Duncan

Tweed 2
Fieldwork report

Vessel: R.V. Tamaris & semi-rigid inflatable

Dates: September 15-20 1996

Personnel: Robb Howland-PML Senior scientist
Bob Clifton-PML
Duncan Plummer-PML
Edward Wright-PML
Jon Barnes-University of Newcastle (Thursday only)
Mike Williams-PML
Ron Easton-PML

Itinerary:
Sunday 15 Sept.: Travelled from Plymouth (departing at 0830) to Berwick-on-Tweed (arriving at 1830).

Monday 16 Sept.: High tide times; 0504 & 1728.
Arrived at the boat at 0800. Tamaris was positioned against the wall, inside the Pilot boat so it was necessary to extricate her and move the pilot boat alongside the wall before we could take Tamaris to the other side of the dock to load equipment. While this was being done we launched the semi-rigid inflatable through the hole in the sea wall between the old and new town road bridges. This was accomplished at half tide by walking the trailer about 100m towards the deep channel.
The scientific equipment was then loaded aboard Tamaris. This operation was completed by 1000, by which time it was not possible to get the boat out of the dock because of insufficient water over the sill. The remainder of the day was taken up with setting up and calibrating the equipment in the laboratory in readiness for the following day.
Once there was enough water, the semi-rigid was used by Mike Williams and Ron Easton, with the portable echo-sounder, to work out precisely where the main channel was situated for navigating Tamaris. A shallow patch was found about a kilometer above the railway viaduct which, with the minimal freshwater flow from the river, meant that Tamaris could not even get as far as the A1 road bridge. However, we do not expect this to be an obstacle under normal flow conditions. Work was completed at 1800.

Tuesday 17 Sept.: High tide times; 0538 and 1803.
Arrived at the boat at 0800. Equipment was run up and Tamaris was moved out of the dock into the river where she was anchored just below the old road bridge at station 5 (see figure 1 and appendix 1). Monitoring of the 'standard suite' (salinity, temperature, turbidity, pH, and dissolved oxygen) and

nutrients (phosphate, silicate. nitrate, nitrite and ammonia) was carried out through the low water period. Even with low run-off the salinity below the bridges dropped to 4.8psu at low water (and at high water reached 33+psu).
The NERC aircraft carried out a number of runs over the estuary between 1200 and 1230.
At approximately half tide we left the anchor station (at 1530) and went downestuary to station 3 (the lighthouse on the end of the breakwater). The wind was northeasterly 4/5 and a large swell was built up in the narrow channel leading to the sea (behind the breakwater). These swell waves were breaking spectacularly on the shoals on the south side of the channel. After this first (successful but very uncomfortable) attempt at reaching the lighthouse it was considered inadvisable to repeat it so, the repetitive transects carried out by Tamaris during the rest of the day were confined to the part of the estuary between the Lifeboat slipway (station 4) and station 8 (about a kilometer above the railway viaduct). The semi-rigid was used to extend the transect up to station 19, just below the Chain (Union) Bridge. During this part of the transect bulk discrete samples were taken in 10l pots for standard suite, nutrients, DOC, chlorophyll, gravimetrics and C/N.
The echo-sounder, with its paper trace output, situated in front of the coxswain proved invaluable. An example of the output is shown in figure 2. This instrument will be used during future surveys to characterise the depth profiles in the 'pits' in the estuary.
Profiling was completed at 1910 and Tamaris returned to the dock. Work was completed at 2000.

Wednesday 18 Sept.: High tide times; 0618 and 1844.
Arrived at the boat at 0800. As on the previous day, the boat was moved out into the river to station 5 and monitoring (as previously detailed) was carried out through the low water period. Also, during this time, discrete samples from the previous days transect in the semi-rigid were processed and at low water an EMP 2000 was deployed on the lifeboat slipway. This instrument will be changed over monthly, during the survey weeks.
Repetitive profiling of the estuary, from stations 3 to 8, was commenced at 1600. The wind had freshened to northeasterly 6 and it was not possible to get out to the lighthouse (station 3). At 1700 the semi-rigid was deployed to extend the estuarine transect up to station 19, taking bulk samples for standard suite, nutrients, dissolved trace metals, gravimetry, chlorophyll and C/N. This part of the transect was completed by 1930 and Tamaris returned to the dock at 1945. Work was completed at 2100. During the late afternoon a large vessel had entered the dock and we had been instructed by the Harbour Master to move Tamaris to another berth. This involved moving several fishing boats, in the dark, and took us nearly an hour to complete.

Thursday 19 Sept.: High tide times; 0705 and 1933.
Arrived at the boat at 0430. Tamaris commenced repetitive axial profiling of the lower estuary from the lighthouse (station 3) to station 8. In addition to the standard suite, nutrients, gravimetry, chlorophyll and C/N, samples were

taken for methane and nitrous oxide determinations. The semi-rigid inflatable was used as on previous days to extend the axial profile up to station 19.
At 0930, when it was no longer possible to navigate the Tamaris in the lower estuary, we anchored at station 5 and continued monitoring through the low tide period until 1730, when we calculated there would be sufficient water to make unloading the equipment easier. This was successfully accomlished by 1815, at which time we recovered the semi-rigid onto its road trailer for the journey back to Plymouth. Work was completed at 1900.

Friday 20 Sept.: Departed Berwick-on-Tweed at 0815 and arrived back in Plymouth at 1830.

Results:
Figure 2 shows results of nutrients profiling carried out on 19 Sept.. Part of the profile, from station 3 (10.4 km downestuary) to 8 (6.6 km downestuary), was sampled from Tamaris while the further upestuary stations were sampled from the semi-rigid inflatable, the samples being analysed aboard Tamaris. The points/stations picked were on a fairly continuous run upestuary; ie Tamaris steamed from station 3 to 8 and the semi-rigid continued from there. On this occasion, despite higher run-off than previously encountered, saline intrusion occurred to within about 2km of the Union Bridge. In the upper and lower sections of the estuary all nutrients behaved conservatively with respect to salinity. However, a sewage effluent discharge at 6km downestuary (20-25 psu) can be seen clearly, particularly for ammonia in figure 2 and for ammonia, phosphate and nitrite in figure 3. The results shown in figure 3 are all the data points acquired on 19 Sept., including all profiles plus the short anchor station which preceded them. From observations made during this and the previous survey it would appear that this discharge is continuous and relatively invariant. Often the smell greets you 1km away, when the wind is in the right direction!
Figures 4 and 5 show the results of a short anchor station carried out on 19 Sept..Figure 4 shows standard suite variables (with the exception of temperature) against time. There is evidence of a small turbidity maximun in the lower estuary (as previously reported by Reg Uncles and John Stephens) although general levels of suspended particulate material are very low when compared to systems like the Humber or Tamar. This maximum occurs at the time of peak ebb velocity, about two hours before low water. Dissolved oxygen and pH vary inversely with salinity. Figure 5 shows nutrients, phosphate, nitrate, nitrite and ammonia with time. The inflection in the traces for nitrite and ammonia occurs at the point at which salinity starts to rise at the beginning of the flood tide.
Figures 6 and 7 give an idea of the depth profile in, and position of, the main channel. The problem area, which stopped Tamaris from navigating to the area above the A1 road bridge occurs on the corner by the 'old fishery' (figure 6), between points 11 and 14.

