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# North West Shoals to Shore Research Program

## Measurements of acoustic pressure, particle motion and ground motion

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AIMS: Australia's tropical marine research agency.

# Passive acoustic monitoring (PAM) : Overview

- Acoustic Metrics
- Sensors
- Deployments:
  - Fish
  - Pearl oyster
- Exposure measurements
  - Sound Exposure Levels (example for evaluating seismic signals)
  - Saturation
  - Received power spectral density (received levels across the sampled frequencies) for a sail line
  - Array characteristics
- Propagation losses
- Relationships between acoustic metrics
- Take home messages

Thanks to the *Solander* crew


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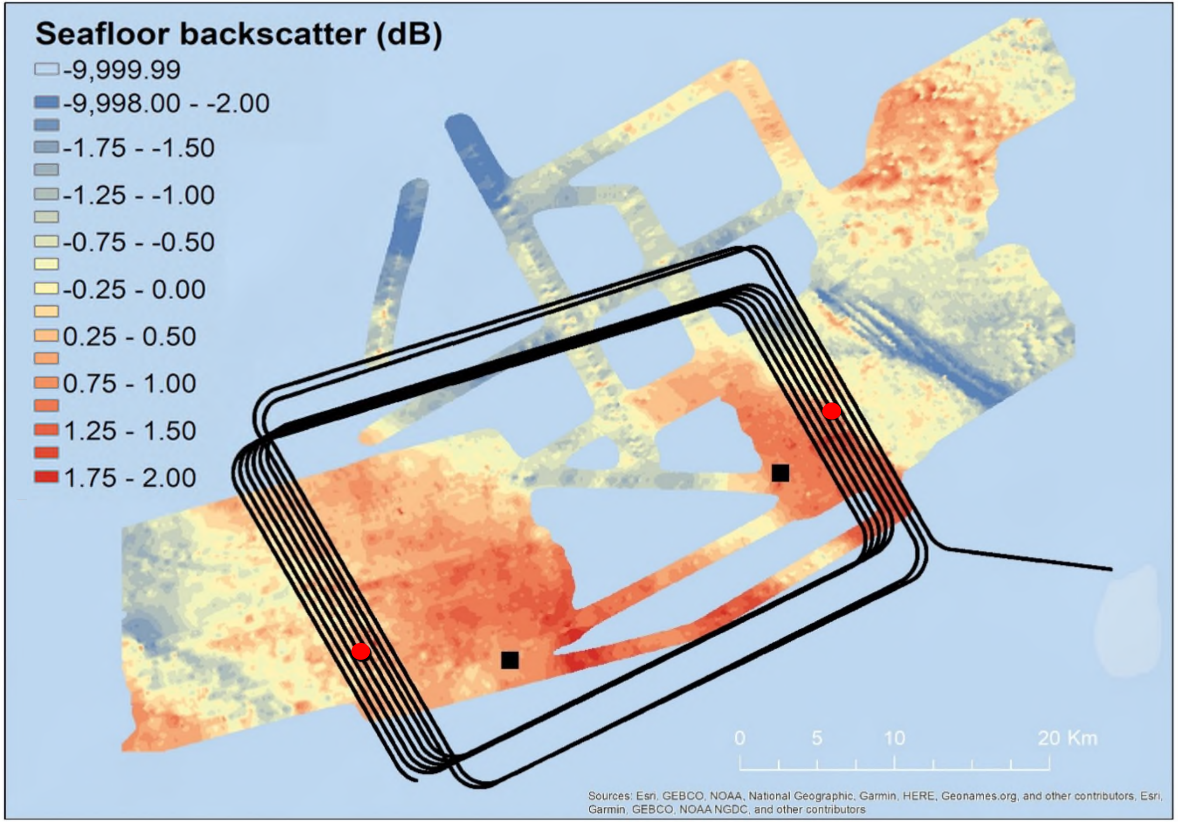
# Passive acoustic monitoring (PAM): Acoustic metrics

- Why different metrics?
  - Different fauna are receptive to different components of the signal
  - Pressure, particle motion, ground motion
  - Which component and which characteristic do we use?
- Pressure (e.g. mammals)
  - Sound pressure levels
  - Cumulative sound exposure levels
  - Peak pressure gradient
  - Sound exposure levels
  - Peak-to-peak pressure
- Particle motion (e.g. fish)
  - Displacement/velocity/acceleration/jerk
  - Individual vectors/overall magnitude
- Ground motion (e.g. invertebrates connected to the seafloor)
  - Displacement/velocity/acceleration/jerk
  - Individual vectors/overall magnitude

# Passive acoustic monitoring (PAM): Sensors


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

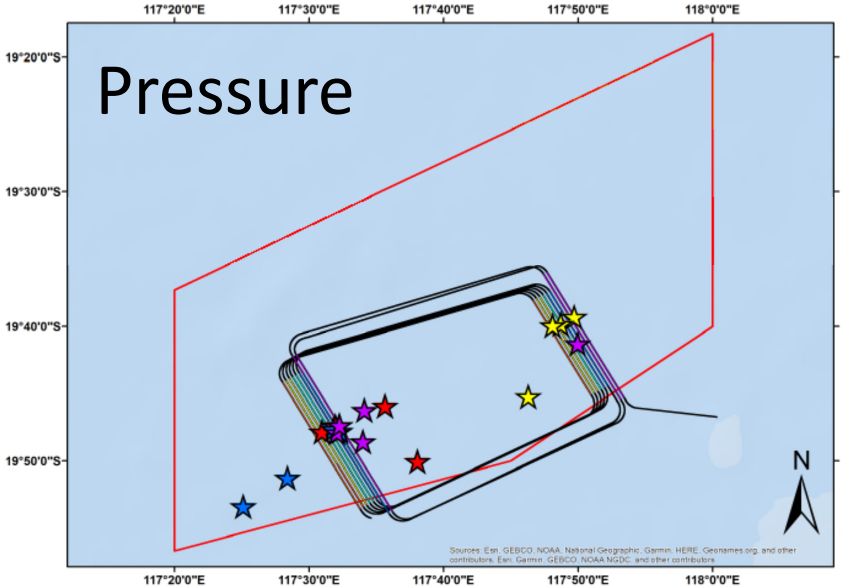
# PAM Fish experiment: Long-term monitoring

