# Movements of plaice and cod

With the exception of sandeels, most commercially important fish are highly mobile, taking little notice of man-made boundaries. Adult fish make seasonal migrations between winter spawning grounds and summer feeding grounds. Eggs and larvae drift with residual currents, which carry them to nursery grounds, where the young fish spend two or three years before recruiting to the adult population. During migration adult fish may move several hundred kilometres in a few weeks to reach the spawning grounds. During spawning and feeding they may only move a few tens of kilometres over several months.

We have been studying the behaviour of plaice and cod to try and understand how and why they move about. We use a variety of techniques, including acoustic tags (Figure 1) and electronic data storage tags (DSTs), which record pressure, temperature and light intensity. Acoustic tags allow individual fish to be tracked continuously by a research vessel for periods of up to 15 days. Data storage tags (Figure 2) allow large numbers of fish to be tagged simultaneously and their behaviour recorded continuously for over a year.

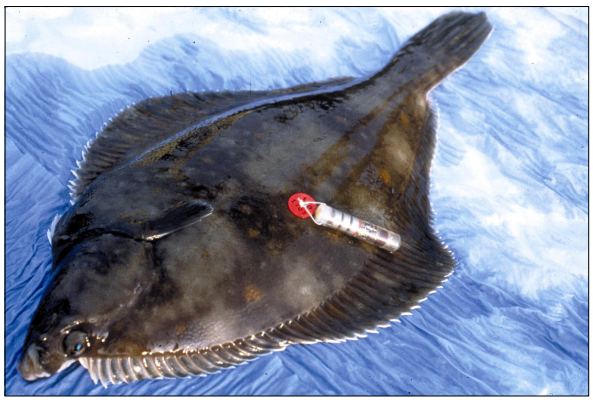

*Figure 1. Tracking fish with acoustic tags and sonar provides detailed information about the route the fish follows. Only one fish can be a tracked at one time by this method.*

*Figure 2. Data storage tags permit the detailed behaviour of many individual fish to be recorded at the same time over long periods. The tags must be recovered through a fishery.*

Tracking provides an accurate and detailed record of the geographical track of the fish (Figure 3) but is expensive and time consuming. DSTs provide much more information at lower cost but have to be recovered through the commercial fisheries. Return rates for tags on plaice and cod in the North Sea often exceed 20%. Information from DSTs can be used to describe the behaviour of natural populations, in particular their vertical movements, which are related to feeding and spawning, as well as migration. DST pressure records, which indicate the depth of the fish, can often also be used to estimate the geographical position of the fish. Tracks of plaice can often be reconstructed in considerable detail (Figure 4).

In the southern North Sea and English Channel, where tides are strong, plaice take advantage of the fast tidal currents and migrate by *selective tidal stream transport* (Figures 3 & 4). Fish leave the seabed at slackwater and remain off the bottom

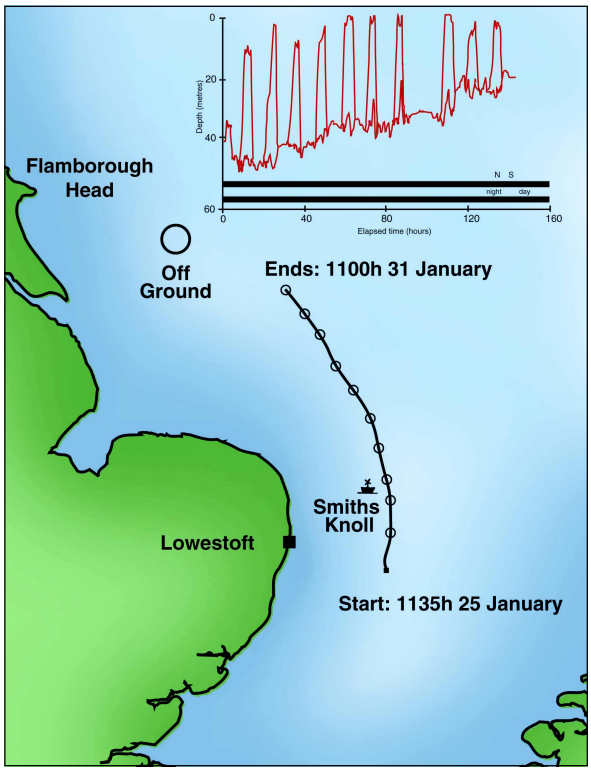


*Figure 3. Track of a maturing female plaice fitted with an acoustic tag and migrating north by selective tidal stream transport. The insert shows the vertical movements of the fish.*

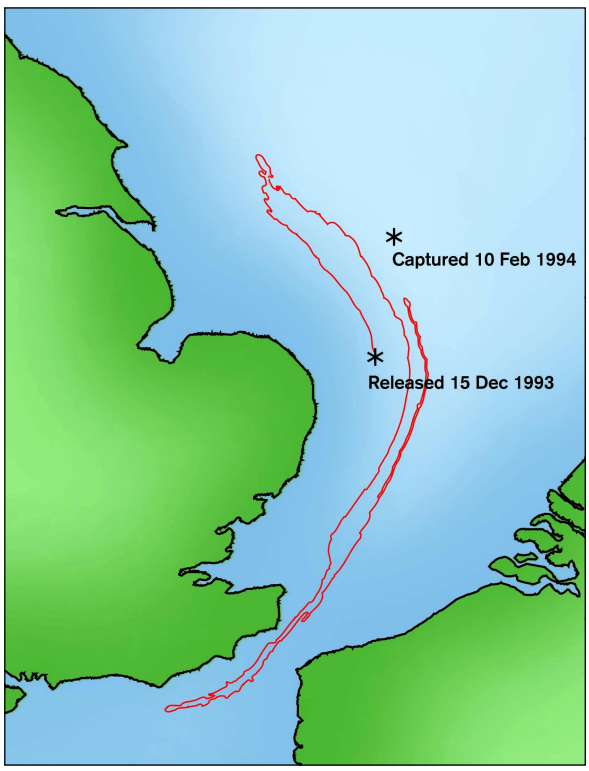


*Figure 4. Track of a maturing female plaice fitted with a data storage tag. The track was reconstructed from depth measurements, which showed that the fish was migrating by selective tidal stream transport. The fish visited two separate spawning grounds (off Flamborough Head and in the eastern English Channel) and the reconstruction was independently validated by tidal and sea temperature data.*

