Cruise Report

FDS Submarine Channels

RV Koca Piri Reis

9^{th}-26^{th} May 2010

Flow dynamics and sedimentation in an active submarine channel:

a process-product approach

Principal Scientist

J Peakall

2012

School of Earth and Environment
University of Leeds,
Leeds, LS2 9JT
Tel: +44 (0)113 343 5205
Email: j.peakall@see.leeds.ac.uk

DOCUMENT DATA SHEET

AUTHOR	*PUBLICATION DATE*
Peakall, J. et al.	2012

TITLE

RV Koca Piri Reis cruise 9th-26th May 2010

REFERENCE

University of Leeds, FDS Submarine Channels Cruise Report

ABSTRACT

The primary aim of the FDS Submarine cruise was to collect high-resolution velocity data from an active submarine channel, using NERC's Autosub 3 autonomous submarine. Data was collected from a saline underflow that passes through a channel network on the Black Sea shelf immediately north of the Bosphorus Strait. Such data for submarine channels is unknown due to the difficulty of measuring such flows which are typically infrequent and destructive. Furthermore, as a result of sea-level rise most flows of this type are out of equilibrium with their bounding topography. This part of the Black Sea is a unique area where a 10-15 m thick underflow of dense Mediterranean water flows across the Black Sea shelf through a series of sinuous channels. Furthermore, this channel network was only initiated round 6,000 years ago when sea-level approached its present level, and flows and channel network have co-evolved together to form a system in equilibrium. Such velocity data is critical for generating predictive models of these deep-sea channels which are the primary transporters of sediment, carbon and pollutant fluxes to the deep sea, and whose ancient deposits form major hydrocarbon reservoirs.

Despite a range of problems including mobilisation, adverse weather, and instrumentation failure the cruise was ultimately successful in providing the first detailed dataset of the three-dimensional flow field of a submarine channel. Cruise highlights included: 1) ADCP velocity data collected on a series of Autosub 3 lines around a major channel bend, 2) collection of CTD data across a series of transects normal to the channel, and 3) collection of grab samples from the base of the channel revealing complex spatial patterns in the seafloor environment.

KEYWORDS

Submarine channel, density current, gravity current, Autosub, RV *Koca Piri Reis*

ISSUING ORGANISATION

School of Earth and Environment
University of Leeds,
Leeds, LS2 9JT
Tel: 0113 343 5205
Email: j.peakall@see.leeds.ac.uk

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CRUISE PERSONNEL

SCIENTIFIC PARTY

PEAKALL, J (Principal Scientist)	University of Leeds, UK
PARSONS, D.R.	University of Leeds, UK
SUMNER, E.	National Oceanography Centre, UK
WYNN, R.B.	National Oceanography Centre, UK
HISCOTT, R.N.	Memorial University of Newfoundland, Canada
WEBB, A.	NMFD AUV team, NOC
WHITE, D.	NMFD AUV team, NOC
PERRETT, J.	NMFD AUV team, NOC

MOBILISATION / DEMOBILISATION AUV TEAM

ROBERTS, R.	NMFD AUV team, NOC
EVANS, J.	NMFD AUV team, NOC
TURNER, D.	NMFD AUV team, NOC

Plus the SHIP MASTER, OFFICERS AND CREW

No individual listing available

ITINERARY

Setup in Urla, Turkey 9th-13th May 2010
Departed Urla, Turkey 14th May 2010
Arrived Istanbul via Marmara, 18th May 2010
Returned Urla, 26th May 2010

SCIENTIFIC OBJECTIVES

This research cruise was focused on the three-dimensional flow dynamics of submarine channels. Flows in such channels are driven by gravity currents on ocean floors. Such channels are very important as transporters of coarse-grained sediment, and other fluxes such as carbon, anthropogenic pollutants etc. The deposits of submarine channels also form important reservoirs for hydrocarbons, particularly offshore of modern ocean shelves. The Bosphorus outlet into the Black Sea provides a spectacular example of a subaqueous channel network through which a pseudo-steady gravity current runs for almost all of the time. This gravity-current is caused by hyper-saline Mediterranean water entering the brackish Black Sea as an underflow. The primary cruise objective was to obtain high-quality velocity data from this channelized system. This was achieved using an autonomous underwater vehicle, Autosub 3, which allowed measurements to be taken throughout the full depth of the flow. Allied objectives were to: obtain detailed density distributions across the channel at multiple cross-sections; and, grab sampling in order to reveal the spatial patterns of seafloor sedimentation. A more detailed coring programme to assess longer-term sedimentary processes was a subsidiary objective, dependent on progress on the key objectives.

