NRA Wales 60

NATIONAL RIVERS AUTHORITY
WELSH REGION
SOUTH WEST DIVISION

THE RESULTS OF TAWE BARRAGE POST-IMPOUNDMENT SALMON AND SEA TROUT TELEMETRY STUDY 1992

PL/EAW/93/2

AUTHOR R.H.BLACKLIDGE AND D.M.MEE
PROJECT SPONSOR A.J.SCHOFIELD
PROJECT MANAGER D.M.MEE

CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Background

The NRA presented Swansea City Council (SCC) with study proposals for assessing the impact of the Tawe barrage on the migration of salmon and sea trout in the estuary, based on the use of fish telemetry. These were rejected by SCC largely on the basis of cost and reservations as to the practicability of the studies. The NRA therefore commenced water quality and fisheries studies, whilst these negotiations were in progress. Fisheries studies in 1990 and 1991 have been reported. These demonstrated that firstly sufficient numbers of salmon and sea trout suitable for tagging could be caught using a bag net in Swansea bay and by relocation from Panteg fish trap, secondly tagged fish could be tracked through the Tawe estuary and past the barrage site, using existing telemetry technology.

An agreement has been reached between the NRA and SCC to jointly fund a scaled down telemetry study, considered by the NRA to be the absolute minimum level of investigation commensurate with the objectives of the study. Welsh Office (WO) have given their assurance that they will accept this study together with trap data as means of evaluating performance with respect to formal fish pass approval. The study will be carried out over 2 years, the extension of the study into a second year will be dependent on the results of year one. The study will start in 1993 as the first complete year following impoundment.

The fisheries studies were continued in 1992 to provide some preliminary data following impoundment on the 29th July 1992. This report describes the result of these investigations.

Results

A total of 22 fish (16 salmon and 6 sea trout) from Panteg fish trap were tagged with combined acoustic and radio tags (CART) and relocated below the barrage. Tracks were obtained from a telemetry system as they migrated the Tawe estuary.

10 fish (8 salmon and 2 sea trout) were not detected post-tagging. 7 fish (5 salmon and 2 sea trout) were detected in freshwater between 7 hours to 17 days post relocation. 4 fish (2 salmon and 2 sea trout) were detected downstream of

the barrage that were not subsequently detected upstream. 1 CART from a salmon was returned from Aberafan beach some 8km east from the Tawe Estuary.

Fish primarily entered the estuary over the early flood tide. 4 fish detected as they passed the barrage did so over the late flood tide or high water when the barrage was overtopped or when the tidal height was less than 0.65m below the primary sill. Fish were detected entering freshwater predominantly at high water or early ebb tide. The average ground speed through the impoundment was $0.5ms^{-1}$ or 0.75 body lengths(bl)s^{-1}. Fish showed no preference for estuarial migration during dawn, dusk, day or night.

At least 2 seals have been regularly observed taking salmon and sea trout from below the barrage immediately downstream of the fish pass.

Conclusions

1. The telemetry system provided estuary tracks which enabled the passage time of tagged fish through the estuary and the exact time that they passed the barrage to be determined and related to environmental factors namely tidal height/state, river flow and period of day.

2. Salmon and sea trout showed preference for estuarial migration during spring tides and elevated river flows irrespective of day/night period. Fish entered the estuary predominately on the early flood tide and migrated through the lower estuary on the incoming tide.

3. The preliminary results suggest that the barrage may be an obstruction to the migration of salmon and sea trout throughout the majority of the tidal cycle but further data will be required.

4. Salmon and sea trout migrated past the barrage when the tide had overtopped or was within 0.65m of the primary weir. There is no evidence to date that fish were able to pass the barrage, either via the fish pass or through the lock, when the tide was significantly below primary weir height.

5. The accumulation of fish below the barrage may increase the predation by seals in the estuary.

1. INTRODUCTION

Construction of a barrage across the lower Tawe estuary as part of Swansea City Council's (SCC) dock redevelopment scheme was first proposed in a Bill presented to Parliament in 1985. It was given Royal assent in 1986 and construction was started in Spring 1989. Impoundment occurred on the 29th July 1992 and the barrage is due to be fully operational by January 1993.

The River Tawe (Figure 1) is a recovering salmon and sea trout fishery. The average annual rod catch (1984-90) is 70 salmon and 473 sea trout (NRA 1991a) which puts the Tawe within the top twelve Welsh fisheries for sea trout (NRA 1991b). The NRA are concerned that the barrage may have potential detrimental effects on fish migration through the estuary, despite the provision of a MAFF approved design, pool and traverse fish pass and also on water quality particularly within the impoundment. Subsequently, the NRA produced a programme for the post-construction monitoring of fisheries migration (Wightman 1989) and water quality (Halfacree 1989).

The NRA undertook a pilot study in 1990 and 1991 to assess the practicability of the fisheries monitoring programme involving the use of fish telemetry to track fish as they migrate past the barrage. This demonstrated that firstly sufficient numbers of salmon and sea trout suitable for tagging could be caught using a bag net in Swansea bay and by relocation from Panteg fish trap, secondly tagged fish could be tracked through the Tawe estuary and past the barrage site, using existing telemetry technology (Blacklidge, Wightman & Wilson 1991, Blacklidge & Wightman 1992).

An agreement has been reached between the NRA and SCC to jointly fund a telemetry study, considered by the NRA to be the absolute minimum level of investigation commensurate with the objectives of the study. This was providing that Welsh Office (WO) accepted this study as means of evaluating performance with respect to formal fish pass approval. WO have given this assurance. The study will be carried out over 2 years, the extension of the study into a second year dependent on the results of year one. An independent arbitrator will consider the first years results if there is a dispute on the necessity of a second years study between SCC and the NRA. The study will start in 1993 as the first complete year following impoundment.

The fisheries studies were continued in 1992 to provide some preliminary data following impoundment on the 29th July 1992. This enabled the telemetry

systems to be tested around the barrage, once it was completed, to overcome any technical and practical difficulties prior to the start of the post-construction study. This report describes the work carried out in 1992 and presents the results.

2. SITE OF STUDY

The River Tawe runs (Figure 1) some 50km south west from its source at 600m on Moel Feity, draining a catchment of about 260km^2 before it discharges into the Bristol Channel at Swansea Dock. The average daily flow for the River Tawe (1982-1992) was 12.7 cumecs. The Tawe estuary is an artificial estuary which is integral with Swansea Dock and includes a Marina complex and a set of three commercial docks.

The Tawe Barrage is located immediately downstream of the Marina complex (Figure 2). It consists of a primary and secondary weir, a lock and a fish pass. The crest of the primary weir is 8.05m above Chart Datum and the secondary weir is 0.3m higher at 8.35m. The barrage incorporates a HEP generator in the east abutment which has an outlet in the floor of the structure immediately downstream of the fish pass. The inlet and outlet are screened to prevent entrainment of adult and juvenile salmonids. An abstraction licence ensures that operation of the lock and generator does not reduce the flow through the fish pass to below one cumec. In addition during smolt migration in April and May a water level of 150mm above the primary weir must be maintained.

3. METHODS

3.1. Fish capture and tagging

Adult salmon and sea trout were captured during routine operation of Panteg Weir fish trap (Mee, Stonehewer & Blacklidge 1993). Suitable fish for tagging were tagged with a Combined Acoustic and Radio Tag (CART) using standard procedures (Clarke, Purvis & Mee 1990). Once tagged the fish were relocated below the barrage (Blacklidge & Wightman 1992).

3.2. Telemetry and tracking

Sonar buoys were deployed at four sites in the estuary shown in Figure 2. Two sonar buoys were sub-surface mounted and deployed at two sites, TA.ES2 and TA.ES3, 500m and 130m upstream of the barrage respectively. One sonar buoy was bed mounted and deployed at site TA.ES5, at the foot of the concrete ferry loading bridge support. A bed mounted sonar buoy was deployed 130 metres below the barrage, site TA.ES4B and was later redeployed 80 metres below the barrage at site TA.ES4A after receiving damage in adverse flow conditions.

The sonar buoys transmitted to automatic listening stations (ALS) located at 2 sites: (i) On the flat roof of the Associated British Ports (ABP) lock control tower (ii) On the barrage. The spare channels of the ALS's not set to receive a signal from a sonar buoy were set to scan the CART radio channels. This enabled detection of tagged fish near the surface or in low salinities especially within the impoundment.

Entry of CART tagged fish into freshwater was detected by 2 ALS's (Figure 1) situated below Beaufort Weir (OSGR SS 672974) which marks the head of tide 5.8km upstream of the barrage. TA.ES1 was located in Morfa Athletics Stadium (OSGR SS 665955), 3.5km upstream and was taken as the site of freshwater entry as there is minimal salt water intrusion. TA1 was situated at a SCC training site (OSGR SS 672972), 5.4km above the barrage site. A third ALS was deployed at Panteg Weir (OSGR SN 764076) to provide information on the number of relocated fish returning to Panteg.

A number of active tracks were carried out by boat, foot or from vehicles to locate fish between Panteg and Beaufort Weir.

3.3. Environmental data

Hydrological data was obtained for the river Tawe from Ynystangws gauging station (OSGR SS 685998) on the main river 4km above Beaufort Weir.

Tidal data was taken from the predicted heights published in the Admiralty tide tables.

Dawn and dusk periods were calculated from sunset and sunrise data produced by HM nautical Almanac Office, c the Science and Engineering Research Council. Dawn was taken as a two hour period spanning one hour before sunrise to one hour after sunrise. Dusk was taken as a two hour period spanning one hour before sunset to one hour after sunset.

