The ambient acoustic environments

at three locations in Laguna San Ignacio, Baja, Mexico

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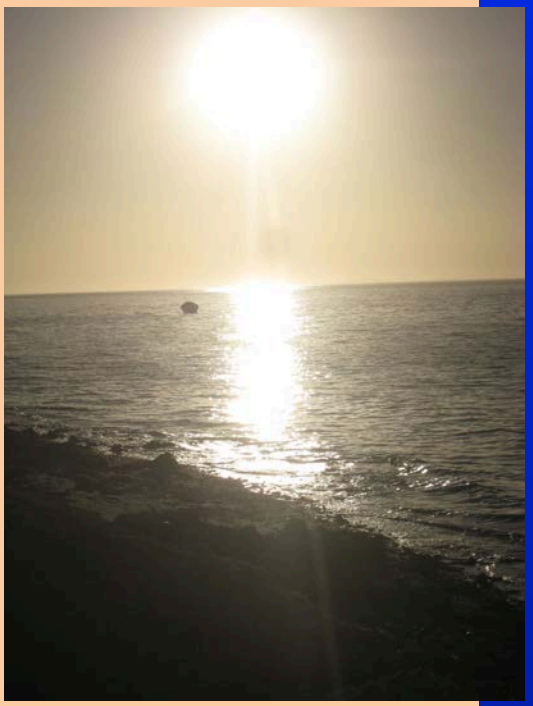
Outline

- **Background** (geography & natural history)
- **Methods** (data collection technique & availability)
- **Results**
  I. Cross-instrument quality check
  II. Inter-annual comparison over 6 years
  III. Transit vs Whale-watching zones
  IV. Transit vs Restricted zones
- **Conclusions**

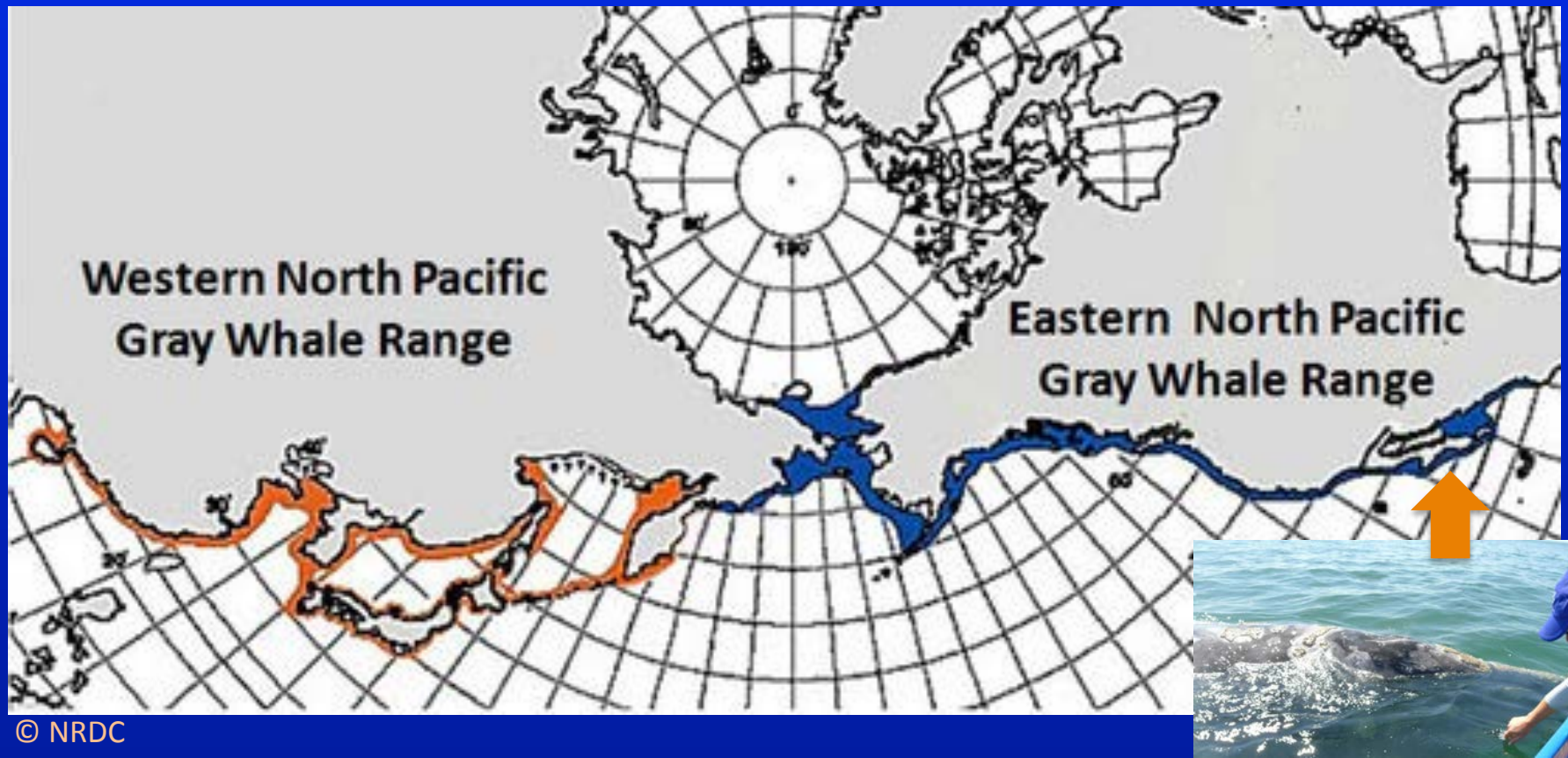


Background (natural history): *Eschrichtius robustus*

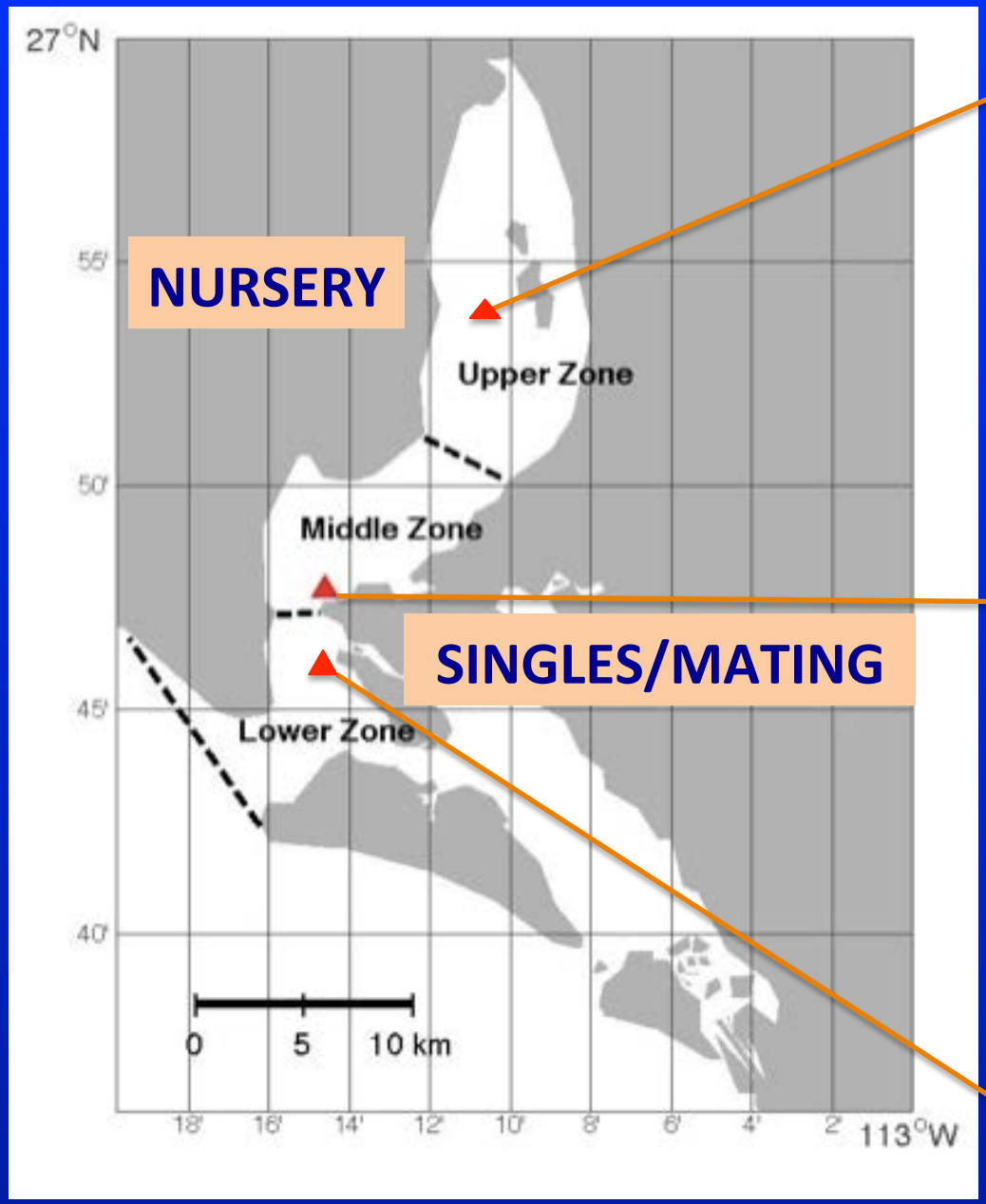
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec

