Acoustic characterization of pelagic fish distribution across the Southern Pacific Ocean

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Introduction
Mesopelagic fish belong to the mid-trophic level functional group in the marine ecosystem, and they are a key component of oceanic food web, linking primary and tertiary consumers. Despite their ecological relevance, little is known about the distribution patterns of mesopelagic fishes (Young et al. 2001), and there is a strong demand for more research on ocean-biogeochemical-population (Lehodey 2004) and ecosystem (Kloster et al. 2009, Handegard et al. 2012) models. Fisheries acoustics provides a suitable tool for monitoring mesopelagic fish abundance and distribution (Simmonds & MacLennan 2005). Using acoustics from vessels of opportunity may provide the best chance of achieving the ocean basin scale spatial coverage required to inform ecosystem models.

Objectives
1. Identify large-scale patterns of pelagic fish abundance using area backscattering coefficient (sₐ in m⁻² km⁻²) at 38 kHz as a measure of biological abundance across the South Pacific Ocean.
2. Determine the vertical distribution of sₐ.
3. Explore the relationship between distribution of sₐ and environmental and geographic variables to determine the major factors driving pelagic fish distribution.

Methods
Two return trips between New Zealand and Chile in Oct-Dec 2007 and 2010 from RV Kaharoa deploying ARGO buoys. Data collected using a Simrad ES60 echosounder with hull-mounted 38 kHz transducer (2000 W power, 1.024 ms pulse). Analysis software Sonardata Echoview 4.90 and 5.0 (Myriax). Acoustic records integrated in 10 m elementary distance sampling units (EDSU) along the vessel track, and in 50 m depth bins. Maximum data range up to 600 m depth. Boosted regression trees (BRT) were fitted in R (version 2.13.2), using GMB package version 1.6-3.1 plus custom code available online (Elith et al. 2008).

Results
Table 1. Comparison of total acoustic area backscattering coefficient (sₐ) along the 4 transects. EDSU: elementary distance sampling unit size (10 m).

<table>
<thead>
<tr>
<th>Transect</th>
<th>Dates</th>
<th>No. of EDSUs</th>
<th>sₐ (m² km⁻²)</th>
<th>Total Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-2007</td>
<td>04 Oct−28 Oct 2007</td>
<td>563</td>
<td>6373.0</td>
<td>11.3 ± 10.5</td>
</tr>
<tr>
<td>T2-2007</td>
<td>03 Nov−20 Dec 2007</td>
<td>638</td>
<td>7533.6</td>
<td>11.8 ± 11.3</td>
</tr>
<tr>
<td>T1-2010</td>
<td>24 Oct–11 Nov 2010</td>
<td>628</td>
<td>12962.1</td>
<td>22.8 ± 20.0</td>
</tr>
<tr>
<td>T2-2010</td>
<td>19 Nov–21 Dec 2010</td>
<td>699</td>
<td>7930.9</td>
<td>11.4 ± 18.4</td>
</tr>
</tbody>
</table>

Conclusions
The key finding was that there was a strong correlation between chl a and distribution of acoustic backscatter as shown by BRT and spatial overlap (Fig. 2). The process underlying this correlation is likely food availability.

Major vertical patterns of pelagic fish distribution were diet migration and layering.

Major horizontal patterns were coastal intensification and oceanic patchiness, with abundance decreasing from the coasts towards the core of the south tropical gyre.

Different mesopelagic species may have different acoustic properties, so correlation between acoustic backscatter and fish abundance may not be linear. Nevertheless, acoustic information based on total backscatter still provided further valuable knowledge about patterns of distribution and productivity.

There is a growing interest for developing programs focused on global ecosystem models for studying large-scale patterns of distribution and abundance of biota and their changes over long time scales. This study provides data to validate model predictions of mid-trophic functional groups.

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References