Environment Agency

South West Region

Restormel Fish Counter

Annual Report 2001

Ecological Appraisal Team
Devon and Cornwall Area
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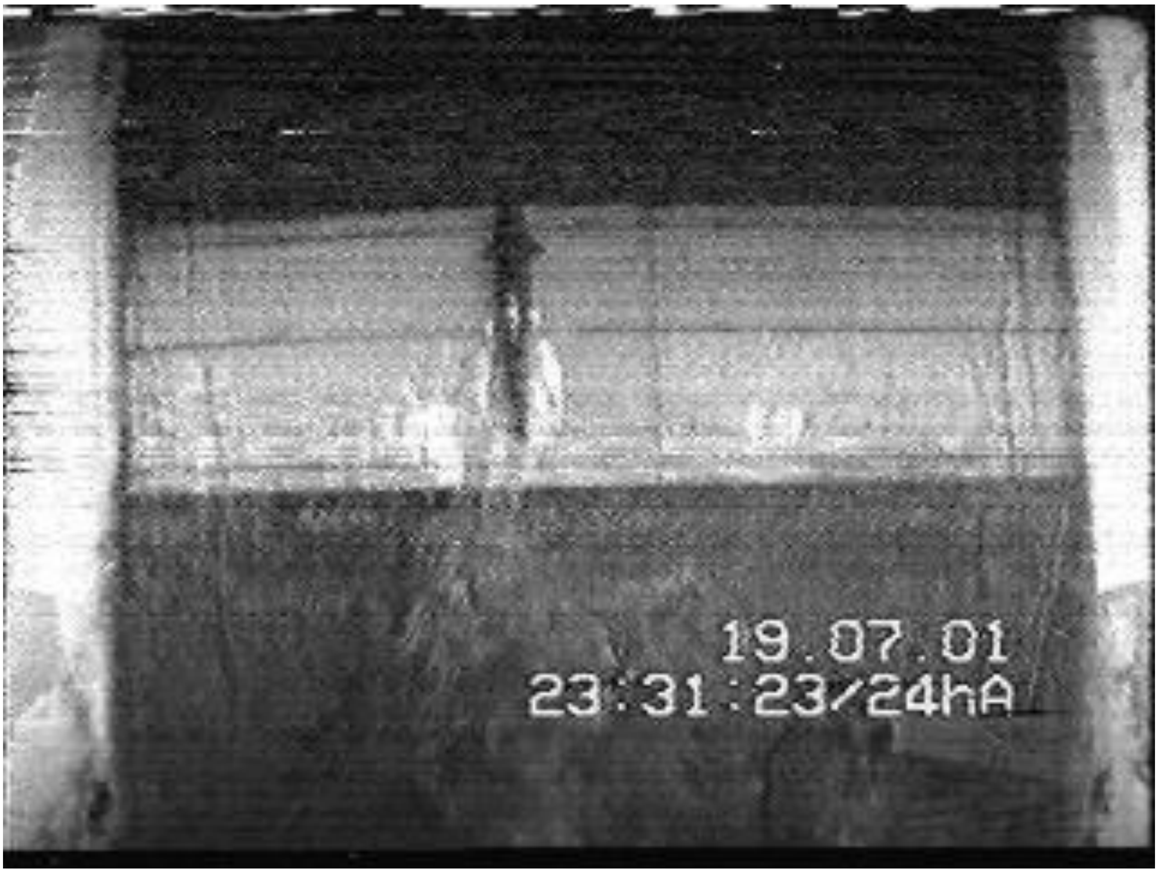

Picture 1- Image of salmon taken at Restormel on the 19/07/01 at 23:31:23. This fish was estimated to be 104cm long and to weigh over 27lb.

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Executive Summary

- The following report presents the daily upstream counts of migratory salmonids byt the fish counter at Restormel Weir (SX 107 613) in 2001. The counter data covers the period of the commercial salmonid net buy back scheme and the national spring salmon byelaws. These reduce the commercial netting season for salmon and sea trout to between 16 June and 31 August.

- The fish counter at Restormel is installed on a crump sectioned weir on the River Fowey and is approximately 2 Km upstream of the tidal limit. The fish counter is a resistivity based system and operates over all three channels of the weir.

- The upstream count for salmon/large sea trout was 1611, a 5% decrease on the 2000 count.

- The number of salmon counted migrating over the weir between September 2001 and February 2002 was 477, a 20% increase on 2000/01.

- The increase in the number of salmon entering the Fowey is encouraging as the trend over the last six years indicated a gradual decrease in numbers of salmon returning.

- Over the same period a general decrease was also seen in the number of rod caught salmon (Environment Agency 2000c). The lack of a comparable increase in the number of rod caught salmon on the Fowey in 2001 could be explained by a 30% decrease in the reported fishing effort between 1995 and 2001.

- 2001 was a good year for large sea trout. The number of returning large sea trout was above average in April, May, June and July and equal to or higher than the previous recorded maximum in those months. The number of large sea trout returning was 9% down on 2000 and 49% up on the 5 year average.

- The main run of small sea trout occurred at a similar time to previous years with the highest numbers of fish entering the Fowey during June and July. The total count for small sea trout in 2001 was 8051 which is the highest on record and a 56% increase on the 6 year average.

- The overall detection efficiency of the counter was 62%. The counter had a much higher detection efficiency for large fish (98% for fish >50cm) than for small fish (62% for fish <50cm). If non-directional events are include the detection rate increase from 62% to 90%. The counter correctly 92% of the fish sampled during the audit of the counter data.

1. Introduction

The following report presents upstream salmon and sea trout counts with respect to:

- daily mean flow (cumecs),
- daily mean water temperature (°C)
- and daily mean barometric pressure (mBar)

recorded during 2000 at Restormel fish counting station (SX 107 613) on the River Fowey. The daily mean flow data reflects the residual flow that exists at Restormel weir following abstraction at Restormel Water Treatment Works (RWTW) by South West Water (SWW). Both the temperature and pressure readings were obtained from the on-site Tinytag data loggers.

The report also includes details of the on-going counter validation work and the annual audit of counter data. This is primarily used to assess counter efficiency, to develop improved methodologies for species apportionment and ensure that the findings of the more intensive validation exercise undertaken in 1997 remain valid.

2. Background

The River Fowey is considered to be a premier game fishery within both Cornwall and the South West of England. Grilse (1 sea winter salmon) are traditionally known to enter the Fowey from the end of June. The River Fowey is renowned for its late run of salmon, which includes large Multi Sea Winter (MSW) fish. Salmon have been known to migrate up into the River Fowey as late as February. The closing date for the salmon rod fishery is 15 December, which reflects the late run of salmon. There is also a small run of MSW fish in the spring period.

A large component of the River Fowey sea trout fishery consists of ‘school peal’. ‘School peal’ are runs of fish returning to the river from June to July. These sea trout are somewhat smaller than the sea trout which return earlier in the year and are thought to spend the winter in nearby coastal waters before returning to the river to spawn.

As the result of a declining trend observed in the rod and net catches of both Atlantic Salmon (Salmo salar L.) and Sea Trout (Salmo trutta L.) over the last 10 years, concern has been expressed with regard to the present and future status of migratory salmonid stocks within the River Fowey). While there is general agreement that there is a national decline in salmon stocks concern has been raised that factors specific to the River Fowey are also having a significant impact in limiting the potential production (Environment Agency, 2000).

The fish counter installed at Restormel Weir is an essential tool in the management of the salmonid fishery. It provides vital baseline data on the size of the migratory salmonid population and information on the times during which these migrations occur. This information used in conjunction with other fisheries data, such as juvenile survey data, trapping data and rod/net catches, significantly enhances the formulation of effective management strategies (E.A, 1999).

The current fish counter at Restormel Weir is a resistivity-based system (Logie 2100A) manufactured by Aquantic Ltd. The counter was installed in 1994 with data collection commencing in 1995.

The fish counter is installed on the gauging weir at Restormel, approximately 2-km upstream of the tidal limit. The weir is ‘Crump’ sectioned with three open channels, a centre channel (3.5 metres) and two side channels (6.5 metres each). The counter operates over all three of these channels via 3 stainless steel electrodes, which are incorporated into the downstream faces of each weir channel. This allows complete coverage of the river, a total width of 17 metres (E.A,1998).

The counter at Restormel is the second resestivity-based system operated by the Cornwall Area Fisheries Science Team. The other counter is located on the River Tamar at Gunnislake Weir (SX 435 713).

3. The Commercial netting season.

National byelaws to protect spring salmon were introduced on 15 April 1999. The implementation of these bylaws prevented the netting season for salmon on the River Fowey from the beginning of the season (2 March) until 1 June. However, as the River Fowey does not have a significant run of ‘spring’ salmon netsmen receive a special dispensation to net for sea trout before the 1 June, as long as any salmon caught before the 1 June are returned.

The effective fishing season was also reduced by the operation of a buy-back scheme of commercial migratory salmonids by South West Water (SWW). The buy back is in effect between the 2 March and the 15 June for sea trout and between 1 June and 15 June for salmon. The main aim of the buy-back scheme is to mitigate for sea trout spawning, which was lost due to the construction of Colliford Reservoir.

The effect of both The National byelaws and the buy-back scheme effectively reduce the netting season for both salmon and sea trout on the Fowey to between 16 June and the 31 August

4. Species Apportionment

The resistivity counter is able to record electrical changes that are directly proportional to the size of the fish that have passed over the counter electrodes. Species apportionment is possible due to the relationship that exists between fish length and deflection size.

However, using this method alone it is not possible to distinguish between a salmon and a sea trout of comparable size. It is therefore inevitable that the salmon count may include some large sea trout. As this situation is most likely to exist between March and the end of June, a data handling protocol has been developed to minimise this eventuality. This is described in Appendix 6.

Knowledge of the run timing of the two species obtained from historical net and trap data can also be used to estimate the number of salmon within the salmon sized upstream fish movements recorded.

5. Validation of counter efficiency

Since the initial validation studies carried out in 1997 counter data is audited, using video footage taken over the weir, on an annual basis. Counter events are matched up with video events, which can then be used to assess the efficiency of the counter and to investigate anomalies in the counter data.

Validation studies carried out on channel 1 of the counter in 1997, Environment Agency (1998), showed that the Restormel fish counter was:

- 90% efficient in detecting upstream migrating fish greater than 45 cm in length.
- 36.7% efficient in detecting upstream migrating fish less than 45 cm in length and 60% efficient, for the same size class, if non-directional events were included.

Video validation and the annual audit of counter data is a vital part of the counter work at Restormel and gives confidence in the accuracy of the data that the fish counter is producing. A description of the validation methodology can be found in Appendix 7.

6. Results

The migratory salmonid counts obtained for the River Fowey recorded at Restormel fish counting station in 2001 are presented as follows:

6.1. Upstream Fish Counts

Figure 1: This presents the Monthly Upstream Counts for Salmon / Large sea trout at Restormel weir in 2001. Including the 6-year average and previous maximum and minimum counts indicated by the Y error bars. The total estimated number of salmon / large sea trout counted moving up the river in 2001 was 1611 (Table 1).

Figure 2: Presents Monthly Upstream Counts for Sea trout at Restormel weir in 2001. Including the 6-year average and previous maximum and minimum counts indicated by the Y error bars. The total estimated number of sea trout counted moving up the river in 2001 was 8051 (Table 1).

Figure 3: This presents the Estimated monthly upstream counts from historical net catch data for salmon, large sea trout and small sea trout at Restormel weir in 2001.

Figures 4 & 5: Presents the estimated daily upstream counts for salmon / large sea trout and small sea trout in relation to daily mean flow (cumecs) recorded at Restormel weir.

Figures 6 & 7: Presents the estimated daily upstream counts for salmon, large sea trout and small sea trout in relation to daily mean water temperature (°C) recorded at Restormel weir.

Figures 8 & 9: Presents the estimated daily upstream counts for salmon / large sea trout and small sea trout in relation to daily mean barometric pressure (mBar) recorded at Restormel weir.

Figures 10 - 33: Each of these figures presents daily upstream counts for salmon / large sea trout and small sea trout, for each month, in relation to daily mean flow (cumecs) recorded at Restormel weir.

Note:

To aid in interpretation of the data, axis scaling may differ between the monthly summary plots. Care should therefore be taken when interpreting the data within each figure.

Figure 1 – Monthly Upstream Counts for Salmon / Large sea trout at Restormel weir in 2001. Including the 6-year average and previous maximum and minimum counts indicated by the Y error bars.

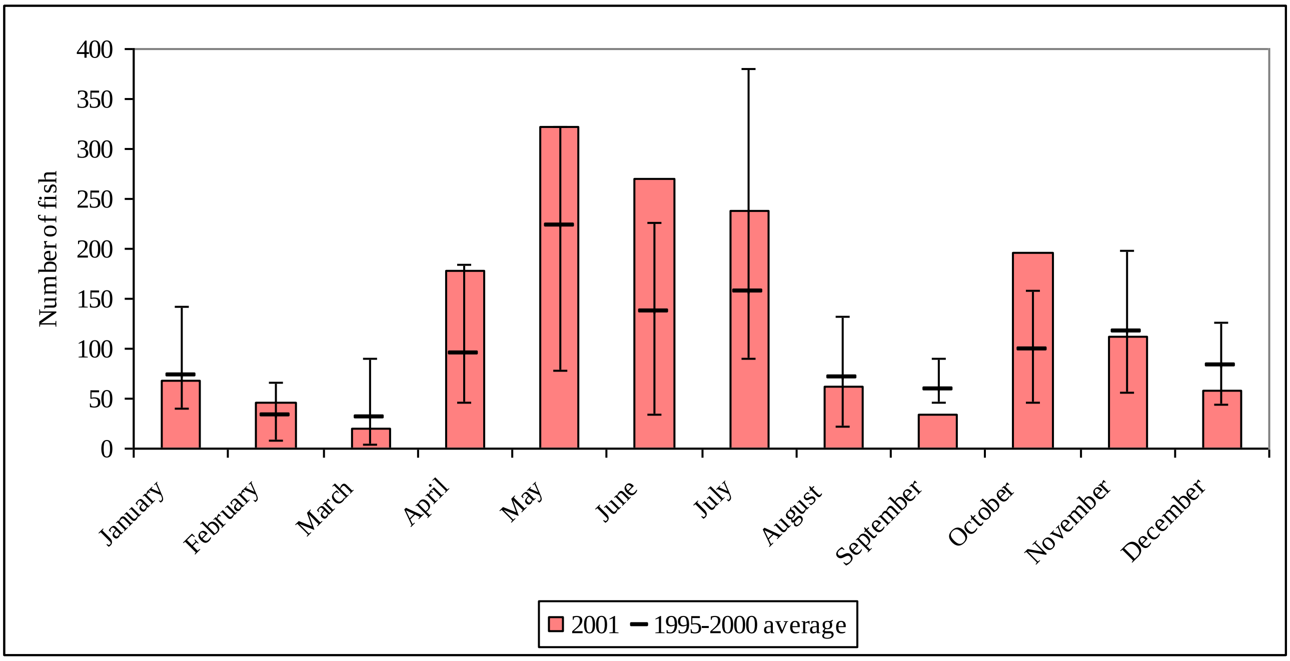

Table 1– Monthly Upstream Counts for Salmon / Large Sea trout at Restormel weir 1995 to 2001 and the 6-year average.

