Can otolith shape discriminate between populations of a widely dispersing galaxiid?

Eimear Egan, Mike Hickford, John Quinn & David Schiel

Background

- *Galaxias maculatus* is amphidromous (Figure 1)
- Juveniles form the basis of New Zealand's whitebait fishery (Figure 2)
- Marine larval development is poorly understood
- Consequently populations are managed as homogeneous entities
- Growing concern of population decline
- Population dynamics must be understood for conservation and management

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

Figure 2. Whitebaiter with his catch

Otolith Shape

- Product of genetics + environment (temperature, feeding history, growth rates)
- Stock discrimination tool (e.g. Baltic cod, herring)
- Geometric approach:
  1. Shape indices (ratio of otolith dimensions)
  2. Elliptical Fourier coefficients (EFcs) (outline trajectory)

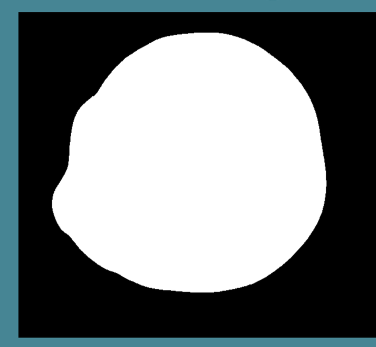

Figure 3. Binarised otolith

Hypotheses

H_0: Populations of *Galaxias maculatus* are homogeneous
H_0: Otolith shape is not different between populations

Methods

- Whitebait collected September 2013
- 3 sites in both Bay of Plenty and Buller (Figure 4)
- 45-55mm TL fish used in analysis (n=52)
- Left sagitta photographed using dark field microscopy
- Sagitta measured and shape indices corrected for otolith length (Table 1)
- 10 EF harmonics generated in SHAPE v1.3*

Table 1. Shape indices used in analysis

Size parameters	Size based shape indices
Area (A)	Roundness (Rnd) = (4A)/(πOL²)
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)

