Acoustic Characterization of Pingers on Shark Control Nets

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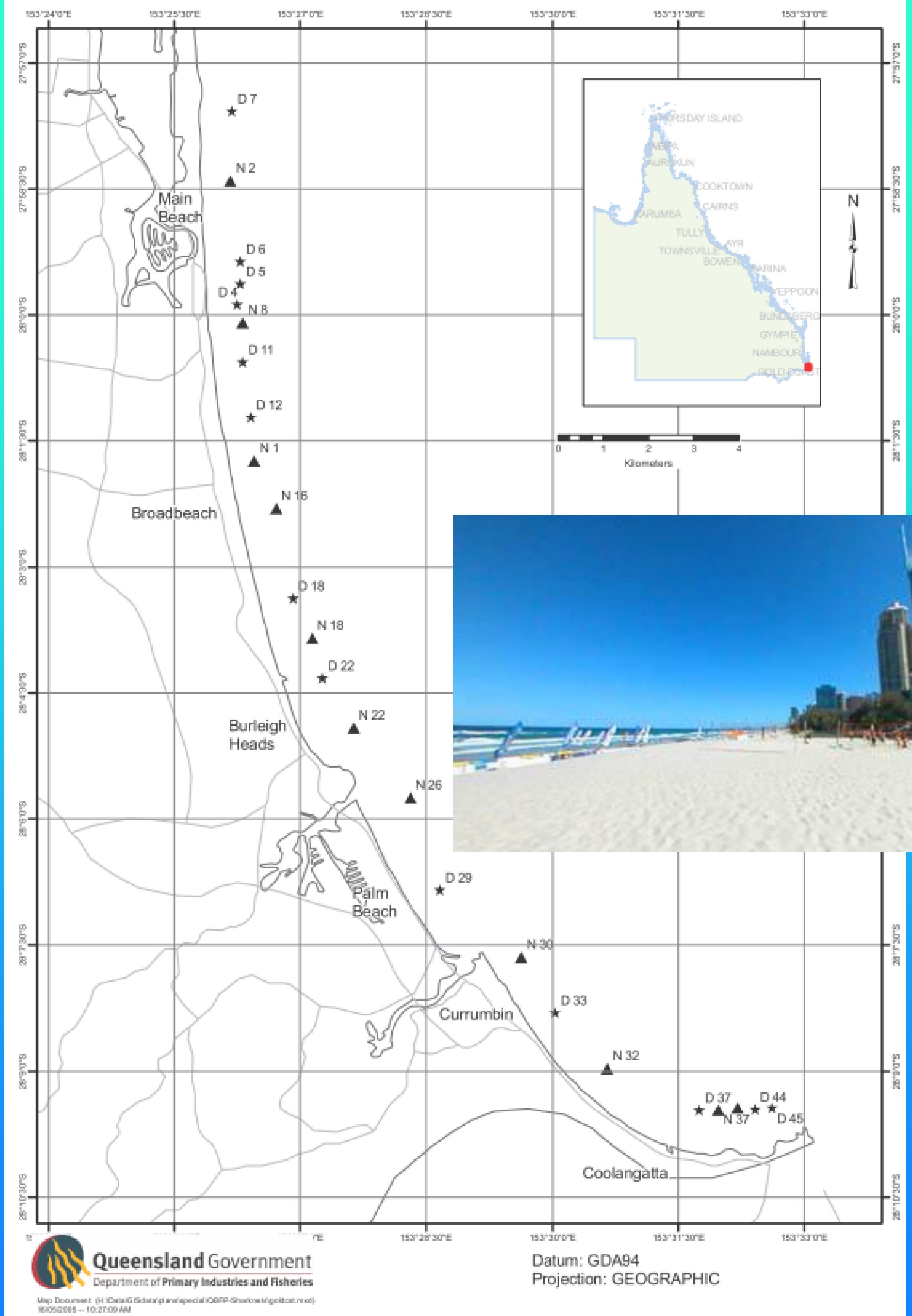
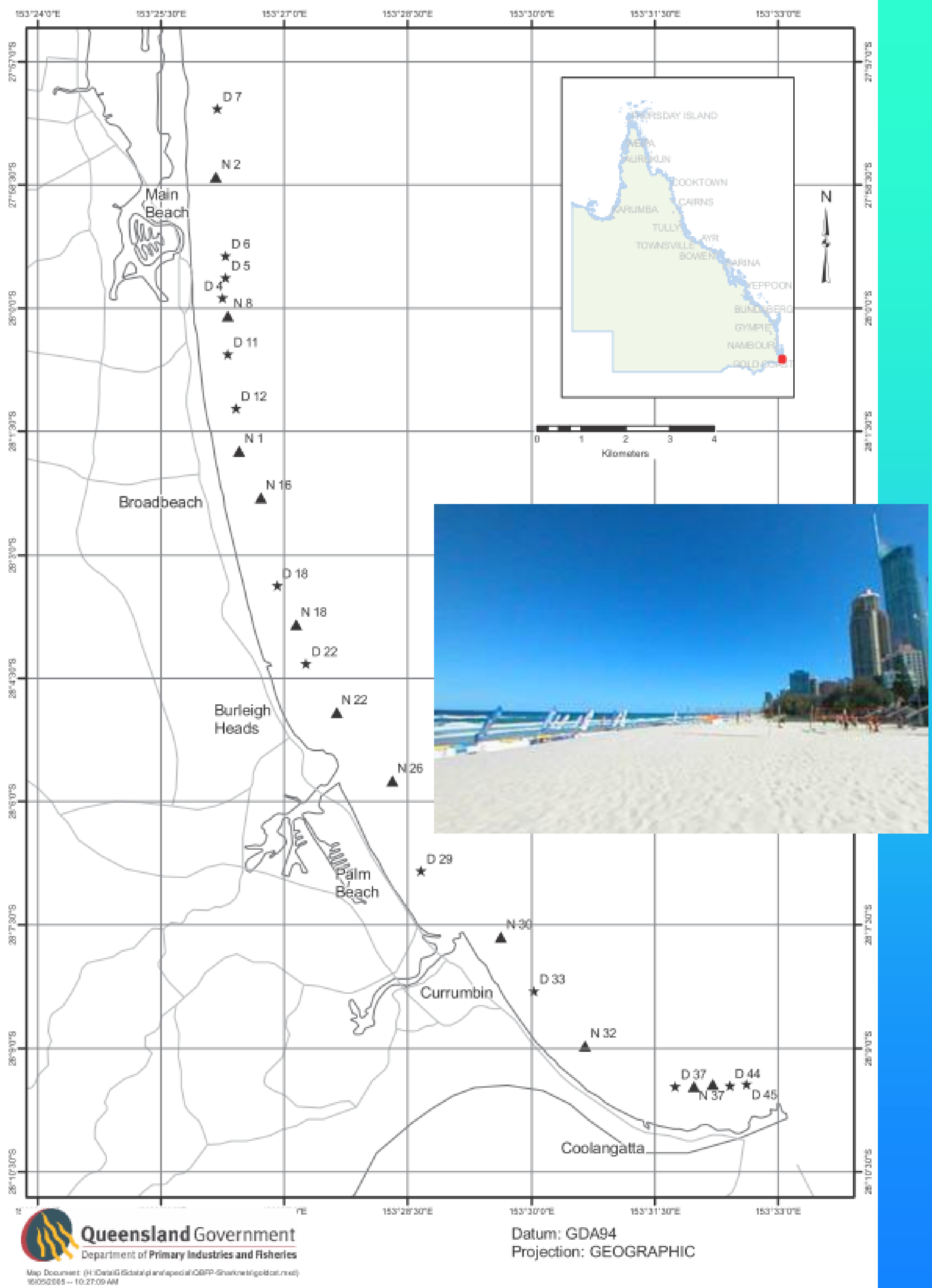
Overview