Water quality data has been obtained from routine sampling, continuous monitoring and profiling surveys of the Tawe estuary. Routine surface sampling has been carried out monthly since 1990 at ten sites along the Tawe estuary. Extra sampling has been carried out post-impoundment including a number of samples taken at depth. Two Datasond hydrolabs have been continuously deployed since impoundment, the first 1.5 metres from the surface and the second 5 metres from the surface, to measure temperature, pH, salinity, dissolved oxygen and conductivity. Routine depth profiles have been carried out at 5 sites above the barrage following impoundment to monitor temperature, dissolved oxygen and salinity.

4. RESULTS

4.1. Environmental conditions

4.1.1. Freshwater discharge

The daily mean flows for the river Tawe are shown in Figure 3. Average monthly mean flows for 1982-1992 and monthly mean flows for 1990, 1991 and 1992 are shown in Table 1. River flows showed a wide variation during 1992. The flows for June and July were low compared to the 11 year average. In contrast the flows in August, September, November and December were much higher with the exception of October when they were again lower than average. During August and September, when the fish were relocated, the flows were considered to be favourable for freshwater entry.

4.1.2 Water quality

Investigations have shown that saline stratification of the water column occurs above the barrage which has been maintained over periods of neap tides when there is little or no overtopping (Rogers 1992). The size of the saltwater 'wedge' and the depth of the surface freshwater layer varies with freshwater flow, the extent of tidal overtopping and lock operation. As a result of stratification the lower saline layers become isolated from the atmosphere and deoxygenation of the wedge has occurred and levels as low as $2.9 mgl^{-1}$ have been recorded. The water quality studies will be reported in detail in a separate report.

4.2. Description tagged sample

A total of 22 fish, 16 salmon and 6 sea trout, were CART tagged and relocated from Panteg Weir between the 23-08-92 and the 3-11-92 (See appendix I).

4.3. Fates of relocated fish

Of the 22 fish relocated, 10 fish were not detected (8 salmon and 2 sea trout), 7 fish were detected in freshwater (5 salmon and 2 sea trout) and 4 fish (2 salmon and 2 sea trout) were detected downstream of the barrage but not subsequently detected upstream (Table 2). One fish was detected by TA.ES1 4 days after relocation and was detected leaving the river system 17 days later. Also a tag was returned from Aberafan beach some 8km east from the Tawe estuary from a salmon.

4.4. Description of typical tracks

Tracks were obtained from 7 fish that entered freshwater. Four of the tracks from fish numbers C2E089, C2E105, C2E075 and C2E077 (Figures 4-7) enabled the precise time the fish passed the barrage to be determined in relation to river flow and tidal height. The time past the barrage was taken as first detection by sonar buoy TA.ES3 (Figure 2). The remaining 3 fish entered freshwater after the acoustic side of the CART had switched off and only freshwater entry information was available. Two tracks are shown in Figures 8-10 of fish which were detected below the site only.

Fish tracks Figures 4-10 are plotted with distance, in relation to the barrage, on the Y axis and the fish track is represented by the green line. Figures 4-9 are plotted with tidal height data on the Y2 axis. The red line represents the barrage at distance 0 on the Y axis this height also corresponds to the height of the primary weir (8.05m) when measured against the Y2 axis to illustrate overtopping and the position of the barrage simultaneously. The Y2 axis in Figure 10 represents river flow in cumecs.

Fish number C2E089 Female sea trout (Figure 4)

Relocated on the 15th September 1992 at 1610hrs the fish entered the estuary on the late ebb tide under falling flows (17 cumecs) within 24hrs of release. The fish migrated passed the barrage 1hr 50mins before high water when the predicted tidal height was 0.65m below the primary sill. Once past the barrage structure the fish migrated rapidly through the impoundment and reached TA1 14hrs 20mins after first estuarial detection.

Fish number C2E105 Male salmon (Figure 5)

Relocated on the 16th September 1992 at 1530hrs the fish entered the estuary 1hr 25mins later under falling flows (13 cumecs) on the early flood spring tide. The fish migrated passed the barrage 1hr before high water when the predicted tidal height was 0.45m above the primary sill. Once past the barrage the fish migrated through the impoundment and passed TA.ES1 5hrs 30mins after first estuary detection. The fish finally past Beaufort Weir 13 days later.

Fish number C2E075 Female salmon (Figure 6)

Relocated on the 24th August 1992 at 2030hrs the fish was detected entering the estuary on 5 occasions before finally passing the barrage. The final estuary entry on the 10th September 1992, as detected directly by the ALS on the barrage, was under rising flows (11 cumecs) on the early flood spring tide. The fish migrated passed the barrage 1hr 30mins before high water when the predicted tidal height was 0.25m above the primary sill. Once past the barrage the fish migrated rapidly through the impoundment and was detected by TA.ES1 1hr 4mins after passing the barrage. The fish finally passed TA1 2 days later following a rise in river flow.

Fish number C2E077 Female salmon (Figure 7)

Relocated on the 24th August 1992 at 2030hrs the fish was first detected as it migrated passed the barrage on the 8th September under average flow conditions (13 cumecs) 13mins before high water when the predicted tidal height was 0.25m below the primary sill. Once past the barrage the fish left the lower estuary 1hr 50mins later passing TA.ES1 after 3hrs 35mins. The fish finally passed TA1 3 days later following a significant rise in river flow.

Fish number C2E052 Male salmon (Figure 8)

Relocated on the 24th August 1992 at 2030hrs the fish entered the estuary 2hrs 20mins later under elevated flows (24 cumecs) on the early flood neap tide and approached the barrage 3hrs before high water. The fish was detected below the barrage for 3hrs 50mins over high water before leaving the estuary. The fish re-entered the estuary on one other occasion on the 4th September 1992 but was not detected upstream of the barrage.

Fish number C2E043 Male sea trout (Figure 9 and 10)

Relocated on the 15th September 1992 at 1610hrs the fish entered the estuary 12hrs 55min later under elevated flows (12 cumecs) on the early flood spring tide and approached the barrage. It remained below the barrage over high water and left the estuary on the early ebb tide. The fish demonstrated this oscillatory behaviour throughout the acoustic life of the tag (16 days). The fish entered the estuary 26 times (19 early flood, 7 flood) showing similar behaviour each time and leaving on the ebb tide. The fish was never detected upstream of the barrage despite entering the estuary over a range of flows and tidal heights.

4.5 Estuarial and freshwater entry

Estuarial detection and freshwater entry times for both salmon and sea trout are shown in Table 3. All fish detected post-relocation were detected within 16 hours after their release. The 7 fish that reached TA.ES1 were detected between about 7 hours to 17 days after their release.

4.6. Fish movement in relation to tidal state

Tidal state for all detections of fish are shown in Table 4. This showed that both salmon and sea trout entered the lower estuary below the barrage on the early flood tide. Four fish detected passing the barrage negotiated the structure during the late flood tide or high water (details Figures 4-7). Both salmon and sea trout reached TA.ES1 between high and low water but predominantly over high water or on the early ebb tide. Fish were detected at TA1 at high water or during early ebb or/ebb tide often several tidal cycles later after passing TA.ES1.

4.7. Estuarial ground speeds

Estuarial ground speeds are given in Table 5. The mean ground speed through the impoundment (TA.ES3 to TA.ES1) was $0.46ms^{-1}$ or 0.74 body lengths(bl)s^{-1}. The average ground speed between TA.ES1 and TA1 was $0.23ms^{-1}$ or $0.36bls^{-1}$. The average estuarial ground speed between TA.ES5 and TA1 was $0.16ms^{-1}$ or $0.24bls^{-1}$.

4.8. Fish movement in relation to period of day

From the limited data set, salmon and sea trout showed no preference for estuarial migration during dawn, dusk, day or night (Table 6).

4.9 Seal predation

At least two seals have been observed on regular occasions around the barrage structure. The seals have been filmed throughout the tidal cycle, around the base of the fish pass over low water and within the chambers during mid and high tide. One of the seals was observed eating a salmon just below the fish pass.

5. DISCUSSION

16 salmon and 6 sea trout were relocated in 1992 compared with 10 salmon and 15 sea trout that were relocated in 1991 (Blacklidge & Wightman 1992). This represents a small data set with several variables for analysis and comparison. The patterns and trends shown in the results cannot therefore be statistically validated.

Comparison of the fates for 1992 (Table 1) and 1991 (Appendix II, Table 1) show that the results for relocated fish to be very similar. The number of non-detected fish was identical for both salmon (50%) and sea trout (33.3%). These numbers are somewhat higher than expected when compared with relocations carried out in other tracking studies. eg. 30% for salmon reported for the river Taff (Gough, Jones, Gregory & Morgan 1992) and 21% for sea trout for the river Tywi (Unpublished NRA data 1990).

The possible fates of non-detected fish are: (i) outward migration to other catchments or back to sea. (ii) tag failure or regurgitation. (iii) death as a result of predation or exploitation (legal or illegal). There is little evidence to suggest that tag failure is a significant factor as shown by laboratory and field trials (Mee & Clarke 1992). Regurgitation appears to be a freshwater phenomena and more commonly found with sea trout (Clarke, Purvis, Mee, Evans & Gee In press). There was only one known possible tag regurgitation this year found on Aberafan Beach from a salmon. Seal predation and illegal exploitation may account for a proportion of the fish.

The detection rates for 1991 and 1992 were also similar. 45 and 67% of the salmon and sea trout respectively were detected post relocation, of which 30-40% returned to freshwater and 10-33% were not detected upstream of the barrage.

The preference for estuarial entry on the early or mid flood tide (Table 4) is consistent with expected behaviour (Clarke & Purvis 1992, Clarke et al In press) and was similar for 1991 (Appendix II Table 4). Comparison of the results from 1992 with the results from 1991 however, suggest that the timing of the estuary migration has changed following impoundment. The barrage appears to delay the migration of the fish until the tide has overtopped or is within 0.65m of the primary weir well into the flood tide.