CRUISE NARRATIVE

9th May

Arrival of the Autosub team into Urla, Turkey.

10th May

Arrival of scientific party into Urla and start of ship mobilization. Work commenced on constructing a support frame for the Autosub across the stern of the vessel, since the normal launch system for the Autosub could not be used due to a lack of space on the aft deck. This Autosub support frame had been designed and constructed at NOC and transported to Turkey. Modifications to this were required however as a result of the 'A'-frame not extending as far as the drawings had indicated. Shipping container with Autosub equipment lifted onto the aft deck. An issue arose over winches and cables on the vessel.

11th May

Construction commenced of the frame for the Autosub on the stern of the vessel. Suppliers for the cruise were obtained. Discussions took place with Turkish partner organisation on collaboration agreement and on additional details for completion of documents for permits for operating in the Black Sea.

12th May

The Autosub frame was completed after extensive welding, and the Autosub was lifted on to the frame using a shore based crane. Tests were then undertaken with the 'A'-frame lifting the Autosub into and out of the water. These tests were all successful. Acquisition of cruise suppliers was completed and materials loaded on board. Discussions continued on the issue of the winches and the requirement to switch cables.

13th May

Sailing delayed whilst winding wire off ship's winches, and due to a problem extracting air freight from customs.

14th May

Scientific party boarded the vessel, final preparations were made, and the ship departed in the early evening.

15th May

A day spent in transit from Urla, travelling up the west coast of Turkey, through the Dardanelles and into the Marmara Sea. The forecast was for extremely bad weather and therefore the ship came into port at Saraylar, on the northern side of Marmara Island. During the transit, work continued on setting up of computer systems, other electronics, and

discussions on the detailed nature of surveys. Testing of communications systems and internet access was also undertaken.

16th May

Poor weather restricted us to staying at Saraylar, and so a series of Autosub tests were conducted in the harbour. Discussions continued with Autosub team on the proposed deployment of Autosub in the Black Sea, including discussion of surveys and the optimal points for starting and finishing these surveys.

17th May

Vessel was delayed in port whilst waiting for improved weather. Departed Marmara Island early evening.

18th May

Traversed through the Bosphorus Strait and into the field area between the main shipping lanes at the northern exit of the Bosphorus. Testing of the CTDs was undertaken and Autosub mission M435 was successfully deployed.

19th May

Grab samples were collected from the sea-floor channel and a series of CTD profiles were collected. Autosub continued on mission M435 independently, though the vessel moved to

periodically check on the position and timing of the AUV using an acoustic tow fish placed over the side of the vessel.

20th May

In the early hours of the morning, CTD profiles were taken, and then the Autosub was recovered. This involved identifying where the submarine has surfaced and then sending out a team in a rigid inflatable dinghy to attach cables to the AUV. The submarine was then pulled in towards the vessel before finally being brought on board. This process proved difficult despite the excellent sea conditions, demonstrating that recovery is restricted to fair weather conditions. The vessel was then anchored until first light before entering the Bosphorus again and transiting to Büyükdere Port, on the western (European) side of the Bosphorus. This is a government owned wharf. The Autosub was then craned off on to the dock. Analysis of the data showed however, that due to a software glitch, data in the correct parts of the water column had not been collected. Stayed in port overnight.

21st May

The Autosub batteries (all 6000 of them) were replaced in the morning, the AUV lifted back onto the vessel, and then the vessel transited back to the field area. In the afternoon the Autosub was launched, but the launch failed. The Autosub was then recovered and the vessel transited back to Büyükdere Port. Dan Parsons was dropped off and flew out of Istanbul Airport. The reasons for the AUV's launch failure were analysed. Stayed in port overnight.