- Introduction: acoustic alarms
- In situ recordings of pingers
- Source characterization
- Contribution of pingers to noise budgets
- Modelling pinger detectability

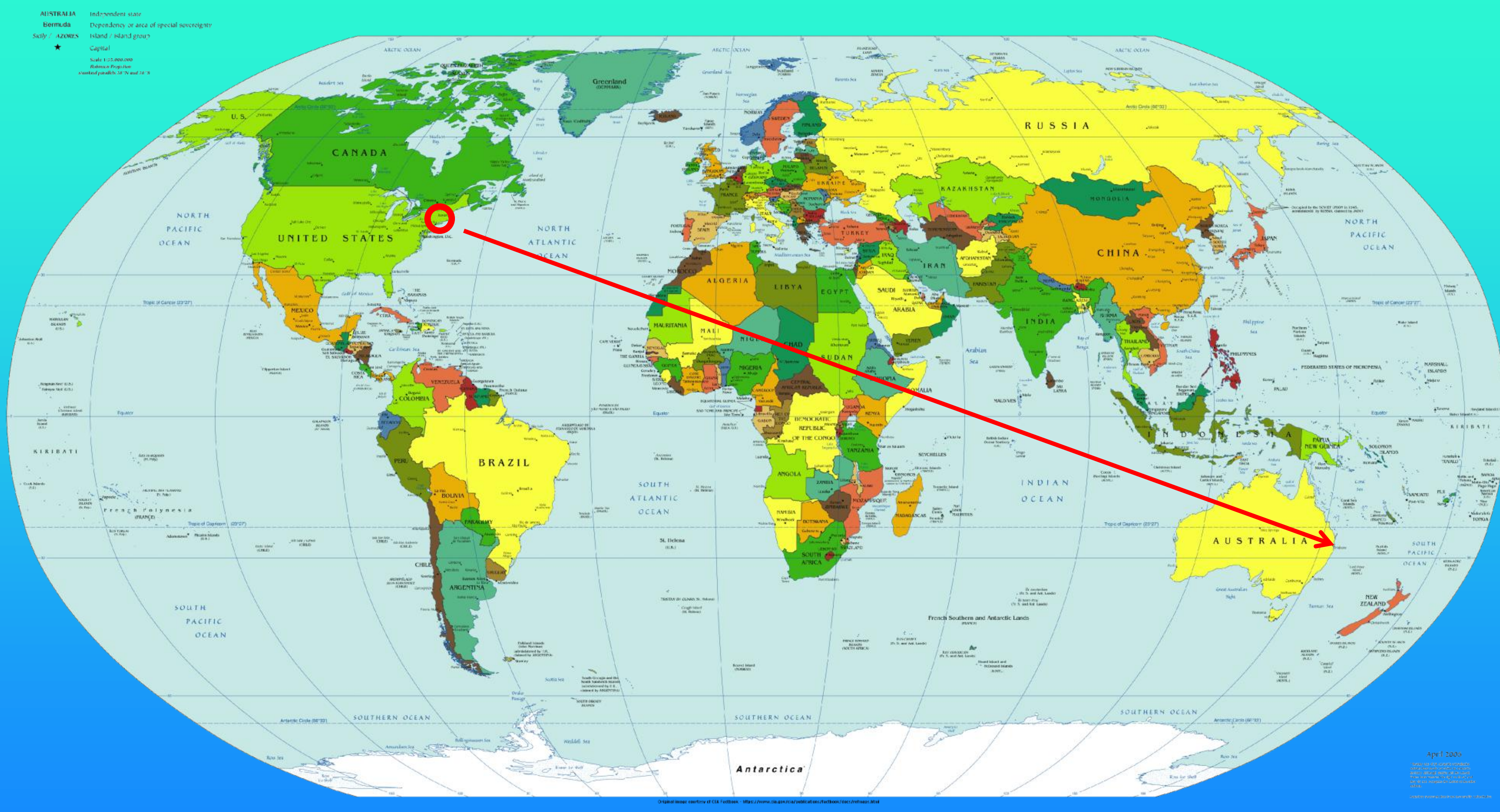
Map of shark nets deployed along the Gold Coast, Queensland, Australia



Map of shark nets deployed along the Gold Coast, Queensland, Australia



Political Map of the World, April 2006



Gold Coast, Queensland, Australia

Acoustic Alarms on Shark Nets

- Are installed to reduce entanglement
- Are intended to highlight the net
- Through associative learning, marine mammals associate the acoustic alarms with the obstruction (the net)
- The intention is not to scare animals away
- In fact, some marine mammals approach pingers to investigate

