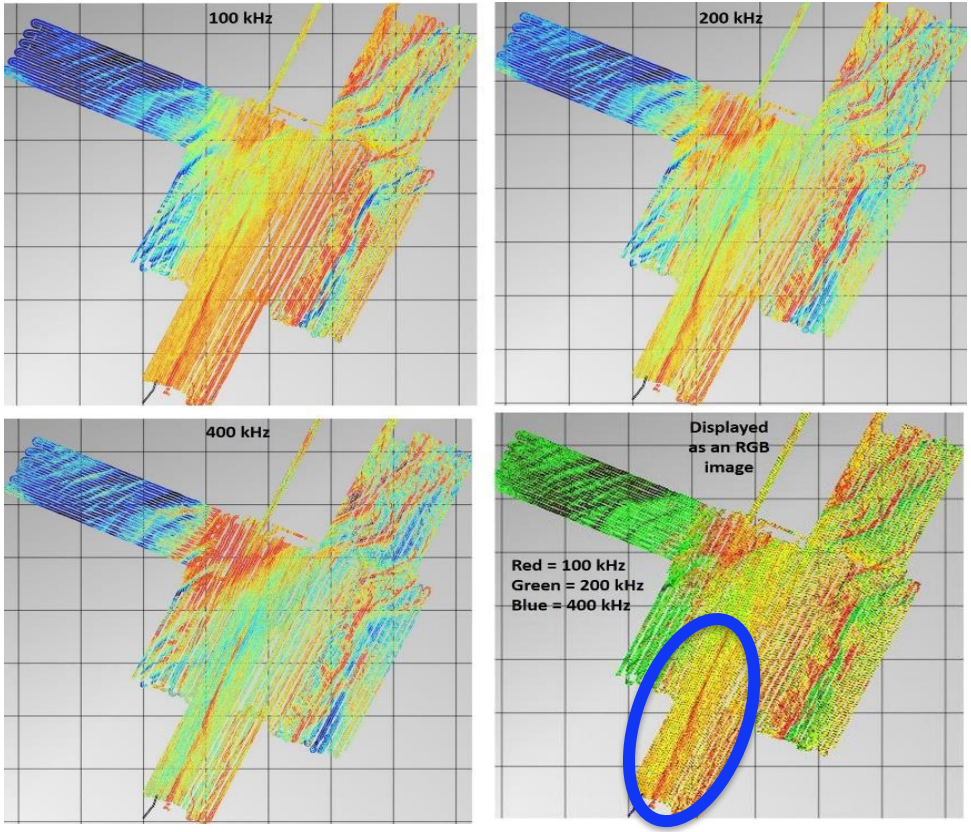
- BRUV deployments (purple)
- Acoustic tag receiver moorings (blue)
- Active seismic lines (blue lines)
- Echosounder transects (red lines)





Visualisation: Parnum,
Curtin University

Pearl Oyster Site Mapping (April)