General comments:
Since this was the first occasion on which the Tamaris had been used in the Tweed and those in the scientific party who had previously worked on Tamaris had not done so for quite a few years, this was something of a shake-down cruise. On the whole everything went very well and a good deal of what was intended was achieved. However a few points emerged which will have a bearing on future Tweed fieldwork campaigns:

1. The loading and setting up of equipment took much longer than anticipated. This was partly due to the tasks required of the boat's crew before Tamaris could be moved, partly the logistics of getting the gear aboard and partly due to the number of things that needed to be set up and calibrated. Clearly, with practise, we will speed up but, we propose that a day be set aside for this purpose (see recommendations).
2. On this occasion Tamaris was unable to navigate past station 8. With more freshwater run-off we anticipate that she will be able to get up to station 12 or 13. However, her endurance in this area (traversing) will be severely restricted to about an hour either side of high water. There are several deep pits between stations 11 and 13 in which she may be able to 'sit out' low water, if necessary.
3. We need to rationalise the way we set up and control the standard suite. We propose to install a shelf at the forward/port side of the lab to take the lap-top which controls the sonde; and the sonde itself is fitted just inside the door. The waste pipe from the flow-through cell which feeds the sonde is led to the sink where it can be used for discrete sampling.
4. The second YSI 6000 will be set up for use in the semi-rigid with the rechargeable hand-held logger.
5. We have agreed with the crew that the stove will be removed during surveys to maximise bench space in the lab. It will be replaced by an electric kettle in the wheelhouse.
6. On this first survey it was not possible to deploy any bed rigs. In hindsight this may be fortuitous because it is clearly not as straightforward as it first appears. We ideally need to pick sites that have sufficient water at all states of the tide for the instruments to be covered and at which we can rig an anchoring system which can be safely deployed from the bank, on foot. We have identified a number of possible sites but need to have time to check the access.
7. Discussions with the Harbour Master and his staff, as well as local fishermen who use the dock, have raised a number of issues related to operating the boats in the estuary during the winter:
a). Severe icing, particularly in the upper estuary and the dock is common during February and March. Operating the boats under these conditions may be extremely hazardous so, we need to discuss alternative sampling strategies.
b). It will be essential that we have adequate clothing to withstand the low temperatures and wind chill factor, particularly when operating from the semi-rigid (see recommendations).

8. We have planned the arrangement of core programme equipment in the lab on Tamaris to maximise space for additional (Special topic) workers. However, such space is still severely restricted.
9. While we hold the option to carry out an offshore leg (stations 1 and 2) it will only be possible under perfect conditions. Whenever possible it will be done.
10. If surveys of the deep pits at the top of the estuary (or indeed anywhere that is inaccessible to Tamaris) are to be done, we will need a suitable 12volt submersible electric pump. We did a bit of research following the July trip but, so far, have not found one suitable for the metals sampling. Any thoughts anyone?

Recommendations:
1. In order to make best use of the survey weeks I suggest the following; travel up on the previous Saturday
allow a day to set up the boat and equipment

2. We have enough survival suits for use in the semi-rigid during the winter but, we also need warm waterproof hats (Musto, with chinstrap!), scarves (ultrafleece) and gloves (wet suit gloves with silk liners have been recommended).

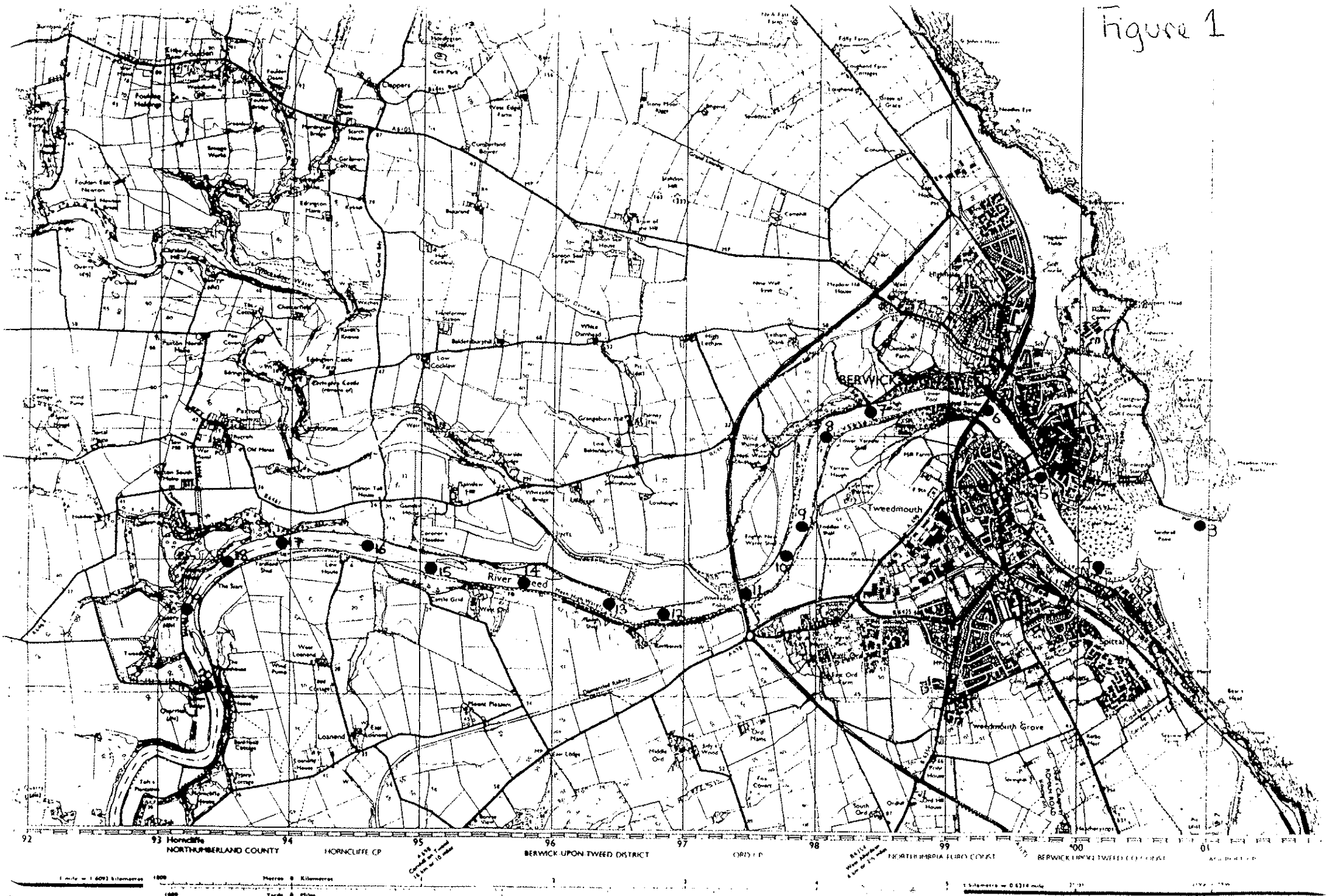
Appendix 1.

