

Supplementary Material. Summary of results of hierarchical time series cluster analysis used to test for similarities in otolith Sr:Ca chronologies among Tidewater Goby (*Eucyclogobius newberryi*) and Prickly Sculpin (*Cottus asper*) individuals. Analyses were implemented in the 'dtwclust' package in the R statistical computing environment (Sardá-Espinosa 2019a,b). The approach is based on shape-based time-series clustering and utilizes the Dynamic Time Warping (DTW) distance as dissimilarity measure. According to Sardá-Espinosa (2019a,b), DTW is based on the cross correlation with coefficient normalization sequence between two series, and is thus sensitive to scale, which facilitates z - normalization. Cluster validity indices implemented in package 'dtwclust' include the Silhouette index, Dunn index, COP index, Davies-Bouldin index, Modified Davies-Bouldin index, Calinski-Harabasz index, and Score Function index (see Sardá-Espinosa 2019a,b and references therein). Overall, results suggested little similarity in Sr:Ca chronologies among individuals of each species. Six of seven cluster validation indices supported a total of 13 unique chronologies among 14 individual Tidewater Gobies; 2 individuals grouped into a single cluster and the remaining 12 individuals were independent of all others. Six of seven cluster validation indices supported a total of 9 unique chronologies among 10 individual Prickly Sculpins; 2 individuals grouped into a single cluster and the remaining 8 individuals were independent of all others. Tables showing cluster validity index values and plots of the clusters of each species appear on the following pages. Considering the small sample sizes, the results should be interpreted cautiously given that small sample sizes typically have low power to reject null hypotheses (i.e., increased likelihood of Type II error).

References

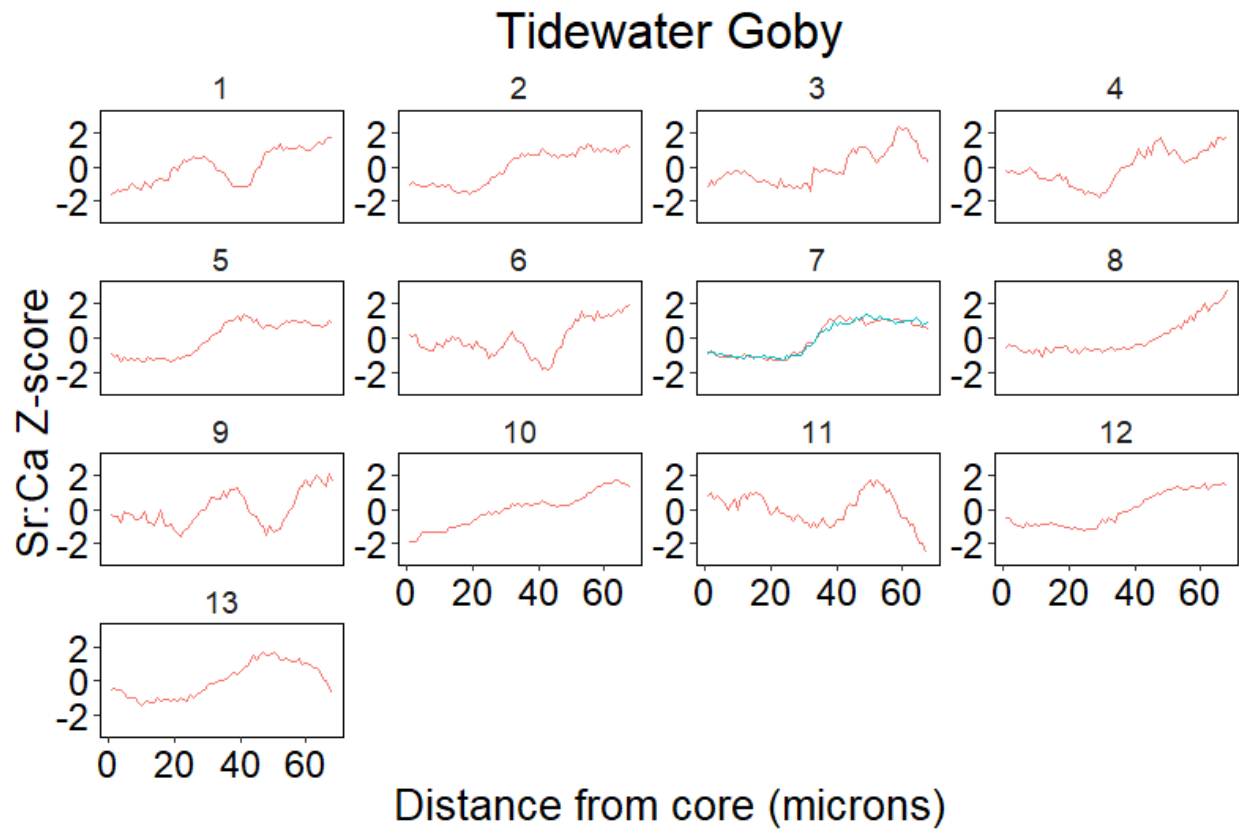
Sardá-Espinosa, A. (2019). dtwclust: Time series clustering along with optimizations for the dynamic time warping distance. R package version 5.5.6. <https://CRAN.R-project.org/package=dtwclust>.

