LEVEN ESTUARY PROJECT
~FISHERIES COMPONENT~
FINAL REPORT

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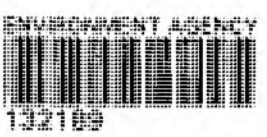

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SUMMARY

The Leven Estuary Project was initiated in 1995 in response to concerns over the effects of consented discharges within the Leven Estuary (South Cumbria) as part of a larger Pollution Control project investigating water quality. The objectives for the fisheries component of the project were to ascertain to what extent, if any, these discharges were having on the behaviour of migratory fish populations as they passed through the estuary. Conventional acoustic tracking methods were used to monitor fish movement within the estuary and radio telemetry techniques were employed for freshwater tracking.

The results of a three year study to examine estuarine and freshwater movements of salmon and sea trout within the Leven Estuary are examined.

During the first year of investigation complications were encountered relating to the reliability of the acoustic tracking hardware resulting in limited information for that period. The second year was more successful with limited disruption to data collection.

Although the number of fish caught and tagged was significantly higher than the previous year (25 in 1996, 7 in 1995) it fell short of what was hoped. The final year of study began well but catches within the estuary fell as the year progressed (total for estuary in 1997 = 10) resulting in limited data collection relating to estuarine fish movement. Catch per unit effort (CPUE) within the estuary for 1996 and 1997 based on numbers of fish caught and tagged per tide were 0.42 and 0.27 respectively. The project ran with a background of low rainfall and a freshwater flows during the first two years with a slight increase in the final year. Due to the low numbers of fish captured and tagged during the project it was deemed that statistical analysis of the data recorded was not appropriate.

The success rate of fish tagged within the estuary in migrating to freshwater has been highlighted as a significantly lower than in other similar studies (range 10% to 29%). The reasons for this are as yet unclear. Migration patterns within the estuary appear to show movement throughout the estuary at all states of tide with the exception of the area close to

the discharges where no detections were made throughout the project suggesting fish are avoiding this area. Time of travel to freshwater post-tagging varied significantly, ranging from seven days to seventy-six days and appeared to be correlated to a certain extent with the next increase in freshwater flows after tagging. Freshwater tracking has shown fish movement (both up and downstream) to be linked to freshwater flow. The final year of the project, when freshwater migration was investigated in greater detail, showed fish holding in the lower River Leven with a proportion of fish migrating out of the system for periods of up to 79 days in one instance. The destination of these fish is unclear although from tracking observations which detected fish around the lower reaches of other rivers (such as Rusland Pool) it appears they are entering other tributaries of the Leven Estuary.

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1. INTRODUCTION.

1.1 THE LEVEN ESTUARY.

The Leven Estuary is on the northern coastline of Morecambe Bay, and is fed by two principal rivers; the Leven itself, and the River Crake. The confluence of the two rivers is located at Greenodd - both rivers being tidal in this area. The town of Ulverston, with a population of nearly 13000, is the only sizeable population centre affecting the estuary, being situated on its western shores. The major discharges into the estuary are from the Waste Water Treatment Works serving Ulverston, and two discharges from the large Glaxo Wellcome pharmaceuticals factory. (see Section 1.4). Figure 1 shows the Leven estuary in a national context.

The estuary is characterised by being very shallow, and shares the extremely variable tides and currents that characterize the whole of Morecambe Bay. On a large ebb tide, the water may retreat more than 5 miles from the estuary, leaving just the freshwater channel and large expanses of sandflats. During a 12 hour tide cycle, the sandflats may be exposed for up to 8 hours. When the tide begins to flood, the bore can race back up the estuary at up to thirty miles an hour. Movement of water within the estuary is very dynamic with the waters of the upper estuary only still at high tide and then only for a few minutes. The freshwater channel itself is constantly shifting, such that in the space of a week it can swap banks. New sand-banks and channels are constantly appearing. Because of this extreme behaviour, the estuary is considered to be a hostile environment, perhaps one of the harshest environments in the British Isles.

The most important fishery within the Leven estuary is that of the shrimp fishery although a small number of licensed commercial netsmen (6) use lave nets to take migrating salmon and sea trout. 'The manner of using a lave net shall be by one person standing or moving in the water and supporting or holding the net and lifting or scooping any fish', (excerpt from Environment Agency North West Fisheries Byelaws 13 (iii)) . In addition a few fishermen take mullet, bass, and flounder both commercially and for sport. Access to the water for boats is very limited; often necessitating crossing unstable mudflats.

Figure 1. The Leven Estuary illustrated within a national context.

1.2 THE RIVER LEVEN CATCHMENT.

The River Leven runs from the southern most point of Lake Windermere, and meets the River Crake at Greenodd. It is a comparatively short length of river, being only about 5.5 km long from lake to tidal limit. However, because the river drains Windermere, its catchment is relatively large and includes all the various rivers and becks which eventually flow into the lake itself. The two main tributaries of the catchment are the Rivers Rothay and Brathay, which both flow into the northern end of Windermere. Windermere itself, at 16 km in length and up to 60m deep, is the largest natural lake in England and has significant effects on the fish populations of the catchment. The lake supports one of the few major arctic char, (*Salvelinus alpinus* L.) populations in England, as well as trout (*Salmo trutta* L.), perch (*Perca fluviatilis* L.), roach (*Rutilus rutilus* L.), and pike (*Esox lucius* L.), (Millington, L.W. 1994). The catchment is a popular game fishing area, and virtually all the tributaries support salmonid spawning grounds, for brown trout from Windermere, and sea-trout and salmon migrating upstream from Morecambe Bay. (McCubbing, D.J.F. 1993).

1.3 THE RIVER CRAKE CATCHMENT.

The Crake is a similar river to the Leven, in that it too drains a major lake and thus has a comparatively large catchment. The lake in question being Coniston, which supports important trout and char populations. The main tributaries which empty into the lake are the Yewdale, Church and Torver Becks. Again, the Crake catchment supports many salmonid spawning grounds and is an important sport fishing area. (McCubbing, D.J.F. 1994).

1.4 THE ULVERSTON DISCHARGES.

There are three discharges into the estuary area under study; one from the Waste Water Treatment Works (North West Water), and two from the Glaxo Wellcome Pharmaceuticals plant. The W.w.T.W. discharge is a typical small town domestic effluent which receives screening treatment. The discharge is authorised by the Agency and seldom exceeds the set levels for BOD and suspended solids. The Glaxo Wellcome Pharmaceuticals discharges are also consented by the Agency.

The 'weak' effluent consists of some domestic type waste and highly diluted solvent wastes. The 'strong' Glaxo Wellcome discharge consists of residues from the production of antibiotics; solvents such as methylene chloride, alcohol and acetone, and high levels of ammonia. The mean ammonia level in the effluent before discharge has been measured at 145 mg/l, and is seen as the key component of the effluent. To put it in context, the BOD in the effluent is equivalent to that in untreated sewage of 250,000 people. All the effluent discharges from outfall pipes close to Hammerside Point, and are released for between 20 to 30 minutes, (although consented for up to 45 minutes), every tide, starting 30 minutes after high water. Hence the discharge forms a 'slug' of effluent that moves out of the estuary as the tide is beginning to ebb. Studies using rhodamine tracer dye have shown that the slug generally remains very defined and narrow as it passes out of the estuary. On small neap tides it can move out towards Chapel Island, but usually follows the path of the freshwater channel, running close to Carter Pool. Figure 2 shows the estuary with discharge points and path of the effluent plume.

Figure 2. The Leven Estuary illustrating discharge points and effluent plume path.
(Modified from Bayliss, B.D. & McCubbing, D.J.F. 1996)

The Glaxo Wellcome plant shuts down once a year for essential repairs and maintenance, and thus there is a period of about two weeks when the discharge volume decreases almost to zero. This period is usually the last week in July and the first week in August.

1.5 THE LEVEN ESTUARY PROJECT.

There is little detailed knowledge of the impact on the Leven estuary, and particularly its fisheries, of the discharges from Ulverston. There has been some concern expressed by the lave netsmen and the general public about the possible harmful effects of the effluents on the biology of the estuary. In the absence of a definite strategy for the protection and management of the estuary, it was decided that, with the focus on the strong discharge, a project should be initiated with the following objectives:

i) To gain detailed knowledge of the actual impact of the effluent, particularly on the migratory fishery.

ii) To provide a sound technical basis on which the Agency might negotiate effluent improvements and discharge arrangements.

iii) To establish a comprehensive understanding of migratory fish behaviour in the estuary.

A further objective was included for the project during 1997, this being :

iv) To gain further detailed knowledge of migratory fish behaviour in freshwater during 1997.

The project involves water quality monitoring, effluent and estuary toxicity testing, tracking of effluent plumes, and salmonid tagging and tracking. The entire project commenced in June 1995 and reached its conclusion in February 1998. The information gained from the project is expected to contribute to the creation of a 'mixing zone' for the effluent, and to improve the environmental management of the estuary and protection of its fishery.

1.6 THE FISHERIES STUDY.

The fisheries element of the project is a study of the behaviour of migrating salmonids in the estuary, investigating to what extent if any the Glaxo Wellcome effluent is having an effect on that behaviour. The study's aim was to establish if the discharge is preventing or delaying fish from entering freshwater to spawn. The method used was sonar tagging and tracking technology over a three year period. It was originally planned to tag up to 100 fish each year, both salmon and large (4 lbs+) sea trout. Their behaviour was monitored in the estuary by the use of both passive and active tracking techniques. The two week shut-down period when the discharge stops acted as a valuable control.

The NRA, the Environment Agency's predecessor, has carried out similar work in estuaries; most notably on the Dee Estuary from 1991-1993. This project used the same technology to assess whether salmonid behaviour would be affected by the construction of a tidal barrage in the estuary. Other projects have been undertaken on the Tywi and the Usk in Wales, and the Stour and Avon in England, mostly investigating possible factors affecting salmon migration.

2. TECHNICAL INFORMATION.

2.1 ACOUSTIC TELEMETRY.

In any telemetry system the transmitted signal must be detected at a distance; therefore the ability of the system to function satisfactorily depends on a number of factors:

i) the amount of power transmitted, usually expressed as acoustic pressure in µPascals at 1 metre distance from transmitter.

ii) signal loss between transmitter and receiver, (also known as attenuation).
- Spherical spreading losses as signal expands to cover a sphere of increasing volume.
- Absorption losses affected by signal frequency, salinity, suspended solids, bubbles etc.
- Energy loss on reflection when signal strikes surface or bottom, and refraction when signal passes through temperature gradients.

iii) the amount of noise in the transmitting medium.
- ambient noise such as rain, soniferous marine life, and wind.
- noise due to flow of tides and currents.
- electrical and mechanical noise in surrounding areas.

iv) the receiver's ability to differentiate between signal and noise.
- for the type of equipment used in this project, it is only important that the signal to noise ratio is sufficient that the tag pulse is distinguishable from the background noise.

2.2 TAGGING TECHNOLOGY.

The use of tagging for the tracking of fish is a firmly established tool for the scientist in the field. First used in 1956, the basic concept of acoustic tagging has not changed since. However, as the technology has developed, it has been possible to place more sophisticated electronic circuitry into smaller tags, thus enabling the behaviour of smaller subjects to be studied. At present the size of an electronic tag is dictated by the size of the battery needed; the circuitry it powers requires

minimum space in comparison. A breakthrough in battery design is needed before tags will be made appreciably smaller, and still have an adequate operation time.

2.3 THE TAGS.

The radio pulses emitted by a small tag are very weak compared to normal radio transmissions, and are therefore easily attenuated by any impurities or particles in the medium through which they travel. For this reason, a radio tag will have a very limited useful range in seawater, but will perform adequately in freshwater. So, as the estuary water is either brackish or saline except at extreme low water, it was decided that radio tagging would not provide adequate performance for the purposes of this study. More commonly used in saline conditions is sonar technology; the use of high frequency sound as a substitute for radio waves. Sound waves are attenuated less by dissolved matter present in seawater, and are therefore more useful in an estuarine environment. The accepted technology used today is the CART (Combined Acoustic and Radio Tag) tag. These are inserted into the stomach of the fish, and transmit a radio pulse and an acoustic pulse simultaneously. However, as the transmission of an acoustic pulse requires more energy than a radio pulse, to conserve battery life the tag is designed to cease acoustic transmission after a set period. Thereafter, the tag continues functioning purely as a radio tag for the remainder of the battery life.

The CART tags are cigar shaped, about 6.5cm long by 1.5cm diameter, and are manufactured so that their radio transmission frequencies cover ten bands. The spacing between bands is 5 KHz, ranging from 173.800 MHz to 173.850 MHz. This region of the radio frequency spectrum is approved by the Department of Trade and Industry for use in animal telemetry. Their acoustic signal is transmitted at a frequency of 76 KHz, and each tag has its own specific pulse rate. Thus an individual fish can be identified by the pulse rate of its tag and the frequency on which it is detected. The acoustic pulse is programmed to cease after approximately 20 days, whilst the radio pulse may last up to 9 months. However, this will vary according to the pulse rate; the higher the rate, the faster the battery will run out. (The pulse rates of tags used ranges from 25 to 72 ppm.)

For the purposes of this project, the CART tags were to be used to provide most of the data about fish behaviour in the estuary, particularly when concerned with the effluent from Hammerside Point. However, as the chain of sonar buoys did not extend into freshwater due to the automatic listening stations being used in this area, radio tags were also purchased. These were to be used to confirm that fish tagged in the estuary were carrying on into freshwater, and not leaving the Leven estuary to enter another river system. Radio listening stations above the tidal limits of the Crake and the Leven would pick up the tagged fish and thus provide information on how long fish remained in the estuary before entering freshwater. Also, by correlating data from these listening stations with environmental data, the environmental factors (eg. temperature, rainfall) which prompt the fish to move upstream can be identified.

The radio tags transmit their pulses on the same frequency bands as the CART tags, and are identical in appearance apart from being 2 cm shorter. Again, each tag is unique due to its specific combination of transmission frequency and pulse rate.

2.4 THE SONAR BUOYS.

The purpose of the sonar buoy is to pick up the acoustic pulses emitted from the tag within the fish, convert these pulses into radio pulses, and transmit them to a land based receiver, in this case an automatic listening station. HS Electronics manufacture a unit which has been used in the projects on the Dee and Tywi mentioned earlier. The unit consists of a PVC bucket which holds the battery, and a lid from which is suspended the electronic circuitry. The lid is bolted to the bucket with 8 bolts, and a watertight seal is made with the use of a rubber 'O' ring and a silicon sealant grease. The hydrophone and aerial socket are mounted on the top of the lid and the whole assembly is bolted to the stainless steel holding cradle.

As described in section 2.1, the main problem with the use of acoustic tagging in water is the fact that the aquatic environment is very noisy. Indeed an estuary such as the Leven is probably the noisiest possible environment in which to use such equipment. To try to combat this problem, the buoy is fitted with automatic gain control circuitry designed to overcome spurious triggering by noise.

In typical tracking locations, trials have shown that the buoy will run for 7 to 10 weeks before its battery runs out. However, this period will be shorter if the buoy is being triggered frequently in a noisy environment.

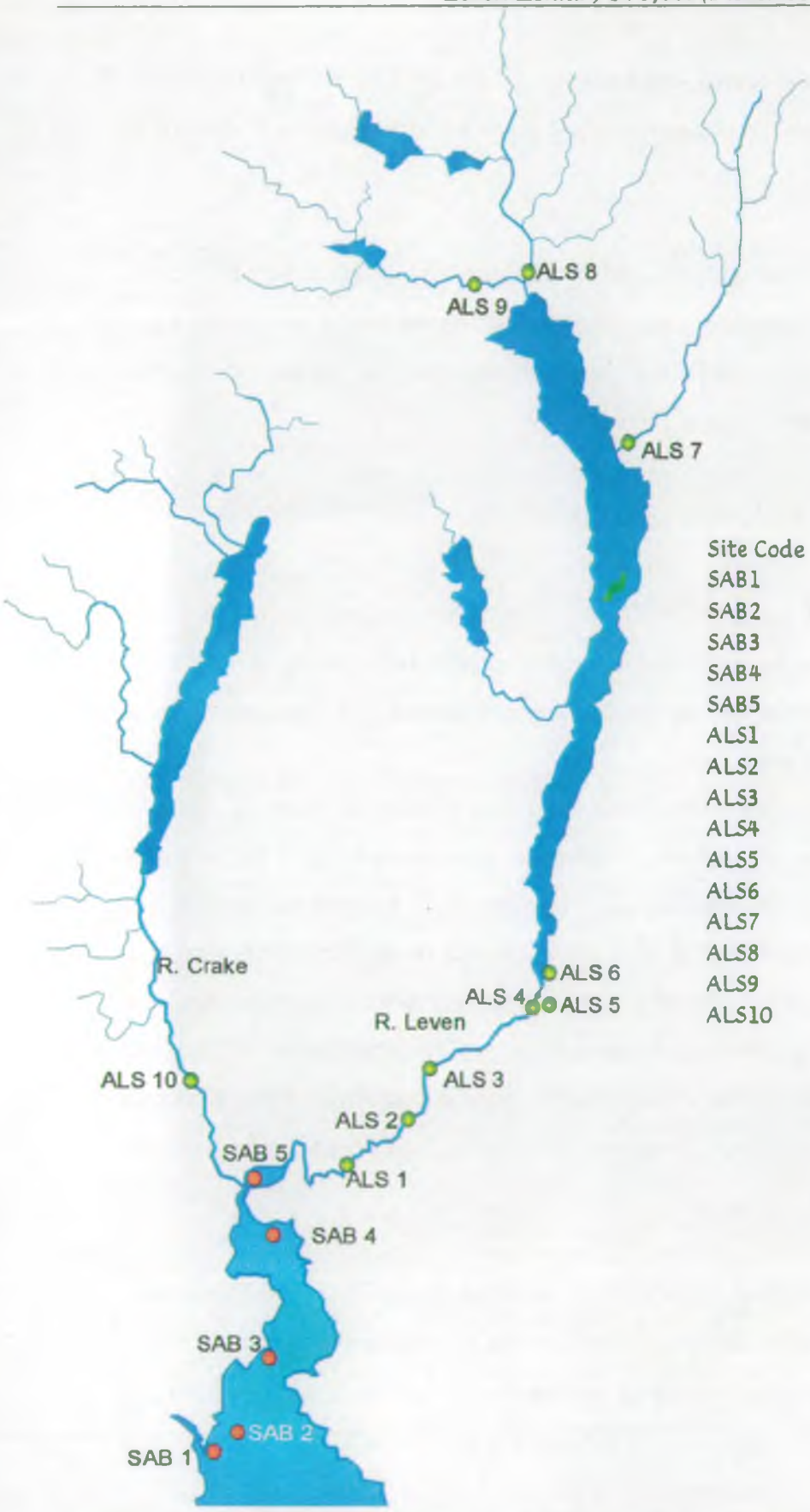
The buoys transmit a pulse every 20 seconds to confirm it is operational; this is useful when no tagged fish or spurious noises trigger the buoy. The buoys' transmissions are in the same frequency band (174 MHz) as the radio and CART tags, with each buoy having its own specific frequency. The sonar buoy sites can be seen in Figure 3.

