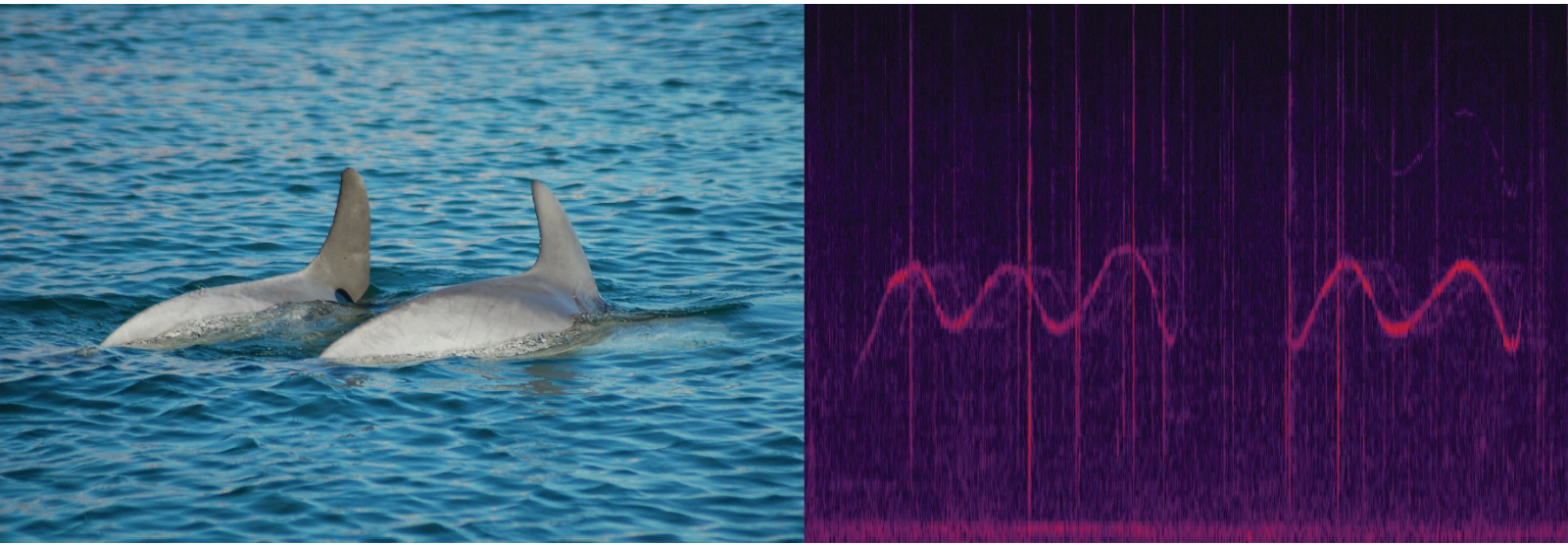
Acoustic habitats and behavioural responses of bottlenose dolphins in Western Australia



Sarah Marley, Chandra Salgado Kent,
Christine Erbe, Iain Parnum and Miles Parsons

Underwater Sound and Marine Mammals

Ocean is full of underwater sound:

- Abiotic (e.g. wind, waves, currents)
- Biological (e.g. crustaceans, fish, marine mammals)
- Anthropogenic (e.g. vessels, seismic, dredging)

As human activities expand across the marine environment, anthropogenic noise is increasing

- Vessel traffic is most widespread source of man-made ocean noise
- This alters the acoustic environment of marine habitats

Underwater Sound and Marine Mammals

Marine mammals, particularly cetaceans, have extreme acoustic specialisations

- Use acoustics to engage in vital processes
- This makes cetaceans susceptible to the impacts of anthropogenic noise
- Responses include:
  - Tolerance
  - Changes in Behaviour
  - Avoidance Reactions
  - Masking
  - Hearing Impairment
  - Physiological Effects
  - Mortality

The Problem…

Growing awareness of acoustic habitats and influence of anthropogenic noise.

May adversely affect many species – particularly those which are acoustically specialised.