Depth and seabed type

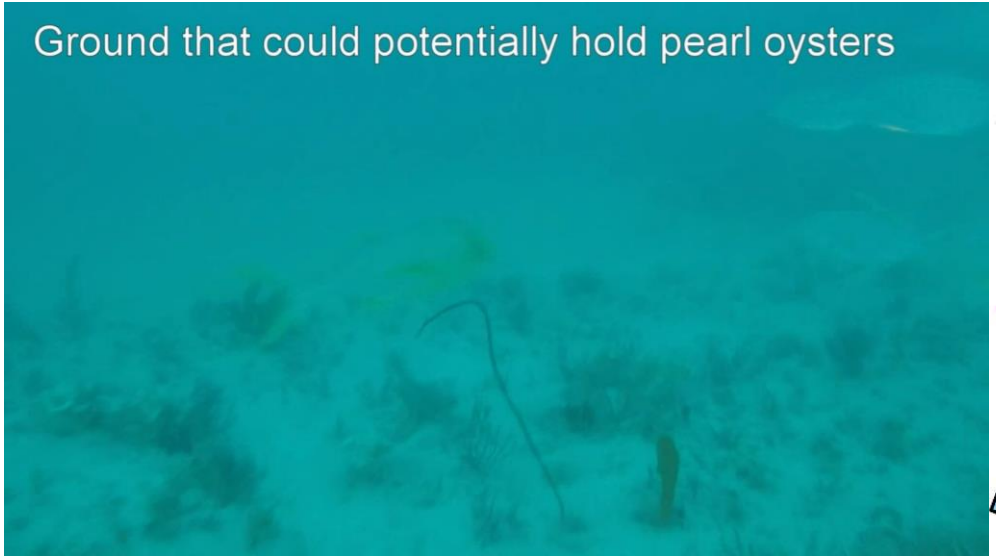
R2Sonic Multi-beam:
100, 200, 400 kHz

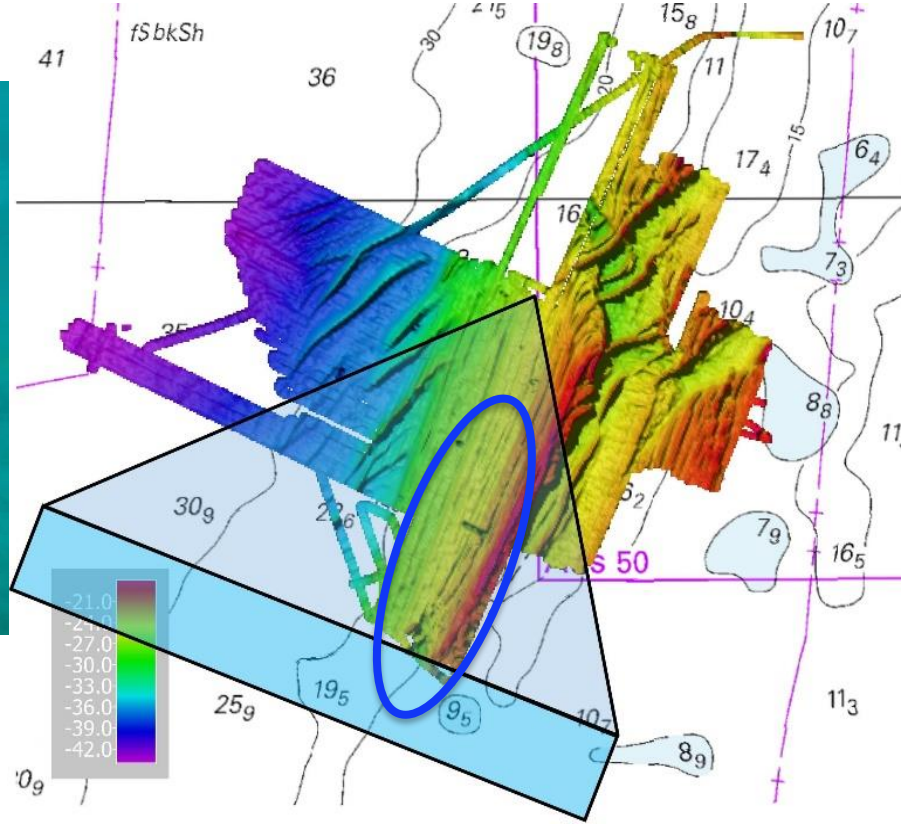
400 kHz – grain size
100 kHz – thickness of sediment layer

Best Ground: Yellow/red areas?