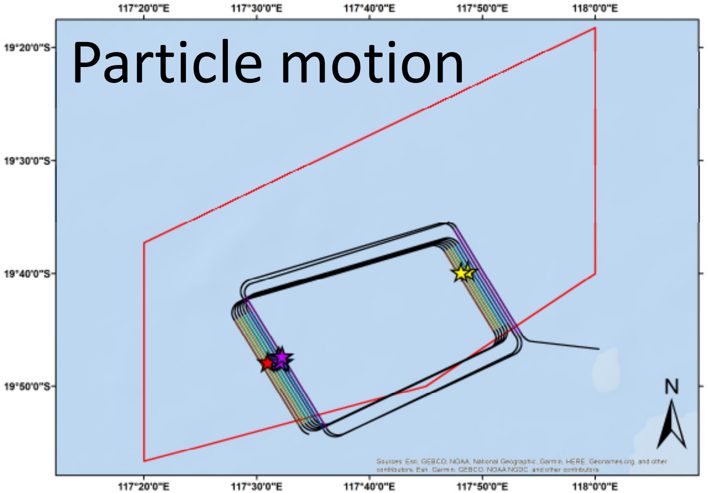


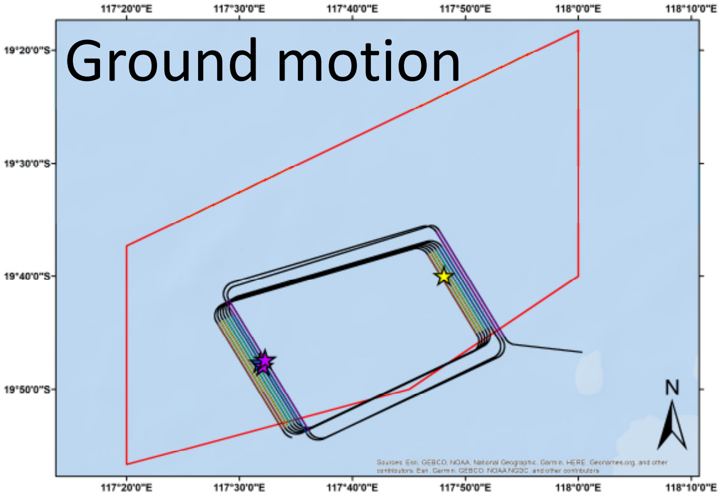

■ First deployment (April-Aug/Sept 2018)

● Second deployment (Aug/Sept 2018-Mar/May 2019)

# PAM Fish experiment: During exposure

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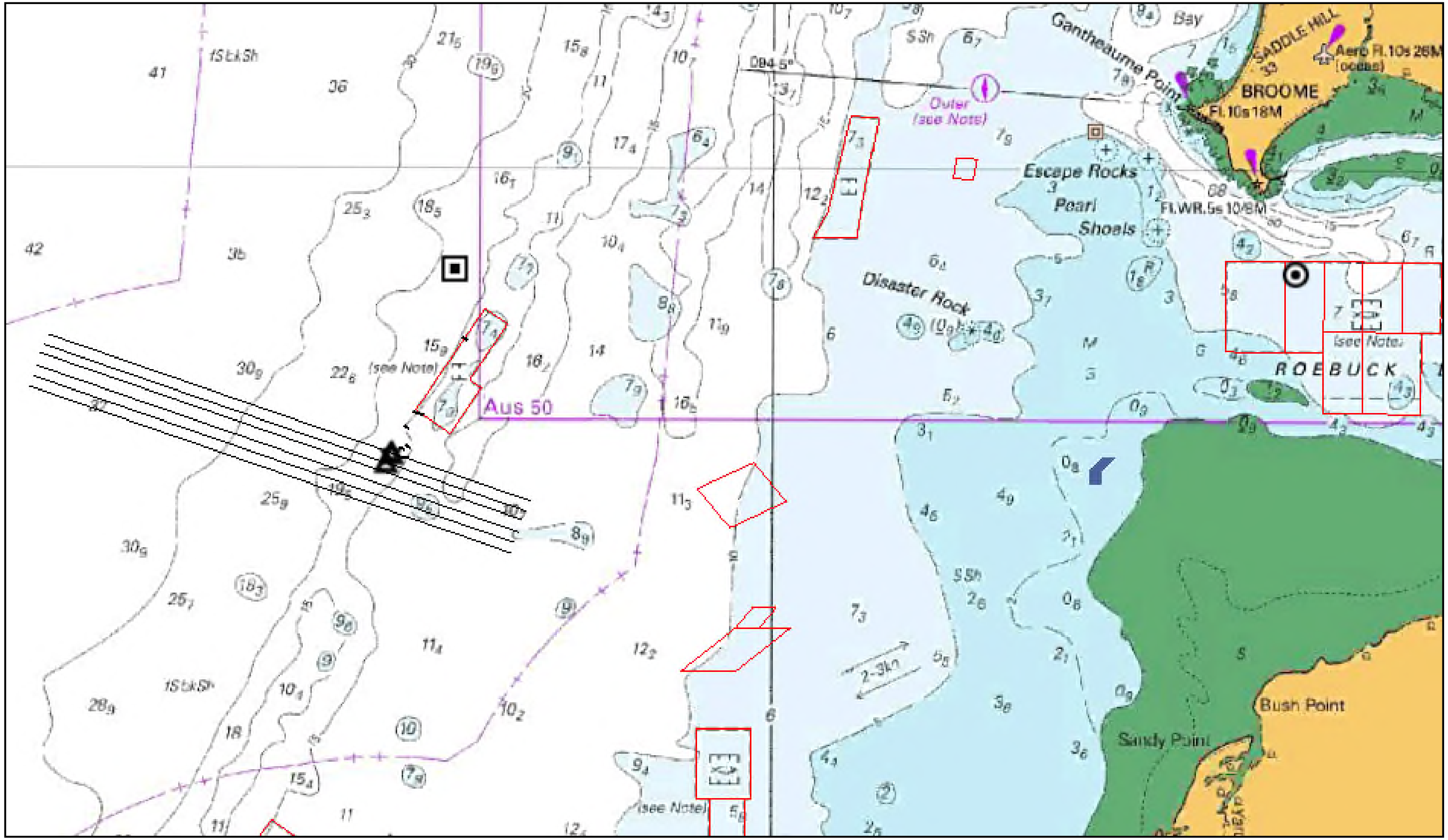
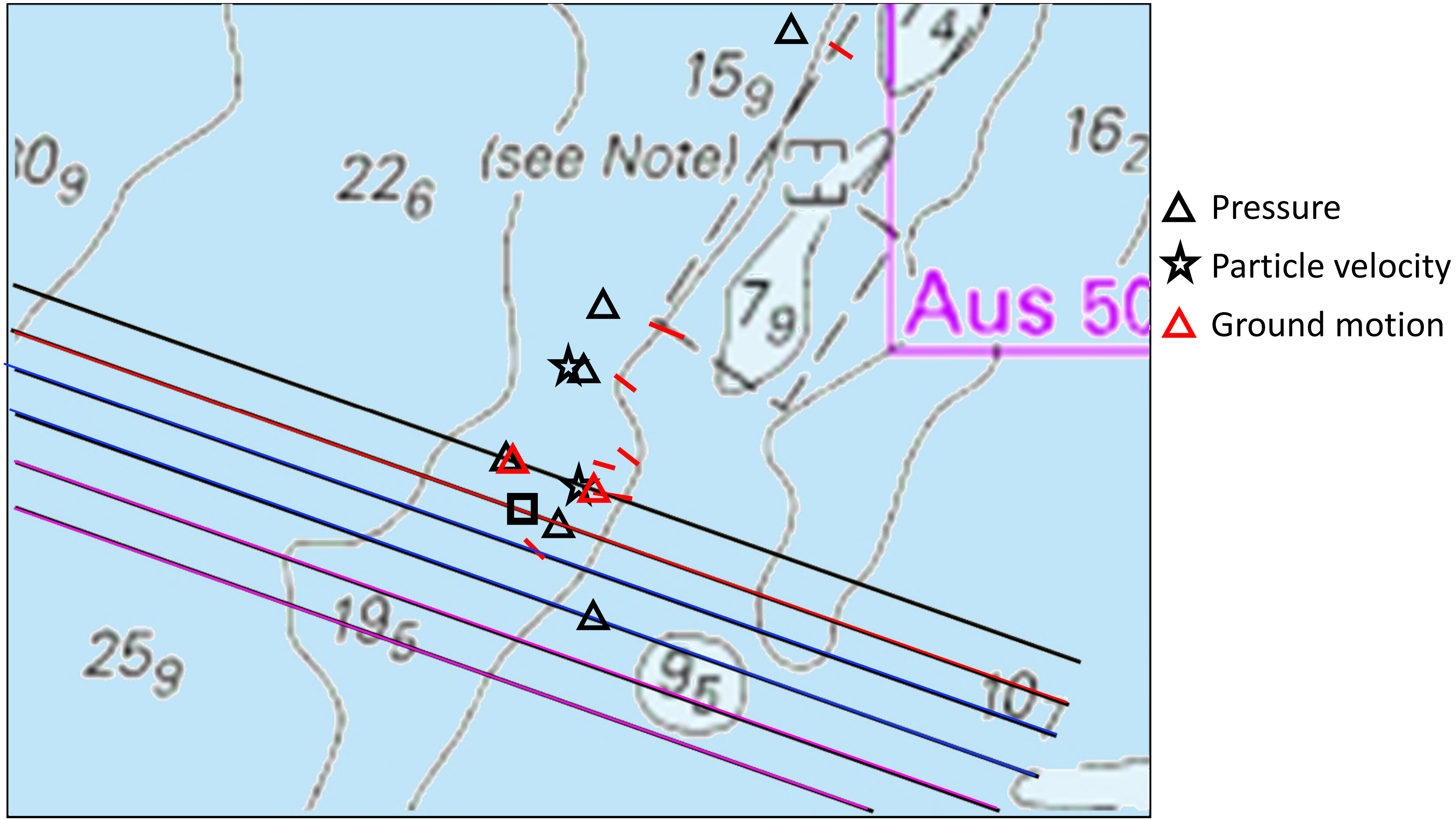
# PAM pearl oyster experiment: Long-term Monitoring