2.5 THE AUTOMATIC LISTENING STATIONS (ALS).

The station consists of a modified Yaesu FT290R radio receiver which is connected to a tape recorder and an electronics unit. The electronics unit has a small printer and contains a timer card. The whole unit is powered by a twelve volt car type battery and housed in a waterproof plastic box which is designed to be placed in the field.

The station functions on a cycle, which can be set to run continuously or every 2, 5, or 10 minutes. Every cycle, the station runs through the 10 frequency channels stored in the receiver's memory, scanning for pulses from the radio tags or sonar buoys. If a signal is detected, the tapedeck records 12 seconds of that signal. A printout at the end of each cycle confirms the presence of any signals for each frequency channel. Using the recording to time the pulse rate, and knowing the frequency channel recorded on the printout, it is possible to deduce which tag (and therefore which fish) has been detected. When the station is in place in the field, it must be visited regularly to collect the tapes and printouts for analysis. The listening station sites can be seen in Figure 3.

A hand held Yaesu radio receiver with an 'H' pattern dipole aerial proved particularly useful in assessing suitable sites for location of the listening stations, and in ascertaining whether the buoys were still functioning. This same equipment was used extensively for mobile or active tracking in areas not covered by the ALS. More intimate fish movements were able to be monitored and recorded.



Site Code	Location	NGR
SAB1	Carter Pool	SD 308 767
SAB2	Hammerside Point	SD 312 772
SAB3	Plumpton Viaduct	SD 321 789
SAB4	Mearness Point	SD 322 817
SAB5	Greenodd	SD 317 826
ALS1	Fish House Lane	SD 339 812
ALS2	Eels Dam	SD 351 841
ALS3	Iron Works	SD 355 848
ALS4	Newby Bridge	SD 368 864
ALS5	Miller Beck	SD 372 861
ALS6	Fell Foot	SD 381 871
ALS7	Troutbeck	SD 396 999
ALS8	River Rothay	NY 372 038
ALS9	River Brathay	NY 360 034
ALS10	Spark Bridge	SD 304 850

Figure 3. The Leven estuary with Leven and Crake catchments showing sonar buoy and listening station locations.

3. ACCOUNT OF TECHNICAL WORK IN 1995, 1996 & 1997

3.1 A SUMMARY OF 1995

Throughout the study period covering the months June to October 1995 there were numerous factors which determined the outcome of that years' project. These centred around the equipment and the weather. Problems with the sonar buoys flooding and subsequent lengthy and expensive repairs meant that tracking within the Leven estuary in 1995 was ineffective. However, the weather also played a role in that extremely low rainfall (i.e significantly below the monthly long term average from April to September) and the drought order imposed on the River Leven catchment resulted in persistently low flows within the river and the estuary. It should be mentioned that any drought order or flow regime imposed on the Leven catchment will effect freshwater flows within the Leven Estuary and consequently the freshwater 'cues' for tributaries of the estuary. Indeed low flows, high water temperatures and other associated factors are known to be detrimental to the migration of returning adult salmonids. (Milner, N.J. (Ed.) 1990). A total of seven fish (six salmon, one sea trout) were tagged and released in the Leven estuary during 1995. Of these two fish (one salmon, one sea trout) made a successful migration into freshwater, of the remaining five fish, two were found dead within the estuary and three were never detected after release. The findings will be discussed in section 4.2.2.

3.2 A SUMMARY OF 1996

It was intended from the outset of the project that 100 fish were to be tagged and released. This figure has not been possible in the first two years of the study due to a combination of low flows within the estuary and a general lack of fish. However, netting in 1996 fared better.
A total of twenty- five fish were tagged during sixty- one netting operations at four locations namely Carter Pool, Plumpton Viaduct, Plumpton Bight and Plumpton Beach. Fourteen salmon, ten sea trout and one steelhead (a sea run rainbow trout) comprised the total. The first fish was caught on 27.06.96 and the last on 15.10.96.

The network of sonar buoys was operational for the entire period of capture and release, however not all fish were detected within the estuary. Of the twenty-five tagged fish, eight (32%) were

detected by various sonar buoys within the estuary and four of the twenty-five (16%) entered freshwater.

Not all fish were fitted with acoustic tags, some were radio tagged due to the size or condition of the individual fish.

3.3 A SUMMARY OF 1997

The main objective of the fisheries component of the Leven Estuary Project was to monitor the behaviour of migrating salmonids in the estuary. Due to conditions experienced during 1995 and 1996 a decision was made to extend the project for a further year, but conditions did not dramatically change. In September and October, 1997, nineteen salmon and sea trout were netted and tagged in the holding pools at the limit of normal spring tides in the River Leven near Low Wood. These tagged fish augmented the six salmon and four sea trout tagged in the estuary.

As was the case in 1995 and 1996, six sonar buoys were deployed throughout the estuary in 1997. The location of these can be seen in Figure 3. Each buoy was allocated an automatic listening station (A.L.S.) which monitored the related frequencies for tagged fish on a set 2, 5, or 10 minute cycle. Carter Pool and Hammerside buoys were served by one A.L.S. at Canal Foot. The buoys were in place prior to the beginning of the netting operations and were operational up to the end of October when they were recovered as the CART tag batteries would have run out, rendering them unserviceable. In other ways it was timely as estuarine conditions became more hostile due to increased river flows, high spring tides and generally colder temperatures making regular buoy maintenance visits difficult and potentially dangerous.

The buoy at the River Crake confluence, Greenodd, was periodically buried under shifting mud banks but this did not seem to affect its transmitting integrity as the 2 metre mast was clear of the substrate surface. The buoy was assumed to have broken its moorings during the highest spring tides of the year on the 20th and 21st August and was not seen again. As a precaution, the Greenodd A.L.S. was kept operational until the 15th September when electrical problems expedited its removal.

4. ACCOUNT OF TAGGING OPERATION IN 1995, 1996 & 1997

4.1 THE GENERAL NETTING REGIME

Each netting operation is relatively labour intensive, requiring the presence of a minimum of two boat trained fisheries staff depending on the location and the nature of the netting exercise. In practise, manpower was reduced to one fisheries staff and one casually employed netsman as experience grew and techniques refined. Over the three years, the services of two experienced estuary fishermen were employed. Their help was deemed necessary as they have valued experience of locating fish holding areas , and also knowledge of potentially dangerous quicksands that characterise much of the Morecambe Bay area.

Netting operations were performed at both low and high tides depending on the method being used and the location in which netting was to be carried out. Netting sites at Plumpton Viaduct (also known as the Leven Viaduct) entailed fishing at low water as deep holding pools were more obvious and easier to fish with a gill net or seine net. The seine net was abandoned after the first year as being too labour intensive. However, netting operations at Carter Pool (downstream of the discharge at Hammerside Point) and Plumpton Beach (upstream of Canal Foot) were generally carried out over the flood period of the tide with a gill net set parallel to the shore prior to the "bore". As the flow decreased over high water, occasionally a gill net was drifted at 90 degrees to the shore with the use of a small inflatable boat.

4.2 TAGGING & TRACKING RESULTS IN 1997

Tagging details and subsequent tracking information within both estuarine and freshwater environments during 1997 is summarised in text form in Appendix 4.

Although it was intended from the outset of the project that 100 fish were to be tagged and released these figures were not realistically obtainable in all three years of the study due to a combination of low flows within the estuary and a general lack of fish.

The network of sonar buoys was operational for the entire period of capture and release, however not all fish were detected within the estuary. During 1996 eight of the CART tagged fish (40%)

were detected by various sonar buoys within the estuary and four of the twenty-five (16%) entered freshwater. During 1997 of the ten tagged fish four (40%) were detected by various sonar buoys and only one detected in freshwater.

4.2.1 ESTUARINE TRACKING IN 1995, 1996 & 1997

During the tracking period of 1995 (June to October) very limited estuarine data on fish movements were recorded due to the problems encountered as outlined previously in section 3.1. However, length of time taken to reach freshwater and freshwater tracks were recorded and are summarised in Appendix 2b. This section concentrates on data obtained during the 1996 and 1997 tracking season.

The sonar tracking equipment is sited within the areas of the estuary which still carry freshwater once the tide has fully ebbed. This allows full tidal cycles to be monitored and thus increases the chances of detecting acoustically tagged fish. Salmon migration through the estuarine environment has been studied using similar technology for many years and as a result a general picture of fish movements has been obtained.

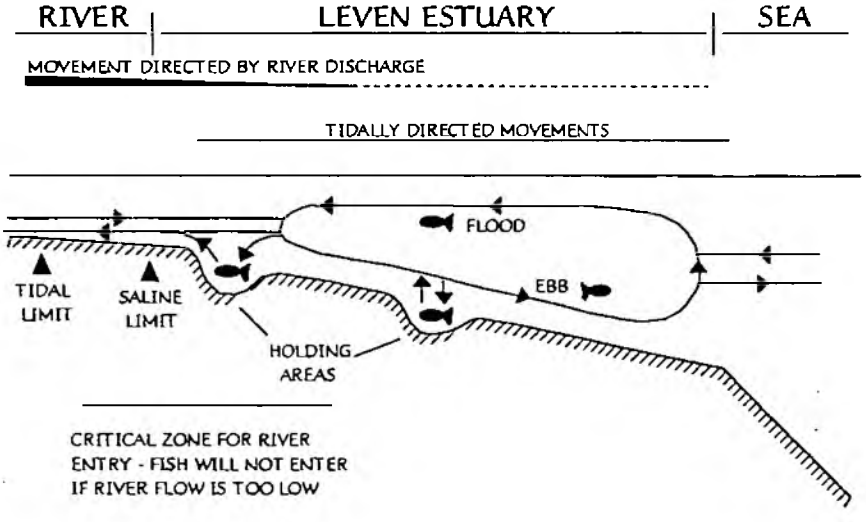


Figure 4. Schematic representation of salmonid migration through the Leven Estuary. (Modified from Milner, N.J. (Ed.) 1990).

Placing the schematic diagram into the context of the Leven estuary, we can relate the low water holding areas illustrated to those of Greenodd in the upper estuary and Plumpton Viaduct in the middle reaches. It is believed from observations and communications with estuary netsmen that the afore mentioned two areas are the primary locations for fish to hold in after high tide and remain resident until the following flood tide (although some fish do move within the flow of the freshwater channels at low water). This is thought to be due to the nature of the holding pools being deep with areas not directly in the main flow allowing fish to rest. Other holding areas exist within the estuary but are generally of a temporal nature (e.g. Skelwith and Mearness) due to unstable sand flats and tidal forces.

During the capture, tagging, release, and tracking period of 1996 (late May to late October) fourteen salmon, ten sea trout, and one steelhead were tagged and released. During the estuarine tracking period of 1997 four of the ten CART tagged fish were subsequently detected within the estuary. The exact time was recorded for each detection event and from the analysed data charts were produced. The charts show the time and numbers of detections and their respective duration in relation to the tidal state. This should then allow movement patterns within the estuary to be plotted. Figure 5a shows the Leven estuary with buoy locations and detections of CART tagged fish during the study of 1996. Figure 5b shows the same information for 1997.

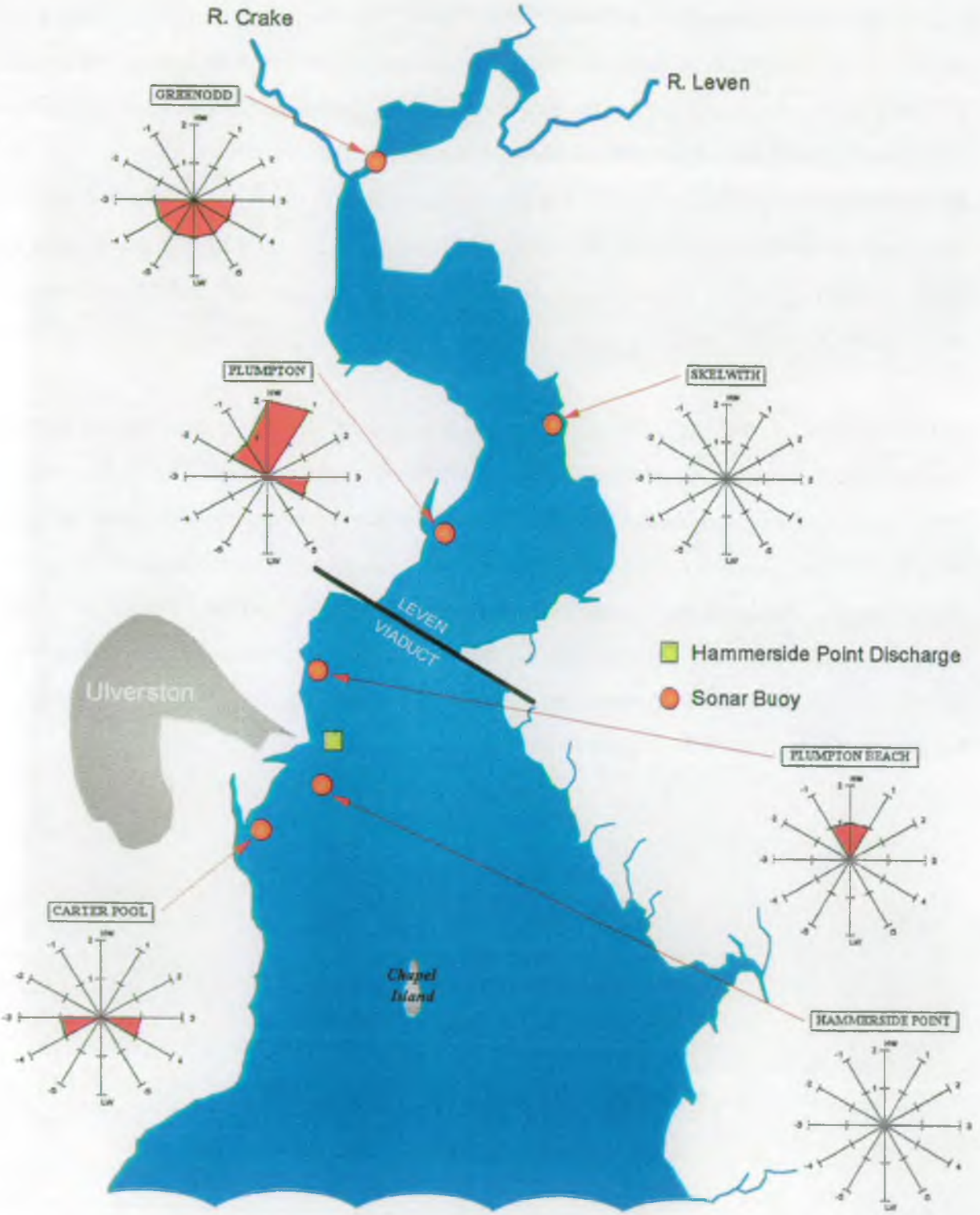


Figure 5a. Distribution of fish detections in relation to high water during 1996.

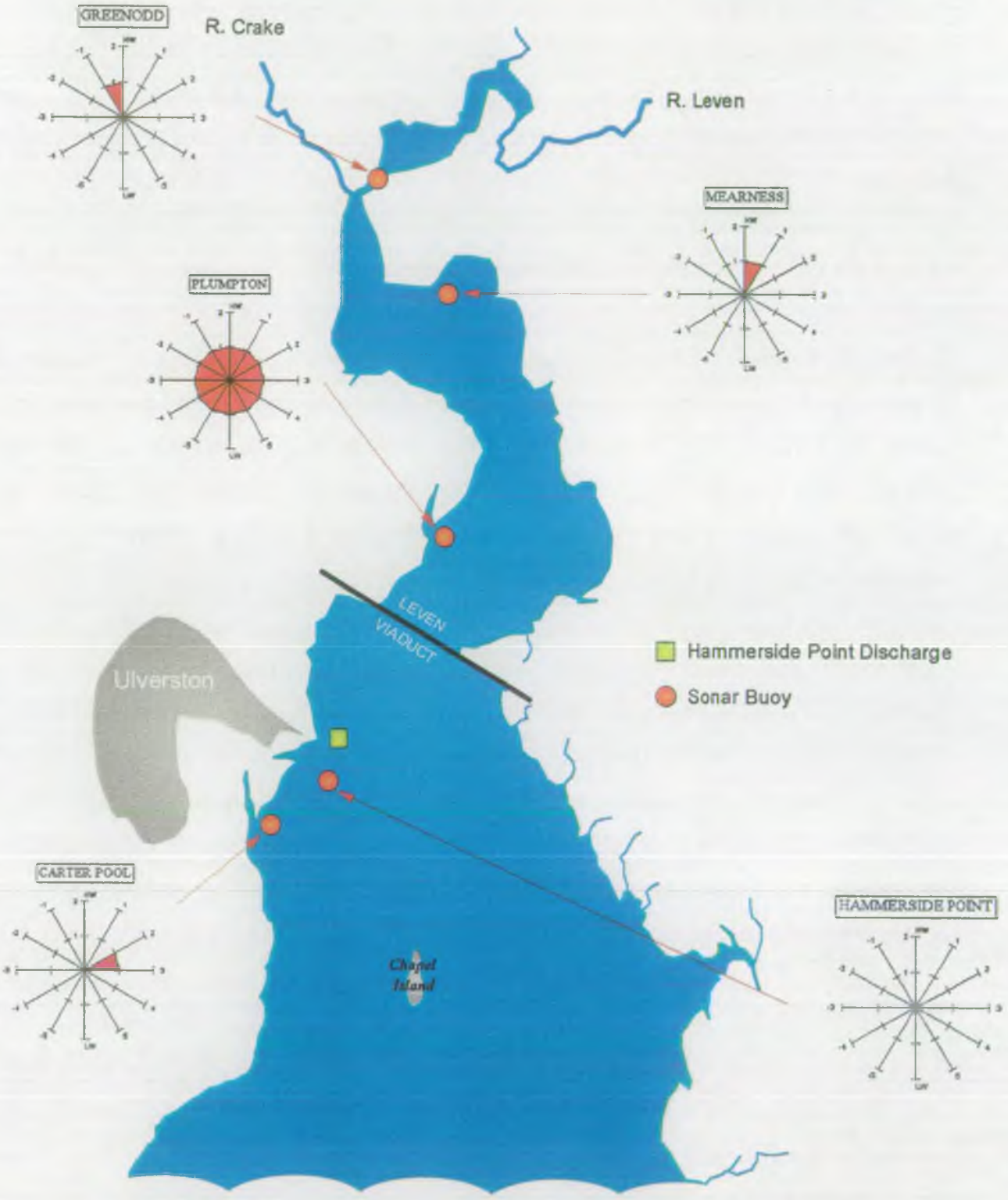


Figure 5b. Distribution of fish detections in relation to high water during 1997.