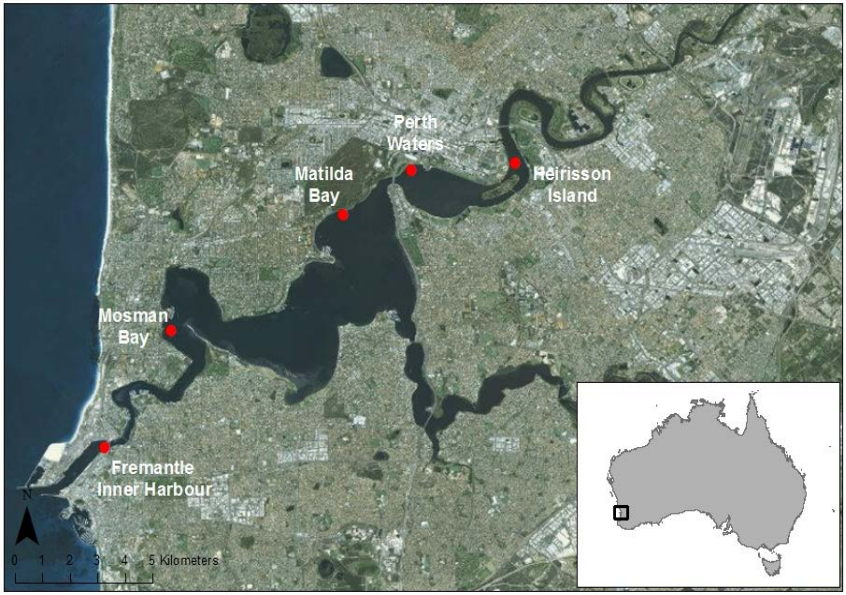
Need baseline information to characterise dolphin acoustic habitats.

Also need to understand how dolphins respond to anthropogenic activities and associated noise in these habitats.

Aims

1) Identify prominent anthropogenic sound sources
2) Describe spatio-temporal patterns in dolphin soundscape
3) Investigate dolphin responses to human activities/noise

- Swan River
- Estuarine system
- Urban
  - > 1.4 million people
  - > 55,000 rec boats
- Resident dolphin community



Methods

Combination of acoustic and visual monitoring.

- Autonomous underwater acoustic recorders
- Deployed at six sites
- Analysed via:
  - Weekly spectrograms
  - PSD percentile plots
  - Octave-band levels
  - Broadband noise levels
  - GAMs and GEEs

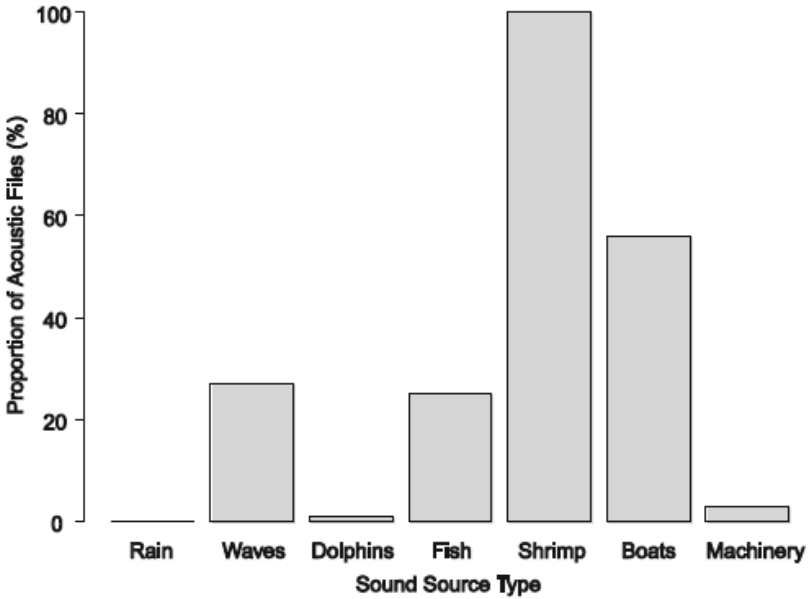
Methods

Combination of acoustic and visual monitoring.

