NATIONAL RIVERS AUTHORITY
WELSH REGION
SOUTH WEST DIVISION

# THE RESULTS OF FISH TELEMETRY TRAILS IN THE R.TAWE ESTUARY,1991.

REPORT No. PL/EAW/92/5

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## EXECUTIVE SUMMARY.

### Background.

The NRA presented Swansea City Council (SCC) with study proposals for assessing the impact of the barrage on the migration of salmon and sea trout in the estuary. These were rejected by SCC largely on the basis of cost despite MAFF agreeing that the level of investigation proposed was required in order to properly assess the barrage's impact. Whilst these negotiations have been continuing, the NRA has commenced water quality and fisheries studies with the intention of recovering the fisheries element of these costs from SCC on resolution of their funding obligation. Fisheries and water quality studies in 1990 have been reported. The fisheries study demonstrated that fish could be caught cost effectively and tracked past the site of the Tawe barrage using radio telemetry. The pilot study was continued in 1991 to further examine the efficacy of a bagnet, relocation of fish from Panteg fish trap and to further develop the telemetry system. The current date for completion of the barrage is mid to late July 1992.

The 1991 pilot study for the Tawe Barrage fish migration and water quality monitoring programme had the following objectives:

(i) To further assess the application of a bagnet by fishing between April and September inclusive in order to cover the main runs of sea trout and salmon missed in 1990.

(iii) To assess the practicability of tagging and relocating at sea, fish caught in a freshwater trap at Panteg weir, some 23km upstream of the barrage.

(iv) To further develop the radio/acoustic telemetry system to enable fish to be tracked past the barrage site.

(v) To assess whether it is possible to provide detailed fish movements under conditions that will be presented by the barrage, using a matrix of short range submerged sonar receiver's (SSR).

(vi) To assess the feasibility of tracking fish through the pass using the Afan fish pass which is a pool-traverse design and the closest available type to the barrage pass.

(vii) To validate the cost estimates of post-construction monitoring.

Results.

Adequate numbers of sea trout were caught in the bagnet during the early part of their run. After the first batch of Combined Acoustic Radio Tags (CART) were deployed the bagnet was not fished over the rest of the main sea trout run due to other priorities. When fishing was resumed in the first week of July catches were lower than expected. This was attributed to holes appearing in the net, the occasional presence of a seal and possible poaching of the net. The catches from Panteg fish trap were more than sufficient to provide the number of taggable fish required.

The telemetry system provided good tracks from tagged fish as they migrated past trough the estuary and past the barrage site. The expected problems due to the busy nature of the Swansea environment were overcome. The SSR matrix did not provide detailed information of fish movements due to the basic nature of the system.

The number of bagnet and relocation fish detected in freshwater (2/11 for bagnet fish and 11/22 for relocated fish) was lower than anticipated, particularly for the relocated fish. This has been attributed to a number of possible reasons:

1. A proportion of the bagnet fish being native to other rivers.
2. Some fish possibly regurgitated their tags.
3. Illegal exploitation.
4. The barrage, which represents a barrier even though not complete, may discourage some fish from migrating the river Tawe.

Conclusions.

The bagnet may not catch sufficient fish to provide the required number of fish tracks for the main study. However, sufficient 'virgin' fish tracks would be obtained to provide adequate information when combined with the tracks from relocated fish. Fish can be tracked past the barrage site using radio/acoustic telemetry. The provision of detailed fish movement around the barrage is not possible using the basic telemetry system. However, developments are taking place, namely the MAFF triangulation system that would enable such information to obtained. A telemetry system could be developed using simple modifications to the current technology to determine the route fish use to migrate past the barrage. This system would have to be tested. The telemetry work may not itself prove an impact of the barrage, if there is one, but it would contribute to the overall picture when combined with the results from other work, namely Regional Salmonid Juvenile Monitoring Programme (RSJMP), Angler log book survey, Panteg fish trap catches and statutory angler returns.

Recommendations.

1. The pilot study should be continued in 1992 in order to obtain tracks from tagged fish, with the telemetry system used in 1991, as they migrate past the barrage as it is finally closed.

2. To test the performance of the telemetry gear immediately in the fish pass, lock and on the weir crest in order to develop a telemetry system to determine the route(s) that fish use to migrate past the barrage.

3. To maintain the momentum of the pilot study, liaison established with Associated British Ports (ABP), Swansea Yacht Haven (SYH) and the Coast Guard should be certainly continued.

# THE RESULTS OF FISH TELEMETRY TRIALS IN THE R.TAWE ESTUARY, 1991.

## 1.INTRODUCTION

Construction of a barrage across the 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. Completion of the Tawe Barrage is due in July 1992 providing there are no further delays.

The River Tawe is a recovering salmon and sea trout fishery. The five year average for annual rod catches is 55 salmon and 497 sea trout (National Rivers Authority 1991). The NRA fears that the barrage may have a detrimental effect on fish migration through the estuary and water quality in the estuary, despite the precaution of a MAFF approved pool and traverse fish pass and a flushing facility in the barrage design to alleviate anaerobic conditions. Subsequently, the NRA produced a programme for the post-construction monitoring of fisheries migration (Wightman 1989) and water quality (Halfacree 1989). SCC as promoters of the scheme have declined to accept responsibility for funding studies to properly assess the impact of the barrage on fisheries. This is despite the fact that SCC have to demonstrate to MAFF, under the terms of the Salmon and Freshwater Fisheries Act (1974) the efficacy of the fish pass incorporated into the barrage design, before the it can give full approval. MAFF and Welsh Office support the requirement for the level of monitoring identified by the NRA. Negotiations are currently taking place between NRA (Welsh Region), Welsh Office and SCC.

The fisheries monitoring programme, to demonstrate the efficacy of the fish pass, revolves around the use of existing telemetric monitoring techniques to track the movement of fish in relation to the barrage and fish pass. The consultants retained by SCC expressed some reservations as to the practicability of the NRA proposal. This has added to their reluctance to fund the impact assessment. Consequently the NRA undertook a pilot study in 1990 which would determine whether the post-construction fisheries monitoring programme was feasible.

The 1990 pilot study demonstrated that fish could be caught in a cost effective manner and once certain technical and practical difficulties were overcome, could be tracked through the estuary, past the barrage site and into freshwater, using radio/acoustic telemetry. The pilot study was continued in 1991 to extend the work carried out in 1990.

## 2. OBJECTIVES

The 1991 pilot study for the Tawe Barrage fish migration and water quality monitoring programme had the following objectives:

(i) To further assess the application of a bagnet by fishing between April and September inclusive in order to cover the main runs of sea trout and salmon missed in 1990.

(iii) To assess the practicability of tagging and relocating at sea, fish caught in a freshwater trap at Panteg weir, some 23km upstream of the barrage.

(iv) To further develop the radio/acoustic telemetry system to enable fish to be tracked past the barrage site.

(v) To assess whether it is possible to provide detailed fish movements under conditions that will be presented by the barrage, using a matrix of short range submerged sonar receiver's (SSR).

(vi) To assess the feasability of tracking fish through the pass using the Afan fish pass which is a pool-traverse design and the closest available type to the barrage pass.

(vii) To validate the cost estimates of post-construction monitoring.

## 3. 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 Tawe Estuary (Figure 2) is a heavily managed artificial estuary being integral with Swansea Dock. The last 2km of the river,. downstream from New Cut Bridge, runs through high sided dock walls discharging into Swansea Bay between the Eastern Breakwater and the West Pier. Swansea Dock includes a marina complex which discharges into the estuary via a lock immediately upstream of the barrage site and three docks which discharge into the estuary via a lock 0.3km downstream. The estuary is heavily used by both commercial shipping and pleasure craft for which there is a frequently dredged channel running from the Swansea Bay, between the Eastern Breakwater and the West Pier, to the ferry loading bridge.

The barrage site is located immediately downstream of the marina complex and upstream of the slipway (Figure 2). When completed, the barrage will consist 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 0.3m higher at 8.35m. Simple modelling from Admiralty charts indicated that the number of tides which will reach the sill height of the secondary weir (the height of water that can be considered a significant over topping of the primary weir) is 403 out of 707 high tides (from 1991 tide tables). There may be no

significant over topping of the primary weir for between 4 to 8 days during each set of neap tides.

## 4. MATERIALS AND METHODS

### 4.1. Fish capture

#### 4.1.2. Bagnet

A bagnet was deployed, at the same site as for the 1990 pilot study, approximately 200m south west from the end of the West Pier outside the main shipping channel (Figure 2).