Each detection of a tagged fish made by the sonar buoy network is represented by 5mm across the axis of the radial chart. During 1996 detections were made by all buoys with the exception of Skelwith and Hammerside Point buoys. During 1997 detections were again made by all sonar buoys with the exception of Hammerside Point. The likely reasons for this are discussed later in section 5.

4.2.2 FRESHWATER TRACKING IN 1995, 1996 & 1997

During 1997 netting operations provided few fish for tracking within the estuary and it was therefore decided to pursue the option of obtaining fish from the lower River Leven in the area known as the Honey Pot (See Figure 6.0). These fish were tagged with radio tags and their movements were monitored using ALS and portable radio receivers. Subsequently nineteen fish were caught and tagged and along with the estuarine tagged fish were tracked within the catchments of the Leven Estuary.

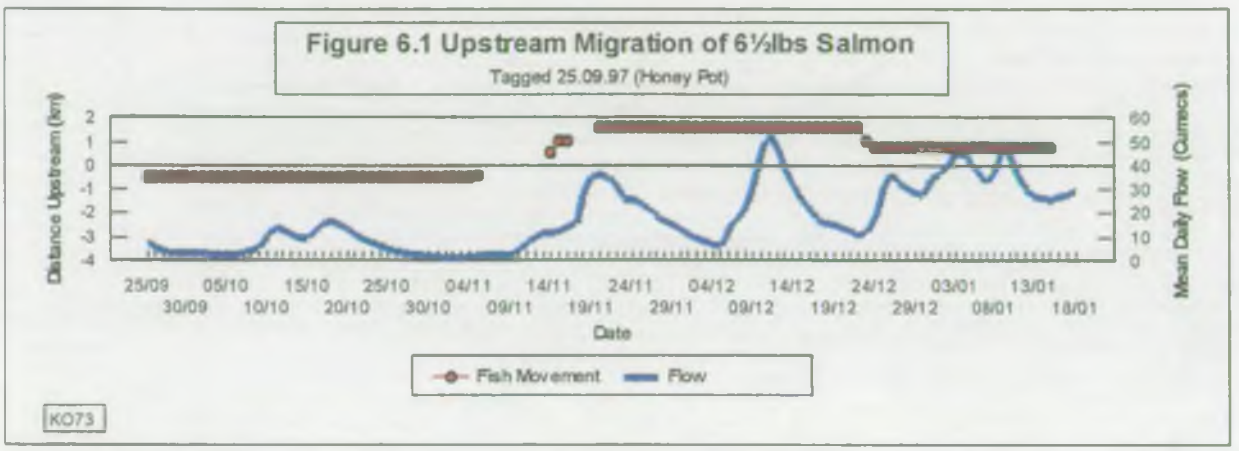
As previously stated in section 4.2; of the twenty five fish that were tagged within the estuary in 1996 four (16%) made a successful migration into freshwater. Three entered the River Leven (1 salmon, 2 sea trout) and one the River Crake (sea trout). In 1995 only seven fish were tagged within the Leven estuary (6 salmon, 1 sea trout) of which two (29%) committed to freshwater, one sea trout in the River Crake and one salmon in the Leven. If these figures are compared to those of other studies involving estuary tagged fish and their migration to freshwater it shows a significantly lower success rate.

This assists in outlining the significantly low success rate of returning adult salmonids within the Leven estuary. The other studies included the Rivers Dee, Tay, Tamar, and Hampshire Avon were related to flow regimes rather than water quality issues . The River Ribble however, with a successful migration rate to freshwater of 22%, was studied due to concerns over effects of low dissolved oxygen (DO) due to a major sewage works discharge within the estuary. (Priede, I.G. Solbe, J.F. et al 1988). The Tywi study was also concerned with the effects of low DO attributed to tidal resuspension of estuarial muds, discharge from a major sewage treatment works in the upper estuary and breakdown of marine algae. (Clarke, D. and Purvis, W.K. 1990). The River

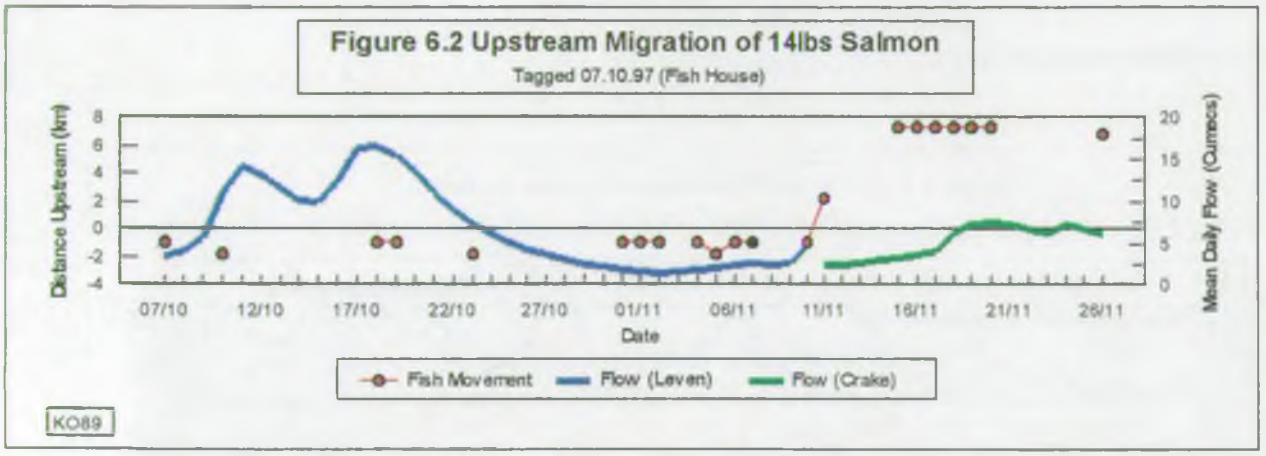
Usk was another river investigated due to concerns over low DO due to resuspended sediments and polluting discharges within its estuary. (Aprahamian, M.W., Strange, C.D., and Dimond, C. 1990). Therefore it would appear from the chart that low returns of estuarine tagged fish to freshwater are linked to water quality problems within the estuary. The severity of the situation within the Leven estuary may well be as a result of the presence of numerous stressors such as treated sewage, pharmaceutical bi-products, reduced freshwater flows, and relatively high water temperatures, each of which has been shown in other studies (references as above) to contribute (in part) to a reduction in number of freshwater entrants. This could be due to an increase in mortality rates due to the stressors mentioned or a return to sea to avoid the stressors within the estuary. What is clear from the study on the Leven estuary is that the majority of estuarine tagged fish 'disappeared' (i.e. there is no way of determining their fate other than they do not enter freshwater during the tag life).

Figure 6.0. River Leven illustrating named pools from White Water to estuary.

Figures 6.1 to 6.15 illustrate tagged fish movements during 1997 within the Leven catchment relating to freshwater flows.

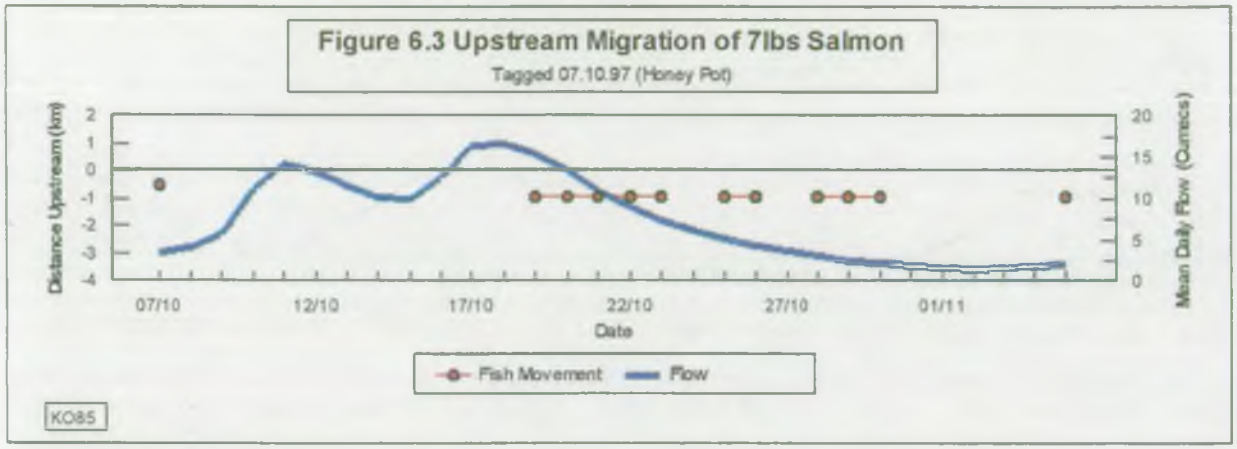


Notes on Figure 6.1 : After tagging, KO73 remained in the Honey Pot for 42 days until 05.11.97. It progressively moved upstream on rising river levels for the next ten days coming to rest at the White Water falls at Backbarrow. A peak level of 36 cumecs afforded ample opportunity to ascend but the salmon remained in the pool at the foot of the falls for 33 days during which time a second opportunity to migrate upstream during a flood on 11.12.97 peaking at 52 cumecs was not taken. On the morning of 23.12.97, KO73 left the pool on rising levels migrating downstream through Eels Dam and into the headrace of the Low Wood Turbine which were operating throughout this period. It was subsequently observed in the race and actively tracked for the last 23 days of its life before being caught, killed and eaten by a mink on 15.01.98. The radio tag was recovered from the minks den and some shed ova observed. Redds had been cut in the race and KO73 seen in the vicinity of them. Little spawning opportunity exists between the White Water falls and the Low Wood headrace.

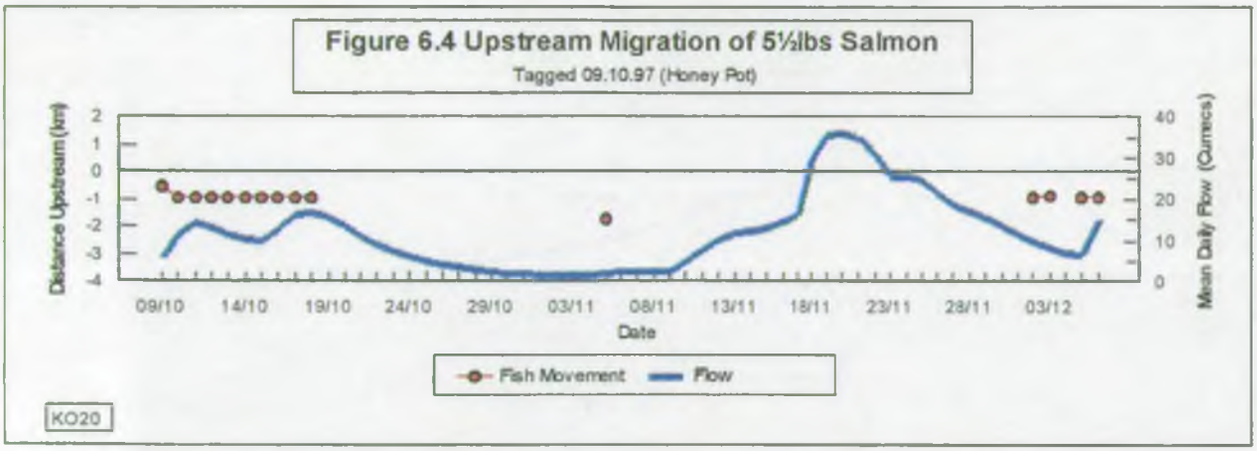


Notes on Figure 6.2 : This male salmon of 14lbs was the largest fish to be radio tagged in fresh water. For a month after tagging it moved freely between the Timber Pond and Fish House Lane until the night of 10.11.97 when on a steadily rising water level it returned downstream to Greenodd and into the River Crake. Its last detection in the River Leven was made at 22.05hrs which would suggest that the fish left at around or just after high tide (8.4m @ 21.38hrs*). Moving during this tidal state would allow the fish to passively move downstream on the tide until it reached the lower River Crake. The Spark Bridge A.L.S. detected KO89 the following day, 11.11.97 between 14.10 and 15.30 (having travelled the 7.5km from Fish House Lane to Spark Bridge in 16hrs) as it swam upstream to Allen Tarn where it was first actively tracked on 15.11.97. KO89 remained in the Tarn for at least a week and was last detected downstream of Bouthrey Bridge on 26.11.97. Much spawning activity takes place in this area of the River Crake and it possible that this fish did indeed spawn in the area around Bouthrey Bridge. The most interesting characteristic of this fish was in it's tendency to stray from the river in which it spent most of it's pre-spawning time. The discovery of straying fish is not a new phenomenon (Potter *et al*, 1992) but its implications may well have a bearing on the management of the salmon populations within the Leven Estuary.

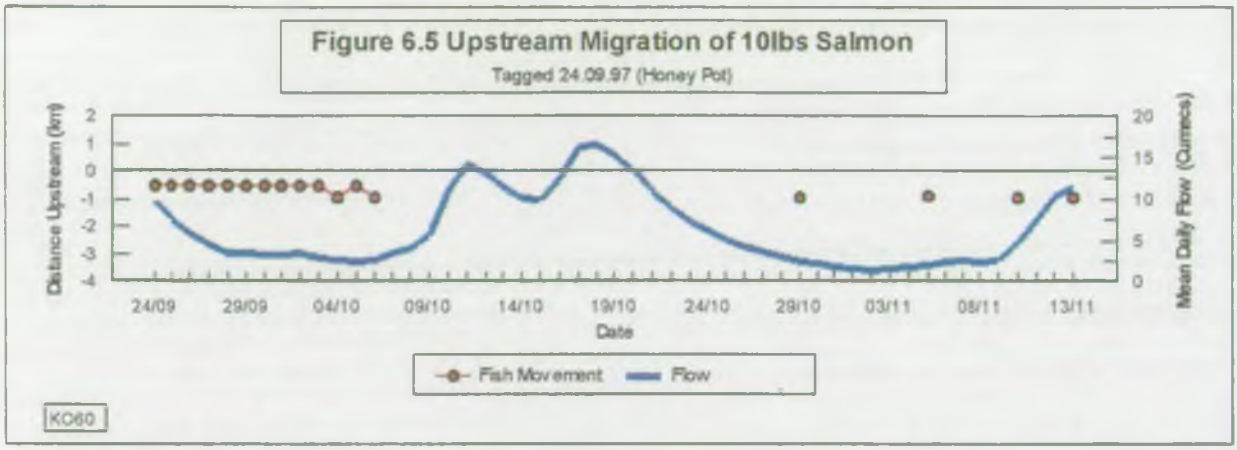
* High tide times taken from Barrow & Silloth Tide Tables published by the Associated British Ports. The time of high tide at Greenodd / Lower River Leven is approximately 2 hours after published times.



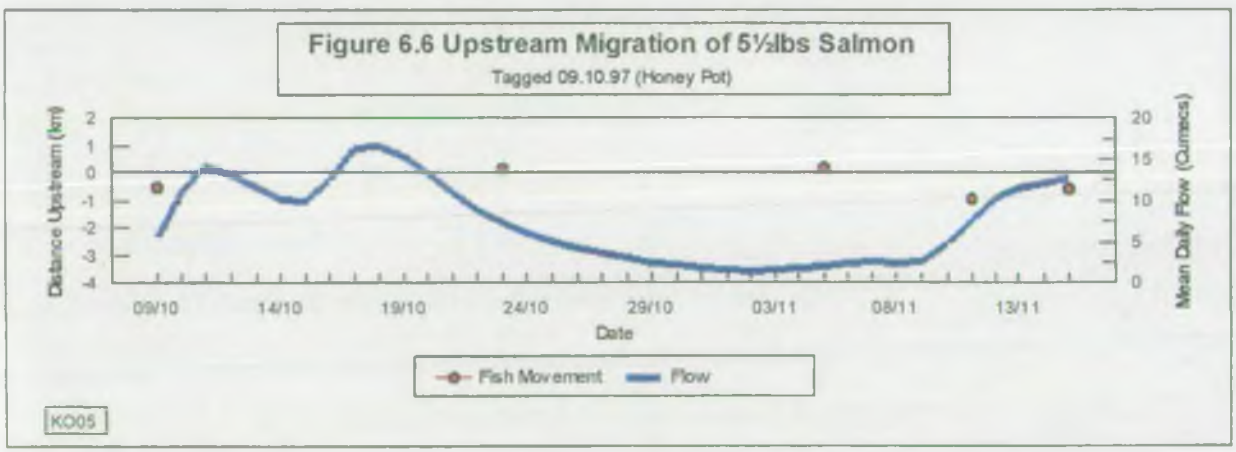
Notes on Figure 6.3 : Tagged on 07.10.97 in the Honey Pot, this fish immediately disappeared from detection during which time two rises in water levels could have enabled it to migrate upstream although from active tracking this does not appear to be the case. It is possible therefore that it may have returned to the upper estuary or one of its other tributaries during this period without being detected. Due to the shortage of A.L.Ss it was only possible to cover the Crake and Leven continuously and therefore the other tributaries were subject to random spot checks with the portable tracking equipment. It returned to Fish House Lane on 19.10.97 and stayed in the area for 11 days as levels dropped. One further detection was made at Fish House Lane on 05.11.97 by active tracking, this being the highest recorded point upstream that KO85 was known to have reached. It is likely therefore that this fish spawned somewhere other than in the River Leven due to the fact that it did not migrate far enough upstream away from the silty bottom of the lower river to the areas suitable for spawning.



Notes on Figure 6.4 : On 09.10.97 this 5½ lb salmon was tagged in the Honey Pot and remained in the area for the next 9 days. As the river level fell from its peak of over 16 cumecs on 18.10.97, KO20 headed downstream and is likely to have left the system on the highest tide of the month (10.1m @ 02.11hrs) it subsequently returned to the Timber Pond on 05.11.97 during a slow, gradual rise in level. After this single detection, KO20 surprisingly left downstream again as levels rose to a respectable flood which peaked at 36 cumecs on 20.11.97 only to return to Fish House Lane on 02.12.97 when levels dropped. This behaviour would again suggest that it is leaving the lower river for other locations within other estuarine tributaries. The last detection was made on 05.12.97 when the river rose from 6.5 to 15 cumecs in 24 hrs. and continued to rise. Migration upstream during seemingly good flows was clearly not attractive to KO20. Reasons for this may include that the fish was not destined to spawn in the River Leven and was using the lower river as a holding area between investigating other tributaries of the Leven Estuary.