List of Stations:

Station No.	Station description	Map reference *
1	Offshore	
2	Offshore	
3	Just short of Lighthouse	009524
4	Lifeboat station	002520
5	Chandlery	997527
6	Just before railway viaduct	993532
7	White house on RHS	984532
8	Derelict building on corner	981530
9	Building past outfall on LHS	979523
10	Prominent trees on either side	978521
11	A1 road bridge	974517
12	2nd set of pylons past bridge	968516
13	Disused fishery on LHS	964517
14	Disused fishery on LHS	958518
15	Next fishery. power cables	951519
16	Next fishery on RHS	946521
17	End of wall/Fishery with icehouse	930522
18	Boat house on RHS	935520
19	End of trees/big house on RHS	932516
20	Chain bridge	934510

* - Ordnance survey Pathfinder 438

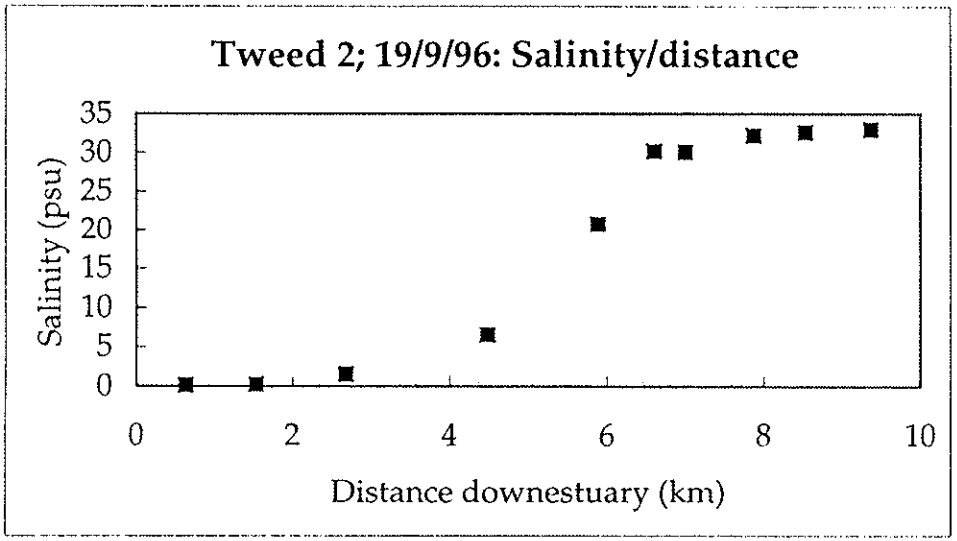
Figure 1

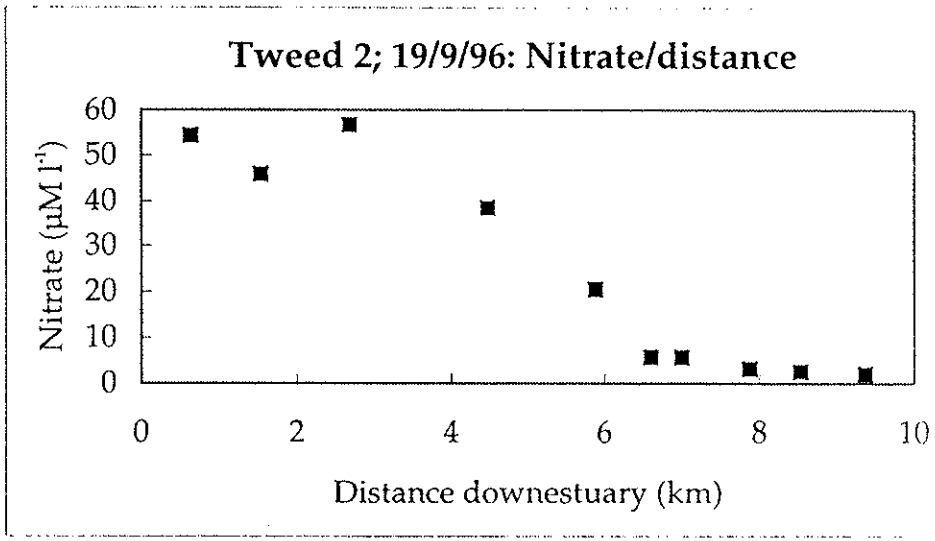


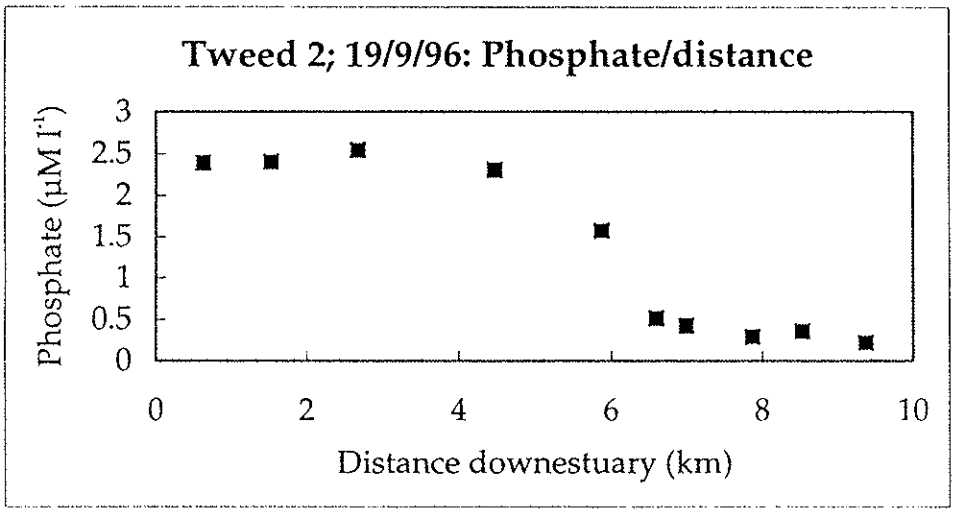
Scale 1:25 000

PATHFINDER 438 (NT

Figura 2


Tweed 2; 19/9/96: Salinity/distance
Salinity (psu)
35
30
25
20
15
10
5
0
0
2
4
6
8
10
Distance downestuary (km)


Tweed 2; 19/9/96: Nitrate/distance
Nitrate (µM l-1)
60
50
40
30
20
10
0
0
2
4
6
8
10
Distance downestuary (km)


Tweed 2; 19/9/96: Phosphate/distance
Phosphate (µM l-1)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
Distance downestuary (km)

