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STUDIES OF VERTICAL MIGRATION OF WILD FAROE PLATEAU COD BY USE OF DATA STORAGE TAGS

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ABSTRACT

Eighty eight wild cod were in October 1997 tagged with data storage tags placed inside the buccal cavity. The release site was approximately 12 nautical miles north-west of the Faroe Islands at 62°19'N 7°39'W (100 m). By August 1999 forty-one (47 %) were recaptured, all from Faroese waters. All cod stayed exclusively in warm (> 5 °C) Atlantic water and usually at shallow (90-130 m) and nearly constant depth (presumably at the bottom) during winter. Vertical migration was rare, but two cod showed very clear diurnal vertical migration, most likely feeding migration, at exactly the same time of the year. Spawning related activities could in some cases be detected by a change in depth.

Keywords: Data Storage Tags, Gadus morhua, spawning migration, temperature and depth, vertical migration.

INTRODUCTION

Tagging experiments with conventional tags reveal horisontal migrations of fish, but normally no information about vertical migration of individual fish. Underwater telemetry has been used since the 1950s (Baras 1991), but is very time-consuming and expensive (Godø 1995) and normally has a short time span (less than a week). During the last decade or so, Data Storage Tags (DST) have been in used to study vertical and horisontal migration of different fish species (see ICES 1997/ICES 1998 for a list of references). Data Storage Tags (or archival tags) have a very great potential to study vertical migration of individual fish, since they can operate for several months.

In the north-east Atlantic, DSTs have been used to tag cod at Iceland, Norway (Barents sea), and the Faroe Islands within the last five years, partially financed by Nordic Council of Ministers (Nord Fiskeri 1998). The Icelandic cod were tagged at the spawning grounds, and were thus fairly large, usually more than 80 cm (Thorsteinsson 1995). The Faroe Plateau cod were tagged outside the spawning time (October) and were considerably smaller (55-70 cm). The reason for the use of different time periods and attachment procedures (Iceland and Faroe Islands used internal tagging but Norway external tagging) was, among other things, that different aspects had to be investigated in order to reveal the potentials in tagging cod with DSTs.

Simultaneous depth and temperature recordings from DSTs show, that some Icelandic cod stayed in shallow (< 150 m), warm water (> 4 °C) during May and June (Thorsteinsson 1995), while some fish migrated to deep water (250-500 m) where the temperature fluctuated very much (0-8 °C) – supposedly feeding on blue whiting near the Faroe Icelandic ridge (Nord Fiskeri 1998).

The objectives of the Faroese tagging program were to investigate vertical and horisontal migrations of wild Faroe Plateau Cod which in turn could reveal important biological features as e.g. feeding preferences (bentic or pelagic preys) and spawning activities. In order to reduce variability when tagging at different locations (Thorsteinsson 1995), all DSTs were used in one, fairly uniform area with respect to depth and temperature. This area, 12 nm north-west of the Faroe Islands, was also chosen since it was in the heart of the main cod distribution (highest cod catches), hopefully giving a representative sample of Faroe Plateau cod.

MATERIALS AND METHODS

Equipment

Data Storage Tags (DST 300) were produced by the Icelandic company Stjørnu-Oddi in 1997. They were able to record temperature, depth and tilt angle. The tempereature range was set at 0-12 °C, the usual temperature range in Faroese waters. The depth range was set at 0-800 m, in order to reveal possible migrations into deep water. The DST was started by removing a trigger magnet from the tag and the first recording of temperature, depth and tilt angle was 40 min afterwards. The recordings were made in two cycles: a short cycle with 40 min intervals (36 recordings during 1 day), and a long cycle with 4 hours intervals (36 recordings during 6 days). The recordings started with the short cycle, then the long cycle, then the short cycle etc.

In order identify a fish with a DST, a spaghetti tag was attached to the DST and hung out through the body wall of the fish.