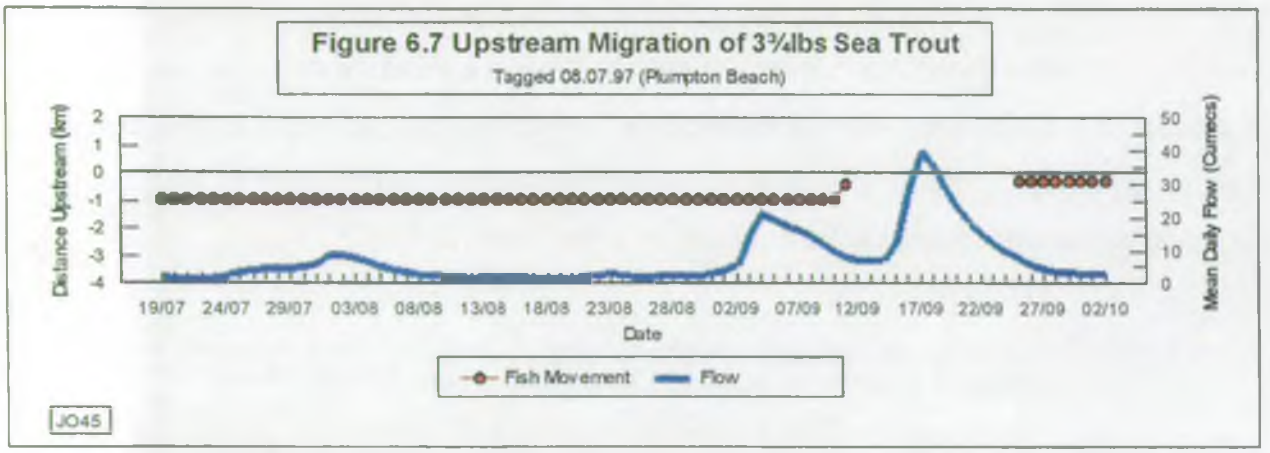


Notes on Figure 6.5 : A very similar pattern of movement was made by this 10 lbs salmon, tagged on 24.09.97 in the Honey Pot to KO20. It remained in and around its site of tagging for 12 days, subsequently disappearing downstream as levels rose sharply, only to return to the same area when levels fell. Again, the last detection was made as levels rose quickly on 13.11.97 and the assumption can be made that KO60 did not spawn in the Leven or Crake.

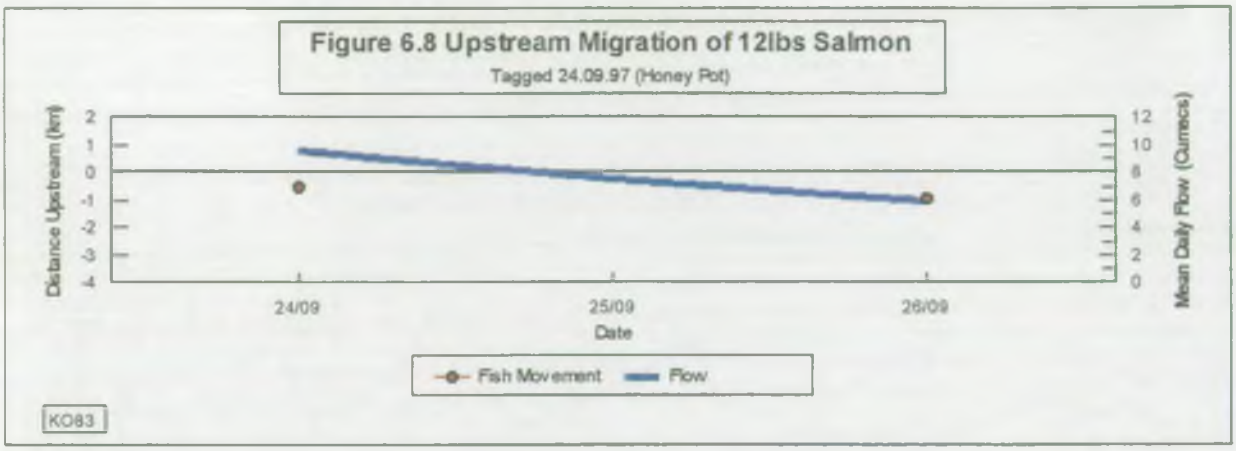


Notes on Figure 6.6 : Tagged on 09.10.97 at the Honey Pot , this 5½ lbs salmon also disappeared downstream during two rises in water level and re-appeared 14 days later as the level fell in the main river. It is unclear where the fish was holding during the period from tagging to being located at the tailrace of the Low Wood Turbine immediately downstream of the turbine house. It is almost certain that the fish dropped out of the system as active tracking during this

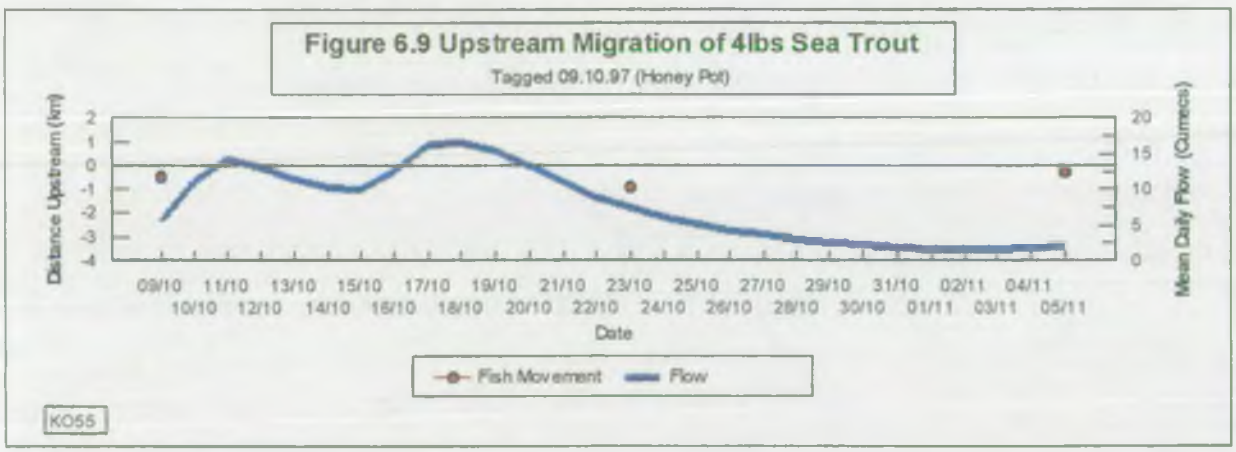
period failed to locate it. The tailrace was an attractive choice to the river as electricity generating at this site uses a considerable volume of water abstracted from the Leven at Eels Dam and released back into the main river approximately 700m downstream at Low Wood. As volume and pressure fell in the tailrace due to the main river level falling, KO05 dropped back and moved upstream in the main river a short distance and took refuge in a pool alongside Ford Island. On 10.11.97 levels rose from 50 cumecs which once again signalled the departure of this fish and the last detection of KO05 was at the Pulpit on 15.11.97 at 10.05 hrs. A spring tide of 9.8m occurred on the same morning shortly after that event. It is therefore possible that this fish spawned in the Ford Island area before leaving on the rising river levels.



Notes on Figure 6.7 : A Sea Trout of 3¾ lbs which was CART tagged at Plumpton Beach on 08.07.97 was first detected by Plumpton Sonar Buoy seven days later over a twenty four hour period from 15.55 on 15.07.97. In very low flows and small neap tides the fish migrated upstream where it was next detected by Fish House Lane A.L.S. just before midnight on 19.07.97. The fish remained in the lower river above Fish House Lane until it was actively tracked in the Ash Pot on 11.09.97 and visually observed. A fortnight later it was found slightly upstream at the Lower Reed Bed where it disgorged its radio tag at a point where 11Kv power lines cross the river. The tag was recovered from the river bed on 02.10.97.

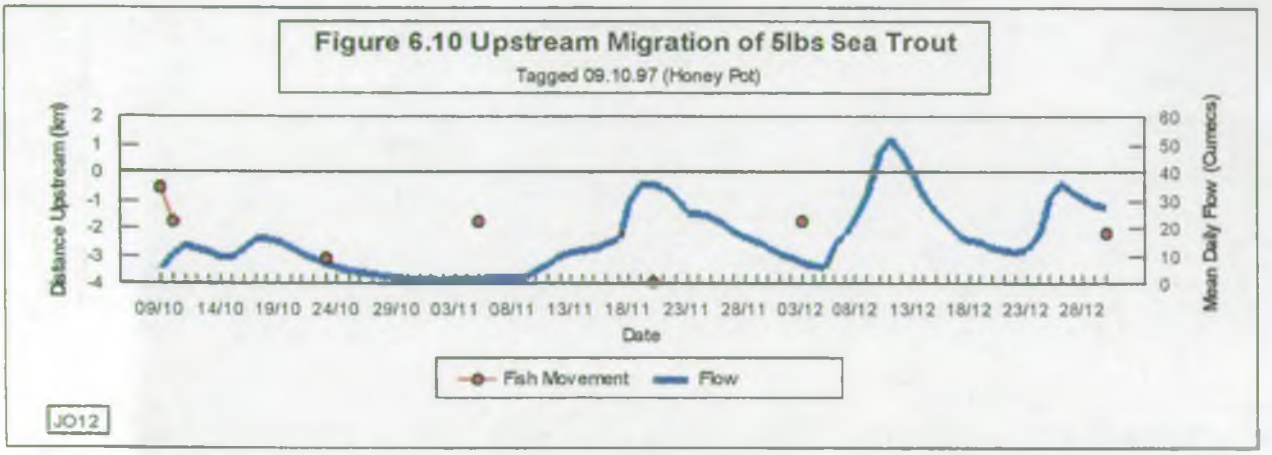


Notes on Figure 6.8 : Two detections of this salmon were made , both at Fish House Lane on 24.09.97 and 26.09.97 being downstream of the Honey Pot tagging site, the latter being two days after capture. Due to the limited amount of time this particular fish spent in the lower River Leven post-tagging it is likely that it spawned elsewhere. Its last detection at Fish House Lane coincides with the time of high tide (09.15hrs and 09.25hrs respectively) and would suggest the fish left the system on that tide.

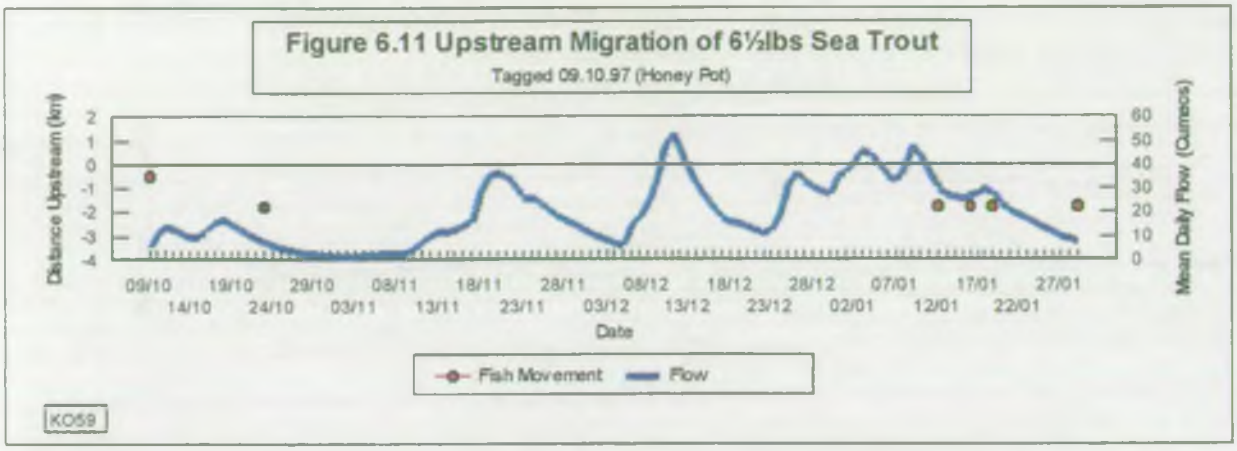


Notes on Figure 6.9 : This Sea Trout left the Honey Pot after tagging on 09.10.97 and re-entered the river to be actively tracked at Fish House Lane on 23.10.97. This behaviour, as with previously discussed fish, would suggest that this fish was destined to spawn in a different tributary of the Leven Estuary. It left the river a second time only to return to the Lower Reed

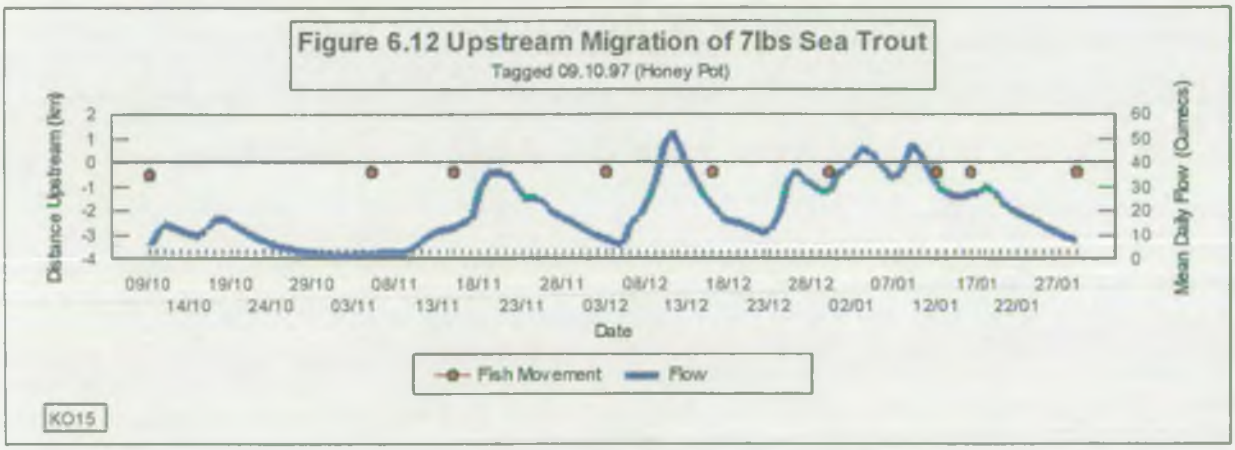
Bed and disgorge its radio tag which was recovered on 05.11.97 from beneath 11Kv power lines which traverse the river at that point.



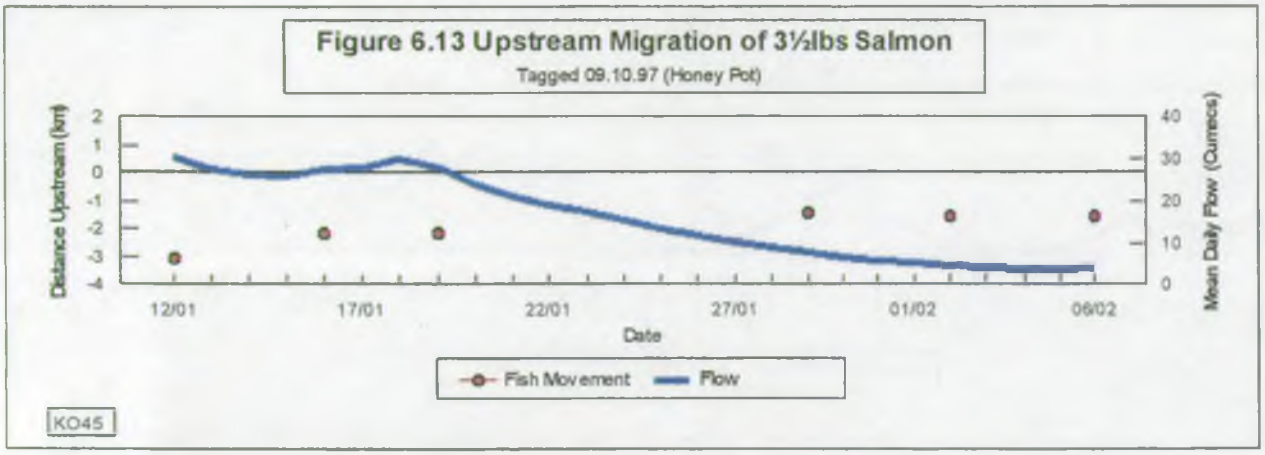
Notes on Figure 6.10 : An active Sea Trout which, after tagging in the Honey Pot on 09.10.97, was actively tracked in the Timber Pond the next day and then disappeared downstream until 23.10.97 when it was found upstream of Pool Foot. As the river level dropped, JO12 carried on upstream to the Timber Pond on 05.11.97. A rise in level to 36 cumecs on 20.11.97 found the fish downstream at Carters and once again when levels dropped, the Sea Trout made its way up to the Timber Pond, and was recorded there on 03.12.97. A following flood peaking on the 11.12.97 saw JO12 disappear downstream until the last detection of this fish during some of the highest flows seen, was made at the Peat Stream Bend. From the migratory behaviour of this fish it is possible that it had been using the lower River Leven as a holding area whilst making short migrations into the lower reaches of Rusland Pool (Leven Estuary tributary, see Fig 6.0) and subsequently spawning here.



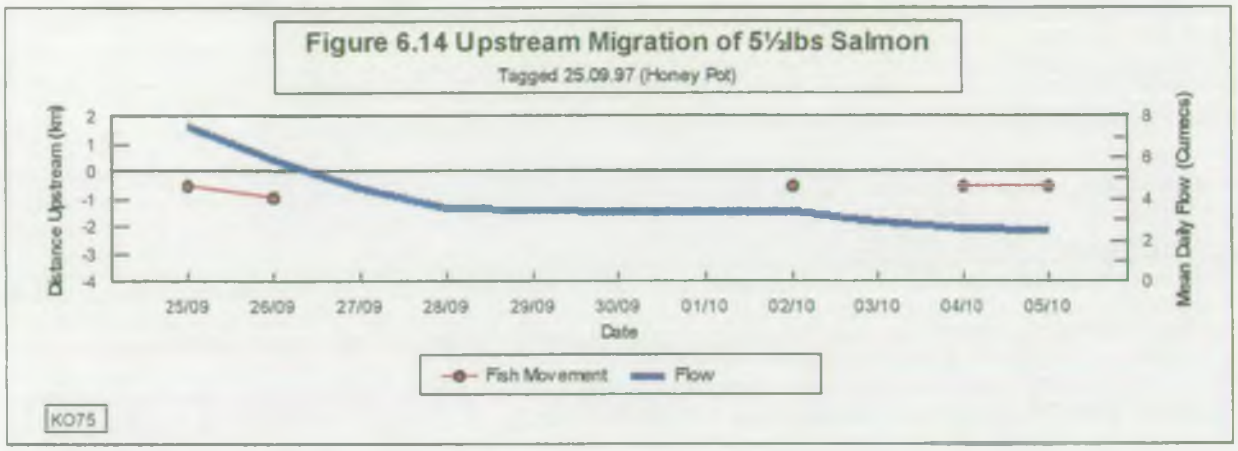
Notes on Figure 6.11 : The 6½lbs Sea Trout was actively tracked in the Timber Pond on 23.10.97 after which it was not detected again until 12.01.98. The fact that this fish left the lower River Leven and did not return until early January would suggest that it left to spawn elsewhere and was using the lower river, as other fish appear to have done, as a holding area.