The bagnet was installed on the 24-04-91 and removed on the 9-09-91. The net was stopped from fishing (slapped) by removing the leader net and closing the bag. Fishing was started again by a reversal of this procedure.

The bagnet was serviced, if possible, 3 times per day at slack water either from a boat or from the shore at tides less than 2m to minimise the disruption to the migration pattern of fish caught.

#### 4.1.2. Tagging

The salmon and sea trout captured were tagged with either a radio tag, a Combined Acoustic and Radio Tag (CART) or a floy tag only using standard procedures (Clarke et al 1990). Only fish greater than 550mm in length and in a suitable condition (ie. no net damage, no obvious signs of stress or fatigue, no parasite or predator marks, not kelts) were selected for tagging with radio tags or CARTs. Those fish too small to radio or CART tag, which were floy tagged only, may provide information on exploitation if recaptured by anglers or netsmen. They may also provide data on the proportion of fish caught in the net which were destined to run rivers other than the Tawe.

#### 4.1.3. Relocation

Adult salmon and sea trout were captured during routine operation of the Panteg weir fish trap located some 23km upstream (Figure 1). The fish for relocation, if suitable (See section 4.1.2.), were tagged with either a CART or radio tag. The fish were transported to the release point at the base of the Approach Jetty (Figure 2) in a tank of isotinic saline solution (approximately 15ppt). The fish were acclimatised to the salinity at the release point, approximately 25ppt depending on river flow and tidal state, by the addition of sea salt in 5ppt steps at regular intervals in order to minimise the osmotic stress. Once acclimatised the fish were carefully released.

## 4.2. Telemetry and Tracking

### 4.2.1. Estuarial

Tagged fish were acoustically tracked through the estuary. The acoustic signals from the CARTs were detected by submerged sonar receivers (SSR) which converted the acoustic pulses to a radio signal which was transmitted to shore based MAFF developed Automatic Listening Stations (ALS). These units were programmed to record the presence of tags at 5 minute intervals and allow their identification on the basis of pulse rate.

Seven SSR's were deployed at four sites on the Estuary shown in figure 2. Two SSR's were sub-surface mounted and deployed at two sites, TA.ES2 and TA.ES3, upstream of the barrage site. Site TA.ES2, as previously in 1990, was approximately 400m below New Cut Bridge close to the left bank and site TA.ES3 immediately upstream of the barrage site. They transmitted to an ALS sited in the lock control room in the Yacht Haven Office, with the aerial mounted on a flag pole attached to the side of the office.

The potential sites downstream of the barrage site were limited by the shipping channel and associated dredging, public access and the low water mark (Figure 2). An SSR was bed mounted and deployed at site TA.ES5, at the foot of the concrete ferry loading bridge support, in a similar position as for 1990.

Four bed mounted SSR's marked by surface marker buoys, were deployed at site TA.ES4 immediately below the barrage in a matrix formation with a short range setting. This was intended to provide more detailed information as to the movement of fish in relation to the entrance of the fish pass. The SSR's downstream transmitted to an ALS situated on the flat roof of the ABP lock control tower, whose aerial was mounted on a flag pole.

The range and reception of the SSR's were tested by placing a CART at increasing distances from a sonar buoy. This enabled the sensitivity of the buoy and ALS to be adjusted to give the best reception with minimum interference at the required range. Due to the width of the estuary SSR's TA.ES5, TA.ES3 and TA.ES2 were adjusted for long range reception to increase the probability of detecting a CART tagged fish moving through the estuary.

### 4.2.2. Freshwater

Entry of CART and radio tagged fish into freshwater was detected by two ALS's situated above and below Beaufort Weir(figure 1) which marks the head of tide. TA.ES1 was located in Morfa Athletics Stadium (OSGR SS 665955), some 1.8km below Beaufort Weir at the limit of salt water intrusion. TA1 was situated in a building immediately above Beaufort Weir (OSGR SS 672975). A third ALS was deployed at Panteg Weir (OSGR SN 763079) to provide information on the number of relocated fish that returned to Panteg. The aerial was mounted in the

weir pool at the entrance to the fish pass in order that tagged fish would not be detected once they had run the pass. It was hoped that this would give information on the length of time that fish remained in the weir pool before migrating upstream or dropping back.

#### 4.2.3. Afan fish pass.

The Afan fish pass is of a pool-traverse design and is the closest available to that incorporated in the Tawe Barrage. Tests were carried out to assess the efficacy of the SSR's in the fish pass with respect to turbulent flow and cavitation caused by bubbles.

## 5. RESULTS

### 5.1. Fish capture

#### 5.1.1. Bagnet

During the 20 weeks that the bagnet was in position it was fished over 163 tides and was serviced 82 times. 7 salmon and 15 sea trout were caught (Figure 3).

The bagnet was not fished from the last week in May to the first week of July (24-5-91 to 30-6-91) mainly as a result of tag limitation due to the restriction of available acoustic pulse rates. Other tides were not fished to allow for the relocation work and the deployment and testing of the telemetry equipment. Some tides were also missed due to bad weather.

The salmon and sea trout caught were generally in good condition with no net marks and did not appear too stressed or fatigued. This also applied to fish that had possibly been in the net over several tides during rough weather.

#### 5.1.2. Tagging

22 fish were caught in the bagnet (Figure 3). 11 of the fish were CART tagged, 6 salmon and 5 sea trout. The remaining 11 fish, 1 salmon and 10 sea trout ,were unsuitable for tagging (section 4.1.2) and were floy tagged only.

#### 5.1.3. Relocation

27 fish were tagged and relocated from Panteg Weir. 2 of the first three fish, all sea trout, relocated on the 31-5-91 were floy tagged only to establish and test the relocation procedure. 17 fish were CART tagged, 8 salmon and 6 sea trout, and 8 fish were radio tagged, 2 salmon and 6 sea trout.

## 5.2. Tracking and telemetry

### 5.2.1. Estuarial

All the SSR's detected a good signal from the test CART and a good signal was received by their ALS's. There was a low level of acoustic interference from the tide, boat traffic and construction work. The SSR's upstream of the barrage (TA.ES2 and TA.ES3) suffered no damage or showed any signs of interference throughout their deployment as a result of being well marked in a relatively quiet area of the estuary. However the aerial from the SSR mounted on the ferry bridge support was severed, most likely by a boat bumping into the support. Fortunately this occurred towards the end of the project when only one CART was acoustically active and as the fish was not detected by the remaining telemetry equipment it is unlikely that any information was lost.

There was very little acoustic interference from the tide and barrage construction work but some triggering of the SSR's was caused by certain boats when they passed overhead. No problem was encountered from silting of the SSR.

Both ALS's were very secure and radio interference was at an acceptable level.

The servicing and maintenance of the telemetry equipment was straight forward. It was carried out on a regular basis and enabled problems to be remedied very quickly reducing the amount of data lost to a minimum.

The SSR matrix immediately downstream of the barrage detected fish in the immediate vicinity of the barrage. This was due to their short range setting and their proximity to each other. However, it was not possible to pinpoint the exact position of the fish with any accuracy due to the variability in the range of the SSR's under the dynamic conditions found below the barrage site with respect to turbidity and turbulence as a result of tidal state and freshwater flow. The problem was further conpounded by the SSR's scanning every 30 seconds, the ALS scanning every 5 minutes and a fish moving out of the SSR range before sufficient information has been recorded for identification. Unfortunately two of the SSR's were rendered inoperable within a month of deployment as a result of the surface marker buoy being entangled with a boat.

### 5.2.2. Freshwater

The site at Morfa Stadium was very secure and the ALS had a good range. The level of radio interference from the computers in the building was acceptable.

Site TA1 situated at Beaufort Weir was very secure. The ALS was set on a short range so as to reduce the level of interference from the computers in the same building. The ALS was serviced up to 5 times

per week to prevent data loss as a result of interference filling a cassette and to check for any CART tagged fish that entered freshwater possibly making another CART with the same pulse rate available for tagging.

ALS TA2 at Panteg Weir installed on the 4-7-92 was initially only operative for a relatively short periods of time due to vandalism of the aerial. The ALS operated continually from 19-9-92 to 31-10-92 once this problem was overcome.

A boat track was carried out on the 24-6-91 between Panteg Weir and Beaufort Weir to detect any tags which may have entered the river undetected. No tags were detected by the active track. Further boat tracks were not carried out due to the urgency of other work.