- Land-based theodolite tracking
- Used at two acoustic sites with help from > 60 undergraduate volunteers
- Analysed via:
  - GAMs
  - Markov Chains

Results

Swan River Soundscape

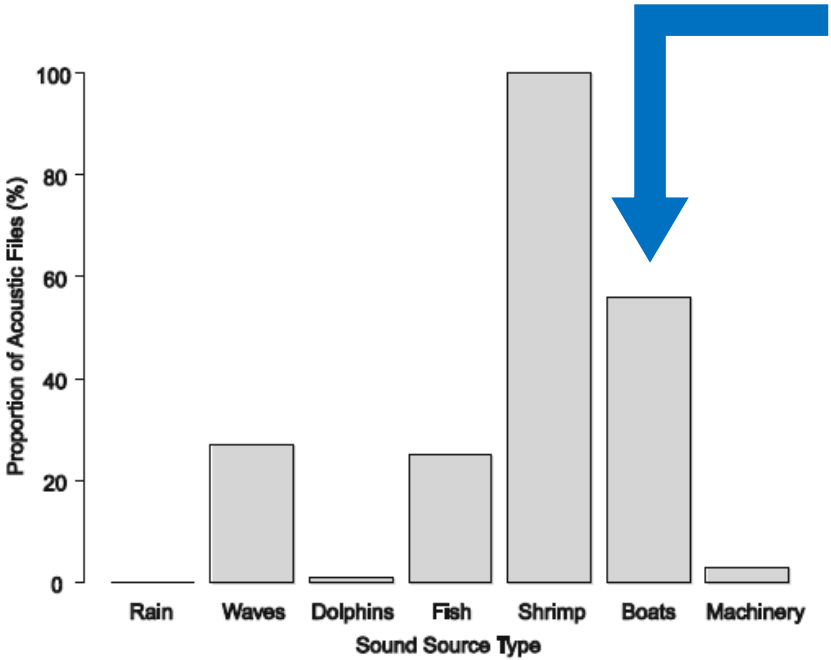


Range of sound sources:

- Abiotic: Rain, waves, tidal movements
- Biological: Snapping shrimp, fish, dolphins
- Anthropogenic: Vessel traffic, bridge/road traffic, pile-driving, machinery, on-shore construction