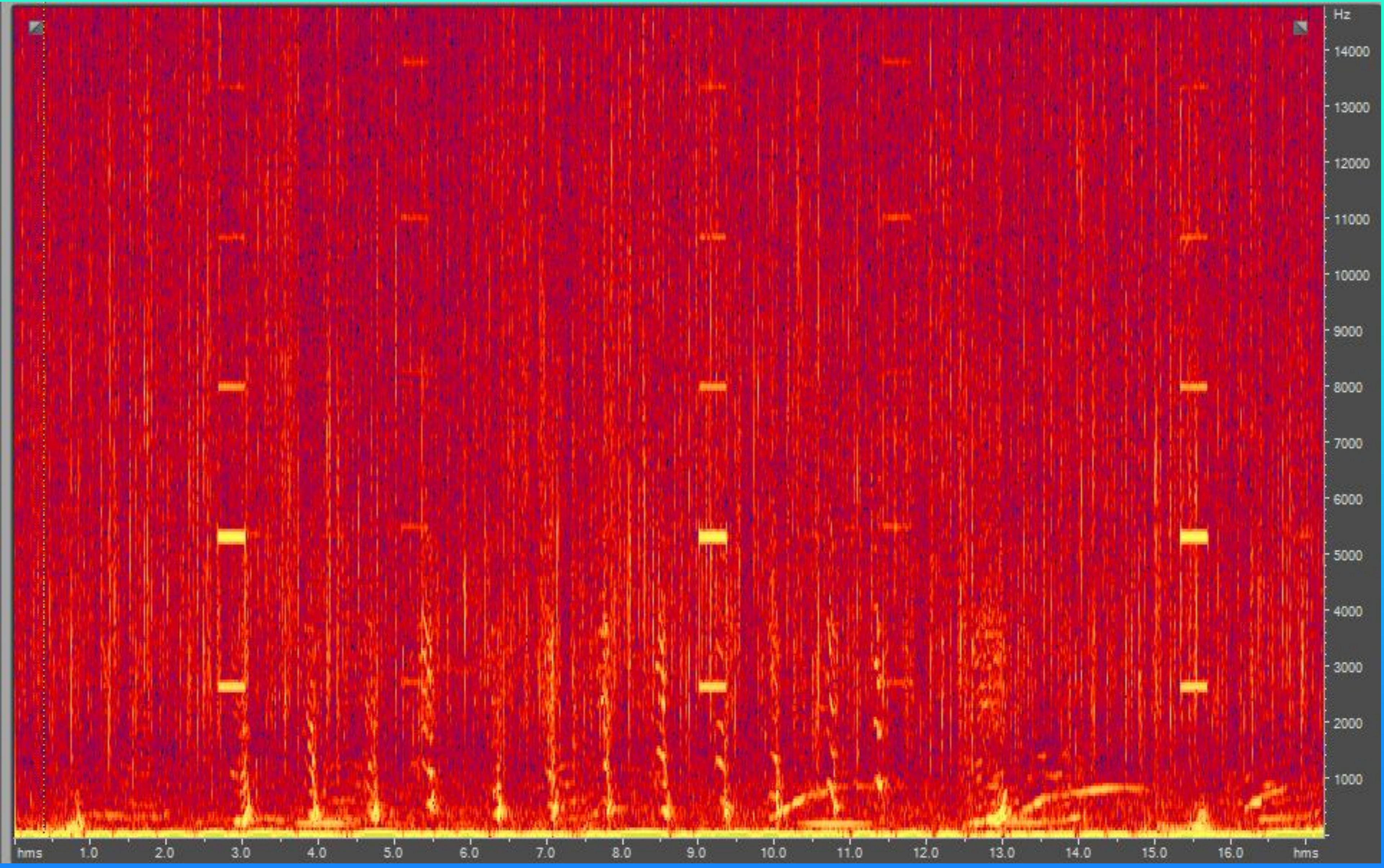
Examples of Acoustic Alarms

Lien & McPherson 2.9 kHz

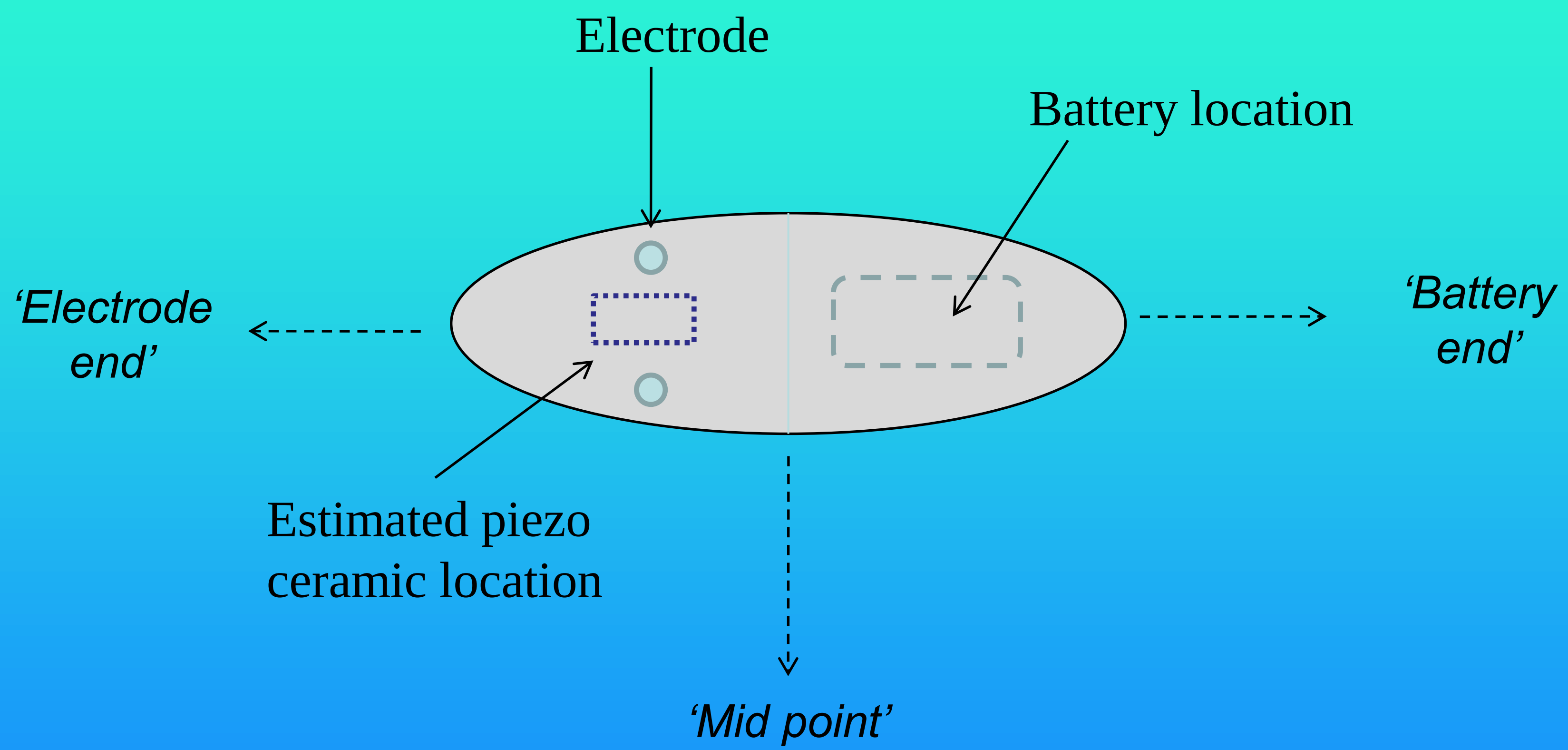
Fumunda 3 kHz

Airmar 10 kHz

Fumunda F3 pinger + humpback whales at the Gold Coast

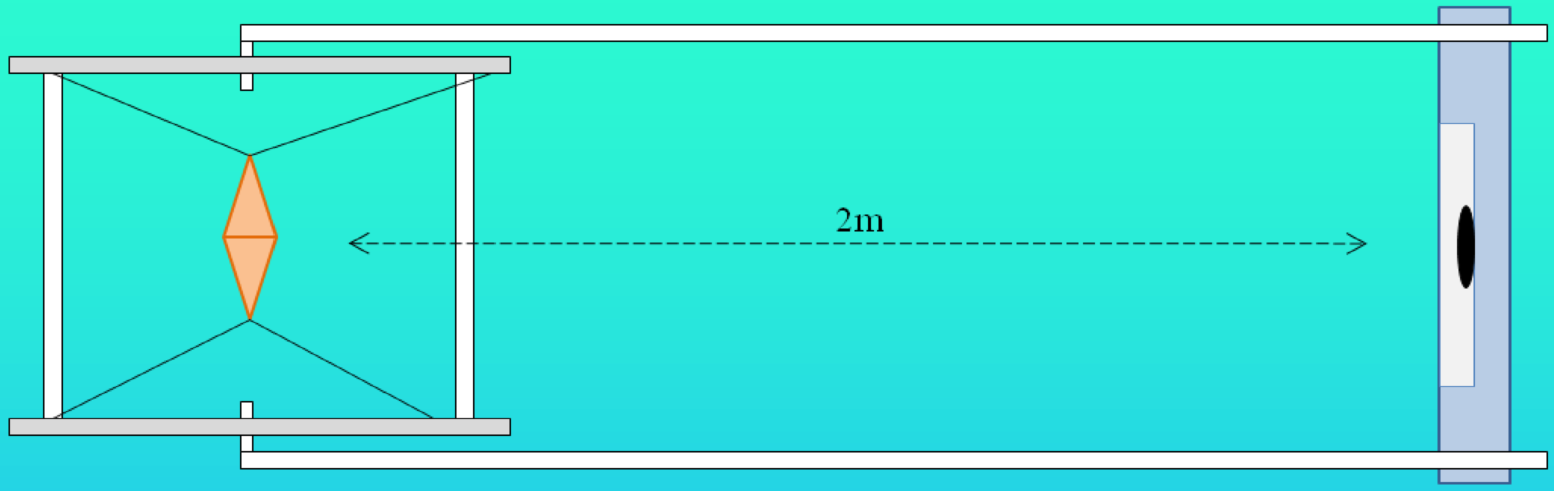


Pinger Interior

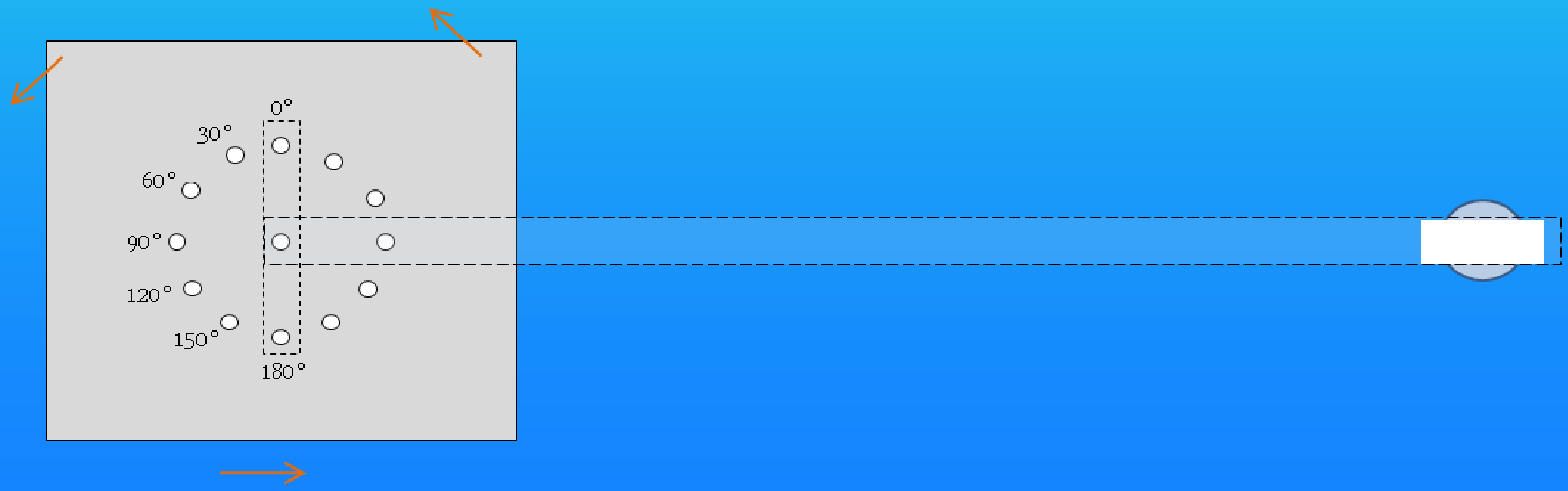


