Environment Agency

South West Region

Restormel Fish Counter

Annual Report 2002

Ecological Appraisal Team
Devon and Cornwall Area
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Executive Summary

- The following report presents the daily upstream counts of migratory salmonids recorded on the River Fowey at Restormel Weir fish counting station (SX 107 613) in 2002.

- Data contained within this report covers the period of the commercial migratory salmonid net buy-back scheme and the National Spring Salmon Bylaws:
  - Net buy-back (2nd March – 15th June inclusive)

- The fish counter at Restormel is a resistivity based system (Logie 2100A – Aquantic limited) and is installed on the weir at Restormel approximately 2 km upstream of the tidal limit.

- The run pattern observed for salmon and sea trout in 2002 was generally consistent with that of previous years. However, the total combined annual count of upstream migrating salmon and sea trout on the River Fowey in 2002 was 7% higher than the 7-year average.

- The upstream salmon / large sea trout count for 2002 was 1804, 12% higher than that recorded in 2001. This count is the highest recorded over the past 8 years. Minimum estimates for salmon and large sea trout derived from the salmon large sea trout count are as follows:

  - The minimum upstream salmon estimate for 2002, over the period July 2002 to February 2003, was 41% higher than that recorded over the same period in 2001. This count is the highest recorded for salmon over the past 8 years.

  - The minimum upstream large sea trout estimate for 2002, over the period March to June, was 10% lower than that recorded over the same period in 2001. This count is the third highest recorded for large sea trout over the last 8 years.

- The upstream (small) sea trout (deflections less than 50) count for 2002 was 6% higher than that recorded in 2001. This count is the highest recorded for (small) sea trout over the last 8 years.

- The significant increases in the salmon and sea trout counts are extremely encouraging. The 2002 data, together with the overall consistency of the numbers over recent years suggests that measures designed to protect salmonid stocks may in fact be working.

1. Introduction

The following report presents upstream salmon and sea trout counts recorded on the River Fowey at Restormel fish counting station (SX 107 613) during 2002. The count data has been considered with respect to:

- daily mean residual flow (cumecs)
- temperature (^oC)
- barometric pressure (mBar)

The flow data reflects the residual flow that exists at Restormel Weir following abstraction by South West Water (SWW) at Restormel water treatment works (SX 107 613).

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 and to develop improved methodologies for species apportionment.

2. Background

Fish counters, such as the one installed at Restormel Weir, are increasingly becoming essential tools in the management of salmonid fisheries. They provide vital baseline data on the size of the migratory salmonid populations and information on the times during which their migrations occur. This information used in conjunction with other fishery data, such as juvenile salmonid survey data and rod / net catches, significantly enhances the formulation of effective management strategies.

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 (Environment Agency, 1998).

The counter at Restormel is the second resistivity-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).

A description detailing the operation of the resistivity fish counter at Restormel is provided in Appendix 5.

3. Net Buy-Back

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.

4. Species Apportionment

The counter has the ability to record electrical changes that are directly proportional to the size of fish that have traversed the counter electrodes. Species apportionment is possible due to the linear relationship that exists between fish length and deflection size. However, 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.

5. Validation of counter efficiency

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

Video validation and the annual audit of counter data is a vital part of the fish counter work at Restormel and gives confidence in the accuracy of the data that the fish counter is recording. A complete description of the video validation strategy and methodology is described in Appendix 10.

6. Results

The migratory salmonid counts obtained for the River Fowey recorded at Restormel fish counting station in 2002 are presented as follows:

6.1. Upstream Fish Counts

Figure 1: Presents the monthly upstream counts for salmon / large sea trout recorded at Restormel weir in 2002. The error bars indicate the 7-year average (arithmetic mean) together with maximum and minimum values (1994 – 2001). The total number of salmon / large sea trout counted moving upstream in 2002 was 1804 (Table 1).

Figure 2: Presents the monthly upstream counts for sea trout recorded at Restormel weir in 2002. The error bars indicate the 7-year average (arithmetic mean) together with maximum and minimum values (1994 – 2001). The total number of sea trout counted moving upstream in 2002 was 8556 (Table 2).

Figure 3: Presents the comparative annual upstream counts (minimum estimates) for salmon on the River Fowey (1994 – 2002) over the period July – February.

Figure 4: Presents the monthly (adjusted) upstream counts for salmon (July – February) at Restormel Weir (1995 – 2002). The error bars indicate the 7-year average (arithmetic mean) together with maximum and minimum values (1994 – 2001).

Figure 5: Presents the adjusted annual upstream counts for sea trout recorded at Restormel Weir (1995 – 2002).

Figures 6 & 7: Presents the daily upstream counts for salmon / large sea trout and sea trout, in relation to monthly mean residual flow (cumecs) at Restormel Weir in 2002 (Appendix 1).

Figures 8 & 9: Present the daily upstream counts for Salmon / Large Sea Trout and sea trout, in relation to daily mean temperature (^{o}C) – Appendix 2.

Figures 10 & 11: Present the daily upstream counts for Salmon / Large Sea Trout and sea trout in relation to daily mean barometric pressure (mBar) – Appendix 3.

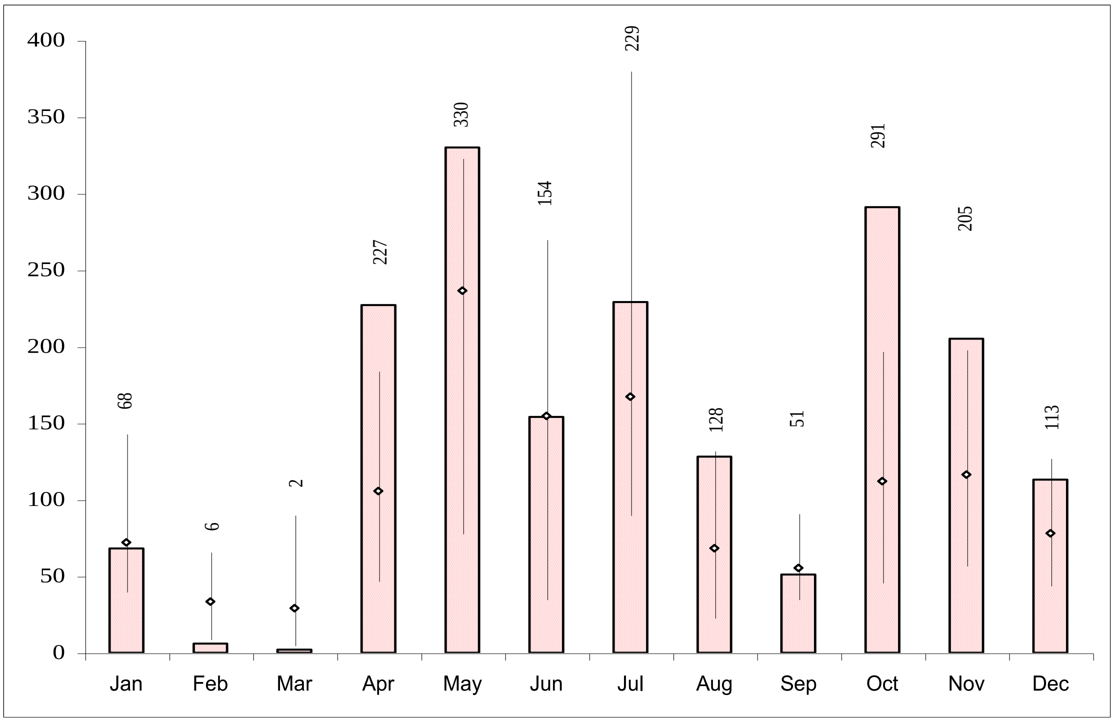
Figures 12 – 35: Each of these figures presents daily upstream counts for salmon / large sea trout and sea trout, for each month, in relation to daily mean residual flow (cumecs) recorded at Restormel weir (Appendix 4).

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.

- The flow data presented is the residual flow that exists at Restormel Weir following water abstraction by South West Water.

Figure 1 – Monthly Upstream Counts for Salmon at Restormel Weir 1994 – 2002.

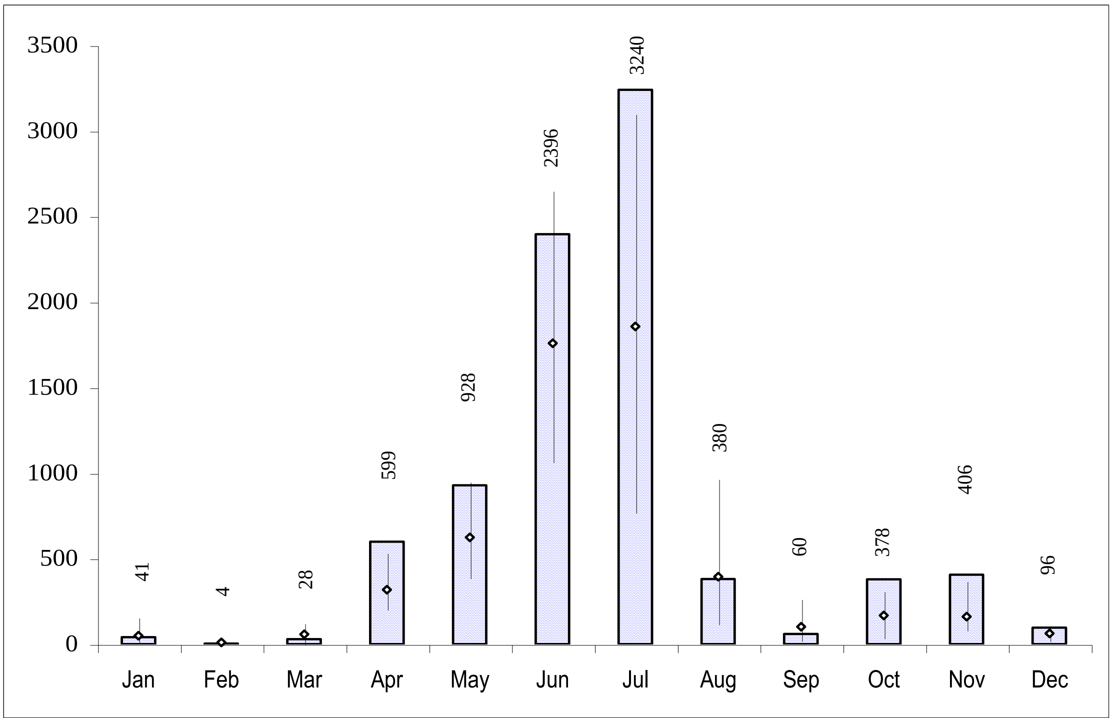


** Data labels and coloured bars indicate 2002 figures. High low bars indicate max, min and average from 1994 - 2001.*

Table 1 - Monthly Upstream Counts for Salmon / Large Sea Trout at Restormel Weir 1994 – 2002.

Month	1995	1996	1997	1998	1999	2000	2001	2002	7-yr average
Jan	108	143	62	40	41	41	69	68	72
Feb	26	9	66	26	27	34	46	6	33
Mar	12	9	5	8	60	90	20	2	29
Apr	47	103	80	56	90	184	179	227	106
May	78	207	264	206	254	323	323	330	236
Jun	35	153	183	69	146	226	270	154	155
Jul	94	129	90	105	135	380	238	229	167
Aug	23	66	63	51	80	132	63	128	68
Sep	50	53	49	64	46	91	35	51	55
Oct	97	159	46	137	72	76	197	291	112
Nov	198	101	85	76	184	57	113	205	116
Dec	122	55	82	44	127	58	58	113	78
Totals	890	1187	1075	882	1262	1692	1611	1804	1228
Correction for counter efficiency	918	1224	1108	909	1301	1744	1661	1860	

Figure 2 – Monthly Upstream Counts for Sea Trout at Restormel Weir 1994 – 2002.