22nd May

In the morning we transited back into the field area. The Autosub was launched but unfortunately the launch failed due to an apparent mechanical problem. At this stage it looked as though we would recover no velocity data from the entire cruise due to a combination of software glitches and hardware problems. However, the Autosub crew were able to ascertain the problem, and then fix it by resetting the calibration coefficients for part of the system, all whilst the AUV remained in the water. A second attempt at launching the AUV was successful at 12:46 (local time) (Autosub mission M436). The vessel tracked the Autosub for several hours in order to check on the AUV's progress and to confirm that all was working correctly. The rest of the day was spent taking a number of CTD profiles.

23rd May

The Autosub was running independently throughout the day. A large number of CTD profiles were undertaken in order to give detailed cross-sectional distributions of density around the subaqueous channel bend. Alongside this, grab samples were taken from positions on the channel floor in order to enhance information on the spatial distribution of sediments around the bend.

24th May

A series of additional CTD profiles were taken. The Autosub was retrieved (it surfaced at 07:31) and brought back on board for the final time. Then the vessel transited to Büyükdere Port, where a number of the scientific staff left to catch flights the following morning. The velocity data from the AUV look promising.

25th May

Transit across the Marmara Sea, through the Dardanelles, and then back down the Turkish coast. Equipment was checked and stored as part of demobilisation preparations. The AUV was stripped down during this time.

26th May

Return to the port of Urla. Demobilisation continued with the AUV and associated equipment packed into a container. The Autosub support frame was left at the Institute at Urla. Remaining scientific staff and crew depart.

SUMMARY OF DATA

36 hours of velocity data were collected from the final deployment of the Autosub. Later analysis revealed that only parts of this dataset are of a high quality. None-the-less the dataset represents the first time that anyone has successfully collected three-dimensional velocity data from a gravity current in a subaqueous bend. The high quality data will enable a number of high profile papers to be written, as well as providing key calibration data for numeric simulations of this system.

Alongside the velocity data, a large number of CTD profiles were taken, both along the channel system but also in a series of cross-sections around the bend. The correlation between density and velocity cross-sections will enable all the forcing terms to be investigated for a submarine channel bend, therefore greatly increasing knowledge of the fundamental underlying processes within these systems.

A large number of grab samples were also collected. These proved to be far more complex than originally thought, revealing a rich array of biology on the seafloor, including mussel beds and abundant tube worms. Areas of clean sediment were also found.

Coring was not possible within the time frame, given delays elsewhere in the programme, and due to the fact that the coring could not be undertaken independently whilst the Autosub was onboard.

Scientific enquiries about any of these datasets should be directed to the Principal Scientist.

Finally, marine wildlife observations were recorded throughout the cruise. Scientific enquiries about these data should be directed towards Dr R. Wynn.