Month	1995	1996	1997	1998	1999	2000	2001	6-yr average
January	108	143	62	40	41	41	69	73
February	26	9	66	26	27	34	46	31
March	12	9	5	8	60	90	20	31
April	47	103	80	56	90	184	179	93
May	78	207	264	206	254	323	323	222
June	35	153	183	69	146	226	270	135
July	94	129	90	105	135	380	238	156
August	23	66	63	51	80	132	63	69
September	50	53	49	64	46	91	35	59
October	97	159	46	137	72	76	197	98
November	198	101	85	76	184	57	113	117
December	122	55	82	44	127	58	58	81
Totals	890	1187	1075	882	1262	1692	1611	1165

Figure 2 - Monthly Upstream Counts for Sea trout at Restormel weir in 2001. Including the 6-year average and previous maximum and minimum counts indicated by the Y error bars.

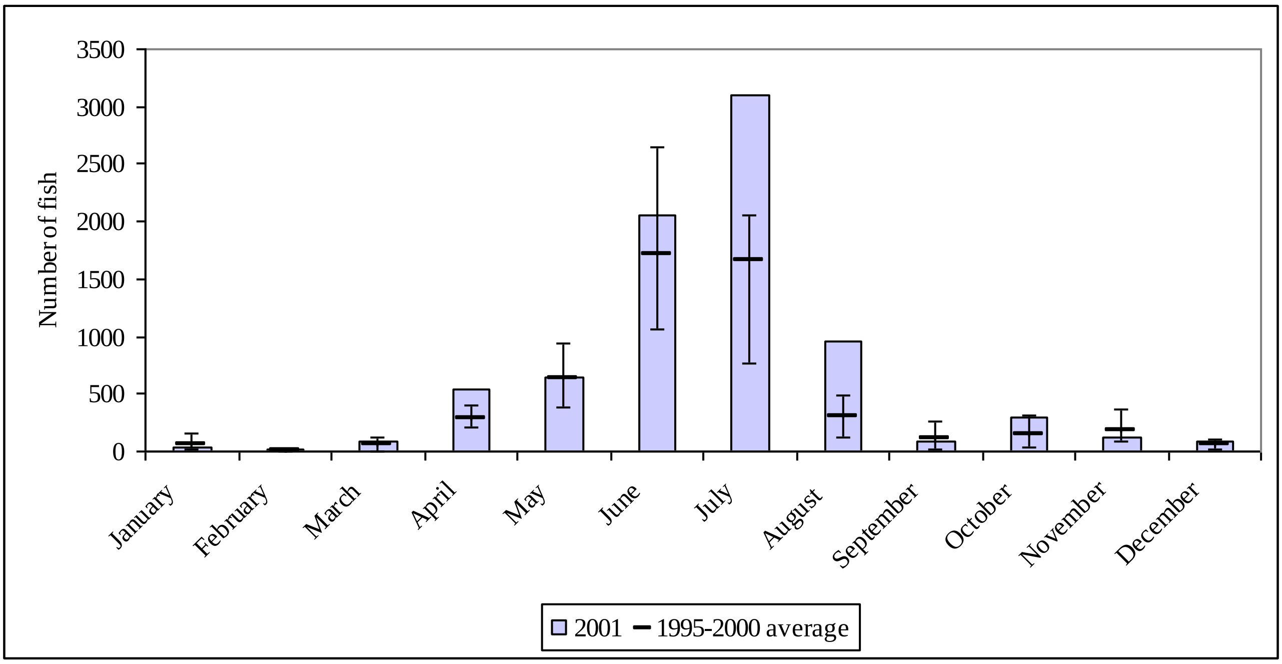

Table 2 - Monthly Upstream Counts for Sea trout at Restormel weir 1995 to 2001 and the 6-year average.

Month	1995	1996	1997	1998	1999	2000	2001	6-yr average
January	52	156	13	46	18	15	38	50
February	8	10	4	6	9	12	26	8
March	47	18	1	35	87	122	95	52
April	274	303	264	256	203	397	533	283
May	446	573	388	948	556	817	639	621
June	1759	1065	1454	1070	2649	2254	2060	1709
July	1513	2578	1237	770	2056	1736	3100	1648
August	368	489	116	214	408	199	966	299
September	263	92	21	36	114	102	86	105
October	310	125	36	107	121	174	298	146
November	368	84	113	82	259	93	128	167
December	98	18	30	20	110	81	82	60
Totals	5506	5511	3677	3590	6590	6002	8051	5146

Figure 3 – Monthly Upstream Counts for Salmon at Restormel weir in 2001/2002 (September to February). Including 6-year average and previous maximum and minimum counts indicated by the Y error bars.

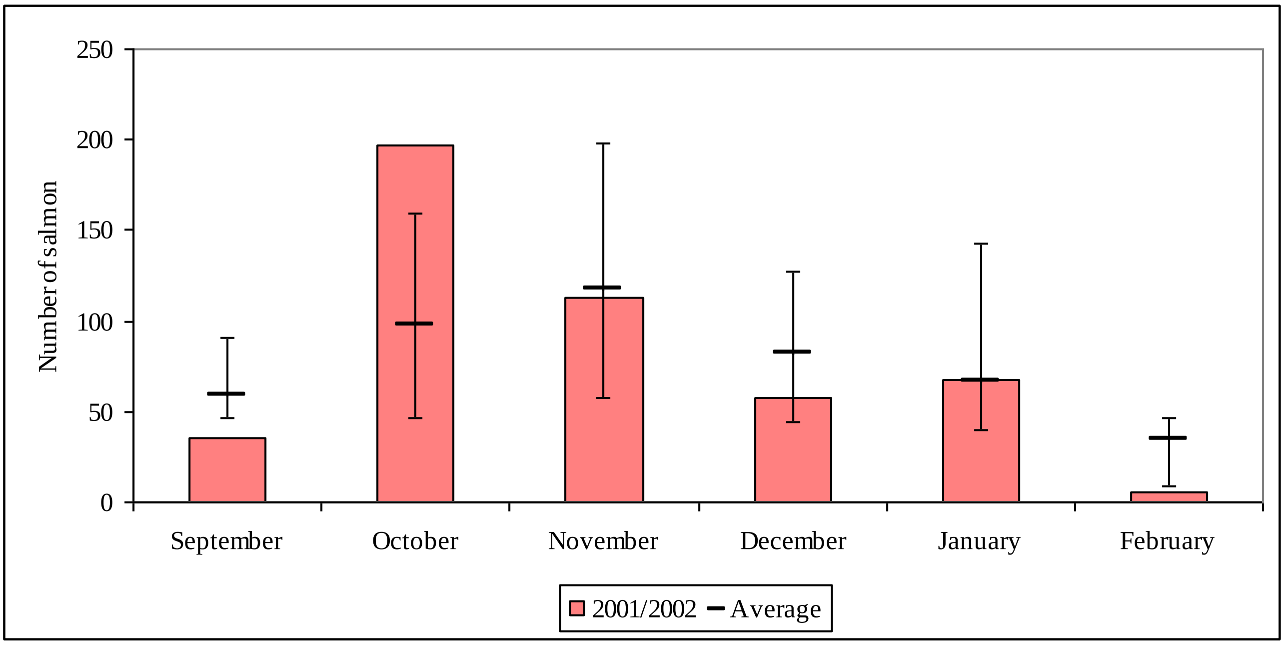

Table 3 - Monthly Upstream Counts for Salmon at Restormel weir in 2001/2002 (September to February) including 6-year average.

Month	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	6-yr Average
September	50	53	49	64	46	91	35	59
October	97	159	46	137	72	76	197	98
November	198	101	85	76	184	57	113	117
December	122	55	82	44	127	58	58	81
January	143	62	40	41	41	69	68	66
February	9	66	26	27	34	46	6	35
Total	619	496	328	389	504	397	477	456

7. Video Validation & Counter Efficiency

7.1. Counter Efficiency

Table 4 – Fish counter detection efficiencies for Restormel fish counter.

Item	Counter	Video	% Efficiency
Total Counts (Upstream, Downstream, Events)	407	461	88
Missed Counts	54	0	
Upstream Salmonid Counts	277	446	62
Upstream Salmonid Counts > 50cm (Individuals)	46	47	98
Upstream Salmonid Counts < 50cm (Individuals)	198	317	62
Upstream Salmonid Counts < 50cm (Individuals) including non directional events	286	317	90

The over all detection efficiency for upstream salmonids was 62%. The detection efficiency was calculated using data for upstream migrating salmonids detected by the counter or seen on video. From table it can be seen that the counter has a much higher detection efficiency for large fish (98% for fish >50cm) than for small fish (62% for fish <50cm). If non directional events are included the detection rate for fish less then 50cm increases from 62 to 90%.

7.2. Sizing ability of the fish counter

Table 5 – Sizing ability of Restormel fish counter

Item	Counter	Video	% Error
Salmonids > 50	265	218	18
Salmonids < 50	358	405	-13
Total	623	623	

Table utilises matched counter and video data for upstream migrating salmonids to calculate the % error in the sizing ability of the counter. From the table it can be seen that for the matched counter and video data the number of fish greater than 50cm was overestimated by 18% whilst the number less than 50cm was underestimated by 13%.

8. Discussion

Figures 1 & 2 show the seasonal run patterns observed for salmon / large sea trout and small sea trout on the River Fowey in 2001 as well as the average for the previous 6 years. The combined total annual count for upstream migrating salmonids on the River Fowey was 9662 in 2001 this is considerably larger than the count of 4694 that was recorded in 2001. Figure 3 shows the monthly upstream counts for salmon at Restormel weir in 2001/2002 (September to February).

8.1. Salmon / Large Sea Trout counts recorded on the River Fowey 1995 – 2000.

- The upstream counts obtained during April – July indicate that a large number of salmon sized fish are entering the river at this time. Deflection values over the period April to July confirm this.

- Traditionally, evidence coming from historical netting, trapping and the rod fishery, salmon are known to enter the Fowey from the beginning of July with a further late run of salmon occurring from October to January. Large sea trout are known to enter the river between March and July.

- As an unknown proportion of the salmon sized events which occur from April to July are caused by sea trout a minimum salmon count for the Fowey is taken just from the months September to February.

8.2. Late run (September to February) Salmon counts recorded on the River Fowey 1995 – 2001.

- The total late run count of salmon was 477 in 2001/02 a 20% increase from the 2000/01 count. The year 2001/02 count was however 5% lower than the previous 6-yr average (Table 3)

- The number of salmon entering the Fowey during this period in 2001 is encouraging. The numbers of late returning salmon on the Fowey has generally followed a downward trend over the previous 6 years.

- Over the same period a general decrease has also been observed in the number of rod caught salmon (E.A., 2000). The lack of a comparable increase in the number of rod caught salmon in 2001 on the Fowey could be explained by a 30% decrease in the reported fishing effort by the Fowey salmon anglers between 1995 and 2001.

8.3. Early run (July to August) Salmon counts recorded on the River Fowey 1995 – 2001.

- For the reasons discussed above it is far harder to obtain an accurate count of the number of salmon migrating upstream during the summer months.

- Rod catch data (E.A, 2000) indicates that the decrease observed in rod caught salmon on the Fowey over the past 5 years has occurred at the end of the fishing season. With the numbers of salmon caught prior to October remaining relatively constant.

- Data from the fish counter and rod returns suggest that the ‘later run’ is decreasing whilst rod returns suggest the summer run is remaining consistent. The contribution to the total run on the River Fowey by the ‘summer run’ of grilse might be increasing. It is therefore important to develop ways to obtain an accurate estimate of the number of salmon returning during these summer months.

- As stated above historical trapping and netting data indicates that only very few salmon enter the River Fowey prior to the end of June. It is therefore likely that most of the salmon sized events prior to July will have been created by sea trout and can be discounted. Further analysis is however needed in order to estimate how many of the 238 salmon sized events counted in July were caused by salmon.

- Discrimnant analysis, of salmonid lengths caught in the River Fowey nets during July between 1990 and 1999, indicates that 239/255 (94%) salmon have a length greater than or equal to 55cm whilst 33/38 (87%) sea trout have a length less than 55cm. Suggesting that 55cm could be used as a reliable cut of point between salmon and sea trout on the Fowey in this month. In July the counter recorded 238 upstream movements by salmon sized fish. 87 of these fish were observed on video and their lengths calculated. 54/87 (62%) had a length greater than or equal to 55cm suggesting they were salmon. From this an estimate of 148 salmon (62% of the 238 salmon sized events) can be obtained for the month of July.

- In the future efforts will be made to record on video and calculate accurate lengths for all the salmon sized events recorded by the counter during the summer months to gain a more accurate count of this potentially important run of salmon.

8.4. Estimated Large Sea Trout counts recorded on the River Fowey 1995 – 2001.

- 2001 was a very good year for large sea trout. The numbers of salmon sized events were above average in April, May, June and July and equal to or higher than the previous recorded maximum in April, May and June.

- The number of large sea trout returning (salmon sized upstream migrations from April to July) was 9% down on 2000. It was however up by 67% on the previous 5 year average.

- Counter data from previous years indicates a general increase in the estimated number of large sea trout over the last six years, with the exception of 1998.

- The buy-back scheme of the River Fowey nets coincides with the timing of the large sea trout run and could be responsible for the increase in large sea trout numbers observed in recent years.