for most of the ensuing tide. They return to the seabed when the tide turns again and stay there for the duration of the opposing tide. Whilst in midwater fish swim downtide and move faster over the ground than the tidal stream. This behaviour saves energy, which can be used to produce more eggs. Maturing fish select the tidal stream flowing towards the spawning ground; spent fish use the opposing tidal stream to return to their feeding grounds. In the Dover Strait, pre-spawning and post-spawning fish can be observed migrating in opposite directions at the same time.

Selective tidal stream transport occurs in several other demersal species, such as sole, cod, dogfish, cod and silver eels. Recent work suggests, however, that the behaviour only occurs where tidal streams are fast and fish can make a significant saving in energy. Plaice in the German Bight, for example, appear not to behave in this way. Instead they swim along the bottom in a steady direction that may not be related to the direction of the tidal stream. Like plaice, cod probably only take advantage of tidal currents when it is energetically advantageous to do so. Some cod marked with acoustic tags have been found to use selective tidal stream transport when migrating north out of the Southern Bight migration into the central North Sea. Other cod following the same route remain in midwater, swim north and make only occasional excursions to the seabed (Figure 5).

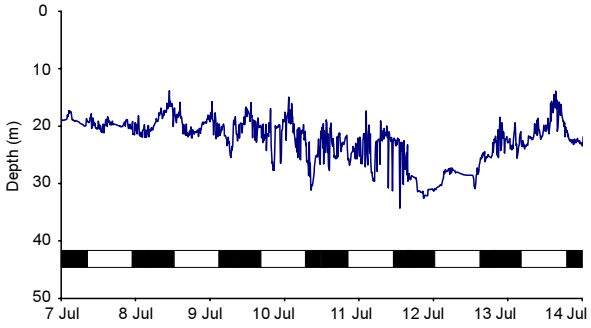


*Figure 5. Vertical track of a post-spawning cod migrating north along the East Anglian coast in spring. Vertical movement is erratic with occasional visits to the seabed. Light and dark bars indicate periods of day and night.*

During the summer months plaice and cod both appear to be largely sedentary, spending long periods on the seabed in one location. Plaice occasionally move into midwater at dusk to be carried to and fro by successive tides, before returning to the seabed the following dawn. They move only a short distance and probably use this behaviour to move from one local feeding area to another. Similar behaviour during the winter is probably associated with finding a spawning partner and releasing fertilised eggs high up in the water column. Unlike plaice, cod can feed in the water column as well as on the seabed; they also exhibit little activity for long periods. Recent data from DSTs suggest that cod can spend most of their time on the bottom during high summer, when they may not feed very much (Figure 6). Later in the year, though, prior to migration, cod probably feed extensively, typically leaving the seabed at nightfall and spending the night in midwater before returning to the seabed by dawn (Figure 7).

It is important to understand fish migration and movement for a number of reasons. Scales of movement are critical in setting closed areas. They are also important in relation to stock identity and distribution and therefore quota management. Multi-species models that take account of predation include critical assumptions about fish distribution, prey availability and feeding behaviour. These assumptions need to be biologically realistic, if the models are to be useful management tools. Reliable ecosystems models also require a sound biological basis.

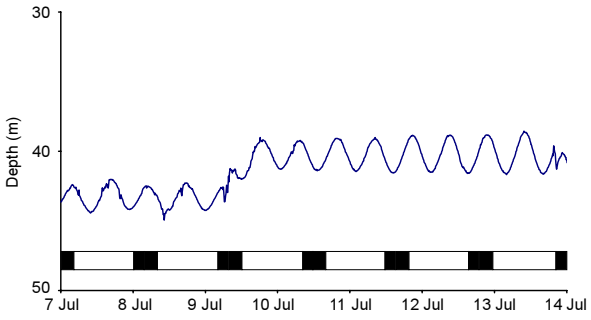


*Figure 6. Vertical track of a cod on feeding grounds in the central North Sea in summer. The profile, which shows the cyclical rise and fall of the tide, indicates that fish remained on the seabed most of the time and was generally inactive.*

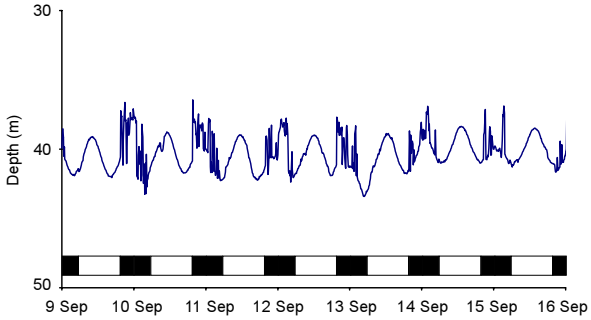


*Figure 7. Vertical track of a cod on North Sea feeding grounds in early autumn. The fish spent the day on the seabed and moved into the water column at night, probably to feed.*

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