Once past the barrage the fish migrate through the impoundment reaching TA.ES1 on the ebb tide or at low water. It appears that the fish do not hold in the impoundment but migrate steadily through it resting in the shallower stretch of estuary between TA.ES1 and TA1. By contrast in 1991, even though the partially completed barrage probably represented a substantial obstruction, fish were able to migrate past the site earlier in the tidal cycle when the tidal height was between 7.5m and 2.9m above chart datum (details Appendix II, Figures 1-3). The fish then reached TA.ES1 on the flood, high water or early ebb. Passage through the shallower stretch between TA.ES1 and TA1 is much slower and fish often rest over several tides before migrating past TA1.

From the limited amount of data available the barrage does appear to delay the migration of fish (Figures 4-7). There is no evidence so far to suggest that fish pass the barrage, either via the fish pass or through the lock, at any time when the tide is substantially below the sill height of the primary weir.

As a result of the delay in migration fish may accumulate in numbers below the barrage. This will expose the fish to an increased threat of predation by seals observed below the barrage attracted to the accumulation of fish.

The migration of salmon and sea trout was dependent primarily on tidal state and river flow irrespective of day/night period. Entry is favoured during spring tides and high river flow. Through August and September river flows and tidal state favoured successful entry. Clarke and Purvis (1989) showed that estuarial migration of salmon was only correlated to low light levels during periods of low river flow. Flows during the tracking period were however high and thus further investigation next year under a wider range of variables will need to be considered.

The potential low oxygen levels in the impoundment are a cause for concern. Low oxygen concentrations may form a barrier to the upstream migration of fish. The sediments in the Tawe estuary are known to contain elevated metal concentrations and remobilisation of metals will occur during contact of deoxygenated water with the sediments and the anaerobic respiration at the sediment/water column interface may result in the release of hydrogen sulphide gas. Optimum conditions for dexoygenation are during neap tides with low river flows and persistent high temperatures. Such conditions are likely to occur during the summer months May to August coinciding with the major salmon and sea trout runs. These conditions did not occur for an extended period after impoundment during 1992 and there was no impact on the run of salmon and sea

trout suggested by evidence from tracking, Angler Logbooks and anecdotal evidence of anglers catches. In fact the rod catch was probably the greatest for many years.

6. CONCLUSIONS

1. The telemetry system provided estuary tracks which enabled the passage time of tagged fish through the estuary and the exact time that they passed the barrage to be determined and related to environmental factors namely tidal height/state, river flow and period of day.

2. Salmon and sea trout showed preference for estuarial migration during spring tides and elevated river flows irrespective of day/night period. Fish entered the estuary predominately on the early flood tide and migrated through the lower estuary on the incoming tide.

3. The preliminary results suggest that the barrage may be an obstruction to the migration of salmon and sea trout throughout the majority of the tidal cycle but further data are required.

4. Salmon and sea trout migrated past the barrage when the tide had overtopped or was within 0.65m of the primary weir. There is no evidence to date that fish were able to pass the barrage, either via the fish pass or through the lock, when the tide was significantly below primary weir height.

5. The accumulation of fish below the barrage may increase predation by seals in the estuary.

ACKNOWLEDGEMENTS

Paul Morris for his considerable enthusiastic input to fieldwork and data collation over the past two years. The Gower area bailiffs under Steve Williams, Sarah Thorne from the Hydrology Department (Swansea) and other members of the South West Environmental Appraisal Unit also made a substantial contribution to the project, particularly Dai Walters for his assistance with the fieldwork and Andrew Rogers and Paul Bryson for the provision of the water quality data.

Also thanks to ABP, Swansea Yacht Haven, Swansea Yacht and Sub-aqua Club, Swansea City Training Centre (Morriston) and the staff at Morfa Athletics Stadium for their help and cooperation.

REFERENCES

Blacklidge,R.H., Wightman,R.P. and Wilson,B. (1991). The results of fish telemetry trials in the River Tawe Estuary, 1990. NRA(Welsh Region, S.W.Division) Report No. PL/EAW/91/2.

Blacklidge,R.H. and Wightman,R.P. (1992). The results of fish telemetry trials in the river Tawe estuary, 1991. NRA(Welsh Region, S.W.Division) Report No. PL/EAW/92/5.

Clarke,D.R.K. and Purvis,W.K. (1989) Migration of salmon (Salmo salar.L) in the R.Tywi, S.Wales. Paper presented to Atlantic Salmon Trust/Wessex Water Conference on Fish Movement in Relation to Freshwater Flow and Quality, University of Bristol, April 1989.

Clarke,D.R.K., Purvis,W.K. and Mee,D.M. (1989). Use of telemetric tracking studies to examine environmental influence on catch/effort indices. A case study of Atlantic salmon (Salmo salar.L) in the R.Tywi, S.Wales. In I.G.Cox (ed.) Catch Effort Sampling Strategies. Fishing News Books.

Clarke,D.R.K., Purvis,W.K. and Mee,D.M. (1990). Migration of sea trout in the R.Tywi estuary during 1989. NRA(Welsh Region). Report No. PL/REAU/90/4.

Clarke,D.R.K., Purvis,W.K., Mee,D.M., Evans,D.M. and Gee,A.(In press). Migration of sea trout in the R.Tywi estuary during 1989,1990 and 1991. NRA(Welsh Region).

Gough,P.J., Jones,G.O., Gregory,J.M. and Morgan,R. (1992). Cardiff Bay Barrage: Assessment of impact on salmonid fisheries. Annual Report 1991: Year two pre-barrage construction. NRA(Welsh Region,S.E.Division) Report No. PL/EAE/92/2.

Halfacree,S.P. (1989). Tawe barrage appraisal-water quality. NRA(Welsh Region, S.W.Division) Technical Memorandum TM/EAU/89/22.

Mee,D.M. and Clarke,D.R.K. (1992). Tag failure controls: their importance in interpretation of tracking statistics. In I.G.Priede and S.M.Swift (eds) Wildlife Telemetry: Remote Monitoring and Tracking of Animals. Ellis Horwood LTD.

Mee,D.M., Stonehewer,R. and Blacklidge,R.H. (1993). Report and validation of Panteg fish trap 1990-1992. NRA (Welsh Region,S.W.Division). Report No. PL/EAW/93/?.

National Rivers Authourity (1991a). Regional Juvenile Salmonid Monitoring Programme Annual Report 1990. NRA (Welsh Region, Fisheries Department).

National Rivers Authority (1991b). Salmon and Sea Trout Catch Statistics 1991. NRA(Welsh Region, Fisheries Department).

Rogers,A. (1992) Tawe Barrage: water quality changes following impoundment. NRA(Welsh Region,S.W.Division) Internal Circula No. EQ/P1/2/7

Wightman,R.P. (1989). Proposal for post-construction monitoring of the effects of the Swansea Barrage on salmonid migration trough the Tawe Estuary. NRA(Welsh Region,S.W.Division) Technical Memorandum TM/EAW/89/21.

Table 1. Monthly mean flows (cumecs) for the river Tawe measured at Ynystanglws gauging station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean of 1982-1992	22	15	16	10	7	7	7	10	10	18	20	21
1990	34	31	9	5	3	7	7	5	5	15	14	18
1991	23	16	19	14	4	9	9	7	6	17	19	9
1992	11	9	15	13	8	3	5	22	16	8	30	26

N.B. Flows are given to the nearest cumec. The 11 year average of ADF is 12.7 cumecs

Table 2. Fate of relocated salmon and sea trout 1992

Category	Salmon	Sea trout
Estuary d/s barrage	2 (12.5)	2 (33.3)
Freshwater	5 (31.25)	2 (33.3)
Regurgitation	1 (6.25)	0
Not detected	8 (50)	2 (33.3)
TOTAL	16	6

% given in parenthesis

Table 3. Entry times for relocated salmon and sea trout 1992

Salmon

Tag number	First detection (days:hours:minutes)	Morfa (TA.ES1) (days:hours:minutes)
C2E050	0:16:05	--------
C2E052	0:02:20	--------
C2E075	0:01:45	16:20:45
C2E077	-------	15:00:55
2C2E081	-------	0:19:20
C2E105	0:01:25	0:06:55

Sea trout

Tag number	First detection (days:hours:minutes)	Morfa (TA.ES1) (days:hours:minutes)
C2D005	0:00:40	--------
C2E043	0:12:55	--------
C2E054	-------	14:18:15
C2E089	0:22:40	1:06:55

Table 4. Tidal state at estuarial migration of salmon and sea trout 1992

Tidal state		Salmon				Sea trout			
		TA.ES5	TA.ES3	TA.ES1	TA1	TA.ES5	TA.ES3	TA.ES1	TA1
High water	-1 to +1	-	1	3	1	-	-	-	-
Early ebb	+1 to +3	1	-	1	2	-	-	2	-
Ebb	+3 to +5	-	-	-	1	2	-	-	1
Low water	+5 to -5	2	-	1	-	-	-	-	-
Early flood	-5 to -3	6	-	-	-	19*	-	-	1
Flood	-3 to -1	1	2	-	-	8*	1	-	-

*includes 26 entries (19 early flood, 7 flood) by fish C2E043

Table 5. Estuarial ground speeds of salmon and sea trout 1992

Fish number	TA.ES5-TA.ES1		TA.ES3-TA.ES1		TA.ES1-TA1		TA.ES5-TA1	
	ms^{-1}	bls^{-1}	ms^{-1}	bls^{-1}	ms^{-1}	bls^{-1}	ms^{-1}	bls^{-1}
C2E054	-	-	-	-	0.58	0.86	-	-
C2E075	-	-	0.99	1.45	0.08	0.12	-	-
C2E077	-	-	0.25	0.39	0.08	0.12	-	-
2C2E081	-	-	-	-	0.42	0.70	-	-
C2E089	0.12	0.20	0.35	0.57	0.11	0.18	0.12	0.19
C2E105	0.27	0.40	0.26	0.56	0.14	0.22	0.20	0.29
MEAN	**0.20**	**0.30**	**0.46**	**0.74**	**0.23**	**0.36**	**0.16**	**0.24**