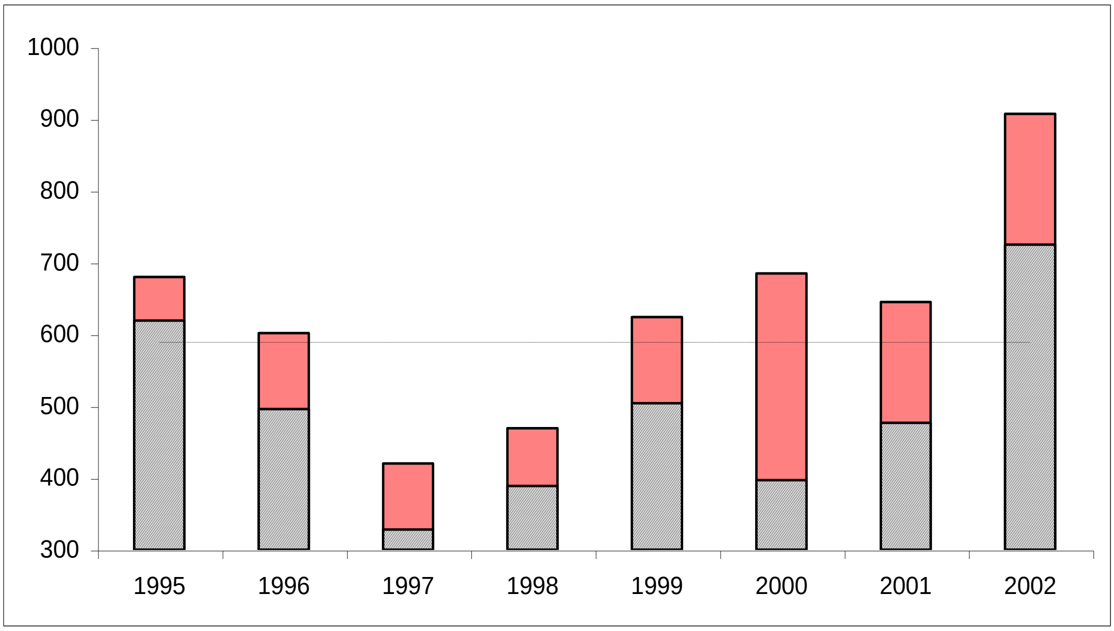


** Data labels and coloured bars indicate 2002 figures. High low bars indicate max, min and average from 1994 – 2001.*

Table 2 - Monthly Upstream Counts for Sea Trout at Restormel Weir 1994 – 2002.

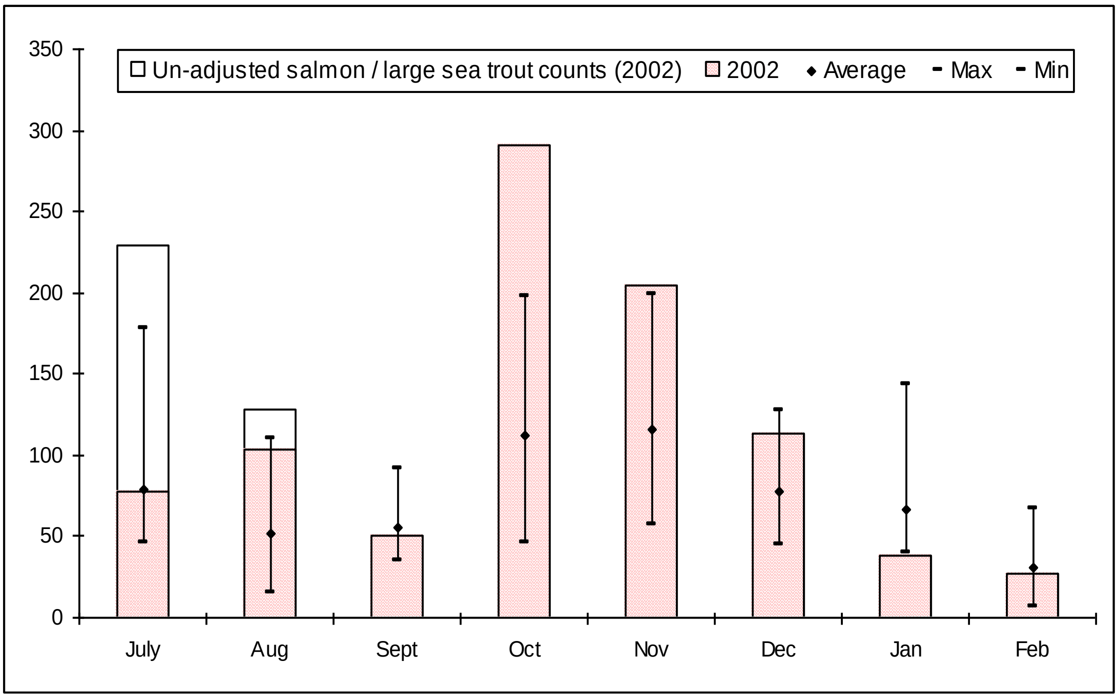
Month	1995	1996	1997	1998	1999	2000	2001	2002	7-yr average
Jan	52	156	13	46	18	15	38	41	48
Feb	8	10	4	6	9	12	26	4	11
Mar	47	18	1	35	87	122	95	28	58
Apr	274	303	264	256	203	397	533	599	319
May	446	573	388	948	556	817	639	928	624
Jun	1759	1065	1454	1070	2649	2254	2060	2396	1759
Jul	1513	2578	1237	770	2056	1736	3100	3240	1856
Aug	368	489	116	214	408	199	966	380	394
Sep	263	92	21	36	114	102	86	60	102
Oct	310	125	36	107	121	174	298	378	167
Nov	368	84	113	82	259	93	128	406	161
Dec	98	18	30	20	110	81	82	96	63
Totals	5506	5511	3677	3590	6590	6002	8051	8556	5561
Correction for counter efficiency	5676	5681	3791	3701	6794	6188	8300	8821	

Figure 3 - Annual upstream counts (minimum estimates) for salmon on the River Fowey over the period July – February (1995 – 2002).



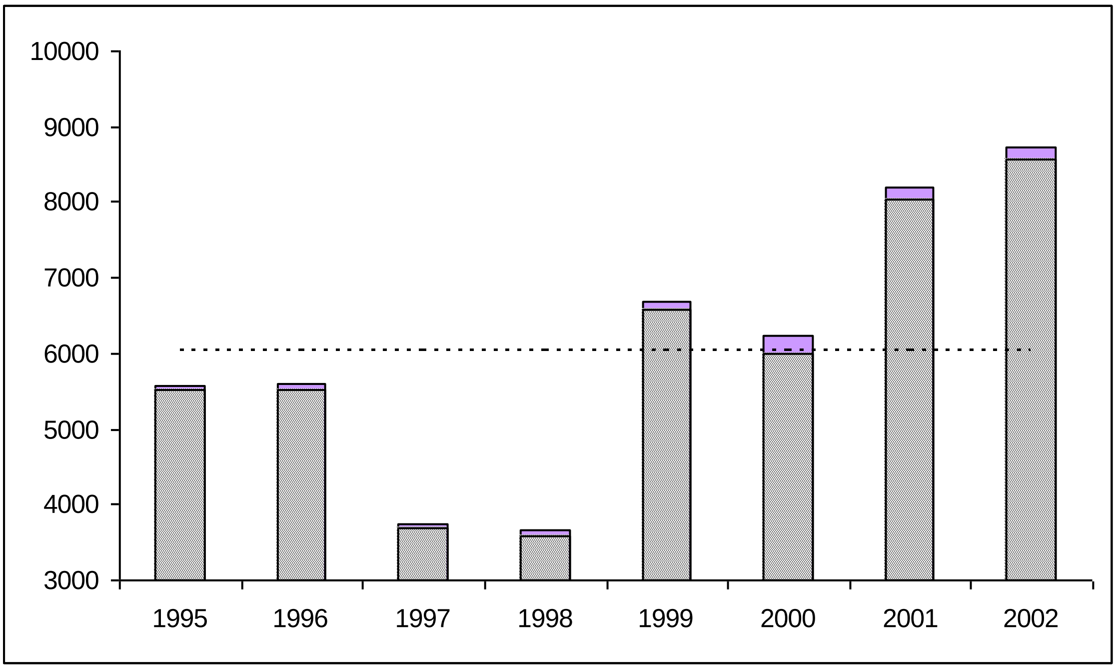
Note: - Dotted line denotes 7-year average (589). The 7-year average takes into account counts for July and August. The coloured bands indicate the additional August and July counts.

Figure 4 – Monthly (adjusted) upstream counts for salmon (July – February) at Restormel Weir (1995 – 2002).



Note: - High low bars indicate max, min and average (adjusted) from 1995 – 2001.

Figure 5 - Adjusted annual upstream counts for sea trout recorded at Restormel Weir (1995 – 2002).



Note: - Dotted line denotes 7– year average. The coloured bands indicate the additional August and July counts resulting from the removal of salmon events from the salmon / large sea trout count data.

6.2. Video Validation & Counter Efficiency

6.2.1 Counter Efficiency

Table 3 – Analysis of video validation data for Restormel fish counter (2002).

Counter Event	Counter	Trace	Video	% Efficiency	
				Counter:Trace	Trace:Video
Upstream Salmonid Counts	44	186	192	24	97
Missed Counts	6	6	0		
Non - directional events (E)	154	12	14		
Downstream events	2	2	0		

The overall detection efficiency for upstream salmonids for the period 12th March to 10th September was 97%, which is higher than that recorded in 2001 (90%). The detection efficiency was calculated using data for upstream migrating salmonids (individuals and groups) detected by the counter or seen on video. Non-target species (otter's etc) or spurious events were removed from the data prior to this analysis. Trace efficiencies have been included to illustrate how trace information can be used as a relatively quick way of checking raw fish counter data and to improve count accuracy when video data is unavailable.

6.2.2 Size Correction Factors

Table 4 utilises matched counter and video data for upstream migrating salmonids to calculate count correction factors for the period 10th May to 24th September 2002. All non-target species i.e. non-salmonids, have been removed for the purposes of this calculation.

Table 4 – Size correction factors for salmonid counts recorded at Restormel fish counter (10th May to 24th September 2002).

Deflection	Counter	Video	Size (cm)	Correction Factor
Salmonids >50	90	70	**Salmonids >50**	0.78
Salmonids <50	110	130	**Salmonids <50**	1.18
Total	200	200		

Table 4 utilises matched counter and video data for upstream migrating salmonids to calculate the percentage error in the sizing ability of the counter. The matched counter and video data indicates that the number of fish greater than 50cm was overestimated by 13% whilst the number less than 50cm was underestimated by 18%.

7. Discussion

Figures 1 and 2 indicate that the seasonal run patterns observed for salmon / large sea trout and sea trout on the River Fowey in 2002 were generally consistent with previous years.

There was a 7% increase in the total combined annual count for upstream migrating salmonids on the River Fowey in 2002 (10360) when compared to 2001 (9662) for the same period.

Comparisons with the 7-year average (6789) indicate that the total combined count for salmonids in 2002 (10360) has increased by 53%.

7.1. Salmon / large sea trout counts recorded on the River Fowey 1995 – 2002.

The minimum salmon / large sea trout count estimate for 2002 was 1804. Overall, the salmon / large sea trout run estimate for 2002 was 12% higher than in 2001 (1611) and was the highest recorded count over the past 8 years. The lowest was recorded in 1998 (882).

The salmon / large sea trout counts for 2002 are up on the 7-year monthly averages with the exception of January, February, March, June and September and 47% up on the 7-year average overall.