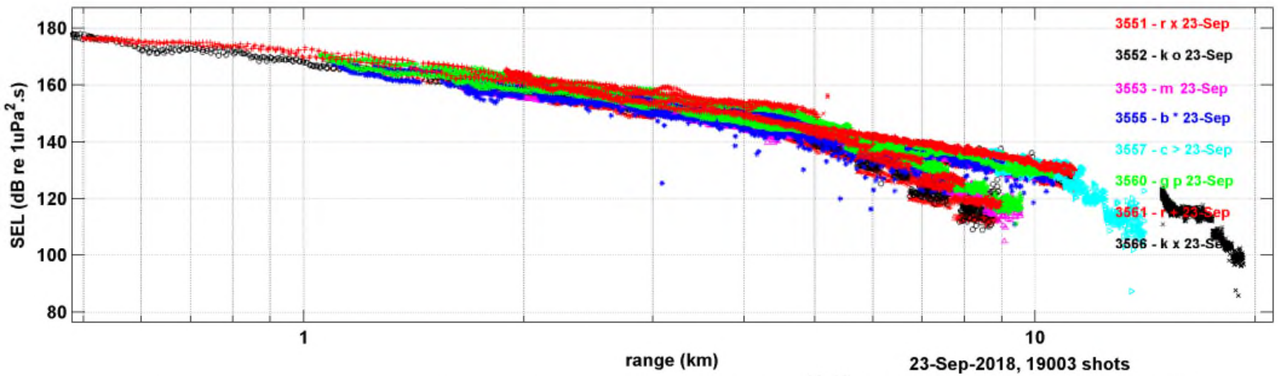


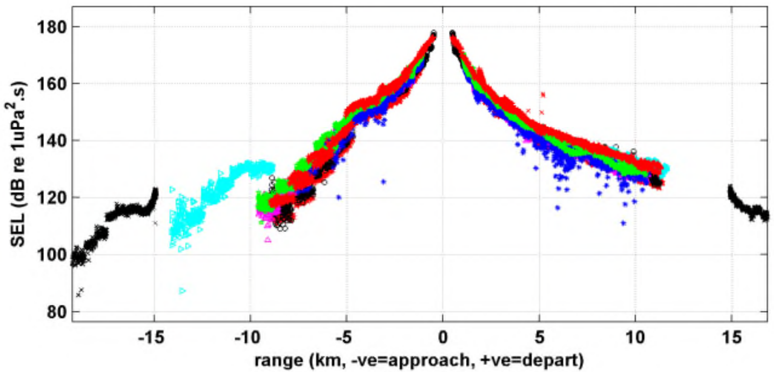
# PAM pearl oyster experiment: During exposure

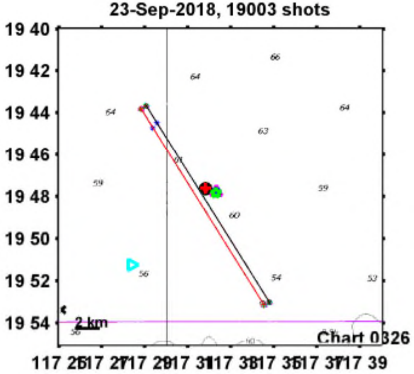


# PAM Fish experiment: Sound Exposure Levels

25-Sep (first sail line) – remarkably uniform – good, allows exposure predictions across fish site