Breed/birth: Baja or East Asia

Feed: coastal Alaska/Russia



Background (geography): *Laguna San Ignacio*



NURSERY

RESTRICTED

TRANSIT

SINGLES/MATING

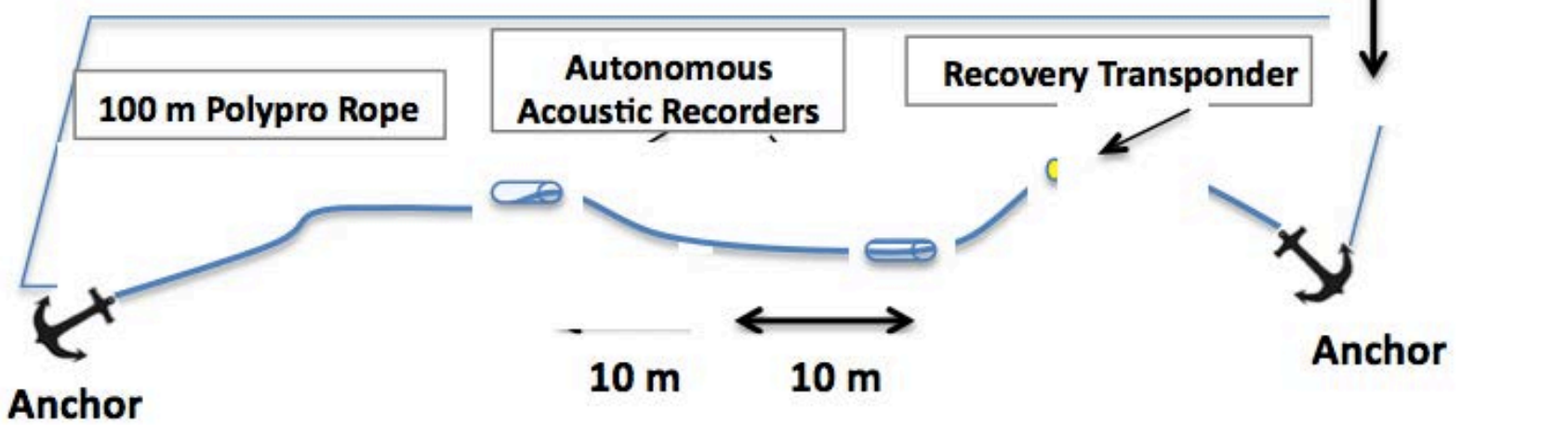
WHALE-WATCHING

Motivation: paved road → increased tourist traffic

UNESCO Site

Baseline study requested

Acoustic recorders deployed for ~30 days



- Sampling rates at 6.25 or 12.5 kHz
- "Back-up" recorders on the line most years
- Deployed on ocean floor to prevent entanglement (sensitive to low noise contamination)

Acoustic recorders deployed 2008-2013

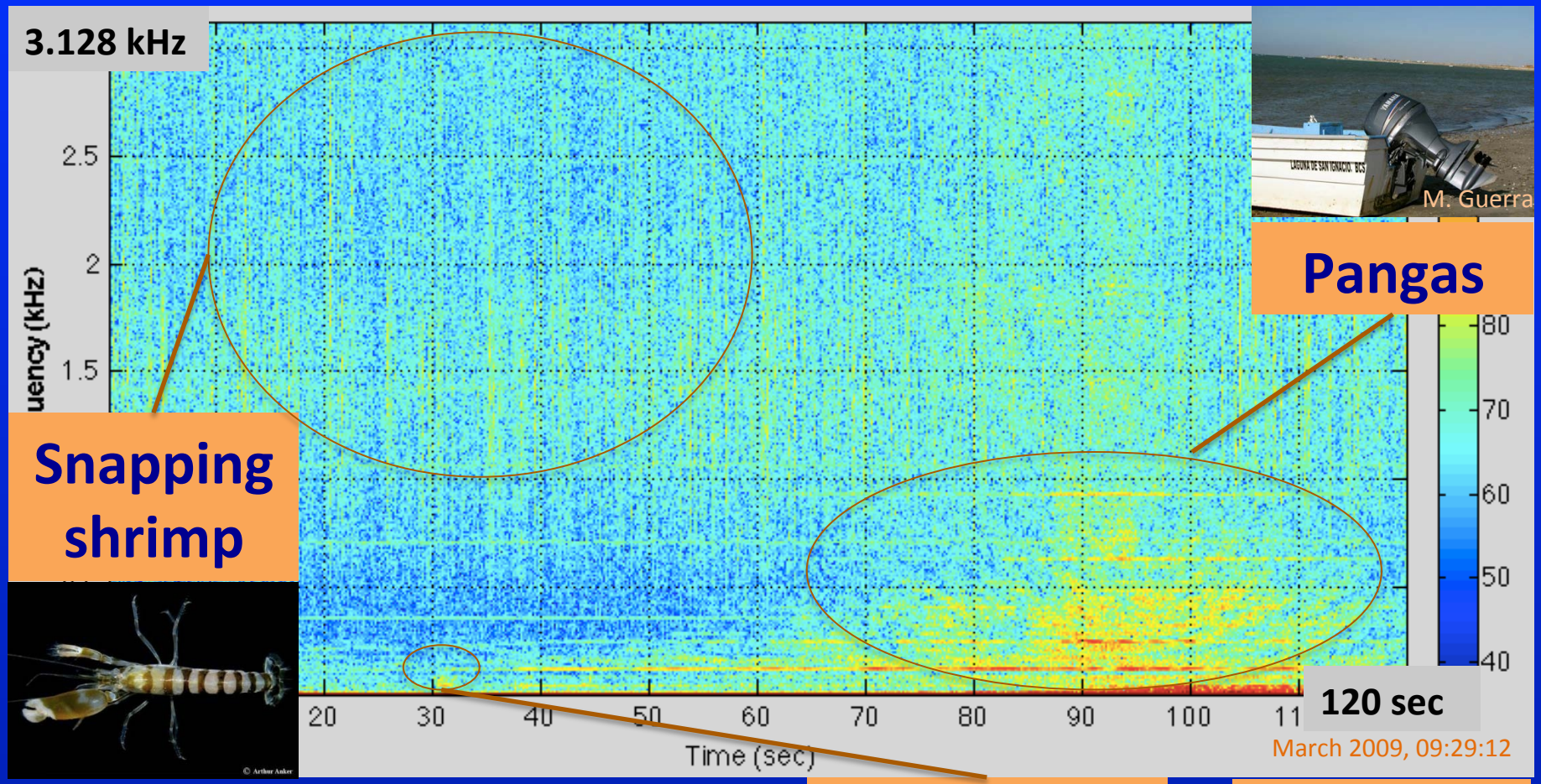
- Transit zone → each year for 6 years
- Whale-watching zone → 1 year
- Restricted zone → 2 years

1 to 3 recorders each year for each zone

Year	"Transit Zone"	Depth	"Restricted Zone"	Depth
2008	1 (Feb 9 – Mar 8)	13 m	0	n/a
2009	2 (Feb 13 – Mar 22)	11 m	1 (Feb 15 – Mar 12)	5 m
2010	6 (Feb 6 – Mar 4)	10 m	0	n/a
2011	2 (Feb 5 – Mar 7)	12 m	1 (Feb 6 – Mar 9)	5 m
2012	3 (Feb 11 – Mar 10)	11 m	0	n/a
2013	1 (Feb 18 – Mar 6)	12 m	0	n/a

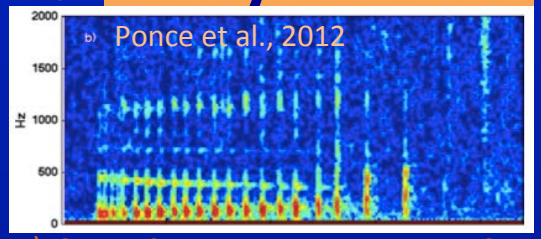
* "Whale-watching Zone" in 2010 from Feb 6 - Mar 4 at 5 m deep

Previous work shows distinct sound sources

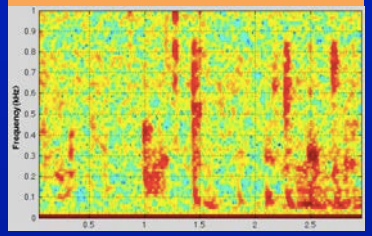


- Dahlheim, M. E. (1987). "Bio-acoustics of the gray whale (Eschrichtius robustus)," Ph.D. thesis, University of British Columbia, Canada.
- Wisdom, S. (2000). "Sound production development in gray whales," M.S. thesis, University of San Diego.