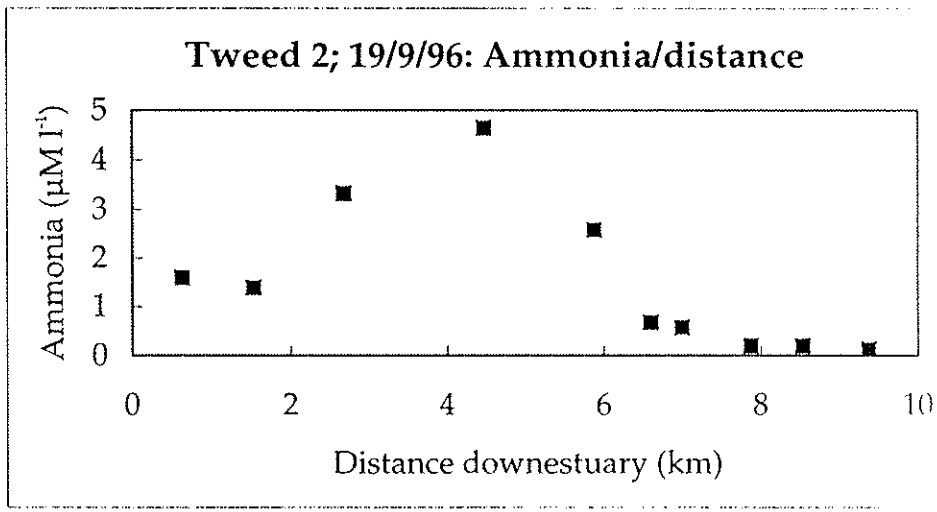
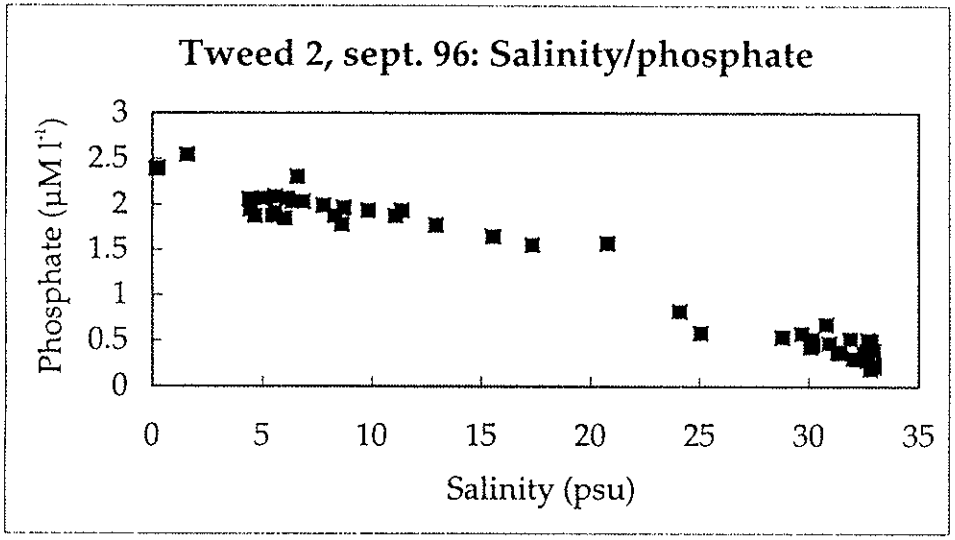
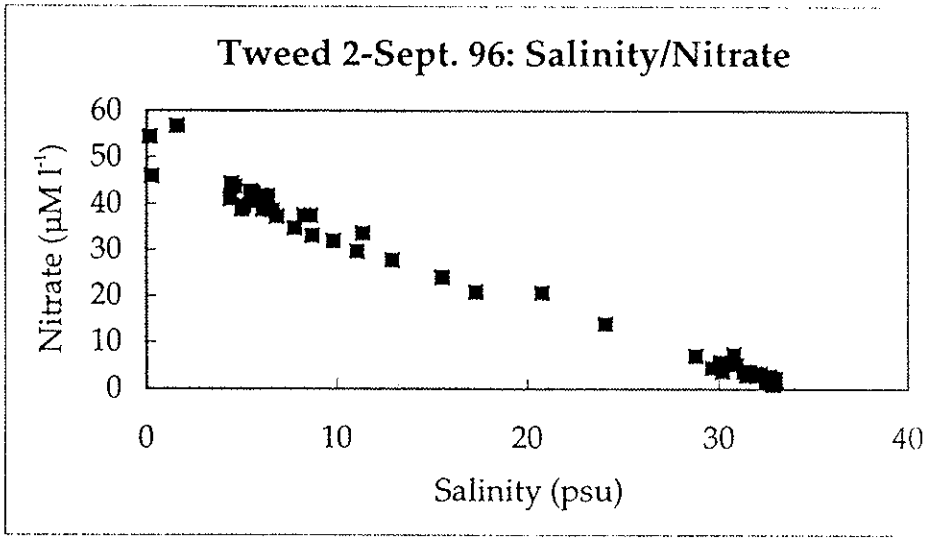
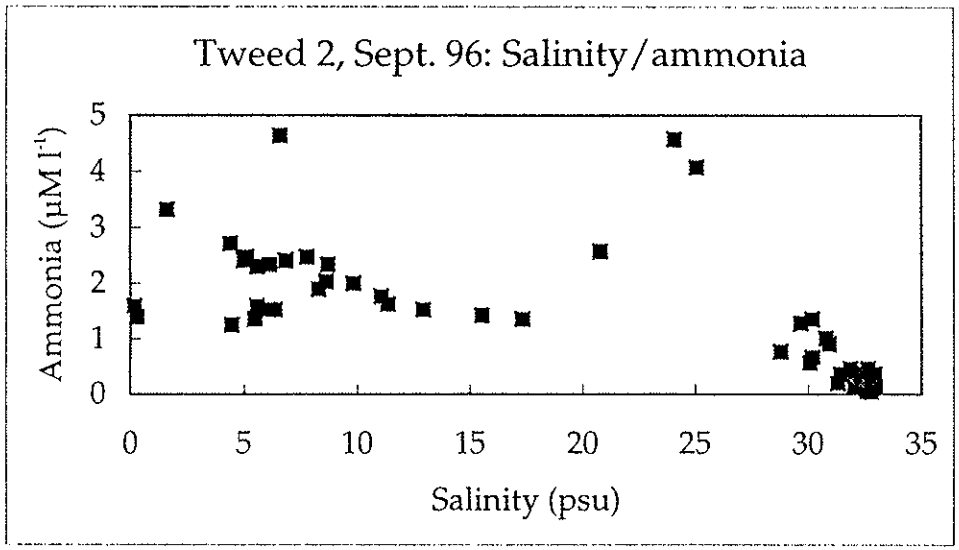

Tweed 2; 19/9/96: Ammonia/distance
Ammonia (µM l-1)
5
4
3
2
1
0
0
2
4
6
8
10
Distance downestuary (km)

Figure 3


Tweed 2, sept. 96: Salinity/phosphate
Phosphate (µM l-1)
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
Salinity (psu)


Tweed 2-Sept. 96: Salinity/Nitrate
Nitrate (µM l-1)
60
50
40
30
20
10
0
0
10
20
30
40
Salinity (psu)


Tweed 2, Sept. 96: Salinity/ammonia
Ammonia (µM l-1)
5
4
3
2
1
0
0
5
10
15
20
25
30
35
Salinity (psu)

