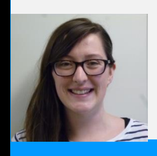
Otolith shape: a novel method to discriminate populations of the migratory galaxiid *Galaxias maculatus* (inanga)?



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Background

- *Galaxias maculatus* is amphidromous (Figure 1)
- Juveniles form the basis of New Zealand's whitebait fishery
- Marine larval development is poorly understood
- Consequently the fishery is managed as an homogeneous entity
- Growing concern of population decline
- Larval population dynamics must be understood for conservation and management

Otolith Shape

- Otolith shape = genetics + environment (temperature, feeding history, growth rates)
- Used as a population discrimination tool (e.g. sprat, herring, anchovy)
- Geometric approach:
  1. Shape indices (ratio of otolith dimensions)
  2. Elliptical Fourier coefficients (EFcs) (describes outline trajectory)

Figure 1. Life cycle of *Galaxias maculatus*

1. Adults sexually mature in freshwater
2. Eggs develop in riparian vegetation for 20 days
3. Hatchlings are washed out to sea and develop in the marine environment for 3-6 months
4. Juveniles recruit back to lowland coastal streams completing their lifecycle

Size parameters	Size based shape indices
Area (A)	Roundness (Rnd) = $(4A)/(\pi OL^2)$
Perimeter (P)	Rectangularity (Rec) = A/(OL x OW)
Otolith Length (OL)	Aspect ratio (Ar) = OL/OW
Otolith Width (OW)	Ellipticity (Ell) = (OL-OW)/(OL+OW)

Table 1. Shape indices used in analysis

Key Questions

1. Are larval populations of Inanga homogenous throughout their distribution?
2. Can otolith shape be used to discriminate populations?

Methods

- Whitebait collected September 2013
- 3 sites in both Bay of Plenty and Buller (Figure 2)
- 45-55mm TL fish used in analysis (n=52)
- Left sagitta photographed using dark field microscopy
- Sagitta measured, shape indices calculated (Table 1) and corrected for otolith length
- 10 EF harmonics generated in SHAPE v1.3

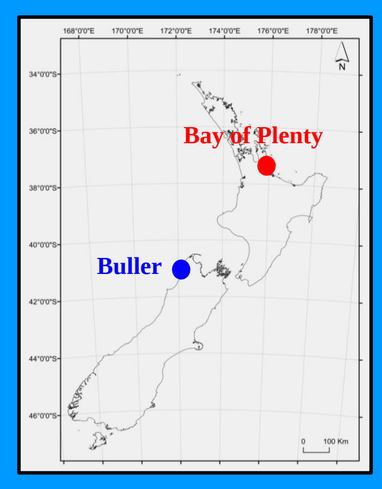
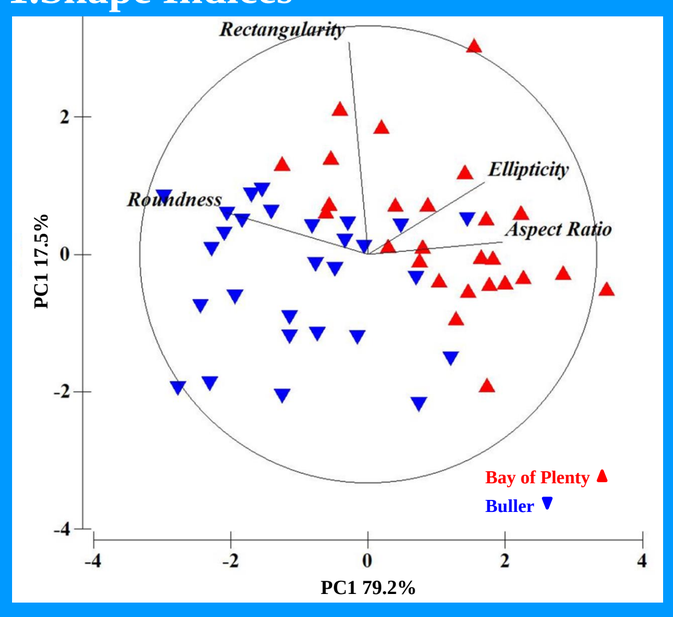


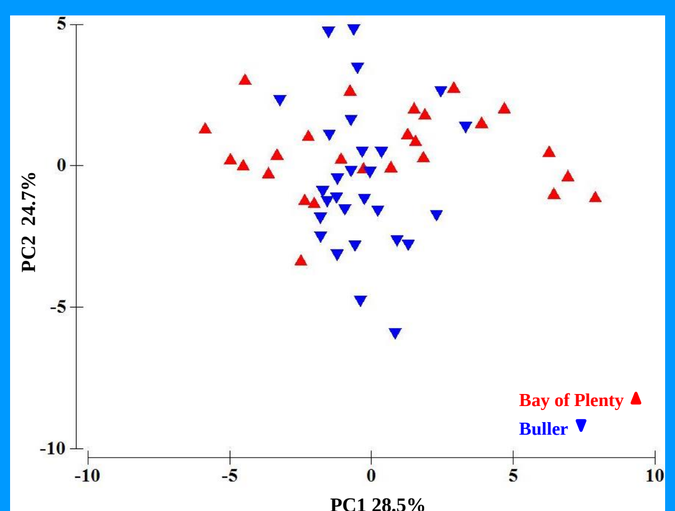
Figure 2. Whitebait collection sites

Results

1.Shape Indices



2. Elliptical Fourier coefficients



1. Shape Indices

- Indices (Rnd, Ar and Ell) significant (ANOVA, $p<0.001$)
- Three PCs explain 99% variation
- Regional grouping evident, (PERMANOVA $p=0.001$)

2. Elliptical Fourier coefficients

- 17 PCs required to explain 90% variation
- No regional grouping evident (PERMANOVA $p=0.073$)

Conclusions

- Results infer larval populations at sea may be separate components and large scale mixing is not occurring
- Otolith shape differences may reflect genetic or environmental history
- Greater spatial and temporal resolution required
- Potentially a valuable tool for discrimination of Inanga populations