Aerial tracks were not carried out because they are too expensive with the insurance cover demanded by the NRA.

5.2.3. Afan fish pass.

The tests showed that there were areas in a fish pass chamber where an SSR could be placed without interference from turbulence. Cavitation had the effect of masking the acoustic pulse. The greater the concentration of air bubbles the greater the masking effect. In areas of high cavitation the acoustic signal was totally blocked.

5.2.4. Tracking

5.2.4.1 Fates of bagnet tagged fish

4 of the 11 floy tagged fish from the bagnet were recaptured. One fish was recaptured in Panteg fish trap, one from the river Tawe, one from the river Neath and the third floy tag was returned from a restaurant in Cardiff which indicates that this fish was not captured in the vicinity of the river Tawe and therefore was not a native Tawe fish.

Of the 11 bagnet CART tagged fish (Table 1) only 2 were detected in freshwater. 2 fish were seen in the estuary one of which was not detected above the barrage. 6 fish were not seen. 1 fish was recaptured from the river Tywi.

5.2.4.2. Fates of relocated tagged fish.

1 of the 2 floy tagged only sea trout was recaptured in the Panteg Weir pool.

Of the 25 CART/radio tagged fish 11 were detected in freshwater, 3 were last detected in the estuary and 11 were lost. 1 CART from a sea trout was located on Swansea beach a few hundred yards west of the West Pier. One radio tagged fish was recaptured in Panteg fish trap.

The fish was not detected entering freshwater probably due to regurgitation of the tag or tag failure.

None of the relocated fish were detected or recaptured in other catchments.

5.2.4.3. Descriptions of some typical fish tracks.

Several good estuary tracks were obtained from the CART tagged fish. A sample of the tracks are described below that demonstrate the range of behaviour observed from both bagnet and relocated fish. The flow data is taken from the average daily flow recorded at Ynystangws gauging station (OSGR SS 685998).

Fish number E113 Female sea trout, bagnet (Figure 4).

Tagged on the 22nd May 1991 at 1330hrs at the bagnet the fish entered the estuary after 9 days under stable flows. The fish moved upstream over the next 8 days and entered freshwater following a significant rise in flow.

Fish number E096 Male salmon, relocation (Figure 5).

Relocated on the 25th June 1991 at 1735hrs the fish entered the estuary after 8 days on elevated but falling flows. The fish moved rapidly upstream and entered freshwater some 10hrs 35mins after passing TA.ES5.

Fish number E094 Female salmon, bagnet (Figure 6).

Tagged on the 17th July 1991 at 1600hrs at the bagnet. The fish entered the estuary four times, on the 23rd July, 28th July, 30th July and 1st August, approaching the barrage site on three of these occasions but was never detected above the site of the barrage. This is an example of oscillatory behaviour.

Fish number E115 Male sea trout, relocation (Figure 7).

Relocated on the 25th June 1991 at 1900hrs the fish entered the estuary 6hrs 30mins later and moved upstream to the barrage site where it remained for 1hr 20mins before it dropped out of the estuary. The fish re-entered the estuary on the 3rd July and 5th July but did not approach the barrage. The fish finally entered the estuary on the 6th July and migrated upstream to the barrage site where it remained for 4hrs 20min before it rapidly dropped out of the estuary. The fish was not detected upstream of the barrage site.

Fish number E083 Male salmon, relocation (Figure 8).

Relocated on the 24th July 1991 at 1030hrs the fish entered the estuary after 2 days on elevated but falling flows. The fish showed oscillatory behaviour during the next 3 days approaching the barrage site several times. On one occasion the fish moved upstream of the

barrage site for 3hrs 50mins before it dropped back to rest below the site. The fish finally migrated upstream past the barrage site leaving the lower estuary and entered freshwater on the 29th July.

Fish number E078 Female sea trout, relocation (Figure 9).

Relocated on the 24th July at 1030hrs. The Y2 axis of the graph shows the tidal height. The fish entered the estuary on falling but elevated flows 2hrs 30mins later at 1300hrs, 2hrs 15mins after low water and moved upstream to the barrage site then immediately dropped back below the site to rest. 1hr 40mins later at 1455hrs the fish approached the barrage site, paused for 15mins, then moved upstream past the barrage site 1hr 45mins before high water. The fish made rapid progress upstream and arrived at TA1 at 1920hrs 2hrs 20mins after high water.

## 6.2. DISCUSSION

### 6.1. Fish capture

#### 6.1.1. Bagnet.

The bagnet was fished over 163 tides during the 20 weeks of its deployment in 1991 (15th April to 9th September) and caught 15 sea trout and 7 salmon. In 1990 the bagnet was fished over 134 tides during 12 weeks of deployment (12th September to 3rd December) and caught 14 salmon and 4 sea trout. The bagnet was deployed during the major sea trout and salmon runs suggested by the rod catch data for 1991 and the Panteg Weir fish trap data (Mee et al in press). The peak rod catches of sea trout occurred in June/July and salmon in July/August (Mee et al in press; Wightman in press). Adequate numbers of sea trout were caught during the early part of their run which eanbled the first batch of CARTs to be deployed. Unfortunately due to other priorities it was not possible to fish the bagnet over the rest of the major sea trout run. When fishing was resumed in the first week of July, to exploit the salmon run and the remaining sea trout run, the catches were lower than anticipated. There may be several possible explanations for this: 1. Holes in the net may have resulted in lost fish; 2. A seal was seen on several occasions at the entrance to the bagnet; 3. The net may have been poached, inbetween the slack water periods when the NRA fished the net.

The net fishes best during periods when conditions for fish to enter the river are unfavourable. It is possible that fish remain in the estuary mouth under these conditions increasing the likelihood of being caught in the bagnet. Conversely when the conditions for freshwater entry are favourable the fish probably head straight in river running the main channel, passing the bagnet. Unfortunately it is not possible to locate the bagnet closer to the main channel due to the shipping.

It is important to obtain a proportion of tracks from 'virgin' fish i.e. those that have not previously negotiated the barrage. The

bagnet alone may not provide numbers of taggable fish required for the post-construction study should the aforementioned problems not be overcome. Alternative methods of capture could be used in conjunction with the bagnet. Jumper nets could be deployed on the foreshore West of the West Pier in the proximity of the bagnet. It may also be possible to use trammel or seine netting at certain times between the barrage site and the ferry terminal but these two methods are less likely to produce fish in a condition suitable for tagging and are very labour intensive.

### 6.1.2 Panteg fish trap.

Panteg Weir fish trap provided a readily available source of salmon and sea trout for relocation of known Tawe origin. The catches were more than sufficient to provide the number of fish required for the post-construction relocations. This is assuming that the barrage does not significantly reduce the Panteg fish trap catches. Although the fish relocated from Panteg will have previously negotiated the barrage, comparison of their behaviour with bagnet fish will provide useful additional information to assess the impact of the barrage.

## 6.2 Telemetry

The telemetry set up during 1990 in the lower estuary was improved upon in 1991 (Figure 2) by the addition of the 2 SSR sites immediately above and below the barrage site (TA.ES3 and TA.ES4 respectively) and the relocation of the Bullnose ALS to the ABP lock control building. The results show that good tracks were obtained from CART tagged fish as they migrated through the Tawe Estuary past the barrage site towards the upper estuary.

The SSR's deployed upstream of the barrage remained undamaged throughout their deployment whilst the SSR's deployed downstream suffered damage as a result of the amount of boat traffic. The ALS sites all proved to be very secure and no vandalism occurred. Verbal permission has been obtained from SYH to place an ALS in the barrage lock control building.

As a result of interference the ALS at Beaufort Weir (TA1) had a short range and required servicing everyday. Unfortunately vandalism is a big problem in the area and the choice of sites was limited. However, there is a possible site 0.5km below the weir in a Swansea City Council training site that may be a suitable alternative should permission be obtained. Site TA.ES2 was taken as the site of entry into freshwater because it was more reliable than TA1. Although there is still saltwater intrusion at TA.ES1 this only occurs during peak tides and fish at this point will be in freshwater.

The matrix did not produce detailed movements of fish below the barrage as a result of the time required between scans and the variability in the range of the SSR's compounded by their short range

and their close proximity. Due to recent modifications to the telemetry equipment it is now possible to scan continuously. A triangulation of SSR's set to scan continuously would give an approximate location of a tagged fish immediately below the barrage and its approximate movements in relation to the fish pass.