8.5. Small sea trout counts recorded on the River Fowey 1995 –2001.

- The main run of small sea trout (mainly school peal) occurred at a similar time to previous years with the highest numbers of fish entering the Fowey during June and July.

- A comparison of figures 1 and 2 reveals the main school peal run to occur a month or two after that of the larger sea trout.

- The total count for small sea trout in 2001 was 8051 which was the highest on record showing a 56% increase on the previous six year average. And a 22% increase on the previous maximum count (6590 in 1999).

9. Environmental factors

Environmental factors routinely measured at Restormel are flow, temperature, barometric pressure and conductivity. Rate of flow is generally considered to be the dominant factor controlling the upstream migration of salmonids especially salmon. However it should not be considered in isolation as its effects are often modified by other factors such as water temperature, changes in barometric pressure; together with wind, weather and tide conditions etc.

9.1. Flows and upstream migration on the River Fowey 1995 – 2001

The patterns of flow recorded at Restormel in 2001 during the period of the main fish runs were generally consistent with that of previous years. The main difference between 2001 and previous years were the low flows during the autumn and early winter. Figure 5 shows four distinct peaks in flow between the start of October and the end of the year (06/10, 28/10, 10/11 and 30/11). Each increase is accompanied by an increase in the numbers of upstream migrating salmon.

The low flows in autumn followed by an increase in October could possibly explain the high number of salmon recorded at Restormel in October (Figure 3). Salmon were possibly held up by the low flows and encouraged to move all at once in October when it finally started to rain.

Unlike the salmon the sea trout appear (figures 4 and 5) to not require an increase in flow to migrate up river. During the main run of both small and large sea trout the fish can be seen to move over a range of flows. Most of the sea trout especially the school peal migrating up stream under low flows (in the order of 2 cumecs).

9.2. Water Temperature

Figures 5 & 6 indicate that the patterns of fish movement coincide with rises and falls in temperature over the period 6 April – 30 October. Although the evidence for the influence of temperature on upstream migration is inconclusive (Banks, 1969) it is generally accepted that salmonids tend to move within an optimum temperature band of between 5^oC – 21.5^oC (Alabaster, 1970). Bearing this is mind the patterns of fish movement with regards to temperature are probably to be expected. However the temperature data is still of interest as part of a long term data set as the energetic costs of migrations outside of this optimum band may, in part, account for the timing of river entry and the subsequent behaviour displayed by the migrating fish (Milner, 1989). With the current interest in climate change temperature data may therefore provide early evidence on the effects of global warming on migratory fish populations and in particular changes in the timing of their migrations.

9.3. Barometric pressure

Figures 7 & 8 indicate that the relationship between barometric pressure and fish movements is not as clear as that existing for temperature and flow. It is also not clear to see from the data whether fish are moving prior to an increase in flow i.e. using a drop in pressure to predict an increase in flow. The data, as might be expected, shows a small degree of correlation between flow and barometric pressure. This is particularly evident in the period from the end of November to the end of December where changes in flow and barometric pressure mirror each other almost exactly.

Changes in barometric pressure have often been thought to a play a part in stimulating the upstream movements of salmonids. However evidence in the scientific literature is inconclusive and often contradictory. Banks (1969) conducted a thorough literature review of the factors affecting the upstream migrations of salmonids and concluded that although temperature had a significant effect on salmonid migrations the effect of changes in barometric pressure were minimal. However, anecdotal evidence seems to suggest that changes in barometric pressure may affect fish movements to a greater degree, once the fish are within the river system, and it is therefore worthy of further investigation.

10. Video Validation and Counter Efficiency

A new wire mounted camera array was installed at Restormel in 2001. This new camera system can be positioned over any of the three channels. In 2001 the array was placed over channel two in order to validate the efficiency of the counter on this side channel.

As in previous years a camera was mounted above channel one. The infra red lighting system that is installed at Restormel allowed footage to be collected 24hours a day.

Table 6 –Summary of Video Validation at Restormel Fish Counter 2001.

Channel	No. of Hours Recorded	Period of Operation	No. of Hours Watched
1	3650	17/04 – 21/12	591
2	3650	17/04 – 21/12	591

The counter efficiencies (Tables 4 & 5) are based on the number of fish that have been seen on the video and recorded by the counter, over the period 01/05/01 – 31/08/01.

The overall detection efficiency of the counter for upstream salmonids in channel one was estimated at 62%. This level of efficiency is better that that reported in the 1997 validation study (Environment Agency, 1998). This can be explained by the difference in the time of year that each validation study was carried out.

The original 1997 study concentrated on the months of July and August. Whilst the present validation study was carried out over the months May to August. The 1997 study placed more emphasis on a time of year in which there were larger numbers of small fish (school peal) which are known to decrease the counters detection efficiency.

In 2001 the detection efficiency for salmonids greater in length than 50cm was 98% which is comparable to that of the original study. The detection efficiency for fish of less than 50cm on length was 62%, which is greater than that of the original study. If non-directional events are included the detection rate for fish less than 50cm increases to 90%.

The sizing ability of the fish counter is shown in Table 5. The number of salmonids greater than 50cm was overestimated by 18% whilst the number less than 50cm was underestimated by 13% (a total of 92% were correctly sized). The sizing ability of the fish counter in this validation study has change form previous studies. The difference can again be explained by the time of year that the study was carried out. The 2001 study was carried out over a period including May and June. These months were not included in the 1997 study. Large numbers of sea trout with lengths between 40cm and 60cm (including maiden sea trout and repeat spawners) migrate up the River Fowey during these months. The higher percentage of incorrectly sized fish in the present study is due to the increased number of fish close to threshold length of 50cm. The change in the sizing efficiency of the counter with respect to the time of year is illustrated in Table 5.

Table 7 – Monthly sizing ability of Restormel fish counter.

Month	Salmonids >50			Salmonids <50			% Correctly Sized
	Counter	Video	%Error	Counter	Video	%Error	
May	113	103	9	5	15	-200	92
June	47	25	47	86	108	-26	83
July	85	74	13	93	104	-12	94
August	20	16	20	174	178	-2	98
Total	265	218	18	358	405	-13	92

11. Data Processing

The data presented in this report represents final adjusted counts, which take into account maintenance work on the weir and non-target species etc. The original monthly summary reports distributed in 2001 were intended to give a general indication of salmonid movements and to provide an estimated minimum salmonid count for each month. Any data contained within the original monthly summary reports have been superseded by this report.

12. Update

- A new wire mounted camera array was installed at Restormel in 2001. This new camera system can be positioned over any of the three channels. In 2001 the array was placed above channel two in order to validate the efficiency of the counter on this side channel.

- The implementation of a new method of stacking video recorders in series enabled 96hrs of continual footage to be recorded without the need to manually change tapes.

- A TRAKER modem was installed in 2001 to allow remote downloading of both the counts and individual graphical outputs.

- In 2001 individual graphical outputs for each events recorded by the counter were inspected as a further validation process.

13. Future Work

- Continued validation of the counters efficiency and ability to apportion species.

- The Agency intends to install a steel gantry with 3 high quality monochrome digital cameras. These will improve the picture quality over all three channels of the weir, especially during the hours of darkness.

- Assessment of fish movements in relation to river flows.

- A period of trapping to reassess and improve the fish counters ability to apportion species – under discussion.

- Reprogramming the fish counter to recognise more of the non-directional fish events as upstream fish.

- Record on video and calculate accurate lengths for all salmon sized upstream migrations recorded by the counter during the summer months. In order to gain a more accurate count of the summer grilse run on the Fowey.

- Review of the operating protocol in June and July to enable counter to improve detection efficiency.

14. Counter Downtime

The counter was operational for 8704 hours out of a possible 8760, approximately equivalent to 363 days out of a total of 365 days. The majority of this downtime can be attributed to the counter being out of operation due to a blown fuse. Renovations were undertaken on the weir in August. During this time 2 channels were always open so it was not included in the downtime. The downtime has been broken down as follows:

Table 8 – Breakdown of counter downtime in 2001.

Item	Downtime		% Downtime	
	Enforced	Routine	Enforced	Routine
Weir	0	0	0	0
Counter Maintenance	0	0	0	0
Counter Fault	56:15	0	100	0
Other	0	0	0	0

Total downtime (Hours)	56.25
Expected Operational Hours	8760
% Of Time Operational	99.36

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16. Appendices

Appendix 1 – Daily Upstream Counts in Relation to Flow (cumecs) at Restormel Weir 2001

Figure 4 Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir 2001

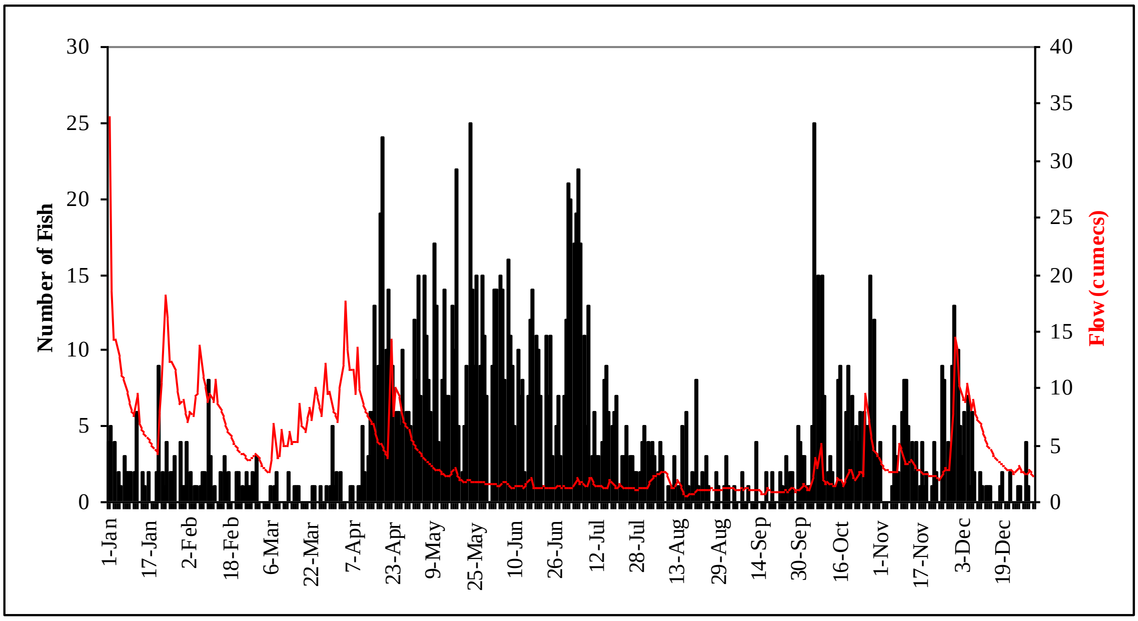
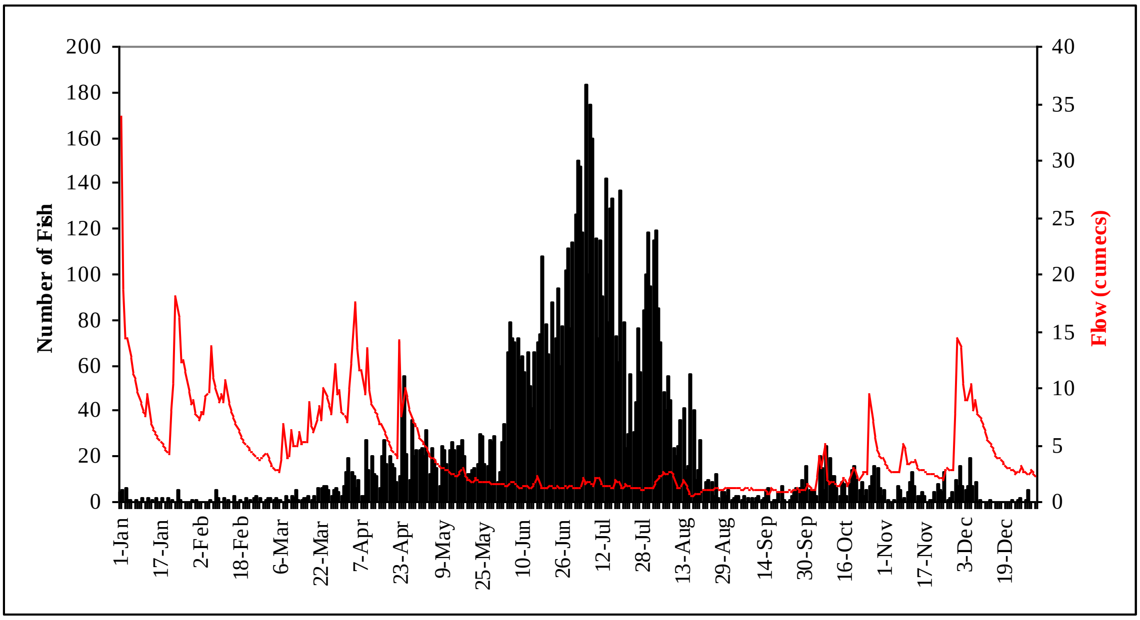


Figure 5 Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir 2001



Appendix 2 – Daily Upstream Counts in Relation to Temperature (°C) at Restormel Weir 2001

Figure 6 Daily Upstream Counts of Salmon/ Large Sea Trout in Relation to Temperature (°C) at Restormel Weir 2001