Table 6. Migration of salmon and sea trout in relation to period of day

Period of day		Salmon				Sea trout			
		TA.ES5	TA.ES3	TA.ES1	TA1	TA.ES5	TA.ES3	TA.ES1	TA1
Day		6	2	3	1	2	-	1	1
Night		4	-	2	2	1	-	1	1
Dawn	2.0hrs	-	-	-	-	-	-	-	-
Dusk	2.0hrs	-	1	-	1	-	1	-	-

Figure 1. River Tawe location map

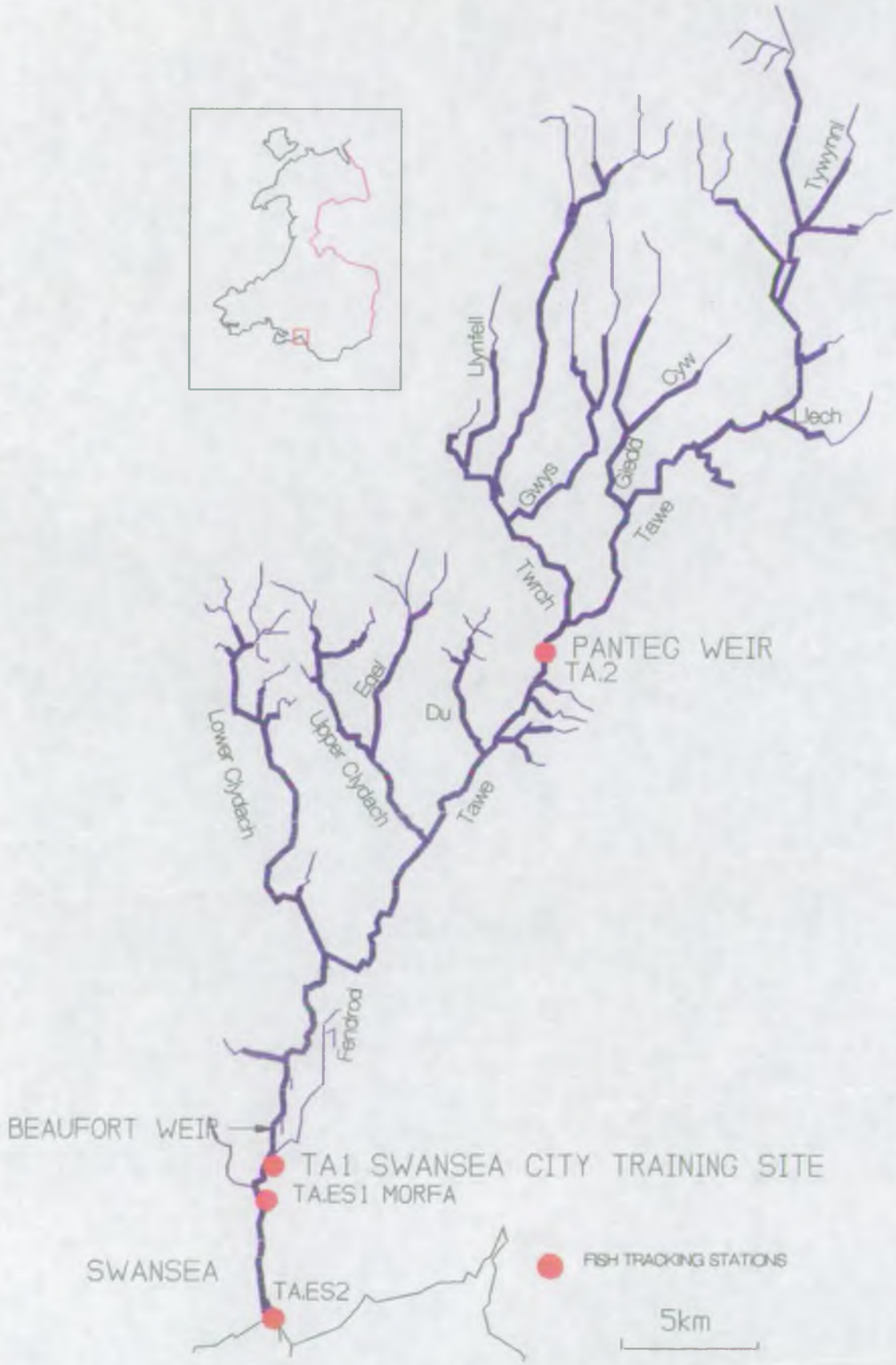


Figure 2. Sketch of the Tawe estuary showing the location of the barrage and telemetry sites

Figure 3. Mean daily flows for the river Tawe 1992

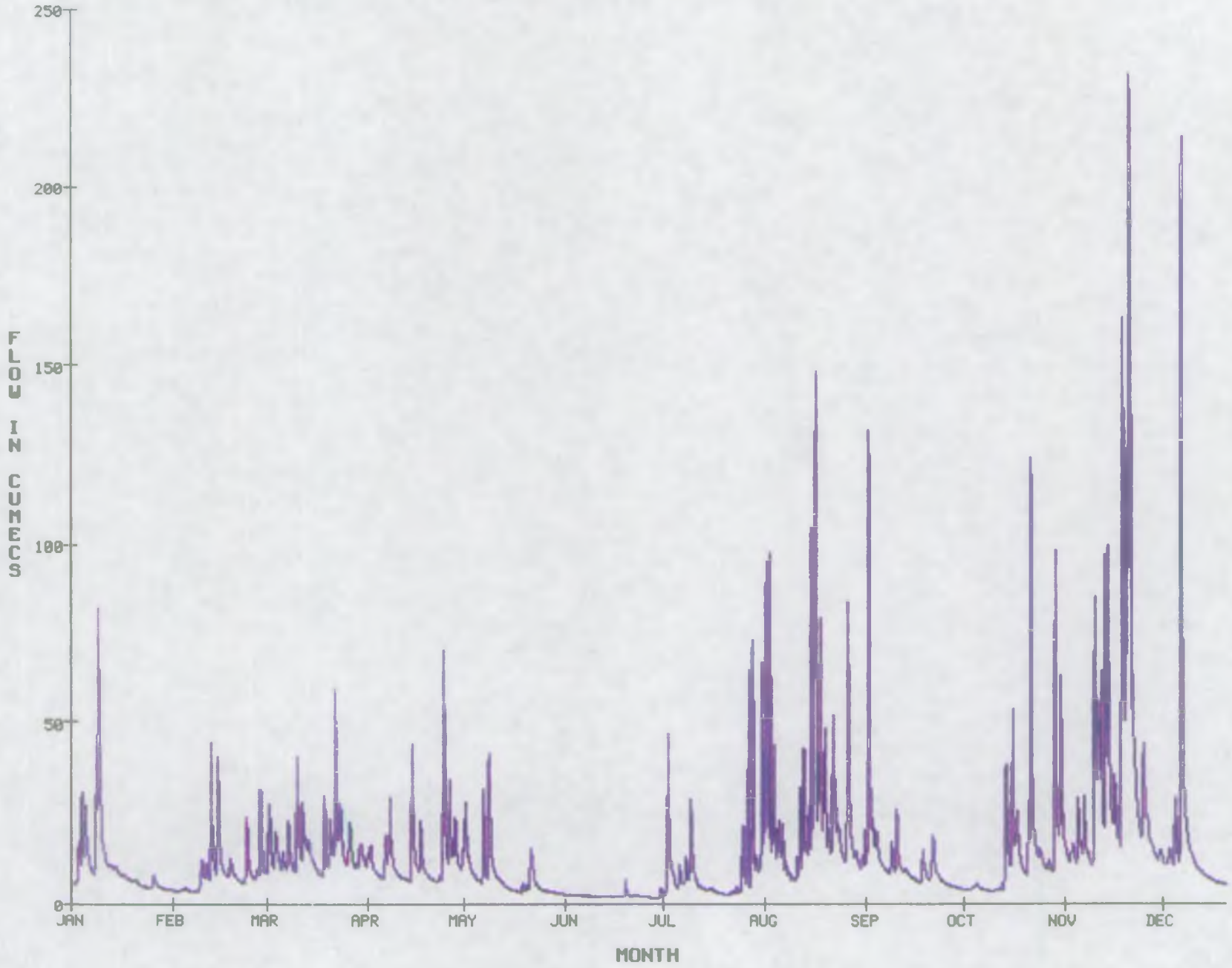


Figure 4. Fish number C2E089
Female sea trout (610mm, 2.1+SM+).