Pinger Recording Apparatus

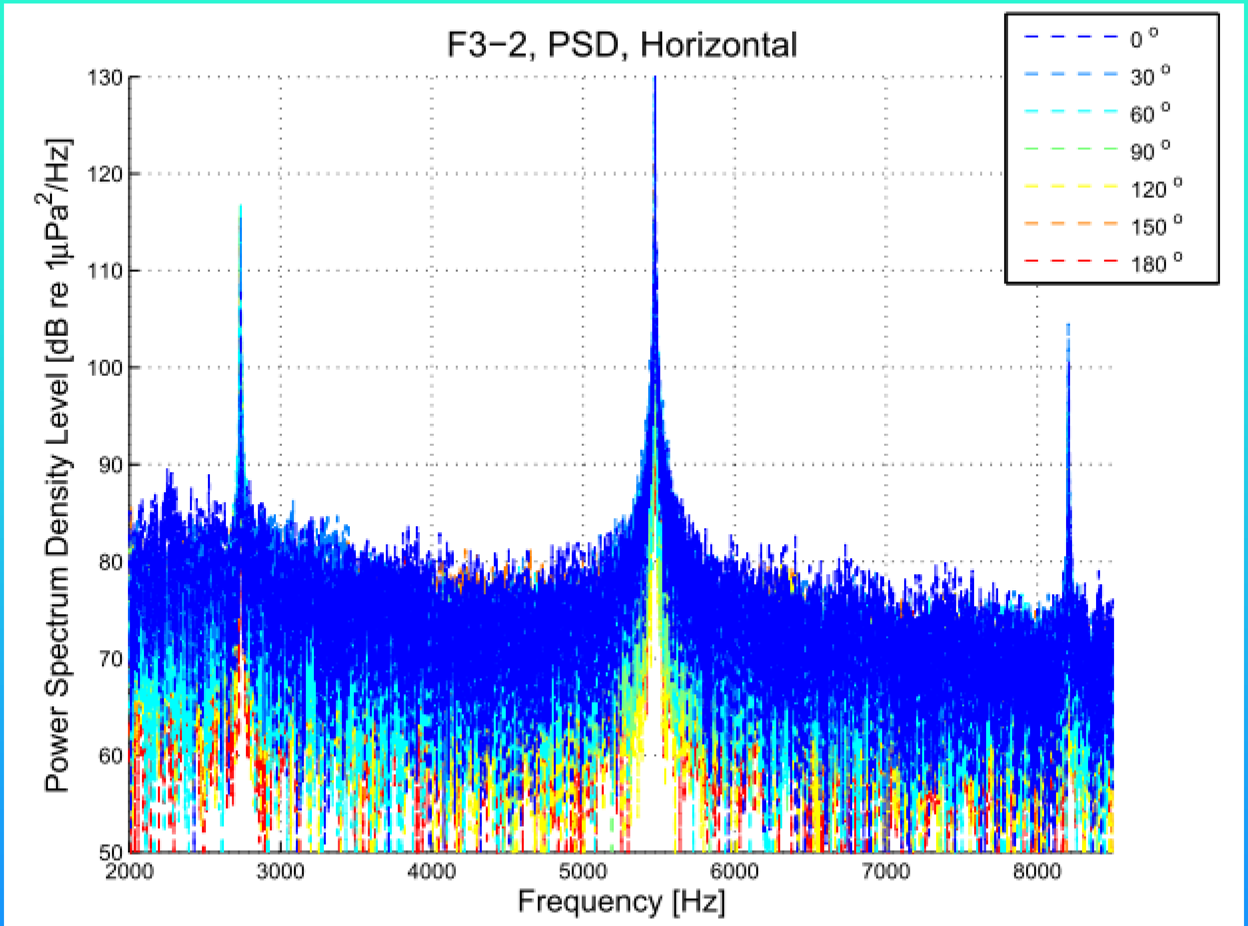
Side view, pinger in vertical position



Top view, with apparatus reference rotation angles

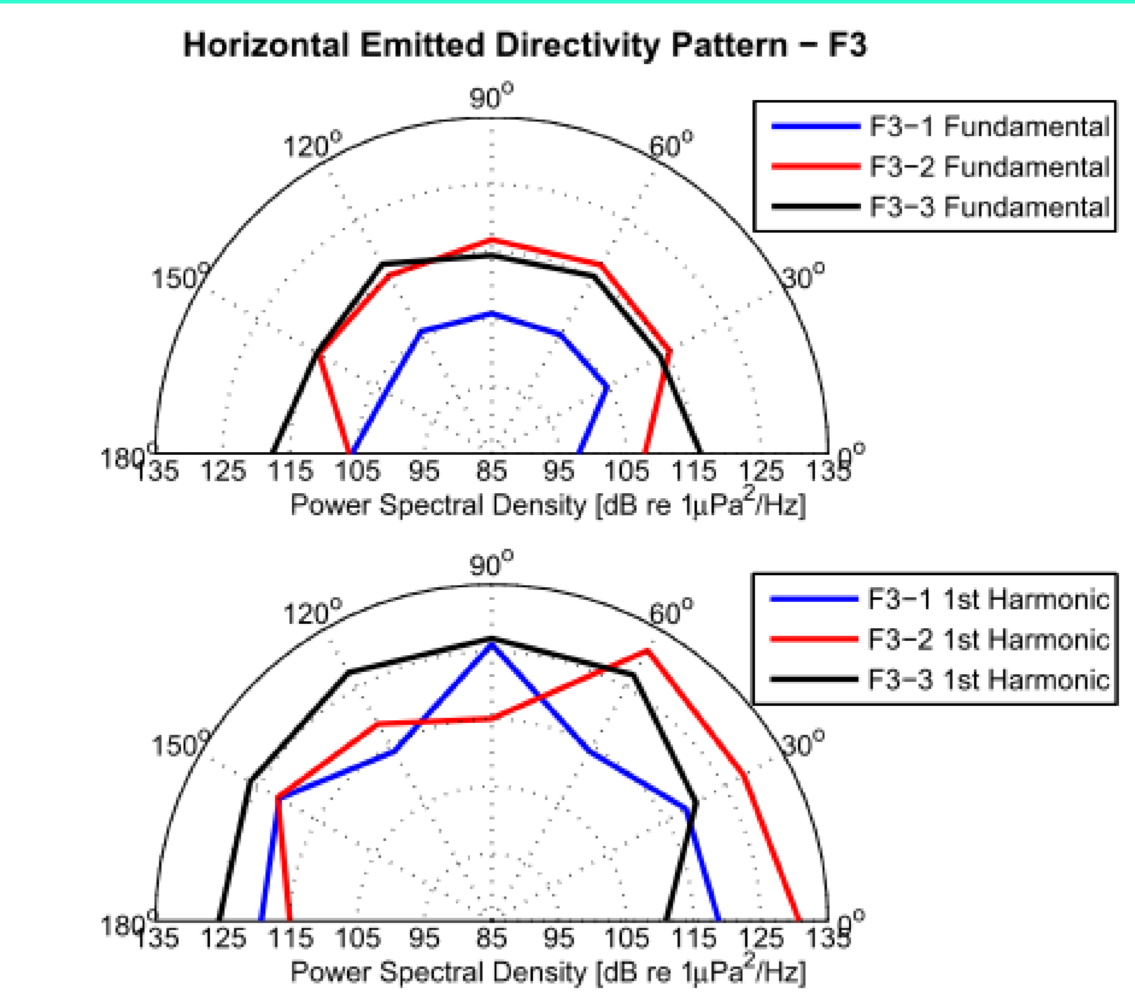


Fumunda F3 pinger spectrum

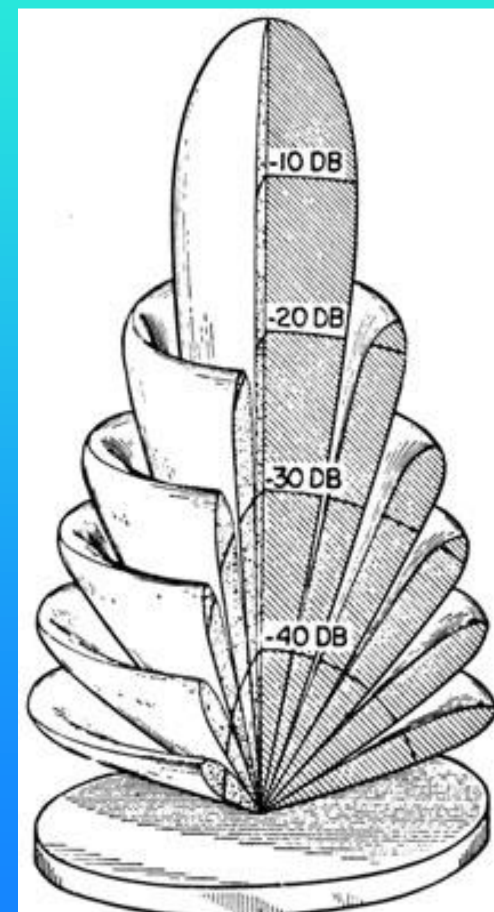


Harmonic is stronger than the fundamental.