Specifications of the DST:
Type: DST300.
Dimensions: length 46 mm and diameter 13 mm.
Weight: 8 g (in air), 1 g (in fresh water).
Depth range: 0-800 m, resolution: 4 m, accuracy: +- 4 m.
Temperature range: 0.0 – 12.0 °C, accuracy: +- 0.1 °C.
Tilt range: +-60 °.
Memory capacity: 2700 simultaneous recordings of temperature, depth and tilt angle (8100 recordings in total).
First recording after removal of magnet: 40 min later.
Time between recordings:
    40 min (short cycle: 36 measurements during 1 day),
    4 hours (long cycle: 36 measurements during 6 days).
Last possible recording: 10 months after removal of the magnet.
Lifetime of battery: more than 10 months.

Synthetic absorbable sutures (Coded Vicryl nr 9321, ETHICON. LTD.UK) were used to close the cuts in the abdominal walls of the fish.

Fishing (tagging) area

The tagging with DSTs was a part of a tagging experiment with conventional tags as well as DSTs. The conventional tags were used in four locations: north, west, south and east of the Faroe Islands. The DSTs were used in the northern area located about 12 nautical miles north-west of the Faroe Islands at approximately 62°19'N 7°39'W (100 m).

Treatment of fish

The fish were caught by bottom trawl (research vessel Magnus Heinason) using 135 mm in the cod-end. The hauls lasted 1 hour. Viable cod were immediately transferred to tanks with running sea-water and kept there for at least 30 minutes in order to judge if they were suited for tagging.

The fish were tagged internally with the DSTs in much the same way as in Thorsteinsson 1995. Each fish was taken from the tank and laid upside down on a "table" with a slit. The total length was measured. Then a tube with running sea-water was placed into the mouth in order to secure oxygen supply. A dark towell was wrapped around the head protecting the eyes, calming the fish and directing the sea-water to pass the gills. No anaesthetics were used. A slit was cut with a scalp through the body wall on the right side, allowing the DST to be placed into the peritoneal cavity. The DST was started by removing the thrigger magnet. The spaghetti tag, attached to the DST, was let through a small hole (located about 2 cm in front of the anus) to the exterior. Both ends of the DST were attached to the body wall by absorbable sutures. The slit was then closed by sutures. The slit and the hole were treated by a desinfecting spray. Thus the DST was located at the most ventral place in the peritoneal cavity, and the length axis of the fish and the tag were almost identical. The procedure of internal tagging took normally about seven minutes and all 88 cod were tagged and released 12.-13. October 1997.

After tagging, the fish was let into a tank with running sea-water and observed for at least 30 min. If the fish did not behave normally it was killed and the tag placed into another individual. The successfully tagged fish was then released carefully to the sea. All cod dived at once, indicating good condition.

Getting information from recaptured DSTs.

The DST was opened and the batteries removed. The chip was then connected via an interface box to an IBM compatible computer (MS-DOS with a RS232 serial port). A computer program from the manufacturer was used to copy the information from the tag. Before the copying, the time of removal of the magnet had to be given. The file with the recordings could be opened by usual spreadsheet programs (e.g. Microsoft Excel).

RESULTS

The tagging return of DSTs was 41 out of 88 (47 %) during 22 months. Of these about 30 tags were used in this analysis, but only five presented, since they had long time span and showed interesting features.

The temperature recordings showed, that all cod stayed exclusively in warm water (> 5 °C) as indicated by five selected tags (Fig. 1). The ambient temperature of the fish decreased almost linearly from October to March, when it rose again. Although one fish (DST036) stayed in a deeper, and somewhat warmer water layer for about three months (Figs. 1 and 2), the maximum difference between fish was about 1 °C, and usually much less.

The fish stayed at a relatively constant depth during the whole winter as shown by three selected tags in Figure 2 in addition to Figure 3 (before about 1st of January 1998). Although not shown in Figure 2, most cod behaved in a similar way as DSTs 046 and 091. A simultaneous change in depth about 27. February 1998 indicates onset of spawning or spawning migration.