Results

Swan River Soundscape



52% of hourly recordings contained vessel traffic

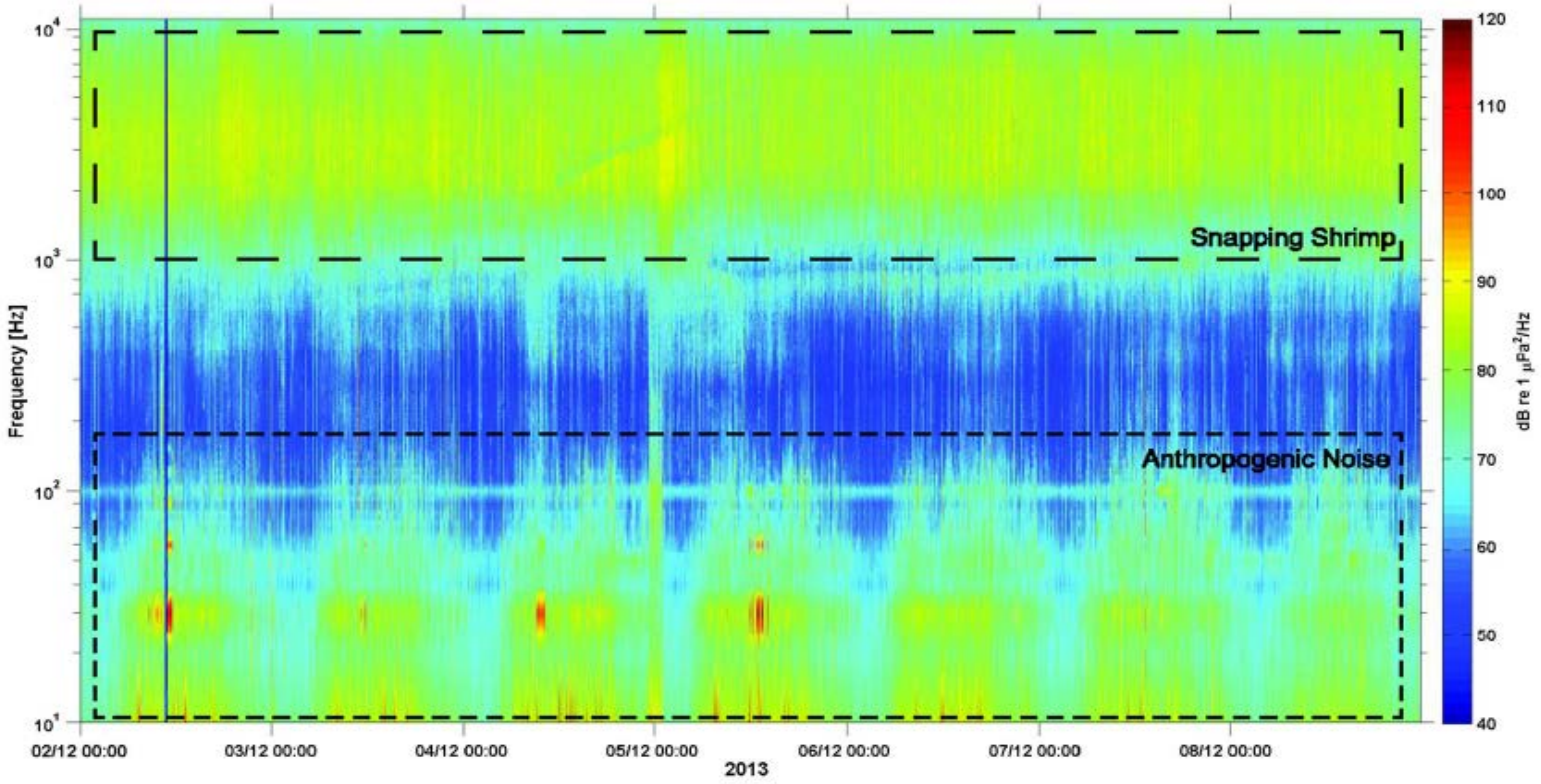
"*rush hour*" vessel traffic in early AM / late PM