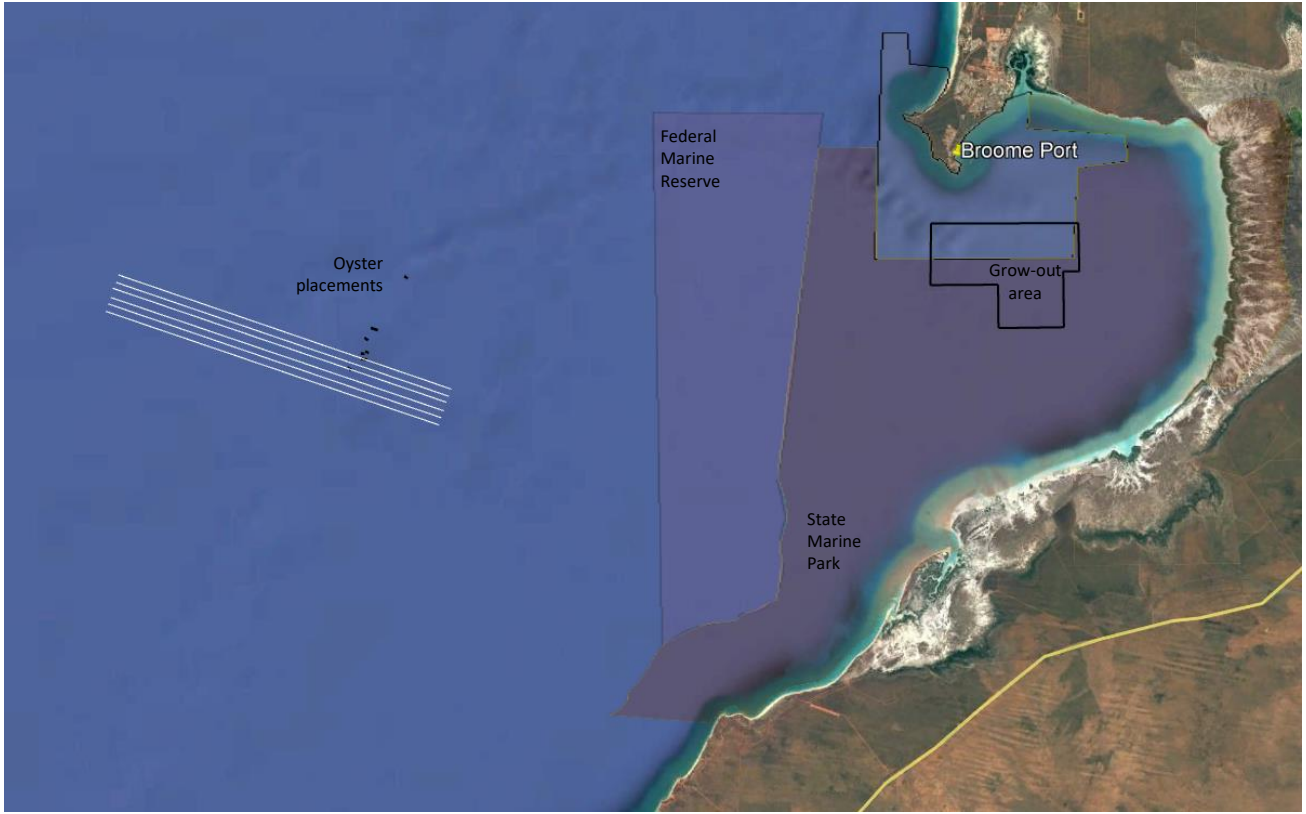
Backscatter Map: Parnum, Curtin University

Pearl Oyster Site Mapping (April)

