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*

Breed/birth: Baja or East Asia

Feed: coastal Alaska/Russia

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Background (geography): *Laguna San Ignacio*

NURSERY

SINGLES/MATING

RESTRICTED

TRANSIT

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 $\rightarrow$ each year for 6 years
- Whale-watching zone $\rightarrow$ 1 year
- Restricted zone $\rightarrow$ 2 years

*1 to 3 recorders each year for each zone*

<table>
<thead>
<tr>
<th>Year</th>
<th>“Transit Zone”</th>
<th>Depth</th>
<th>“Restricted Zone”</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>1 (Feb 9 – Mar 8)</td>
<td>13 m</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>2009</td>
<td>2 (Feb 13 – Mar 22)</td>
<td>11 m</td>
<td>1 (Feb 15 – Mar 12)</td>
<td>5 m</td>
</tr>
<tr>
<td>2010</td>
<td>6 (Feb 6 – Mar 4)</td>
<td>10 m</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>2011</td>
<td>2 (Feb 5 – Mar 7)</td>
<td>12 m</td>
<td>1 (Feb 6 – Mar 9)</td>
<td>5 m</td>
</tr>
<tr>
<td>2012</td>
<td>3 (Feb 11 – Mar 10)</td>
<td>11 m</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>2013</td>
<td>1 (Feb 18 – Mar 6)</td>
<td>12 m</td>
<td>0</td>
<td>n/a</td>
</tr>
</tbody>
</table>

* “Whale-watching Zone” in 2010 from Feb 6 - Mar 4 at 5 m deep
Previous work shows distinct sound sources for different marine species:

- **Snapping shrimp**
- **Grey whales**
- **Pangas**
- **Fish**

**Time (sec)**

- **3.128 kHz**
- **2.5 kHz**
- **2 kHz**
- **1.5 kHz**
- **1 kHz**

**March 2009, 09:29:12**


1-min avg PSD levels were analyzed.
Sound Intensity of 90th Percentile, 2008 (log)

10th, 50th, 90th Percentiles are displayed on a logarithmic scale.
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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Goal: Any unit malfunction that would discard it from analysis?

No, but need to be careful of <100 Hz
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?

Sound Intensity of 90th Percentile, All Years PP 2010 Unit"2" (log)

Frequency (Hz)

dB re 1uPa²/Hz

300 Hz minimum
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
Conclusion:

- Whale-watching zone “louder” than Transit zone <500 Hz in 90th percentile
Results III: (DIEL) Whale-watching pangas possible mechanism?

24 hours

Sound Intensity of 90th Percentile, 2010 AM vs PP (log)

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

**Transit**

**Whale-watching**

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**Sound Intensity of 90th Percentile, AM vs PP 2010, Day (log)**

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

**Sound Intensity of 90th Percentile, AM vs PP 2010, Night (log)**

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

Approximate Sound Intensity Differences:
- 2009: ~2 to 9 dB
- 2011: ~8 to 18 dB
- ~5 to 15 dB
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?

Sound Intensity of 50th Percentile, PP vs North (log)

2009 transit/restricted

2011 transit/restricted
Results IV: (DIEL) Frequency dependence different day/night?

2009 transit/restricted
2011 transit/restricted
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)

*Lammers et al. 2006
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 Transit and Whale-watching zones (acoustic niche per Dahlheim)
   - No minimum in Restricted zone (50 Hz → negligible)
   - Results <100 Hz not reliable

III. Transit and Whale-watching zones differ <500 Hz in 90th percentile
   - Night has higher PSD than day between 100-1000 Hz
   - Pangas unlikely source

IV. Restricted zone “louder” than Transit zone >300 Hz
   - Transit zone has higher PSD than Restricted zone <300 Hz
   - No difference in day vs. night
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

Questions?

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Delphine Mathias
Sergio Martinez
Liria Del Monte
Alejandro Gomez Gallardo
Ludovic Tenorio
Alexa Hasselman
All past LSI visual teams