As a result of recent modifications by MAFF to current acoustic telemetry technology, namely a continuous scanning facility and the development of a directional hydrophone, a telemetry system could be devised to determine which of the three possible routes fish use to migrate past the barrage (See appendix I). The three routes are via the fish pass, through the lock or over the weir when overtopped. The type of potential problems faced are: 1. Studies on the Afan fish pass show that cavitation and turbulence can cause the acoustic pulse to be masked. Detection of a fish will depend on the level of cavitation and turbulence in the fish pass chambers. 2. Interference in the lock may result in a requirement for frequent servicing of the ALS and subsequent data processing. 3. There will be potentially a high level of turbulence over the weir crests which could result in a large amount of interference.

It is important that the NRA study the impact of the barrage in detail. This should include fish movement around the barrage to determine which of the three possible routes fish use, the effectiveness of the fish pass and any resulting delay in migration. This would provide vital evidence/information for representation in light of future barrage proposals.

## 6.3. Tagging and tracking

The number of bagnet and relocated fish detected in freshwater (2/11 for bagnet fish and 11 /22 for relocated fish, table 1) was lower than anticipated particularly for the relocated fish. There are a number of possible explanations for this: 1. It is likely that a proportion of the bagnet fish were of non-Tawe stock and so have entered other river systems. This is supported by the recapture of 2 tagged bagnet fish from the Neath and the Tywi plus the return of the floy tag from the Cardiff restaurant; 2. There were 2 definite tag regurgitations and 2 possible regurgitations from sea trout and there may have been more. On the Tywi this was found to be a freshwater phenomenon (Mee et al in press) 3. Illegal exploitation may also account for fish losses; 4. The barrage which represents a barrier even though not complete may discourage some fish from migrating the river Tawe. 2 relocated fish and 2 bagnet fish were detected in the lower estuary but not above the barrage.

In order to eliminate problem of tag regurgitation it is possible to use the technique of body cavity tagging. This involves inserting a CART or radio tag into the body cavity of the fish through a small incision made in the body wall.

The fish tracks show an interesting variation in behaviour. There were similarities between relocation and the bagnet fish. Due to the

nature of the study few comparable tracks were obtained so it is not possible to substantiate the behaviour shown. In addition there is no pre-construction data for comparison. The tracks do however give some important information which cannot be ignored. For example, even in its partially completed state the barrage offered a barrier to migration, even though small, which delayed the migration of some fish. Fish rest immediately downstream of the barrage until there is a sufficient height of water to allow the fish to pass. Even when there was sufficient water several of the fish did not pass the barrage. Prior to construction the barrage site may have been a natural resting and turning point prior for fish but this cannot be proved one way or another.

## 7. CONCLUSIONS.

1. The bagnet should provide enough taggable Tawe fish to obtain the required 'virgin' fish tracks. These tracks would provide essential information in conjuction with the tracks from relocation fish.

2. Panteg Weir provided a readily available source of taggable Tawe fish to produce enough tracks for the purpose of the study. This assumes that the barrage does not have a significant effect on the catches at Panteg.

3. The existing radio/acoustic telemetry gear was adapted to work in the Tawe estuary and tracked fish through the estuary and hence past the barrage site.

4. Due to the basic nature of the SSR matrix detailed movements of fish immediately below the barrage were not obtained. A triangulation of SSR's set to scan continuously would give an approxiamate location of a tagged fish immediately below the barrage and its approximate movements in relation to the fish pass.

## 8. RECOMMENDATIONS.

1. The pilot study should be continued in 1992 in order to obtain tracks from tagged fish, with the telemetry system used in 1991, as they migrate past the barrage as it is finally closed.

2. To test the performance of the telemetry gear immediately in the fish pass, lock and on the weir crest in order to develop a telemetry system that would enable the route(s) that fish use to migrate past the barrage to be determined.

3. To maintain the momentum of the pilot study, liaison established with Associated British Ports (ABP), Swansea Yacht Haven (SYH) and the Coast Guard should be certainly continued.

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**Table 1**

The fate of CART/radio tagged fish

| Category | Bagnet | Relocation |
|---|---|---|
| Detected in freshwater | 2 | 11 |
| Last detected in estuary | 2 | 3 |
| Not detected | 6 | 11 |
| Non-Tawe | 1 | 0 |
| TOTAL | 11 | 25 |

Figure 1. River Tawe location map

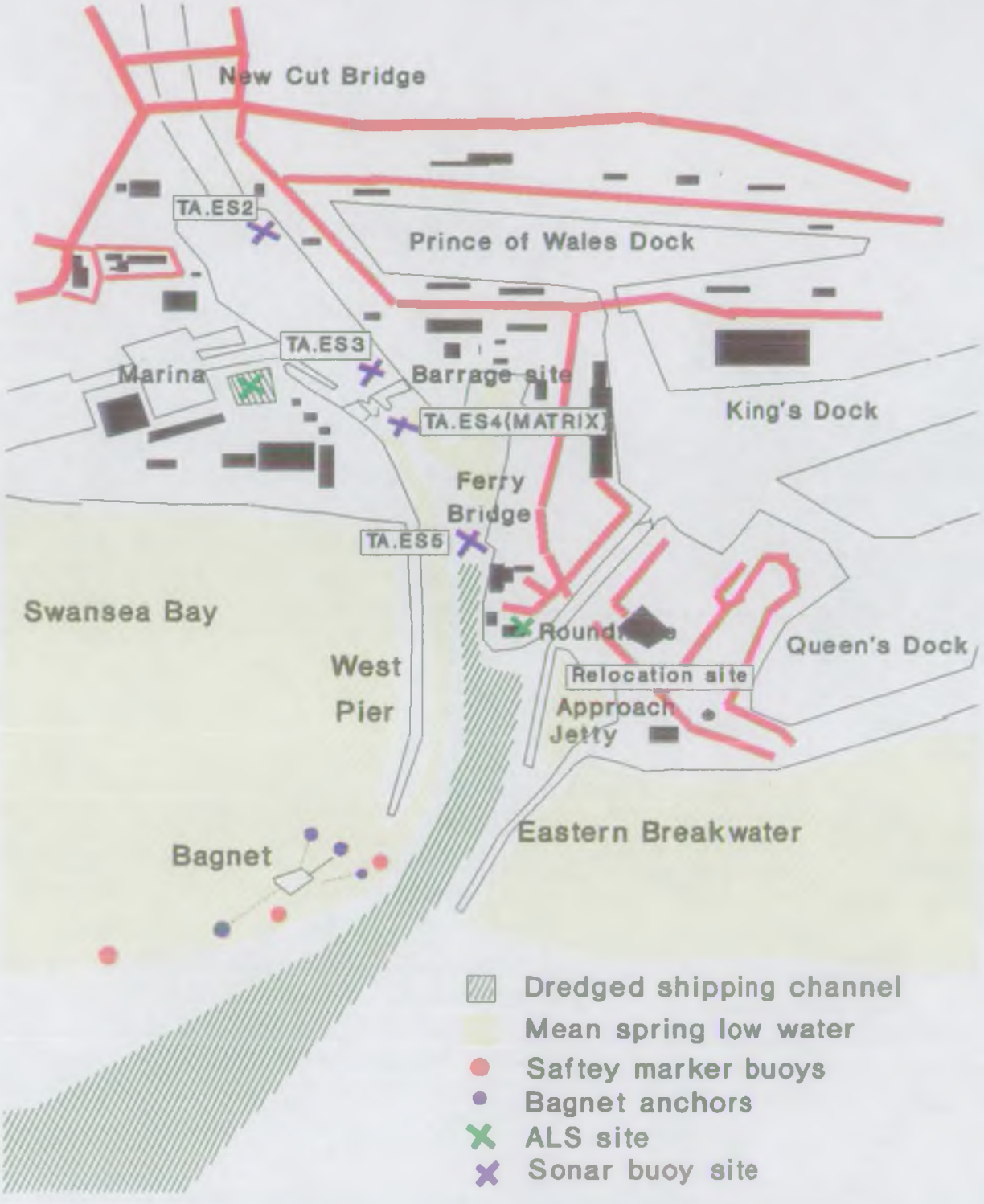



Figure 2. Telemetry sites and bagnet site.