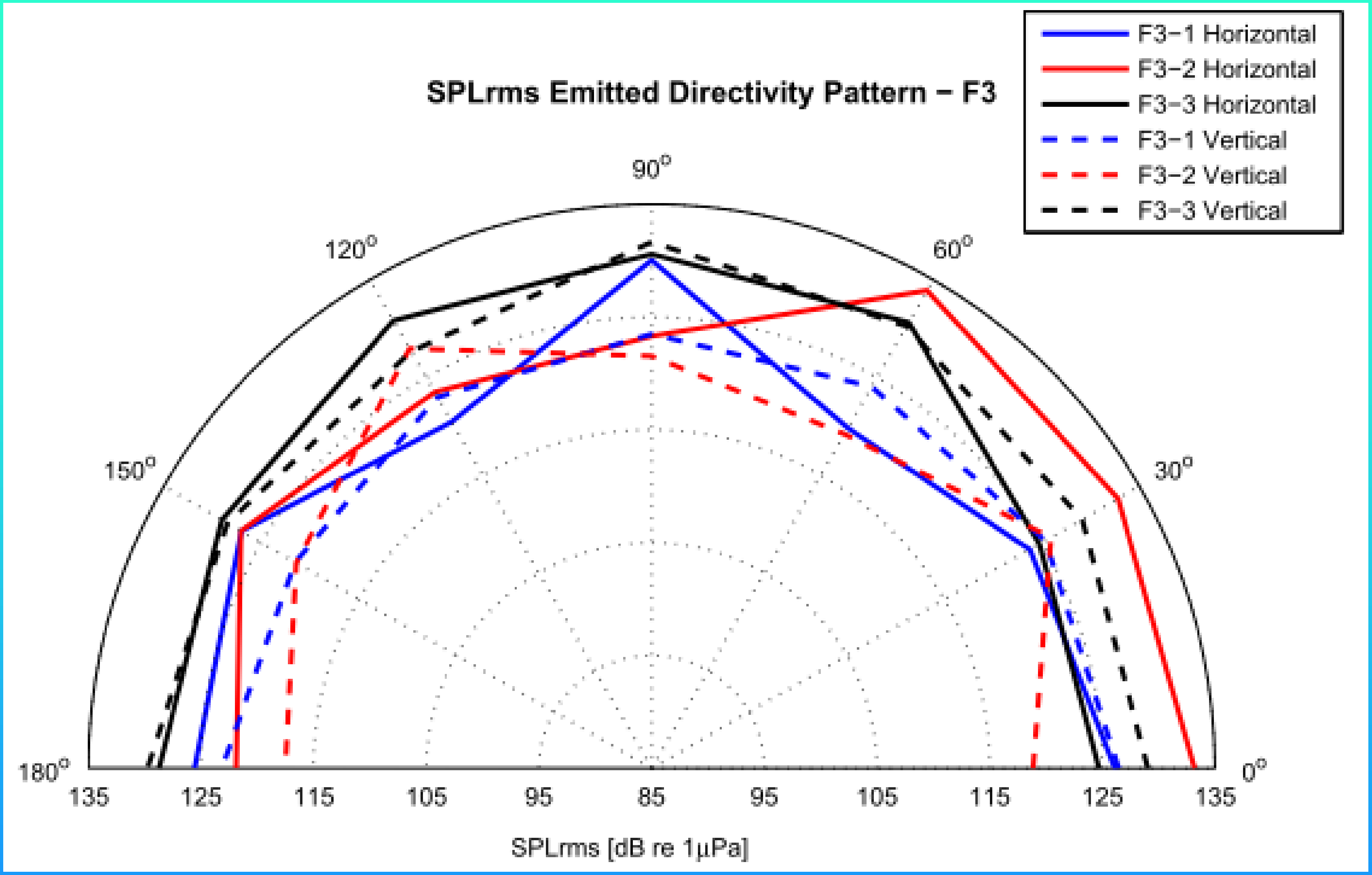
f = 2.6 – 2.8 kHz, not 3 kHz



Directivity patterns inconsistent due to variable piezo placement inside pingers.



Theoretical three-dimensional directivity pattern for a circular plate.



Nominal 135 dB SPL was only reached for some pingers at some angles.