**Saturation/noise floor:**

Three sets instruments

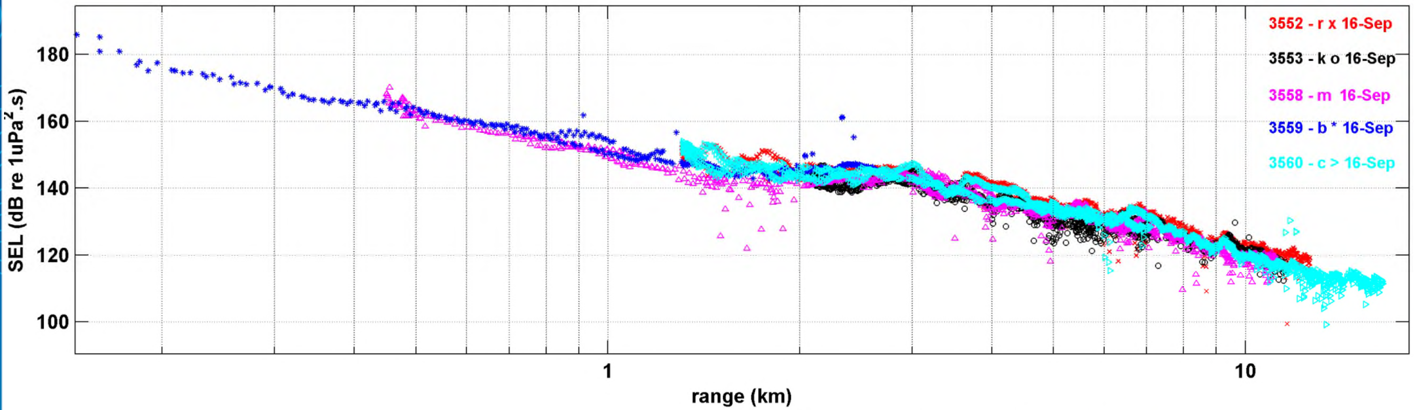
1: < 100 m

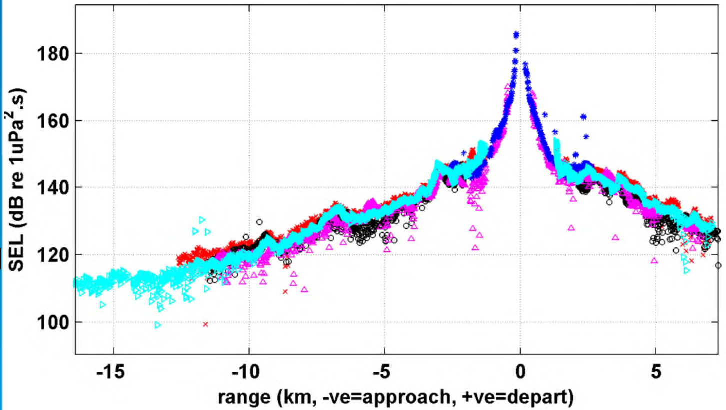
2: 100 m to 1 km

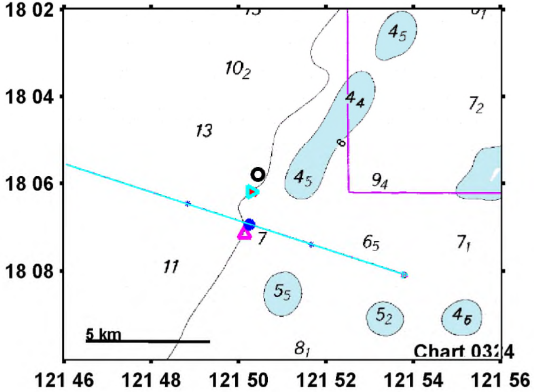
3: > 1 km

- Uniform
- Distribution increases with distance
- Exposure predictions each BRUV site

# PAM Pearl oyster experiment: Sound Exposure Levels




- Uniform
- Distribution increases with distance
- Exposure predictions each pearl oyster site

# Signal saturation: Ratio of unsaturated to total signals with horizontal range

Particle velocity

Fish

Pearl

Pressure
(pre-amplifier/secondary gain)

