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
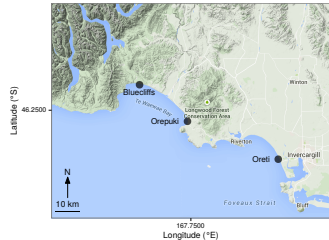
Sampling methods

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

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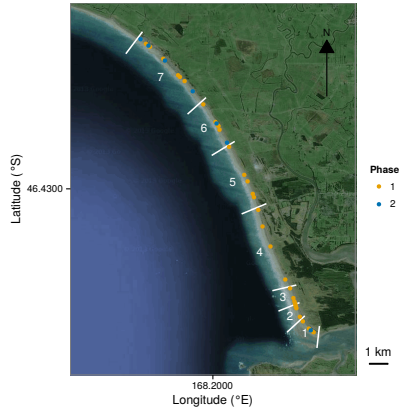
Sampling methods

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

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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)

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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

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:

$$toheroa \sim s(distance) + s(quadrat) + gravel + shrimp + sieved$$

Toheroa at Oreti Beach, 2014

Estimated population size

| Site	Size	Mean (No.)	CV (%)
Oreti Beach	Large ≥40 mm	1 395 000	16.2
	Juvenile <40 mm	2 052 000	32.2
	Target ≥100	1 005 000	18.4
	All	3 447 000	20.3

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)
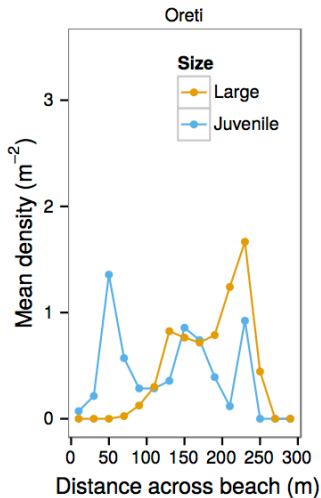
(Beentjes 2010)

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Distribution of toheroa at Oreti Beach

- Large toheroa
  （≥40 mm shell length）

- Juvenile toheroa
  （<40 mm shell length）

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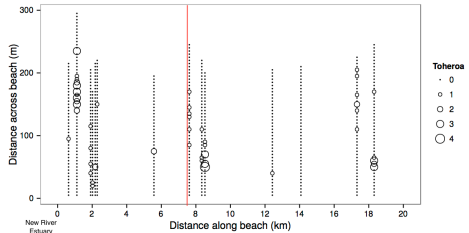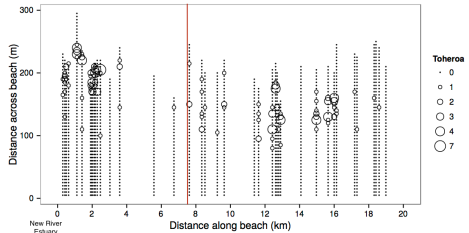
Intertidal distribution of toheroa

Highest densities of:

- large toheroa ($\geq 40\,\text{mm}$) in low intertidal zone,

- juvenile toheroa ($< 40\,\text{mm}$ shell length) in high intertidal zone.

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Habitat characteristics at Oreti Beach

Quadrats containing gravel

Stratum	No. quadrats	Gravel (%)
1	234	0
2	202	62
3	169	49
4	168	8
5	206	0
6	262	11
7	452	34

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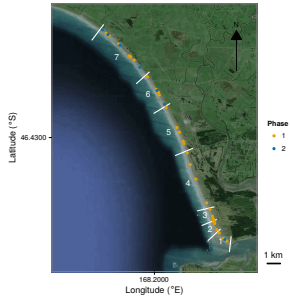
Oreti Beach ghost shrimp distribution

Number of burrow holes

Number of ghost shrimp to number of burrow openings: 0.5 - 2.3.

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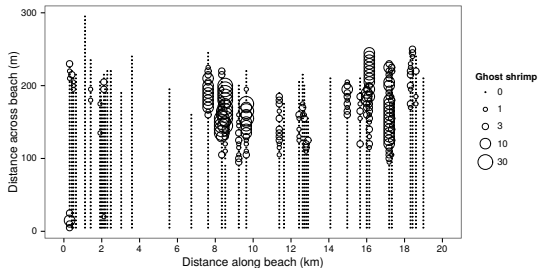
Relationship between toheroa, ghost shrimp, and gravel

Generalised Additive Model - summary of coeffcients

Toheroa size	Covariate	Estimate	SE	*P* value
Large	Ghost shrimp	-0.00	0.02	0.8944
	Gravel	0.10	0.24	0.6791
	Sieved	-0.13	0.18	0.4819
Juvenile	Ghost shrimp	-0.19	0.09	0.0439
	Gravel	-2.07	0.37	<0.001
	Sieved	1.28	0.25	<0.001

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

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Acknowledgments

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- local iwi and communities who shared their knowledge of the beaches,
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