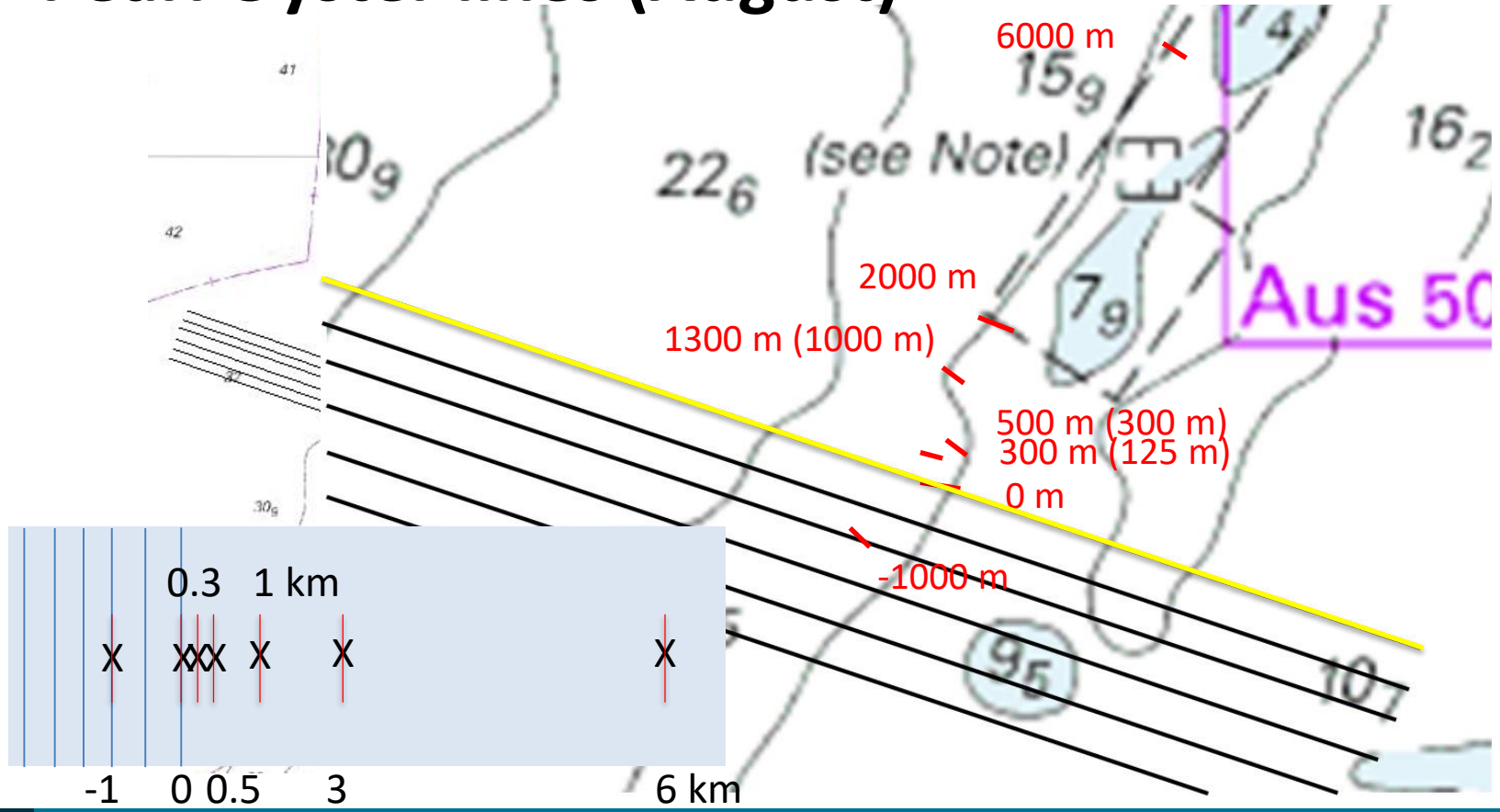




Final Location (July)



Pearl Oyster lines (August)



During the Seismic Survey Exposure: Ten days

Pearl Oyster: 16th-20th September, 2018
Fish: 21st-25th September, 2018

During seismic exposure survey: Pearl oysters

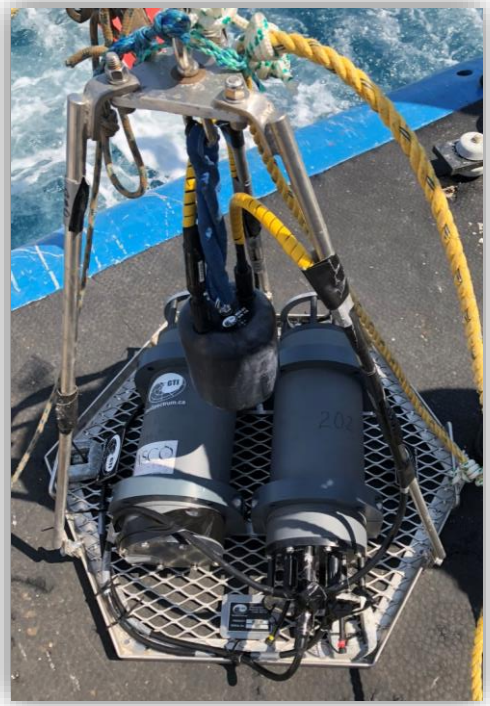
No. pearl oysters in study:	10,880	(1360 panels of 8 oysters)
No. pearl oyster lines:	7	(120 or 336 panels of 8 oysters each line)
No. exposure retrievals:	5	(1 set per day)
Controls:	Vessel control, Transport control, Farm control	
No. tags to monitor panels:	2407	
Sampling Periods:	5	(4 laboratory and 1 grow-out)
No. laboratory tested oysters:	1850	
No. Grow-out oysters:	7000	(7920 less oysters for grafting)

