SEASONAL MIGRATION OF THORNBACK RAYS AND IMPLICATIONS FOR CLOSURE MANAGEMENT

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Introduction

Previous tagging studies of the thornback ray, *Raja clavata* L., in the North Sea have suggested that these form local sub-populations, between which little exchange of individuals is thought to occur (Walker *et al*. 1997). This feature of the biology of thornback rays coupled with late maturation and low fecundity make these fish highly vulnerable to localised extinction due to fishery exploitation. A significant decline in the abundance of a range of commercially exploited elasmobranchs has further highlighted a growing need for sustainable management strategies.

Towards this end, a total of 197 thornback rays (Figure 1) were tagged with electronic data storage tags (DSTs) and released in the Thames Estuary (ICES Div. IVc) in 1999 and 2000 (Figure 2).

Figure 1: Thornback ray, Raja clavata L., tagged with an electronic data storage tag.

Seasonal distribution

We used a method of geolocation based on tidal data recorded when rays remained on the sea-bed over a full tidal-cycle (see Hunter *et al*. 2003) to reconstruct the movements of the fish throughout their liberty period (Figure 2).

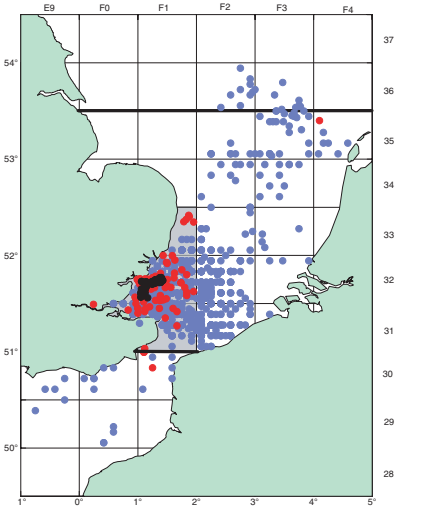

Figure 2: Distribution of DST-tagged thornback rays released in the Thames Estuary, defined as the ICES rectangles 31F0, 31F1, 32F0, 32F1 and 33F1 (shaded area). Release positions shown as black circles. Ninety-six percent of these fish were recaptured within the Thames Estuary (red circles), but fisheries-independent geolocations (blue circles) demonstrate that 77% of the rays had spent time outside the Thames Estuary.

These results demonstrate that rays were not restricted to the Thames Estuary, but moved more widely in the southern North Sea, with a seasonal pattern of migration (Figure 3).

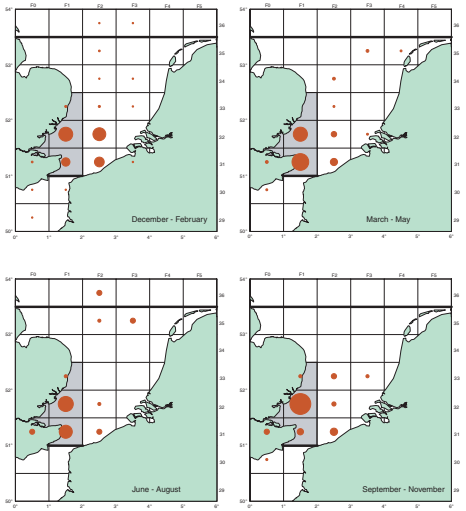

Figure 3: Seasonal distribution of Thames Estuary thornback rays between 1999-2001. Maximum distribution of the ray population occurred in winter, with 85% of the population located in rectangles 31F1, 31F2, 32F1 and 32F2. In spring and summer the population concentrated in rectangles 31F1 and 32F1, at which time the rays migrate into shallow water to reproduce. Following egg-laying, the rays migrate back into deeper water in the autumn.

Evidence from individual fish suggests that the rays may demonstrate migration route and spawning site fidelity (Figure 4).

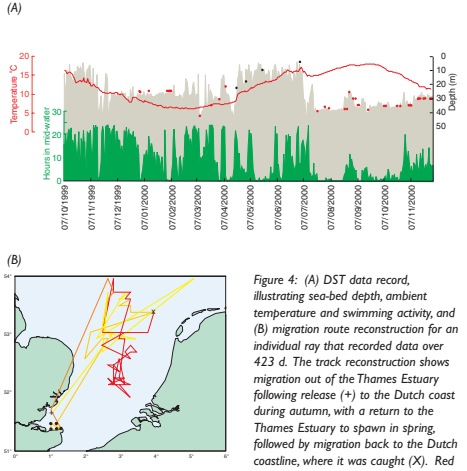

Figure 4: (A) DST data record, illustrating sea-bed depth, ambient temperature and swimming activity, and (B) migration route reconstruction for an individual ray that recorded data over 423 d. The track reconstruction shows migration out of the Thames Estuary following release (+) to the Dutch coast during autumn, with a return to the Thames Estuary to spawn in spring, followed by migration back to the Dutch coastline, where it was caught (X). Red dots indicate sequential geolocations made when the ray remained motionless on the sea-bed throughout a full tidal cycle. Black dots indicate geolocations made within the inner Thames Estuary. The track reconstruction progressively darkens from yellow (following release) to red.