Historical netting, trapping and rod fishery data indicates that salmon start moving into the Fowey from the beginning of July with a further late run of salmon occurring from October to February (Appendix 7, Figure A). The same data suggests that large sea trout (deflections greater than 50) enter the river between March and June.

As the majority of the salmon sized events, which occur from March to June, can assumed to be caused by large sea trout the minimum salmon count for the Fowey has been calculated from the period July to February.

7.2. Salmon counts (minimum estimates) recorded on the River Fowey (July 2002 – February 2003).

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. Bearing this in mind a protocol has been developed to ensure that any large sea trout are excluded from the minimum salmon estimate (Appendix 7).

The salmon counted between July 2002 – February 2003 (907) represents a 41% increase in the total salmon run estimate, in relation to 2001 (645). Comparing this to the 7-year average (589) over the same period suggests a 54% increase in the size of the salmon run in 2002. The minimum count estimate for the period July to February (907) is the highest figure recorded over the past 8 years.

The upstream salmon count recorded at Restormel in 2002 is very encouraging when compared to those reported in 2001. Overall, the upstream counts are the highest recorded at Restormel over the past 8 years with 55% of the run moving upstream over the period October to November.

The overall trend over the past few years seems to suggest that salmon numbers are increasing, albeit slowly. This suggests that measures designed to protect this component of the stock, such as the National Spring Salmon Bylaws, may in fact be working.

It must also be noted that immediately after an increase in flow levels on the 13th October there were substantial increases in the numbers of salmon recorded moving upstream. This was particularly obvious in the middle part of the month where on one day (14th October) 56 upstream salmon were counted traversing the weir.

7.3. Estimated Large Sea Trout Counts (March – June) Recorded on the River Fowey 1995 – 2002.

The minimum large sea trout count estimate for 2002 was 713. Overall, the large sea trout run estimate for 2002 was 10% lower than in 2001 (792) although it was the third highest recorded count over the past 8-years. The lowest was recorded in 1995 (172).

The large sea trout counts for 2002 are up on the 7-year monthly averages, with the exception of March and 35% up on the 7-year average overall.

The figures recorded for large sea trout over the period March to June for 1995 – 1998 indicate that the number of these fish returning is fairly constant between years. Even so, it is interesting to note that from 1999 onwards the data shows that the numbers of these large sea trout have increased by a significant amount. This suggests that the operation of the net buy backs may be protecting this component of the stock and could be responsible for the increase in large sea trout numbers observed in recent years.

7.4. Small Sea Trout Counts (deflections less than 50) Recorded on the River Fowey 1995 – 2002.

Historically, the main sea trout run on the River Fowey has been consistent with that of many other Southwest rivers. The run of the smaller sea trout run normally begins in April / May with the peak movement, predominantly ‘school peal’, taking place during June and July. The smaller, but still significant, runs of sea trout tend to occur in April, May and August. The numbers decline sharply near the end of August with only small numbers moving upstream thereafter.

The counter data (Figure 5,Table 2) indicates that 2002 was a good year for (small) sea trout (8556). The minimum run estimate for 2002 represents a 6% increase when compared to the 2001 estimate (8051) and is 54% up on the 7-year average. The 2002 count is the largest count recorded over the past 8 years of counter operation. The lowest count that has been recorded over the period was in 1995 (5506).

The timing and pattern of the run is generally consistent between years except for the notable increases in the numbers of sea trout overall. It is however, interesting to note that the upstream counts for February and September are significantly lower than the 7-year average.

The numbers of fish moving upstream are higher than the 7-year monthly averages for all months with the exception of January, February, March, August and September. As Figure 2 indicates, the majority of the run (66%) was concentrated in June and July.

It appears that flow has been the major influencing factor on the numbers of sea trout passing through the fish pass during the period June to July, historically the peak migration time for sea trout.

7.5. Other Species

These events were identified from counter data and video footage and the counts adjusted to remove these species from the salmonid count. No other species were identified from video footage.

7.6. Environmental Factors

The environmental variables routinely measured at Restormel are flow, temperature, barometric pressure and conductivity (fish counter). Rate of flow is generally considered to be the dominant factor controlling the upstream migration rate of salmonids. 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 tidal conditions etc.

7.6.1. Flows on the River Fowey

The residual patterns of flow at Restormel in 2002 (Figure 6, Figure 7) during the period of the main fish runs were generally consistent with that of previous years although flow rates were lower than usual for the period end of August to the beginning of October.

As in previous years the majority of upstream migrating salmonids (April – October) tended to utilise flows between 1 – 10 cumecs (90 – 95%). Analysis of the count figures for 2002 indicated that the majority of salmon (65%) and sea trout (53%) moved upstream when daily mean flows were greater than 2 cumecs.

The periods January to April and November to December showed some marked and extended elevations in flow rates. Flows over 10 cumecs were present for 17% of the time but only accounted for 5% of salmonid movements overall.

7.6.2 Water Temperature

Figures 8 and 9 indicate that the patterns of fish movement coincide with rises and falls in temperature over the period of the main runs for salmon and sea trout. Data for the 2nd April to 6th August is unavailable due to corruption of the data files for this period.

The temperature profiles for 2002 (based on monthly averages) are consistent with those for 2000 and 2001 although November was noticeably warmer. 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 $5^{o}C$ – $21.5^{o}C$ (Alabaster, 1970). Although the data for 2002 implied no salmonid movements below $5^{o}C$ the loss of data means that the percentage of fish moving within this band can only be assumed during 2002.

Milner (1989) suggested that temperature accounted, in part, for the timing of river entry but thereafter flow probably provided the biggest environmental stimulus for upstream migrants. With the current interest in global warming temperature data may provide important clues into the effects of climate change on migratory fish populations and in particular, changes in the timing of their migrations.

7.6.3 Barometric Pressure

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 affect the behaviour of migratory fish, once the fish are within the river system and it is therefore worthy of further investigation.

As in 2000 and 2001, Figures 10 and 11 indicate that the relationship between barometric pressure and fish movements is not as clear as that existing for temperature and flow. Generally, 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 exception to this is the period around the first half of October where a rapid drop in pressure coincided with large numbers of salmonids moving upstream following a long period of low flows. As the numbers of fish moving did not increase substantially until the 14^{th} October, when flows increased, it is probably more likely that fish were responding to an increase in flow rather than the drop in pressure. Although difficult to prove, it is possible that the rapid drop in pressure may have acted as a trigger to ‘prime’ the fish to move when the flows increased i.e. got them in a state of readiness to move upstream. This may also explain the increased levels of activity often reported by anglers after a rapid drop in barometric pressure.

7.7. Video Validation and Counter Efficiency

Video data was collected 24-hours per day over period of the main salmon and sea trout runs during 2002. Table 5 details the period over which video footage was recorded and also the total number of hours of video collected.

Table 5 – Summary of Video Validation at Restormel Fish Counter 2002.

Camera	No. of Hrs. Recorded	Period of Operation	No. of Hrs. Watched
Channel 1 & 2	3222	12/4 - 10/9	159

The counter efficiencies (Table 3) are based on the number of fish that have been seen on video and recorded by the counter, predominantly during the hours of darkness, over the period (1/6/02 – 24/9/02).

The overall detection efficiency of the counter for upstream migrating fish was estimated at 97%. The level of efficiency is comparable to previous years and in the initial validation study conducted in 1993 (90%). Slight losses in efficiency can be attributed to the large numbers of sea trout passing over the weir in groups of two or more. In many cases these were recorded as single fish counts or as "non-fish" events, which resulted in a slight under estimate for sea trout.

Video evidence allows us to correct for these events but these slight losses in efficiency only have a small effect on the figures for the run estimates overall. It is this type of information that can be used to fine tune the settings of the fish counter and improve the detection efficiency in the long term.

Counts have not been extrapolated or estimated for the period 25th March – 5th April when the counter suffered a loss in data due to a fault. It was thought unlikely that a reliable and accurate estimate of upstream fish counts could be made for this period.

8 Data Processing

The data presented in this report represents final adjusted counts, which takes into account maintenance work on the fish pass and non-target species etc.

The original monthly summary reports distributed in 2002 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 has been superseded by this report.

9 Update

- The fish counter at Restormel site has suffered from only one major period of data loss during 2002 (25th March – 5th April). This was due to a counter fault.

- A study was carried out to investigate improvements to the fish detection ability of the counter. The study concluded that by reducing counter thresholds to 10 the fish counter would be able to detect a greater number of events as upstream fish. It must be noted that at present these fish are already included in the counts as non-directional events and verified as upstream fish during analysis of the trace data.

10 Future Work

- Continued validation of the counter's performance and efficiency will be carried out on an annual basis using overhead video cameras.

- To assess the presence and abundance of non-target species traversing the fish pass e.g. Otter's.

- Collection of temperature and barometric pressure at hourly intervals via two sensors / data-loggers will be continued in 2003.

- Use of fish counter data to improve information on flows required for species specific upstream migrations i.e. salmon, sea trout etc. An Environment Agency report coming out at the end of March 2003 will outline a methodology for calculating flow response curves for salmonids, which will improve our understanding of fish movements on the River Fowey.

- A scoping study has been undertaken to look into the practicalities of installing a walkway over the weir. This will allow for improvements to the camera system and allow safe access for maintenance.

11 Downtime

The counter was operational for 8432 hours out of a possible 8760, approximately equivalent to 13.7 days out of a total of 365 days. The majority of this downtime can be attributed to a counter fault. The downtime has been broken down as follows:

Table 6 – Breakdown of Counter Downtime in 2002.

Item	*Downtime*		*Sub-Total*	*% Downtime*	
	Enforced	*Routine*		*Enforced*	*Routine*
1. Weir cleaning (gate shut)	0.00	5.77	5.77	0.00	10.58
2. Counter Maintenance	0.00	0.00	0.00	0.00	0.00
3. Camera Maintenance	0.00	0.00	0.00	0.00	0.00
4. Counter Fault	272.93	0.00	272.93	99.63	0.00
5. Other	1	48.77	49.77	0.37	89.42
Total Downtime (Hours)	273.93	54.54	**328.47**		
Expected Operational Hours	8760.00				
% Time Operational	96.25				

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13. Appendices

Appendix 1 – Daily upstream counts in relation to flow at Restormel Weir 2002.

Figure 6 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Restormel Weir 2002.