Paspaley: Deploying, retrieving, transferring pearl oysters (Dave Mills)
Facilitating the tagging of oyster panels (Mark Chinkin and Pippa Wilson)
Four vessels (two dive teams, one retrieval/tagging vessel, one accommodation)
One vessel (seeding)
Farm and laboratory facilities

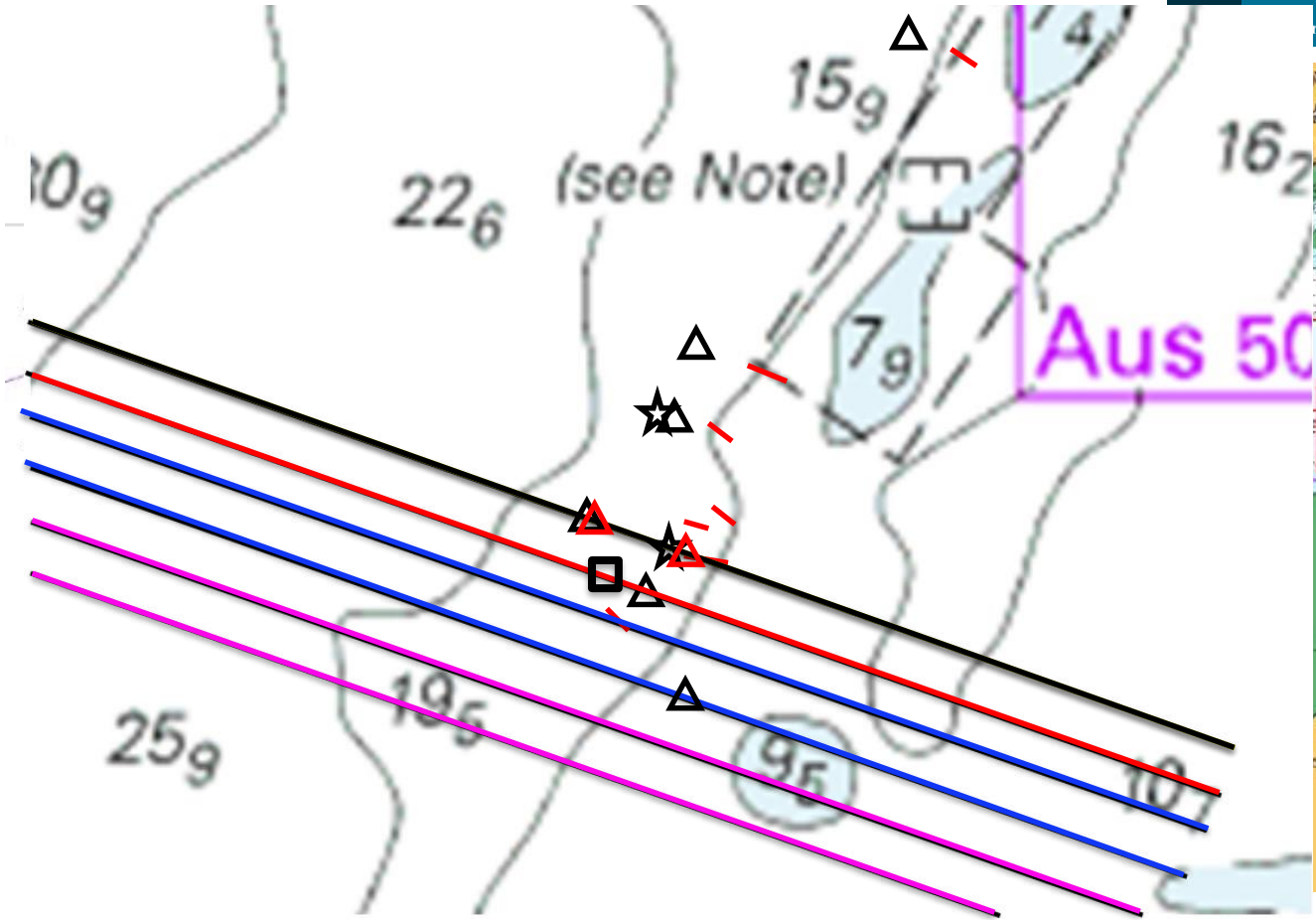
Laboratory work

Passive acoustic monitoring

- Pressure
- Particle velocity
- Ground motion



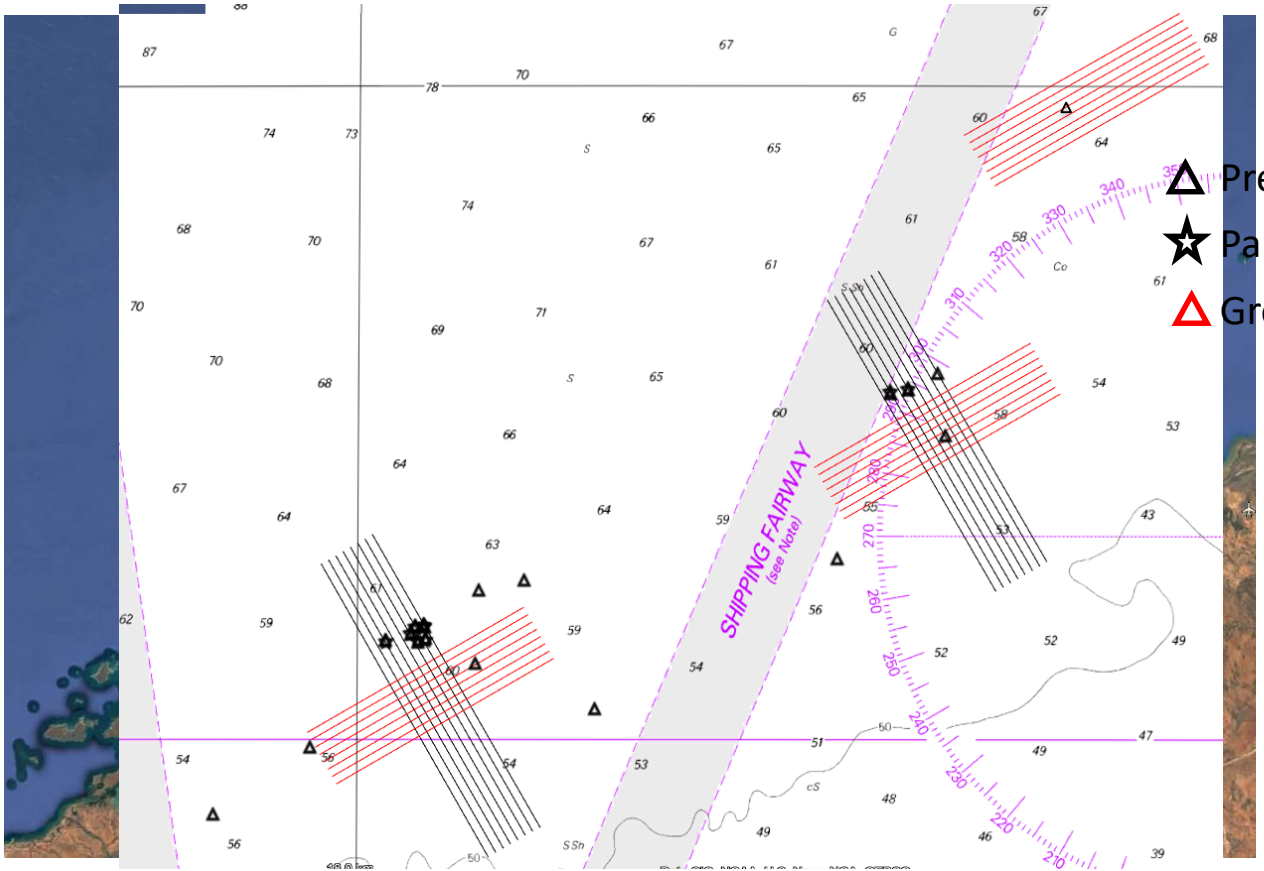

PINCH POINT
TOWNSVILLE



Pressure

Particle velocity

Ground motion