-40/0 dB

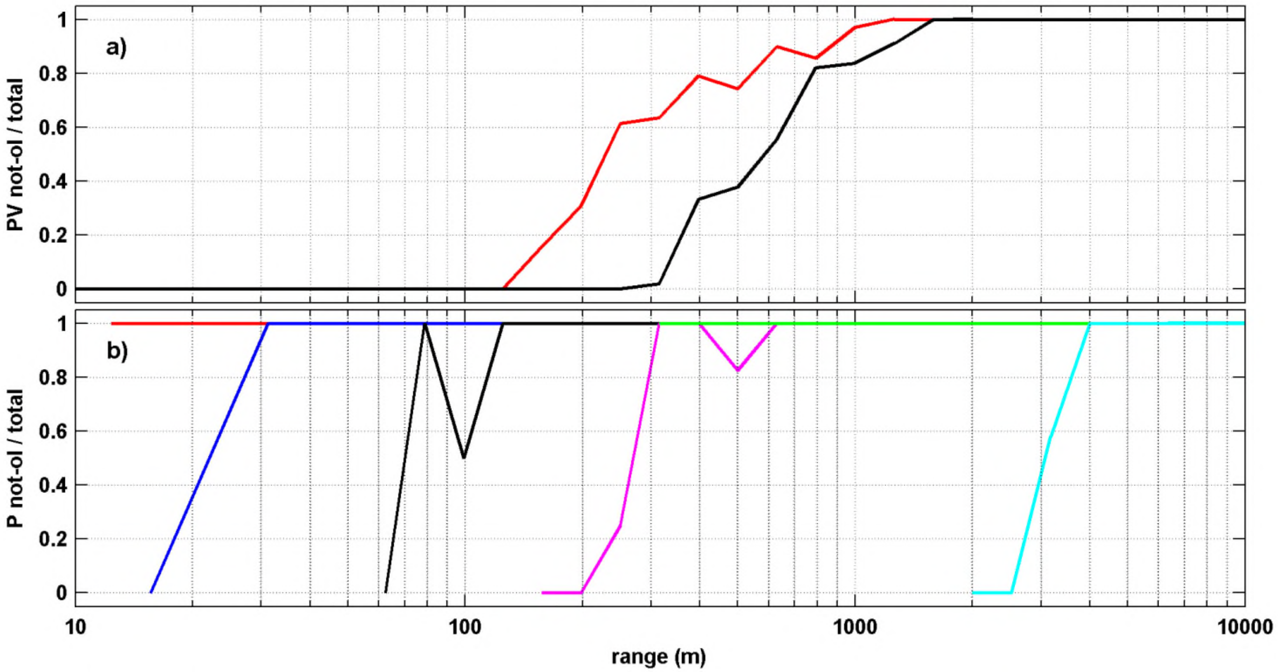
-20/0 dB

0/0 dB

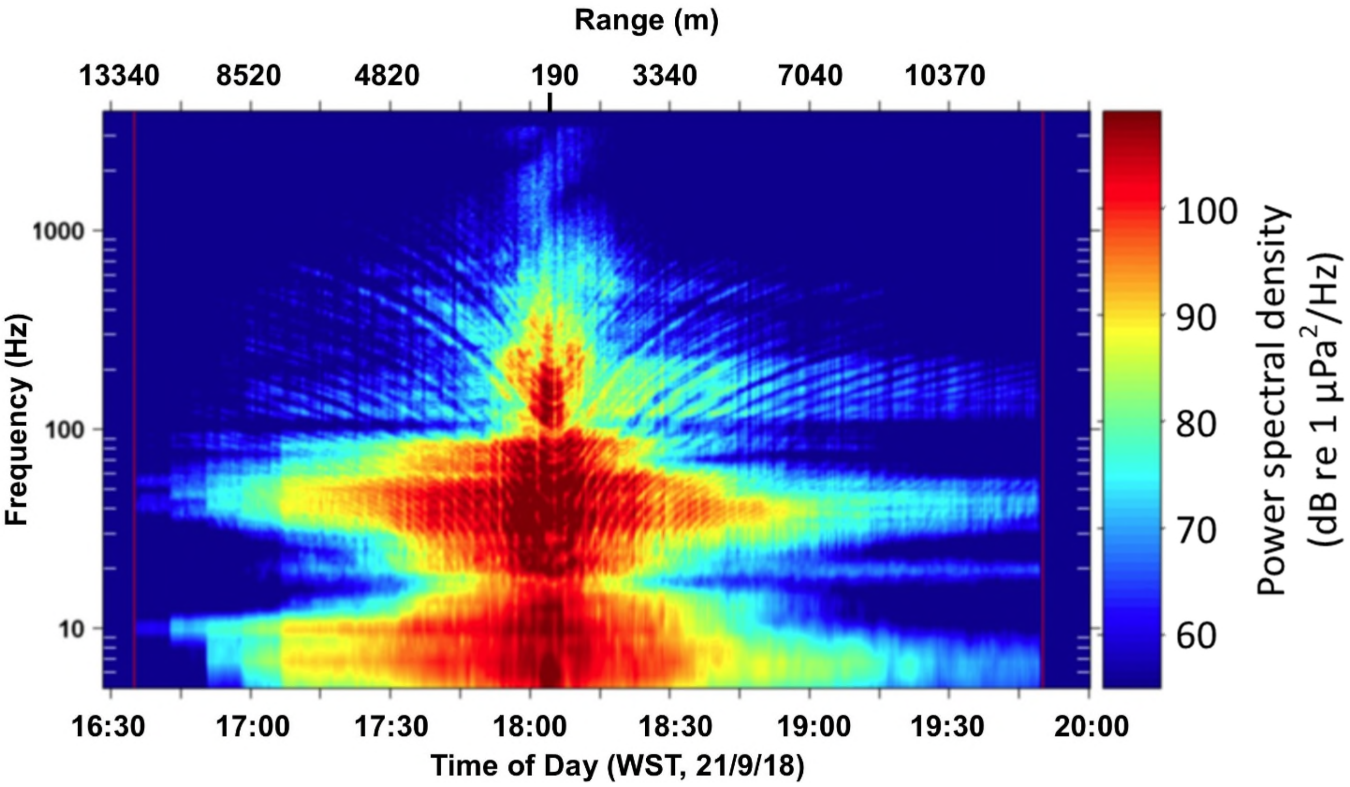
0/20 dB

20/0 dB

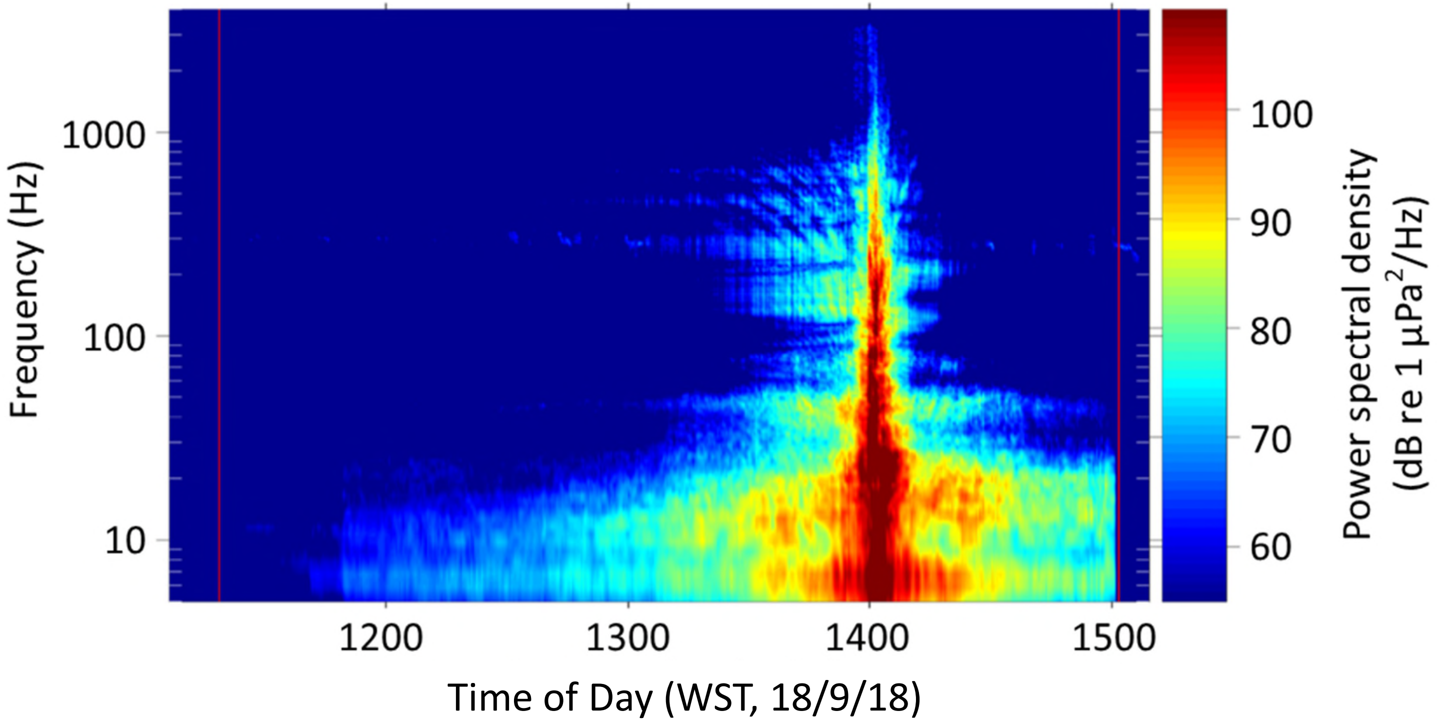
20/20 dB



# Received power spectral density for a single sail line (Fish site)



# Received power spectral density for a single sail line (Pearl oyster site)



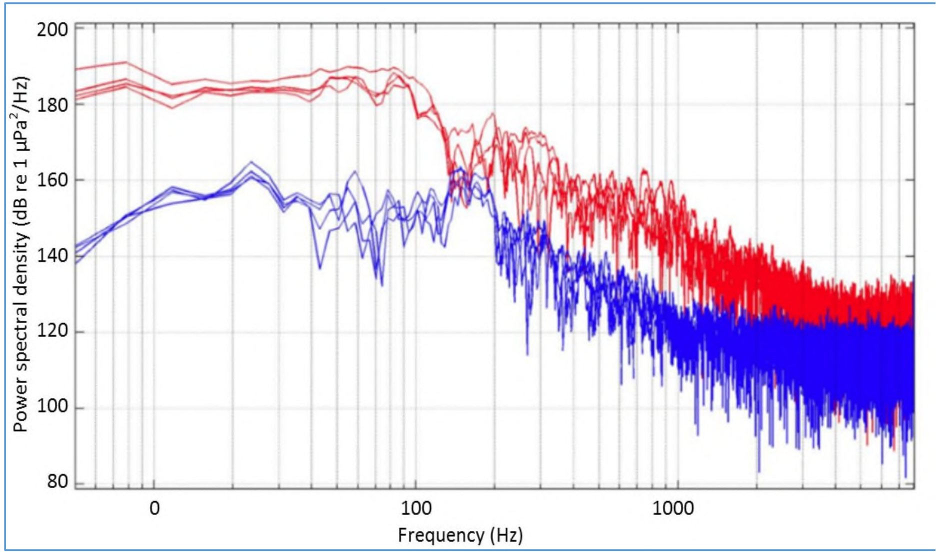
# Air-gun array characteristics

Source modelling predicted an effective source level directly below the array of:

- 247 dB re 1µPa Peak-peak
- 228 dB re 1µPa$^2$·s Sound Exposure Level
- 231 dB re 1µPa Sound Pressure Level

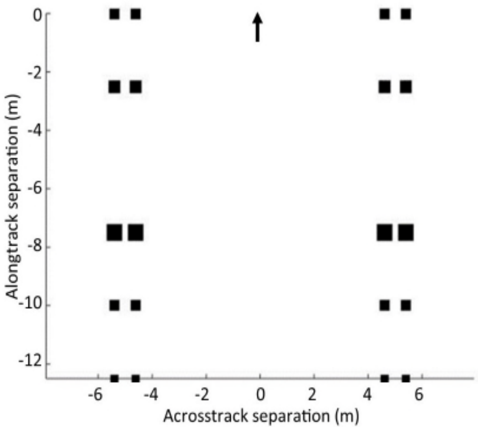
Power spectral density:

- Most energy occurred below 100 Hz
- Almost all below 1 kHz,
- Small notch between 100 and 200 Hz




0 m horizontal range (~50 m slant range)
190 m horizontal range (~200 m slant range)