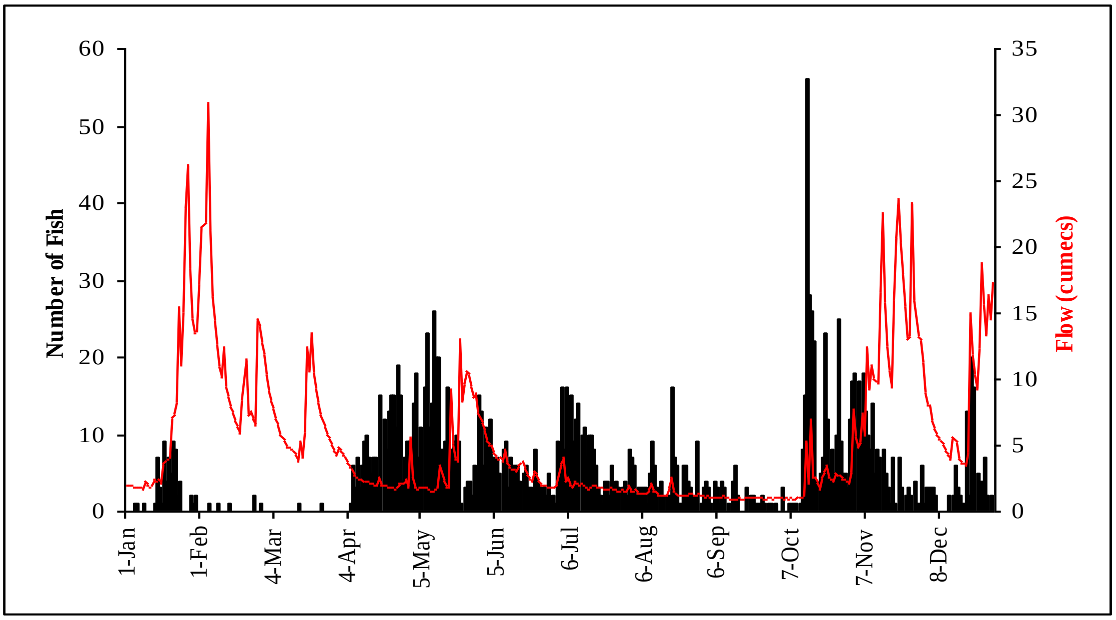
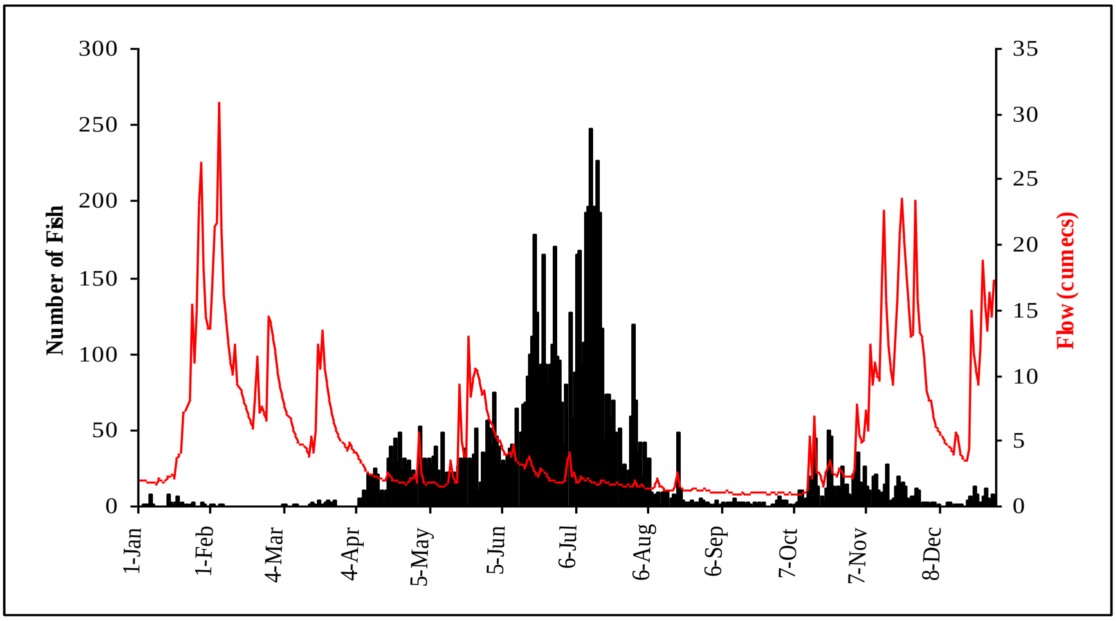


Figure 7 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir 2002.



Appendix 2 – Daily Upstream Counts in Relation to Temperature (°C) at Restormel Weir 2002.

Figure 8 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Temperature (°C) at Restormel Weir 2002.

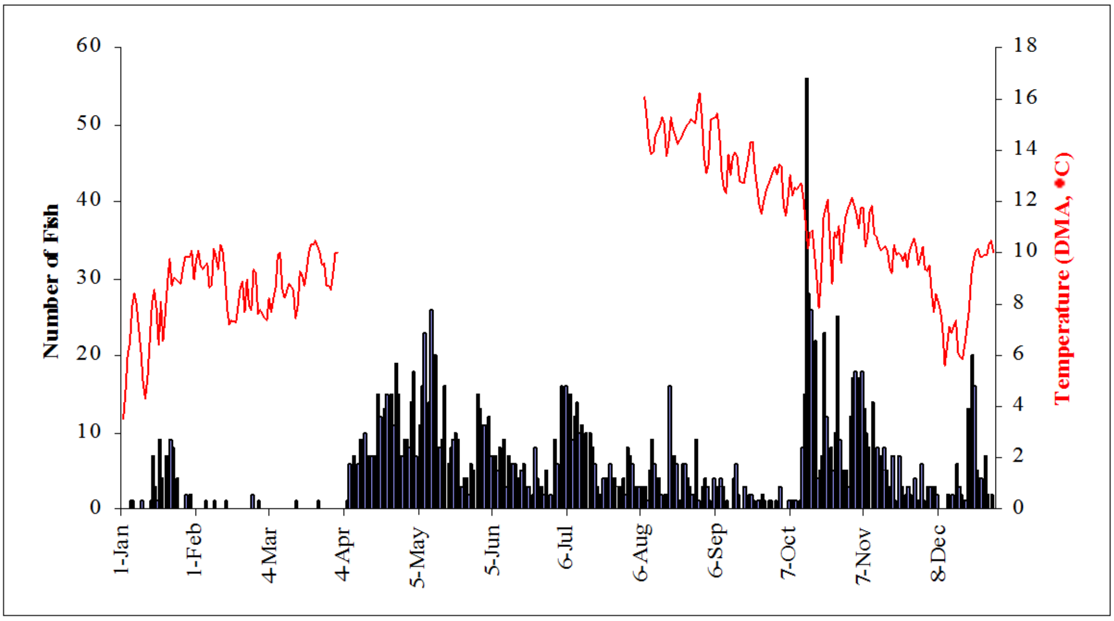
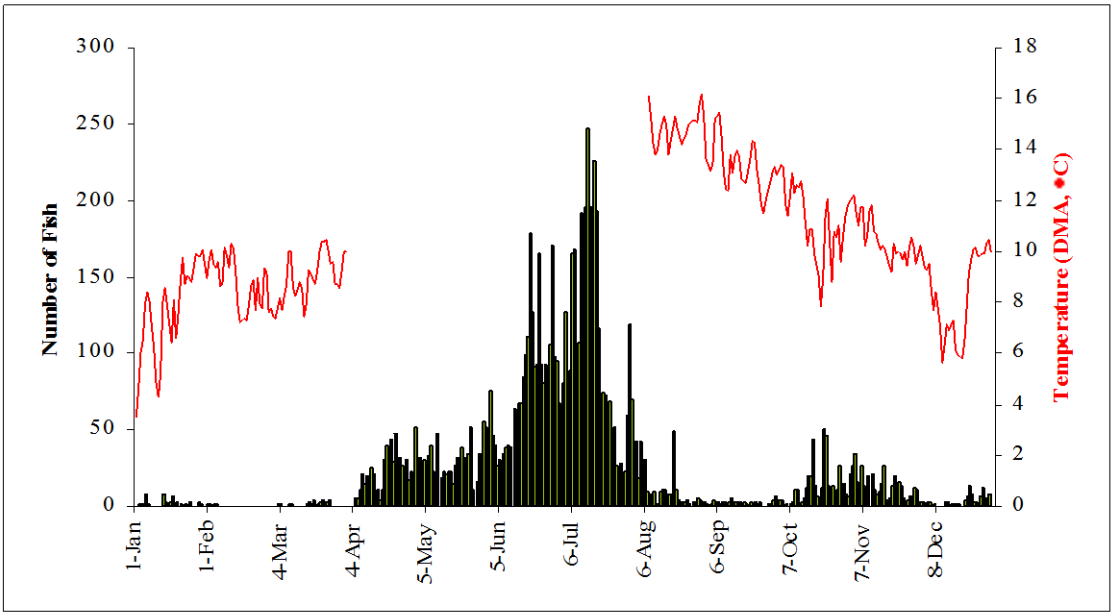


Figure 9 - Daily Upstream Counts of Sea Trout in Relation to Temperature (°C) at Restormel Weir 2002.



Appendix 3 – Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Changes in Barometric Pressure at Restormel Weir 2002.

Figure 10 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Changes in Barometric Pressure (mBar) at Restormel Weir 2002.

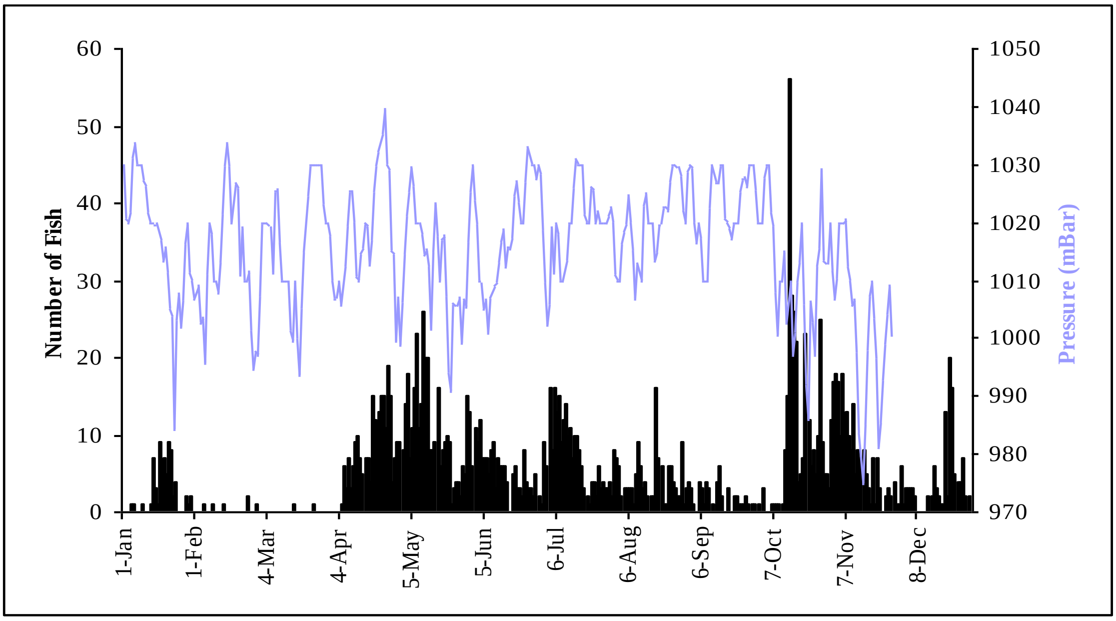
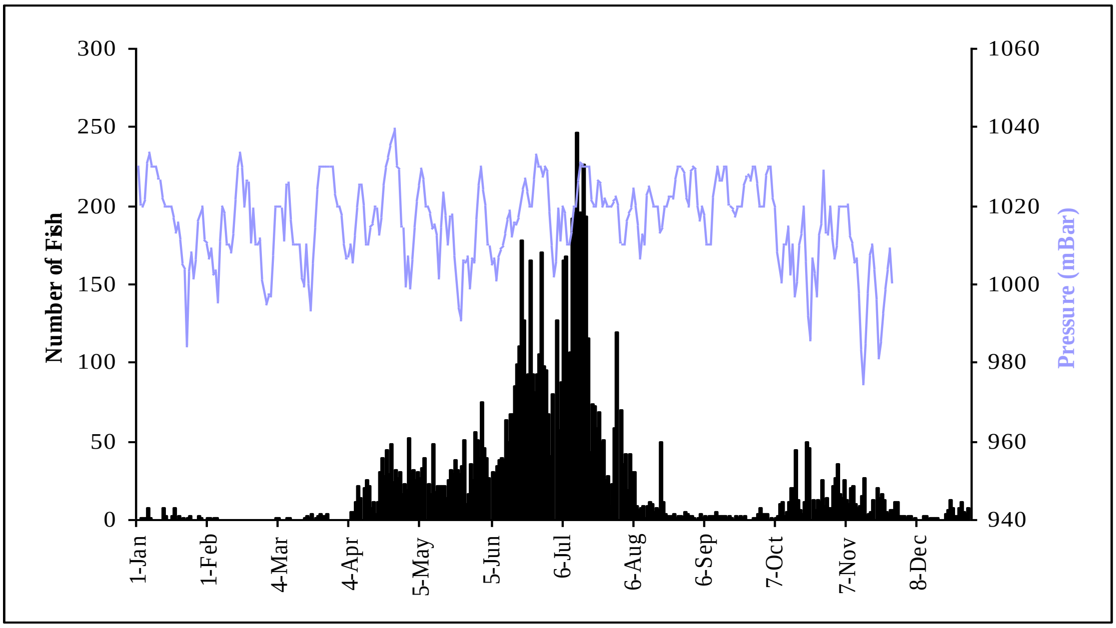


Figure 11 - Daily Upstream Counts of Sea Trout in Relation to Changes in Barometric Pressure (mBar) at Restormel Weir 2002.