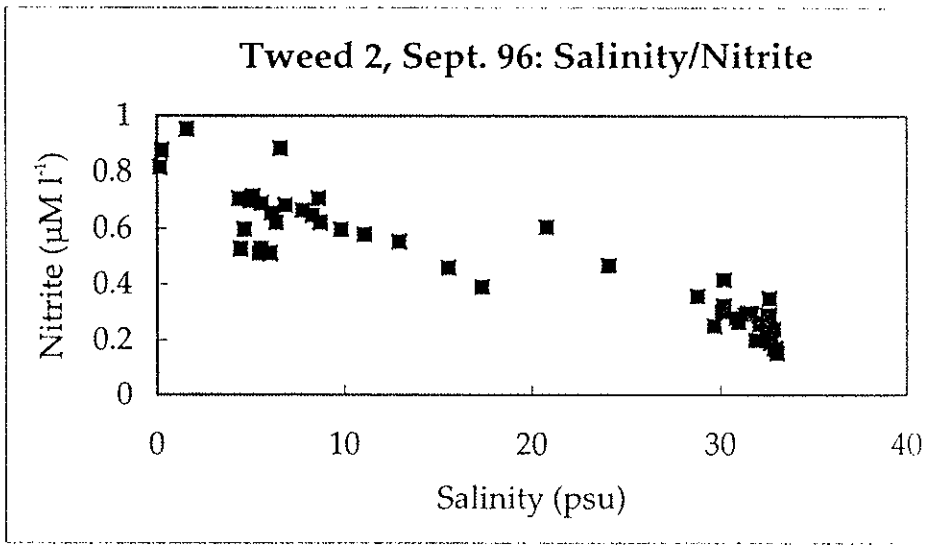
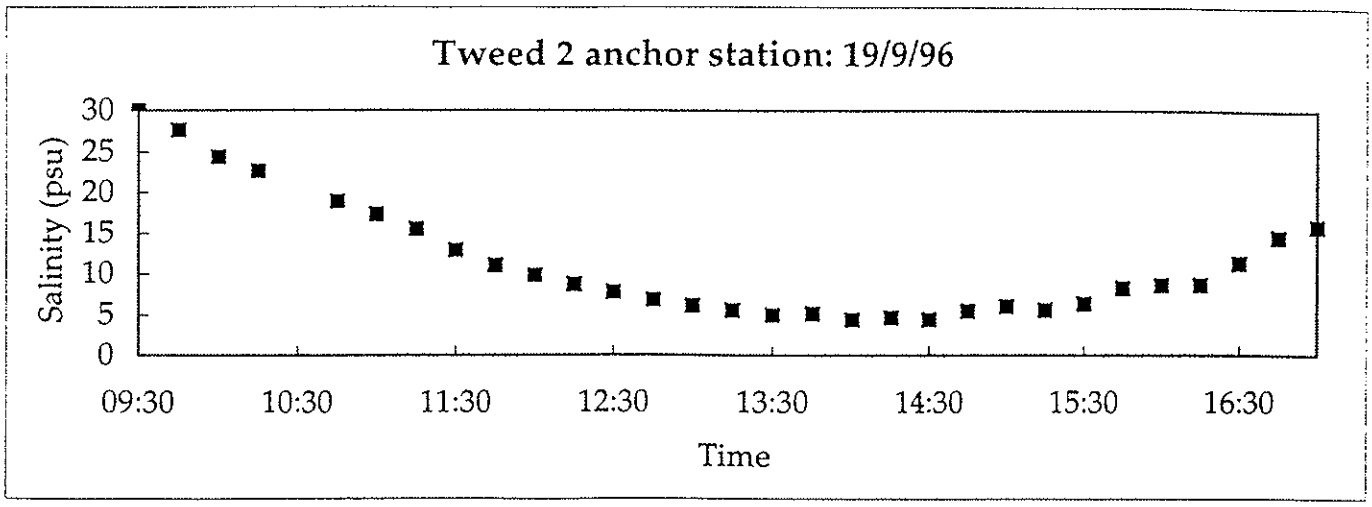
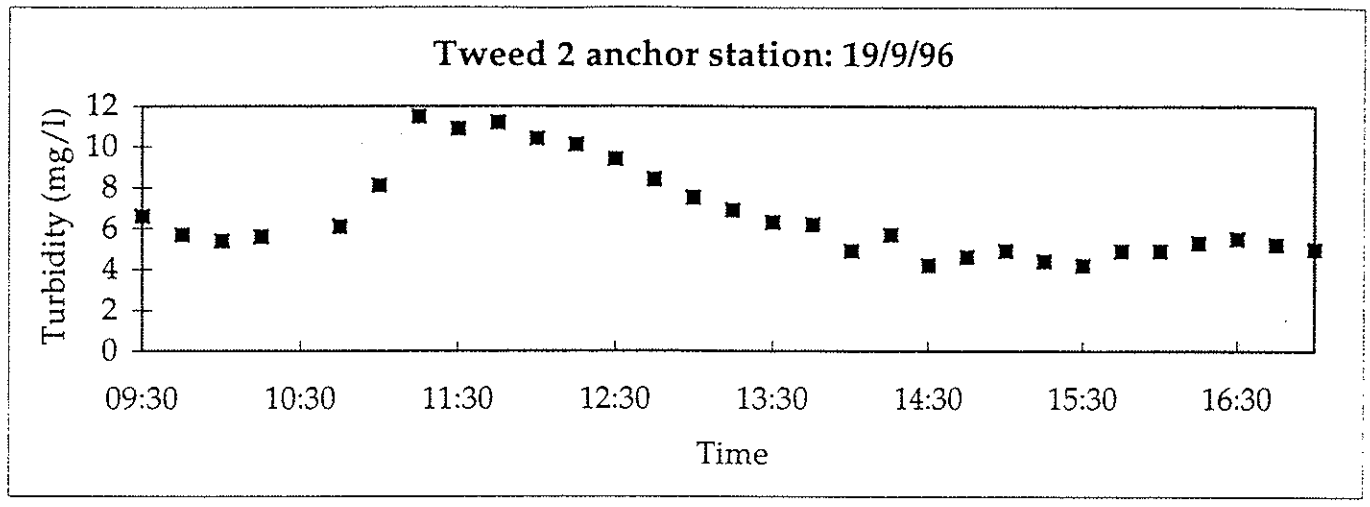
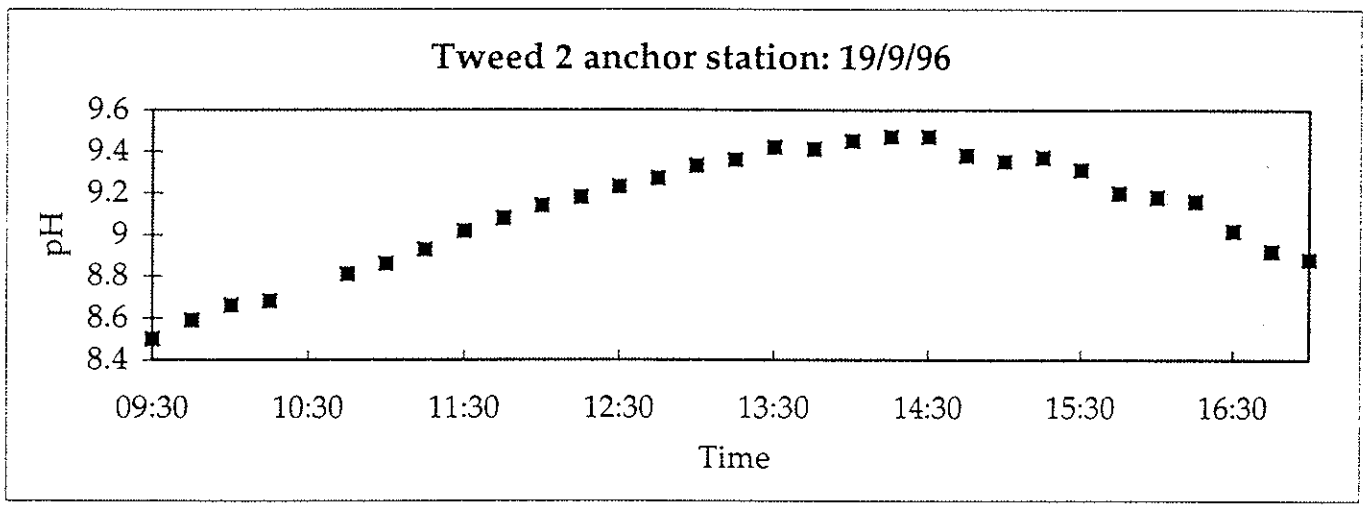