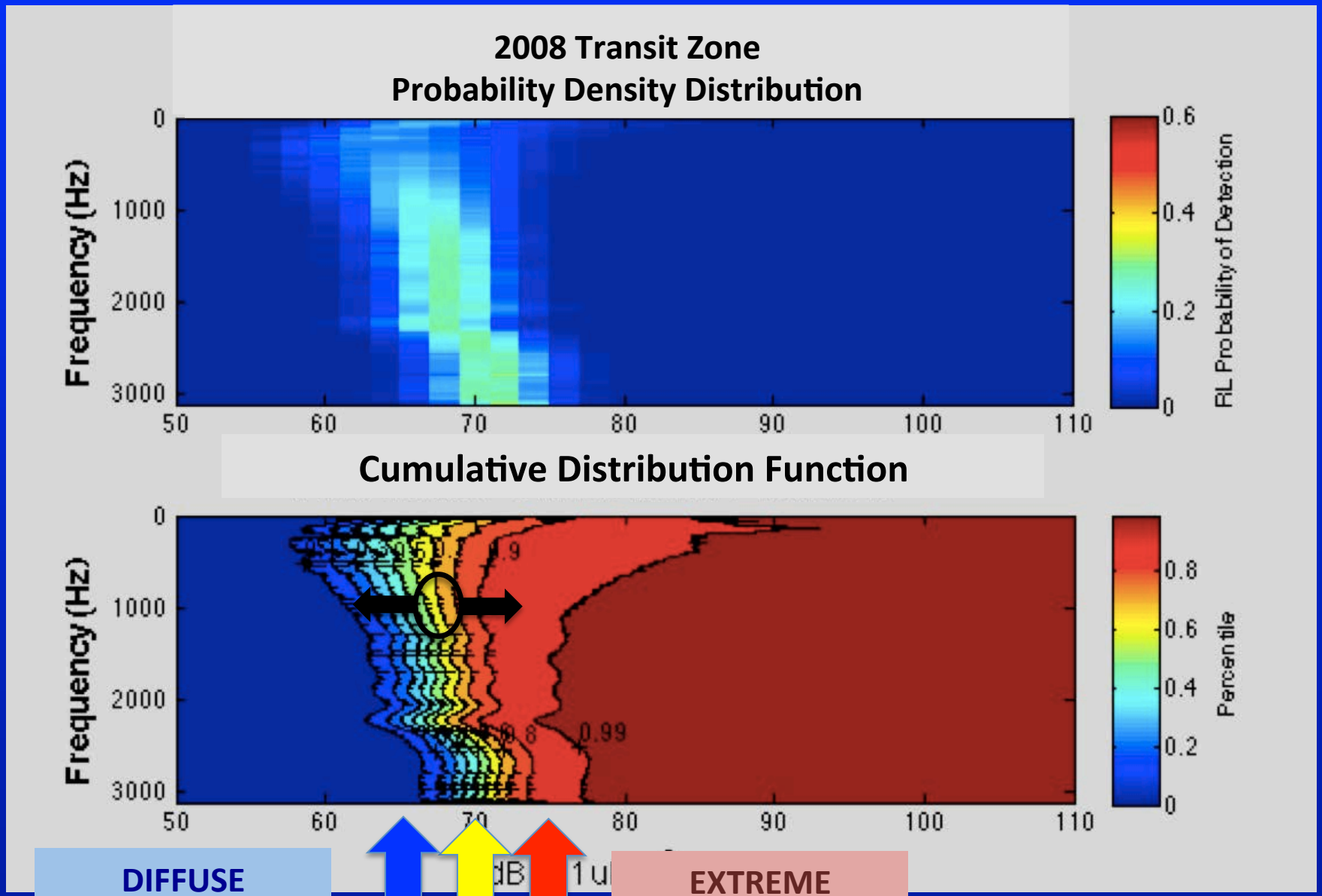
S4 **Grey whales**



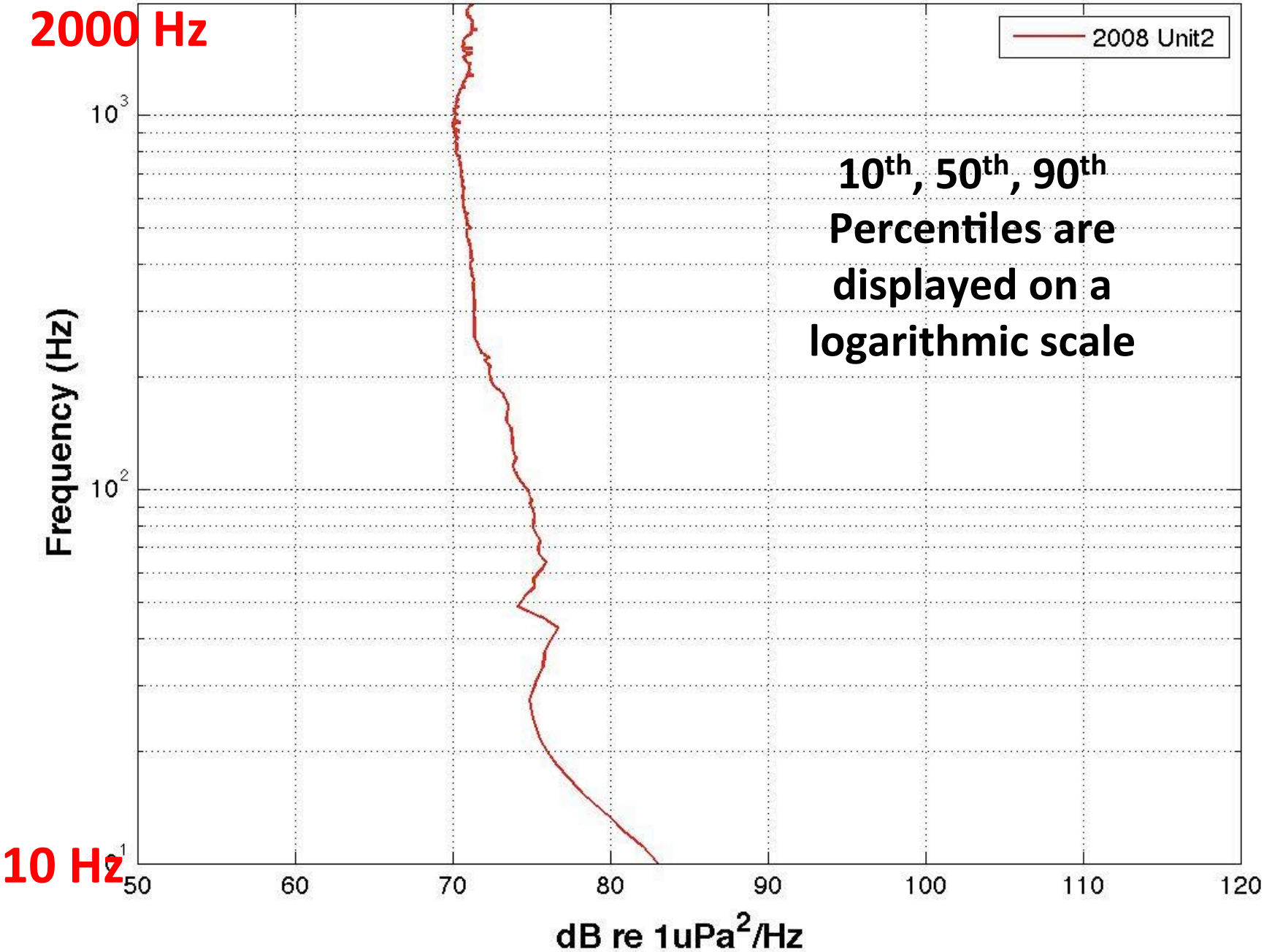
Fish



1-min avg PSD levels were analzyed

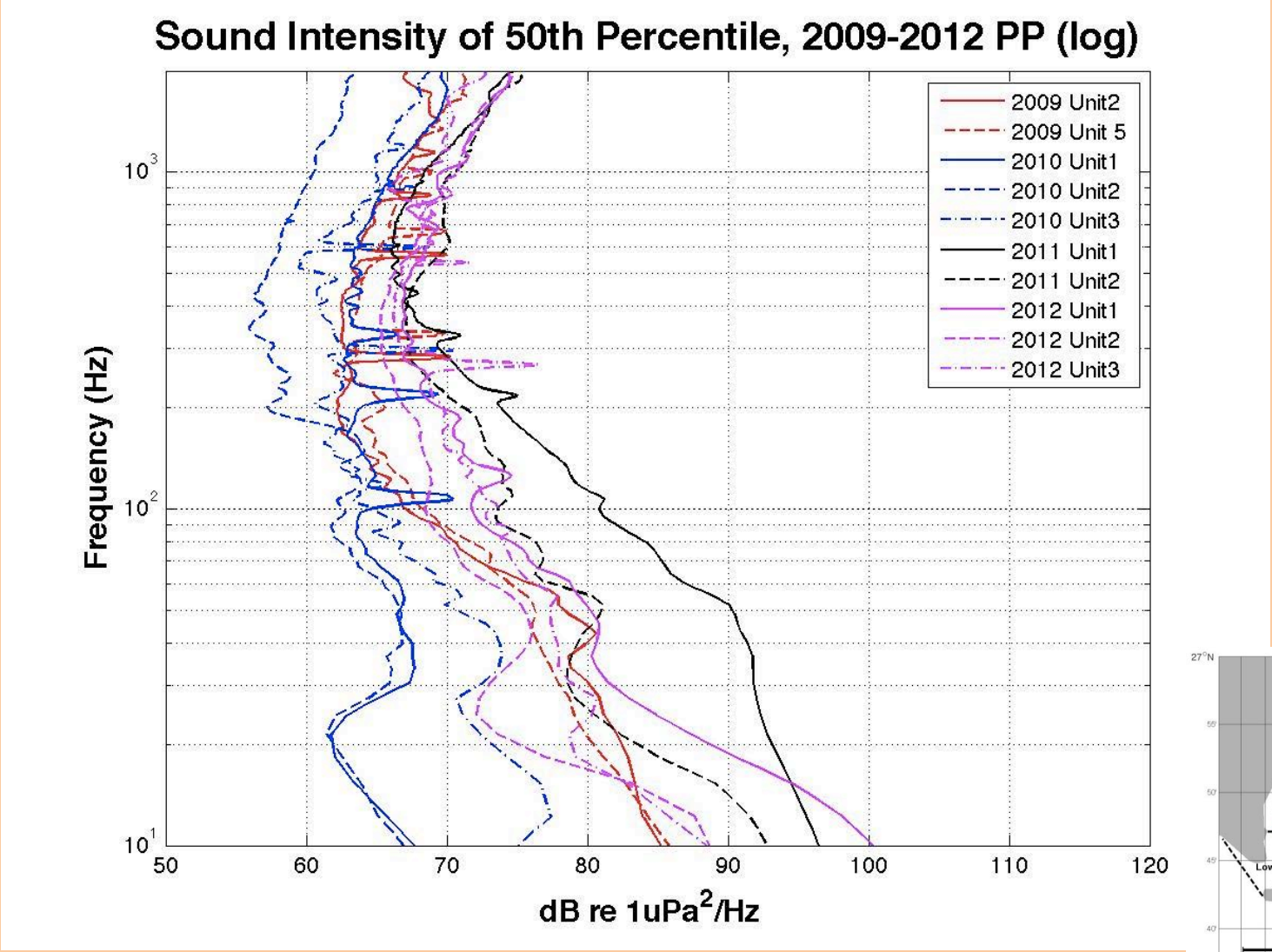


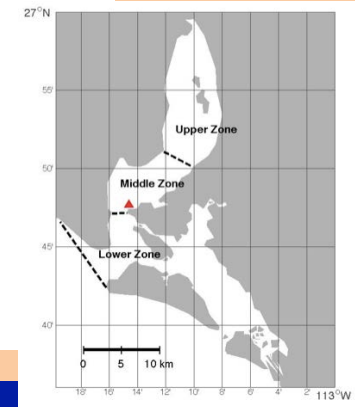
Sound Intensity of 90th Percentile, 2008 (log)



Results I: Final outputs as log percentile plots (allows comparison across years & units)