Appendix 4 – Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir 2002.

Figure 12 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – January 2002.

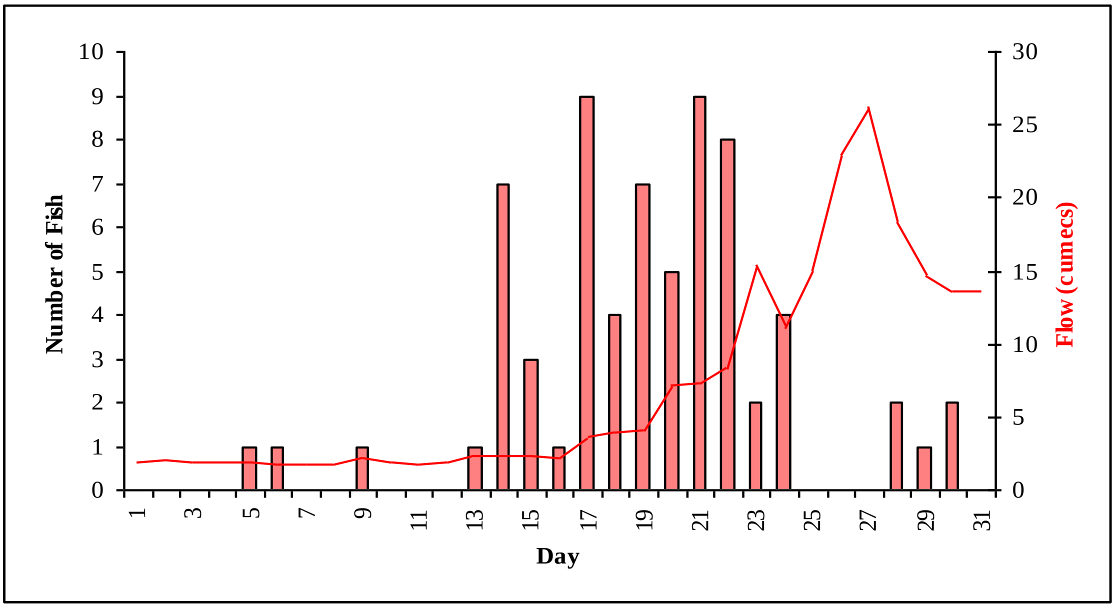


Figure 13 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – January 2002.

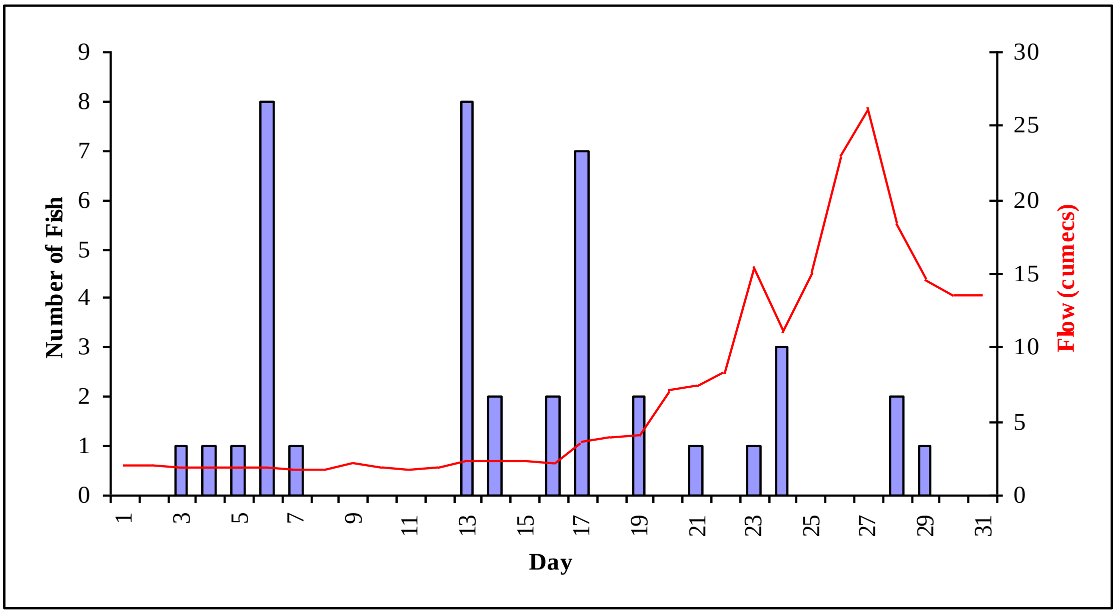


Figure 14 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – February 2002.

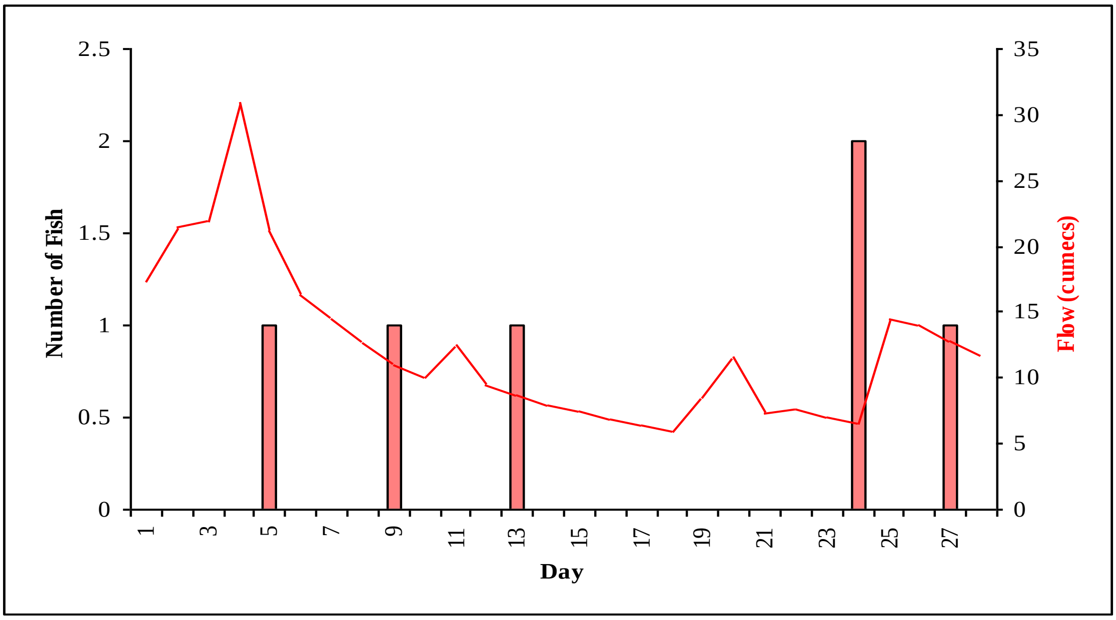


Figure 15 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – February 2002.

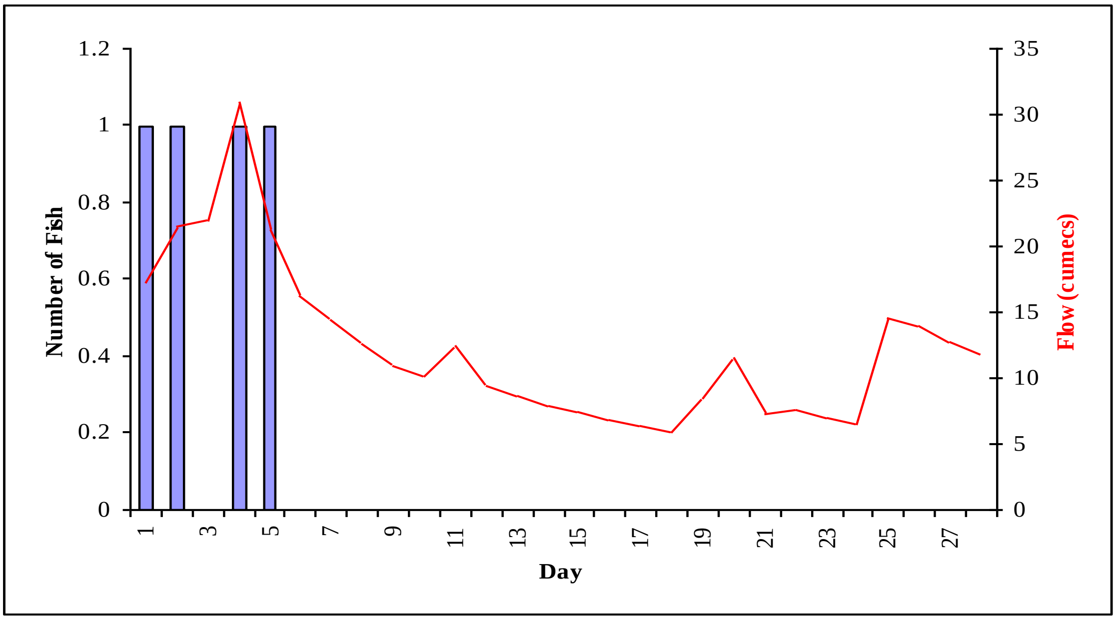


Figure 16 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – March 2002.

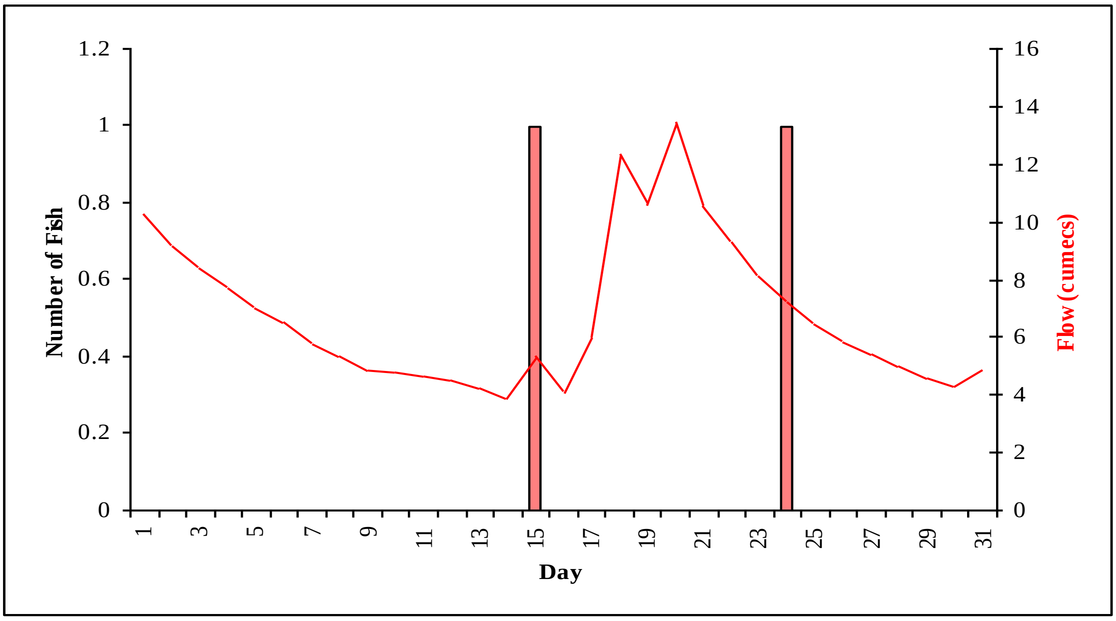


Figure 17 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – March 2002.