Clear vertical migration was seldom observed, but two very clear excamples are shown in Figure 3 and enlarged in Figure 4. In some cases the cod moved up during the night and down (assumingly to the bottom) at day as DST0073 shows. In other cases it was opposite as DST0086 shows. The spectacular thing is, that this vertical migration started at almost excactly the same time 30.-31. December 1997. Interestingly DST046 is showing the same tendencies in Figure 2. The vertilcal migrations almost disappeared 5.-15. January 1998, but continued then until about 7. February for both individuals.

DISCUSSION

A tag return of 47 % shows, that the catching and tagging procedures were satisfactory.

Contrary to Icelandic cod, Faroe Plateau cod stayed exclusively in warm (> 5 °C), shallow (< 200 m) water. One reason to this difference could be the small size (55-70 cm) of the tagged cod, since large (> 80 cm) cod actually is present in deep, cold (1 – 3 °C) Faroese waters at 400-600 meters, as observed in the Greenland halibut fishery. The decrease in temperature during the winter is considered to reflect seasonal changes in temperature and not migration. The similarities between ambient temperature of dividuals indicate, that all cod stayed on the Faroe Plateau during the whole period.

The change in depth in late February indicates spawning related activities (unfortunately the maturity stage of the fish in Fig. 2 is unknown). Some fish did not, however, change depth in this period, probably because they were not sexually mature or because spawning areas are located less than 40 nautical miles from the release site at about the same depth.

Faroe Plateau cod mainly stayed near the bottom, as indicated by very moderate changes in depth with time. Diel activity patters, however, demonstrated for cod off northern Norway (Løkkeborg and Fernõ 1999), could be present since horisontal movements were not recorded by the tag.

Two individuals, however, showed clear vertical migration, for about one month each. It is unknown why this happened at the same time of the year. According to the Coastal Guard, no seismic shooting or other disturbing activities were conducted on the Faroe Plateau just prior, or during that period. It is also unlikely that the fish should have used tidal currents as transport medium (as cod in the North Sea, Arnold *et al.* 1994), since the migrations did not have a 6 hour cycle (using both tidal stream directions) or 12 hour cycle (using one direction). Thus the cod most likely fed in the upper water layers. Changes in food availability could have caused the pause in vertical migrations 5.-15. January 1998 (no dramatic changes in tidal current speeds were observed).

In the future, it is planned to tag large (> 80 cm) cod from cold (1 – 3 °C) and deep (> 400 m) Faroese waters in order to find out if the differences in behaviour between Faroese and Icelandic cod are due to fish size or stock origin.

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REFERENCES

Arnold G.P., M. Greer-Walker, L.S. Emerson, and B.H. Holford 1994. Movements of cod (*Gadus morhua* L.) in relation to the tidal streams in the southern North Sea. ICES J. mar. Sci., 51: 207-232.

Baras E. 1991. A Bibliography on Underwater Telemetry, 1956-1990. Canadian Technical Report of Fisheries and Aquatic Sciences 1819.

Godø O.R. 1995. Transplantation-tagging-experiments in preliminary studies of migration of cod off Norway. ICES J. mar. Sci., 52: 955-962.

ICES 1997. Report of the study group on ocean salmon tagging experiments with data logging tags. ICES CM 1997/M:3.

ICES 1998. Report of the study group on ocean salmon tagging experiments with data logging tags. ICES CM 1998/G:17.

Løkkeborg S. and Fernö A. 1999. Diel activity pattern and food search behaviour in cod, *Gadus morhua*. Environmental Biology of Fishes 54: 345-353.

Nord Fiskeri 1998 (North Fishery 1998). Elektronisk merking forteller mer om fiskens bevegelser (electronic tagging tells more about fish migrations). Newsletter from Nordic Council of Ministers, December 1998.

Thorsteinsson V. 1995. Tagging experiments using conventional tags and electronic Data Storage Tags for the observations of migration, homing and habitat choice in the icelandic spawning stock of cod. ICES CM 1995/B:19.