Goal: Any unit malfunction that would discard it from analysis?





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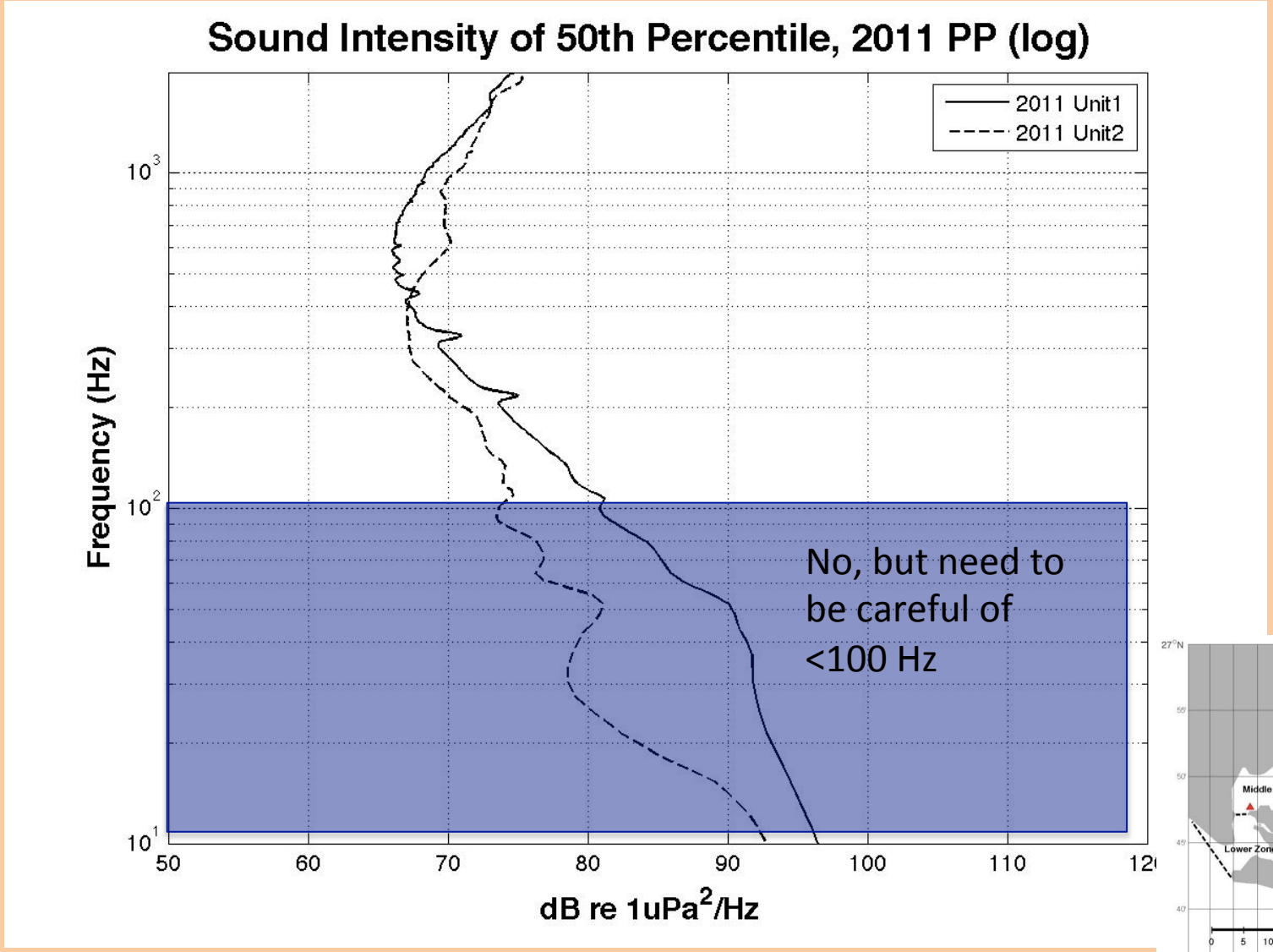
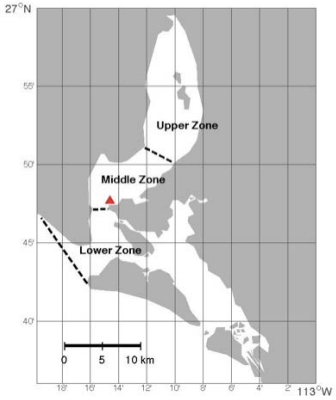




Results I: Final outputs as log percentile plots (allows comparison across years & units)