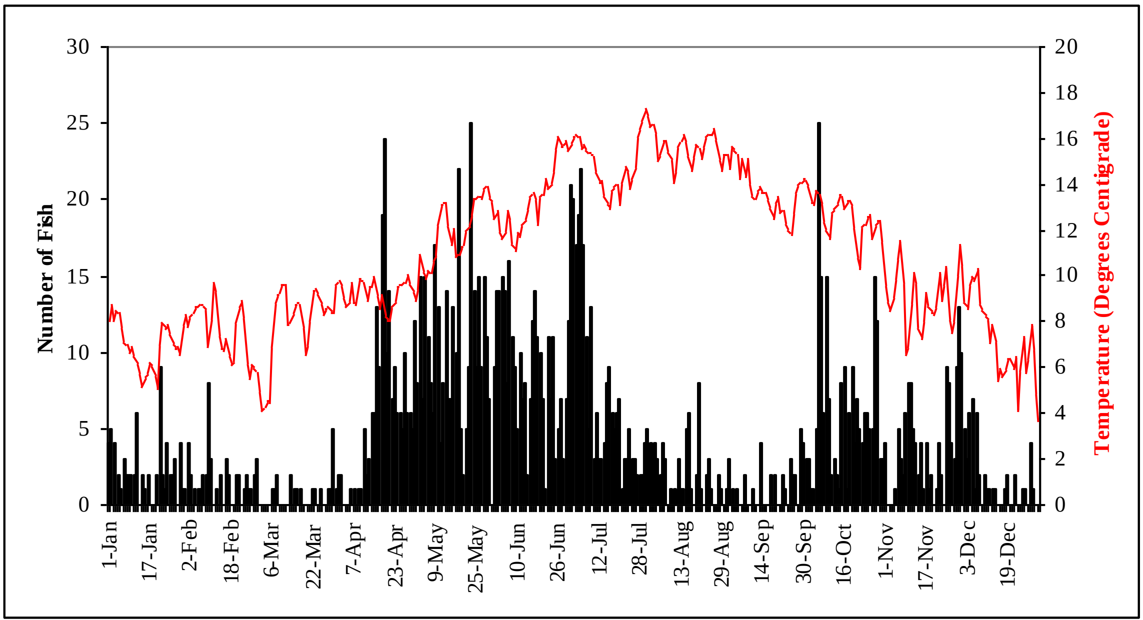
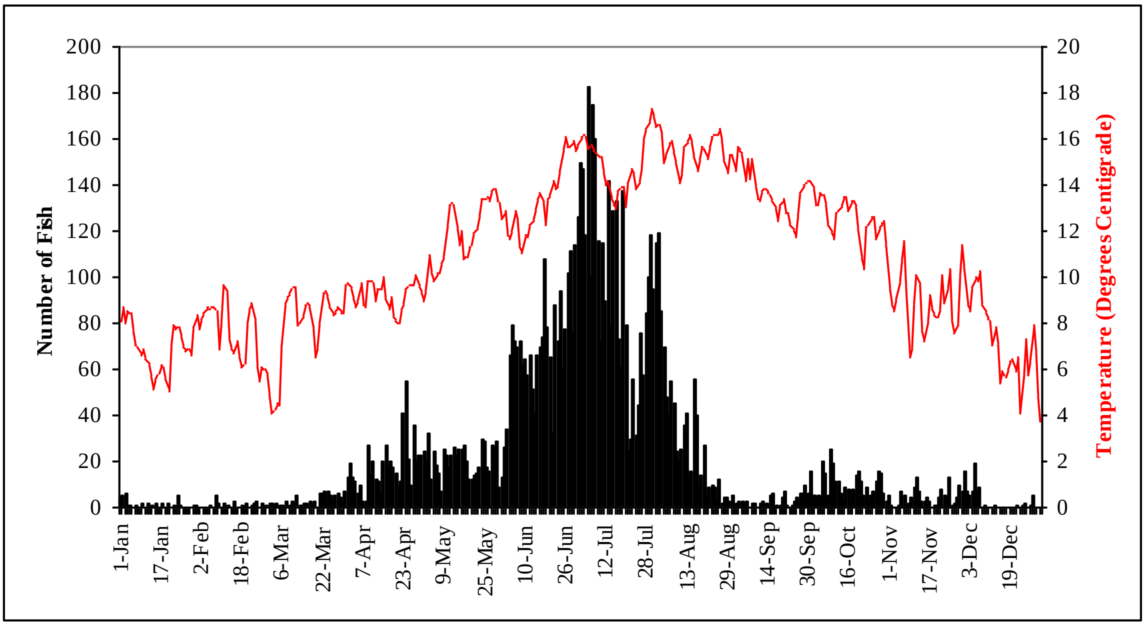


Figure 7 Daily Upstream Counts of Sea Trout in Relation to Temperature (°C) at Restormel Weir 2001



Appendix 3 – Daily Upstream Counts in Relation to Changes in Barometric Pressure at Restormel Weir 2001

Figure 8 Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Changes in Barometric Pressure (mbar) at Restormel Weir 2001

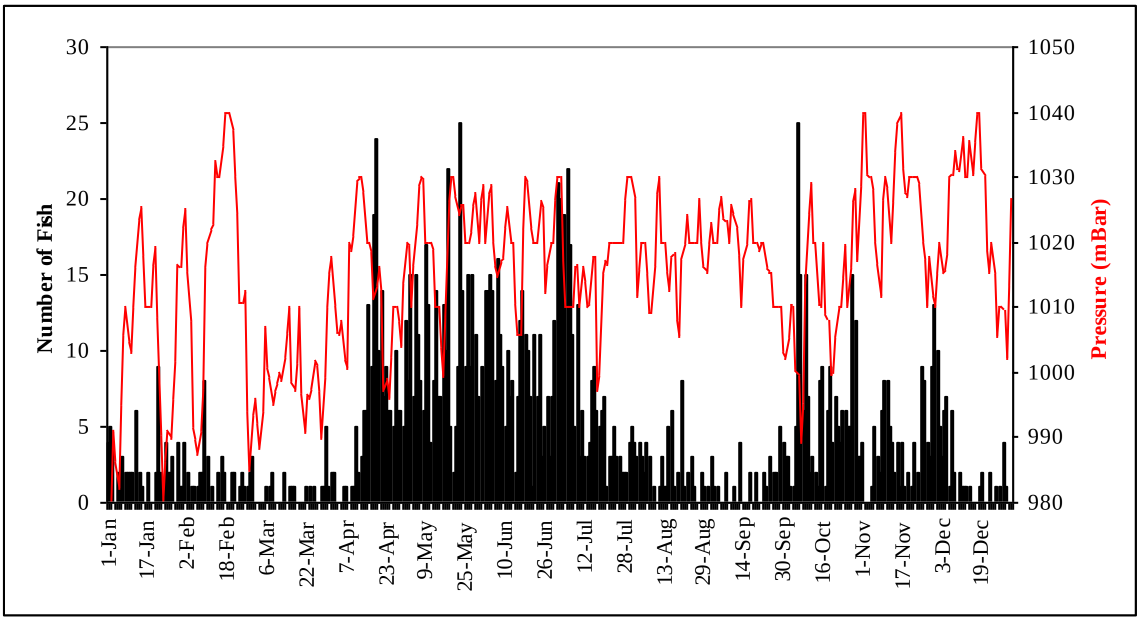
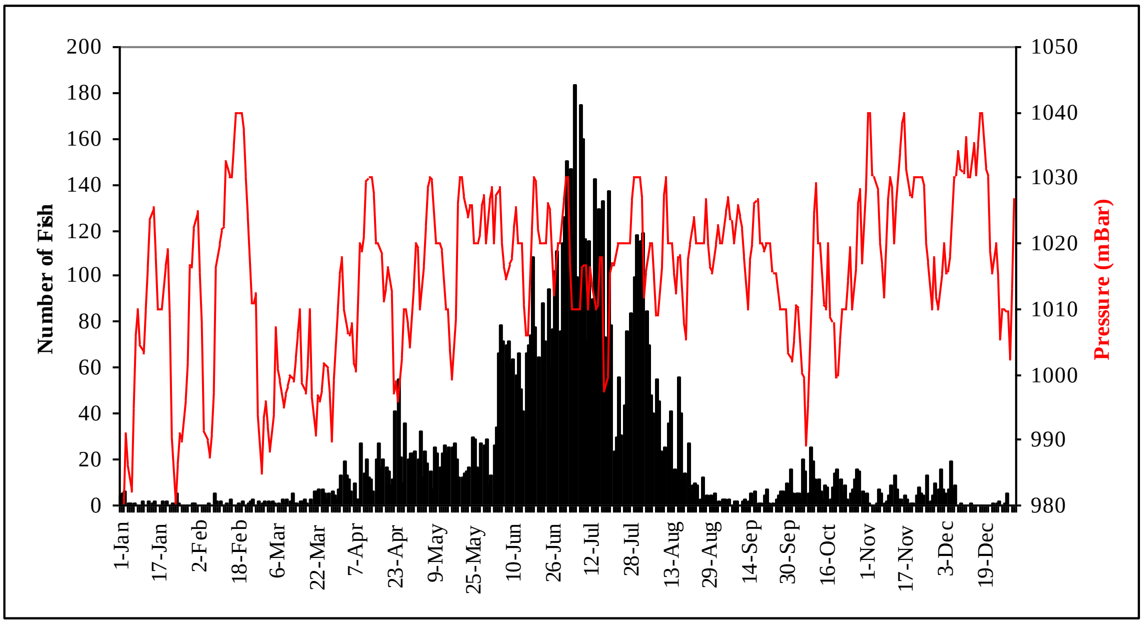


Figure 9 Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Changes in Barometric Pressure (mbar) at Restormel Weir 2001



Appendix 4 – Daily Upstream Counts in Relation to Flow (cumecs) at Restormel Weir 2001

Figure 10 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – January 2001.

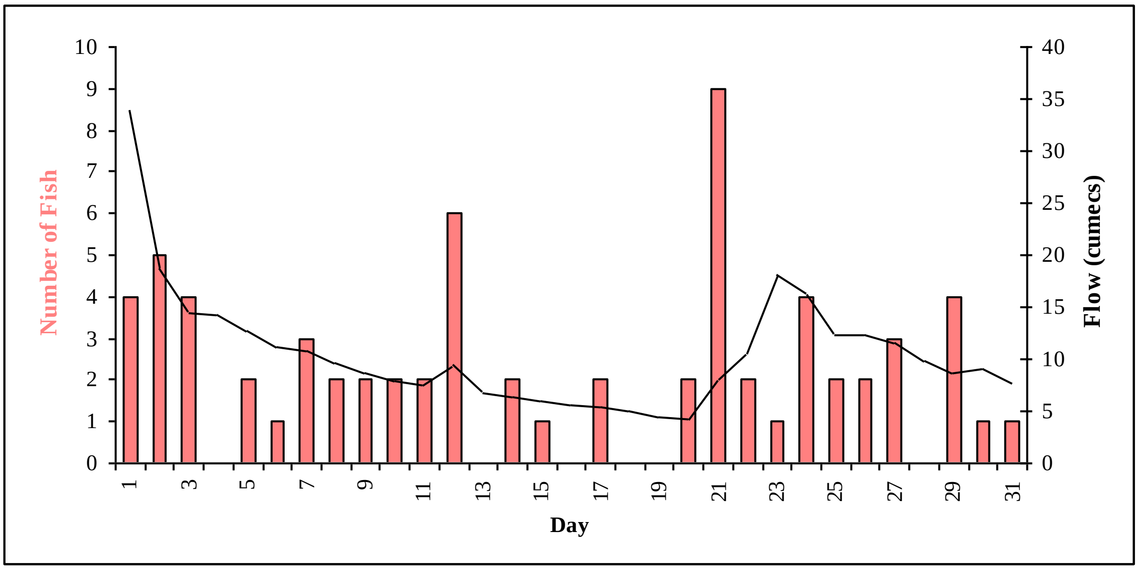


Figure 11 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – January 2001.

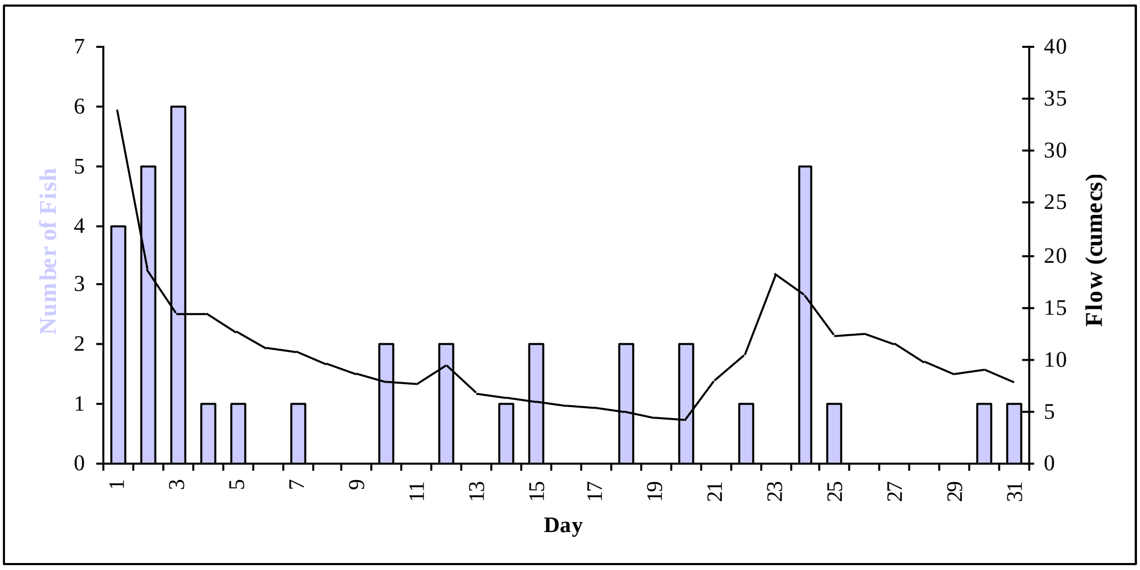


Figure 12 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – February 2001.

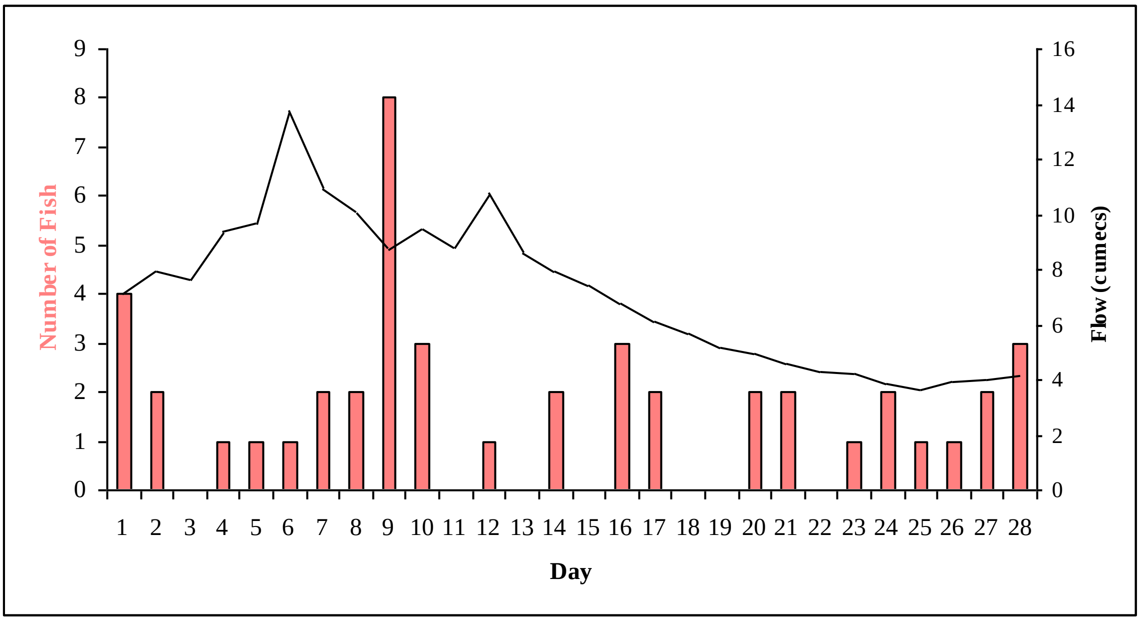


Figure 13 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – February 2001.