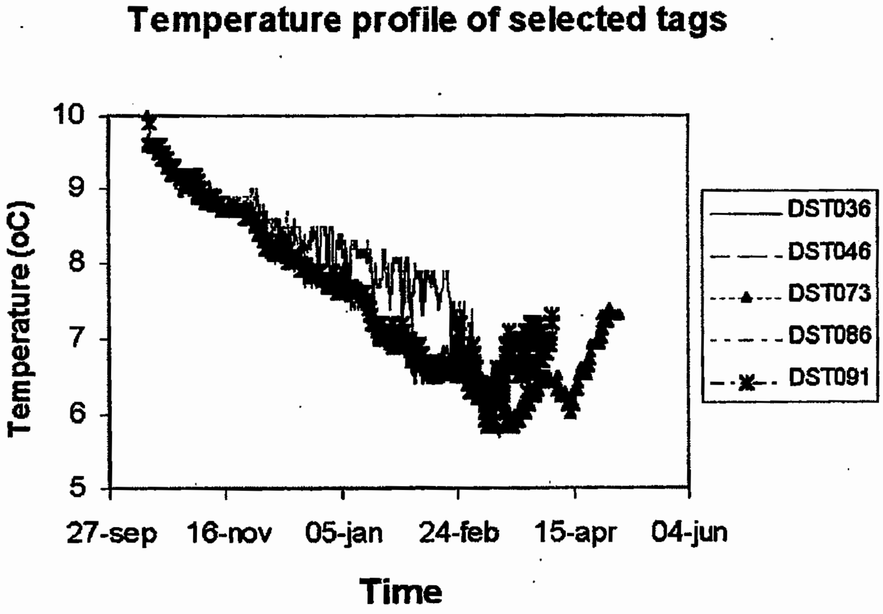

Figure 1. Temperature profile of selected tags.

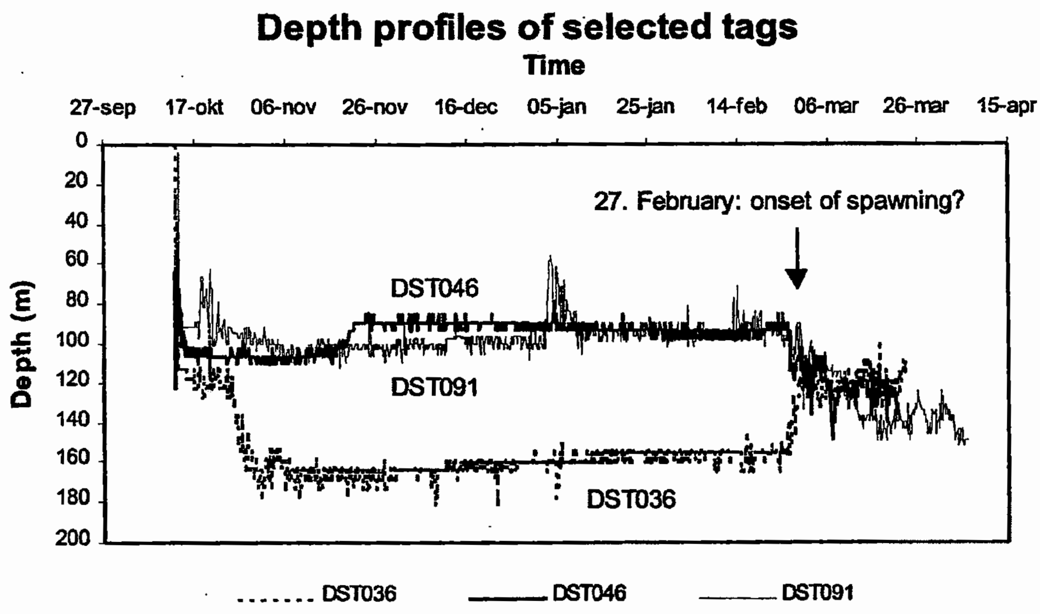

Figure 2. Depth profile of selected tags showing possible onset of spawning.