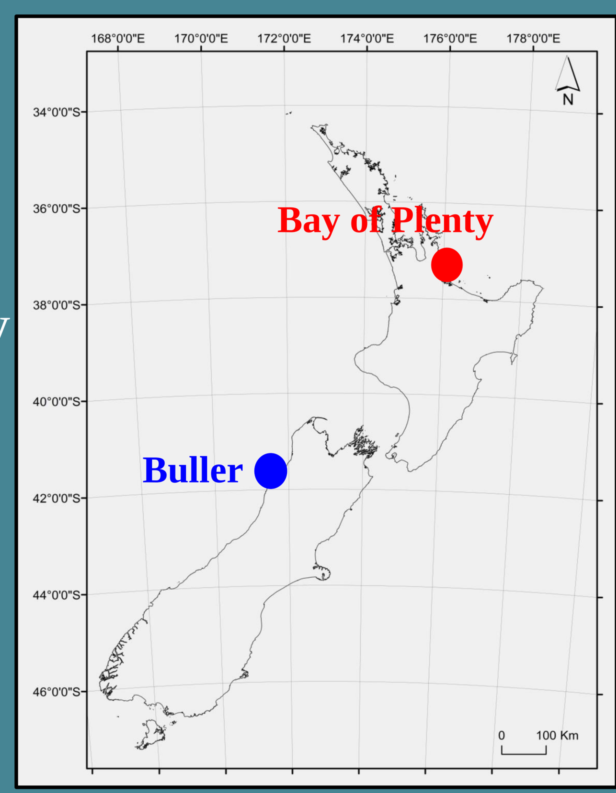

Figure 4. Whitebait collection sites in New Zealand

Results

1. Shape indices

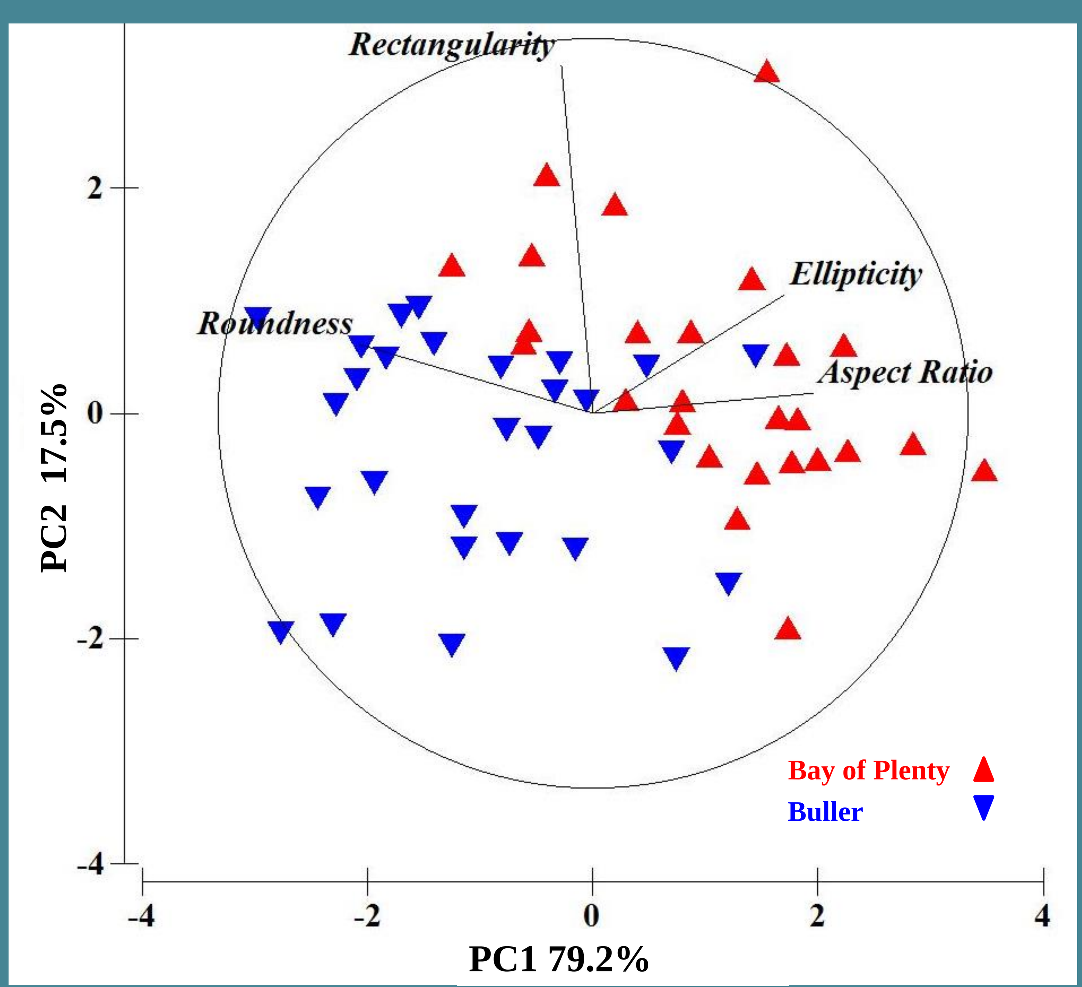

Figure 5. Principal component analysis of shape indices

2. Elliptical Fourier coefficients

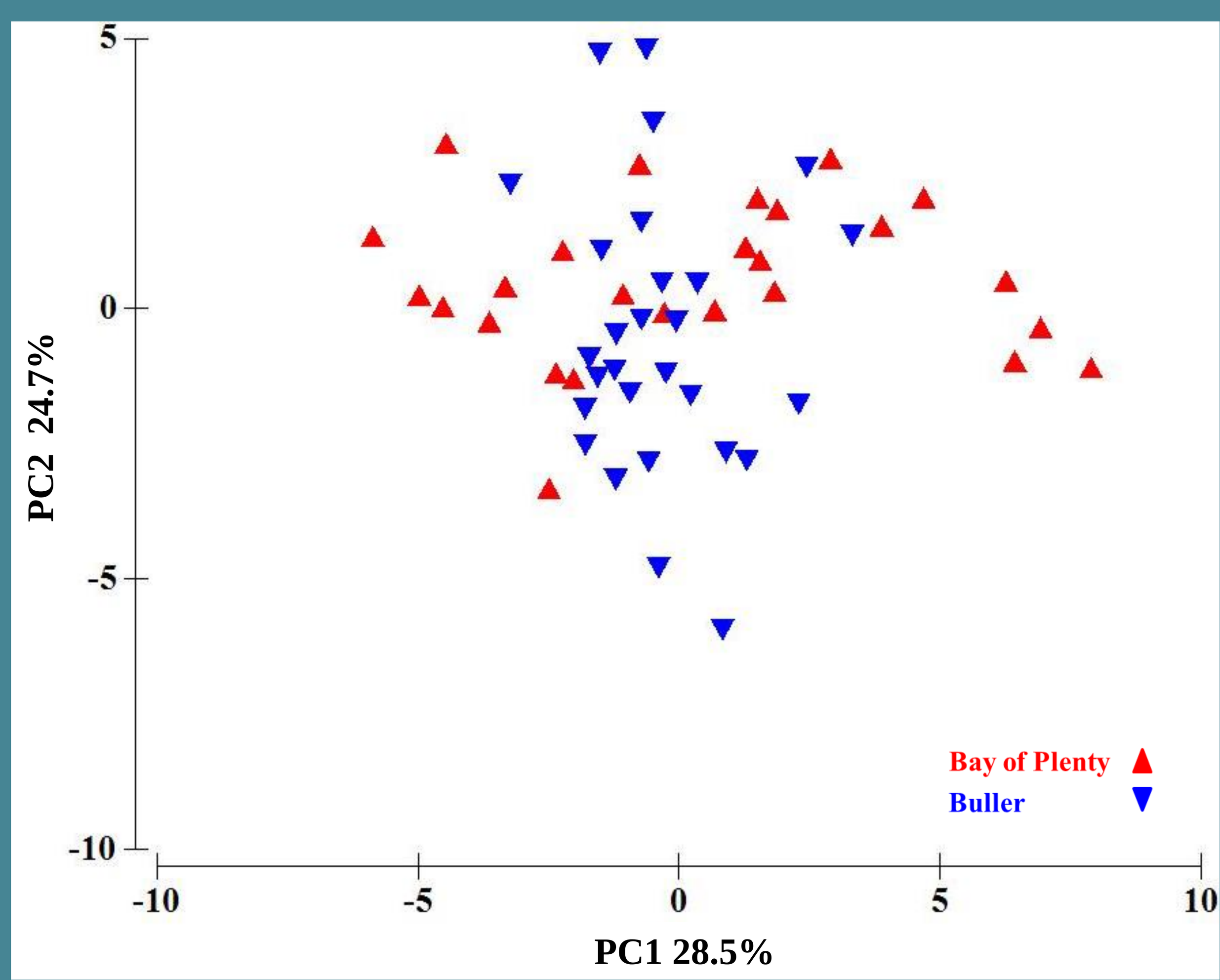

Figure 6. Principal component analysis of Elliptical Fourier coefficients

1. **Shape Indices**
   - Indices (Rnd, Ar and Ell) significant (ANOVA, $p<0.001$)
   - Three PCs explain 99% variation
   - Regional grouping, (PERMANOVA $p=0.001$)
2. **Elliptical Fourier coefficients**
   - 17 PCs required to explain 90% variation
   - No regional grouping evident (PERMANOVA $p=0.073$)