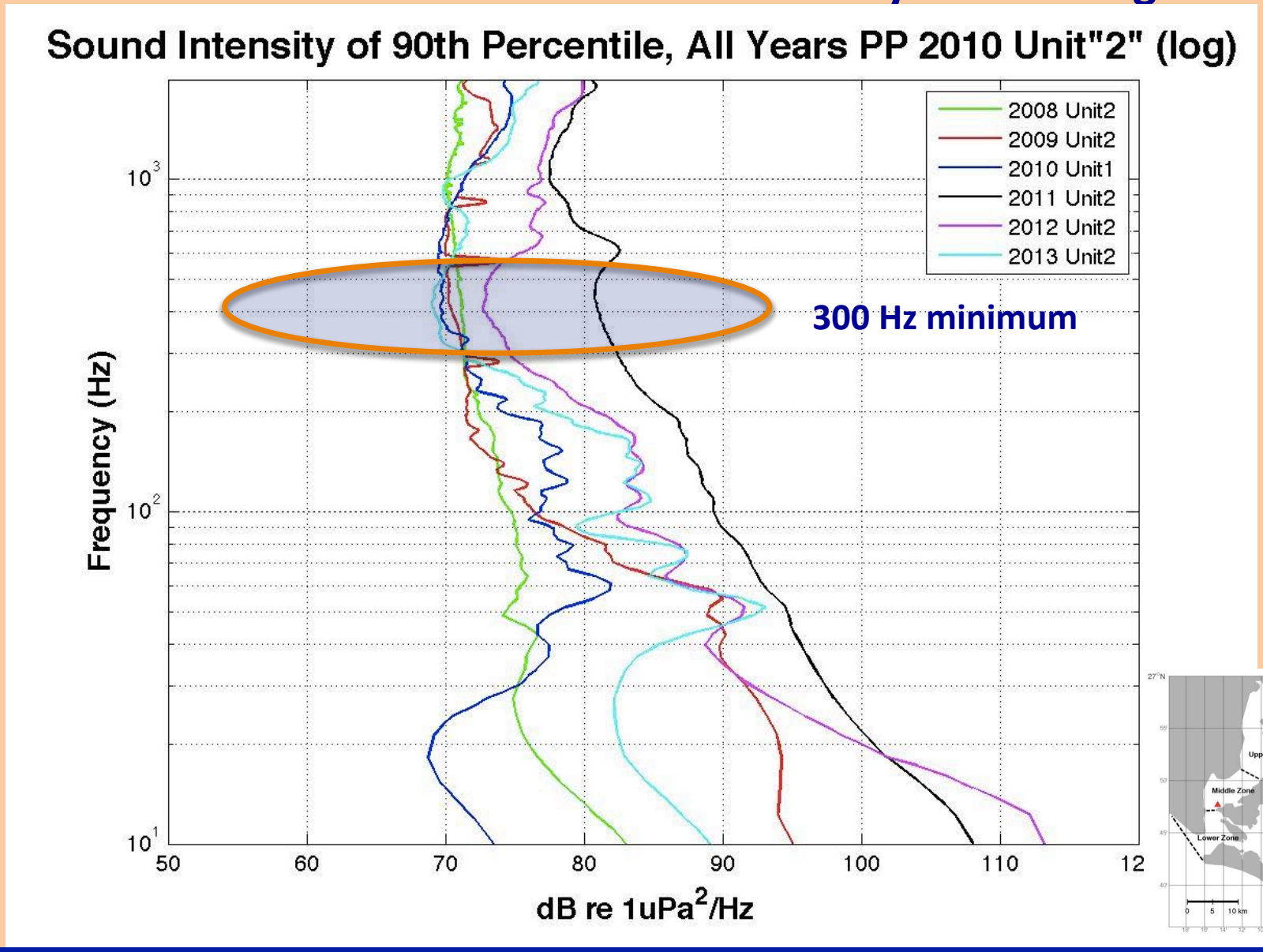
Conclusion:

- Units in good agreement >100 Hz
- Explanation: differences because of bottom deployment

(plant rubbing, burial, tidal flow, etc.)

Results II: Multi-year comparison in Transit Zone

Goal: How does the acoustic environment vary 2008 though 2013?

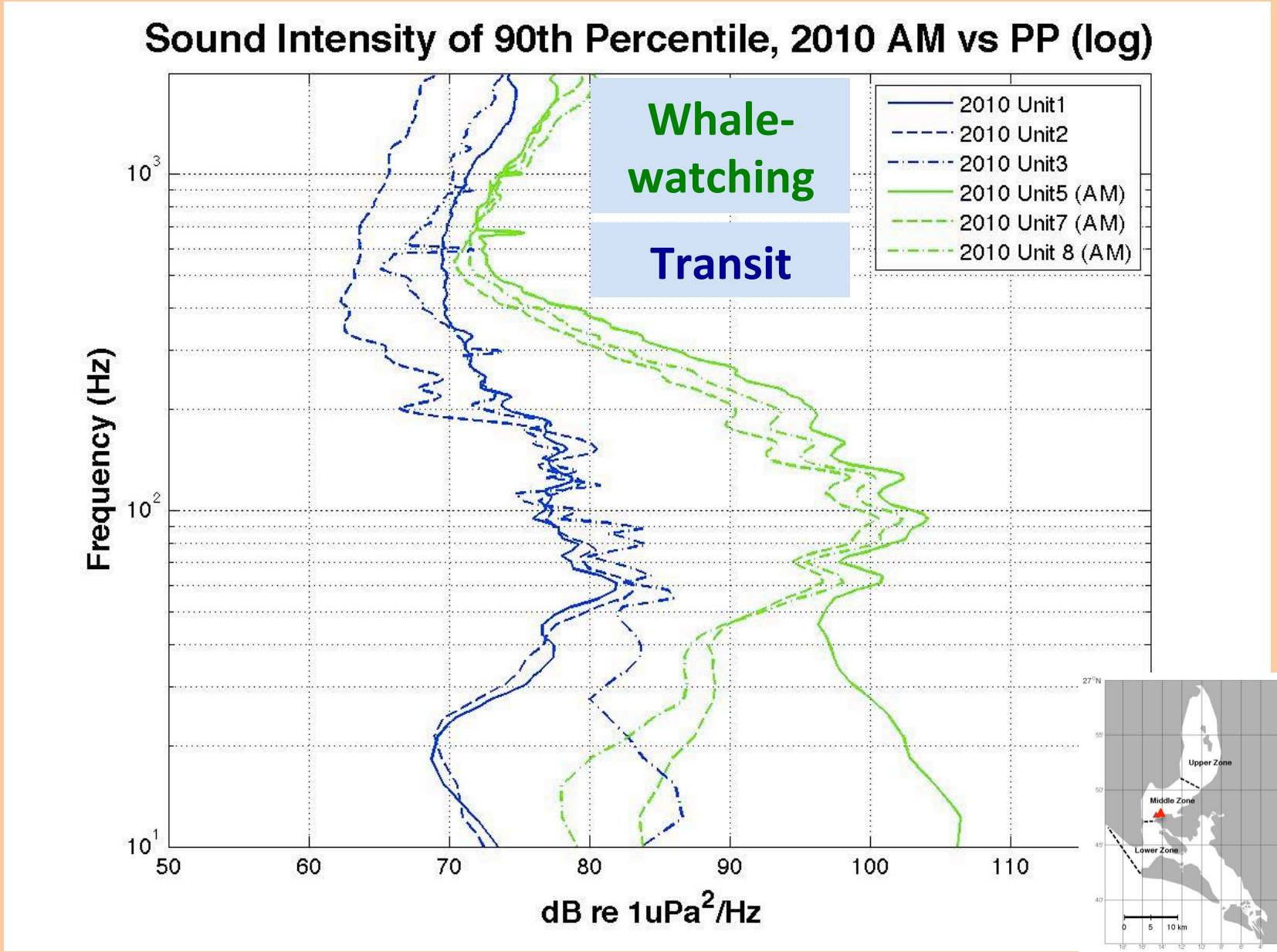


Results II: Multi-year comparison in Transit Zone

Conclusions:

- The "Transit Zone" is a stable acoustic environment
- Noise minimum around 300 Hz ("acoustic spectral niche"→ Dahlheim)

