SUBDIVISION OF THE NORTH SEA PLAICE POPULATION: EVIDENCE FROM ELECTRONIC TAGS

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Migration is widespread among marine fishes, yet little is known about variation in the migration of individuals within localities. We tested the hypothesis that variation in the migratory behaviour among plaice (*Pleuronectes platessa*) in the North Sea could be explained by large-scale differences in the speed and directions of the tidal streams, which the fish use as a transport mechanism.

Towards this end, 752 mature female plaice tagged with electronic data storage tags were released at eight locations with contrasting tidal flow properties, between December 1993 and September 1999 (figure 1).

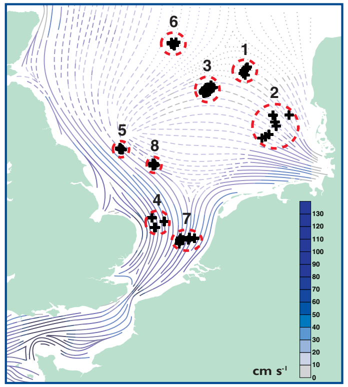

Figure 1: Release locations of mature female plaice tagged with electronic data storage tags. Each cross represents a release point. Lines indicate the average strength (thickness) and the direction of tidal flow (colour scale = cm s^{-1}).
Release 1, 29/10/97 – 30/10/97;
Release 2, 29/10/97 – 13/11/97; Release 3, 5/12/97 – 6/12/97;
Release 4, 17/02/98 – 20/02/98 (+15/12/93 – 27/01/97);
Release 5, 9/10/98; Release 6, 9/10/98;
Release 7, 15/02/99 – 25/02/99;
Release 8, 22/09/99 – 23/09/99.

The experiment yielded 20 403 days of data from 145 plaice. Individual tags recorded depth and temperature for up to 512 days. The position of each fish was determined at intervals throughout the liberty period using the tidal location method (Hunter *et al.* 2003).

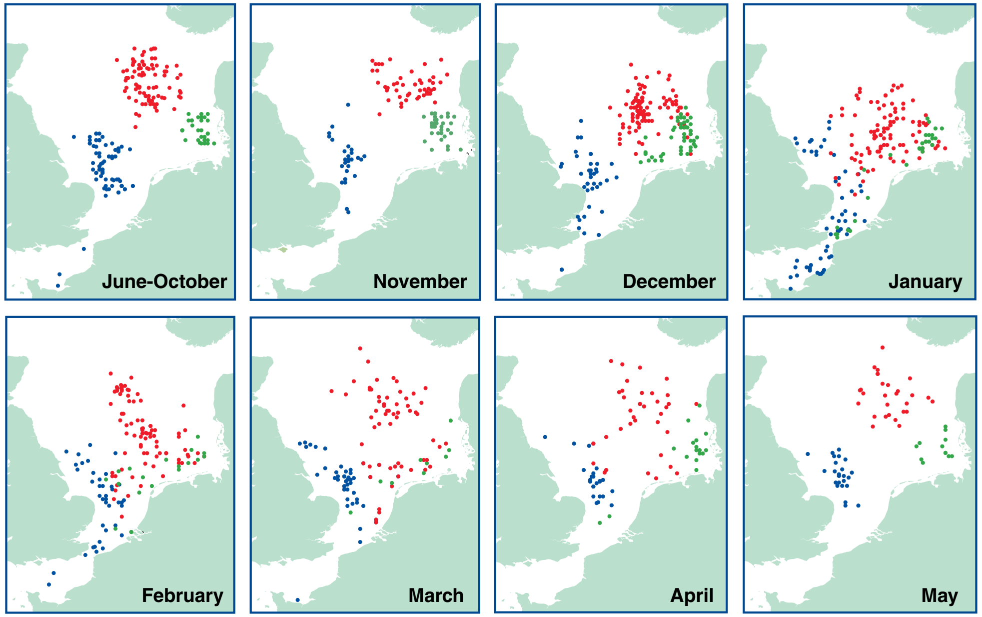

Figure 2: Monthly composite plots of geolocations for 144 electronically tagged plaice. Each filled circle represents a single geolocation calculated from tidal data recorded when plaice remained on the seabed for a full tidal cycle (see Hunter et al. 2003). During the summer months (June-October), the horizontal movement of plaice was minimal, therefore these positions were plotted together. Three geographically distinct feeding aggregations were identified on the Indefatigable Banks to the west (blue), on the Amrum Ground to the east (green) and on Ekofisk Field to the north (red), which dispersed onto mixed spawning areas during the winter (see figure 4).