vessel traffic busiest on weekends vs weekdays

vessel traffic higher during summer holidays

Results

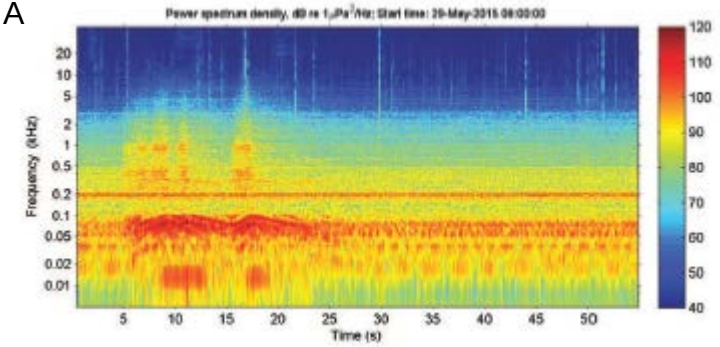
Swan River Soundscape



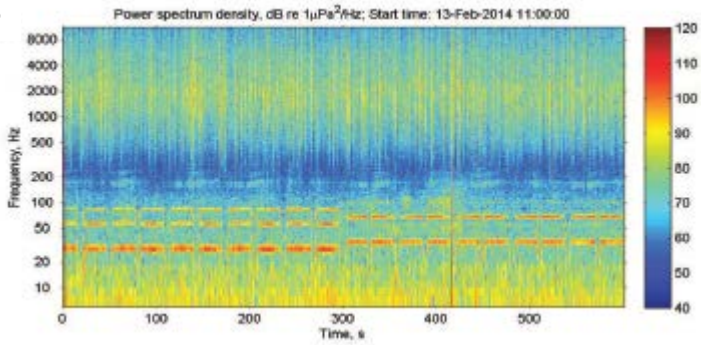
Results

Swan River Soundscape

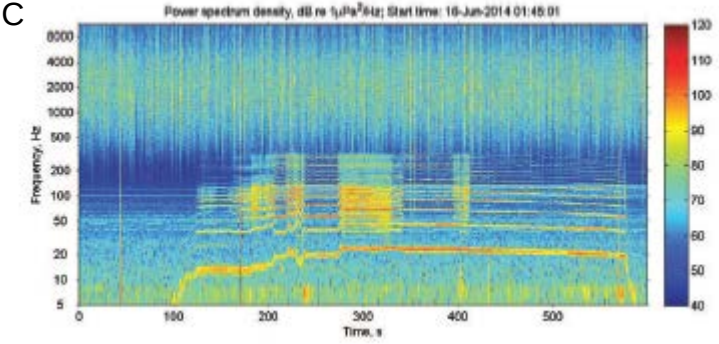
A



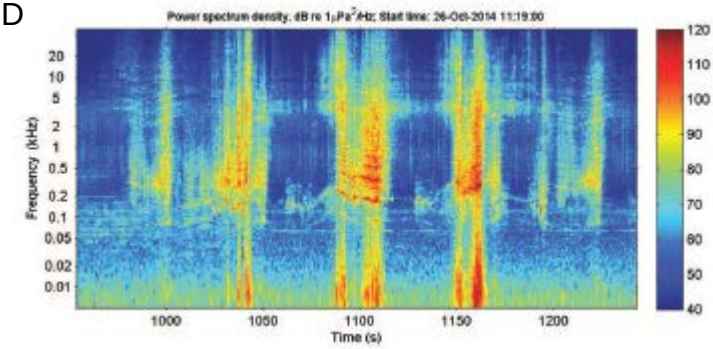
B



C



D

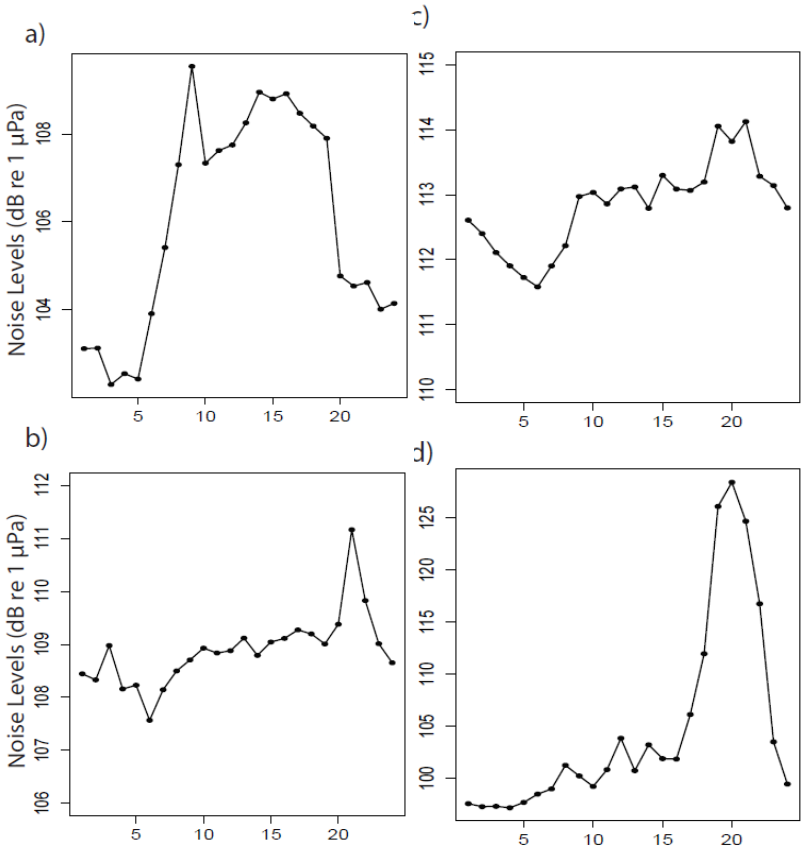


Results

Swan River Soundscape

Spatio-temporal patterns:

- Distinct spatial and temporal patterns within and between sites

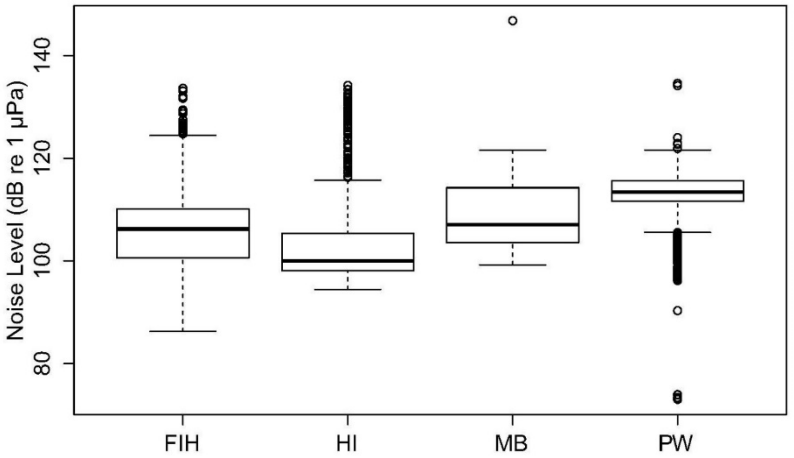


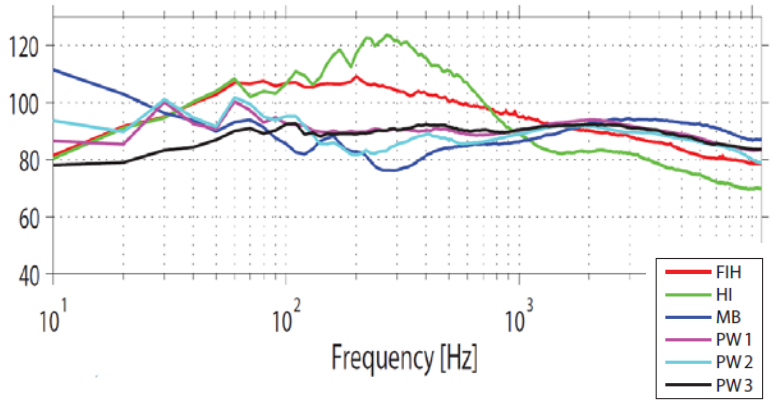
Results

Swan River Soundscape

Spatio-temporal patterns:

- Distinct spatial and temporal patterns within and between sites



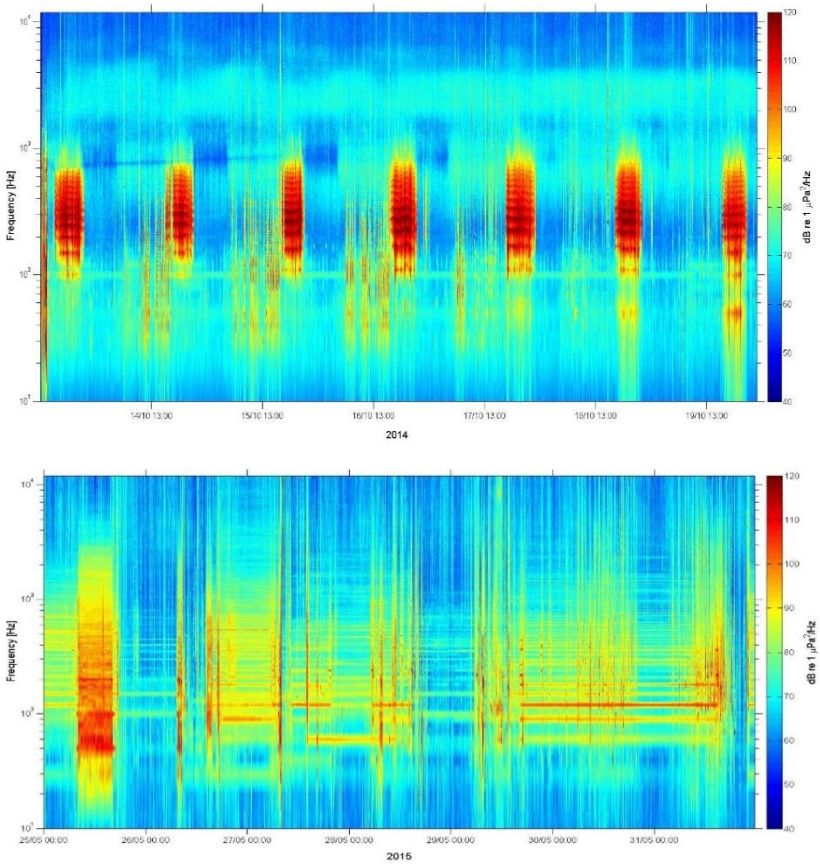


Results

Swan River Soundscape

Spatio-temporal patterns:

- Distinct spatial and temporal patterns within and between sites
- Some sites biologically noisy, other sites noisy anthropogenically

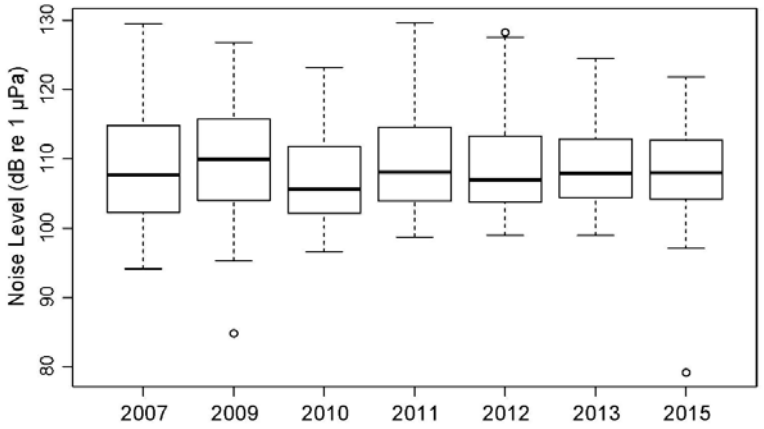


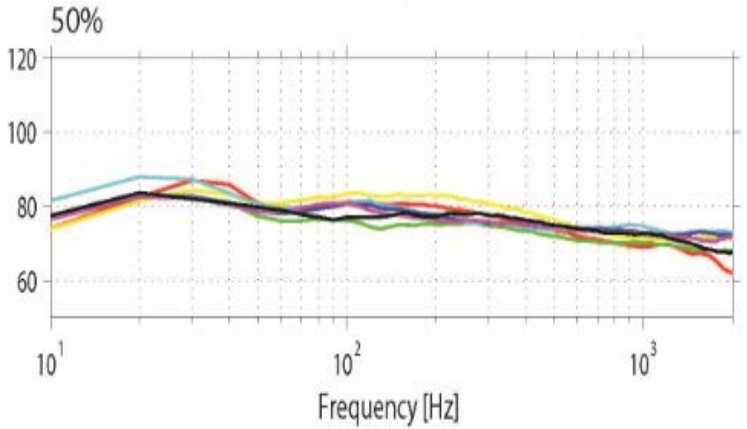
Results

Swan River Soundscape

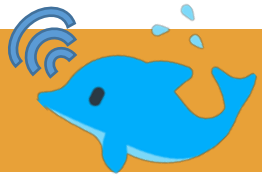
Long-term patterns:

- Data from one site collected yearly from 2007 - 2015
- Some inter-year variation
- No overall increase / decrease in noise levels
- Long-term acoustic stability?





Results



Dolphin Responses

- Fremantle Inner Harbour 'noisiest' site anthropogenically
  - Average 16 vessels per hour
  - Maximum 56 vessels per hour
- Dolphin Occurrence
  - Presence/absence; number of sightings; time spent in area
  - Dolphins continued using area despite it being a busy, noisy environment
- Key foraging site, so perhaps not surprising
- But just because you don't leave the area, doesn't mean you aren't disturbed…