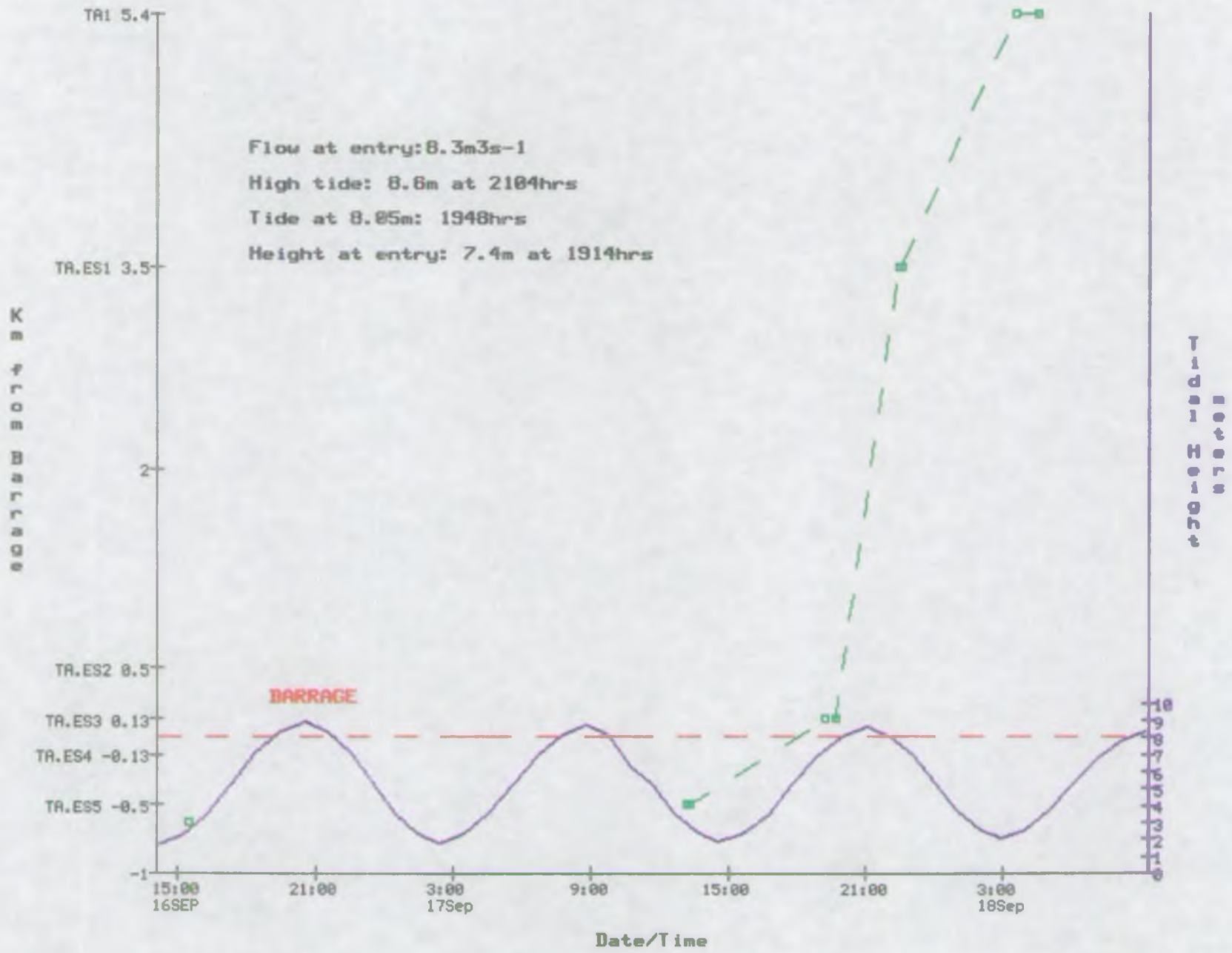


Figure 5. Fish number C2E105
Male salmon (670mm, 2.1+).

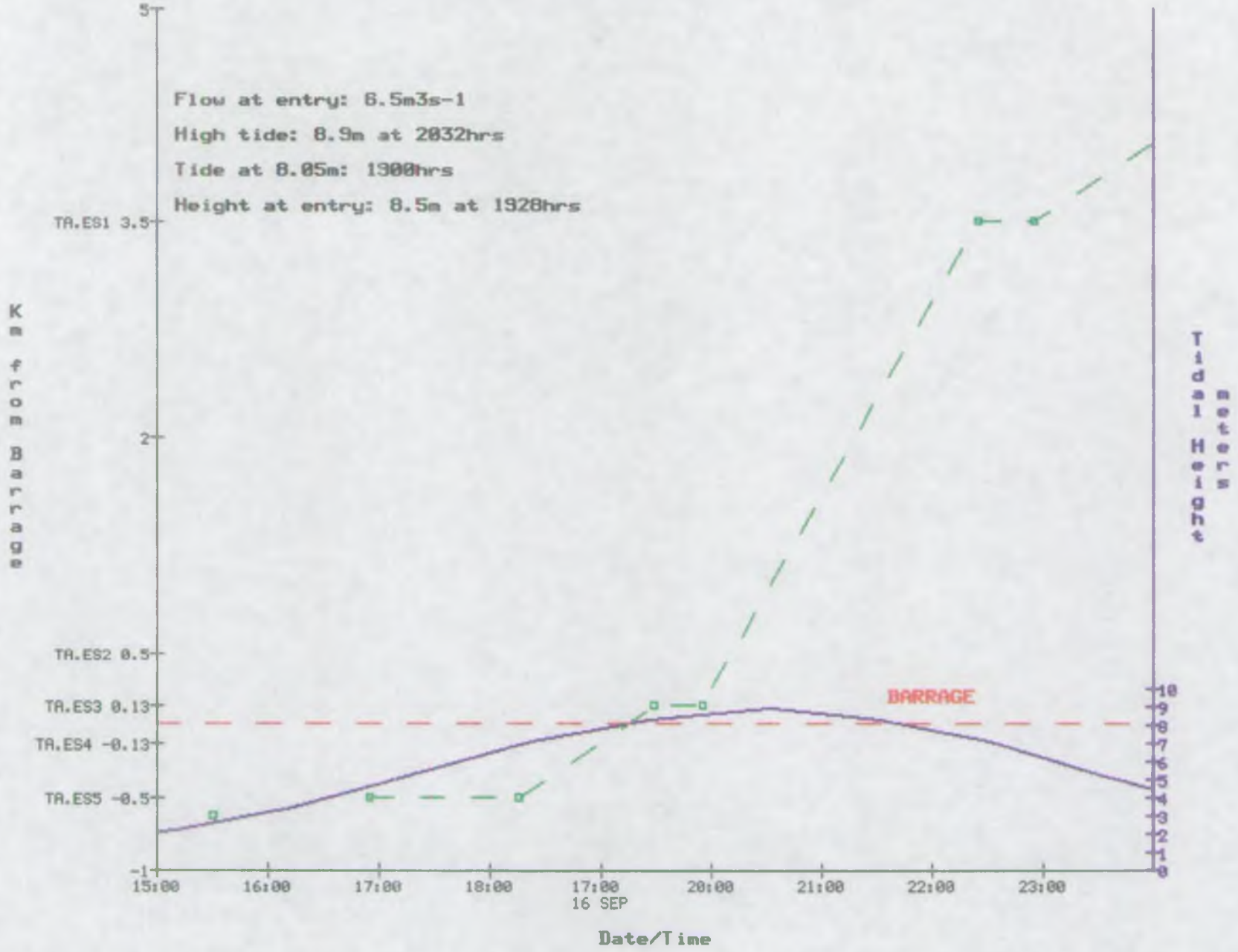


Figure 6. Fish number C2E075
Female salmon (680mm, 2.1+).

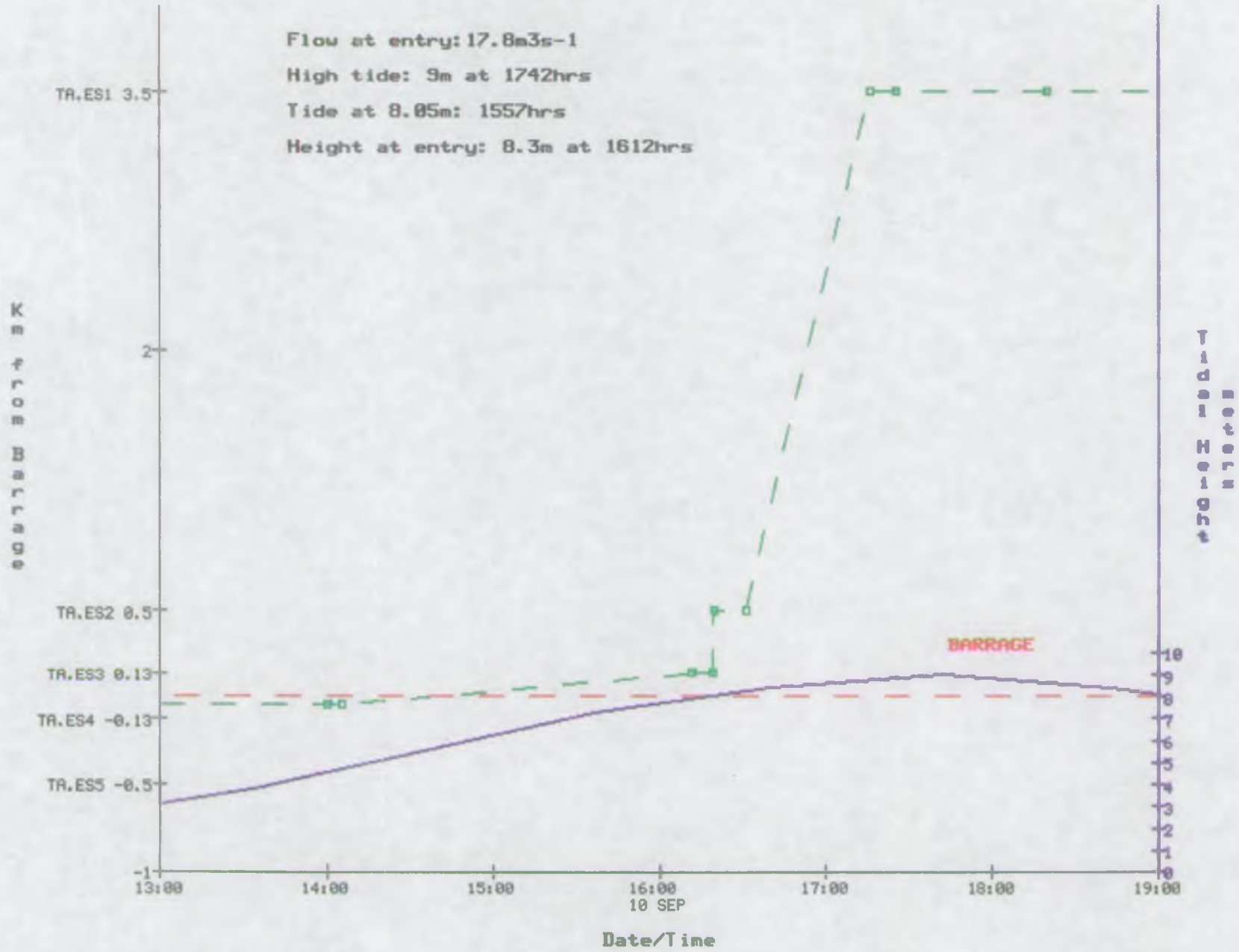


Figure 7. Fish number C2E077
Female salmon (635mm, 2.1+)