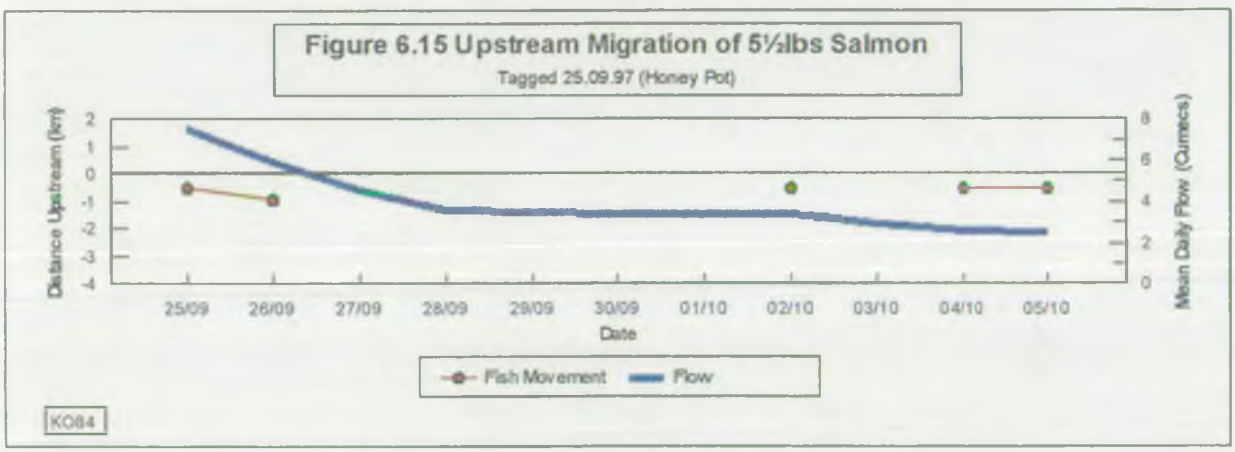
Notes on Figure 6.12 : Actively tracked at the Black Hole between the date of tagging and 29.01.98 the lack of migratory movement would suggest that the tag has been disgorged.



Notes on Figure 6.13 : The first time this salmon was detected after tagging in the Honey Pot on 09.10.97 was three months later when it was actively tracked 200m upstream of Pool Foot on 12.01.98. This would appear to suggest that the fish either left the river for the sea or for another catchment. It then made its way slowly upstream to the Limit where it was tracked on 29.01.98, this being the furthest point upstream of its progress. As the fish only moved up to this point where there is no spawning substrate available for some distance it is possible that the fish had spawned elsewhere within the Leven Estuary catchment and was using the lower River Leven as a holding area . On 02.02.98 the fish was observed lying behind a submerged log and on 06.02.98 an attempt was made to capture the fish to ascertain its breeding condition. Gill nets were placed immediately up and downstream of the location but the salmon could not be disturbed from its lie. Subsequently, it is thought that the fish had died while the tag remains transmitting.



Notes on Figure 6.14 : This salmon of 5½ lbs which was tagged at the Honey Pot on 25.09.97 had a brief journey downstream before returning to its place of capture six days later where it remained for three days. A rise in river level between 06.10.97 and 11.10.97 may have prompted the departure of this fish from the River Leven after its last detection on 05.10.97.



Notes on Figure 6.15 : After tagging at the Honey Pot on 25.09.97, this salmon behaved in a similar way to KO75 in that it was not detected in the river after 05.10.97 and the associated rise in level after that date.

4.2.2.4. GENERAL COMMENTS REGARDING FRESHWATER TRACKING IN 1995, 1996 & 1997

- From data collected during 1995 to 1997 upstream and / or downstream fish movements would appear to be freshwater flow related.

- Fish counter data recorded at Backbarrow on the River Leven for 1996 back up the theory that fish behaviour post-tagging (i.e. migration into freshwater) is 'normal'. Tagged fish are detected during times of increased upstream fish movements.

- Fish counter data shows fish movements across the fish counter to be strongly correlated with freshwater flows.

- Freshwater migration data collected during 1997 (and to a lesser extent in previous years) shows fish holding in the lower tidally effected River Leven but not necessarily spawning within the Leven catchment.

- During the tracking period of 1997 a proportion of the fish monitored in the River Leven appeared to be migrating in and out of the system. Unfortunately it is impossible to say exactly how many fish left the lower River Leven and for how long, although it is known from active tracking the full length of the lower river that some fish were absent for lengthy periods, one fish left for 79 days. There is also the case of the salmon tagged in the lower Leven leaving to spawn in the Crake.

5. DISCUSSION

During the period of 1995 and 1996, rainfall and consequently freshwater flows were well below the long term average. In 1997 conditions were less severe although still not ideal. Therefore when discussing the results found it must be remembered that these relate to periods of lower than the long term average flows and should only be taken in that context. It would be purely speculative to suggest that the results obtained would be different to those found in a more 'normal' non-drought year.

- Results obtained for 1995 were limited by factors already discussed, however some data were collected relating to time of travel from tagging to freshwater. Although not directly in relation to fish behaviour within the estuary (and more importantly the effects of the discharge), it did allow a comparison with other studies with similar project criteria (see 4.2.2.). From this it showed a notable difference in successful migration rates to freshwater between studies related to water quality issues and those related to flow regimes. The study of 1995 had a 29% success rate of fish tagged entering freshwater, the mean for the other rivers examined being 47%. Reasons for low numbers of fish tagged during this period can be partly attributed to persistent low flows experienced throughout the Leven and Crake catchments and within the estuary itself. Fish counter figures from Backbarrow on the River Leven indicated an overall reduction of upstream fish movements in the region of 25% when compared to those obtained for 1994. (McCubbing, D.J.F. pers comms). The effect of the discharges within the estuary on the returning adult fish is therefore unquantifiable for 1995.

- During the study period of 1996 more information was obtained from the sonar buoy network within the estuary. 40% of CART tagged fish within the estuary were detected by various buoys with the notable exceptions of Skelwith and more importantly Hammerside Point buoys. Reasons for non-detection of tagged fish by these buoys can be explained to a certain extent. The Skelwith buoy was located in the same location as in 1995, however during late '95 early '96 the holding pool at this site was lost due to shifting sands resulting in an expanse of sand flats with a wide shallow freshwater channel

running down the centre of the estuary. The buoy was sited there in the hope that the pool would reform, but this was not the case and consequently the buoy was only functioning efficiently during the mid to latter flood tides and early to mid ebb tides. Its positioning was such that if, as is generally accepted, the majority of fish follow the freshwater channel during the flood and ebb it would be unlikely that the buoy would detect it due to distance.

However, with the Hammerside Point buoy the case is slightly different. The buoy was positioned such that it was directly in the path of the effluent discharges and monitoring occurred for the full period of flood tide and up to four hours after high water (i.e it was on an exposed sand bar for the remaining period prior to the returning flood tide). It would be unlikely for fish not to be detected here because of its location, as buoys up and downstream have detected fish. It is possible that fish hold further up the estuary and drop back down the freshwater channel at low water without being detected by the Hammerside Point buoy. Equally it may be that there is some other factor affecting this area causing the fish to stay some distance away, which could be related to the discharges and their associated water quality characteristics. Observations on the overall external condition of the buoys relating to barnacle growth were taken every six to seven weeks at the same time as battery changes took place. It became apparent that buoys were becoming covered in barnacles after approximately two weeks with the exception of the Hammerside Point buoy which was devoid of all barnacle growth.

- During the netting period of 1997 it became apparent that, due to conditions within the estuary, stocks of migratory fish were not present in the numbers anticipated. Netting was undertaken on a minimum of three occasions per week and frequently exceeded this. However, this increase in effort did not result in the predicted rise in numbers of fish caught. During the period 23.06.97 to 23.09.97 only ten fish were tagged (for the same period in 1996 twenty-two were tagged). Locations, methods and tidal states used were the same for both years. Due to the poor results within the estuary it was decided to use the remaining time in which salmonids were migrating to concentrate on freshwater migration patterns. A number of netting operations were undertaken in the River Leven resulting in a further thirteen tagged salmon and six tagged sea trout.

Results obtained from the sonar buoy network would appear to suggest that fish movement within the Leven estuary is widespread throughout the tidal cycle, as was outlined in Figure 4. Detections were made at high water in the middle reaches of the estuary (i.e. the Plumpton area) and during the ebb and low water periods in the lower and upper reaches (Carter Pool and Greenodd respectively) during 1996. Fish detections in 1997 were made around high water in the mid to upper reaches of the estuary, (Plumpton, Mearness, and Greenodd), and on the ebb tide in the mid to lower estuary, (Plumpton and Carter Pool). Plumpton sonar buoy detected fish presence throughout the full tidal cycle suggesting adequate holding for fish at that time. Other detections would appear to suggest fish passage as opposed to holding, possibly due to the lack of pools in these areas. From this information it is apparent that fish have the ability to hold during low water in the upper estuary (critical decision zone) where pools are available, and that they are also present, albeit temporarily, during the latter half of the ebb tide and prior to the flood tide in the lower estuary. Therefore a general overall picture of fish movement would appear to be that fish move in on the flood tide (not with the initial bore but soon thereafter) and progress up the estuary and enter freshwater. The fish also has the option of holding in the upper estuary including the lower River Leven or dropping back with the ebb tide and holding in low water pools such as Plumpton, should they exist. The other option is to leave the estuary completely on the ebb tide.

Looking at the direct influence of the discharges on the behaviour of the tagged fish within the Leven estuary the three years of study have produced inconclusive results although hypotheses have been suggested. These include:

(a) - no fish were detected by the Hammerside Point buoy therefore the fish may be actively avoiding the area. This would not explain the low numbers of successful freshwater entries.
(b) - a large proportion of fish which enter the estuary are succumbing to the prevailing environmental stressors, (see (c)) and perishing.
(c) - tagged fish move through the estuary and encounter a number of stressors such as, discharges, low flows, warm water temperatures. Each of which will have an effect on the fish but some more than others. It is unclear whether the lack of fish successfully migrating to freshwater is solely due to one of these stressors or as a result of a combination of them.

The study of freshwater migration within the River Leven and Crake catchments generally has shown fish movements relating to changes in flows. Fish movements observed during 1996 can be described as discontinuous in nature as individual fish moved in a short stepped migration rather than a rapid river entry followed by a lengthy quiescent (holding) phase. (Milner, N.J. (Ed.) 1990). However, during 1997 many fish did indeed exhibit the quiescent holding characteristics. River entry itself appeared to be linked with river flows, to a greater extent in the early summer when fish entered and left in relation to flows. The upper end of the 'critical decision zone' (see fig. 4) is the lower tidal reaches of the River Leven it would appear that fish are using this as a holding area prior to leaving for neighbouring catchments. There are no specific data relating this to the River Crake.

6. CONCLUSIONS

- The Leven Estuary Project (Fisheries Component) has not fully achieved its main objectives in ascertaining the effects, if any, the estuarine discharges are having on the returning adult salmonid population. The main reason for this being the drought and low riverine flow conditions experienced in particular during the first two years of study and to a lesser extent the third.

- Results would appear to suggest the possibility of a problem but without further investigations it is not possible to state if these problems are natural environmental problems or estuarine water quality problems.

- The weather conditions experienced throughout the study period were of persistently low rainfall and low river flows particularly during the summer months (June to September) when the bulk of the fish are normally migrating through the estuary.

- During 1995 a total of 29% of estuarine tagged fish successfully migrated through the estuary and into freshwater. During the summer of 1995 no rain fell within the Lake District for over seven weeks. For the same period in 1996 only 16% made a successful passage. During 1997 the situation was a similar one with below the long term average rainfall and consequently river flows during the main migration period, (Appendix 1a to 1c). The success rate of fish migrating into freshwater may be partly, or totally due to the prevailing drought conditions. However, estuarine tracking information gathered during 1997 is insufficiently detailed to draw any firm conclusions.

- Time of travel to freshwater post-tagging varied significantly, ranging from seven days (1996) to seventy-six days (1995). There appears to be some correlation between the next increase in flows after tagging and entry to freshwater. However, whilst this does go some way to explaining the behaviour of those fish which did successfully migrate into freshwater it does not explain why the unaccounted for fish did not enter freshwater.

Theories as to where the 'lost' fish have gone include :

- (a) - After tagging they return to sea and migrate up other rivers within the Morecambe Bay area but outside the Leven estuary. Catchments within the Leven estuary, including Colton Beck, Newlands Beck, Rusland Pool and the River Eea, were searched for tagged fish on numerous occasions without detecting any 'stray' fish. Other adjacent catchments were not searched however, it would seem very unlikely that such a large proportion of fish (1995 - 71%; 1996 - 84%; 1997 - 90%) caught within the Leven estuary were in fact destined for catchments other than those within the Leven estuary.

- (b) - If freshwater flows were frequently very low within the Leven estuary, as was the case in all three years of study, then other additional stressors become more of a problem to the fish. These include warmer water temperatures, potentially low dissolved oxygen levels, ammonia and the presence of sewage and pharmaceutical discharges. Each of these on its own may not be significant enough to hinder, deter, or prevent fish from entering freshwater but when a combination of them occurs it may well be. If this is the case and the stressors were having an effect then it is possible that a number of fish may have perished or returned to the sea.

- (c) - Following on from above, it is possible that fish are being deterred or delayed in some way because of these stressors. They may than return to sea and await changes in environmental conditions such as an increase in rainfall. Should no change in weather conditions occur within a certain length of time then the fish may not enter the system at all.

- (d) - Some fish did 'disappear' for long periods of time (up to 76 days) before entering freshwater. Possible reasons for this could be that they have returned to the sea or lower holding areas within the estuary (e.g Wadhead) and awaited environmental changes and then re-entered the estuary and subsequently freshwater.

- (e) - Fish may regurgitate their tags on returning to sea. This would occur on commencing of feeding.

- (f) - If fish choose not to commit to freshwater for what ever reasons they may have no option other than to leave the estuary due to lack of stable holding areas within the estuary as a whole.

- (g) - Further suggestions have been made as to the possible reasons why fish are reluctant to hold within the estuary and / or enter freshwater. These include :
  - Lack of stable, permanent holding areas which are kept 'open' by higher (long term average) river flows in upper estuary.
  - Removal of a railway viaduct situated in the upper estuary which historically afforded ample holding for fish during all states of tide.
  - Cessation of ballast tipping at Plumpton (Leven) Viaduct resulting a reduced scouring action of tides causing unstable holding areas around bridge base.
  - Chronic deposition of silt / sand in estuary reducing the number and size of available holding areas.
  - Erosion of the saltmarsh upstream of Plumpton (Leven)Viaduct (right bank) giving further scope for freshwater channel movement away from historical holding pool (i.e. Skelwith).

7. RECOMMENDATIONS

- Any future alterations to the abstraction regime on the Leven catchment including the possible future imposition of Drought Orders on the Leven catchment should include considerations on the effects on flows within the Leven Estuary on salmon and sea trout. It should also consider the consequential effects on the freshwater 'cue' within the estuary on fish destined for other estuarine tributaries. The potential reduction in freshwater flows in the lower river and estuary may also increase the likelihood of siltation in these areas.

- Investigate the fate of estuarine tagged fish which 'disappeared' using suitable telemetry equipment such as current radio tracking hardware. Automatic Listening Stations would be positioned immediately upstream of the tidal limit on all tributaries within the Leven Estuary and adjacent estuaries.

- Investigate the movements of fish within the lower River Leven to determine possible reasons for poor upstream migration in relation to flow regimes and abstractions. This could also incorporate an investigation into where fish holding in the lower river, as seen in the study of 1997, ultimately spawn.

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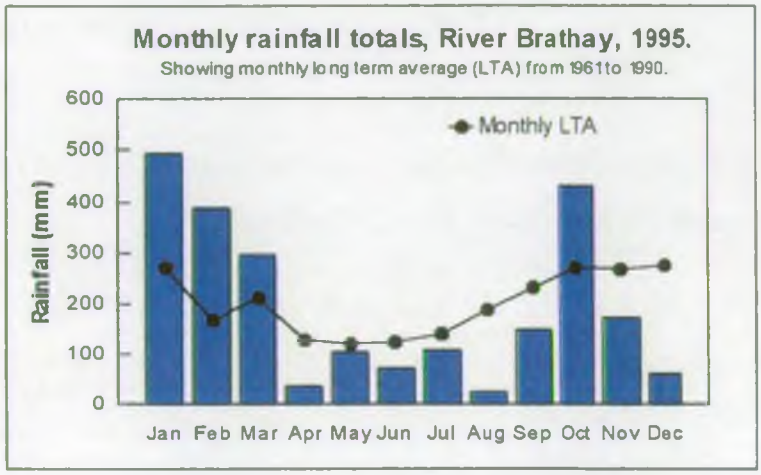
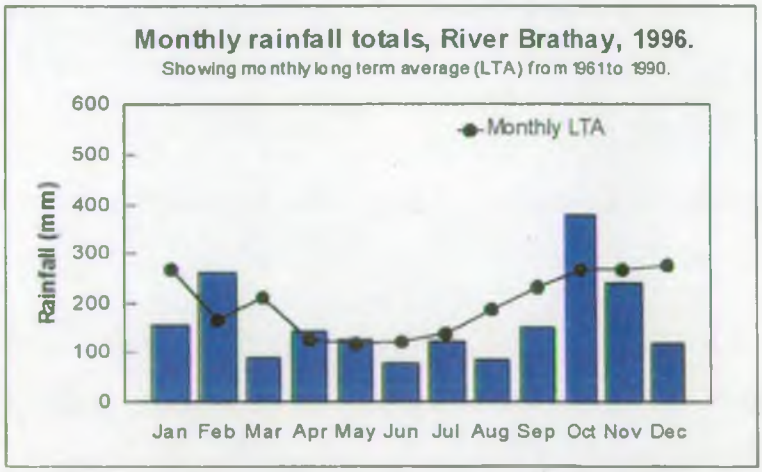
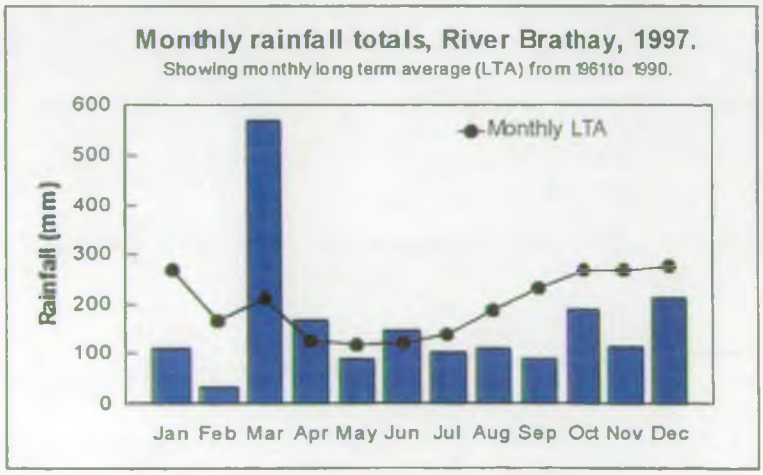
APPENDIX 1a

RAINFALL GRAPHS FOR R. BRATHAY @ BRATHAY HALL (R. LEVEN CATCHMENT) ILLUSTRATING REDUCED RAINFALL DURING THE THREE YEARS OF STUDY. 1995, 1996 & 1997.