STATION LOG

Station	Date	Time (local)	Latitude	Longitude	Water depth (m)	Samples	Data type
1	18/05/10	11.40	N41°24.447’	E029°05.430’	84.5	Turkish CTD	H10
2	18/05/10	11.58	N41°22.480’	E029°05.575’	-	Autosub M435	D71/G74
3	18/05/10	19.33	N41°18.944’	E029°10.000’	-	Turkish CTD	H10
4	18/05/10	20.31	N41°18.810’	E029°10.453’	-	Leeds CTD	H10
5	19/05/10	07.08	N41°16.159’	E029°11.719’	50.3	KPR10_1grab	G02
6	19/05/10	07.41	N41°17.636’	E029°11.785’	55.2	KPR10_2grab	G02
7	19/05/10	08.05	N41°17.582’	E029°11.447’	56.3	KPR10_3grab	G02
8	19/05/10	08.16	N41°17.589’	E029°11.151’	72.0	KPR10_4grab	G02
9	19/05/10	08.30	N41°17.577’	E029°11.016’	75.0	KPR10_5grab	G02
10	19/05/10	08.44	N41°17.599’	E029°10.842’	72.6	KPR10_6grab	G02
11	19/05/10	09.01	N41°17.538’	E029°10.690’	67.5	KPR10_7grab	G02
12	19/05/10	09.23	N41°17.544’	E029°10.523’	61.4	KPR10_8grab	G02
13	19/05/10	09.37	N41°17.572’	E029°10.360’	62.5	KPR10_9grab	G02
14	19/05/10	11.18	N41°17.567’	E029°11.179’	72.1	Leeds CTD	H10
15	19/05/10	11.52	N41°18.502’	E029°09.750’	63.6	KPR10_10grab	G02
16	19/05/10	11.56	N41°18.440’	E029°09.716’	-	Leeds CTD	H10
17	19/05/10	12.30	N41°18.426’	E029°10.077’	56.3	KPR10_11grab	G02
18	19/05/10	12.35	N41°18.428’	E029°10.078’	-	Leeds CTD	H10
19	19/05/10	13.03	N41°18.680’	E029°10.078’	72.0	KPR10_12grab	G02
20	19/05/10	13.06	N41°18.612’	E029°10.050’	63.5	Leeds CTD	H10
21	19/05/10	13.30	N41°18.709’	E029°10.251’	74.5	KPR10_13grab	G02
22	19/05/10	13.42	N41°18.736’	E029°10.239’	77.4	Leeds CTD	H10
23	19/05/10	13.58	N41°18.758’	E029°10.348’	76.7	KPR10_14grab	G02
24	19/05/10	14.00	N41°18.719’	E029°10.336’	78.6	Leeds CTD	H10
25	19/05/10	14.16	N41°18.831’	E029°10.492’	74.0	KPR10_15grab	G02
26	19/05/10	14.20	N41°18.788’	E029°10.455’	74.5	Leeds CTD	H10
27	19/05/10	14.44	N41°18.908’	E029°10.732’	60.3	KPR10_16grab	G02
28	19/05/10	15.05	N41°18.969’	E029°10.787’	60.5	Leeds CTD	H10
29	19/05/10	15.18	N41°19.030’	E029°10.929’	58.6	KPR10_17grab	G02
30	19/05/10	15.22	N41°19.001’	E029°10.882’	59.4	Leeds CTD	H10
31	19/05/10	15.55	N41°16.257’	E029°09.814’	52.4	KPR10_18grab	G02
32	19/05/10	15.59	N41°16.234’	E029°09.790’	52.0	Leeds CTD	H10
33	19/05/10	16.10	N41°16.218’	E029°10.119’	50.5	KPR10_19grab	G02
34	19/05/10	16.15	N41°16.215’	E029°10.110’	50.7	Leeds CTD	H10
35	19/05/10	16.26	N41°16.149’	E029°10.295’	68.8	KPR10_20grab	G02
36	19/05/10	16.30	N41°16.126’	E029°10.306’	71.5	Leeds CTD	H10
37	19/05/10	16.45	N41°16.142’	E029°10.409’	74.6	KPR10_21grab	G02
38	19/05/10	16.49	N41°16.144’	E029°10.387’	74.5	Leeds CTD	H10
39	19/05/10	17.06	N41°16.101’	E029°10.486’	73.5	KPR10_22grab	G02
40	19/05/10	17.09	N41°16.099’	E029°10.516’	73.6	Leeds CTD	H10
41	19/05/10	17.33	N41°16.096’	E029°10.540’	72.5	KPR10_23grab	G02
42	19/05/10	17.37	N41°16.081’	E029°10.530’	72.6	Leeds CTD	H10
43	19/05/10	19.00	N41°16.020’	E029°10.801’	53.0	KPR10_24grab	G02
44	19/05/10	19.03	N41°16.022’	E029°10.821’	52.7	Leeds CTD	H10
45	19/05/10	19.17	N41°15.922’	E029°11.171’	49.2	KPR10_25grab	G02
46	19/05/10	19.21	N41°15.928’	E029°11.161	49.3	Leeds CTD	H10
47	19/05/10	20.05	N41°16.050’	E029°10.416’	73.8	Leeds CTD	H10
48	19/05/10	20.22	N41°15.6’	E029°10.0’	78.0	Leeds CTD	H10
49	19/05/10	20.36	N41°15.2’	E029°09.7’	62.5	Leeds CTD	H10
50	19/05/10	20.51	N41°14.75’	E029°09.25’	58.4	Leeds CTD	H10
51	19/05/10	21.04	N41°14.35’	E029°08.95’	60.1	Leeds CTD	H10
52	19/05/10	21.13	N41°10.97’	E029°08.45’	65.5	Leeds CTD	H10