Figure 3. Tag summary chart

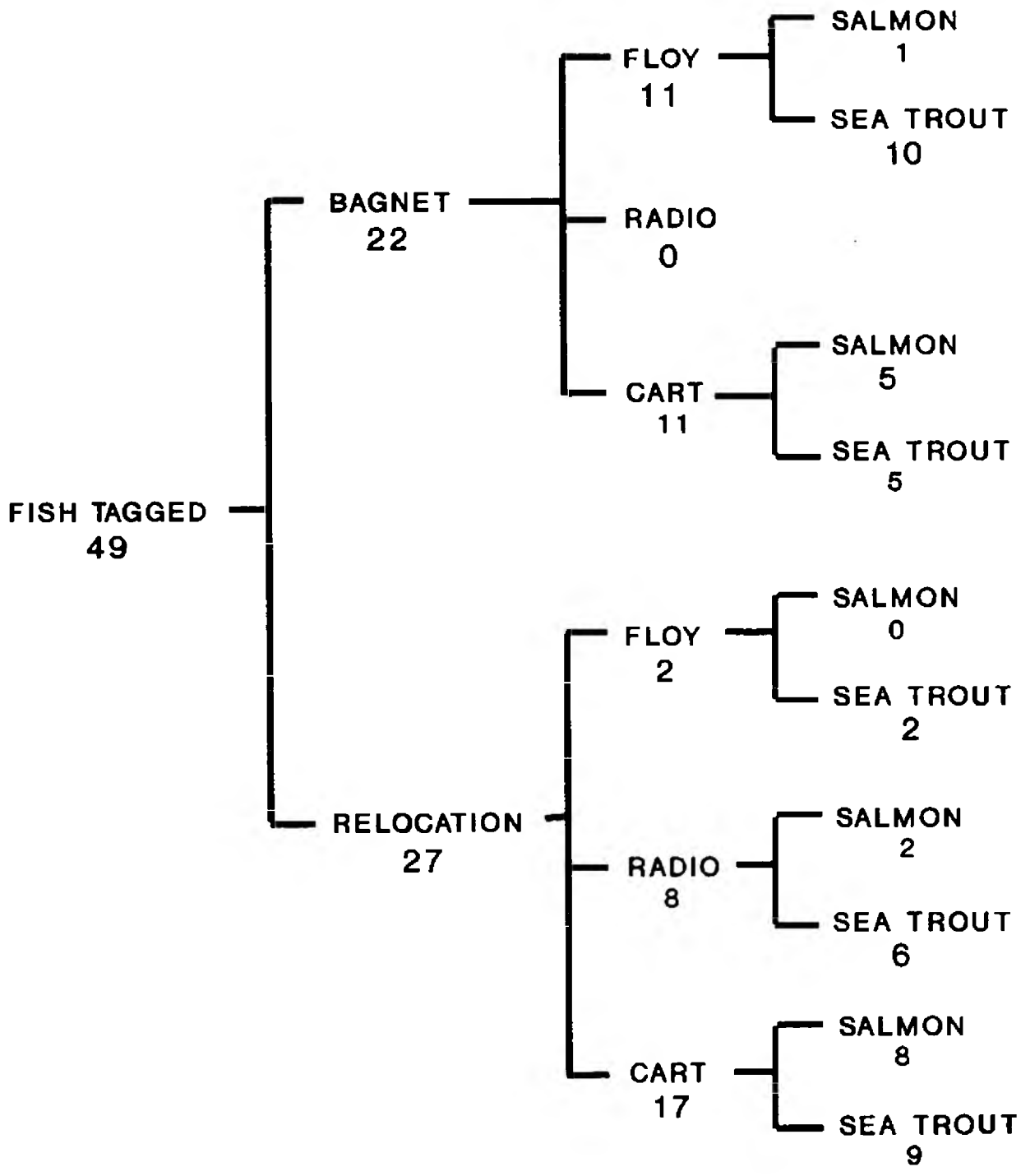


Figure 4. Fish number E113
Female sea trout, Bagnet.

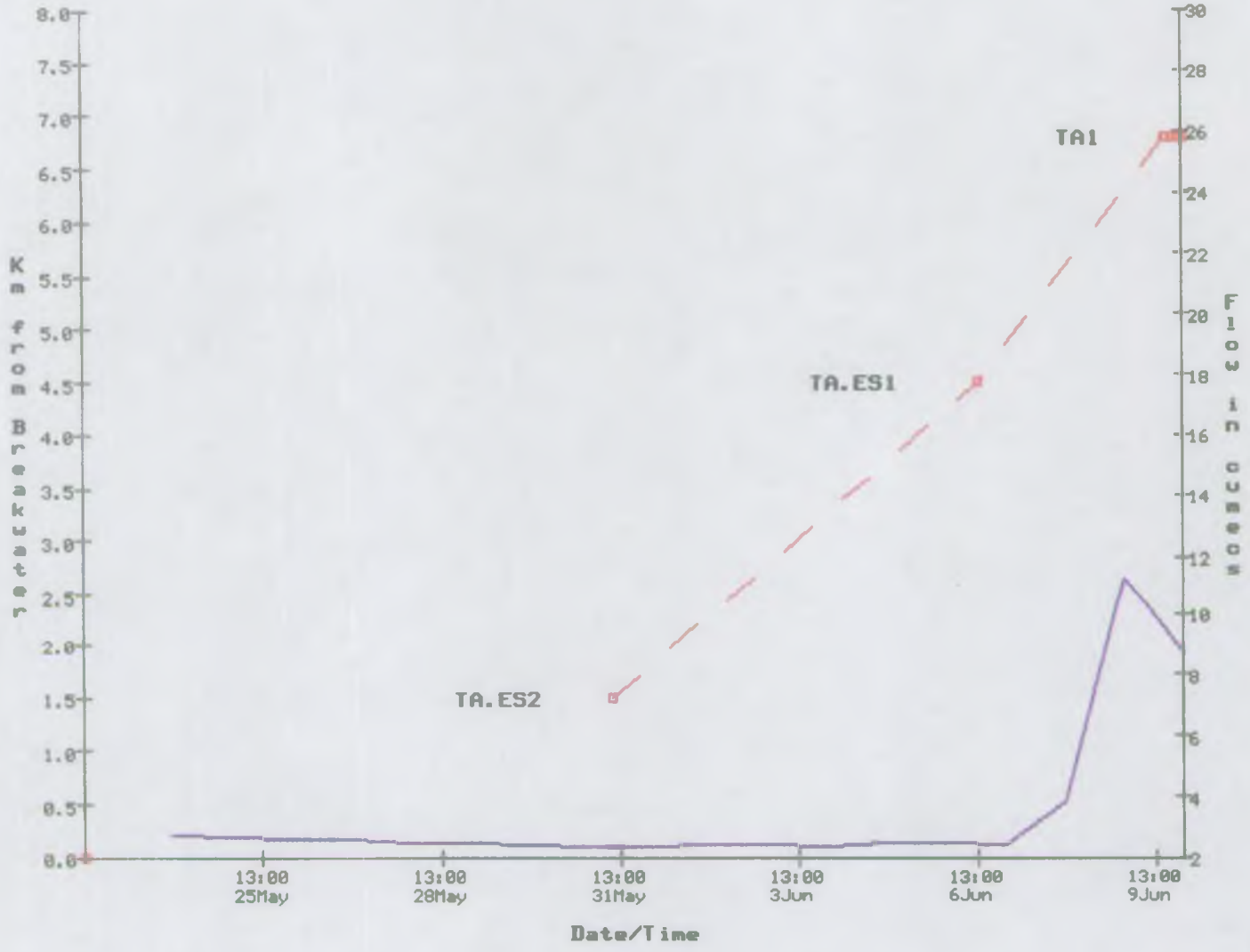


Figure 5. Fish number E096 Male salmon, relocation.