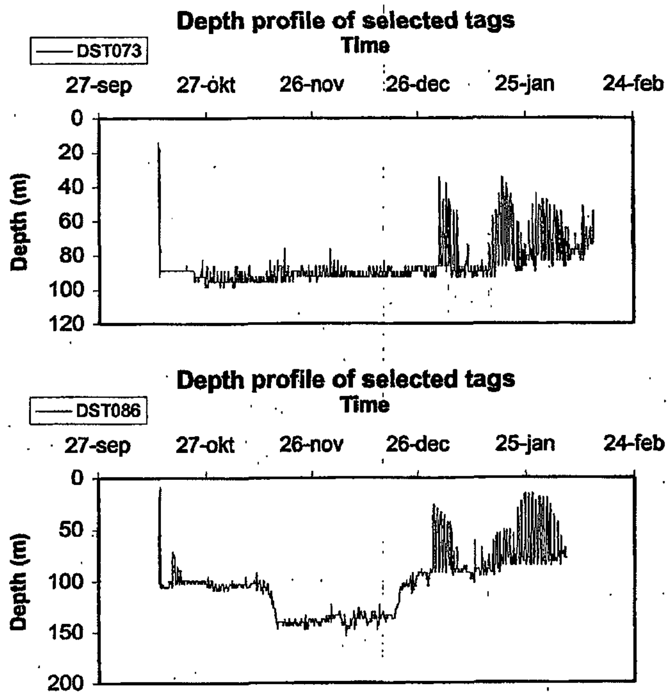

Figure 3. Depth profile of selected tags showing vertical migration.

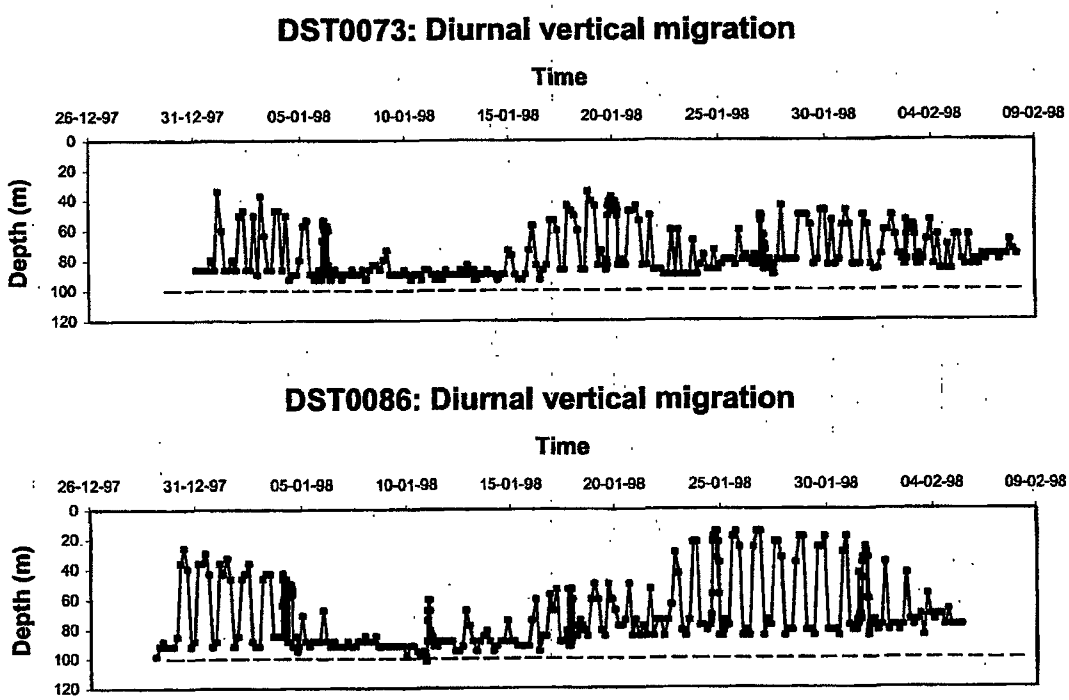

Figure 4. Enlarged part of Figure 3 showing regular diurnal migration. Vertical bars at the 100 m line indicate length of night.