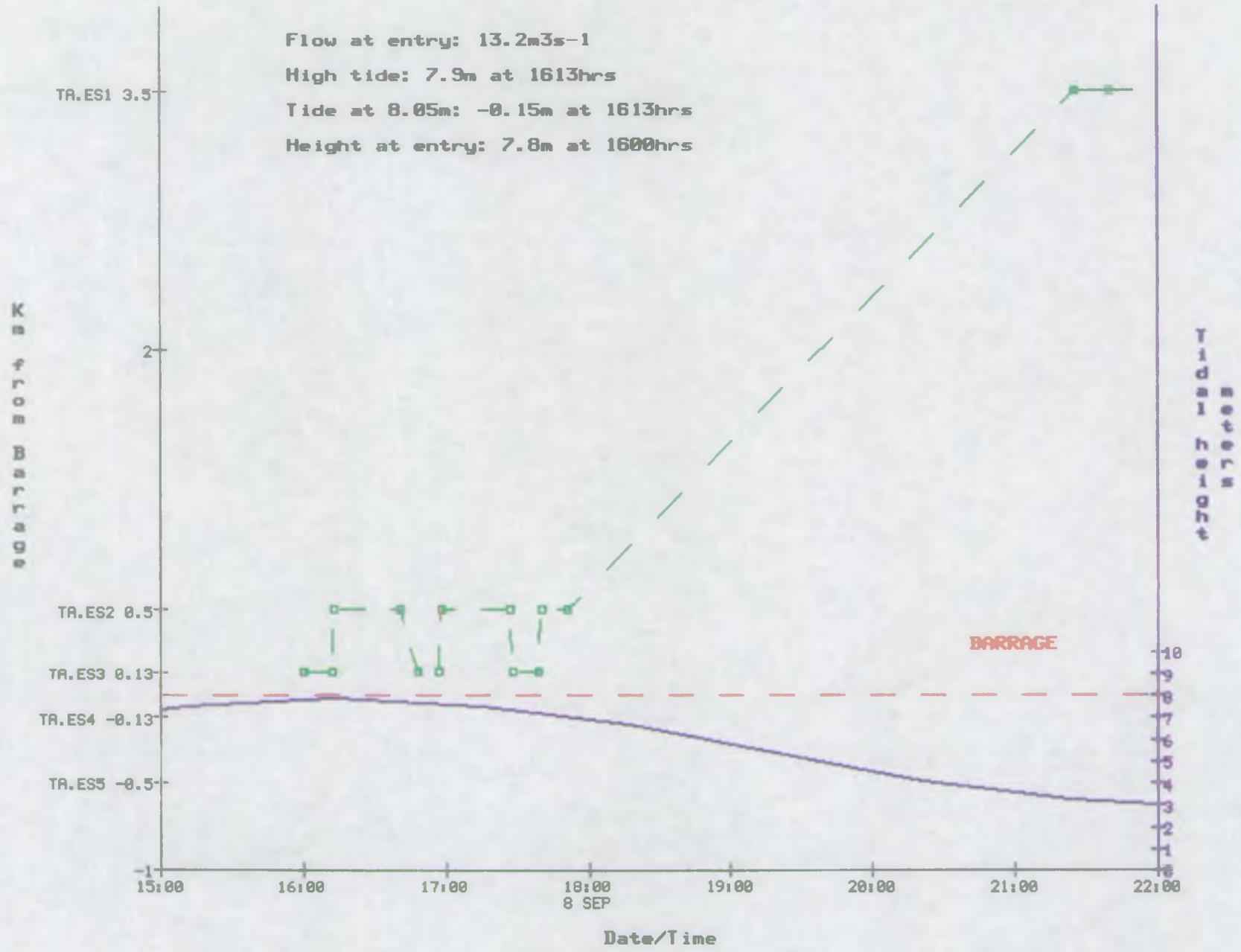


Figure 8. Fish number C2E052
Male salmon (670mm, 2.1+).

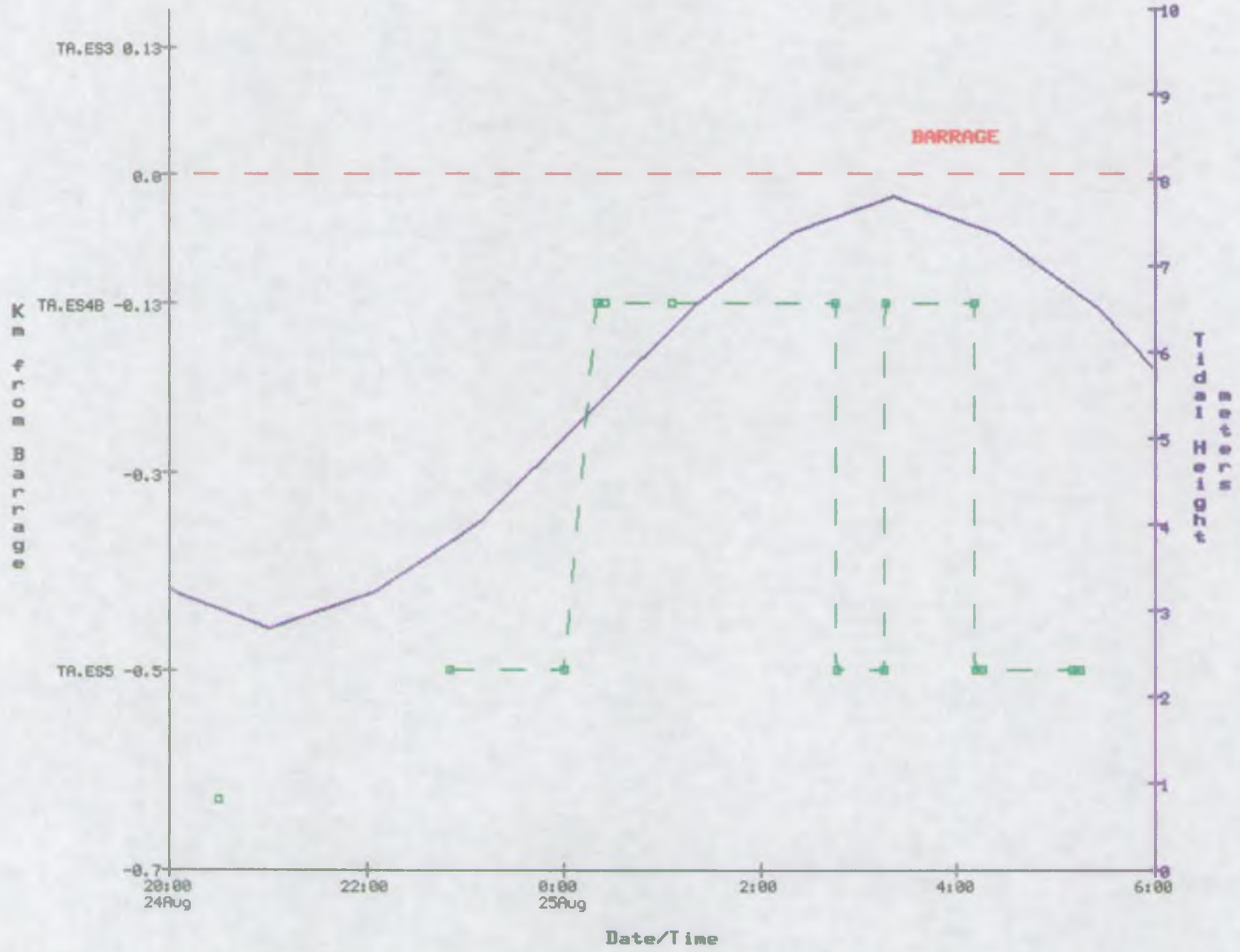


Figure 9. Fish number C2E043
Male sea trout (650mm)