Results III: 2010 “Whale-watching” vs “Transit” Zones



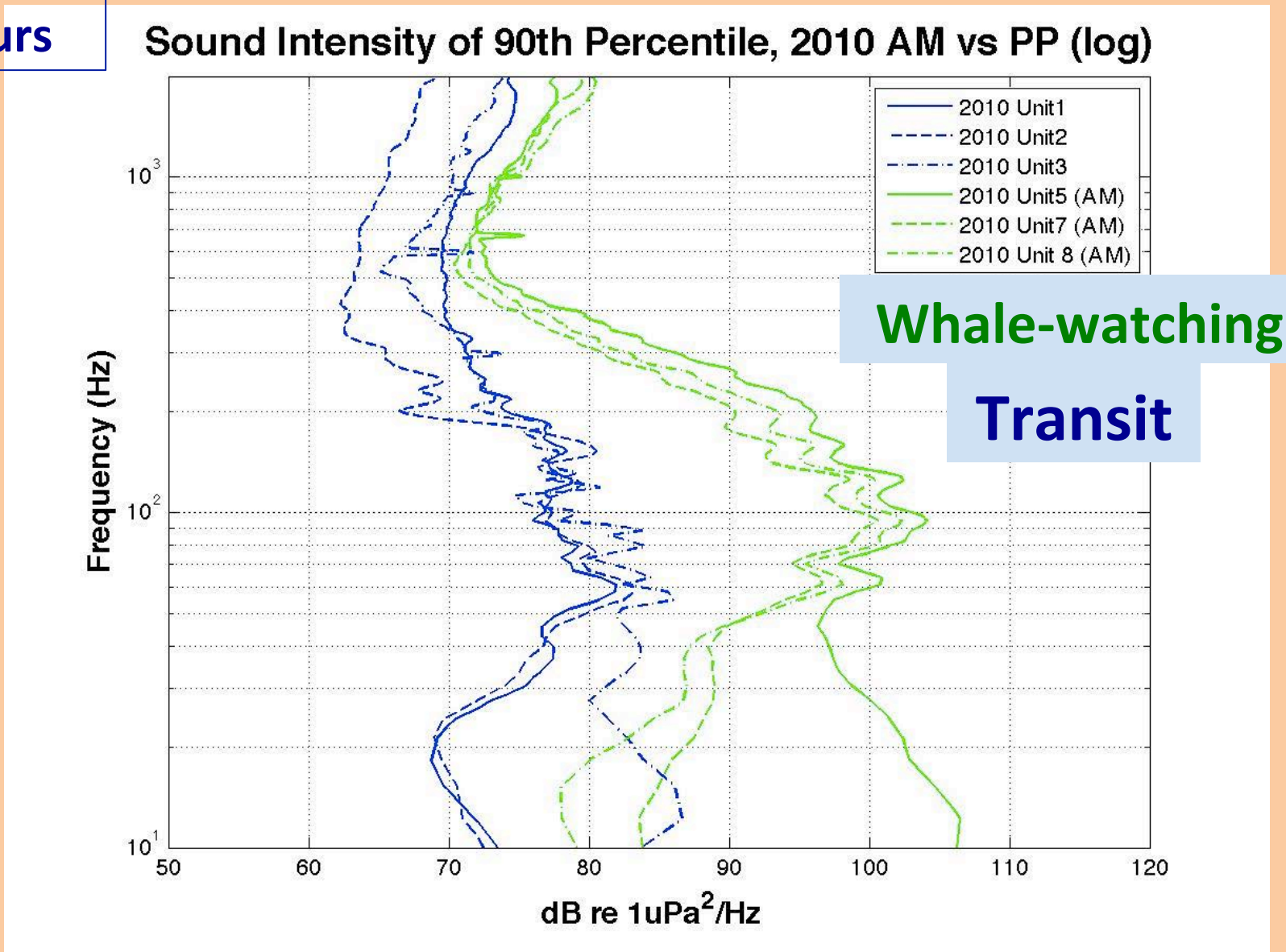
Results III: 2010 “Whale-watching” vs “Transit” Zones

Conclusion:

- Whale-watching zone “louder” than Transit zone <500 Hz in 90th percentile

Results III: (DIEL) Whale-watching pangas possible mechanism?

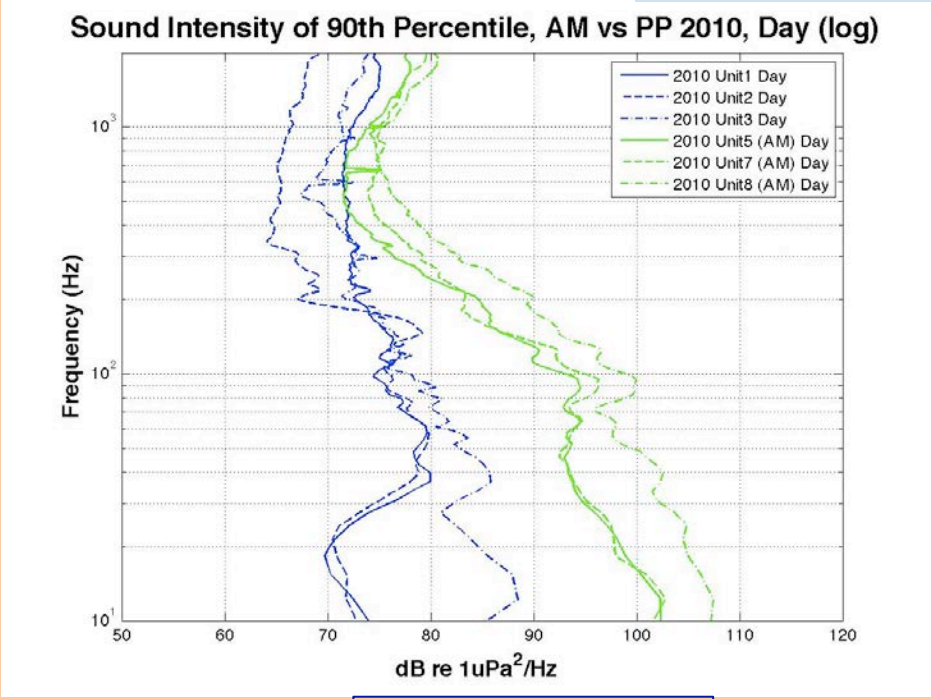
24 hours

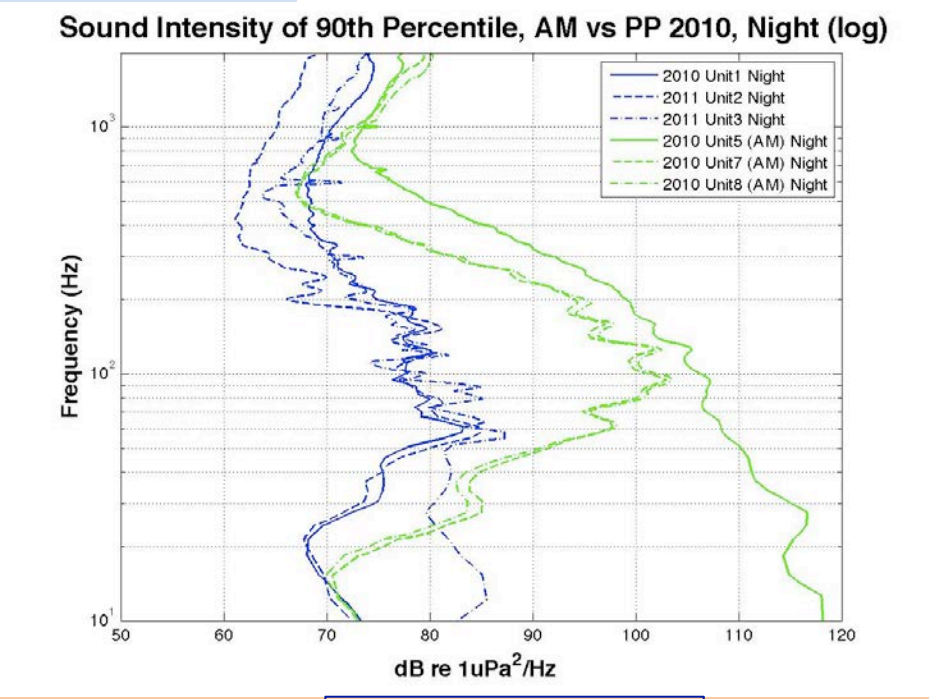


Results III: (DIEL) Whale-watching pangas possible mechanism?

Transit

Whale-watching





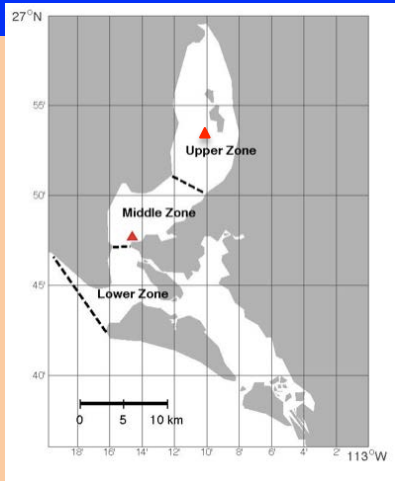
0600-1800	1800-0600
DAY	***NIGHT***

Results III: (DIEL) Whale-watching pangas possible mechanism?