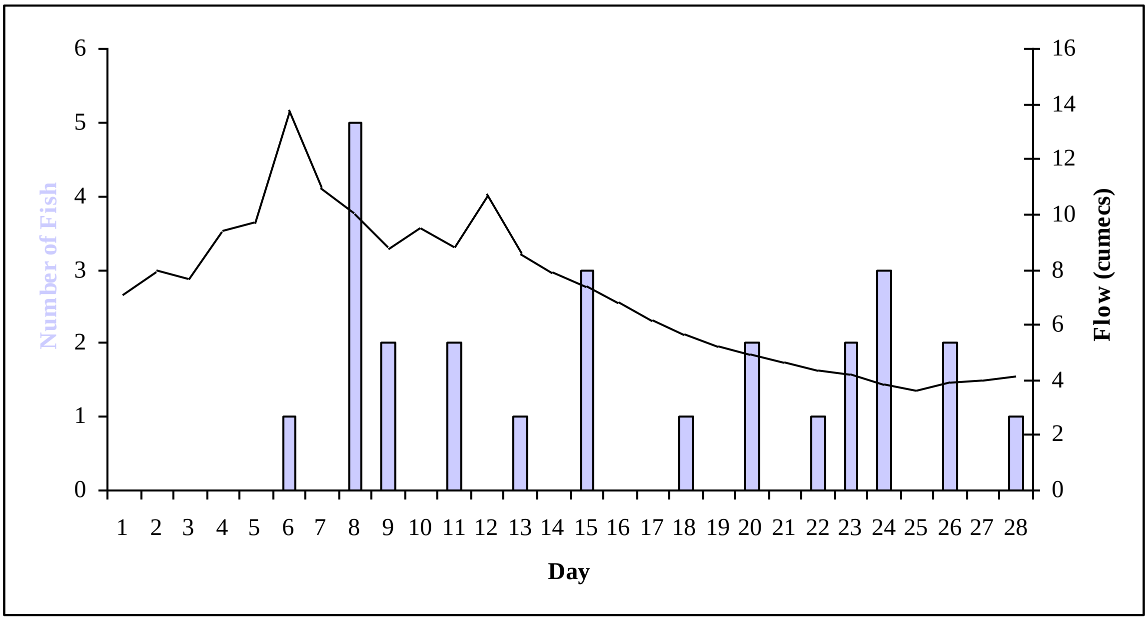


Figure 14 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – March 2001.

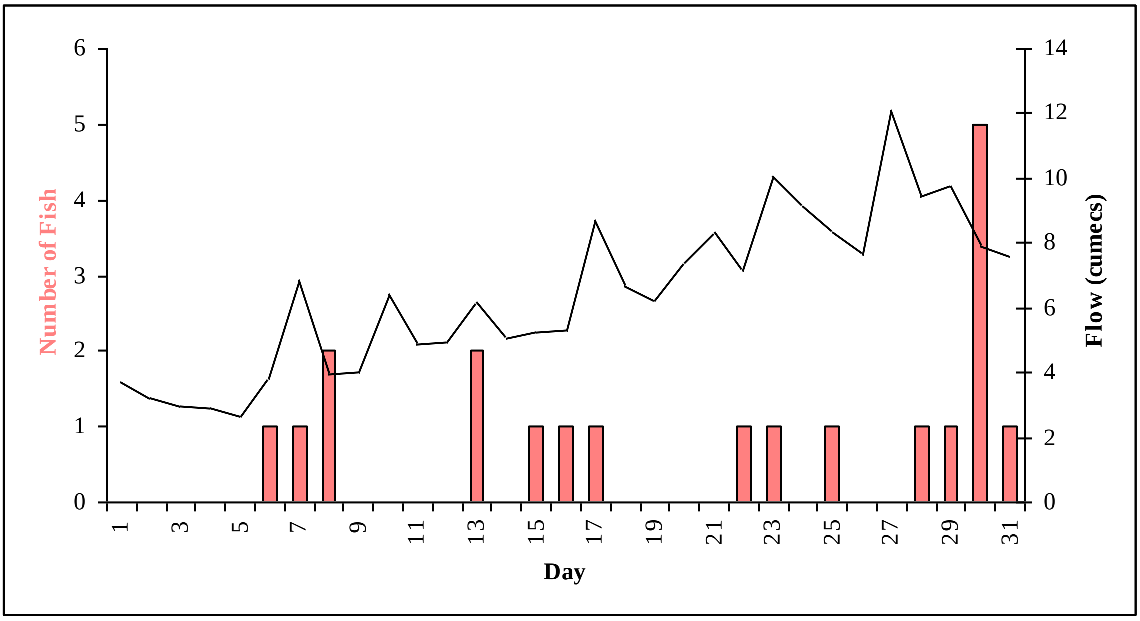


Figure 15 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – March 2001.

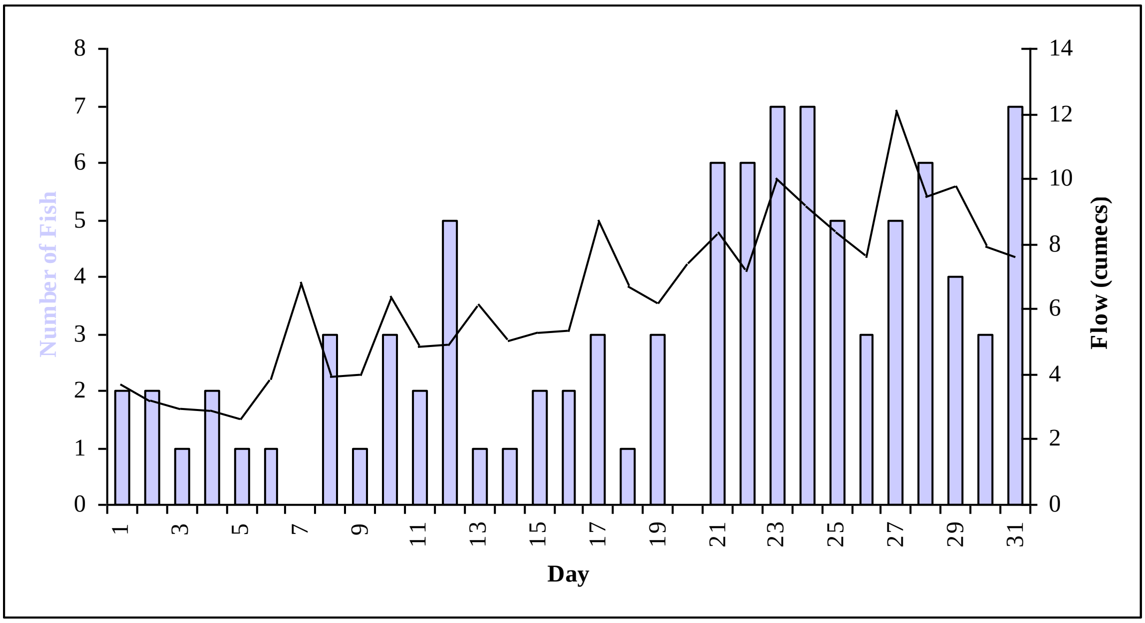


Figure 16 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – April 2001.

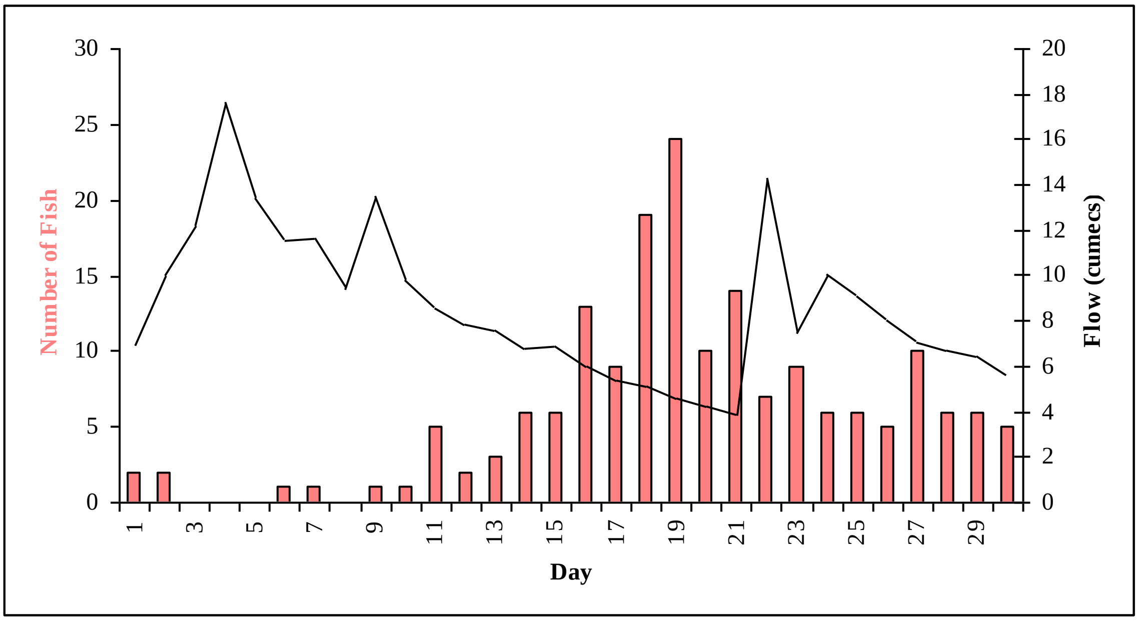


Figure 17 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – April 2001.

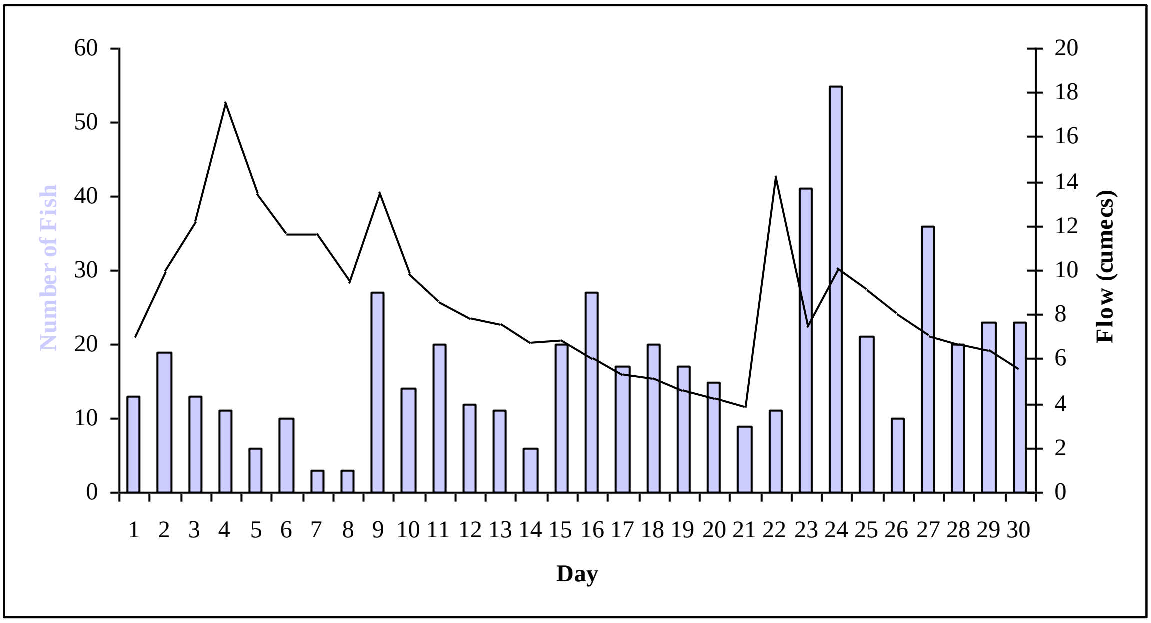


Figure 18 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – May 2001.

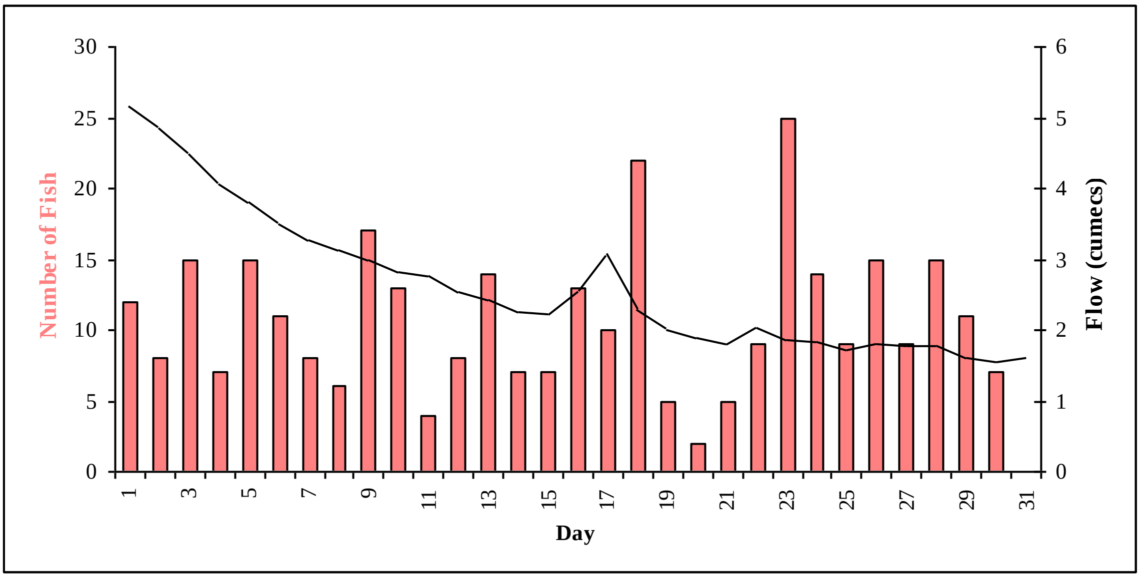


Figure 19 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – May 2001.

