

# Open sea fish tracks: plaice fitted with compass tags

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**Fisheries Research Data Report No 35**  
Directorate of Fisheries Research, Lowestoft, 1994

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

DIRECTORATE OF FISHERIES RESEARCH

FISHERIES RESEARCH DATA REPORT  
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Data Rep., MAFF Direct. Fish. Res., Lowestoft, (35): 60pp.

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## SUMMARY

Since the early 1970s, scientists at the Ministry of Agriculture, Fisheries and Food (MAFF), Directorate of Fisheries Research (DFR), Lowestoft, have been trying to understand the behavioural mechanisms of fish migration by tracking free-ranging fish in the open sea using sector scanning sonar and transponding acoustic tags. Although many representative fish tracks have appeared in scientific journals, much of the basic information has, by virtue of its bulk, remained unpublished. Because of the inherent value of these data, and a continuing need to refer to them, it has now been decided to publish them in full in a series of laboratory Data Reports, of which this is the first. It should be noted that these reports are simply a presentation of the original tracking data. For an analysis of the data, the reader is referred to the relevant publications (see Section 1).

### 1. INTRODUCTION

The aim of this study was to observe the orientation of plaice in the southern North Sea in relation to tidal streams using acoustic tags which telemetered the compass heading of the fish. The data were collected during *RV CLIONE* cruises 6/79, 7/80, (SIC<sup>1</sup>: F.R.Harden Jones) and cruise 8/80 (SIC: G.P.Arnold). The compass data obtained, and the analysis of the results have been presented elsewhere (Harden Jones, 1981; Harden Jones and Arnold, 1982; Harden Jones, 1984; Arnold and Metcalfe, 1989; Arnold *et al.*, 1990; Metcalfe *et al.*, 1993).

### 2. MATERIALS AND METHODS

#### 2.1 The fish

Fish 1 and 2 were caught by a light otter trawl operated from *RV TELLINA* at Smiths Knoll on 23 March 1979, and Fish 3, 4, 5, 6 and 7 were caught by *RV CLIONE* during cruise 12/79. The plaice were subsequently tagged with a Petersen disk and held at the laboratory. Prior to their release the fish were kept unfed on the ship in a deck tank.

#### 2.2 Tracking procedure

Fish were fitted with 300 kHz acoustic transponding compass tags, (Mitson *et al.*, 1982), and were tracked from *RV CLIONE* using the MAFF scanner (Holley *et al.*, 1975). The compass tag, which has been described in detail by Pearson and Storeton West (1987), consisted of a magnet attached to a disk with a 45° segment removed from its outer edge. The disk was mounted horizontally on a jewelled pivot and direction was sensed optically using a vertical array of eight infra-red emitters and detectors to identify the bearing of the missing segment. In this way the heading of the fish could be assigned to one of eight, nominally 45° sectors (mean 45°, sd ± 10°; range 28° - 63°). The sector was indicated by the time interval between two, 3 ms, pulses of sound emitted by the tag when it was insonified by the sonar. This interval ranged from 24 to 66 ms in 6 ms steps. The first pulse provided an unambiguous reference signal on the sonar screen for determining the position or depth of the fish (Greer Walker *et al.*, 1978). The two pulses were monitored on the B-scan display of the sonar and simultaneously recorded at a frequency of 1 Hz on an Alden paper recorder. The tag was attached to the fish by two conventional Petersen tag wires and a wedge shaped support kept the compass horizontal. The tag was placed towards the head of the fish in the region of minimal flexure and aligned along the body axis on the upper surface between the lateral line and the left marginal (dorsal) fin.