Conclusions:

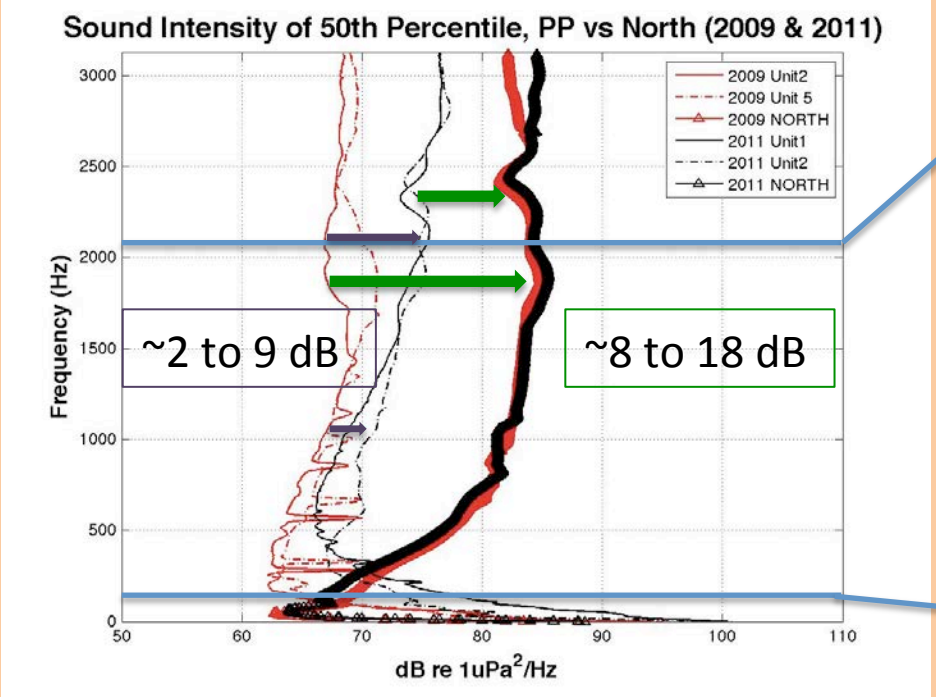
- Night ~6 dB “louder” than day 100-1000 Hz
  - Pangas unlikely mechanism

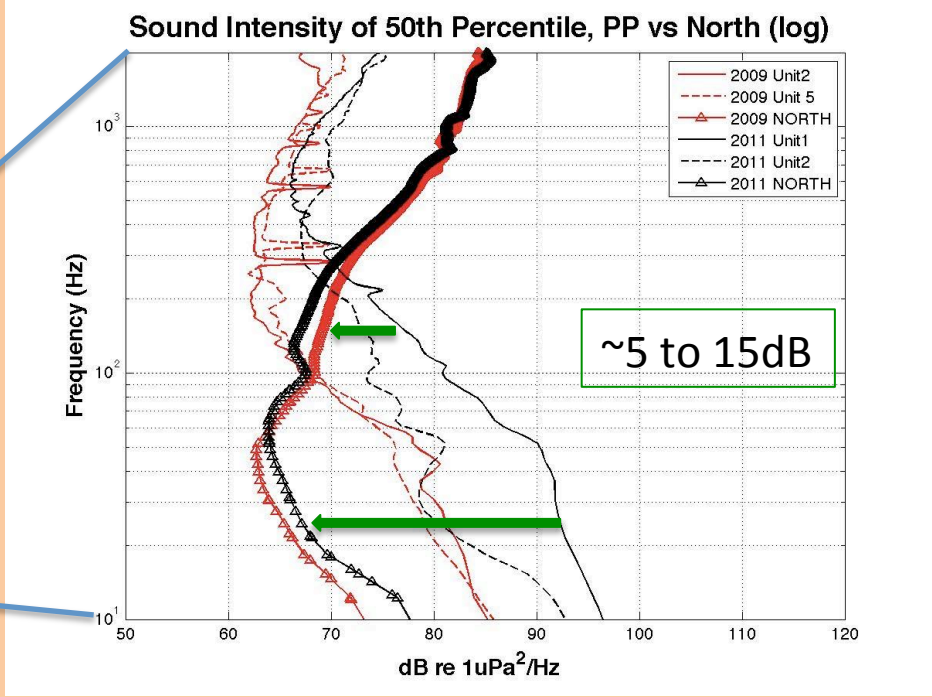
Results IV: 2009&2011 "Transit" vs "Restricted" Zones



2009 transit/**restricted**

2011 transit/**restricted**





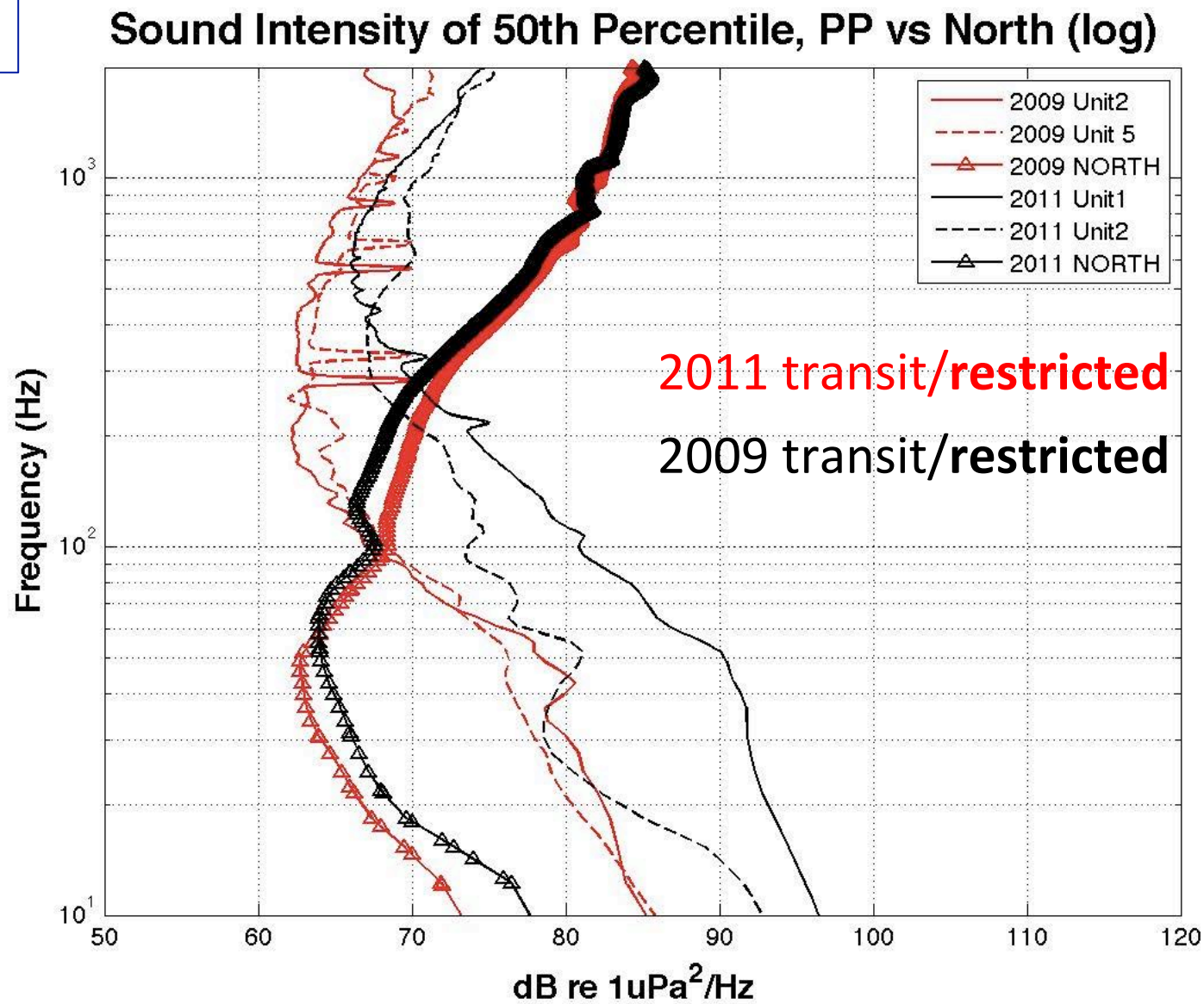
Results IV: 2009&2011 “Transit” vs “Restricted” Zones

Conclusions:

- Restricted zone (“nursery”) has a higher PSD than Transit zone >300 Hz

Results IV: (DIEL) Frequency dependence different day/night?