Tweed 2, Sept. 96: Salinity/Nitrite
Nitrite (µM l-1)
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
Salinity (psu)

Figure 4


Tweed 2 anchor station: 19/9/96
Salinity (psu)
30
25
20
15
10
5
0
09:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
Time


Tweed 2 anchor station: 19/9/96
Turbidity (mg/l)
12
10
8
6
4
2
0
09:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
Time


Tweed 2 anchor station: 19/9/96
pH
9.6
9.4
9.2
9
8.8
8.6
8.4
09:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
Time

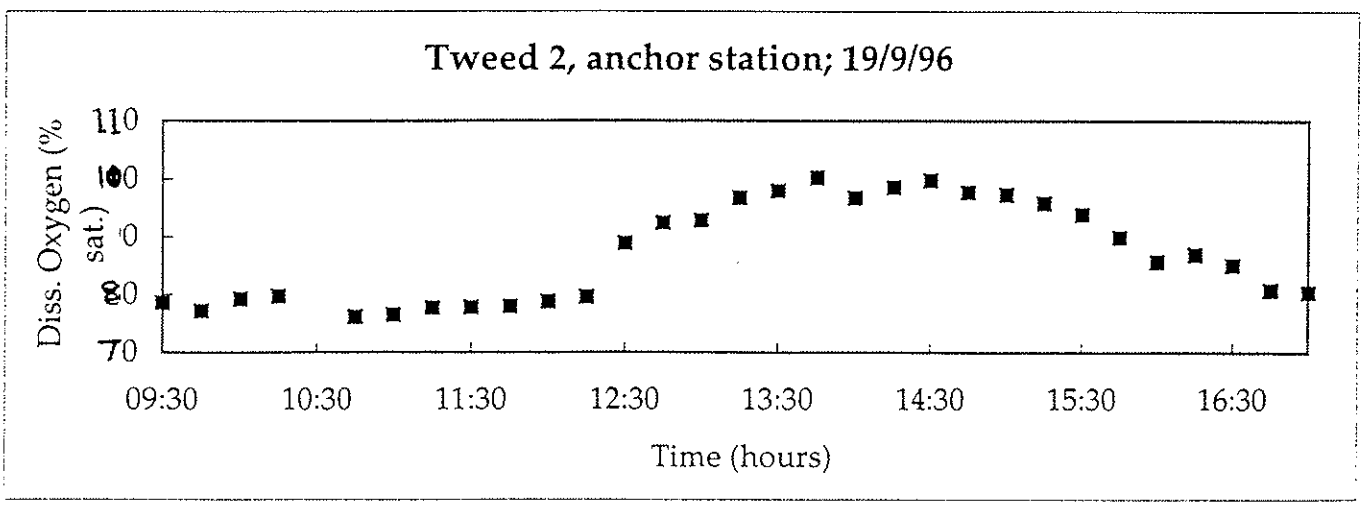
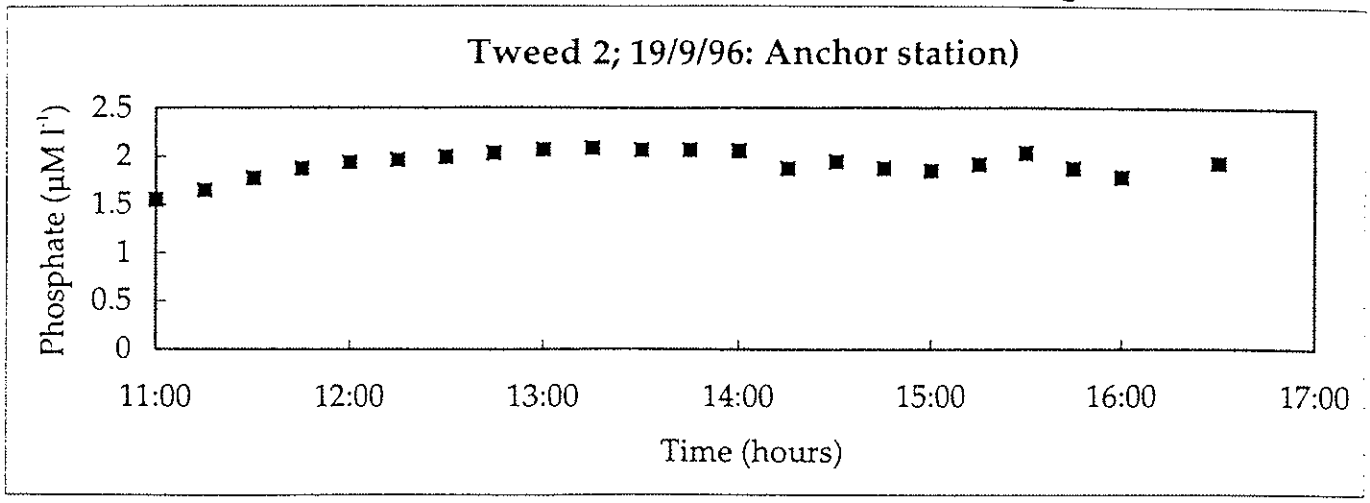
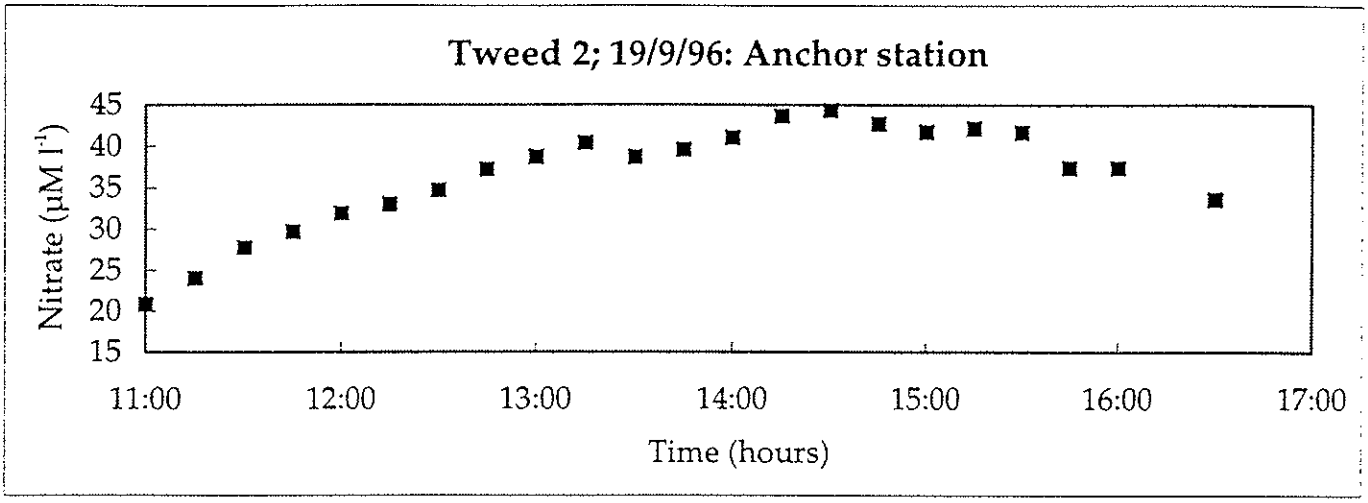
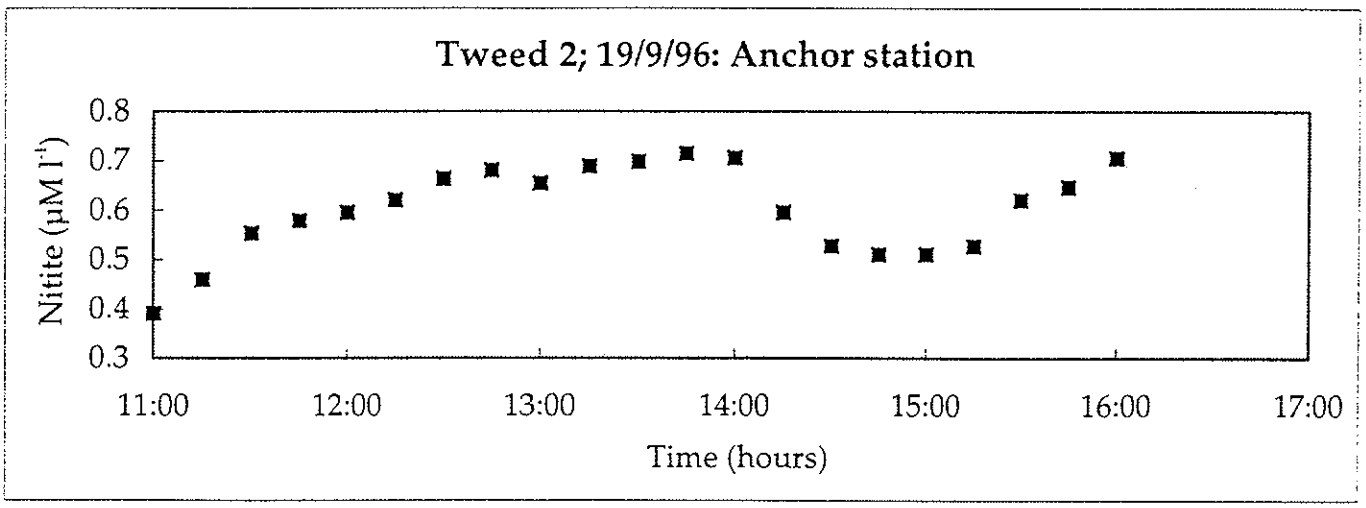