# Modelled air-gun array signature




100 cui

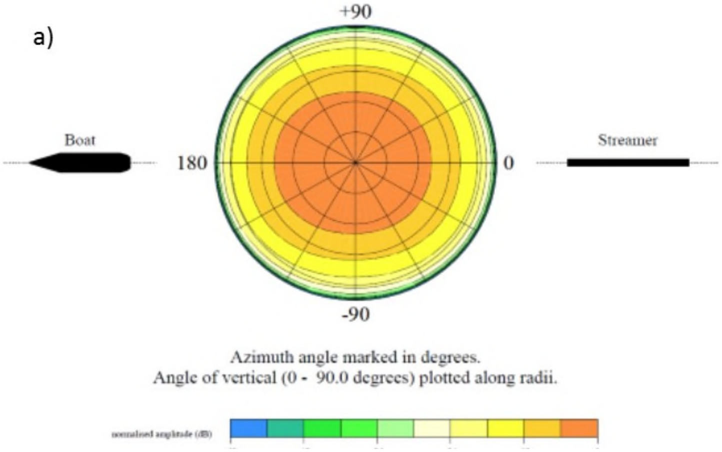
150 cui

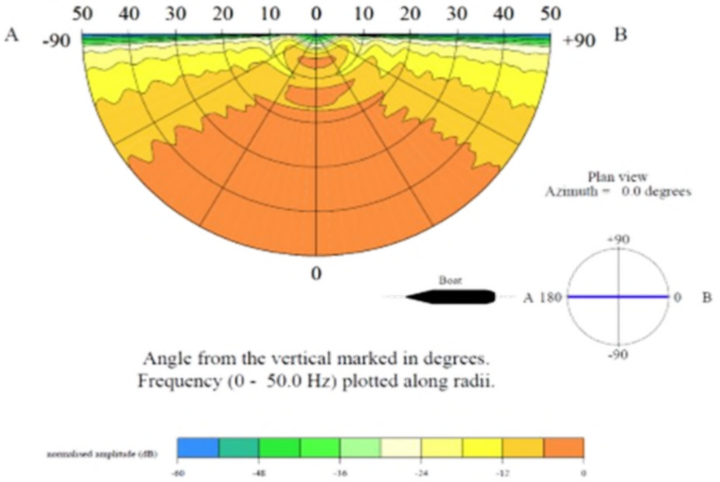
250 cui

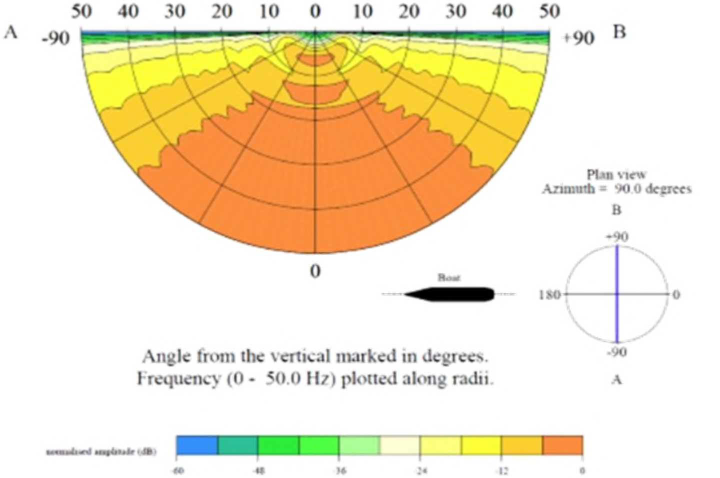
90 cui

60 cui

a)