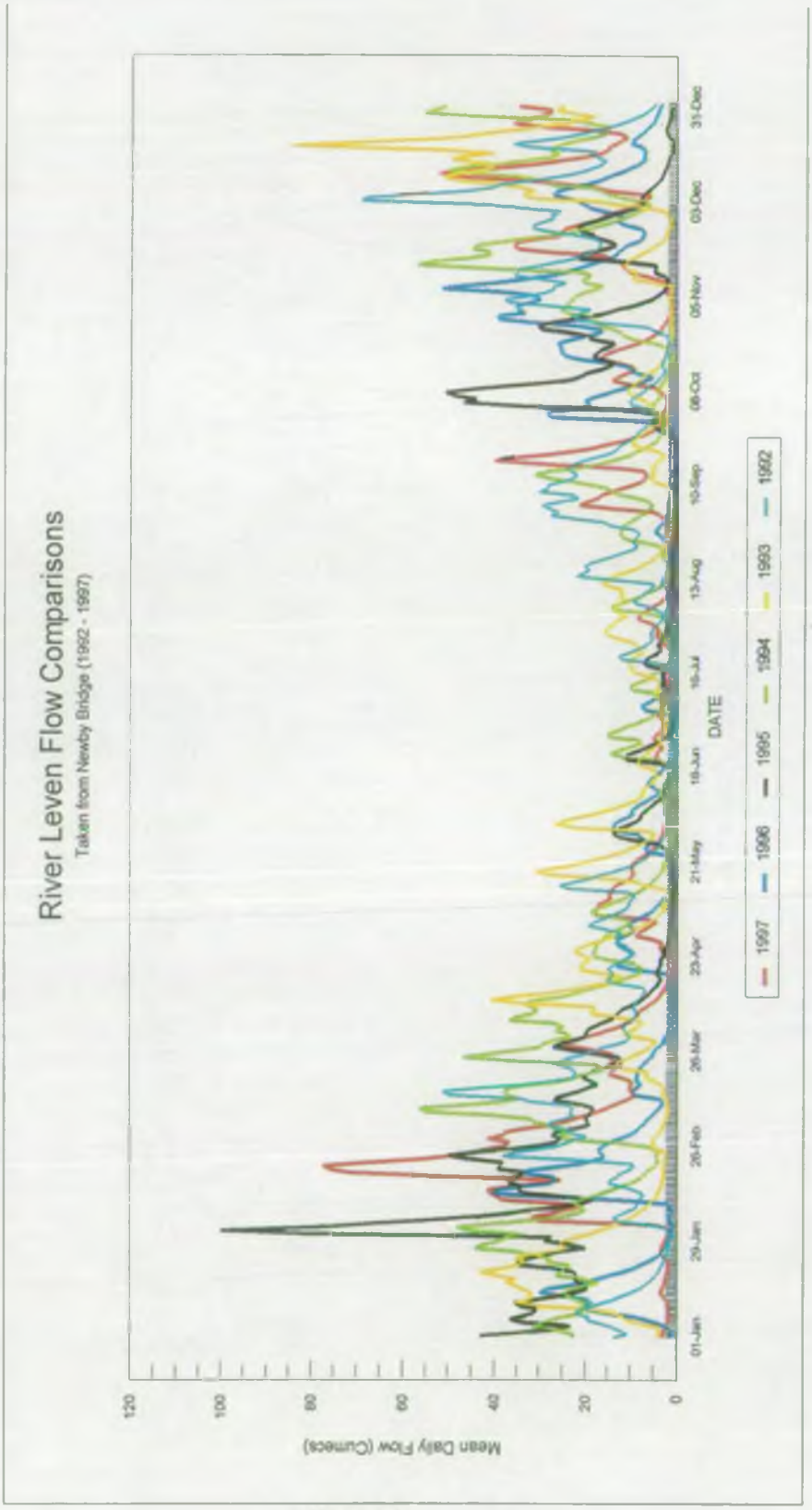






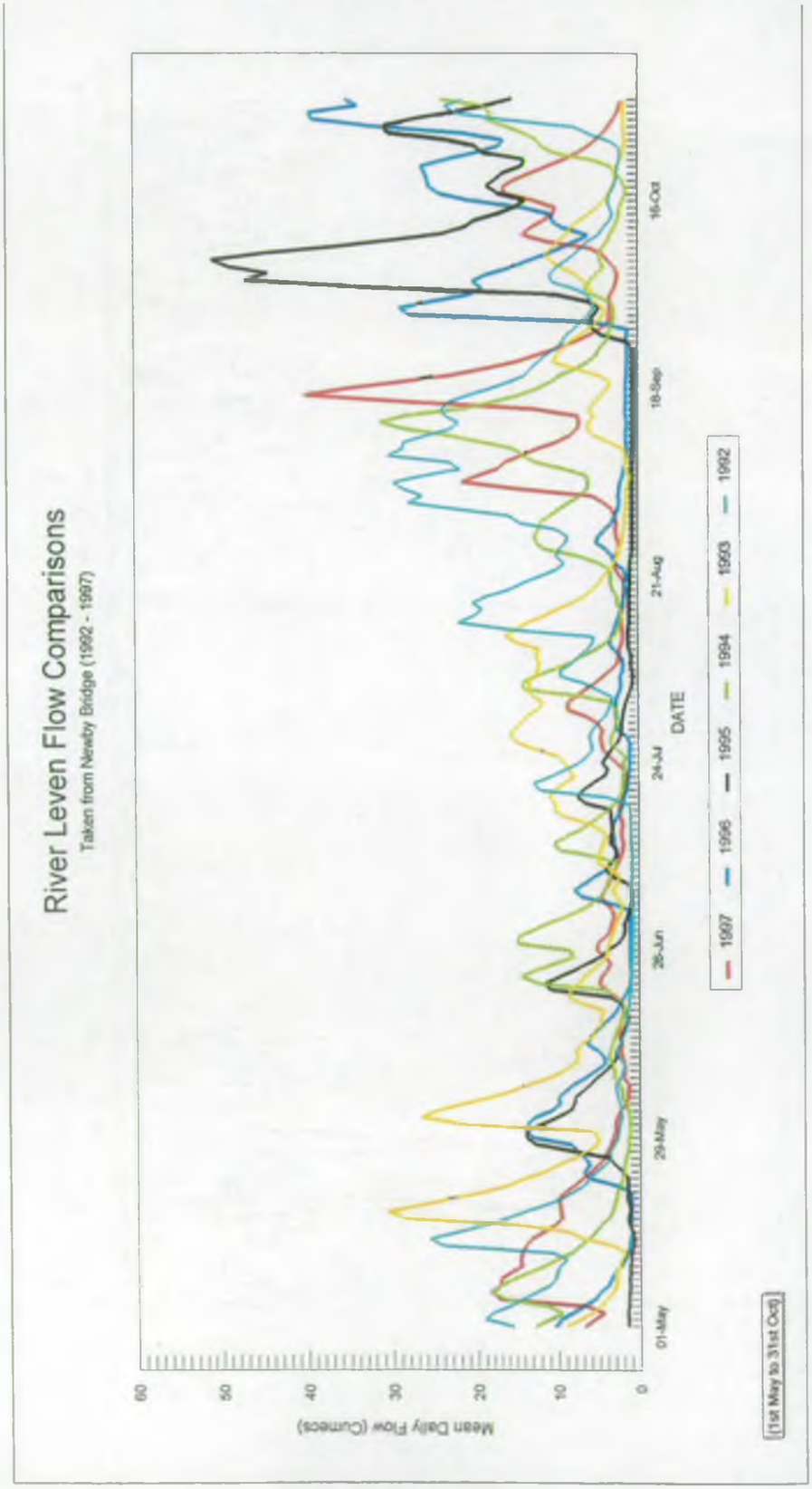
APPENDIX 1b

ANNUAL FLOW CHARTS FOR THE RIVER LEVEN AT NEWBY BRIDGE 1992 - 1997



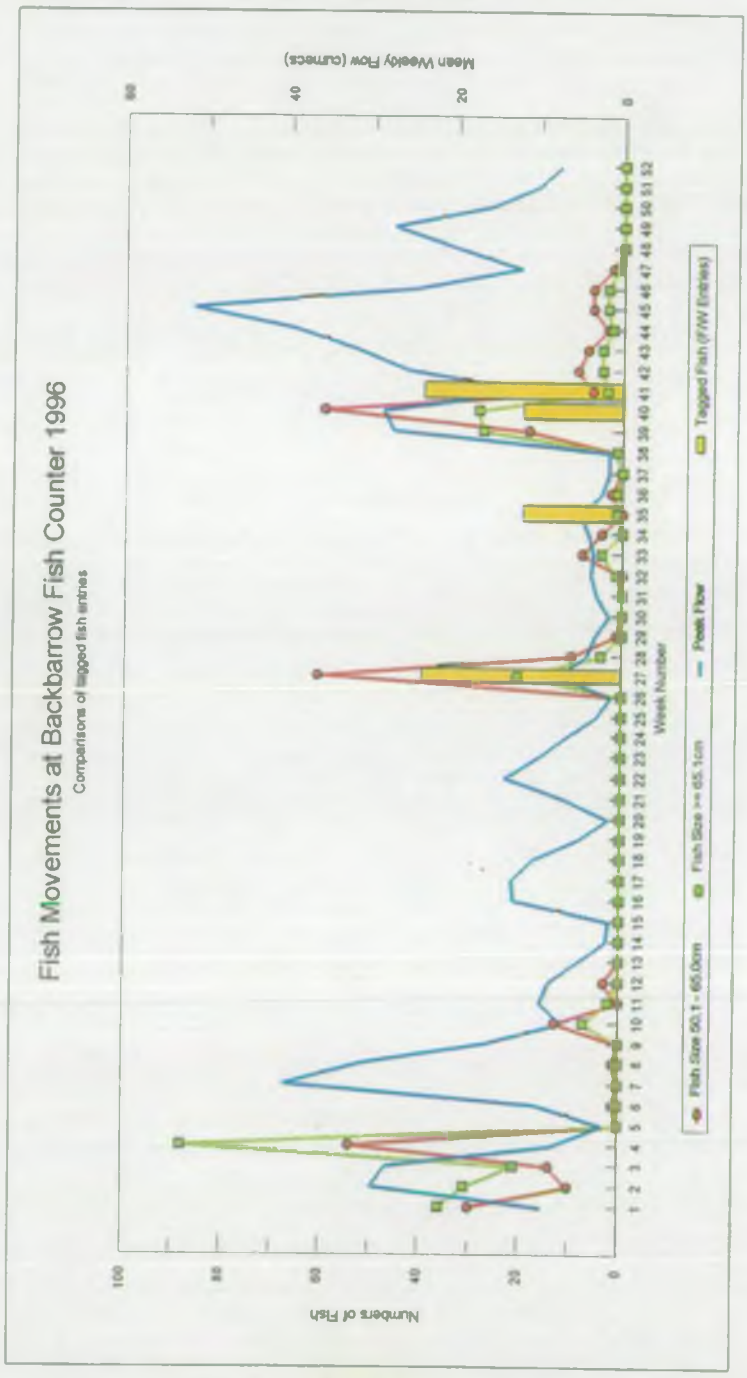
APPENDIX 1c

FLOW CHARTS FOR THE RIVER LEVEN AT NEWBY BRIDGE 1992 - 1997
OVER THE MAIN ADULT MIGRATION PERIOD (MAY - OCTOBER)



APPENDIX 1d

ILLUSTRATION OF TAGGED FISH MOVEMENTS WHEN RELATED TO UPSTREAM FISH MOVEMENTS AT BACKBARROW FISH COUNTER 1996



No data for the study period of 1997 was processed as only one of the ten fish tagged within the estuary subsequently entered freshwater. No comparison in movement of tagged and non-tagged fish over the fish counter in relation to freshwater flows has been made as freshwater tagged fish exhibited behaviour such that their spawning destination was uncertain (i.e. it is debatable whether they are genuine 'Leven' fish).

APPENDIX 2a

LEVEN ESTUARY NETTING INFORMATION 1996 & 1997

NETTING OPERATIONS 1997

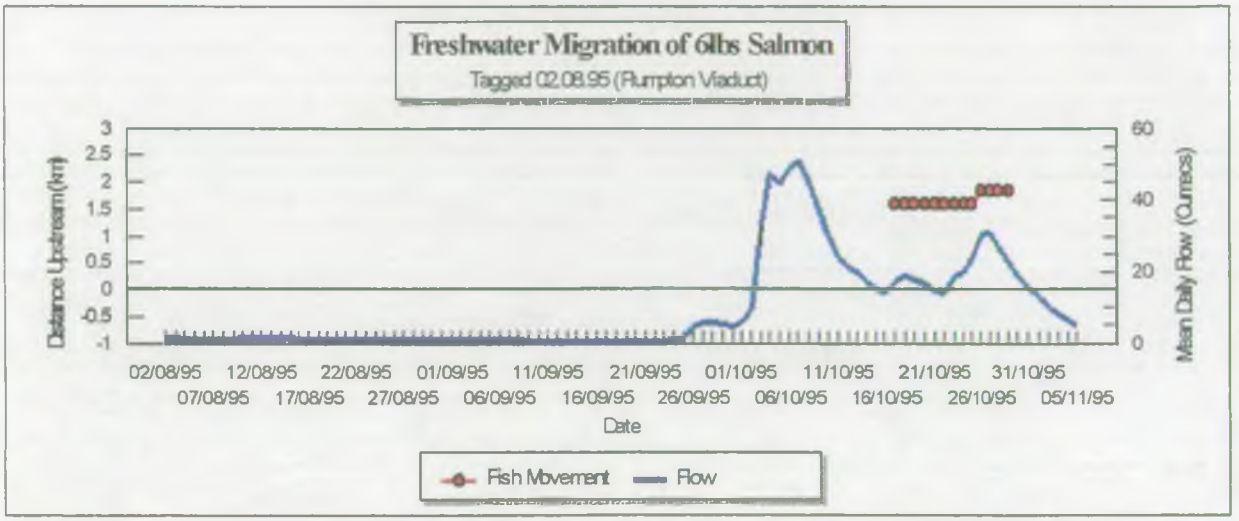
DATE	LOCATION	METHOD	TIDAL STATE	CATCH	TAGGED
23.06.97	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT	1SEA TROUT
27.06.97	MEARNESS POINT	GILL NET	LW		
0107.97	PLUMPTON BEACH	GILL NET	HW		
02.07.97	PLUMPTON BEACH	GILL NET	HW		
03.07.97	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT	1SEA TROUT
08.07.97	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT & 1SALMON	1SEA TROUT & 1SALMON
1107.97	PLUMPTON VIADUCT	GILL NET	LW		
16.07.97	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT	1SEA TROUT
2107.97	PLUMPTON BEACH	GILL NET	HW		
2107.97	PLUMPTON BEACH	GILL NET	HW		
22.07.97	PLUMPTON BEACH	GILL NET	HW		
24.07.97	CARTER POOL	GILL NET	LW	2SALMON	1SALMON
29.07.97	CARTER POOL	GILL NET	LW		
3107.97	PLUMPTON BEACH	GILL NET	HW	1SALMON	1SALMON
0108.97	MEARNESS POINT	GILL NET	LW		
04.08.97	PLUMPTON BEACH	GILL NET	HW		
06.08.97	PLUMPTON BEACH	GILL NET	HW		
07.08.97	PLUMPTON BEACH	GILL NET	HW		
1108.97	CARTER POOL	GILL NET	HW		
12.08.97	CARTER POOL	GILL NET	HW		
12.08.97	PLUMPTON VIADUCT	GILL NET	LW		
13.08.97	CARTER POOL	GILL NET	LW		
14.08.97	CARTER POOL	GILL NET	LW		
15.08.97	CARTER POOL	GILL NET	LW		
2108.97	PLUMPTON BEACH	GILL NET	HW		
22.08.97	PLUMPTON BEACH	GILL NET	HW		
23.08.97	PLUMPTON VIADUCT	GILL NET	LW		
24.08.97	PLUMPTON VIADUCT	GILL NET	LW	1SALMON	1SALMON
26.08.97	PLUMPTON BEACH	GILL NET	HW		
27.08.97	PLUMPTON VIADUCT	GILL NET	LW	2SALMON	1SALMON
28.08.97	PLUMPTON VIADUCT	GILL NET	LW	1SALMON	1SALMON
0109.97	PLUMPTON VIADUCT	GILL NET	LW		
02.09.97	PLUMPTON BEACH	GILL NET	HW		
05.09.97	PLUMPTON VIADUCT	GILL NET	LW		
06.09.97	PLUMPTON VIADUCT	GILL NET	LW		
07.09.97	PLUMPTON VIADUCT	GILL NET	LW		
08.09.97	PLUMPTON BEACH	GILL NET	HW		