Conclusions

- Otolith shape indices are different between populations, but EFcs are not
- Greater spatial and temporal resolution needed
- Differences may reflect genetic or environmental history
- Shape differences may be related to growth rates at sea (Figure 7)
- Ontogeny must be accounted for
- Potentially a valuable tool for discrimination of *Galaxias maculatus* populations

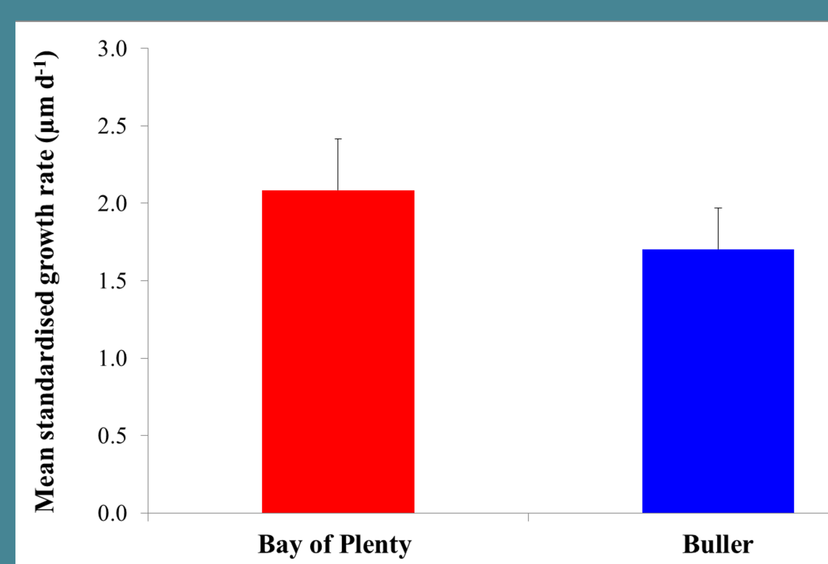

Figure 7. Mean standardised growth rate (μmd⁻¹)

References
* Iwata, H. and Y. Ukai (2002) SHAPE: A computer program package for quantitative evaluation of biological shapes based on elliptic Fourier descriptors. Journal of Heredity 93: 384-385