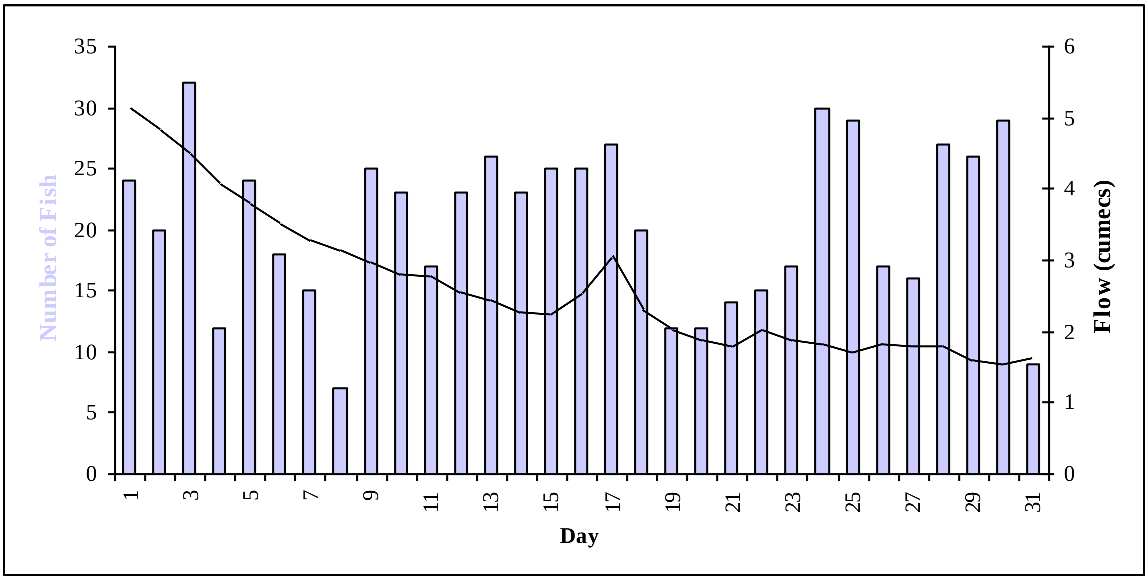


Figure 20 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – June 2001.

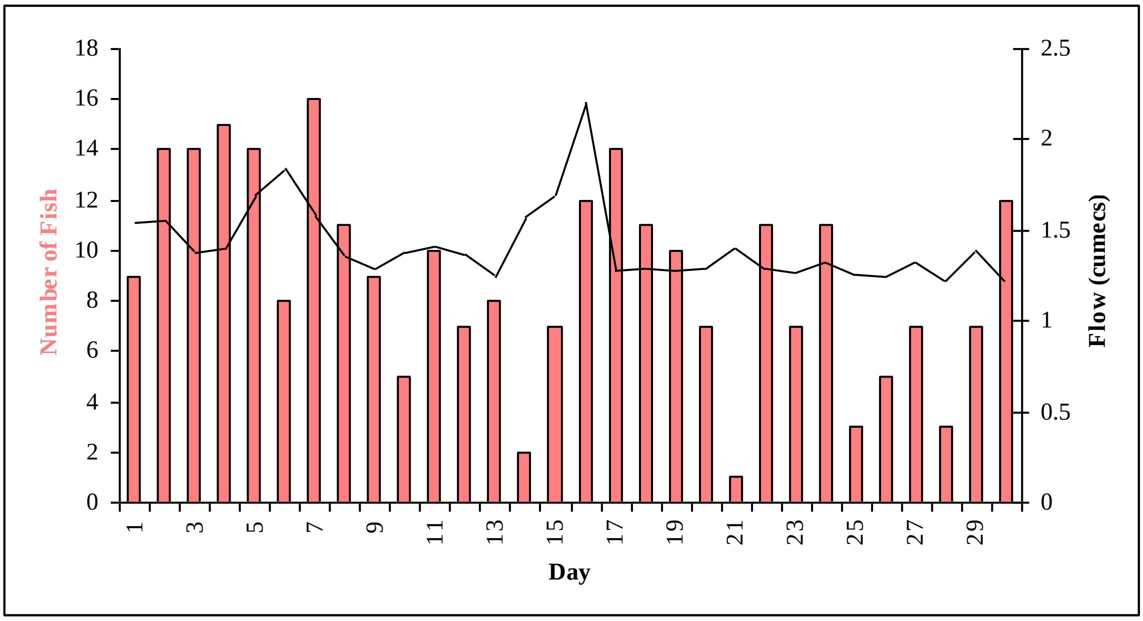


Figure 21 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – June 2001.

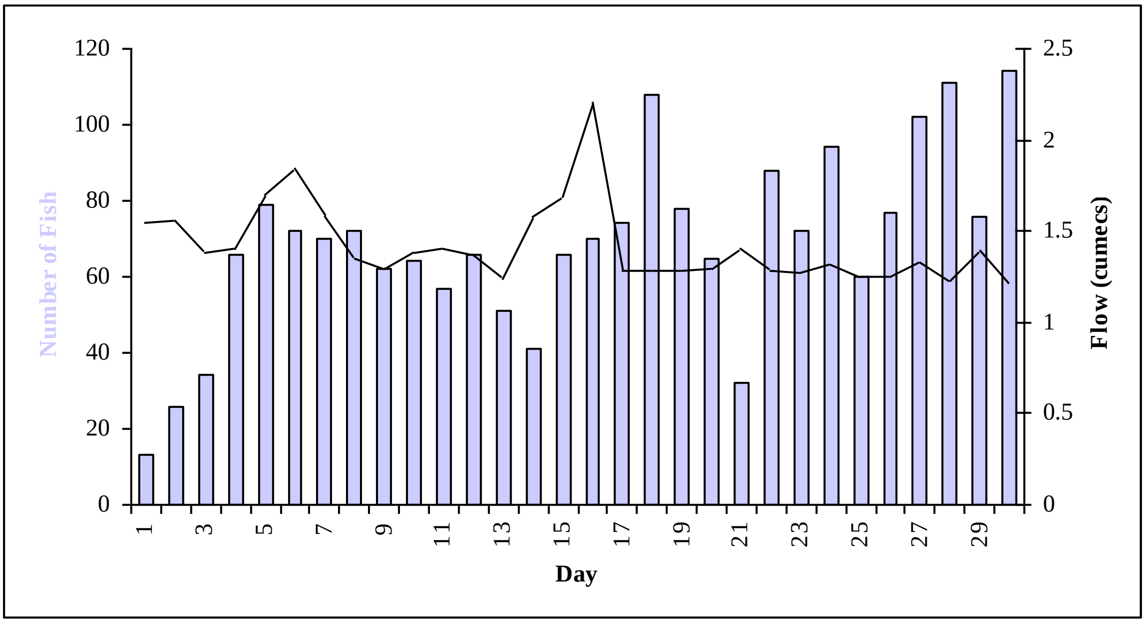


Figure 22 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – July 2001.

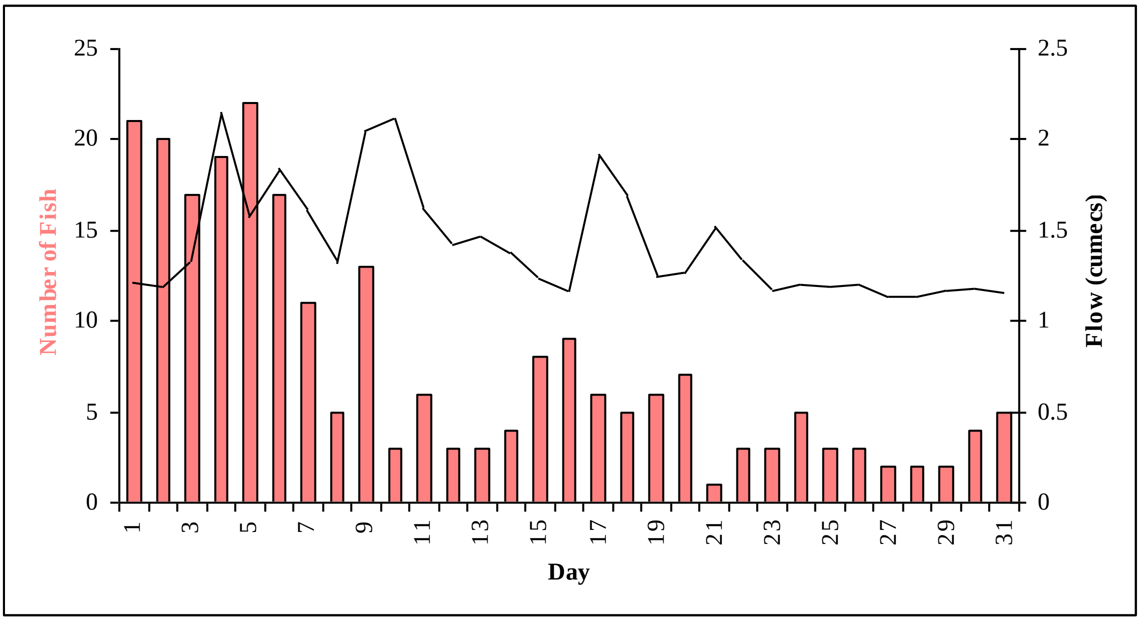


Figure 23 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – July 2001.

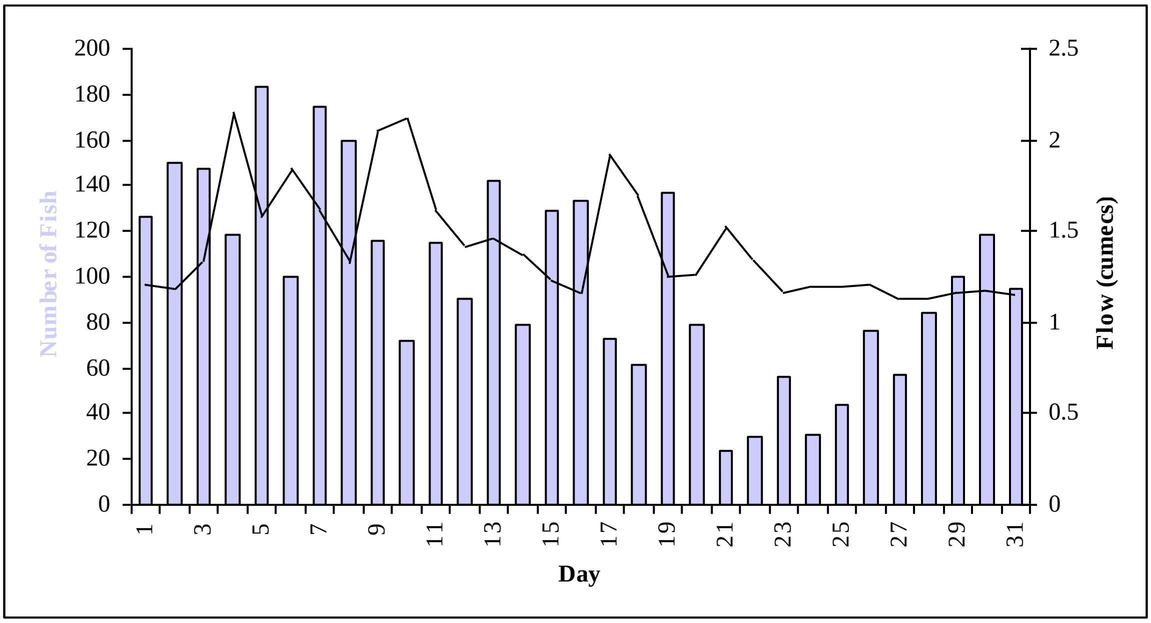


Figure 24 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – August 2001.

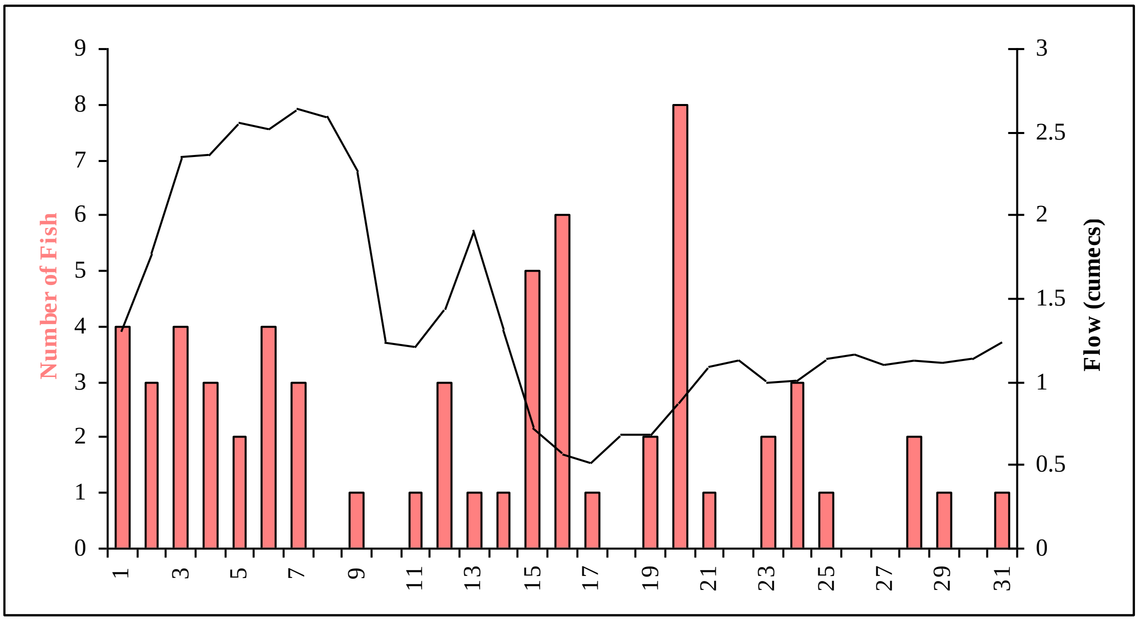


Figure 25 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – August 2001.