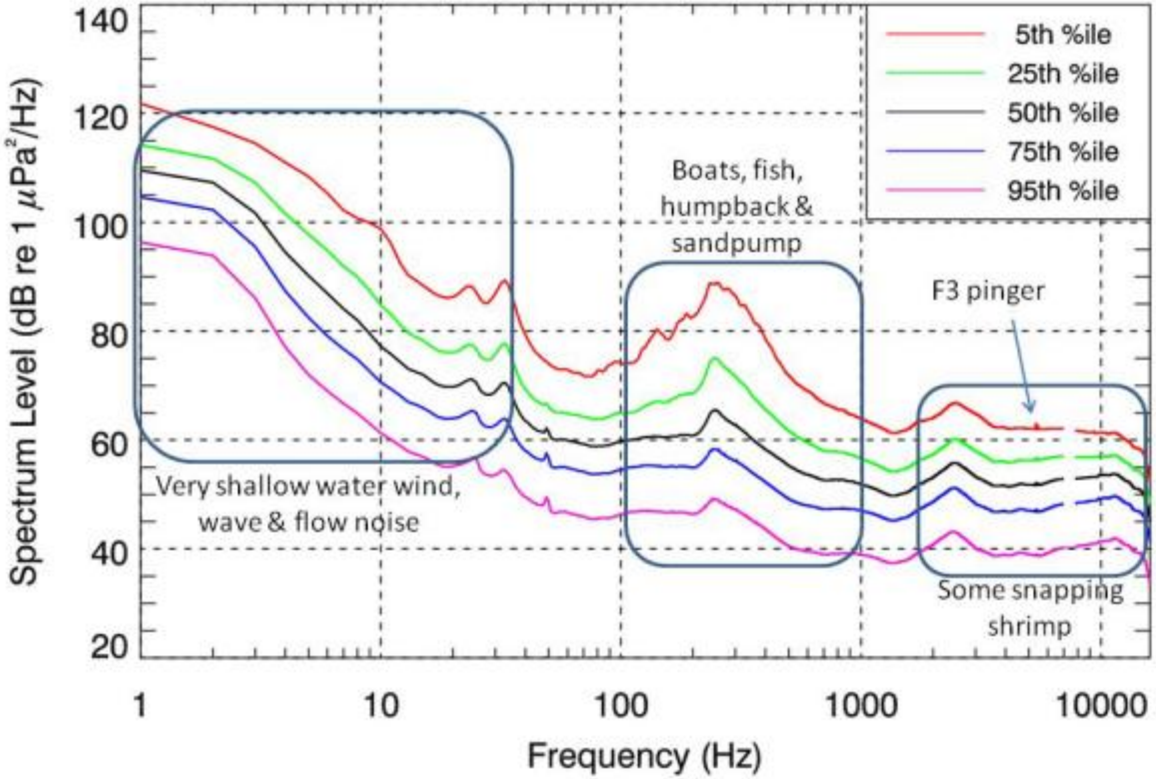
Substantial Variability in Output Level

- 3 dB ping to ping
- 5 dB broadband, pinger to pinger
- Larger variability of tone levels, pinger to pinger

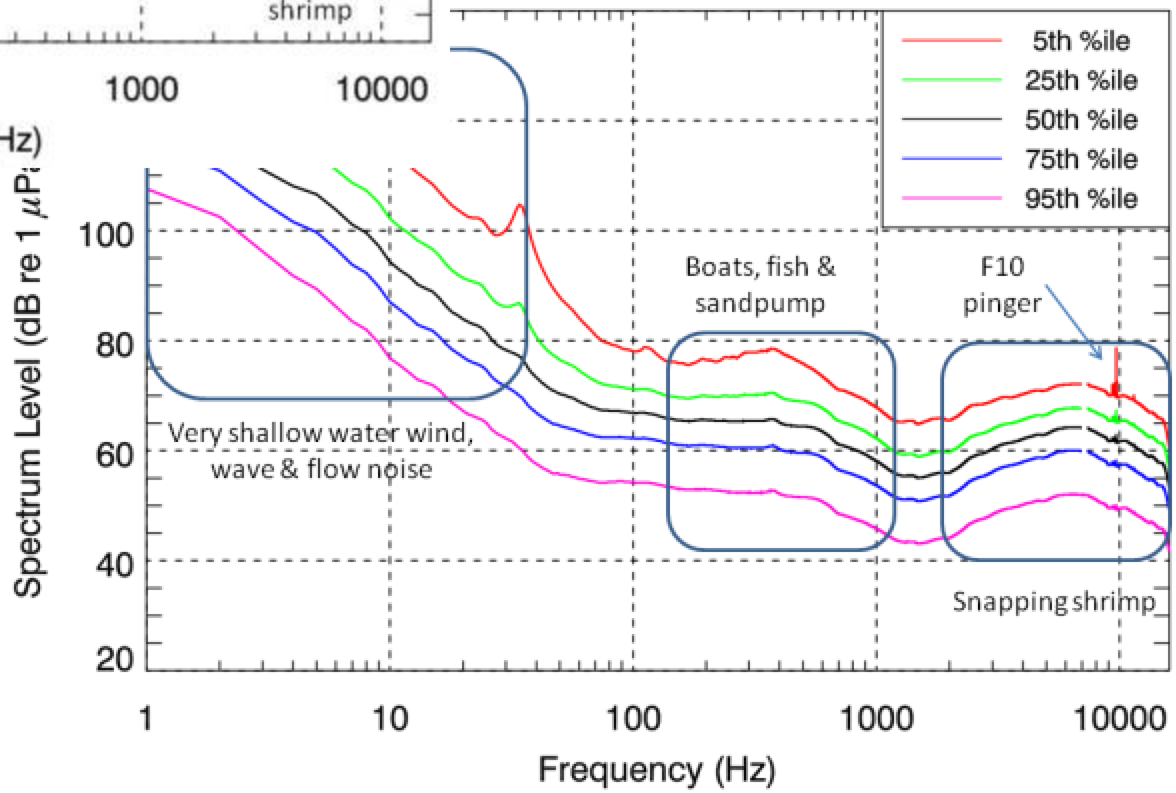
	Minimum (dB re 1 μPa²/Hz)	Mean (dB re 1 μPa²/Hz)	Standard Deviation of Mean (dB re 1 μPa²/Hz)
Fundamental			
F3-1	87.24	97.58	7.11
F3-2	99.43	109.28	5.67
F3-3	113.93	118.02	3.48
Harmonic 1			
F3-1	112.85	118.14	3.59
F3-2	106.85	118.18	6.62
F3-3	102.48	121.31	6.50
Harmonic 2			
F3-1	86.63	98.43	4.51
F3-2	83.24	93.43	6.33
F3-3	100.27	106.39	3.09
SPLrms (>2kHz)	**Minimum (dB re 1 μPa)**	**Mean (dB re 1 μPa)**	**Standard Deviation of Mean (dB re 1 μPa)**
F3-1	119.84	123.81	2.70
F3-2	117.51	124.76	5.04
F3-3	122.60	128.14	2.66