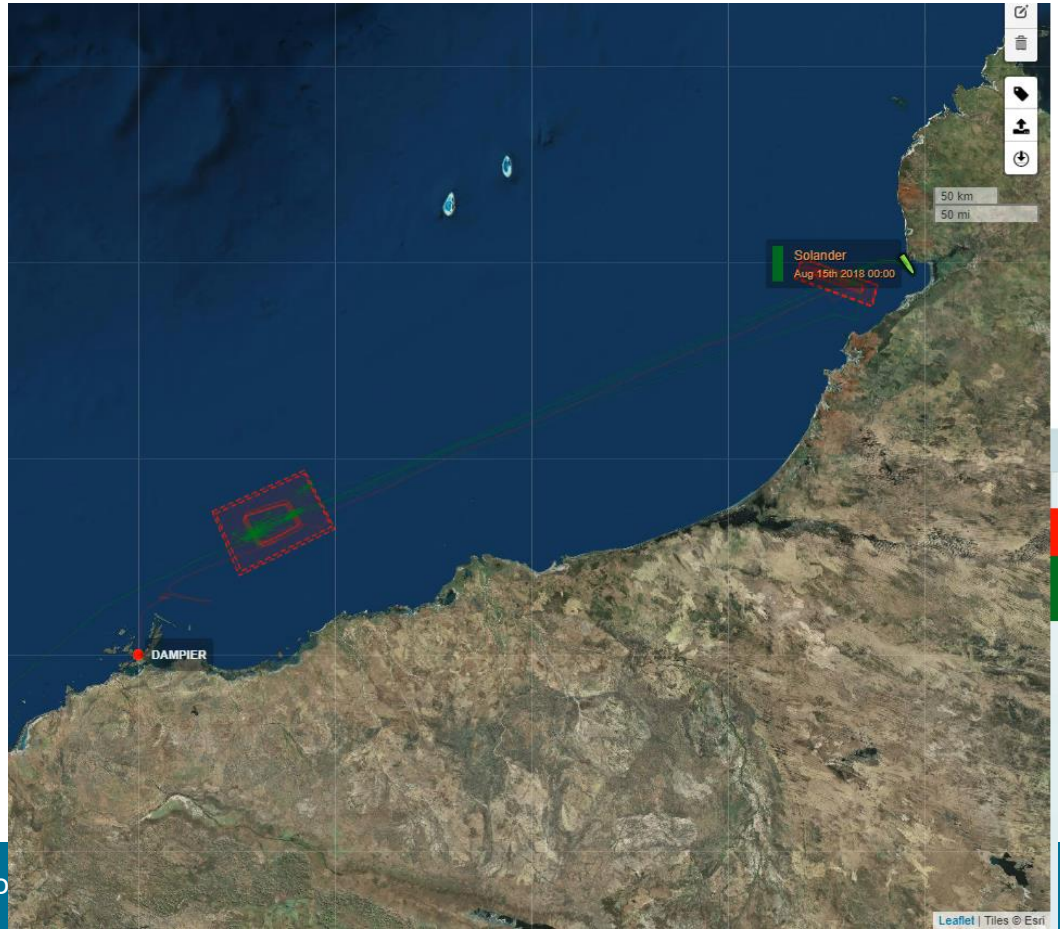

SHIPPING FAIRWAY
(see Note)
Pressure
Particle velocity
Ground motion

Data summary: Fish and oyster sampling

Method	Information gathered
Seismic	Ten days of operation completed on time, including 14 active lines across two sites
Passive acoustic sensing	>130 datasets of passes from the seismic vessel (including active and inactive air-gun operations) across the two sites
	> 100,000 air-gun shot recordings at discernible signal-to-noise level
Acoustic tagging	387 fish tagged and tracking data recovered for ≈6 months from 98 acoustic receivers
BRUVS	584
Echosounder (fish)	Transects conducted at HE and VC sites before and after exposure
Sediment sampling	Grab samples collected for 15 sites before and after exposure across HE and VC
Oysters	10,880 oysters either exposed (seismic and/or vessel only) or at a control site
Laboratory sampling	Three sampling trips completed, testing 1130 pearl oysters (720 remain)
Commercial audit	On-going monitoring of 7000 oysters
Audit after two years	Pending

Project Planning and Execution

The seismic source exposure



Thank you