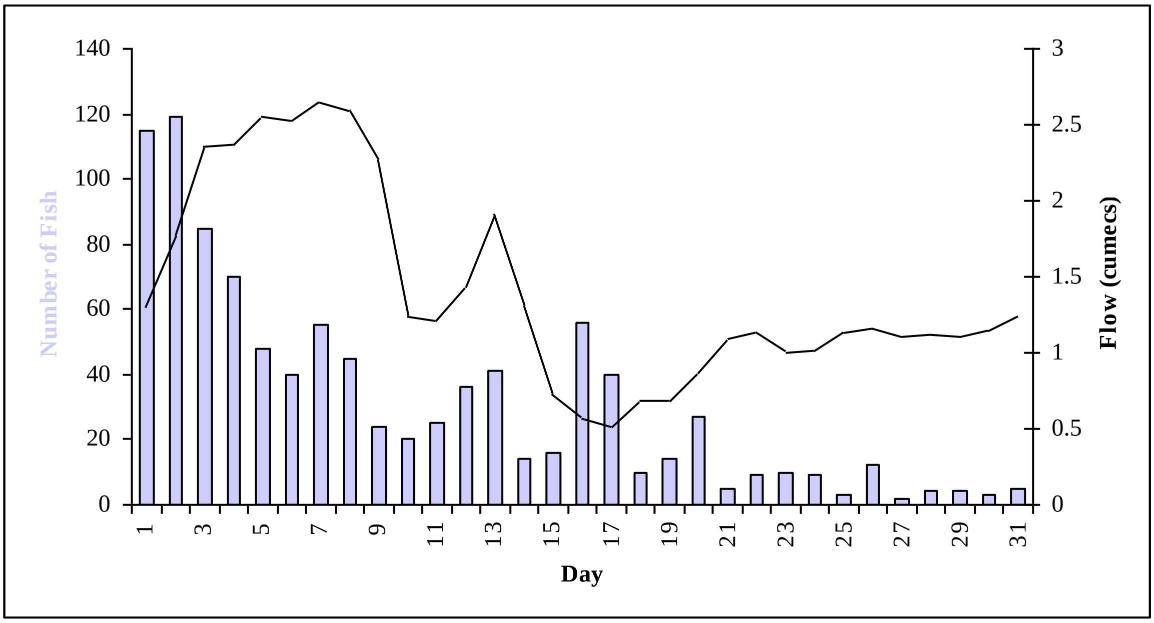


Figure 26 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – September 2001.

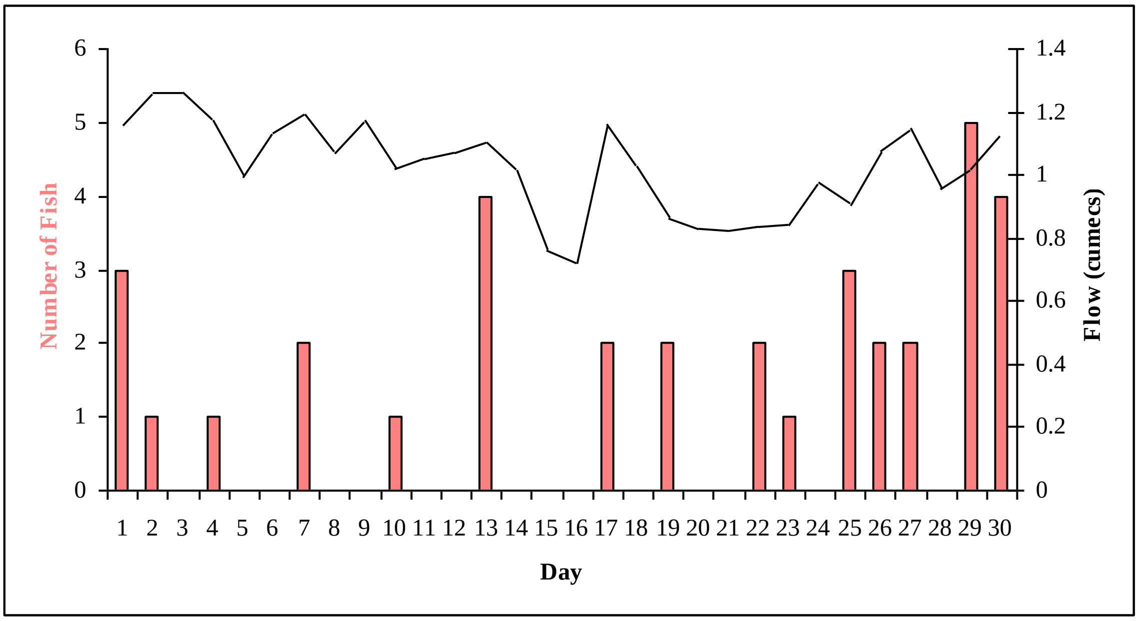


Figure 27 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – September 2001.

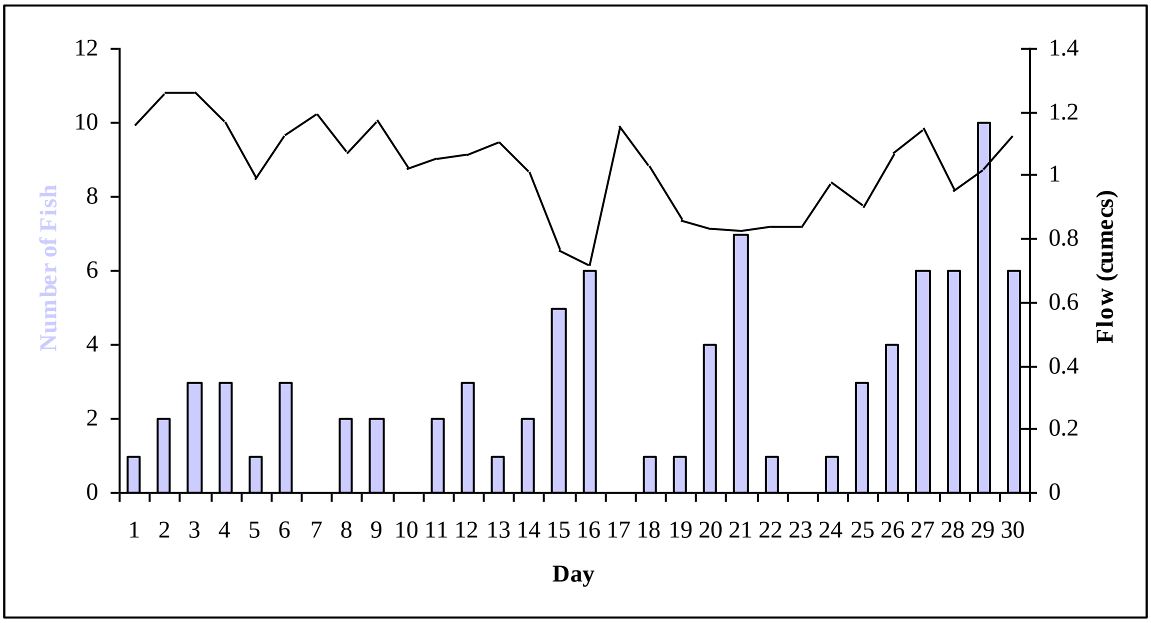


Figure 28 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – October 2001.

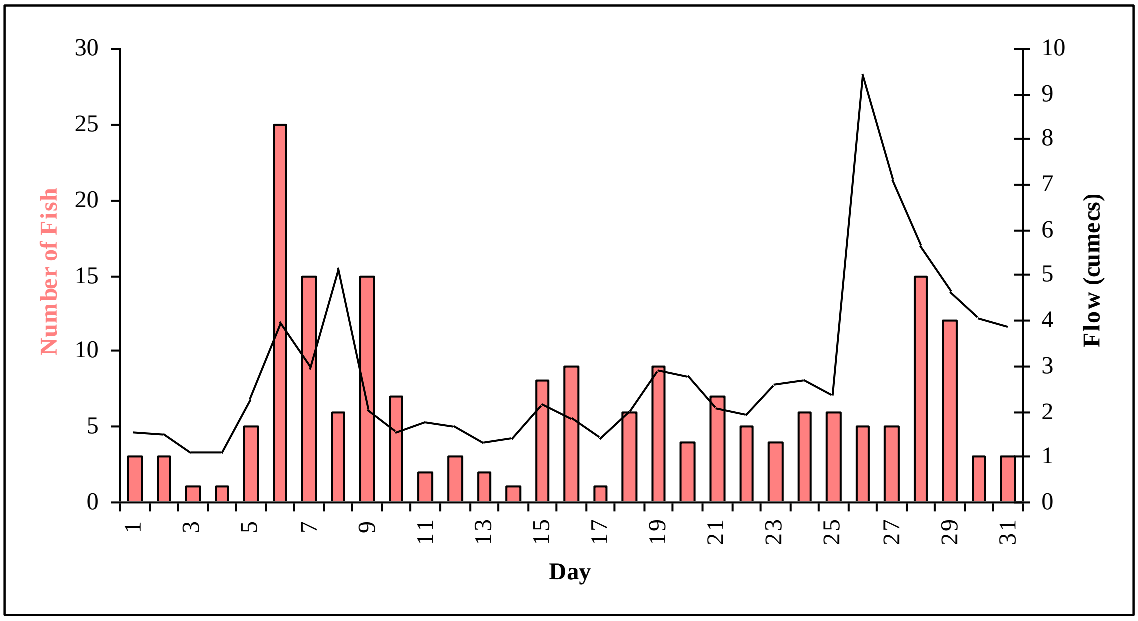


Figure 29 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – October 2001.

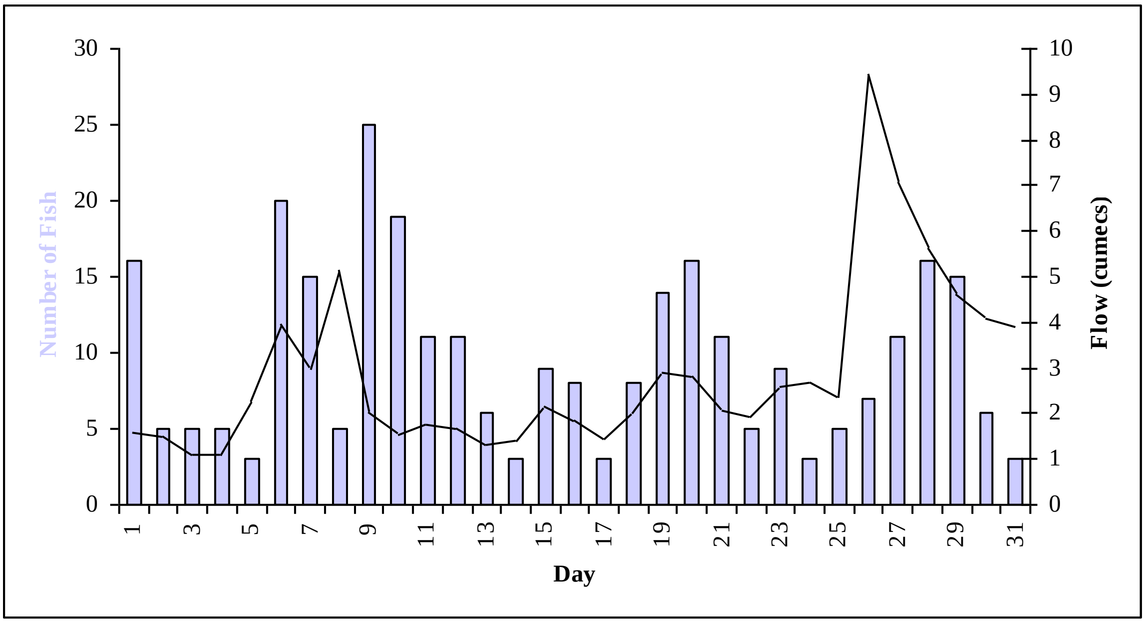


Figure 30 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – November 2001.

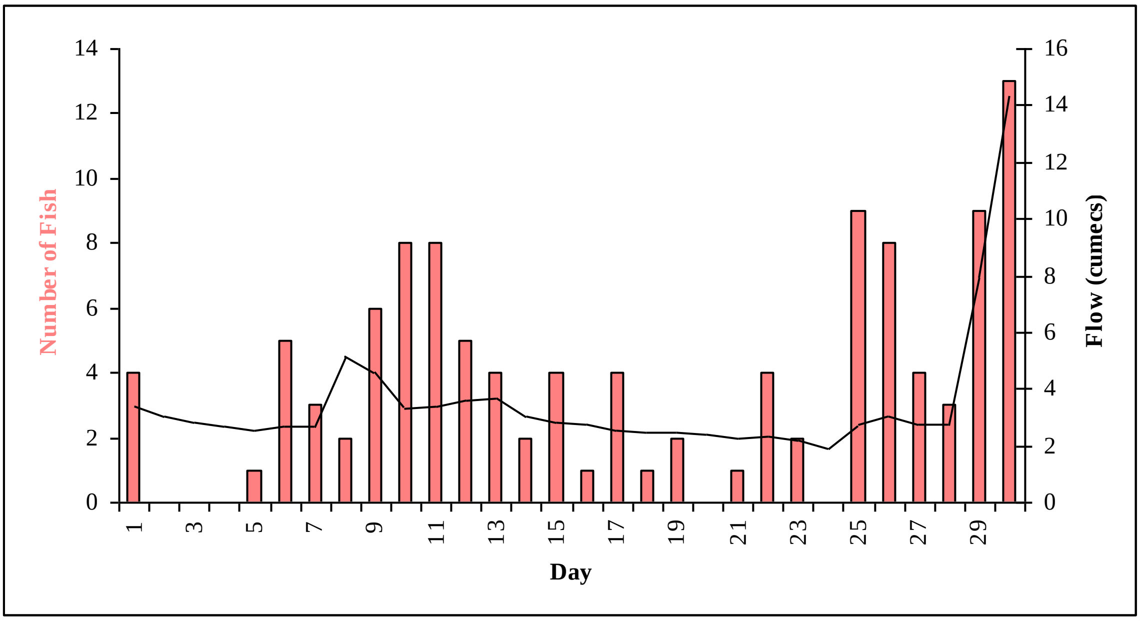


Figure 31 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – November 2001.