Ambient Noise @ Gold Coast

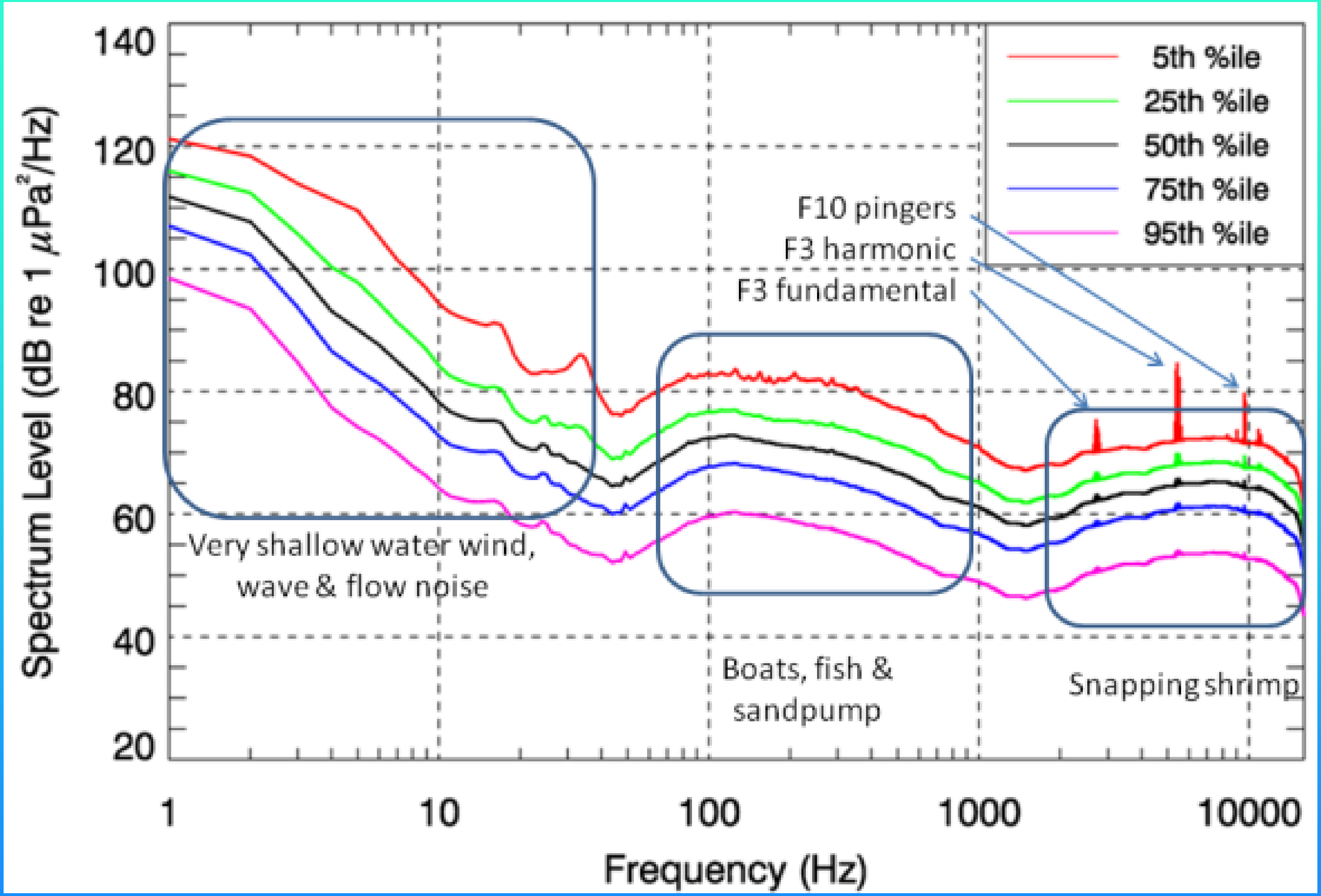
Sept. 2010, 1.5 km range



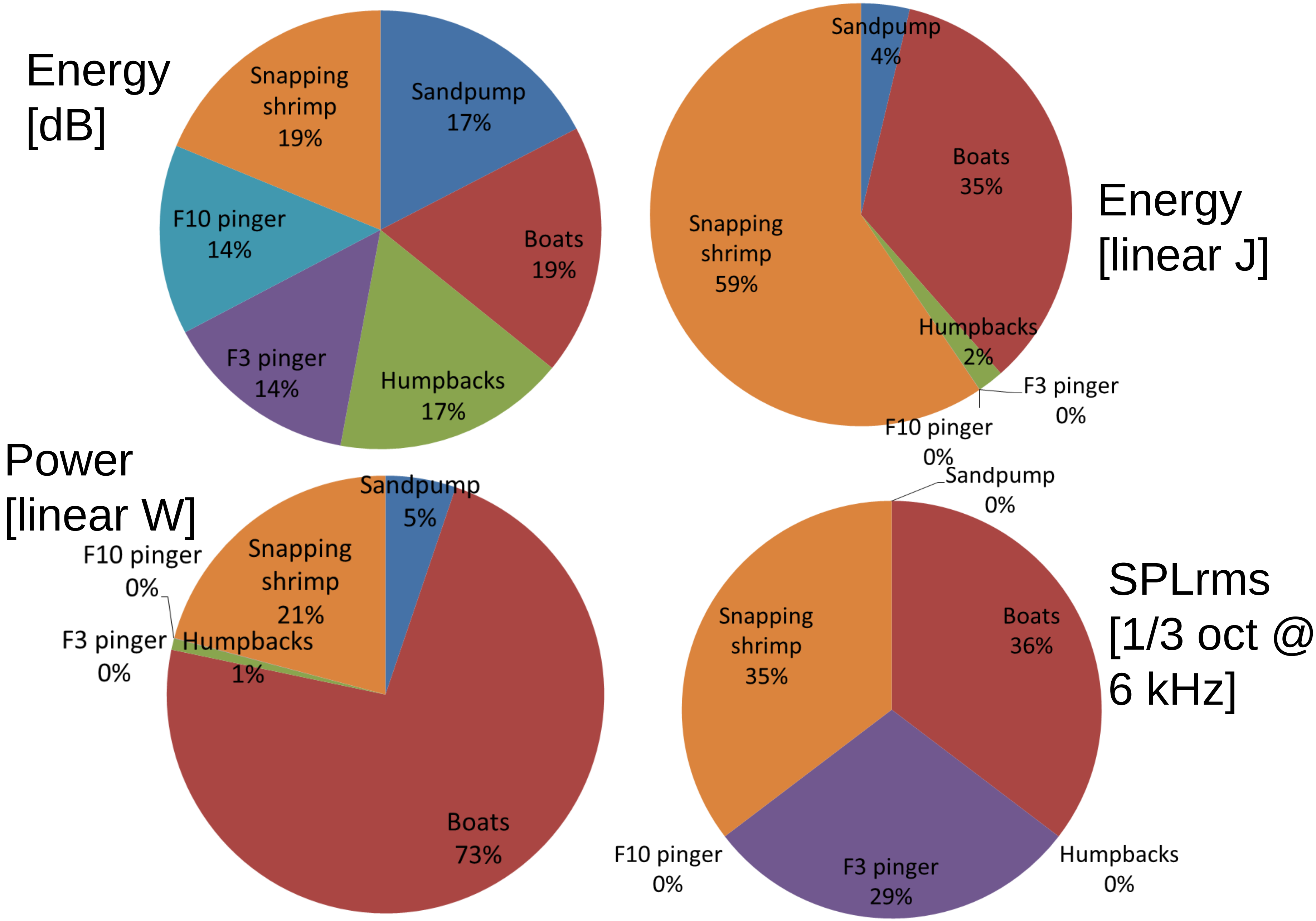
Jan. 2011, 0.5 km range



May 2011, 0.5 km range

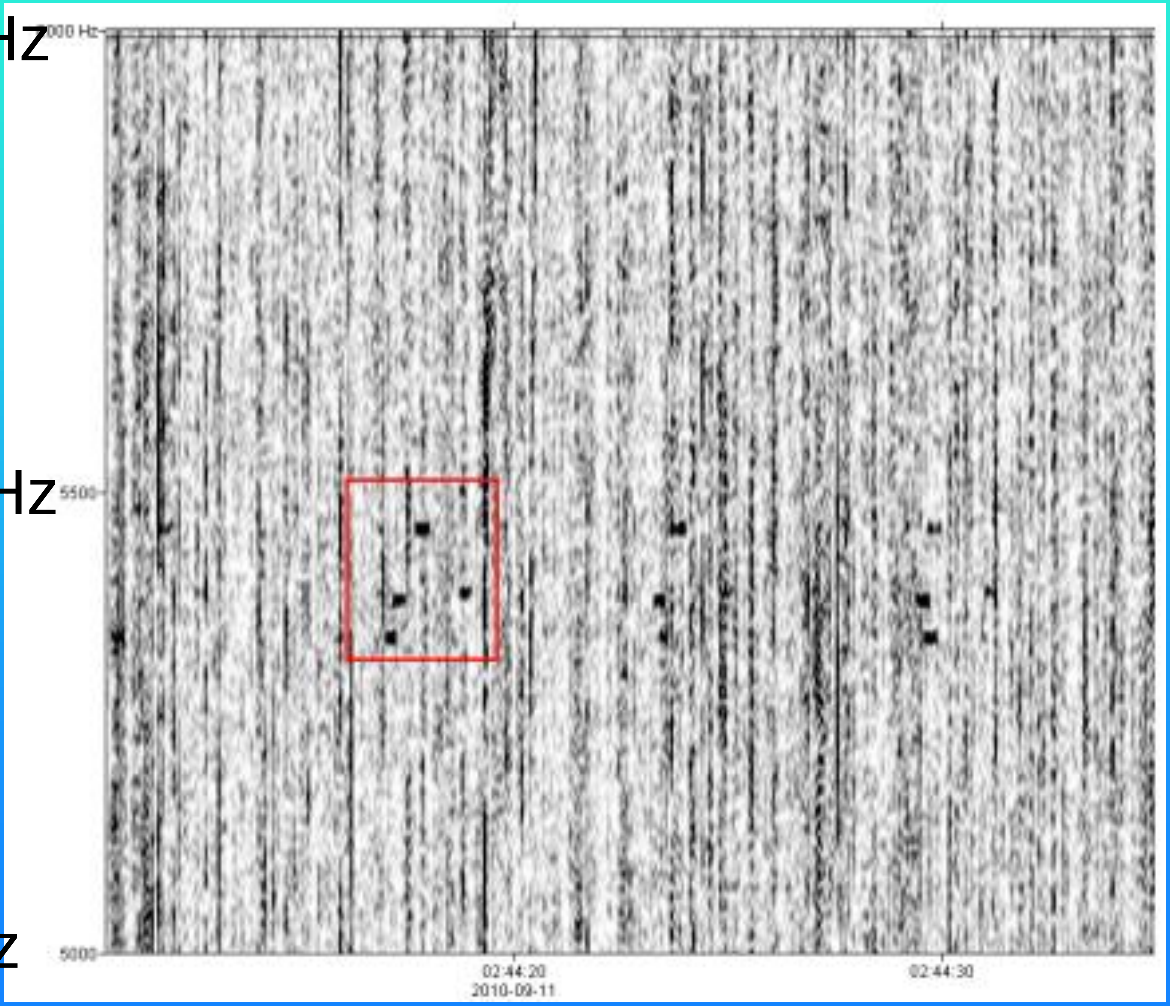


Pie charts of sound ‘budgets’ measured over a 24h period at one location.



Spectrogram of Pings in Ambient Noise

from 4 pingers on a net



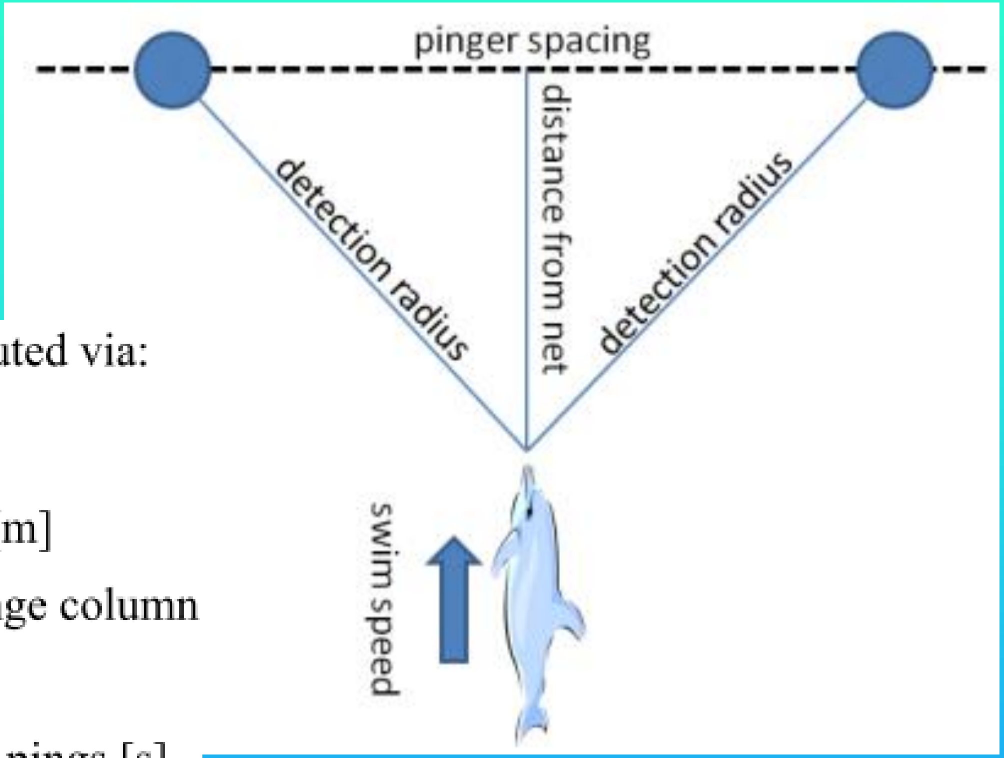
Pinger Detectability

1. Measure pinger source levels in the field
2. Model sound propagation
3. Measure ambient noise in the field
4. Estimate audiograms (ambient noise limited due to high levels of snapping shrimp noise)
5. Estimate critical ratios (20-25 dB)

- Detection ranges 50 – 200 m
- Would be much longer (> 1 km) for nominal SL (135 dB SPL)

		Humpback & Dugong			Tursiops, Sousa, Orcaella, Delphinus		
f [kHz]	SL [dB re 1 µPa]	Ambient + 20 dB CR	TL [dB]	Range [m]	Ambient + 25 dB CR	TL [dB]	Range [m]
2.7	108	80	28	90	85	23	45
5.4	119	83	36	210	88	31	110
8.1	99	83	16	10	88	11	10
10.0	114	82	32	130	87	27	40

Optimal Pinger Spacing



The minimum pinger spacing d can be computed via:

$$d = 2\sqrt{r^2 - v^2 T^2}$$

where d = minimum pinger spacing [m]

r = detection radius [m] = Range column

v = swim speed [m/s]

T = quiet time in between two pings [s]

- Dugong: 250 – 400 m
- Dolphins: 50 – 100 m
- Humpbacks: 200 – 400 m

Conclusion

- We measured Fumunda F3 and F10 pingers
- Variability in f (10%), SL (<15 dB), directivity
- Ping-to-ping and pinger-to-pinger variability
- No need for sophistication...
- SL < specified by manufacturer
- Expect SL decrease as battery power decreases
- Behavioural studies should include recording of pingers rather than assuming a nominated SL.
- There are currently 3-4 pingers per net of 200m. All pingers were modelled audible to marine mammals anywhere along the net.
- Taking swim speed into consideration, for an animal swimming straight at a net, the current spacing gives enough warning, except for high burst speeds of dolphins.
- Caveat: audiogram & critical ratio data missing from resident populations


Thank you !