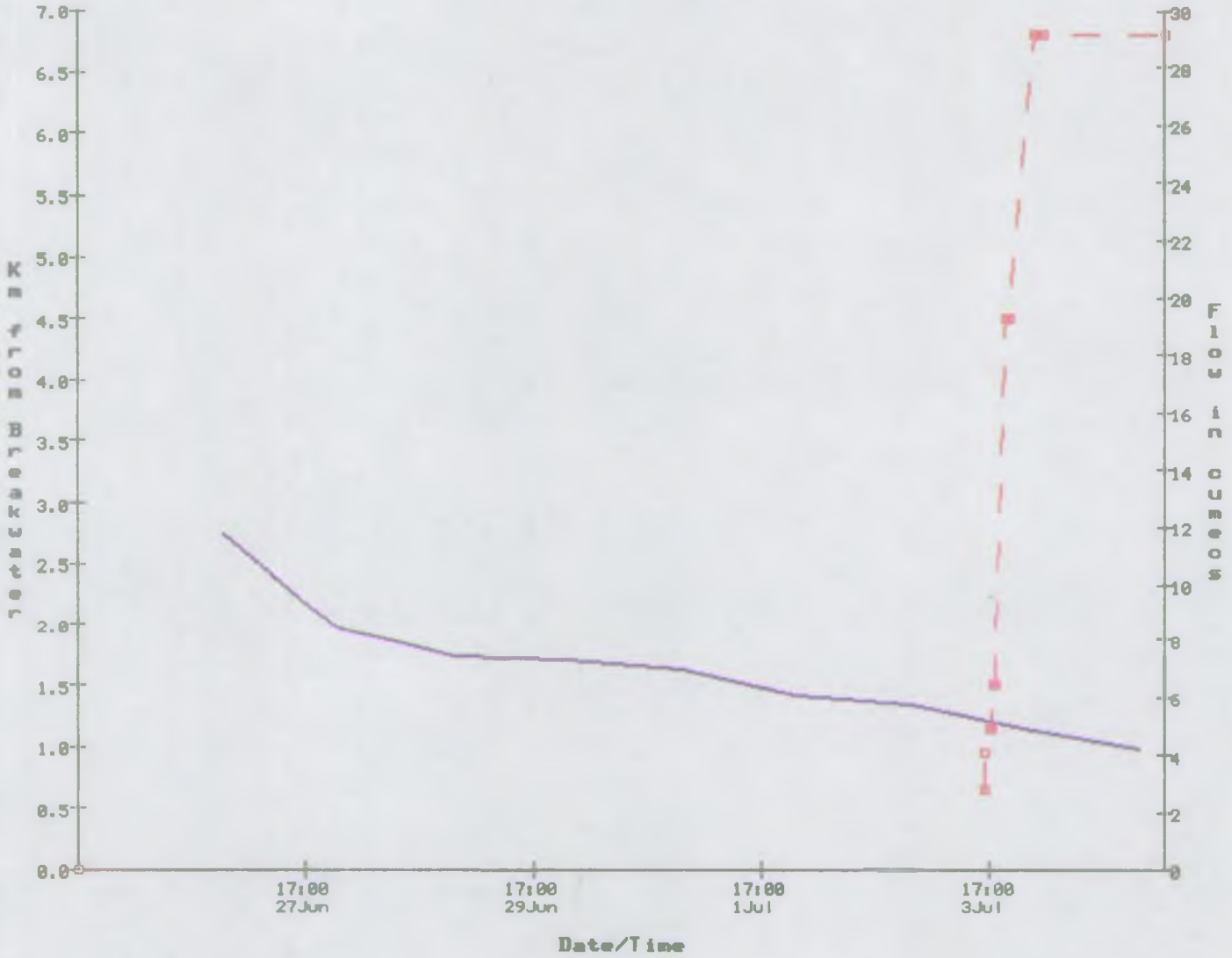


Figure 6. Fish number E094 Fenale salmon, bagnet.

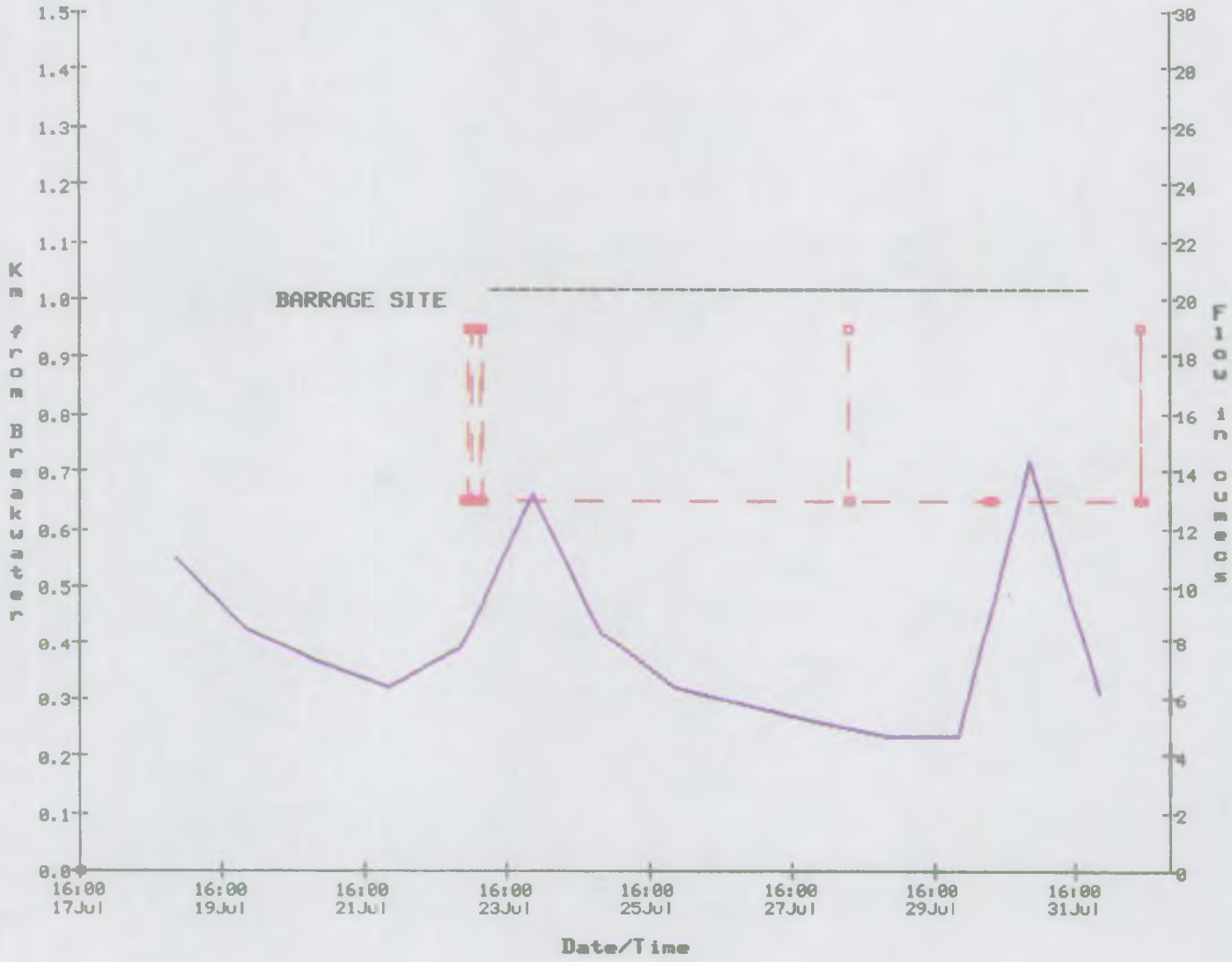


Figure 7. Fish number E115 Male sea trout, relocation.