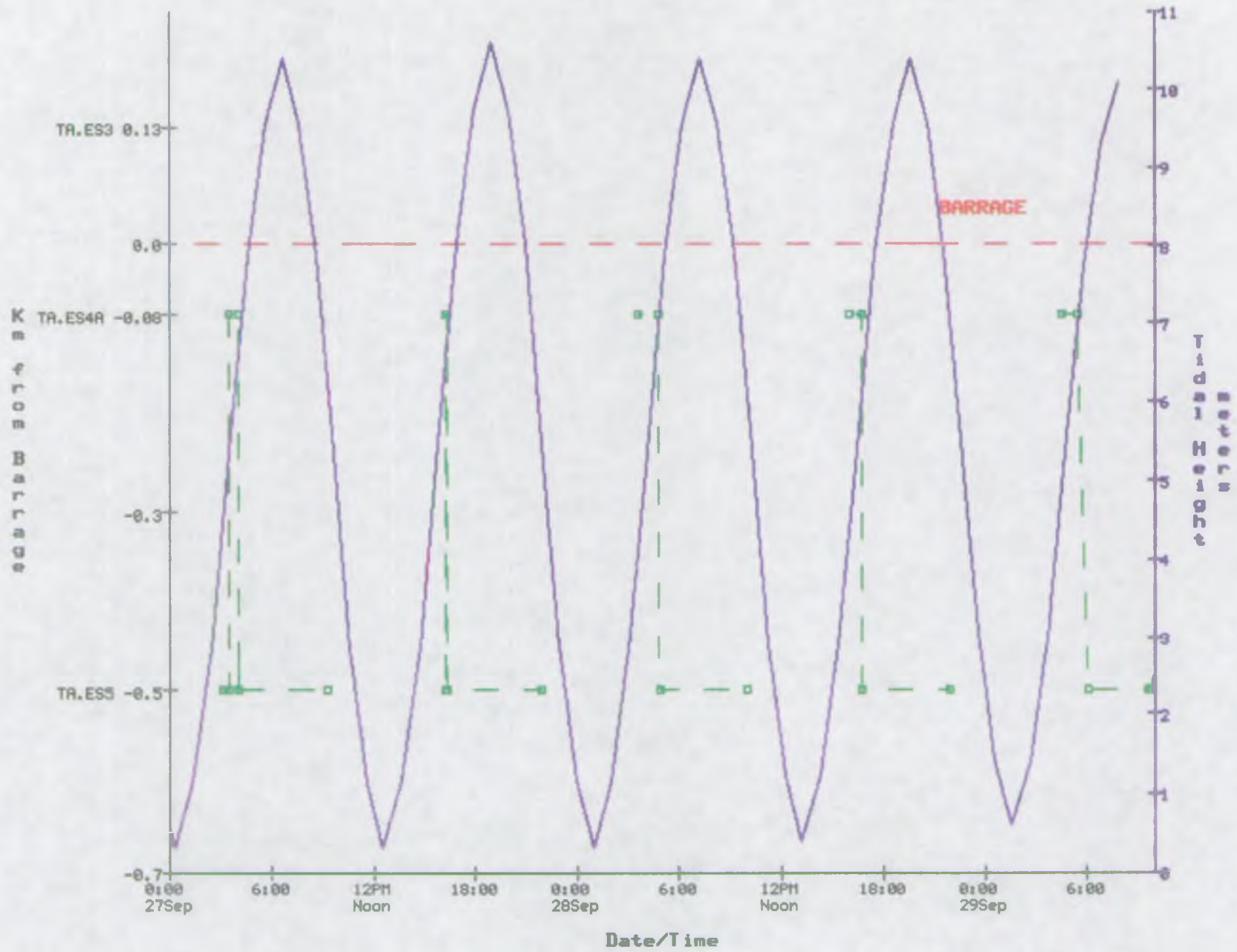
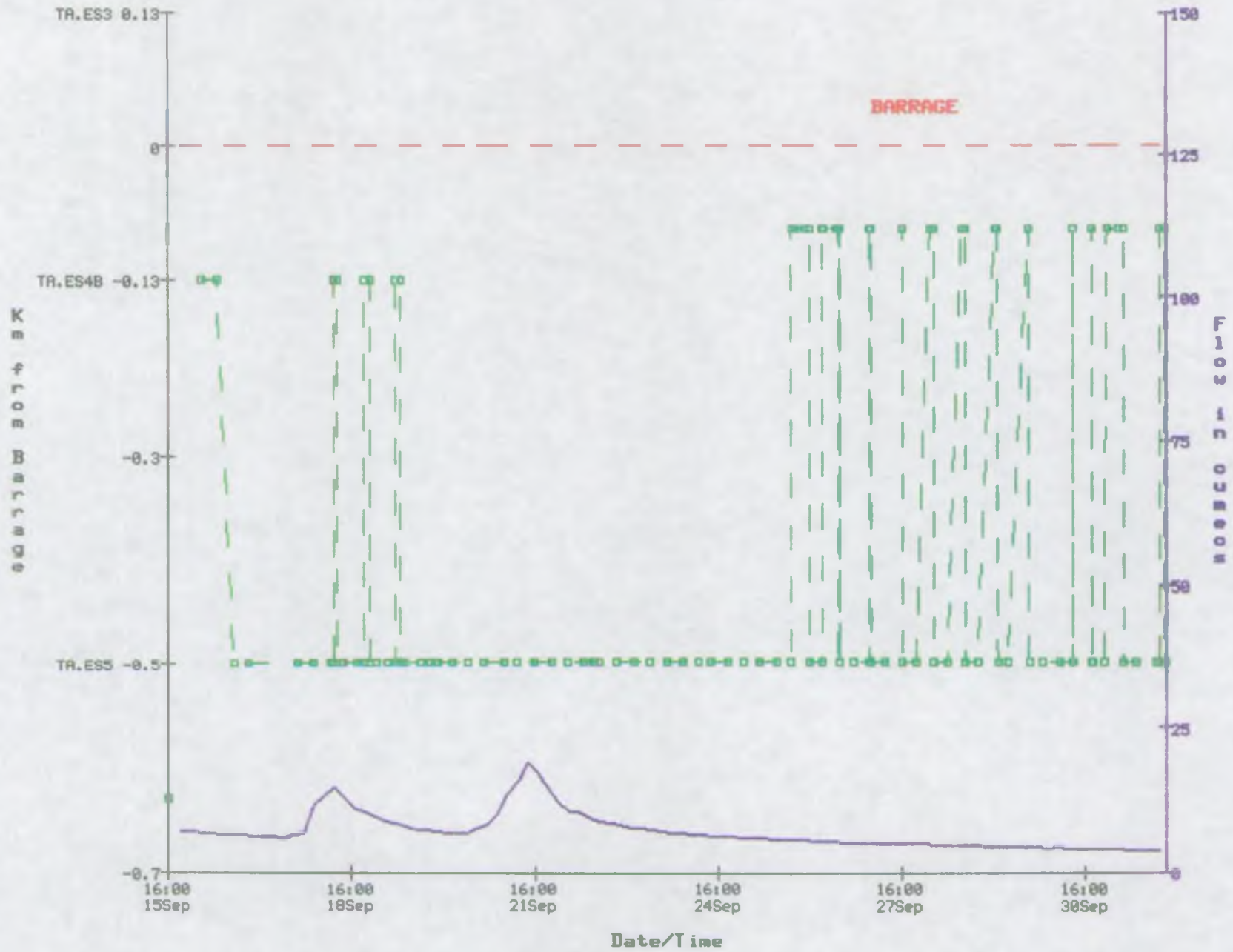


Figure 10. Fish number C2E043
Male sea trout (650mm).



APPENDIX I

Table 1. Summary of CART tagged fish Tawe Barrage project 1992

Tag number	Date/time relocated	Species	sex	length	condition	scale reading
C2D005	15-SEP 16:10	ST	F	600	**	R.1+SM+
C2D034	24-AUG 20:30	SL	F	645	LF,***	2.1+
C2E041	16-SEP 15:30	SL	F	660	*	2.1+
C2E043	15-SEP 16:10	ST	M	650	*	NS
C2E045	18-AUG 12:00	SL	M	770	*	2.2+
C2E047	04-SEP 11:20	SL	M	650	**	2.1+
C2E048	29-SEP 12:30	ST	M	620	***	3.1+
C2E049	24-AUG 20:30	SL	F	620	***	2.1+
C2E050	24-AUG 20:30	SL	F	635	**	2.1+
C2E051	04-SEP 11:20	SL	M	600	***	2.1+
C2E052	24-AUG 20:30	SL	M	670	LF,*	2.1+
C2E053	04-SEP 11:20	ST	F	730	*	3.1+3SM+
C2E054	15-SEP 16:10	ST	F	670	**	R.1+2SM+
C2E055	24-AUG 20:30	SL	M	680	**	R.1+
C2E075	24-AUG 20:30	SL	F	680	LF,**	2.1+
C2E077	24-AUG 20:30	SL	F	635	***	2.1+
C2E086	24-AUG 20:30	SL	M	710	LF,**	2.1+
C2E089	16-SEP 15:30	ST	F	610	*	2.1+SM+
C2E090	24-AUG 20:30	SL	M	740	***	R.1+
C2E105	16-SEP 15:30	SL	M	670	**	2.1+
C2E106	16-SEP 15:30	SL	M	700	**	2.1+
2C2E081	24-AUG 20:30	SL	M	605	LF,***	2.1+

SL=Salmon, ST=Sea trout, LF=Freshwater lice, * = coloured to *** = very fresh

APPENDIX II

Table 1. Fate of CART/radio relocated and bagnet salmon and sea trout 1991.

	Relocation*		Bagnet	
Category	Salmon	Sea trout	Salmon	Sea trout
Estuary d/s barrage	1 (10)	2 (13.3)	1	0
Estuary u/s barrage	0	0	0	1
Freshwater	4 (40)	7 (46.6)	1	1
Regurgitation	0	1 (6.6)	1	0
Not detected	5 (50)	5 (33.3)	2	3
Non-Tawe	-	-	1	0
TOTAL	10	15	6	5

* Includes 2 radio tagged salmon and 6 radio tagged sea trout.
% shown in parenthesis

Table 2. Entry times for relocated salmon and sea trout 1991.

Salmon

Tag number	First detected (days:hours:minutes)	Morfa (TA,ES1) (days:hours:minutes)
C2E083	2:01:25	5:10:20
C2E096	7:20:10	8:00:45
C2E111	0:01:05	0:13:15
390D8	-------	42:07:00

Sea trout

Tag number	First detected (days:hours:minutes)	Morfa (TA.ES1) (days:hours:minutes)
C2D015	20:08:00	--------
C2E078	0:02:30	0:07:00
C2E109	--------	0:20:55
C2E115	0:06:30	--------
380D8	--------	2:09:50
2390D8	--------	3:16:30
33ME6	--------	0:17:00
35ME6	--------	3:06:55

Table 3. Entry times for CART tagged bagnet salmon and sea trout 1991.