Results

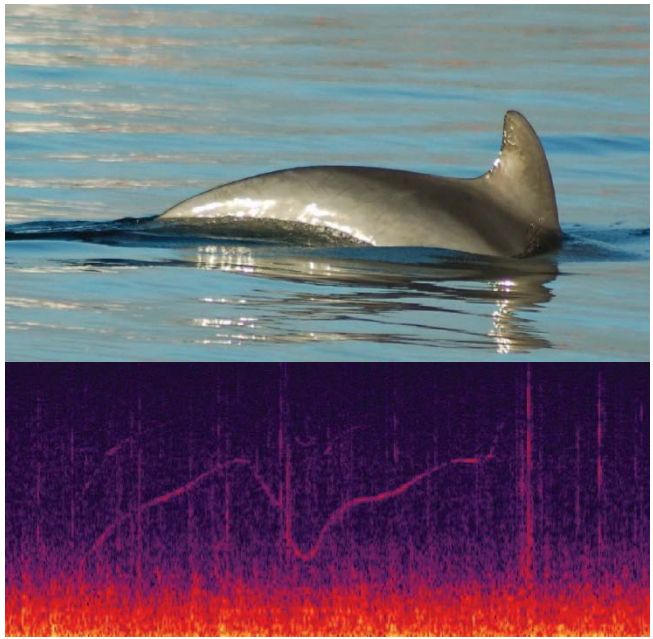
Dolphin Responses

- Movement speeds
  - High vessel densities =
    ↑ average movement speeds
  - But only for some activity states (resting and socialising)
- Activity states
  - Behavioural budgets changed at varying vessel densities
  - High vessel densities = ↑ travelling
    ↓ resting or socialising

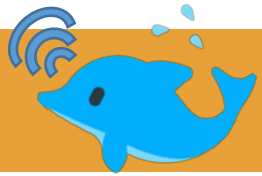
Results

Dolphin Responses

- Whistle Characteristics
  - Increased broadband noise = All nine characteristics varied
  - However, whistles also varied naturally according to activity state, group size, and calf presence
  - Strongest acoustic response was to low-frequency noise (1 kHz OBL)



Conclusions

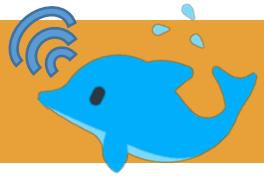


- Swan River comprised of multiple acoustic habitats, each with its own characteristic soundscape and temporal patterns in underwater noise
- Anthropogenically noisiest site was Fremantle Inner Harbour, which is also a key dolphin foraging site
- Dolphins maintain occupancy at key foraging sites, despite high vessel densities
- However, vessel traffic and broadband noise levels still appear to elicit subtle behavioural and acoustical responses

Thank you!

- **Acoustic Fieldwork:** Many people for assistance in deploying and recovering some frankly very disgusting loggers from the sea bed, but particularly Dave Minchin, Mal Perry, and Sylvia Parsons.
- **Visual Fieldwork:** Over 60 undergraduate and work experience students, and Eric Kniest for assisting with theodolite set-up.
- **Assistance with acoustic data review:** Mariana Barbosa, Mat Bentley
- **Support:** Fremantle City Council, Fremantle Port Authority, Swan River Trust, and Department of Parks and Wildlife.
- **Funders:** Holsworth Wildlife Research Endowment (Equity Trustees Charitable Foundation & the Ecological Society of Australia); British Ecological Society; Society for Marine Mammalogy; Australian Acoustical Society (AAS); Fisheries Research and Development Corporation (FRDC); the Australian Government.

More info:



Effects of vessel traffic and underwater noise on the movement, behaviour and vocalisations of bottlenose dolphins in a highly urbanised estuary. *Scientific Reports.*

Underwater recordings of the whistles of bottlenose dolphins in the Fremantle Inner Harbour. *Scientific Reports.*

A Tale of Two Soundscapes: Comparing the acoustic characteristics of urban vs pristine coastal dolphin habitats in Western Australia. *Acoustics Australia.*

Spatial and temporal variation in the acoustic habitat of bottlenose dolphins within a highly urbanised estuary. *Frontiers in Marine Science.*

Occupancy of bottlenose dolphins in relation to vessel traffic, dredging and environmental variables within a highly-urbanised estuary. *Hydrobiologia.*

Underwater sound in an urban estuarine river: Sound sources, soundscape contribution, and temporal variability. *Acoustics Australia.*