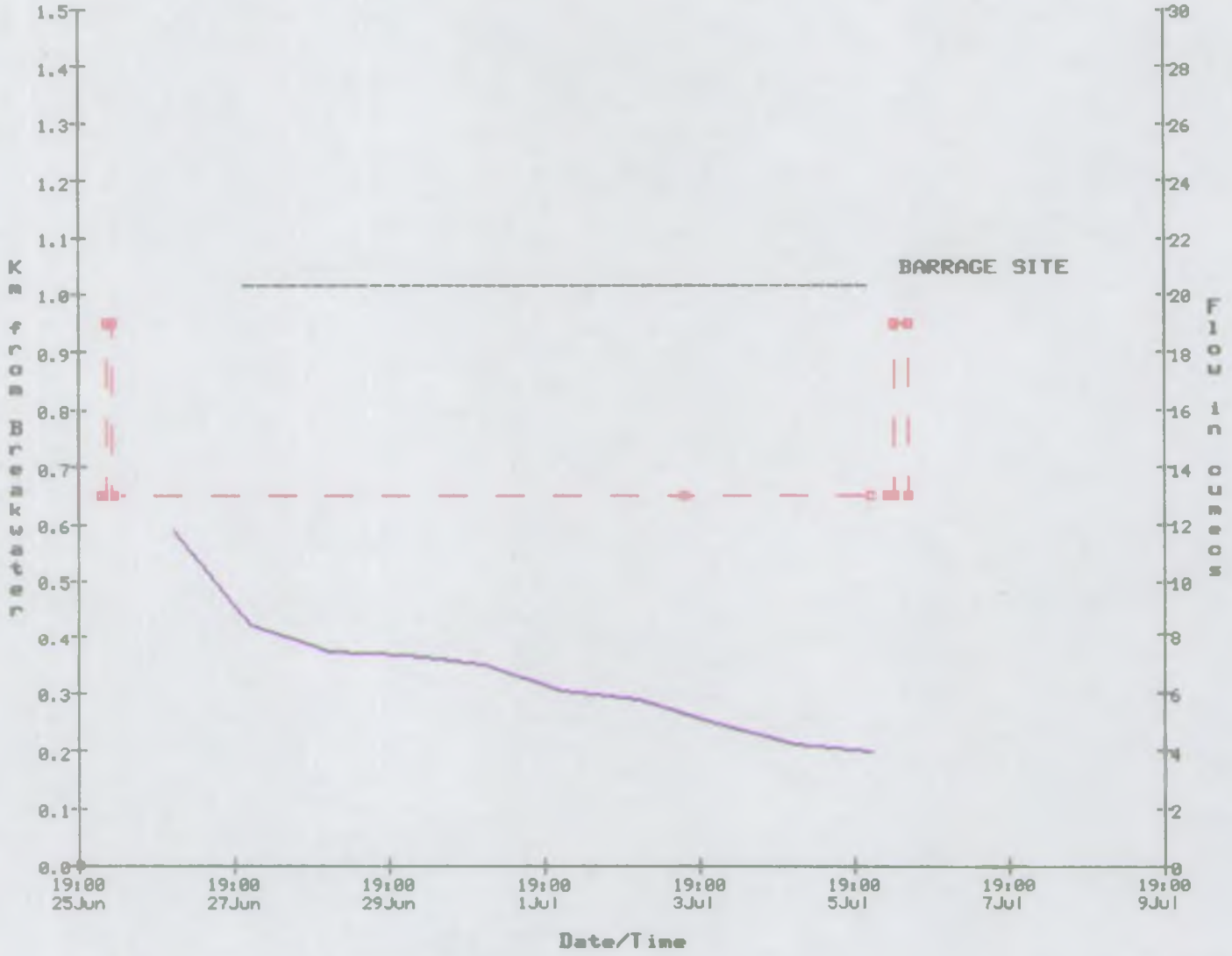


Figure 8. Fish number E083 Male salmon,relocation.

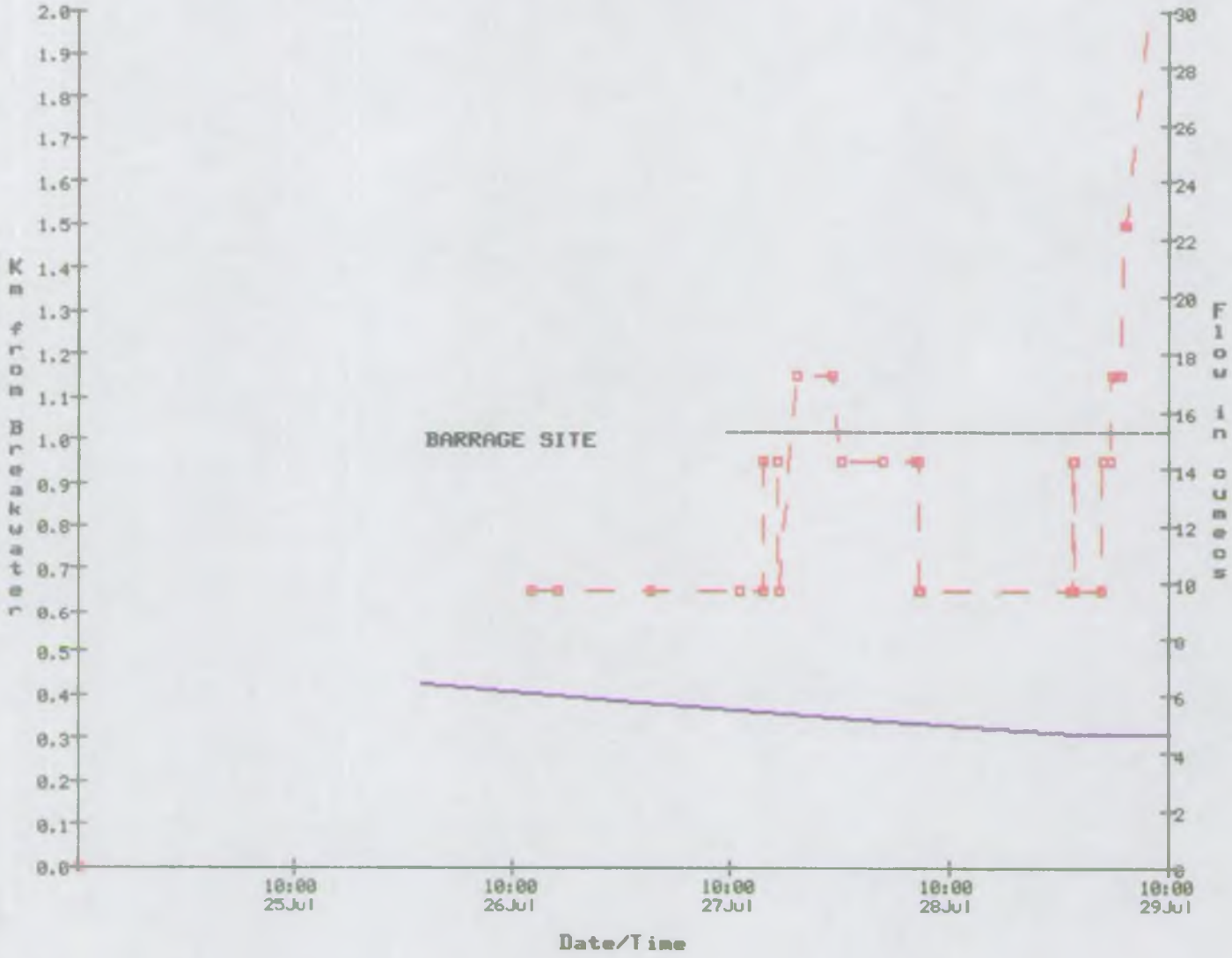
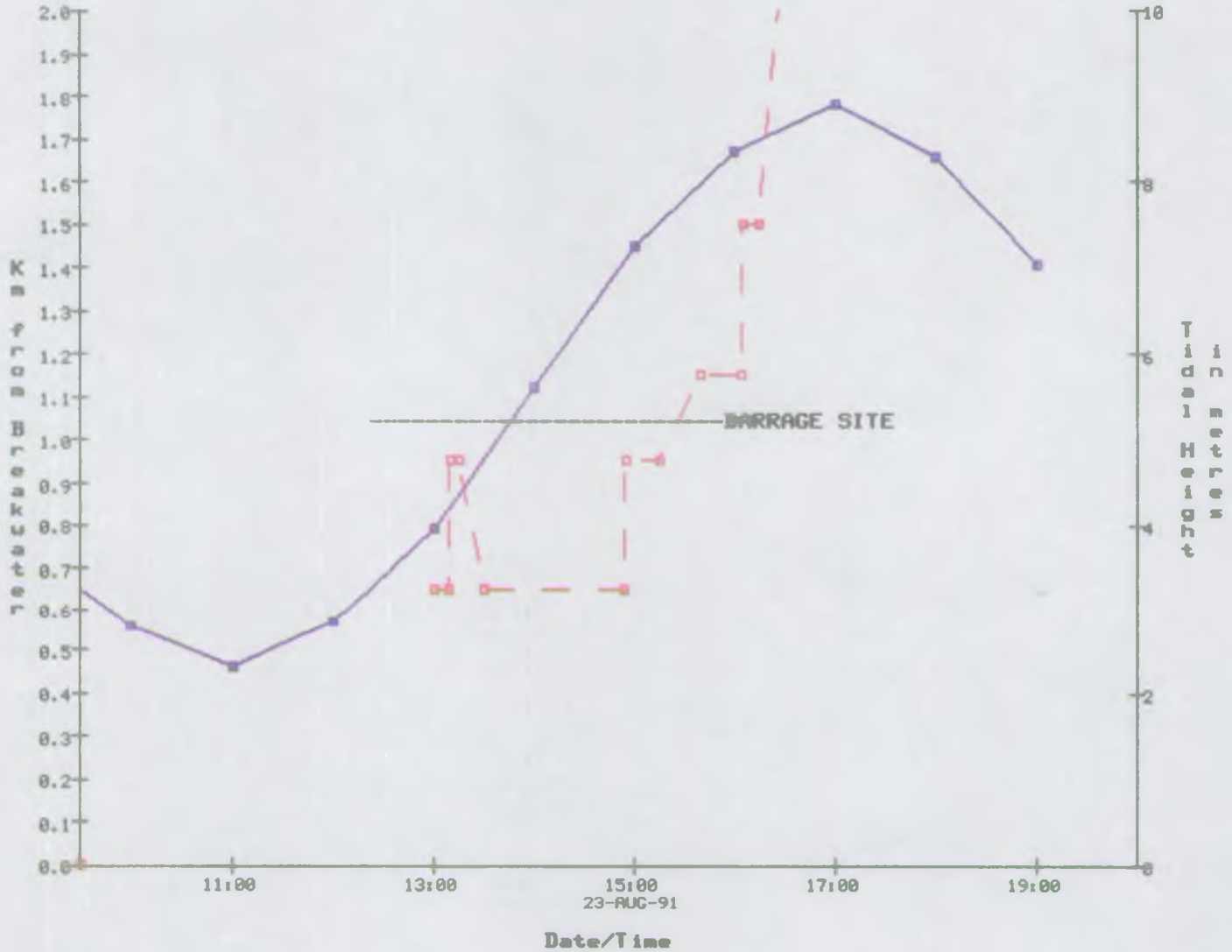


