USING GIS TO ANALYSE THE SPACE USE OF FISH: TERRITORIALITY OF BUTTERFLYFISHES

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Geographic Information Systems (GIS) offer a wealth of features that can be used to analyse and aid the interpretation of telemetry data.
We used the Animal Movement Analysis Extension (AMAE) for ArcView to analyse the territorial behaviour of two species of Red Sea butterflyfishes.

The Animal Movement Analyst Extension (AMAE) add-on for ArcView was introduced in 2000 with an explicit focus on the marine environment. Despite its many features, it has rarely been used to describe the space use of individual fish. As a test case, we used AMAE to map the territoriality of two species of coral feeding butterflyfishes. Butterflyfishes are large, brightly coloured and abundant on coral reefs and the territoriality of many species has been established by long-term observation of known individuals. However, different methods for mapping and analysing the territoriality of butterflyfishes make comparisons between studies difficult. AMAE is therefore ideal for standardised and objective analysis of territoriality.

Study area and methods

All research was carried out in shallow water on three fringing reefs in the Ras Mohammed National Park, Sinai, Egypt (composite figure of satellite maps and photo of fringing reef). The movements of 26 pairs of *C. austriacus* and 26 *C. trifascialis* individuals were monitored for periods of 50 minutes during the morning, midday and afternoon, with position fixes taken every 30 seconds.

Satellite photos taken from NASA's 'Visible Earth' website.

Assessing data suitability

We evaluated the suitability of each dataset by bootstrapping the minimum convex polygonal area (MCPA) at different sample sizes. If MCPA did not reach an asymptote at a sample size of ~ 150 locations, then the dataset was discarded (Figure 1).

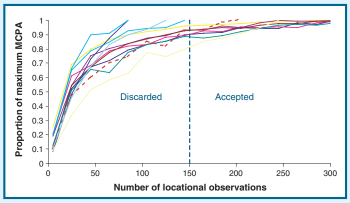

Figure 1

Measuring territory area

Several measures of territory area were then computed for each accepted territory using the AMAE in ArcView.

- Hand-drawn boundaries. Intuitive territory boundaries were delineated by observation of the distribution of points and the location of aggressive interactions.
- Minimum convex polygonal area (MCPA). Values of MCPA were calculated from the full observation set for each suitable territory.
- Kernel probability density function (KPDF). Kernel probability density surfaces were generated of each of the suitable observation sets. The surface was contoured for 95% (total area), 70% and 50% (core area of activity) volume estimates under the three-dimensional KPDF surface

Comparing territory data

At all sites, pairs of *C. austriacus* maintained exclusive territories with clear, contiguous boundaries and minimal overlap (Figure 2a). In contrast, *C. trifascialis* had a more variable territory system and individuals held territories that either overlapped entirely with that of a neighbour, overlapped partially, or did not overlap at all (Figure 2b).

All methods of territory area estimation provided values that correlated strongly with those derived from other methods, but hand-drawn estimates were typically the least well correlated with other methods, particularly the KPDF 50% estimates.

C. trifascialis territories were, overall, four to five times larger than *C. austriacus* territories. The largest *C. trifascialis* territory observed (MCPA method) was 971 m^2, whereas the smallest was 74 m^2. In contrast, the largest *C. austriacus* territory was 379 m^2 and the smallest 13 m^2. (Table 1)

	C. austriacus	*C. trifascialis*
Mean MCPA	99.6 ± 81.5	456.4 ± 295.2
Mean KPDF 95%	106.5 ± 87.4	398.2 ± 293.5
Mean KPDF 70%	56.5 ± 45.9	128.1 ± 108
Mean KPDF 50%	21.2 ± 16.9	55.5 ± 45.7
Mean hand-drawn	72 ± 62	259.5 ± 222

C. austriacus

C. trifascialis

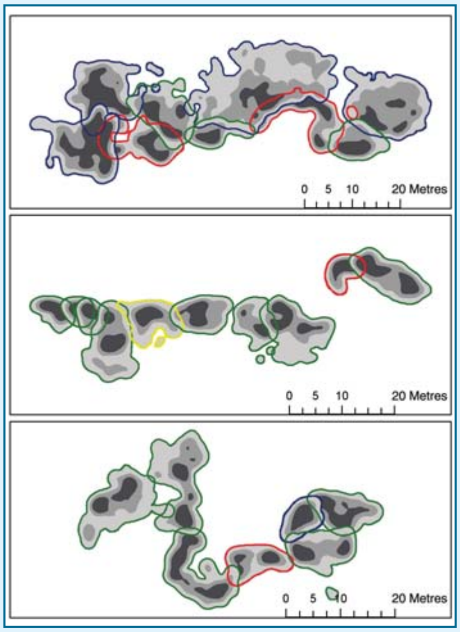

Figure 2a

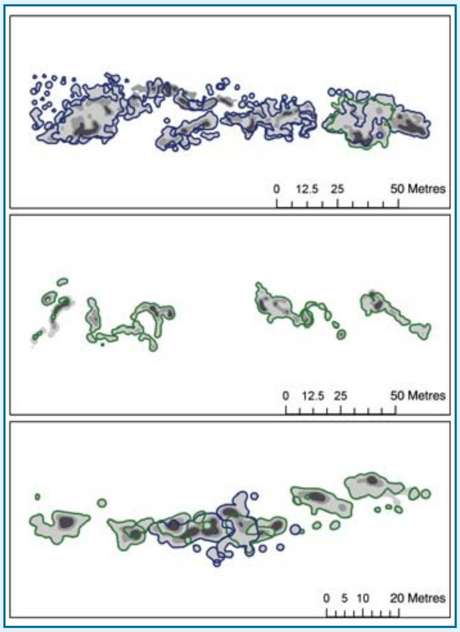

Figure 2b

Conclusions

Our study shows that different computational methods can provide quite different absolute estimates of territory area. Clearly, the most appropriate computational technique depends upon the questions that are being asked, but the availability of home range and territory size algorithms available in AMAE enables the rapid application of a variety of computational techniques. Understanding and mapping the space use of individual fish with objective and robust methods is important because it can help to define the requirements of marine protected areas, and also be used to monitor any changes in the environment that might otherwise be difficult to measure e.g. degradation of coral reefs through chronic pollution.

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