<sup>1</sup>SIC : Scientist in Charge

The horizontal and vertical positions of the fish were recorded routinely every 15 minutes (Harden Jones *et al.*, 1973; Greer Walker *et al.*, 1978) or more frequently, when required. The range of the fish from the ship was estimated directly from the sonar screen to the nearest 5 m and bearing to the nearest 1°, using the sonar in horizontal (azimuth) mode. The geographical position of the fish was estimated from these data and the position of the research vessel, which was determined by reference to the Decca Navigator system (Anon, 1973). The depth of the fish was estimated by elevation scanning with the sonar transducer in vertical mode. The tilt of the transducer was increased until the tag signal was on the centre line of the sonar display and the tilt angle measured to the nearest 1°. The depth of the seabed was measured at the same range in the same way. Depth (D) in the water column was calculated from:

$$D = R \sin \theta + d$$

where:

*R* - range of the fish from the ship

$\theta$  - angle of tilt of the transducer from the horizontal

*d* - the depth of the transducer below the sea surface (4 m).

For fish in midwater, height above the bottom was calculated from the difference between the depth of the tag and the depth of the seabed. For fish close to the seabed, position was recorded as *just off the bottom* when the acoustic tag signal was clearly separated from the echo of the seabed, but by an angle of less than 1°. The errors associated with the estimation of the depth of the fish are discussed by Arnold and Greer Walker (1992).

### 2.3 Method of release

After the attachment of the acoustic tag the fish were released over the rail of the ship.

### 2.4 Astronomical and tidal stream data

Predicted tidal stream data were obtained from the nearest tidal station on the appropriate British Admiralty chart. Times of high water at Dover, or at another standard port as indicated, were taken from Volume 2 of the Admiralty Tide Tables for the relevant year. Times of local slack water were estimated by interpolating the corresponding minimum speeds of the tidal stream from the data given for each Admiralty tidal station; an interval of 10 minutes was used for the interpolation. Times of sunrise (SR) and sunset (SS) were taken from the Nautical Almanac for the nearest tabular latitude and corrected for the latitude and longitude of a point approximating to the mid-point of each track.

### 2.5 The data

Summary data are presented in Tables 1 and 2, the first of which gives, where known, the size and sex of the fish. This table also includes the dates and localities of capture and release and the research vessel cruise. Localities are given by ICES Division and statistical rectangle. Table 2 gives astronomical and tidal stream data, and details of times of sunset and sunrise during each track, together with times of local slack water, the direction of the ensuing tidal stream and the Admiralty tidal station from which the data were derived.

Subsequently, two figures for each fish show the equivalent horizontal and vertical tracks of the fish. In each case the vertical track of the fish when off the bottom has been plotted from a 7 point running mean of the fish depths listed in the relevant table; bottom depths were treated in the same way.

These figures are followed by an annex of data, which gives for each fish:

1. **Geographical position:** sequential positions are given in decimal degrees for elapsed time in decimal hours after release.
2. **Vertical position:** the depth of the fish and the depth of the seabed are given in metres for elapsed time. Occasions where the two depths were the same, but where the gap between the tag and the bottom on the sonar display indicated the fish to be *just off the bottom* (JOB), are denoted by italics.

*N.B. The horizontal and the vertical data were recorded separately, and usually recording commenced shortly after the fish was released, consequently the time of release, the time of first horizontal record and the time of first vertical record differ slightly. The start time on each ground track figure refers to the time of the first horizontal record.*

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**Table 1. Summary details of tracked fish**

Fish No.	Date and location of capture	Sex and length (cm)	Details of release			Duration of track (decimal hours)	Time, date and location of end of track
			Date, time and location	Cruise	Petersen tag number		
1	23-Mar-79 IVc 12*	39.5	31-May-79 1730 IVc 11*	RV Clione Cruise 06/79	E60-0186	32.8	2-Jun-79 0230 IVb 12* (Fish abandoned)
2	23-Mar-79 IVc 12*	37	3-Jun-79 1733 IVc 11*	RV Clione Cruise 06/79	E60-0187	54.3	6-Jun-79 2400 IVc 12* (Fish abandoned)
3	12-Dec-79 IVc*	-	23-May-80 1654 IVc 11*	RV Clione Cruise 07/80	EY67-85	50.0	25-May-80 1900 IVc 12* (Fish lost)
4	12-Dec-79 IVc*	-	26-May-80 1702 IVc 12*	RV Clione Cruise 07/80	EY67-84	48.7	28-May-80 1752 IVc 11* (Fish abandoned due to tag failure)
5	12-Dec-79 IVc*	-	29-May-80 1702 IVc 12*	RV Clione Cruise 07/80	EY67-87	51.4	31-May-80 2030 IVc 12* (Fish abandoned)
6	12-Dec-79 IVc*	39.8	12-Jun-80 1735 IVc 03*	RV Clione Cruise 08/80	EY67-90	52.7	14-Jun-80 2215 IVc 03* (Fish abandoned)
7	12-Dec-79 IVc*	Female 40	16-Jun-80 1205 IVc 03*	RV Clione Cruise 08/80	EY67-88	67.9	19-Jun-80 0800 IVc 03* (Fish abandoned)