Figure 9. Fish number E078 Female sea trout, relocation.



## APPENDIX I

## TAWE BARRAGE IMPACT ASSESSMENT: FUTURE PROPOSAL.

### 1. PILOT STUDY RESULTS.

The pilot studies undertaken in 1990 and 1991 showed that it was possible to catch sufficient salmon and sea trout for the main impact assessment project. Fish were obtained from two sources: a bagnet mounted just off the West Pier at the mouth of the estuary; by relocating fish caught in a trap located at Panteg Weir. The studies also showed that CART tagged fish could be tracked past the barrage site and into freshwater using current radio/acoustic telemetry techniques.

### 2. 1992/93 PILOT STUDY.

### 2.1. FISH CAPTURE.

30 fish, 15 salmon and 15 sea trout, will be CART tagged and relocated from Panteg Weir fish trap.

### 2.2. TELEMETRY AND TRACKING.

A telemetry system will be deployed to enable fish to be tracked past the barrage site. Submerged sonar receivers (SSR) will be deployed:-

1. Ferry terminal, to give notice of a fish entering the estuary.

2. Immediately below the barrage, to determine the length of time fish remain below the barrage.

3. Immediately above the barrage, to detect fish once they have past the barrage.

4. Below New Cut bridge, to detect fish leaving the lower estuary.

The SSR's located downstream of the barrage site will be bed mounted in order to minimise interference with shipping. The SSR's upstream of the barrage site will be mounted sub-surface for ease of maintenance.

Automatic listening stations (radio) will be deployed:-

1. Associated British Ports lock control office, to receive the signal from the downstream SSR's.

2. Barrage lock control building, to receive the signal from the upstream SSR's.

3. Morfa sports stadium, to detect fish entering freshwater.

4. A site downstream of Beaufort Weir, as a backup for detecting freshwater entry.

5. Panteg Weir, to detect returning relocated fish.

To determine which of the three possible routes fish use to migrate past the barrage the following telemetry set up will be tested:-

Via the fish pass. Preliminary observation of the fish pass suggests that due to the low gradient and the design of the chambers that turbulence and cavitation are low. An SSR placed in one of the chambers should detect a tagged fish as it migrates through the fish pass. A number of SSR's will be placed in the top chambers to determine their best location.

Through the lock. An SSR mounted on the lock floor should be sufficient to detect any tagged fish migrating through the lock. The fish would be detected during the quiet periods over the lock operation cycle. Different frequencies of scanning will be tested to determine the maximum possible time between scans to guarantee detection of a fish. This will minimise the amount of interference recorded.

Over the weir crest. 2 directional hydrophones sub-surface mounted on buoys immediately above the weir crest will detect any fish that use this route. The hydrophones will be set to scan continuously due to the limited time that a fish will be in its detectable range.

A float switch will be mounted on the primary weir. This will log the periods of significant overtopping. A pressure transducer will also be mounted at a suitable location on the barrage to log the depth of water overtopping the weir. This will be used to determine which period of the tidal cycle that fish pass the barrage.

Verbal permission has been obtained to place a cabinet on the barrage structure to house the telemetry equipment. The cabinet must be sympathetic with the design of those already situated on the barrage structure. Verbal permission has also been obtained to place equipment in the barrage lock control building.

Regular active boat tracks will be carried in the estuary and in freshwater to provide more detailed tracking information and to backup the telemetry system.

## 2.3. TAGGING.

Tag regurgitation, especially with sea trout, has been identified as a probable reason for some of the fish failing to be detected. To eliminate this problem a technique of body cavity tagging will be tested on some of the sea trout. This involves the insertion of the CART into the body cavity of the fish through a small insertion made dorsal anterior to the anal fin.

## 2.4. BARRAGE FISH TRAP.

A trapping facility has been incorporated into the barrage fish pass. The trap will be operated to provide additional information on the numbers of fish using the fish pass.

## 3. 1993/94 POST-CONSTRUCTION STUDY.

### 3.1. FISH CAPTURE.

50 fish will be CART tagged. 24 fish, 12 salmon and 12 sea trout, will be relocated from Panteg Weir. 26 fish, salmon or sea trout, will be tagged from the bagnet. The bagnet should catch the required number of taggable fish to obtain the necessary 'virgin' fish tracks.

### 3.2. TELEMETRY AND TRACKING.

The basic telemetry system that enables fish to be tracked past the barrage will again be deployed as in 1992. The telemetry system to determine the route that fish use to migrate past the barrage will again be deployed subject to it being shown to work.

## 4. 1994/95 POST-CONSTRUCTION STUDY.

A repeat of the 1993/94 study if the assessment of the 1993/94 results indicate that this is necessary.

## APPENDIX II

## TAWE BARRAGE IMPACT ASSESSMENT: COST ESTIMATES

1992/93

SALARIES

| | | |
|---|---|---|
| 1 12 month temporary at grade 4 | @ | £17 000 |
| 1 6 month temporary at grade 2 (April -Sept.) | @ | £6 500 |
| SUB-TOTAL | | £23 500* |

* includes 17% oncosts and 20% overtime allowance.

EQUIPMENT

| | |
|---|---|
| 5 Submerged sonar receivers | £5 000 |
| Maintenance | £5 000 |
| SUB-TOTAL | £10 000 |
| TOTAL | £33 500 |

1993/94

SALARIES

| | | |
|---|---|---|
| 1 12 month temporary at grade 4 | @ | £18 400 |
| 2 6 month temporaries at grade 2 (May-October) | @ | £14 000 |
| 40 m.d. management/reporting from EAO level | @ | £4 000 |
| SUB-TOTAL | | £36 400* |

* includes 17% oncosts and 25% overtime allowance (grade 2 and grade 4 posts).

EQUIPMENT

| | |
|---|---|
| 7 Automatic listening stations | £17 500 |
| 5 Submerged sonar receivers | £5 000 |
| 50 CARTs @ £200 each | £10 000 |
| Active tracking equipment | £1 500 |
| Nets | £1 800 |
| Maintenance | £3 000 |
| SUB-TOTAL | £38 800 |
| TOTAL | £75 200 |

1994/95

SALARIES

| | | |
|---|---|---|
| 1 12 month temporary at grade 4 | @ | £18 400 |
| 2 6 month temporaries at grade 2 (May-October) | @ | £14 000 |
| 40 m.d. management/reporting from EAO level | @ | £4 000 |
| SUB-TOTAL | | £36 400* |

* includes 17% oncosts and 25% overtime allowance (grade 2 and 4 posts).

EQUIPMENT

| | |
|---|---|
| 50 CARTs @ £200 each | £10 000 |
| Maintenance | £5 000 |
| SUB-TOTAL | £15 000 |
| **TOTAL** | **£51 400** |