Tweed 2, anchor station; 19/9/96
Diss. Oxygen (% sat.)
110
100
90
80
70
09:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
Time (hours)

Figure 5


Tweed 2; 19/9/96: Anchor station)
Phosphate (µM l-1)
2.5
2
1.5
1
0.5
0
11:00
12:00
13:00
14:00
15:00
16:00
17:00
Time (hours)


Tweed 2; 19/9/96: Anchor station
Nitrate (µM l-1)
45
40
35
30
25
20
15
11:00
12:00
13:00
14:00
15:00
16:00
17:00
Time (hours)


Tweed 2; 19/9/96: Anchor station
Nitite (µM l-1)
0.8
0.7
0.6
0.5
0.4
0.3
11:00
12:00
13:00
14:00
15:00
16:00
17:00
Time (hours)

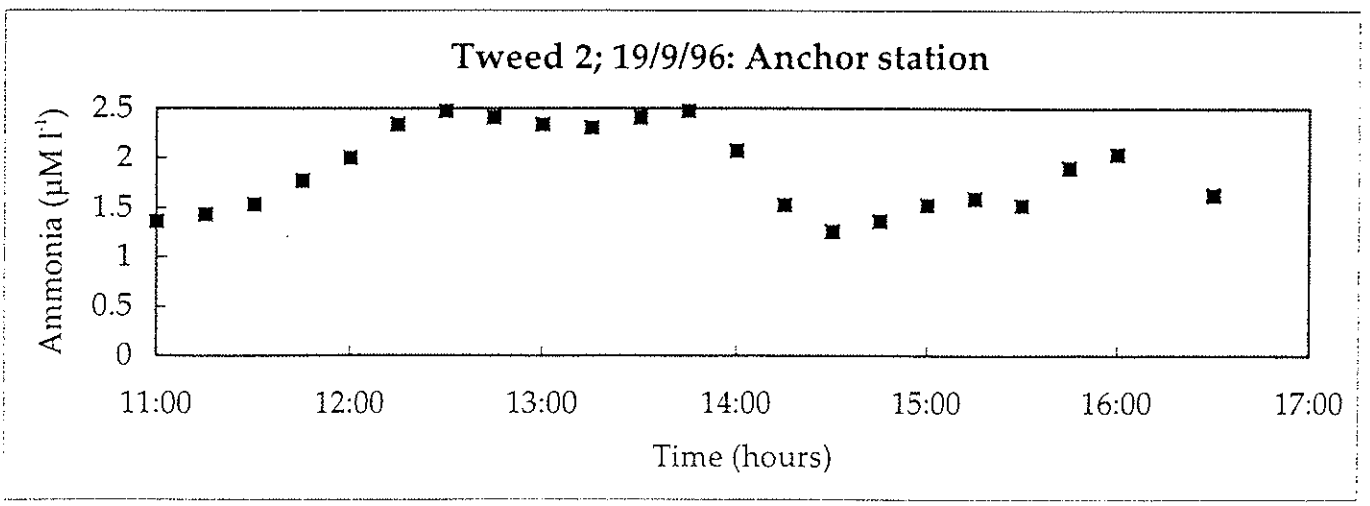
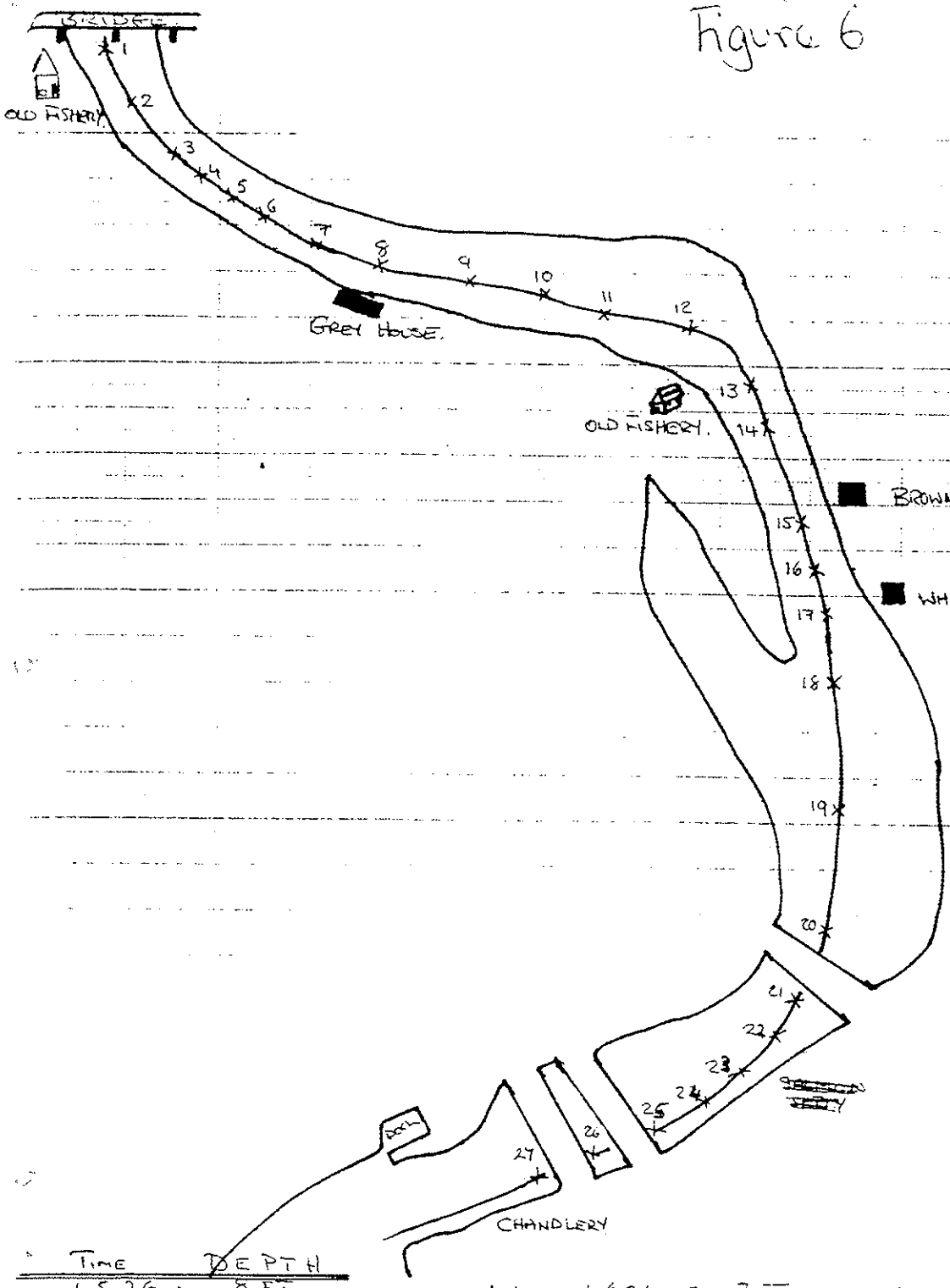