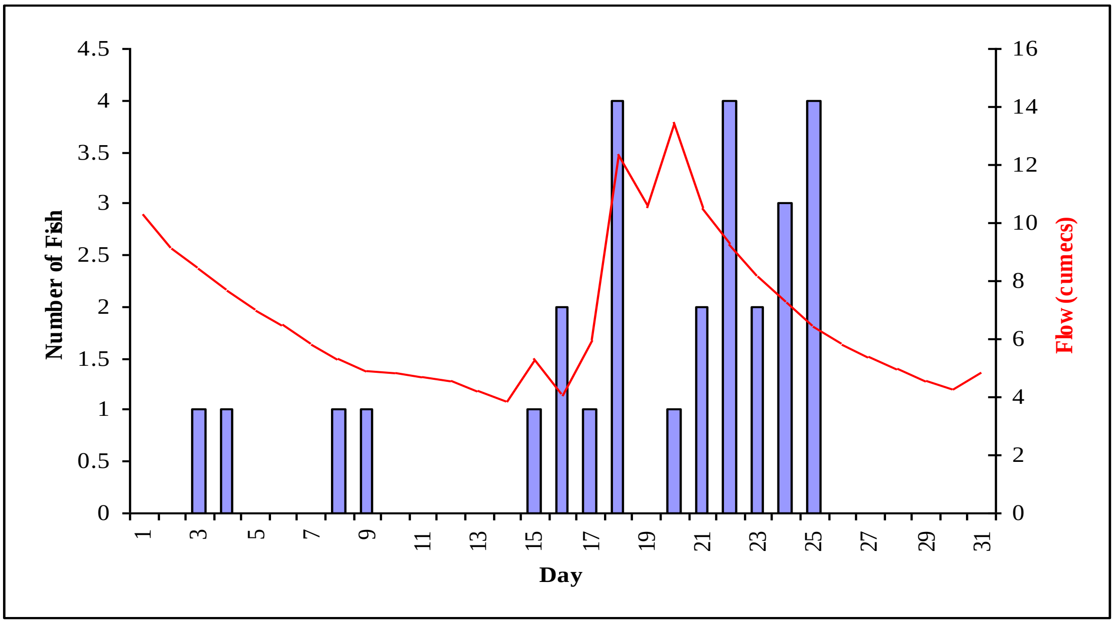


Figure 18 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – April 2002.

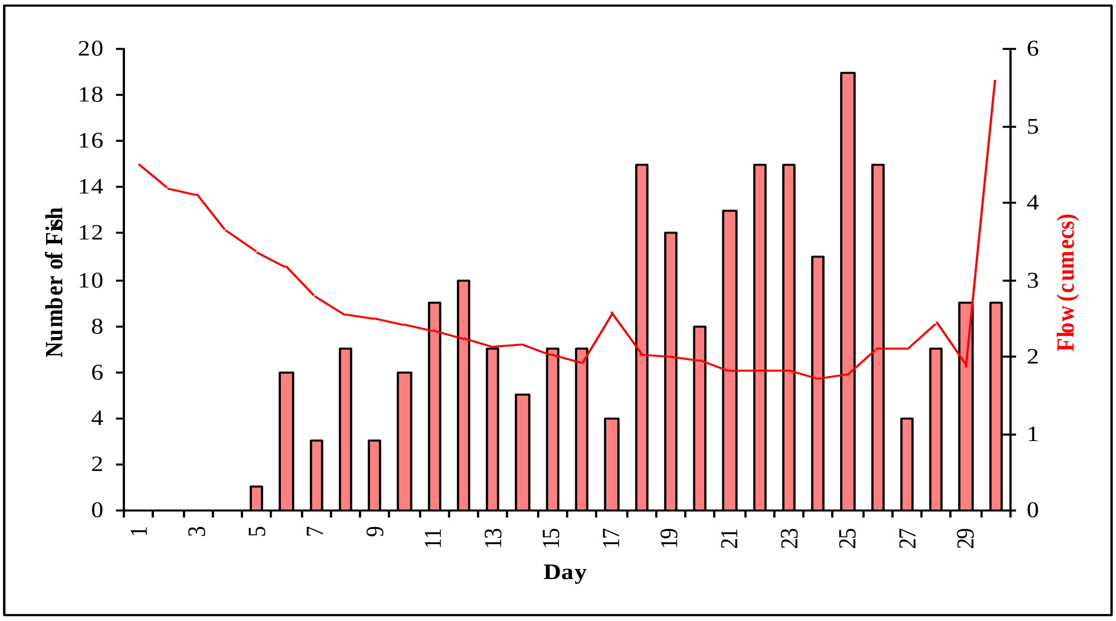


Figure 19 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – April 2002.

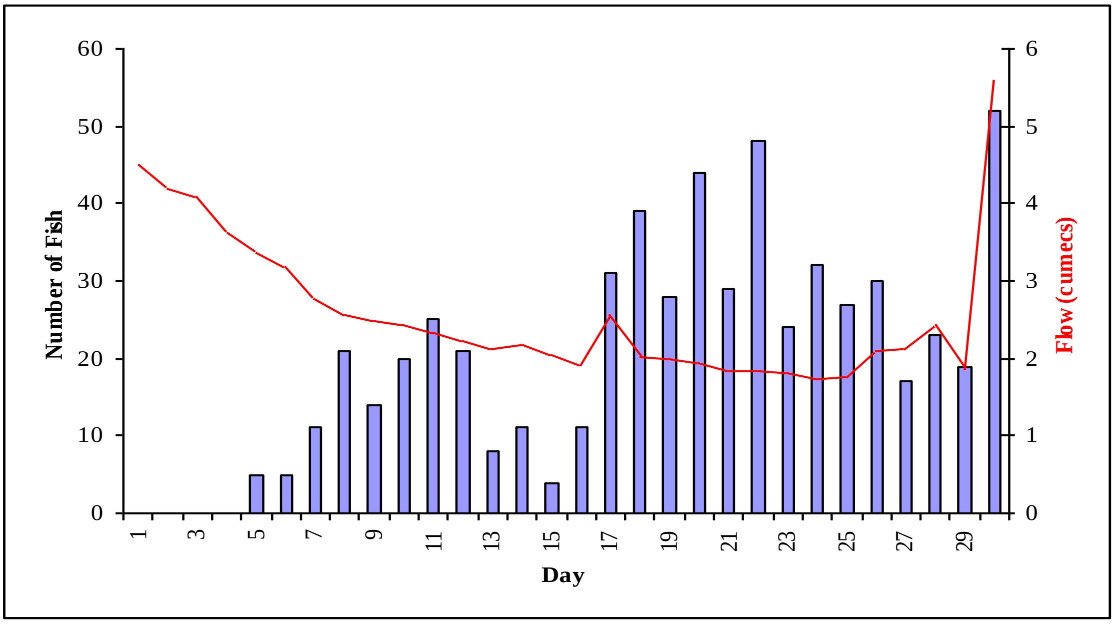


Figure 20 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – May 2002.

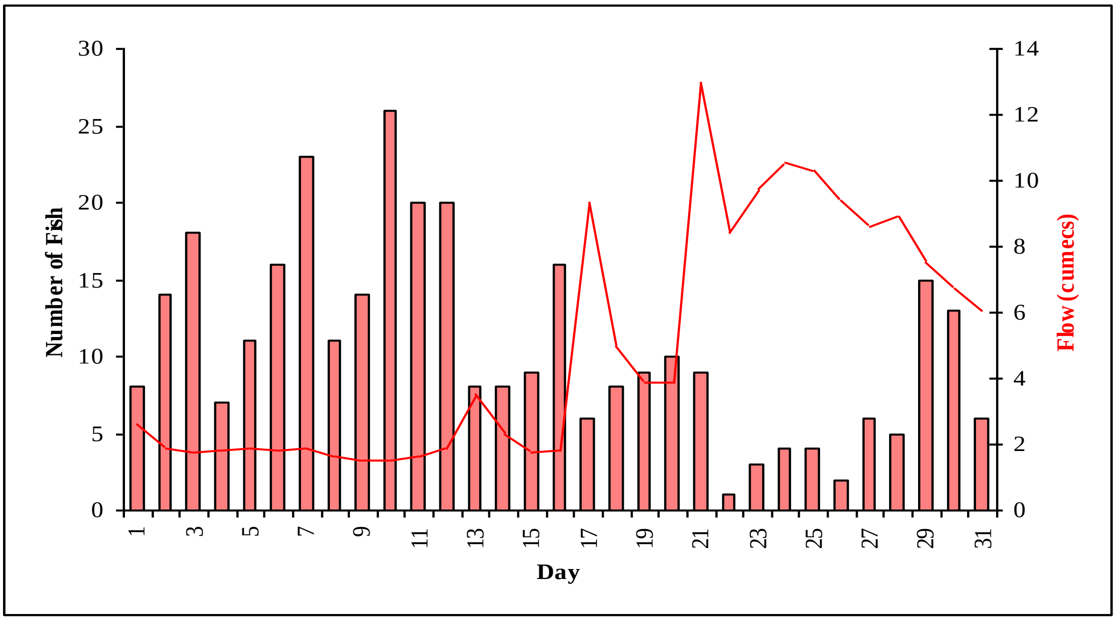


Figure 21 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – May 2002.

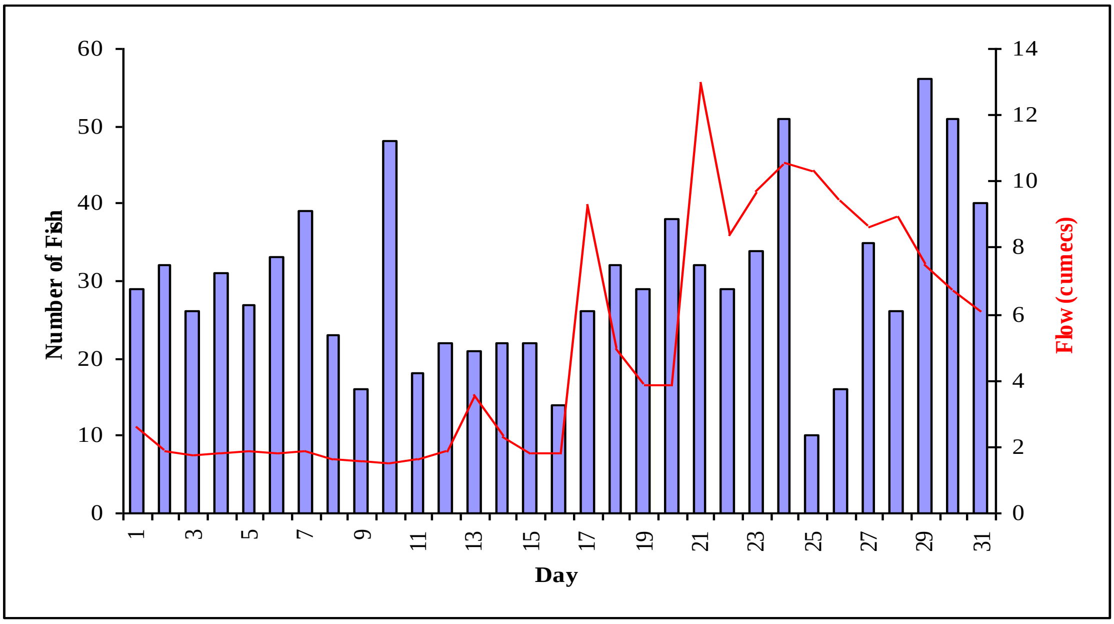


Figure 22 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – June 2002.