\* I.C.E.S Division and Rectangle

Table 2. *Astronomical and tidal stream data*

Fish No.	Date	Times (GMT)			Direction of ensuing tidal stream	§ Reference number	British Admiralty chart and tidal station
		Sunrise	Sunset	Local slackwater			
1	31-May-79	0346	2010	2036	S	1	1610 A 1610 B 1504 H
	1-Jun-79	0336		0236	N	2	
				0905	S	3	
				1555	N	4	
				2129	S	5	
2	3-Jun-79	0333	2013	2349	S	1	1610 A
	4-Jun-79	0333		0549	N	2	
				1214	S	3	
	5-Jun-79	0333	2013	1814	N	4	
				0052	S	5	
				0652	N	6	
				1313	S	7	
				1913	N	8	
				6-Jun-79	2013	0147	S
3	23-May-80	0356	1958	1831	N	1	1610 B
	24-May-80	0356		0114	S	2	
				0724	N	3	
	25-May-80	0358	2002	1327	S	4	
				1937	N	5	
				0219	S	6	
				0909	N	7	
				1429	S	8	
				2109	N	9	
4	26-May-80	0353	2002	2202	N	1	3371 F 1504 H
	27-May-80	0349		0339	S	2	
	28-May-80		0349	2006	1029	N	3
		1550			S	4	
		2250			N	5	
		0414			S	6	
		1114			N	7	
		1627			S	8	
5	29-May-80	0346	2009	1751	S	1	1543 M
	30-May-80	0345		0001	N	2	
				0622	S	3	
	31-May-80	0344	2010	1222	N	4	
				1833	S	5	
				0033	N	6	
				0546	S	7	
				1256	N	8	
				1757	S	9	
6	12-Jun-80	0337	2029	2233	N	1	1408 C 1187 G
	13-Jun-80	0337		0333	S	2	
				1004	N	3	
	14-Jun-80	0337	2029	1604	S	4	
				2220	N	5	
				0420	S	6	
				1050	N	7	
				1650	S	8	
				2307	N	9	
7	16-Jun-80	0327	2029	1214	N	1	1187 G
	17-Jun-80	0327		1814	S	2	
				0031	N	3	
				0631	S	4	
				1254	N	5	
				1854	S	6	
	18-Jun-80	0327	2035	0113	N	7	
				0713	S	8	
				1337	N	9	
				1937	S	10	
				0203	N	11	
				0803	S	12	

§ These reference numbers correspond to the diamonds on the figures of the ground tracks.  
S South-going tide. N North-going tide.

## FIGURES

Figure 1 indicates the locations of the 7 fish tracks in the southern North Sea; subsequent figures show the individual ground track and vertical track of each fish.

Scale: 1 minute of latitude = 1853 m (1 nautical mile).

The ground tracks show hourly positions of the fish (where possible) in relation to the direction of tide;

- ▲ north-going tide at night
- △ north-going tide by day
- ▼ south-going tide at night
- ▽ south-going tide by day

Slack waters are indicated with reference to slack water number (Table 2);

- ◆ slack water at night
- ◇ slack water by day

The 30 m isobath is symbolised by  $\sim 30 \sim$ , which indicates shallower water above the 30 and deeper water below.

The vertical plots show the depth of the fish (solid line) in relation to the sea bed (dashed line) and the direction (N - north-going, S - south-going) of the tidal stream by day and night.