Salmon

Tag number	First detected (days:hours:minutes)	Morfa (TA.ES1) (days:hours:minutes)
C2E094	5:08:10	--------
C2E101	--------	41:13:40

Sea trout

Tag number	First detected (days:hours:minutes)	Morfa (TA.ES1) (days:hours:minutes)
C2E102	9:15:45	--------
C2E113	--------	14:22:25

Table 4. Tidal state at estuarial migration for bagnet and relocated salmon and sea trout 1991.

Tidal state		Salmon				Sea trout			
		TA.ES5	TA.ES3	TA.ES1	TA1	TA.ES5	TA.ES3	TA.ES1	TA1
High water	-1 to +1	-	-	-	1	1	-	1	-
Early ebb	+1 to +3	-	-	1	1	-	-	-	1
Ebb	+3 to +5	1	-	1	-	1	-	1	2
Low water	+5 to -5	4	-	-	-	1	-	-	1
Early flood	-5 to -3	1	2	-	-	3	-	-	-
Flood	-3 to -1	-	1	1	-	-	1	4	-

Table 5. Migration of salmon and sea trout in relation to period of day (1991)

Period of day	Salmon				Sea trout			
	TA.ES5	TA.ES3	TA.ES1	TA1	TA.ES5	TA.ES3	TA.ES1	TA1
Day	4	2	-	1	3	1	4	2
Night	2	1	1	1	2	-	-	-
Dawn 2 hours	-	-	-	-	1	-	2	1
Dusk 2 hours	-	-	2	-	-	-	-	1

Figure 1. Fish number E083 (1991)
Male salmon (695mm, 2.1+)

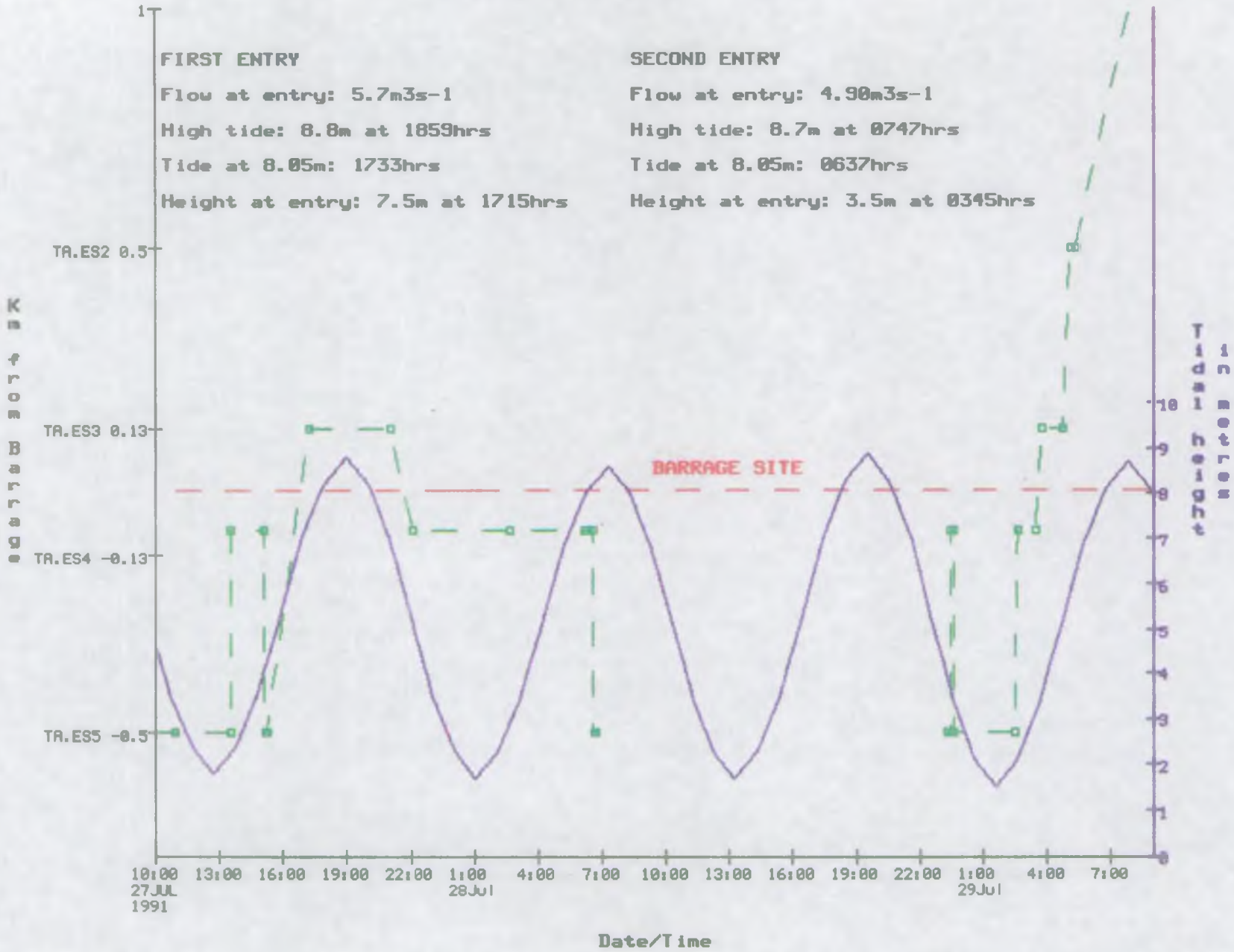


Figure 2. Fish number E096 (1991)
Male salmon (740mm, 2.1+SM+)

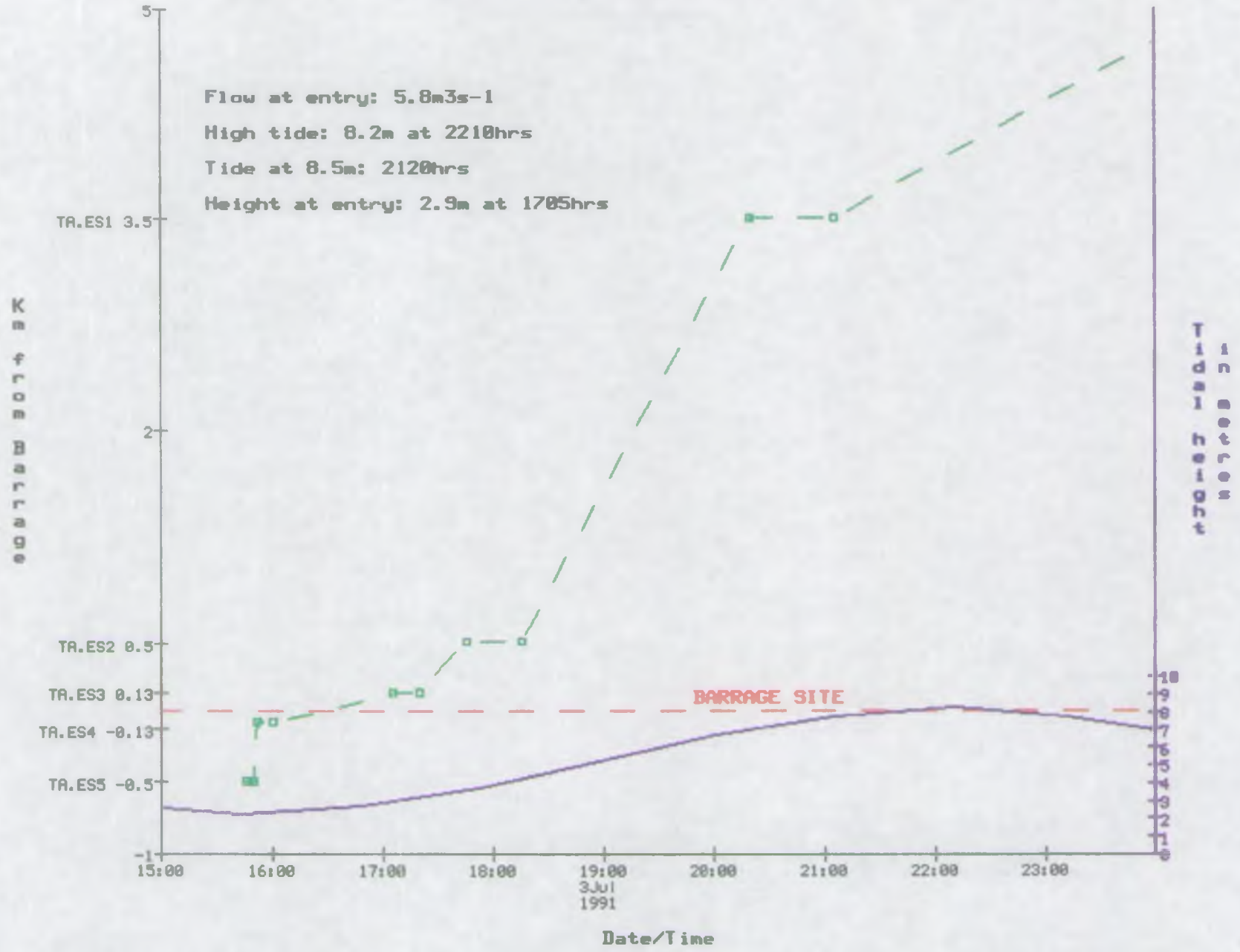


Figure 3. Fish number E078 (1991)
Female sea trout (625mm, 2.3SM+)