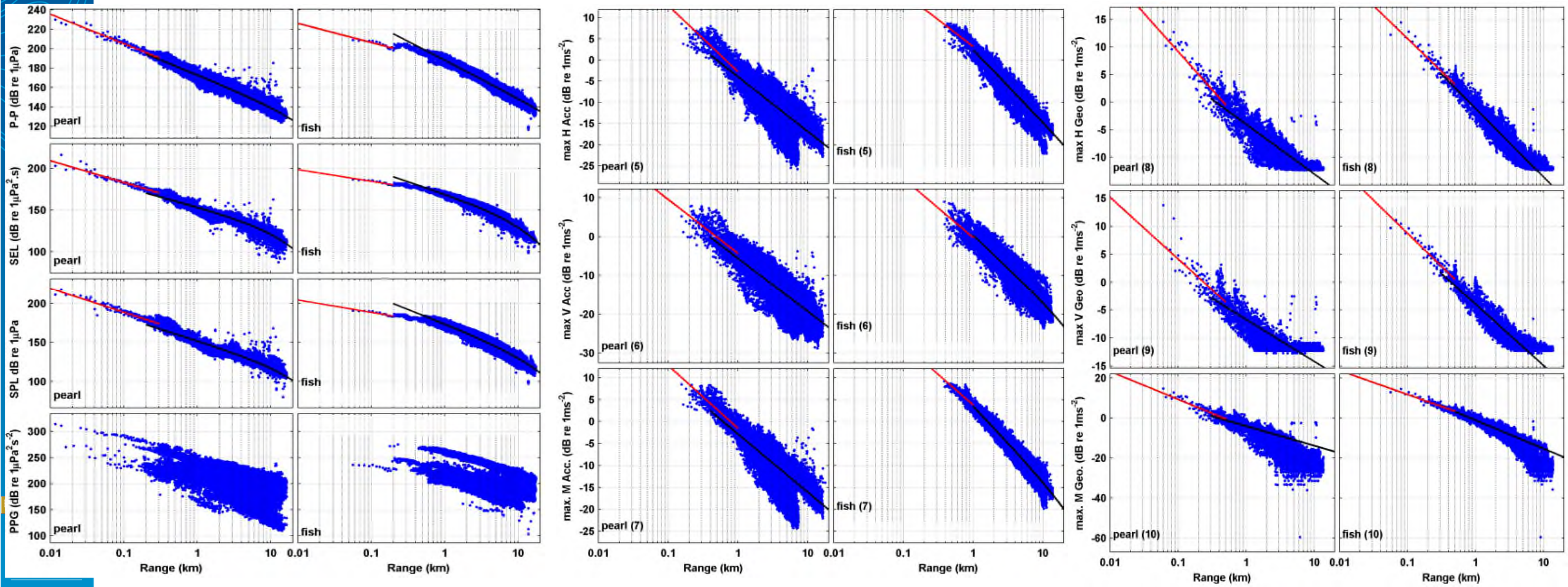



# Propagation losses: Regression models

Pressure

Particle motion

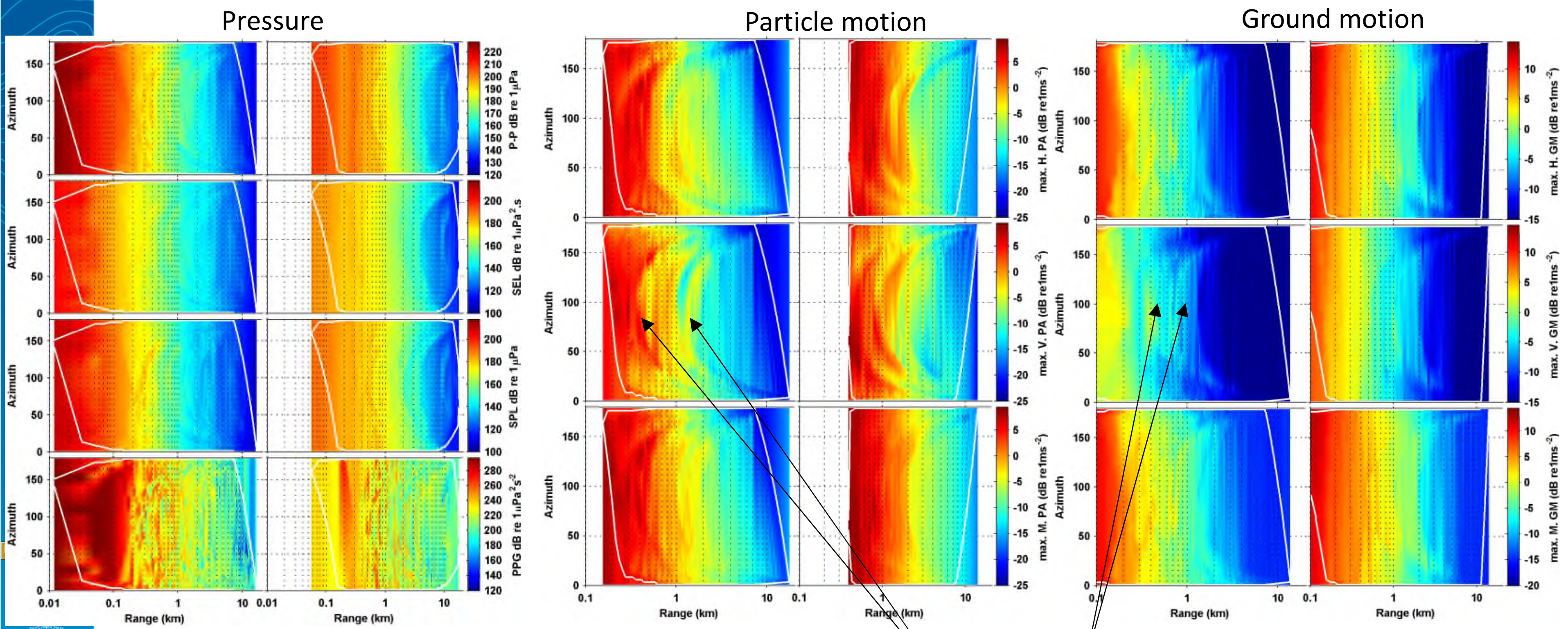
Ground motion




Short-range models

Long-range models

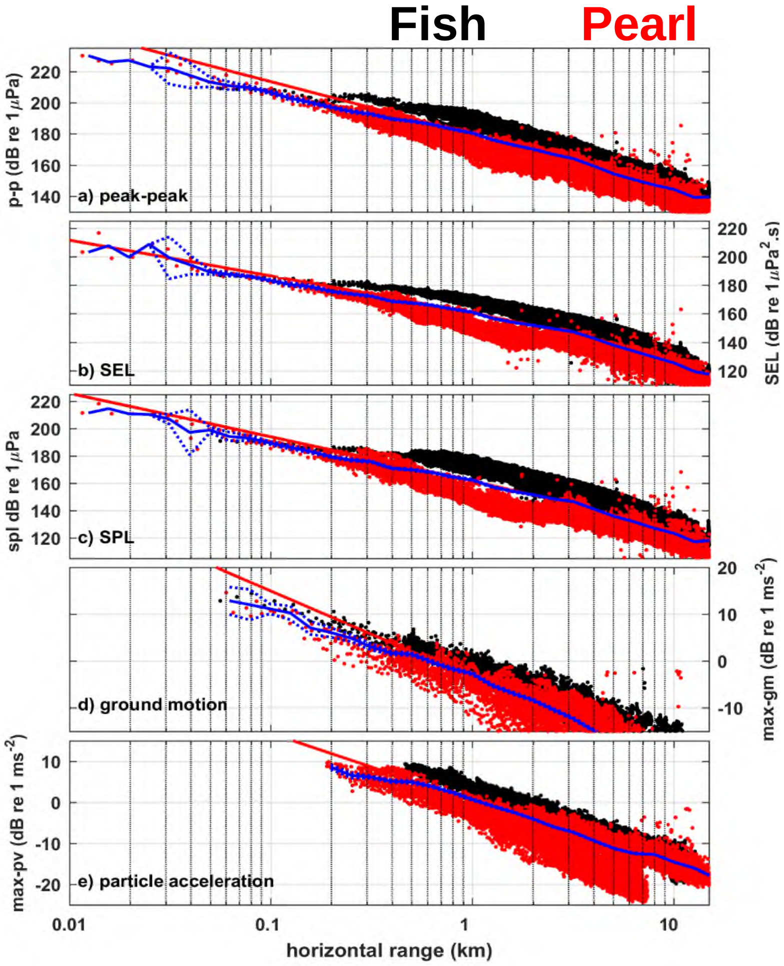
# Propagation losses: Ground motion

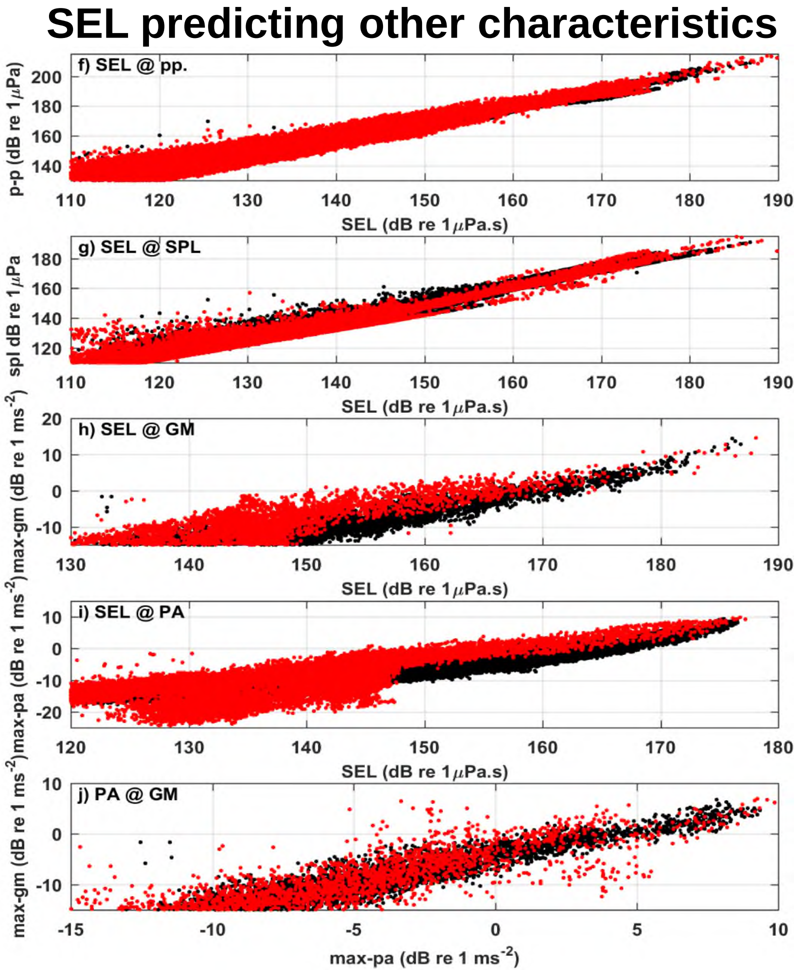



Little to no directionality in the array signal

Sampling artefact

# Relationships between pressure/particle motion/ground motion metrics



# Conclusions

- Effective source level - similar to other seismic surveys for the same conditions (water depth)
- Propagation losses greater than elsewhere around Australia, but likely typical of NW Shelf
- Pressure, particle velocity and ground motion highly correlated (linear relationship) in far-field
- Pressure and ground motion highly correlated (linear relationship) at close ranges (down to ~50 m range)
- Signal saturation of the majority of particle velocity measurements below 500 m means this relationship requires further exploration in the near-field
- Sound exposure level is a good proxy for all tested exposure metrics in the far-field, but requires further data to confirm its ability to predict particle motion in the near-field and transition zone between near- and far-fields

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