Station	Date	Time (local)	Latitude	Longitude	Water depth (m)	Samples	Data type
53	19/05/10	21.51	N41°16.41’	E029°10.67’	74.5	Leeds CTD	H10
54	19/05/10	22.03	N41°16.92’	E029°10.86’	72.8	Leeds CTD	H10
55	19/05/10	22.21	N41°17.40’	E029°10.90’	74.2	Leeds CTD	H10
56	19/05/10	22.32	N41°17.77’	E029°10.96’	75.0	Leeds CTD	H10
57	19/05/10	22.43	N41°18.06’	E029°10.91’	78.3	Leeds CTD	H10
58	19/05/10	22.53	N41°18.48’	E029°10.76’	79.4	Leeds CTD	H10
59	19/05/10	23.08	N41°18.83’	E029°10.36’	76.2	Leeds CTD	H10
60	19/05/10	23.20	N41°19.11’	E029°09.92’	74.4	Leeds CTD	H10
61	19/05/10	23.34	N41°19.39’	E029°09.35’	70.4	Leeds CTD	H10
62	19/05/10	23.57	N41°19.70’	E029°09.75’	70.7	Leeds CTD	H10
63	20/05/10	00.12	N41°19.87’	E029°08.12’	70.5	Leeds CTD	H10
64	20/05/10	00.29	N41°20.48’	E029°09.29’	68.2	Leeds CTD	H10
65	20/05/10	00.49	N41°20.46’	E029°09.74’	70.5	Leeds CTD	H10
66	22/05/10	12.46	N41°22.60’	E029°05.54’	-	Autosub M436	D71/G74
67	22/05/10	19.15	N41°18.84’	E029°10.396’	73.5	Leeds CTD	H10
68	22/05/10	21.10	N41°18.188’	E029°10.859’	79.3	Leeds CTD	H10
69	22/05/10	22.55	N41°16.087’	E029°10.432’	74.4	Leeds CTD	H10
70	22/05/10	23.15	N41°16.885’	E029°10.885’	72.5	Leeds CTD	H10
71	22/05/10	23.40	N41°17.619’	E029°10.915’	74.7	Leeds CTD	H10
72	23/05/10	10.39	N41°19.825’	E029°08.067’	70.6	Leeds CTD	H10
73	23/05/10	11.40	N41°18.057’	E029°10.156’	63.3	KPR10_26grab	G02
74	23/05/10	11.44	N41°18.021	E029°10.129	63.5	Leeds CTD	H10
75	23/05/10	12.00	N41°18.096’	E029°10.478’	63.5	KPR10_27grab	G02
76	23/05/10	11.05	N41°18.059’	E029°10.451’	63.0	Leeds CTD	H10
77	23/05/10	12.25	N41°18.129’	E029°10.705’	74.0	KPR10_28grab	G02
78	23/05/10	12.30	N41°18.080’	E029°10.684’	70.6	Leeds CTD	H10
79	23/05/10	12.48	N41°18.172’	E029°10.830’	79.0	KPR10_29grab	G02
80	23/05/10	12.54	N41°18.114’	E029°10.812’	77.6	Leeds CTD	H10
81	23/05/10	13.06	N41°18.154’	E029°10.922’	79.2	KPR10_30grab	G02
82	23/05/10	13.17	N41°18.099’	E029°10.918’	78.5	Leeds CTD	H10
83	23/05/10	13.35	N41°18.207’	E029°10.980’	79.8	KPR10_31grab	G02
84	23/05/10	13.39	N41°18.158’	E029°10.948’	79.0	Leeds CTD	H10
85	23/05/10	14.07	N41°18.159’	E029°11.235’	53.5	KPR10_32grab	G02
86	23/05/10	14.02	N41°18.207’	E029°11.260’	55.6	Leeds CTD	H10
87	23/05/10	14.27	N41°18.246’	E029°11.500’	62.0	KPR10_33grab	G02
88	23/05/10	14.33	N41°18.189’	E029°11.469’	60.7	Leeds CTD	H10
89	23/05/10	15.23	N41°16.716’	E029°11.579’	58.0	KPR10_34grab	G02
90	23/05/10	15.28	N41°16.667’	E029°11.534’	52.0	Leeds CTD	H10
91	23/05/10	16.13	N41°16.786’	E029°11.284’	60.8	KPR10_35grab	G02
92	23/05/10	16.17	N41°16.797’	E029°11.267’	60.5	Leeds CTD	H10
93	23/05/10	16.52	N41°16.829’	E029°11.073’	72.3	KPR10_36grab	G02
94	23/05/10	16.58	N41°16.854’	E029°11.068’	72.9	Leeds CTD	H10
95	23/05/10	17.17	N41°16.823’	E029°10.879’	71.7	KPR10_37grab	G02
96	23/05/10	17.21	N41°16.855’	E029°10.823’	71.6	Leeds CTD	H10
97	23/05/10	17.36	N41°16.866’	E029°10.697’	71.7	KPR10_38grab	G02
98	23/05/10	17.51	N41°16.853’	E029°10.518’	62.0	Leeds CTD	H10
99	23/05/10	18.50	N41°16.911’	E029°10.393’	56.3	KPR10_39grab	G02
100	23/05/10	18.55	N41°16.905’	E029°10.420’	57.0	Leeds CTD	H10
101	23/05/10	19.14	N41°16.928’	E029°10.081’	57.0	KPR10_40grab	G02
102	23/05/10	19.17	N41°16.938’	E029°10.098’	56.7	Leeds CTD	H10
103	23/05/10	20.40	N41°17.571’	E029°10.315’	62.9	Leeds CTD	H10
104	23/05/10	20.50	N41°17.555’	E029°10.500’	61.5	Leeds CTD	H10
105	23/05/10	21.01	N41°17.567’	E029°10.647’	67.0	Leeds CTD	H10