The results show 3 geographically discrete feeding aggregations during the summer, located in warm, thermally mixed water in the eastern and western North Sea, and in deeper, cold, thermally stratified water to the north (figure 2). Only a single individual migrated north into Scottish waters (figure 3). The feeding aggregations dispersed over the southern North Sea and Eastern English Channel to spawn during winter (figure 4).

During spawning (December-April), eastern and northern sub-unit plaice occurred simultaneously on the German Bight spawning grounds, and individuals from all three sub-units visited spawning grounds in the Southern Bight (figure 4). The only fish that left the North Sea were western sub-unit plaice that visited spawning grounds in the eastern English Channel.

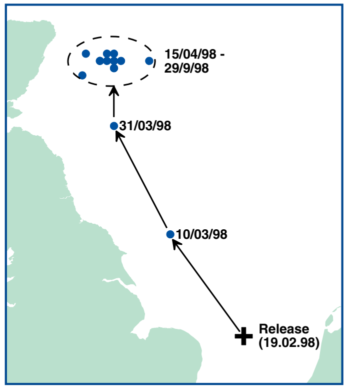

Figure 3: Migration route of the only plaice in the current study to migrate into Scottish waters. The fish was released on 19/02/98 (cross), and the tag ceased recording on 30/09/99. Filled circles represent 14 geolocations made between these dates. Arrows indicate the probable migration route. No recapture position was returned with the tag, which was landed in Eyemouth in the Scottish Borders.

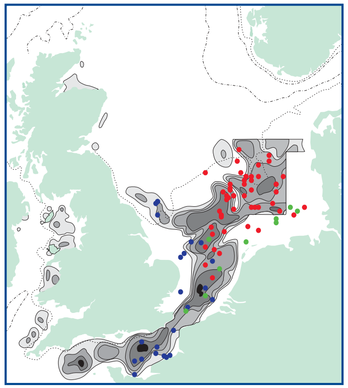

Figure 4: Assumed spawning locations of 82 plaice tagged with electronic data storage tags. Colours indicate the feeding aggregations with which the plaice were associated (see figure 2). Spawning locations are plotted over the distribution of plaice eggs, where dark colouration indicates the highest egg densities (modified from Harding et al., 1978).

Our results re-affirmed the major role of the tidal streams in the southern North Sea in structuring plaice dispersion, both by providing transport and guidance, and by delimiting the extent of distribution due to thermal stratification during the summer (figure 5). Northern North Sea plaice also migrated south, but did not use the tidal stream currents to migrate.

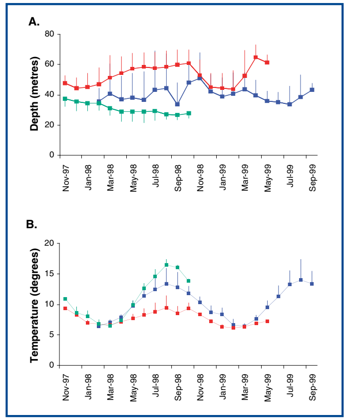

Figure 5: Average monthly (A) sea-bed depth (m), and (B) temperature (°C), experienced by plaice tagged with electronic data storage tags.
blue = western sub-unit; green = eastern sub-unit; red = northern sub-unit.

These results confirm the prediction that large-scale variation in migration behaviour can be explained in part by the tidal guidance and transport mechanisms available. They have revealed features of spatial dynamics not previously observed from a century of conventional tagging experiments and illustrate how the study of individual fish can successfully define the migratory characteristics of populations.

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