NETTING OPERATIONS 1996

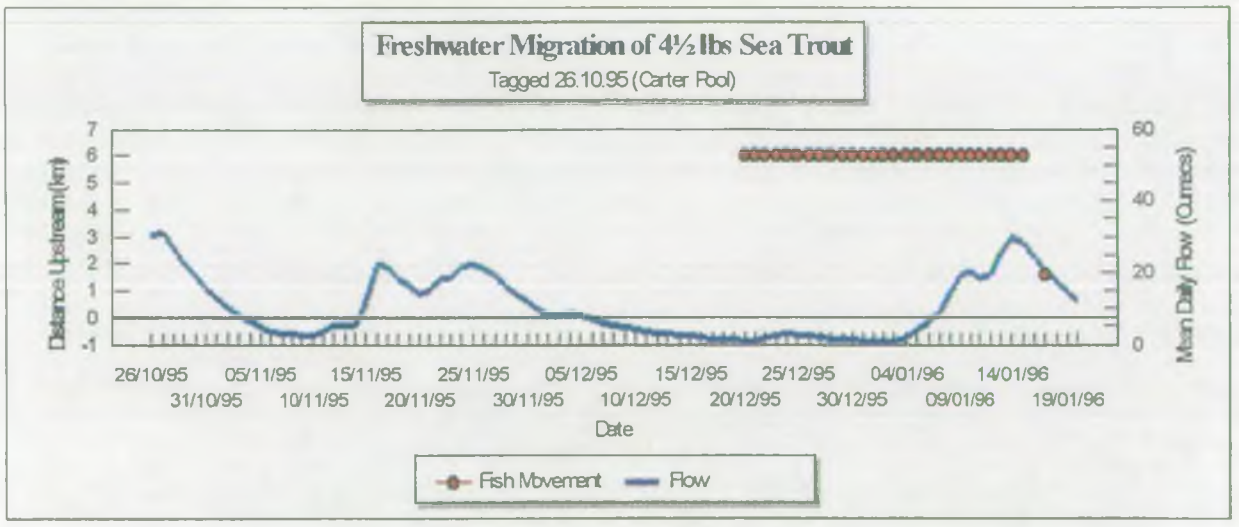
DATE	LOCATION	METHOD	TIDAL STATE	CATCH	TAGGED
24.05.96	PLUMPTON VIADUCT	GILL NET	LW		
29.05.96	PLUMPTON VIADUCT	GILL NET	LW		
30.05.96	CARTER POOL	GILL NET	HW		
31.05.96	CARTER POOL	GILL NET	HW		
06.06.96	PLUMPTON VIADUCT	GILL NET	LW		
11.06.96	PLUMPTON VIADUCT	GILL NET	LW		
13.06.96	CARTER POOL	GILL NET DRIFT	HW		
14.06.96	PLUMPTON BIGHT	GILL NET	HW		
20.06.96	PLUMPTON VIADUCT	GILL NET	LW		
20.06.96	CARTER POOL	GILL NET DRIFT	HW		
21.06.96	PLUMPTON VIADUCT	GILL NET	LW		
21.06.96	CARTER POOL	GILL NET DRIFT	HW		
27.06.96	PLUMPTON VIADUCT	GILL NET	LW	4 SEA TROUT	3 SEA TROUT
28.06.96	CARTER POOL	GILL NET	HW		
28.06.96	PLUMPTON VIADUCT	GILL NET	LW		
02.07.96	CARTER POOL	GILL NET	HW		
04.07.96	PLUMPTON VIADUCT	GILL NET	LW		
09.07.96	PLUMPTON VIADUCT	GILL NET	LW		
10.07.96	PLUMPTON VIADUCT	GILL NET	LW	2 SEA TROUT +1SALMON	1SEA TROUT +1SALMON
11.07.96	PLUMPTON VIAOUCT	GILL NET	LW	1SEA TROUT	1SEA TROUT
16.07.96	PLUMPTON BEACH	GILL NET	HW		
17.07.96	PLUMPTON VIADUCT	GILL NET	LW	1SEA TROUT	
18.07.96	PLUMPTON VIADUCT	GILL NET	LW	1SEA TROUT	
23.07.96	PLUMPTON VIADUCT	GILL NET	LW	2 SEA TROUT +1SALMON	1SALMON
24.07.96	PLUMPTON VIADUCT	GILL NET	LW	2 SEA TROUT	
26.07.96	PLUMPTON VIADUCT	GILL NET	LW	3 SEA TROUT +1SALMON	1SEA TROUT +1SALMON
30.07.96	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT +3 SALMON	1SEA TROUT +2 SALMON
31.07.96	PLUMPTON VIADUCT	GILL NET	LW	1SALMON	1SALMON
31.07.96	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT +1SALMON	1SEA TROUT +1SALMON
01.08.96	PLUMPTON BEACH	GILL NET	HW		
07.08.96	PLUMPTON VIADUCT	GILL NET	LW		
08.08.96	PLUMPTON VIADUCT	GILL NET	LW		
13.08.96	PLUMPTON BEACH	GILL NET	HW	1SALMON	1SALMON
14.08.96	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT +1STEELHEAD +16ALMON	1STEELHEAD +1SALMON
15.08.96	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT +1SALMON	1SALMON
15.08.96	PLUMPTON BEACH	GILL NET	HW		
20.08.96	PLUMPTON VIADUCT	GILL NET	LW		
22.08.96	PLUMPTON VIADUCT	GILL NET	LW		
27.08.96	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT	
28.08.96	PLUMPTON BEACH	GILL NET	HW	1SALMON	1SALMON
29.08.96	PLUMPTON BEACH	GILL NET	HW	1SALMON	1SALMON
30.08.96	PLUMPTON BEACH	GILL NET	HW		
03.09.96	PLUMPTON VIADUCT	GILL NET	LW		
05.09.96	PLUMPTON VIADUCT	GILL NET	LW	1SALMON	1SALMON
10.09.96	PLUMPTON BEACH	GILL NET	HW		
12.09.96	PLUMPTON BEACH	GILL NET	HW		
13.09.96	PLUMPTON BEACH	GILL NET	HW		
16.09.96	PLUMPTON BEACH	GILL NET	HW		
17.09.96	PLUMPTON BEACH	GILL NET	HW		
18.09.96	PLUMPTON VIADUCT	GILL NET	LW		
25.09.96	PLUMPTON BEACH	GILL NET	HW		
26.09.96	PLUMPTON BEACH	GILL NET	HW		
27.09.96	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT	1SEA TROUT
01.10.96	PLUMPTON VIADUCT	GILL NET	LW	1SEA TROUT	
02.10.96	PLUMPTON VIADUCT	GILL NET	LW	1SEA TROUT	1SEA TROUT
10.10.96	PLUMPTON BEACH	GILL NET	HW		
11.10.96	PLUMPTON BEACH	GILL NET	HW		
14.10.96	PLUMPTON BEACH	GILL NET	HW	1SEA TROUT*	*PREVIOUSLY TAGGED 27.09
15.10.96	PLUMPTON BEACH	GILL NET	HW	1SALMON	1SALMON
24.10.96	PLUMPTON BEACH	GILL NET	HW		
25.10.96	PLUMPTON BEACH	GILL NET	HW		

APPENDIX 2b

1995 FRESHWATER TRACKS



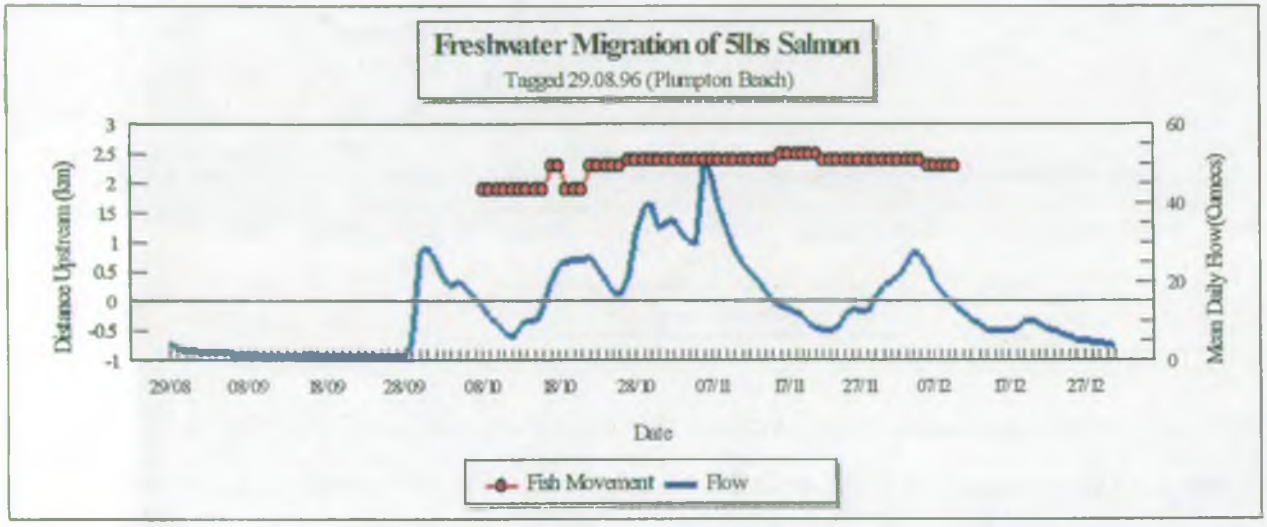
The track above shows persistent low flows from the date of capture until 03.10.95 when freshwater discharges rose rapidly. It is possible that this initial rise in discharge was a 'cue' for the fish to migrate through the estuary and into freshwater. The fish was first detected on 17.10.95 shortly after flows began to fall, making a short upstream migration on the next rise in flows. The fish was subsequently 'lost' within the river. Without the sonar buoy network it is impossible to say where the fish was from 02.08.95 to 16.10.95, although it is likely that it returned to the sea.



The track obtained from the above sea trout shows little migratory behaviour although it

would appear that it entered the system under low freshwater discharge and subsequently returned to the estuary on elevated flows. It seems likely that the fish spawned at the upper reaches of its migration around the Bouthrey Bridge area.

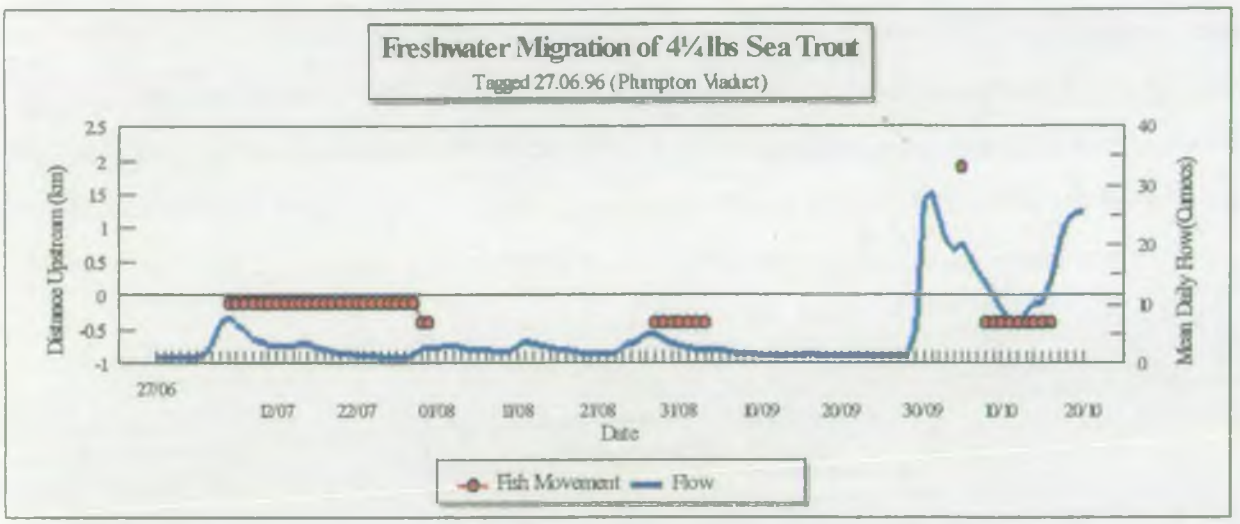
1996 FRESHWATER TRACKS



The trace obtained from the salmon successfully migrating into the freshwater of the River Leven is the most detailed of the three traces recorded. The fish committed itself to freshwater a maximum of 41 days post tagging. However, as the fish was initially detected by the Backbarrow listening station it is probable that it entered shortly before this date. The reason for it not being detected by the Fish House Lane listening station is that the fish probably entered freshwater during a high tide cycle at which point the river in this area is effected by salinity and therefore will no longer pick up the radio signal from the tag. Tide tables for this period show a peak high tide of 9.7m on the date of capture.

When comparing date of capture and river flows it would appear likely that the fish entered the estuary during a slight elevation in freshwater flow. The freshwater flow on which the fish most probably entered freshwater (29.09.96) was the highest experienced since late February and was likely therefore to have been a significant 'cue' for migration through the estuary and on into freshwater. The first upstream migration can also be linked to the rise in freshwater flows. Its subsequent return to the Backbarrow area may be attributed to a stabilisation of flows although

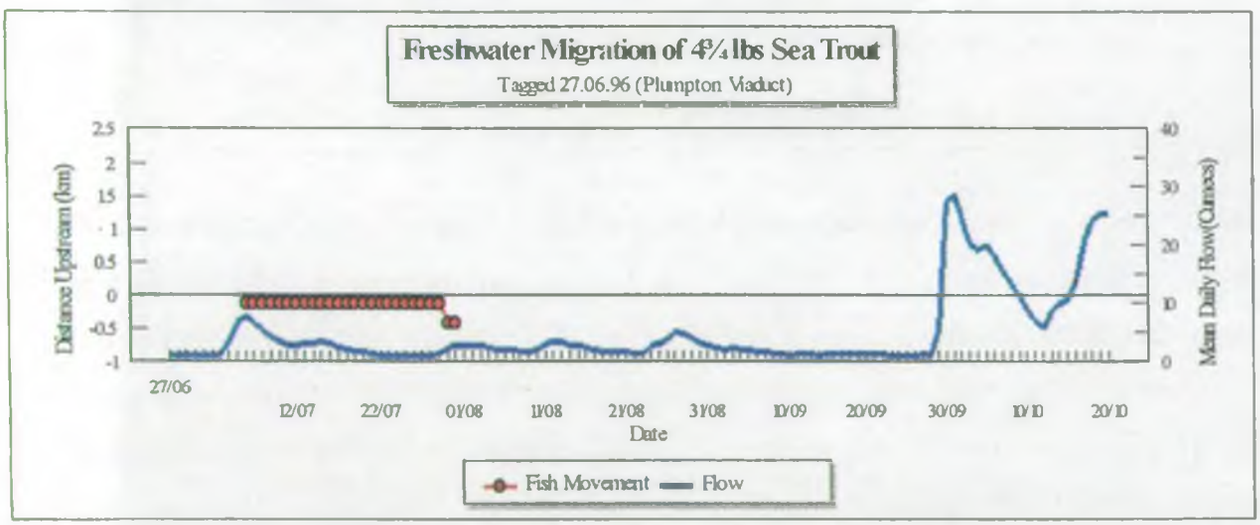
from other studies fish are known to make short upstream and downstream forays. (Evans, D.M., Purvis, W.K., and Clarke, D.R.K. 1994). Further short upstream migrations were recorded, the furthest point (2.5km u/s of the tidal limit) being upstream of the White Water Hotel road bridge (16.11.96 to 21.11.96) where it is assumed the fish spawned. It was subsequently tracked for an additional week at which point the fish was lost and presumed to have left the catchment.



The trace of freshwater movements of the sea trout illustrated above is quite revealing in that it appears that the fish is returning to the estuary for lengthy periods (approx 1 month) before returning to freshwater. The fish was one of the first to be CART tagged within the estuary during 1996 and committed to freshwater on the next rise in river flows (06.07.96) one week post tagging. This increase in river flows coincided with tide heights of 9.4m which would allow the fish to move on the flood tide directly into the lower reaches of the River Leven. However, the fish remained resident in the lower tidally affected reaches for almost a month at which point it returned to the estuary. This would appear to be due to persistent low flows during this period. Its' return to the estuary coincided with a 10.1m tide allowing it to passively migrate back on the ebb tide. No further detections were made until 28.08.96 at which point the fish re-entered the lower tidal limits of the river. Again this coincided with a small increase in flows and a tide height of 9.4m. The fish remained in this area for the following week as flows steadily fell and returned to the estuary again (tide 8.4m). Freshwater flows remained low for the duration until a substantial rise in discharge occurred on the 29.09.96; this date is also the highest tide for the

month. The sea trout was briefly detected at Backbarrow via the listening station on the 05.10.96 and it is probable that it entered freshwater on the previous spate and rapidly migrated upstream. Three days later the fish returned to the lower river as flows dropped where it remained until the 16.10.96 upon which it left the catchment on the peak tide of 9.1m.

It is possible the fish spawned at its uppermost migration point at Backbarrow although this area of main river is known to be unsuitable for sea trout spawning (Foster, P.J. pers comms). An alternative theory behind the reasons for this fish repeatedly entering freshwater and returning to the estuary / sea is that it was a non-native fish and eventually returned to the estuary / sea to migrate to another catchment (outside the Leven estuary). Similar studies quote a proportion of fish migrating upstream circa 20 kilometres in non-native rivers prior to emigrating to other river systems, (Clarke, D.R.K., Evans, D.M., Ellery, D.S., et al 1994).



The sea trout trace illustrated above is of a fish tagged during the same netting operation as that discussed in the previous trace and exhibited the same behaviour. However, after returning to the estuary for the first time it was not detected thereafter within the Leven or any of its neighbouring catchments.

APPENDIX 3

PHOTOGRAPHS OF LEVEN ESTUARY EQUIPMENT

Plate 1. Sonar Buoys (Hammerside Point buoy far left) illustrating barnacle growth.

Plate 2. Automatic Listening Station in situ.

APPENDIX 4

CAPTURE, TAGGING AND TRACKING INFORMATION 1997

For information regarding details of fish caught and tracking information for 1995 and 1996 please refer to reports :

BAYLISS, B.D., & McCUBBING, D.J.F. (1996) - Internal Interim Report - Leven Estuary Project 1995.

BAYLISS, B.D. (1997) - Leven Estuary Project ~ Fisheries Department ~ Final Report.

EA/NW/FTR/97/8

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Plumpton Beach **DATE :** 23.06.97

RELEASE SITE : Plumpton Beach **TIME :** 11.45

HEIGHT OF HIGH TIDE (m): 9.3

FLOY TAG No.: A1251 **CART \ RADIO TAG No.:** CART J047

FREQUENCY : 845 (CH9)

PULSE RATE (ppm) : 36

ACOUSTIC LIFE : 20 Days

FISH LENGTH : 55cm **FISH WEIGHT :** 3½lbs

TRACKING NOTES :

Dectected by Mearness Sonar Buoy 01.07.97 between 08.30 and 08.50 GMT.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Plumpton Beach **DATE :** 03.07.97

RELEASE SITE : Plumpton Beach **TIME :** 09.45

HEIGHT OF HIGH TIDE (m): 8.6

FLOY TAG No.: A1201 **CART \ RADIO TAG No.:** CART J043

FREQUENCY : 835 (CH7)

PULSE RATE (ppm) : 51

ACOUSTIC LIFE : 14 Days

FISH LENGTH : 60cm **FISH WEIGHT :** 4½lbs

TRACKING NOTES :

Dectected by Greenodd Sonar Buoy 19.07.97 @ 22.20 to 22.40 GMT.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Plumpton Beach **DATE :** 08.07.97

RELEASE SITE : Plumpton Beach **TIME :** 13.00

HEIGHT OF HIGH TIDE (m): 8.5

FLOY TAG No.: A1252 **CART \ RADIO TAG No.:** CART J045

FREQUENCY : 840 (CH8)

PULSE RATE (ppm) : 49

ACOUSTIC LIFE : 15 Days

FISH LENGTH : 55cm **FISH WEIGHT :** 3¾lbs

TRACKING NOTES :

Detected by Plumpton Sonar Buoy 15.07.97 @ 15.55 to 16.07.97 @ 15.55.
Detected by Fish House Lane ALS 19.07.97 @ 23.20 to 23.55 GMT
Actively Tracked 11.09.97 @ Ash Pot (visually observed)
Actively Tracked 25.09.97 @ Lower Reed Bed
Actively Tracked 02.10.97 @ Lower Reed Bed tag recovered from river.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Plumpton Beach **DATE :** 08.07.97

RELEASE SITE : Plumpton Beach **TIME :** 14.30

HEIGHT OF HIGH TIDE (m): 8.6

FLOY TAG No.: A1253 **CART \ RADIO TAG No.:** CART J041

FREQUENCY : 830 (CH6)

PULSE RATE (ppm) : 56

ACOUSTIC LIFE : 13 Days

FISH LENGTH : 91cm **FISH WEIGHT :** 15 lbs

TRACKING NOTES :

Detected by Carter Pool Sonar Buoy 08.07.97 @ between 16.20 to 16.50 GMT.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Plumpton Beach

DATE : 18.07.97

RELEASE SITE : Plumpton Beach

TIME : 09.00

HEIGHT OF HIGH TIDE (m): 8.3

FLOY TAG No.: A1254

CART \ RADIO TAG No.: CART K002

FREQUENCY : 830 (CH6)

PULSE RATE (ppm) : 34

ACOUSTIC LIFE : 20 Days

FISH LENGTH : 53cm

FISH WEIGHT : 3½lbs

TRACKING NOTES :

No detections.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Carter Pool

DATE : 24.07.97

RELEASE SITE : Carter Pool

TIME : 08.30

HEIGHT OF HIGH TIDE (m): 9.3*

* Indicates fished at low water. The figure given is the previous high tide height.