Station	Date	Time (local)	Latitude	Longitude	Water depth (m)	Samples	Data type
106	23/05/10	21.14	N41°17.578’	E029°10.789’	72.8	Leeds CTD	H10
107	23/05/10	21.23	N41°17.572’	E029°10.884’	75.0	Leeds CTD	H10
108	23/05/10	22.44	N41°17.601’	E029°11.097’	72.4	Leeds CTD	H10
109	23/05/10	22.59	N41°17.592’	E029°11.395’	56.5	Leeds CTD	H10
110	23/05/10	23.11	N41°17.599’	E029°11.744’	56.3	Leeds CTD	H10
111	24/05/10	05.13	N41°30.998’	E029°00.521’	97.5	Leeds CTD	H10
112	24/05/10	05.27	N41°30.844’	E029°01.077’	94.0	Leeds CTD	H10
113	24/05/10	05.37	N41°30.755’	E029°01.395’	98.0	Leeds CTD	H10
114	24/05/10	05.49	N41°30.705’	E029°01.633’	98.0	Leeds CTD	H10
115	24/05/10	06.10	N41°30.178’	E029°03.607’	97.4	Leeds CTD	H10
116	24/0/5/10	06.24	N41°30.142’	E029°03.829’	94.2	Leeds CTD	H10
117	24/05/10	06.55	N41°28.827’	E029°01.731’	91.9	Leeds CTD	H10
118	24/05/10	07.09	N41°28.741’	E029°01.101’	92.0	Leeds CTD	H10
119	24/05/10	08.00	N41°27.114’	E029°01.463’	90.0	Leeds CTD	H10
120	24/05/10	08.13	N41°26.887’	E029°01.196’	84.7	Leeds CTD	H10
121	24/05/10	08.37	N41°25.046’	E029°02.648’	85.0	Leeds CTD	H10
122	24/05/10	08.58	N41°23.726’	E029°03.395’	80.6	Leeds CTD	H10
123	24/05/10	09.20	N41°21.894’	E029°02.966’	80.7	Leeds CTD	H10
124	24/05/10	09.39	N41°22.541’	E029°04.248’	80.5	Leeds CTD	H10
125	24/05/10	09.50	N41°21.864’	E029°04.569’	80.6	Leeds CTD	H10
126	24/05/10	11.30	N41°21.400’	E029°05.118’	81.3	Leeds CTD	H10
127	24/05/10	11.49	N41°20.716’	E029°06.550’	78.0	Leeds CTD	H10
128	24/05/10	12.06	N41°19.878’	E029°07.907’	75.3	Leeds CTD	H10
129	24/05/10	12.32	N41°20.869’	E029°09.682’	76.0	Leeds CTD	H10
130	24/05/10	13.00	N41°22.390’	E029°10.116’	79.6	Leeds CTD	H10
131	24/05/10	14.03	N41°15.505’	E029°09.822’	73.0	Leeds CTD	H10
132	24/05/10	14.21	N41°14.750’	E029°09.163’	60.2	Leeds CTD	H10

TRACK CHARTS