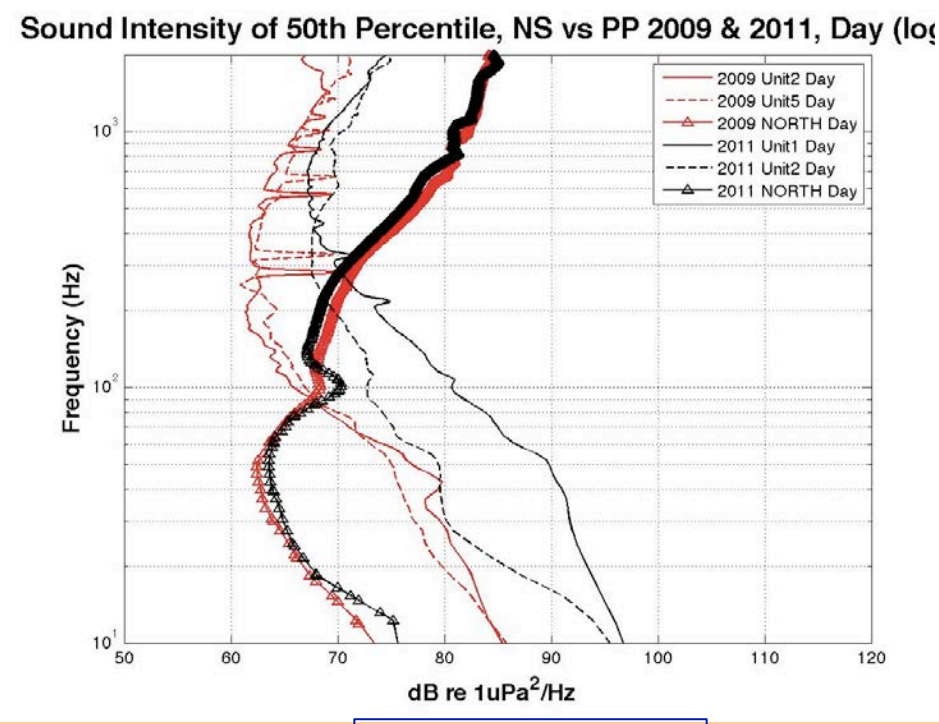
24 hours

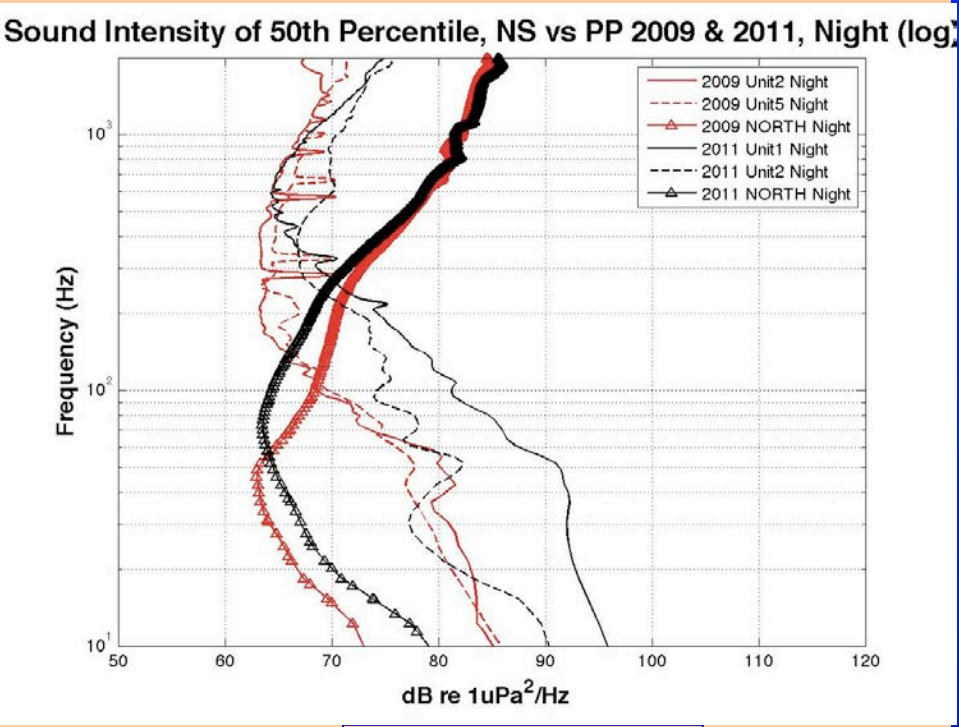


Results IV: (DIEL) Frequency dependence different day/night?

2009 transit/**restricted**

2011 transit/**restricted**





0600-1800
DAY

1800-0600
NIGHT

Results IV: (DIEL) Frequency dependence different day/night?

Conclusion:

- No discernible difference between day and night

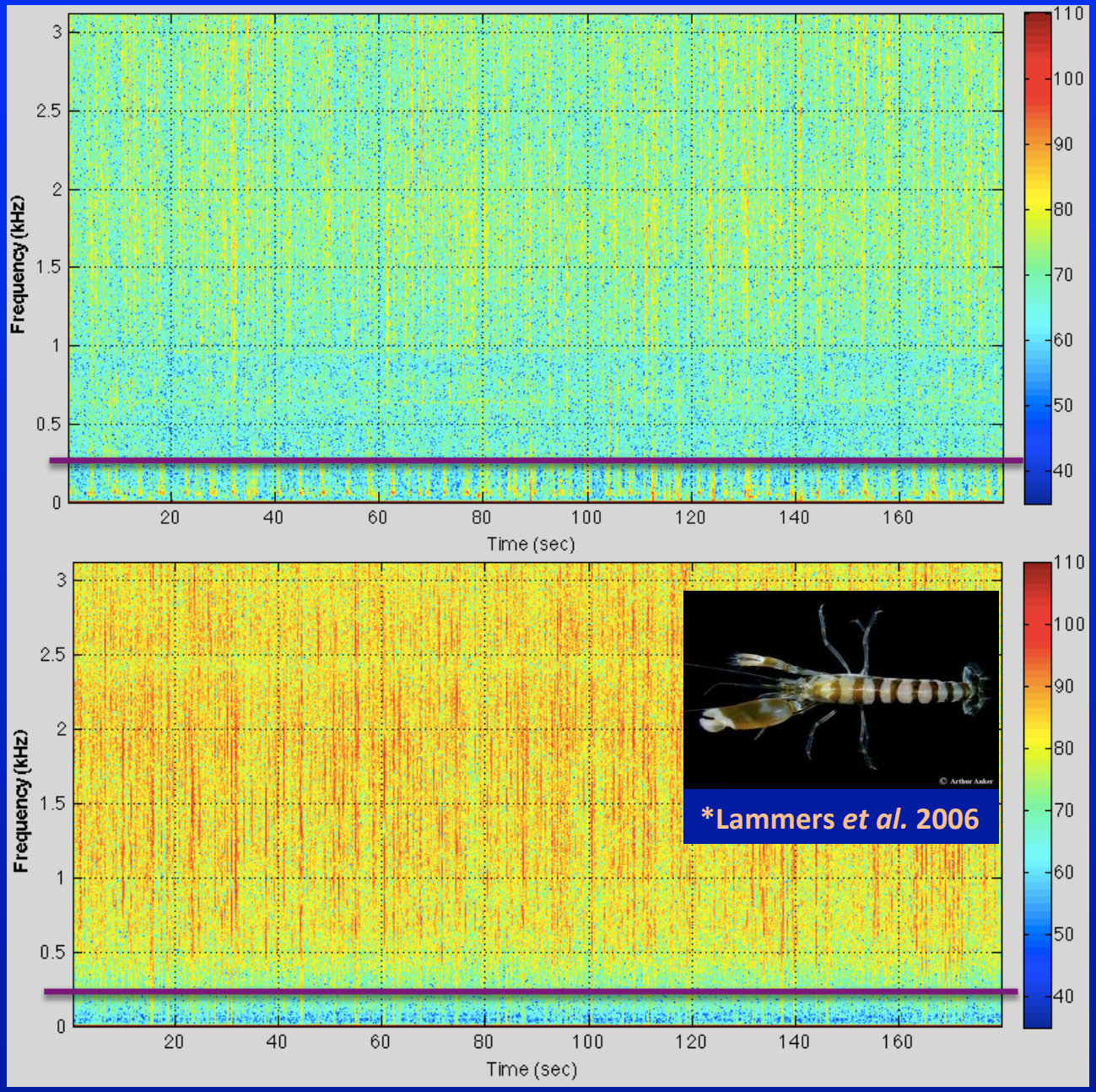
Results IV: Why is the "nursery" louder?

"Transit Zone" (singles)

Feb 27, 2009
17:58:28

Min dB: 35
dB spread: 75
FFT size: 1024
% overlap: 90

"Restricted Zone" (nursery)



Overall Conclusions

I. **Units in good agreement >100 Hz across years**

II. **Signs that all zones are stable across years**

- **Noise minimum ~300 Hz in <u>Transit</u> and <u>Whale-watching</u> zones (acoustic niche per Dahlheim)**
- **No minimum in Restricted zone (50 Hz → negligible)**
- **Results <100 Hz not reliable**

III. **<u>Transit</u> and <u>Whale-watching</u> zones differ <500 Hz in 90th percentile**

- ***Night* has higher PSD than *day* between 100-1000 Hz**
- **Pangas unlikely source**

IV. **<u>Restricted</u> zone "louder" than <u>Transit</u> zone >300 Hz**

- ***Transit* zone has higher PSD than *Restricted* zone <300 Hz**
- **No difference in day vs. night**

Current Impressions

Lagoon is naturally "loud"

- Gets louder >300 Hz further from the mouth
- Mechanism likely biological (snapping shrimp)

A "gray" perception?

Anthropogenic sources not seemingly dominant

- But what about the future?
- This data provides baseline

Thank You

Laguna San Ignacio ecosystem science program
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Alexa Hasselman
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telcel M.R.

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Questions?