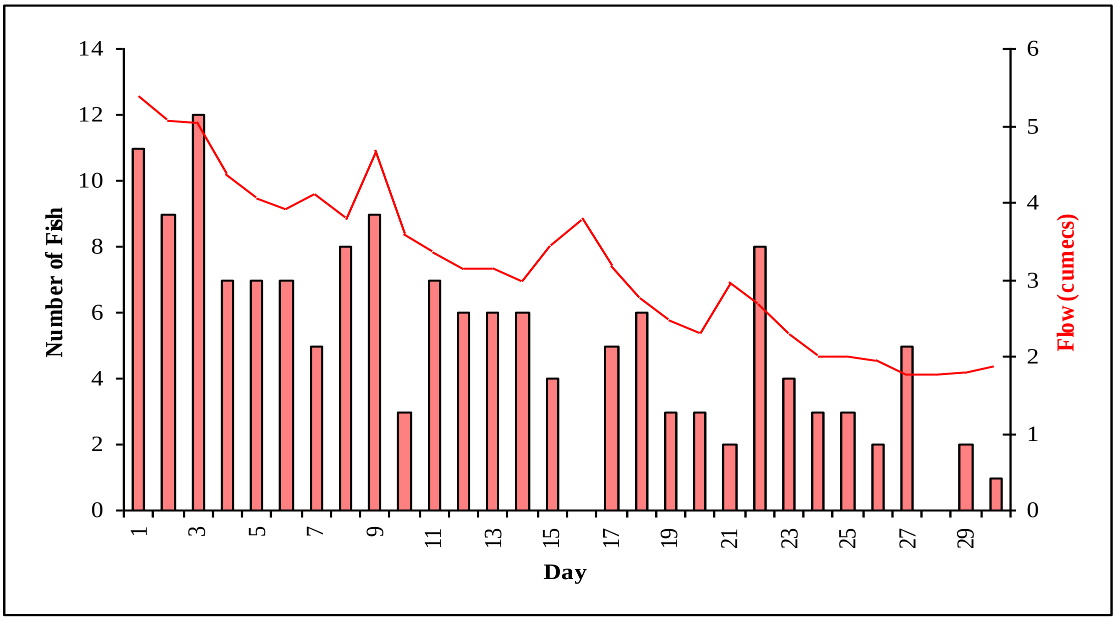


Figure 23 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – June 2002.

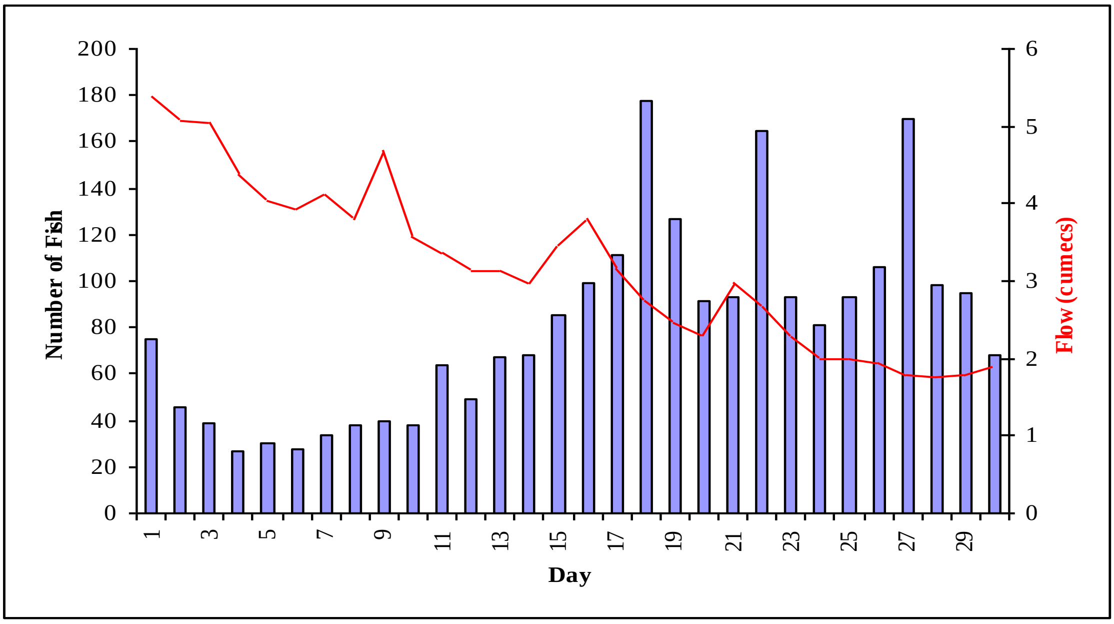


Figure 24 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – July 2002.

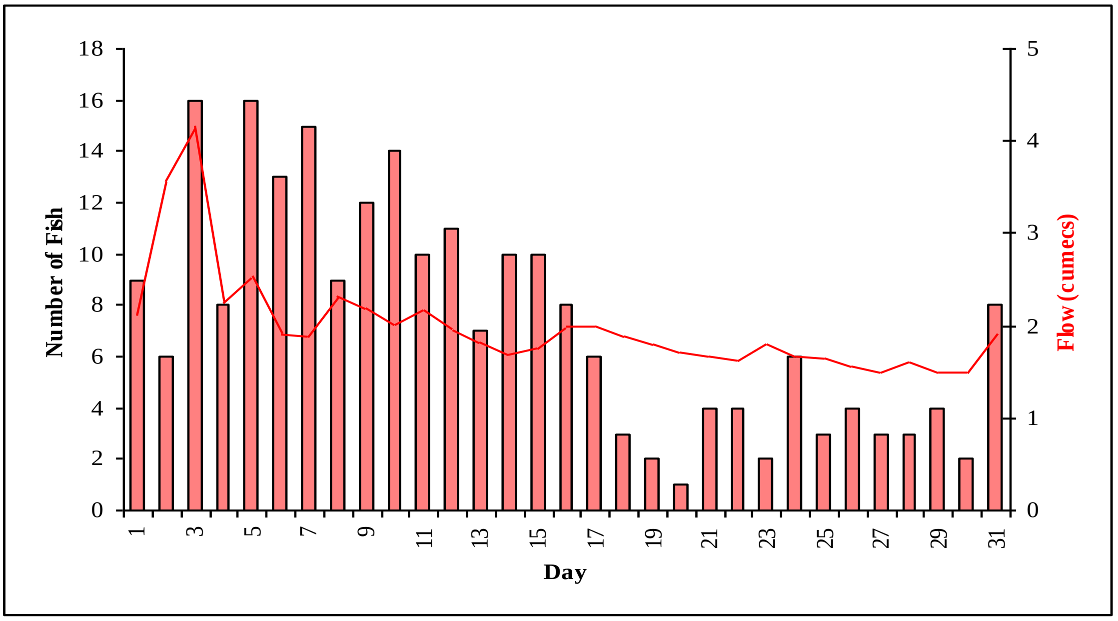


Figure 25 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – July 2002.

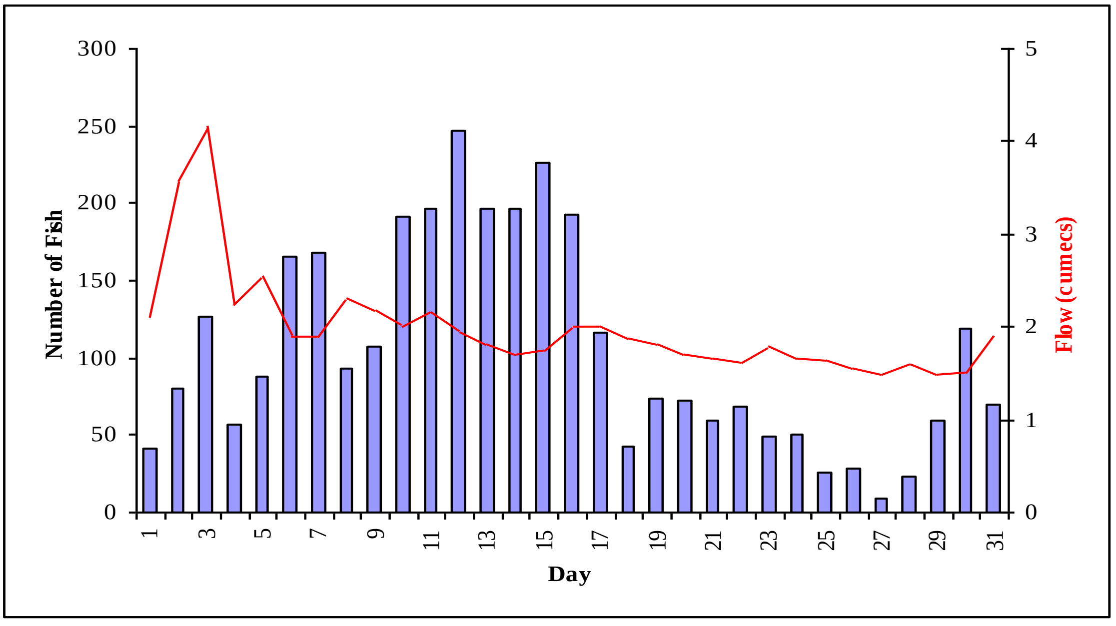


Figure 26 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – August 2002.

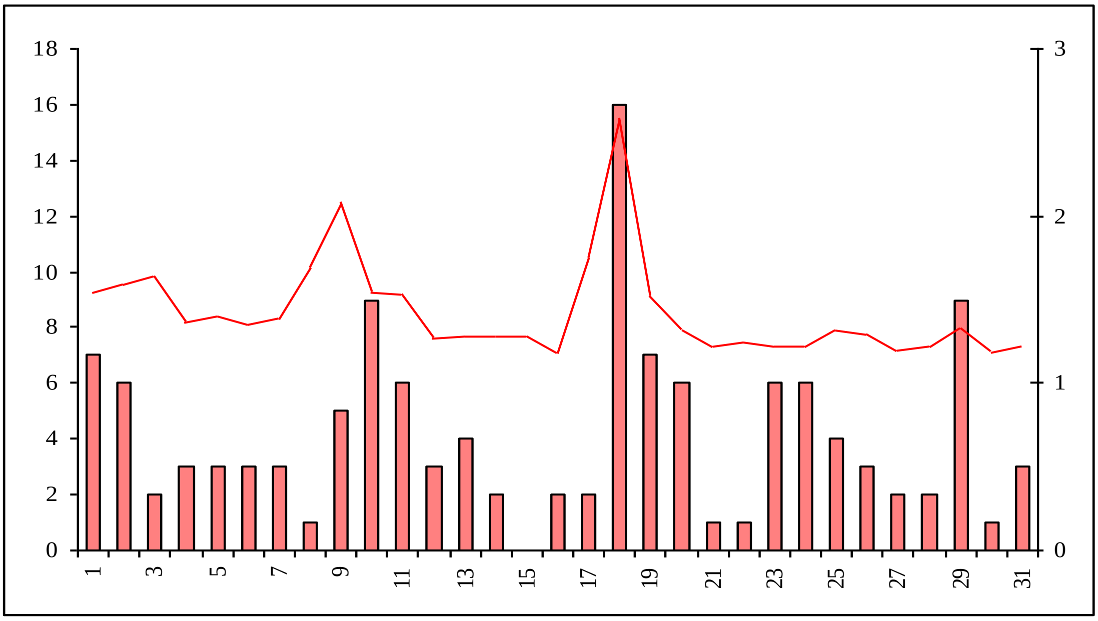


Figure 27 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – August 2002.