FLOY TAG No.: A1255

CART \ RADIO TAG No.: CART J020

FREQUENCY : 850 (CH10)

PULSE RATE (ppm) : 72

ACOUSTIC LIFE : 20 Days

FISH LENGTH : 65cm

FISH WEIGHT : 6 lbs

TRACKING NOTES :

No detections.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Plumpton Beach

DATE : 31.07.97

RELEASE SITE : Plumpton Beach

TIME : 09.00

HEIGHT OF HIGH TIDE (m): 8.0

FLOY TAG No.: A1256

CART \ RADIO TAG No.: CART J015

FREQUENCY : 845 (CH9)

PULSE RATE (ppm) : 51

ACOUSTIC LIFE : 14 Days

FISH LENGTH : 58cm

FISH WEIGHT : 5½ lbs

TRACKING NOTES :

No detections.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Plumpton Viaduct

DATE : 24.08.97

RELEASE SITE : Plumpton Viaduct

TIME : 10.00

HEIGHT OF HIGH TIDE (m): 8.5*

* Indicates fished at low water. The figure given is the previous high tide height.

FLOY TAG No.: A1257

CART \ RADIO TAG No.: CART J033

FREQUENCY : 845 (CH9)

PULSE RATE (ppm) : 29

ACOUSTIC LIFE : 25 Days

FISH LENGTH : 56cm

FISH WEIGHT : 3½ lbs

TRACKING NOTES :

No detections.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Plumpton Viaduct

DATE : 27.08.97

RELEASE SITE : Plumpton Viaduct

TIME : 13.20

HEIGHT OF HIGH TIDE (m): 7.4*

* Indicates fished at low water. The figure given is the previous high tide height.

FLOY TAG No.: A1258

CART \ RADIO TAG No.: CART J042

FREQUENCY : 830 (CH6)

PULSE RATE (ppm) : 66

ACOUSTIC LIFE : 11 Days

FISH LENGTH : 63cm

FISH WEIGHT : 6½ lbs

TRACKING NOTES :

No detections.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Plumpton Viaduct **DATE :** 28.08.97

RELEASE SITE : Plumpton Viaduct **TIME :** 14.40

HEIGHT OF HIGH TIDE (m): 7.7*

* Indicates fished at low water. The figure given is the previous high tide height.

FLOY TAG No.: A1259 **CART \ RADIO TAG No.:** CART J049

FREQUENCY : 850 (CH10)

PULSE RATE (ppm) : 60

ACOUSTIC LIFE : 12 Days

FISH LENGTH : 61cm **FISH WEIGHT :** 5½ lbs

TRACKING NOTES :

No detections.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 24.09.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 12.45

HEIGHT OF HIGH TIDE (m): 7.4

FLOY TAG No.: A1260 **CART \ RADIO TAG No::** RADIO K060

FREQUENCY : 845 (CH 9)

PULSE RATE (ppm) : 65

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 81 cm **FISH WEIGHT :** 10 lbs

TRACKING NOTES :

Actively Tracked 25.09.97 @ Honey Pot 10.30 GMT
Actively Tracked 02.10.97 @ Honey Pot 09.15 GMT
Actively Tracked 04.10.97 @ Honey Pot 11.00 GMT
Actively Tracked 05.10.97 @ Honey Pot 11.00 GMT
Actively Tracked 29.10.97 @ Fish House Lane 09.00 GMT
Actively Tracked 05.11.97 @ Hand Rail 10.25 GMT
Detected by Fish House Lane ALS 10.11.97 between 17.30 and 20.30 GMT
Detected by Fish House Lane ALS 13.11.97 @ 10.50 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 24.09.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 13.30

HEIGHT OF HIGH TIDE (m): 7.4

FLOY TAG No.: A1262 **CART \ RADIO TAG No.:** RADIO K084

FREQUENCY : 820 (CH 4)

PULSE RATE (ppm) : 54

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 44 cm **FISH WEIGHT :** 3 lbs

TRACKING NOTES :

Actively Tracked 25.09.97 @ Honey Pot 10.30 GMT
Actively Tracked 26.09.97 @ Fish House Lane 09.15 GMT
Actively Tracked 02.10.97 @ Honey Pot 09.15 GMT
Actively Tracked 04.10.97 @ Honey Pot 11.00 GMT
Actively Tracked 05.10.97 @ Honey Pot 11.00 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 24.09.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 13.45

HEIGHT OF HIGH TIDE (m): 7.4

FLOY TAG No.: A1263 **CART \ RADIO TAG No.:** RADIO K083

FREQUENCY : 815 (CH 3)

PULSE RATE (ppm) : 56

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 79 cm **FISH WEIGHT :** 12 lbs

TRACKING NOTES :

Detected by Fish House Lane ALS 24.09.97 between 16.15 to 17.10 GMT
Actively Tracked 26.09.97 @ Fish House Lane 09.15 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 25.09.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 08.10

HEIGHT OF HIGH TIDE (m): 7.2

FLOY TAG No.: A1264 **CART \ RADIO TAG No.:** RADIO K075

FREQUENCY : 825 (CH 5)

PULSE RATE (ppm) : 45

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 65 cm **FISH WEIGHT :** 5½ lbs

TRACKING NOTES :

Actively Tracked 25.09.97 @ Honey Pot 10.30 GMT
Actively Tracked 26.09.97 @ Fish House Lane 09.15 GMT
Actively Tracked 02.10.97 @ Honey Pot 09.15 GMT
Actively Tracked 04.10.97 @ Honey Pot 11.00 GMT
Actively Tracked 05.10.97 @ Honey Pot 11.00 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 25.09.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 08.45

HEIGHT OF HIGH TIDE (m): 7.2

FLOY TAG No.: A1265 **CART \ RADIO TAG No.:** RADIO K073

FREQUENCY : 815 (CH 3)

PULSE RATE (ppm) : 46

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 63 cm **FISH WEIGHT :** 6½ lbs

TRACKING NOTES :

Actively Tracked 25.09.97 @ Honey Pot 10.30 GMT
Actively Tracked 02.10.97 @ Honey Pot 09.15 GMT
Actively Tracked 04.10.97 @ Honey Pot 11.00 GMT
Actively Tracked 05.10.97 @ Honey Pot 11.00 GMT
Actively Tracked 05.11.97 @ Black Hole 10.20 GMT
Actively Tracked 15.11.97 @ Notch 10.40 GMT
Detected by Eels Dam ALS 15.11.97 @ 22.20 to 16.11.97 @18.15 GMT
Actively Tracked 16.11.97 @ Eels Dam 09.30 GMT
Actively Tracked 20.11.97 @ Iron Works 09.20 GMT
Detected by Iron Works ALS 20.11.97 @ 14.00 to 23.12.97 @ 09.15 GMT
Detected by Eels Dam ALS 23.12.97 @ 12.45 to 13.00 GMT
Actively Tracked 30.12.97 @ Low Wood Head Race 10.00 GMT
Actively Tracked 05.01.98 @ Low Wood Head Race 13.00 GMT
Actively Tracked 12.01.98 @ Low Wood Head Race 13.00 GMT
Tag recovered 15.01.98 @ Low Wood Head Race 11.00 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 07.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 09.30

HEIGHT OF HIGH TIDE (m): 8.3

FLOY TAG No.: A1266 **CART \ RADIO TAG No.:** RADIO K051

FREQUENCY : 805 (CH 1)

PULSE RATE (ppm) : 66

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 75 cm **FISH WEIGHT :** 10 lbs

TRACKING NOTES :

Detected by Fish House Lane ALS 10.10.97 @ 12.00 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 07.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 17.00

HEIGHT OF HIGH TIDE (m): 8.1

FLOY TAG No.: A 1267 **CART \ RADIO TAG No.:** RADIO K050

FREQUENCY : 845 (CH 9)

PULSE RATE (ppm) : 61

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 61 cm **FISH WEIGHT :** 6 lbs

TRACKING NOTES :

Actively Tracked 23.10.97 @ Reed Bed 12.05 GMT
Actively Tracked 05.11.97 @ Reed Bed 10.00 GMT
Actively Tracked 15.11.97 @ Reed Bed 09.45 GMT
Actively Tracked 16.11.97 @ Reed Bed 10.00 GMT
Actively Tracked 03.12.97 @ Reed Bed 09.45 GMT
Actively Tracked 16.12.97 @ Reed Bed 08.25 GMT
Actively Tracked 30.12.97 @ Reed Bed 10.30 GMT
Actively Tracked 12.01.98 @ Reed Bed 15.35 GMT
Actively Tracked 16.01.98 @ Reed Bed 12.20 GMT
Actively Tracked 29.01.98 @ Reed Bed 10.15 GMT
Tag recovered 06.02.98 @ Reed Bed 10.30 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven)

DATE : 07.10.97

RELEASE SITE : Honey Pot (R. Leven)

TIME : 17.00

HEIGHT OF HIGH TIDE (m): 8.1

FLOY TAG No.: A 1268

CART \ RADIO TAG No.: RADIO K085

FREQUENCY : 825 (CH 5)

PULSE RATE (ppm) : 54

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 68 cm

FISH WEIGHT : 7 lbs

TRACKING NOTES :

Detected by Fish House Lane ALS 19.10.97 between 21.45 and 21.10.97 @ 04.50 GMT
Detected by Fish House Lane ALS 21.10.97 between 21.20 and 23.10.97 @ 22.35 GMT
Detected by Fish House Lane ALS 25.10.97 between 23.15 and 28.10.97 @ 05.40 GMT
Detected by Fish House Lane ALS 28.10.97 between 19.40 and 30.10.97 @ 04.00 GMT
Actively Tracked 05.11.97 @ Fish House Lane 10.35 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 07.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 17.00

HEIGHT OF HIGH TIDE (m): 8.1

FLOY TAG No.: A 1269 **CART \ RADIO TAG No.:** RADIO K042

FREQUENCY : 810 (CH 2)

PULSE RATE (ppm) : 60

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 58 cm **FISH WEIGHT :** 6 lbs

TRACKING NOTES :

Adipose fin absent upon capture.
Numerous active tracking sessions detected the tag at the Timber Pond between 23.10.97 and 29.01.98
Still present at time of printing and assumed to be regurgitated.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 07.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 18.00

HEIGHT OF HIGH TIDE (m): 8.1

FLOY TAG No.: A 1270 **CART \ RADIO TAG No.:** RADIO K089

FREQUENCY : 845 (CH9)

PULSE RATE (ppm) : 54

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 81 cm **FISH WEIGHT :** 14 lbs

TRACKING NOTES :

Actively Tracked 10.10.97 @ Timber Pond 10.10 GMT
Detected by Fish House Lane ALS 18.10.97 @ 13.05 to 19.10.97 @ 07.10 GMT
Actively Tracked 23.10.97 @ Timber Pond 10.20 GMT
Detected by Fish House Lane ALS 31.10.97 @ 12.40 to 02.11.97 @ 14.10 GMT
Detected by Fish House Lane ALS 04.11.97 @ 21.50 to 07.11.97 @ 01.45 GMT
Detected by Fish House Lane ALS 10.11.97 between 13.50 and 22.05 GMT
Detected by Spark Bridge ALS (R. Crake) 11.11.97 between 14.10 and 15.30 GMT
Actively Tracked 15.11.97 @ Allen Tam 15.20 GMT
Actively Tracked 26.11.97 @ D/S Bouthrey Bridge 14.20 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 09.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 05.30

HEIGHT OF HIGH TIDE (m): 7.6

FLOY TAG No.: A 1279 **CART \ RADIO TAG No.:** RADIO K045

FREQUENCY : 825 (CH5)

PULSE RATE (ppm) : 61

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 55 cm **FISH WEIGHT :** 3½ lbs

TRACKING NOTES :

Actively Tracked 12.01.98 @ 200m u/s Pool Foot 14.05 GMT
Actively Tracked 16.01.98 @ 200m u/s Peat Stream 12.00 GMT
Actively Tracked 19.01.98 @ 200m u/s Peat Stream 11.40 GMT
Actively Tracked 29.01.98 @ d/s Limit 10.40 GMT
Actively Tracked 02.02.98 @ 100m d/s Limit 10.30 GMT
Attempted recovery of tag 06.02.98 @ 100m d/s Limit 12.00 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 09.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 05.30

HEIGHT OF HIGH TIDE (m): 7.6

FLOY TAG No.: A 1271 **CART \ RADIO TAG No.:** RADIO K079

FREQUENCY : 845 (CH9)

PULSE RATE (ppm) : 44

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 66 cm **FISH WEIGHT :** 4 lbs

TRACKING NOTES :

Actively Tracked 05.11.97 @ Timber Pond 11.05 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 09.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 05.30

HEIGHT OF HIGH TIDE (m): 7.6

FLOY TAG No.: A 1273 **CART \ RADIO TAG No.:** RADIO K005

FREQUENCY : 825 (CH 5)

PULSE RATE (ppm) : 46

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 66 cm **FISH WEIGHT :** 4 lbs

TRACKING NOTES :

Actively Tracked 23.10.97 @ Low Wood Turbine Tail Race 11.40 GMT
Actively Tracked 05.11.97 @ Ford Island 09.00 GMT
Detected by Fish House Lane ALS 11.11.97 between 06.20 and 15.30 GMT
Actively Tracked 15.11.97 @ Pulpit 10.05 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 09.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 05.30

HEIGHT OF HIGH TIDE (m): 7.6

FLOY TAG No.: A 1274 **CART \ RADIO TAG No.:** RADIO K015

FREQUENCY : 825 (CH5)

PULSE RATE (ppm) : 49

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 71 cm **FISH WEIGHT :** 4½ lbs

TRACKING NOTES :

Actively Tracked 05.11.97 @ Last Gap 10.20 GMT
Actively Tracked 15.11.97 @ Black Hole 10.00 GMT
Actively Tracked 03.12.97 @ Black Hole 10.05 GMT
Actively Tracked 16.12.97 @ Black Hole 09.00 GMT
Actively Tracked 30.12.97 @ Black Hole 11.30 GMT
Actively Tracked 12.01.98 @ Black Hole 15.30 GMT
Actively Tracked 16.01.98 @ Black Hole 12.15 GMT
Actively Tracked 29.01.98 @ Black Hole 10.05 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 09.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 05.30

HEIGHT OF HIGH TIDE (m): 7.6

FLOY TAG No.: A 1275 **CART \ RADIO TAG No.:** RADIO K059

FREQUENCY : 840 (CH8)

PULSE RATE (ppm) : 67

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 68 cm **FISH WEIGHT :** 4 lbs

TRACKING NOTES :

Actively Tracked 23.10.97 @ Timber Pond 10.30 GMT
Actively Tracked 12.01.98 @ Timber Pond 13.50 GMT
Actively Tracked 16.01.98 @ Timber Pond 11.00 GMT
Actively Tracked 19.01.98 @ Timber Pond 11.30 GMT
Actively Tracked 29.01.98 @ Timber Pond 10.45 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 09.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 05.30

HEIGHT OF HIGH TIDE (m): 7.6

FLOY TAG No.: A 1276 **CART \ RADIO TAG No.:** RADIO J037

FREQUENCY : 810 (CH2)

PULSE RATE (ppm) : 76

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 53 cm **FISH WEIGHT :** 3½ lbs

TRACKING NOTES :

No detections.

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 09.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 05.30

HEIGHT OF HIGH TIDE (m): 7.6

FLOY TAG No.: A 1277 **CART \ RADIO TAG No.:** RADIO J012

FREQUENCY : 810 (CH2)

PULSE RATE (ppm) : 52

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 66 cm **FISH WEIGHT :** 4 lbs

TRACKING NOTES :

Actively Tracked 10.10.97 @ Timber Pond 10.10 GMT
Actively Tracked 23.10.97 @ u/s Pool Foot 09.20 GMT
Actively Tracked 05.11.97 @ Timber Pond 10.55 GMT
Actively Tracked 20.11.97 @ Carters 10.05 GMT
Actively Tracked 03.12.97 @ Timber Pond 10.20 GMT
Actively Tracked 30.12.97 @ Peat Stream Bend 11.15 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SALMON

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 09.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 05.30

HEIGHT OF HIGH TIDE (m): 7.6

FLOY TAG No.: A 1278 **CART \ RADIO TAG No.:** RADIO K020

FREQUENCY : 845 (CH9)

PULSE RATE (ppm) : 50

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 63 cm **FISH WEIGHT :** 3¼ lbs

TRACKING NOTES :

Detected by Fish House Lane ALS 09.10.97 @17.00 GMT
Actively Tracked 10.10.97 @ Fish House Lane 09.45 GMT
Detected by Fish House Lane ALS 10.10.97 @ 12.10 to 13.10.97 @ 07.25 GMT
Detected by Fish House Lane ALS 13.10.97 @ 07.32 to 18.10.97 @ 02.45 GMT
Actively Tracked 05.11.97 @ Timber Pond 11.10 GMT
Detected by Fish House Lane ALS 02.12.97 between 17.15 and 17.20 GMT
Actively Tracked 03.12.97 @ Hand Rail 10.00 GMT
Detected by Fish House Lane ALS 05.12.97 @ 18.20 to 06.12.97 @ 21.00 GMT

LEVEN ESTUARY PROJECT : FISH TAGGING 1997

SPECIES TAGGED : SEA TROUT

CAPTURE SITE : Honey Pot (R. Leven) **DATE :** 09.10.97

RELEASE SITE : Honey Pot (R. Leven) **TIME :** 05.30

HEIGHT OF HIGH TIDE (m): 7.6

FLOY TAG No.: A 1280 **CART \ RADIO TAG No.:** RADIO K055

FREQUENCY : 825 (CH5)

PULSE RATE (ppm) : 67

ACOUSTIC LIFE : Not Applicable

FISH LENGTH : 58 cm **FISH WEIGHT :** 3½ lbs

TRACKING NOTES :

Actively Tracked 23.10.97 @ Fish House Lane 10.40 GMT
Actively Tracked 05.11.97 @ Lower Reed Bed 10.15 GMT
Tag recovered 05.11.97 @ Lower Redd Bed 13.00 GMT