Sardá-Espinosa, A. (2019). Time-series clustering in R using the dtwclust package. The R Journal. doi:
10.32614/RJ-2019-023.

Cluster validation indices calculated for otolith Sr:Ca chronologies of Tidewater Gobies. Strongest indices are highlighted in bold.

Number of clusters	Silhouette (highest)	Score Function (highest)	Calinski-Harabasz (highest)	Davies-Bouldin (lowest)	Modified Davies-Bouldin (lowest)	Dunn (highest)	COP (lowest)
2	0.551	0.585	4.595	0.202	0.202	0.705	0.356
3	0.429	0.546	4.406	0.949	0.949	0.337	0.193
4	0.355	0.583	4.383	0.462	0.513	0.337	0.144
5	0.308	0.594	5.462	0.323	0.355	0.391	0.091
6	0.342	0.582	6.360	0.399	0.416	0.598	0.064
7	0.275	0.600	5.879	0.335	0.379	0.743	0.050
8	0.238	0.605	6.625	0.319	0.395	0.762	0.033
9	0.189	0.627	8.050	0.153	0.209	0.762	0.020
10	0.187	0.622	9.560	0.285	0.330	0.842	0.012
11	0.134	0.633	12.653	0.099	0.135	0.912	0.006
12	0.143	0.634	20.133	0.086	0.101	1.194	0.002
13	0.071	0.636	21.851	0.054	0.072	1.355	0.001

Figure showing plots of the 13 clusters for Tidewater Gobies that were best supported by cluster validation indices.



Cluster validation indices calculated for otolith Sr:Ca chronologies of Prickly Sculpins. Strongest indices are highlighted in bold.

Number of clusters	Silhouette (highest)	Score Function (highest)	Calinski-Harabasz (highest)	Davies-Bouldin (lowest)	Modified Davies-Bouldin (lowest)	Dunn (highest)	COP (lowest)
2	0.397	0.570	2.653	0.369	0.369	0.751	0.362
3	0.390	0.584	2.840	0.307	0.307	0.760	0.256
4	0.283	0.555	3.125	0.658	0.670	0.535	0.173
5	0.203	0.562	2.894	0.552	0.621	0.675	0.131
6	0.120	0.609	3.231	0.301	0.354	0.675	0.090
7	0.038	0.615	3.361	0.284	0.327	0.489	0.058
8	0.113	0.607	3.183	0.392	0.443	0.742	0.036
9	0.083	0.634	7.090	0.085	0.101	1.421	0.008

Figure showing plots of the 9 clusters for Prickly Sculpins that were best supported by cluster validation indices.