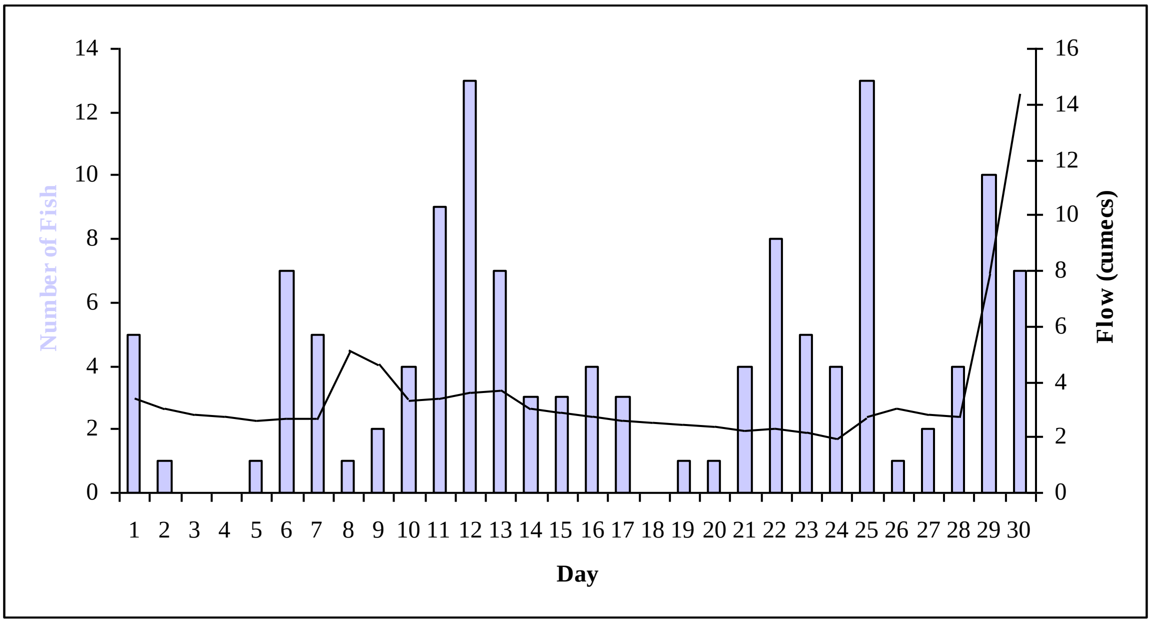


Figure 32 – Daily Upstream Counts of Salmon/Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – December 2001.

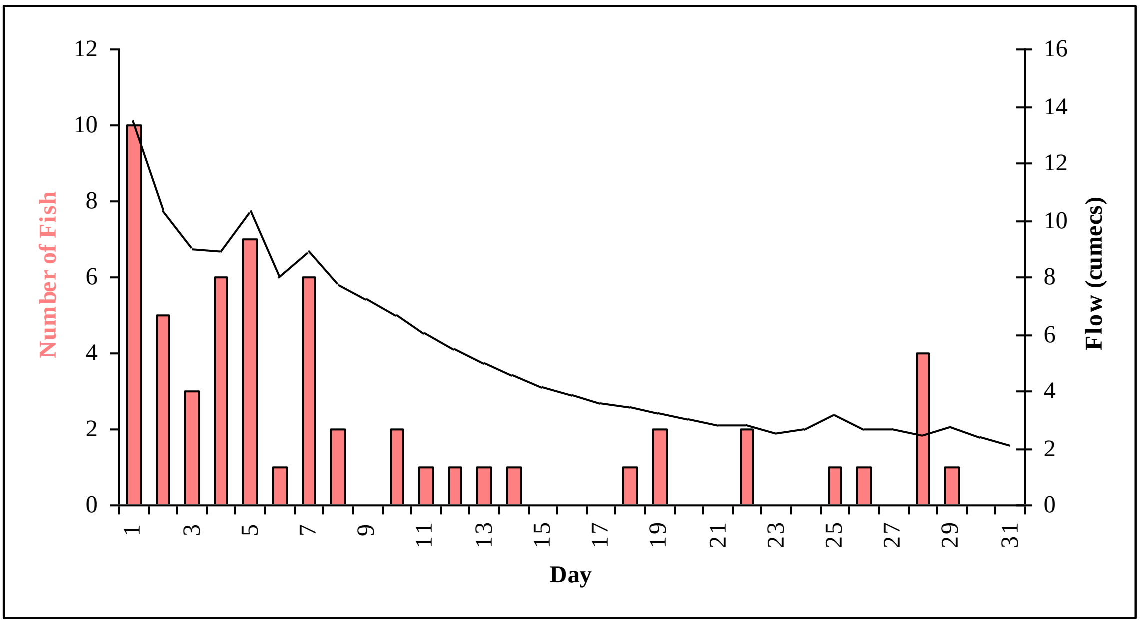
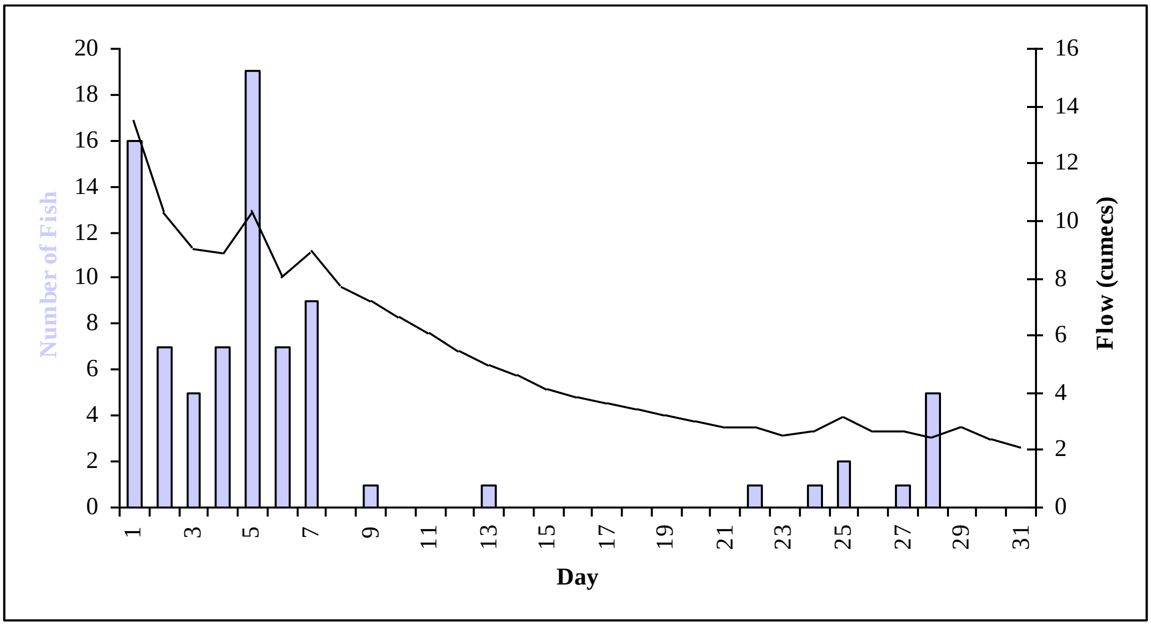


Figure 33 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – December 2001.



Appendix 5 - Operating protocol for the Logie 2100A resistivity fish counter at Restormel Weir.

To detect fish passing upstream, the Logie 2100A utilises three stainless steel electrodes that are set into the downstream face of each of the three weir channels at Restormel Weir. The construction of the fish pass ensures a smooth laminar flow of water over the electrodes and allows the fish to ascend the weir in close proximity to the electrode array. The electrodes are set into polythene blocks to reduce fluctuations in resistivity due to current “leakage” through the structure and between the electrodes.

The counter operates by applying a low positive/negative voltage (5 volts) at high frequency to the upper (+5 volts) and lower (-5 volts) electrodes. The net voltage at the central electrode is virtually zero as the two voltages effectively cancel each other out. As a fish passes over the bottom electrode it acts as a weak electrical conductor, causing an increase in the negative voltage at the central electrode. As a fish passes over the central and upper electrode it causes an increased positive voltage at the central electrode. The net result of a fish passing over the electrode array is a typical sine wave, the amplitude of the waveform being governed by the size of the fish.

The counter processes the signal received from the electrodes and uses an algorithm, together with pre-set parameters, to assess whether the object is a fish or not. If the positive and negative parts of the waveform are similar the counter recognises the ‘event’ as a fish and logs it as either an ‘upstream’ or a ‘downstream’ fish. The counter also records information connected to the event such as date, time, direction, water conductivity and signal strength (deflection signal size). If the deflection signal does not conform to that of a ‘typical fish’, it is logged as an event or discarded. In this way the counter can distinguish between fish and inanimate objects such as leaves and twigs.

Appendix 6 - Species Apportionment and Data Analysis

Species apportionment is made on the basis of the deflection signal size that is generated by the counter when a fish passes over the electrodes on the weir. The validation study conducted by the Environment Agency (1997) using video equipment to identify and measure fish traversing the weir found a linear relationship between fish length and deflection signal size. The study concluded that a deflection signal size of 50 could be used to differentiate between the majority of salmon and sea trout between June and February (88% of all fish greater than 50 cm attained a deflection size greater than 50).

Data from previous years indicated that larger sea trout run into the river from March – May. In order to eliminate these larger sea trout from the salmon count within this period, the deflection signal size to differentiate salmon from sea trout is increased to 70. It must be stressed that this relationship is not 100% accurate and that some large sea trout, those greater than 70 cm, may be counted as salmon.

It is hoped that together with video, net catch and rod catch data that the ability of the counter to apportion species can be improved to get a more accurate split both between species and within species.

Appendix 7 - Video Validation / Audit Strategy and Methodology.

Video validation studies are carried out every 5-years, or during the commissioning of a new counter, and involve a detailed analysis of video and count data.

Data audits are carried out between validation studies to provide a ‘snapshot’ of the main fish runs and to highlight any errors in the counter data. Data audits aim to watch between 10-20% of the available video over a range of flow conditions.

Video Validation / Audit Strategy.

The following strategy is valid for both validation and auditing purposes.

Video footage of fish movements is collected over the fish pass between April and August. This is when the greatest numbers of fish and a wide range of river flows have been identified. The videotape is checked for quality before the operator leaves the site to ensure that any potential problems with picture quality or equipment failure are identified and rectified.

The aim is to carry out an initial review of the videotape within 7 days of collection. As each video is watched the “viewer” is required to complete a “video session recording sheet.” This provides a record of each video session that the person has viewed and other relevant details e.g. picture quality, camera orientation etc.

The videos are reviewed twice. Initially the tapes are watched ‘blind’ i.e. without referring to the counter data. The tapes are then reviewed a second time, over the same period, using the data from the counter, to highlight fish that may have been missed during the first review. This ensures an unbiased video count and an accurate video record of fish passage.

The protocols for data audits and validation are as follows:

Data Audits

Video footage over a range of flow conditions is selected to ensure that counter efficiencies do not significantly alter with changes in flow rate. If a problem is detected in the count data then further periods are analysed to identify and rectify the problem.

The flow ranges are selected by constructing a cumulative percentage frequency curve of all the flows available to fish over the period for which video is available (Figure A). Arbitrary cut-off points of 40% and 70% are then selected to separate the flows into high, medium and low flows. Generally, most of the video footage selected for the audit covers periods of low and medium flows due to poor visibility conditions that exist during high flows, which make fish difficult to see on the video footage.

Video Validation

The watcher randomly selects, through the use of random number tables, two one-hour periods within each recorded video session. This acts as an initial screening of video data. Additional hourly periods may need to be reviewed to reach a required number of fish for statistical validity or because of poor picture quality etc.

Each period is viewed until an event i.e. fish, is seen. All events are identified. If it is a fish event then the fish is identified, where possible, and its total length and orientation (upstream/downstream) recorded.

- **Video Event Sample Size**

As large amounts of video data are collected, a meaningful method of quickly and accurately reviewing footage collected has been developed. This is based on an assumption of counter efficiency and a level of confidence required for statistical validity. Comparing the numbers of salmon and sea trout recorded by the counter with the numbers on the video footage, an estimate of counter efficiency can be made.

The following method is used as a guide to assess how many fish per sample group are required for an estimate of the counter detection efficiency at different levels of precision and confidence. A sample group could be defined as either upstream migrating salmonids or even a single species. The same criteria can be applied for different species, size classes or environmental conditions. The level of confidence for the purposes of counter validation should be between 90 - 95%.

As an example, assume that we were interested in assessing the detection efficiency of the counter for:

- Upstream migrating salmonids
- At a confidence level of 95%
- At a precision level of 5%

If we also assume a counter efficiency of 50%*, then reading the information from Table A, we can see that we would need to have seen and recorded 384 upstream salmonids on the videotapes over the year. This means that a sample size of 384 fish is required to ensure with

95% confidence that the estimated efficiency will be within ±5% of the true estimate - Environment Agency R&D Technical Report (1997).

**Based on the lowest efficiency that we could expect.*

Table A – Sample size required at various levels of confidence and precision, assuming a 50% counter efficiency.

Precision / Confidence	90%	95%	99%
0.01	6765	9604	16590
0.05	271	384	664
0.1	67	96	166
0.2	17	24	42

Table extract taken from Environment Agency R&D Technical Report (1997).

To reach the given sample size, two one-hour periods per 24-hour period are randomly selected. The periods are reviewed and the number of upstream migrating salmonids within each one-hour period recorded. If the required sample size is not reached then additional one-hour periods can be reviewed until the required sample size is reached. In practice, all of the video footage for the year is first reviewed using the above technique. If, at the end of the tape review, the sample size for the whole year is below the required sample size or level of confidence/precision, then the tapes are reviewed again. This time, only one hour per day would be randomly selected until the required sample size is reached. Alternatively, a lower level of confidence, requiring a smaller sample size, could be selected.

- **Matching Counter Data and Video Events**

To determine the efficiency of the:

i. Counter
ii. Video watching

During the second videotape review, the counter data is utilised to identify events that have been detected or missed by the counter. The video data is then matched to the corresponding counter data and recorded as one of the following:

- Upstream Fish - Salmon, Sea Trout or other species.
- Downstream Fish - Salmon, Sea Trout or other species.
- Upstream Event
- Downstream Event