The influence of habitat characteristics on toheroa

*Paphies ventricosa*

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Toheroa (*Paphies ventricosa*)

- Endemic to New Zealand
- Main populations in Northland & Southland
- Intertidal zone of exposed sandy beaches
- In sediment to 20–30 cm depth
- Feed during high tide through siphons at the sediment surface
Toheroa in Southland / Murihiku

- At Oreti, Bluecliffs, and Orepuki beaches
- Largest population at Oreti Beach
- Population studies at Oreti Beach since 1960s
- Present population assessment in 2014
Sampling methods

Toheroa population

- Similar sampling as previous studies along 18 km of beach
- Two-phase stratified random transect sampling
- Division into 7 strata
- Randomly-spaced transects in each stratum (toe of the dune to mean low water)
- Total of 40 across-shore transects
Sampling methods
Toheroa population

- Quadrats at 5-m intervals along each transect
- Each quadrat 0.5 m x 0.5 m to 30 cm depth
- All sediment dug up and sorted
- All toheroa counted and measured
- 14 transects sieved on 5-mm mesh to determine number of juveniles
Sampling methods

Habitat characteristics

- Qualitative record of gravel or sand for each quadrat
- Ghost shrimp *Biffarius filholi* abundance for each quadrat via burrow hole count (validated)
- Sediment sampling for grain size and organic content analyses (per stratum)
- Beach profiles (per stratum)
Data analysis
Toheroa population

- Abundance estimates (incl. uncertainty) for juvenile (<40 mm shell length) and large (≥40 mm) toheroa
- For large toheroa: based on each stratum, then summed over all strata
- For juvenile toheroa: based on sieved transects only, across the entire beach
Data analysis
Habitat characteristics

Generalised additive models (GAM) to predict the distribution of toheroa along and across the beach, and to investigate the relationship between:

- toheroa and the presence of gravel,
- toheroa and the number of ghost shrimp burrows,
- toheroa abundance and the influence of sieving.

Poisson model with a log link function:

\[ \text{toheroa} \sim s(\text{distance}) + s(\text{quadrat}) + \text{gravel} + \text{shrimp} + \text{sieved} \]
### Toheroa at Oreti Beach, 2014

#### Estimated population size

<table>
<thead>
<tr>
<th>Site</th>
<th>Size</th>
<th>Mean (No.)</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oreti Beach</td>
<td>Large ≥40 mm</td>
<td>1,395,000</td>
<td>16.2</td>
</tr>
<tr>
<td></td>
<td>Juvenile &lt;40 mm</td>
<td>2,052,000</td>
<td>32.2</td>
</tr>
<tr>
<td></td>
<td>Target ≥100</td>
<td>1,005,000</td>
<td>18.4</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>3,447,000</td>
<td>20.3</td>
</tr>
</tbody>
</table>

#### Toheroa population in 2009

- 1.470 million large toheroa (≥40 mm shell length; CV: 10.0%)
- 6.030 million juvenile toheroa (<40 mm shell length)

(Beentjes 2010)
Distribution of toheroa at Oreti Beach

- Large toheroa ($\geq 40$ mm shell length)
- Juvenile toheroa ($< 40$ mm shell length)
Intertidal distribution of toheroa

Highest densities of:
- large toheroa (≥40 mm) in low intertidal zone,
- juvenile toheroa (<40 mm shell length) in high intertidal zone.
## Habitat characteristics at Oreti Beach

### Quadrats containing gravel

<table>
<thead>
<tr>
<th>Stratum</th>
<th>No. quadrats</th>
<th>Gravel (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>234</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>202</td>
<td>62</td>
</tr>
<tr>
<td>3</td>
<td>169</td>
<td>49</td>
</tr>
<tr>
<td>4</td>
<td>168</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>206</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>262</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>452</td>
<td>34</td>
</tr>
</tbody>
</table>
Oreti Beach ghost shrimp distribution

Number of burrow holes

Number of ghost shrimp to number of burrow openings: 0.5 - 2.3.
## Relationship between toheroa, ghost shrimp, and gravel

### Generalised Additive Model - summary of coefficients

<table>
<thead>
<tr>
<th>Toheroa size</th>
<th>Covariate</th>
<th>Estimate</th>
<th>SE</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>Ghost shrimp</td>
<td>-0.00</td>
<td>0.02</td>
<td>0.8944</td>
</tr>
<tr>
<td></td>
<td>Gravel</td>
<td>0.10</td>
<td>0.24</td>
<td>0.6791</td>
</tr>
<tr>
<td></td>
<td>Sieved</td>
<td>-0.13</td>
<td>0.18</td>
<td>0.4819</td>
</tr>
<tr>
<td>Juvenile</td>
<td>Ghost shrimp</td>
<td>-0.19</td>
<td>0.09</td>
<td>0.0439</td>
</tr>
<tr>
<td></td>
<td>Gravel</td>
<td>-2.07</td>
<td>0.37</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Sieved</td>
<td>1.28</td>
<td>0.25</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Summary

• Population of large toheroa at Oreti Beach appeared stable

• Smaller juvenile population at Oreti Beach in 2013–14 than in 2009 (1.9 M c.f. 6.0 M)

• Occurrence of gravel at Oreti Beach

• Some evidence of an antagonistic interaction at Oreti Beach between gravel, ghost shrimp, and juvenile toheroa
Acknowledgments

Thanks to:

- local iwi and communities who shared their knowledge of the beaches,
- the field assistants who helped conduct the toheroa survey.

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