Fishery data

British and Dutch commercial landings of rays caught in Div. IVc were collected for the years 1999-2001 (Figure 5), corresponding to the period that fishery-independent distribution data were available from the DST-tagging study (Figure 3). A small-scale tangle-net fishery targets rays off the south-east coast of England, though they are taken largely as by-catch in a variety of fishing gears including otter trawls and long lines. Landings data did not differentiate between ray species but survey data indicates that up to 95% of rays caught commercially in the southern North Sea are thornbacks (Walker & Heesen 1996). Dutch landings were caught almost entirely by beam trawl.

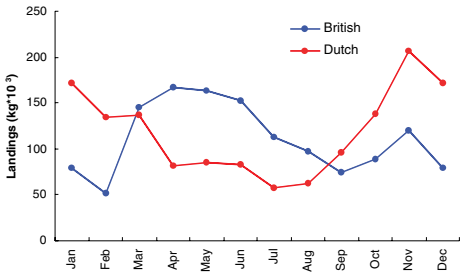

Figure 5: Total British and Dutch landings of thornback ray in ICES Div. IVc from 1999-2001.

British ray landings peaked in spring (Figure 5) while Dutch landings peaked during winter. British landings were taken predominantly within the Thames Estuary, while Dutch landings originated mainly outside the Thames Estuary (Figure 6).

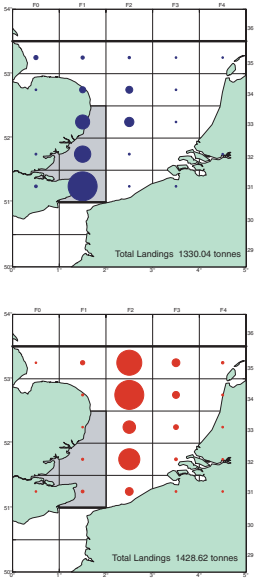

Figure 6: Spatial distribution of total British (blue circles) and Dutch (red circles) landings of thornback ray in ICES Div. IVc from 1999-2001.

Management options

Simulations of a number of closed area scenarios in IVc were performed to assess the potential catch reduction of thornback rays, based on the fishery independent 1999-2001 stock density distribution and total landings over the same period (Figure 7).

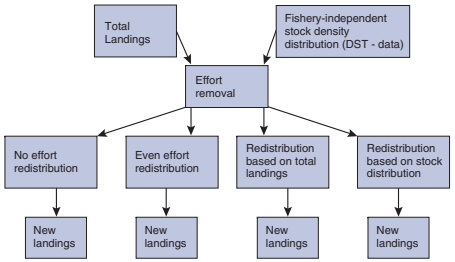

Figure 7: Schematic representation of the steps taken to calculate the effects of spatial closures on total landings of thornback ray, incorporating the redistribution of fishing effort.

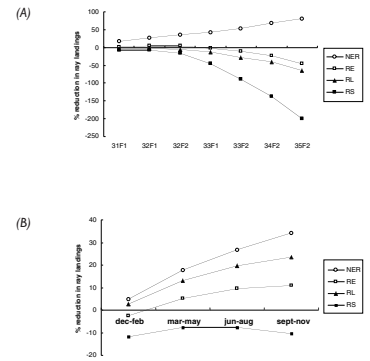

Figure 8: Cumulative reduction in ray landings in IVc after imposing different closure management scenarios. (A) Permanent spatial closures of individual ICES rectangles. Closure of 31F1 results in a 17% reduction in ray landings, however this reduction is lost after effort redistribution. (B) Seasonal closures of the Thames Estuary to UK fleets. High catch reduction results from a spring or summer closure, even after effort has been redistributed into adjacent areas. NER = no effort redistribution; RE = even effort redistribution; RL = redistribution based on total landings; RS = redistribution based on stock distribution.

Permanent closures of individual ICES rectangles are not as effective at reducing ray landings as a seasonal closure of the Thames Estuary in spring or summer (Figure 8). The most effective management scenario in terms of protecting female rays during the spawning season would be to shut the whole Thames Estuary between March and August (Figure 8). Further work is currently under way to consider the effects of spatial and temporal closures on landings by specific gear types, and also to examine how these closures might affect other fisheries.

References

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