Tweed 2; 19/9/96: Anchor station
Ammonia (µM l-1)
2.5
2
1.5
1
0.5
0
11:00
12:00
13:00
14:00
15:00
16:00
17:00
Time (hours)

Figure 6

HIGH WATER 17:30
LOW WATER 11:0
Down River.



	Time	Depth
1	1526 =	5 FT
2	1527 =	7 FT
3	1540 =	8 FT
4	1543 =	12 FT
5	1544 =	16 FT
6	1546 =	15 FT
7	1548 =	20 FT
8	1554 =	10 FT
9	1558 =	4 FT
10	1600 =	9 FT
11	1604 =	7 FT
12	1609 =	6 FT
13	1609 =	6 FT
14	1611 =	8 FT
15	1620 =	10 FT
16	1622 =	11 FT
17	1625 =	12 FT
18	1627 =	11 FT
19	1629 =	10 FT
20	1631 =	14 FT
21	1635 =	20 FT
22	1636 =	12 FT
23	1639 =	13 FT
24	1649 =	11 FT
25	1652 =	13 FT
26	1653 =	17 FT
27	1653 =	22 FT

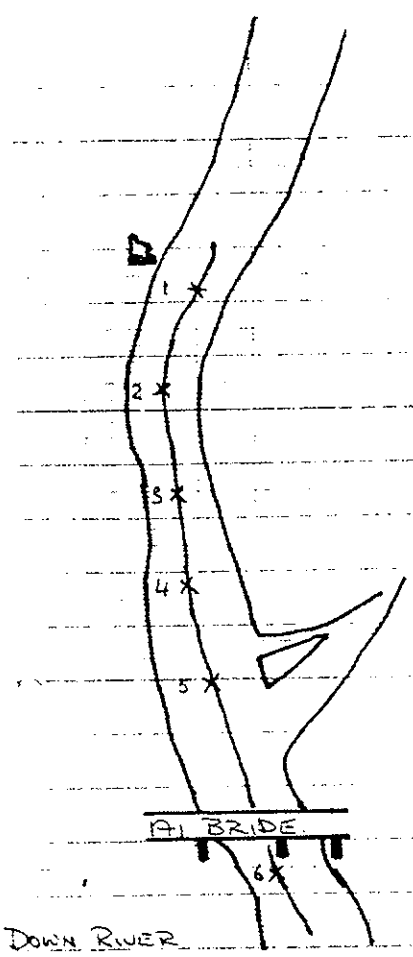
Figure 7

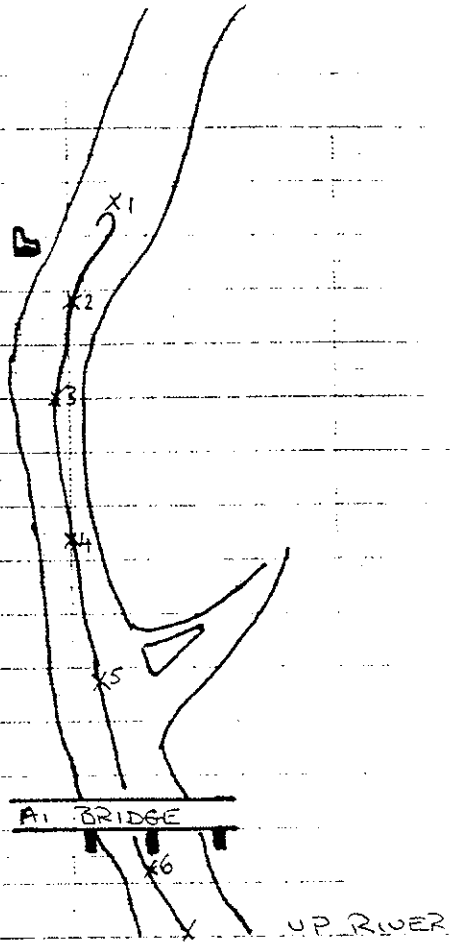
Berwick-upon-Tweed

16-7-96

HIGH WATER 1729

LOW WATER 1116





	TIME	DEPTH
1	1515	10 FT
2	1517	9 FT
3	1513	9 FT
4	1520	5 FT
5	1522	4 FT
6	1526	5 FT

	TIME	DEPTH
1	1506	12 FT
2	1504	10 FT
3	1503	9 FT
4	1502	7 FT
5	1500	5 FT
6	1459	9 FT