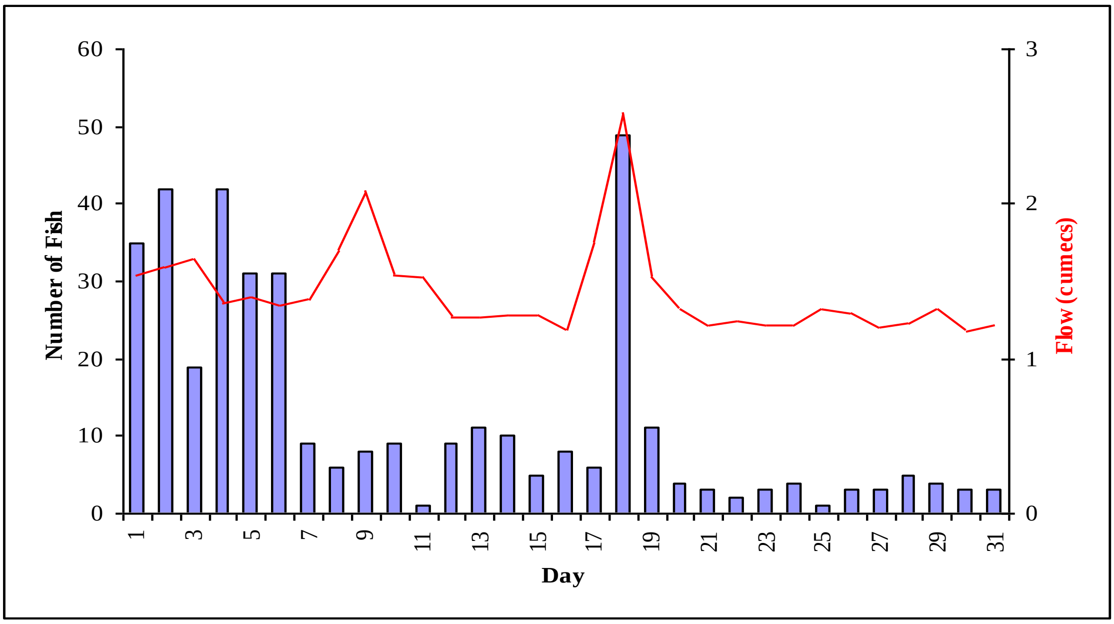


Figure 28 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – September 2002.

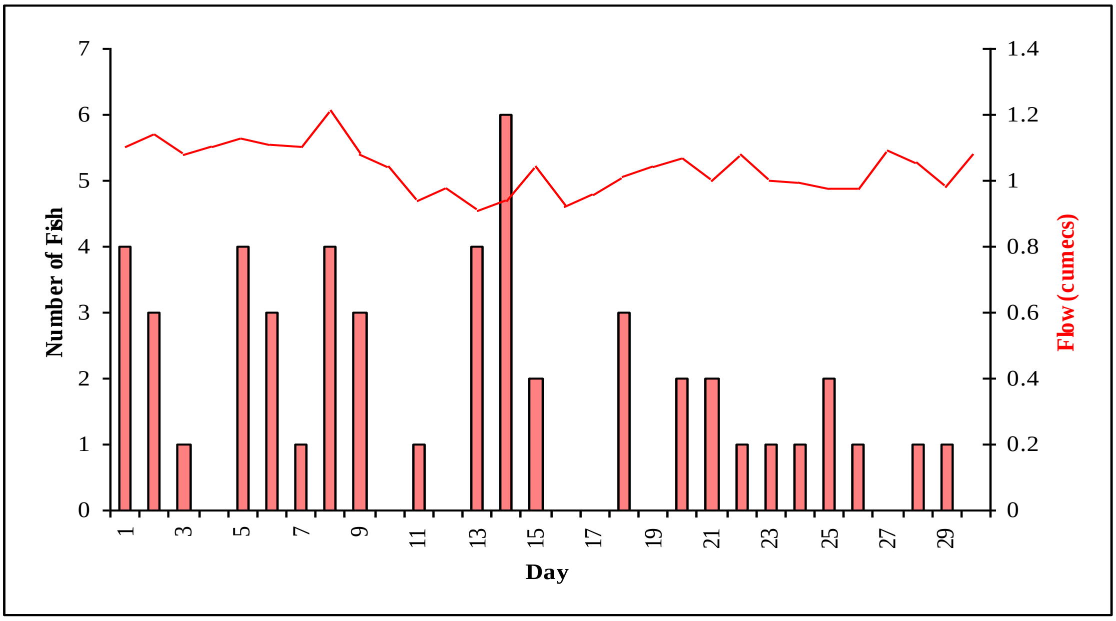


Figure 29 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – September 2002.

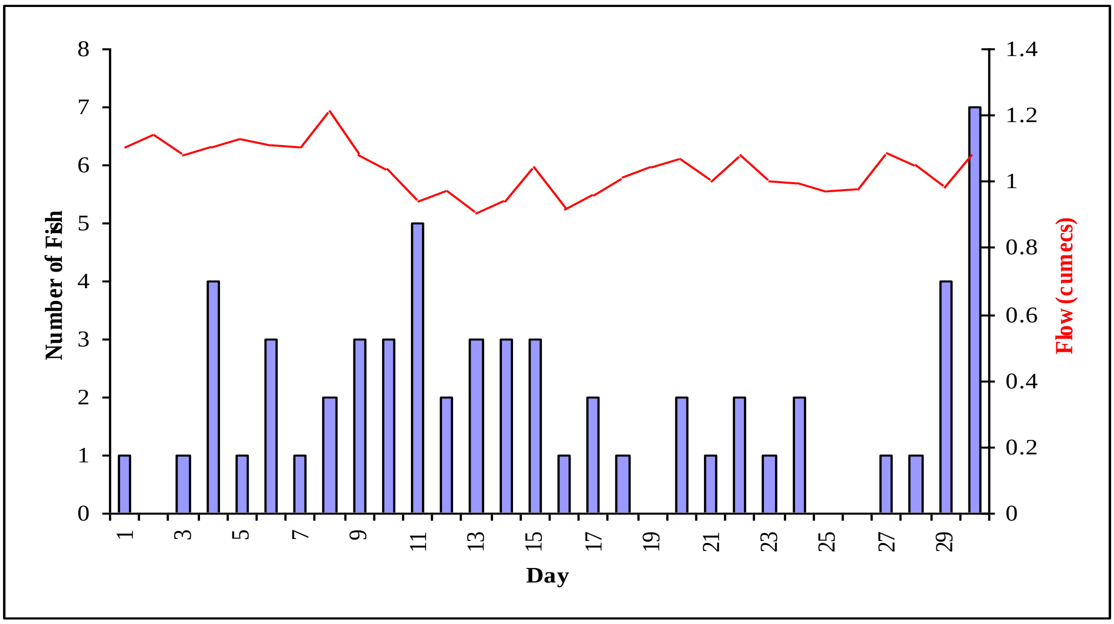


Figure 30 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – October 2002.

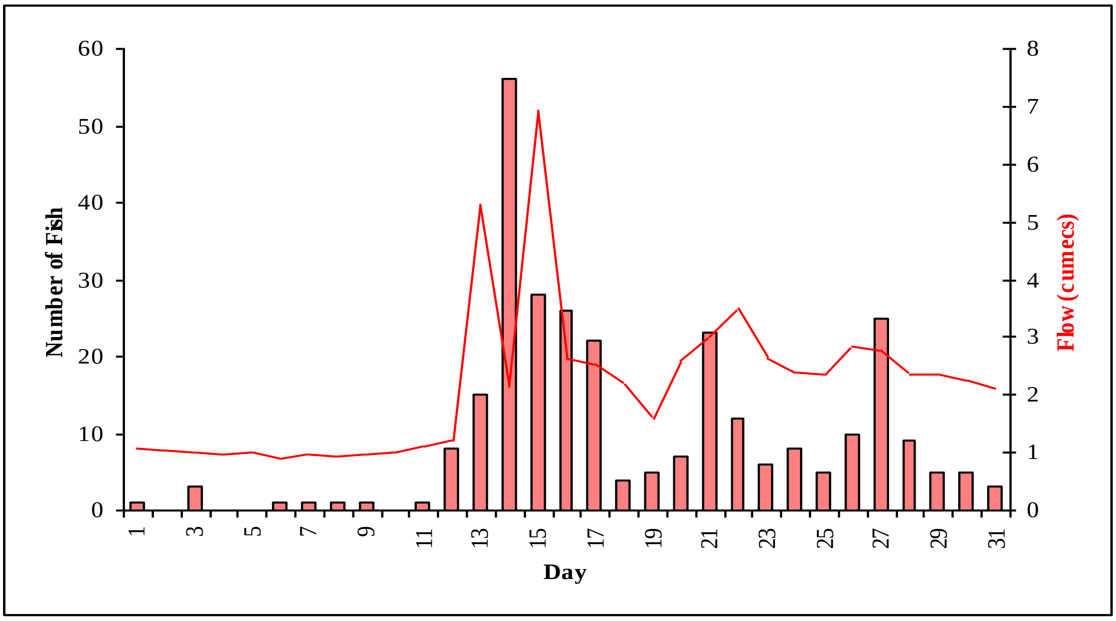


Figure 31 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – October 2002.

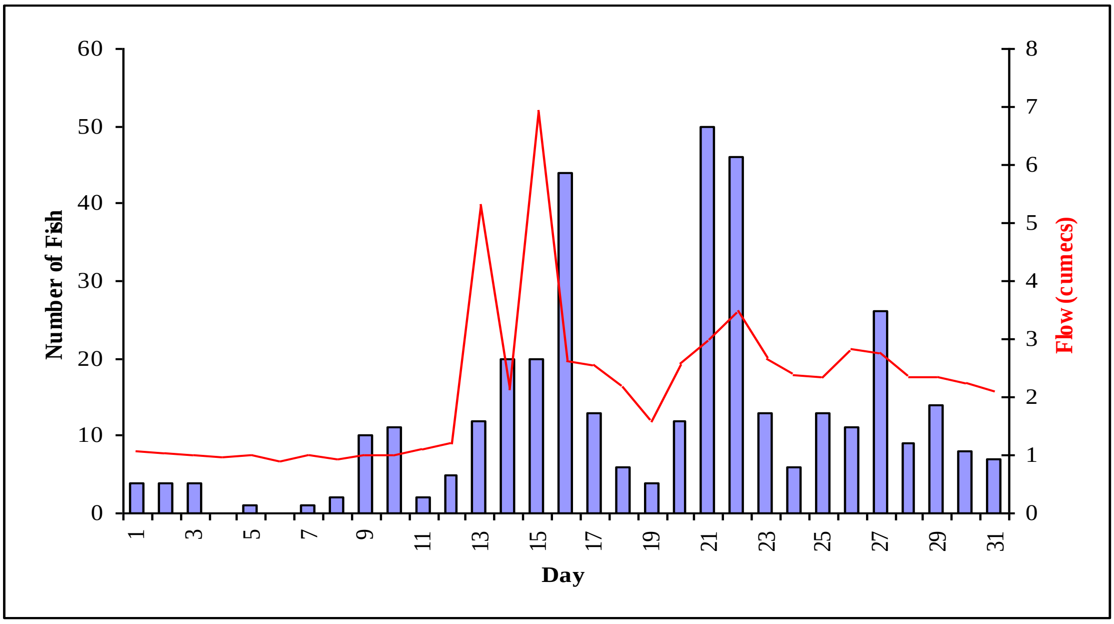


Figure 32 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – November 2002.

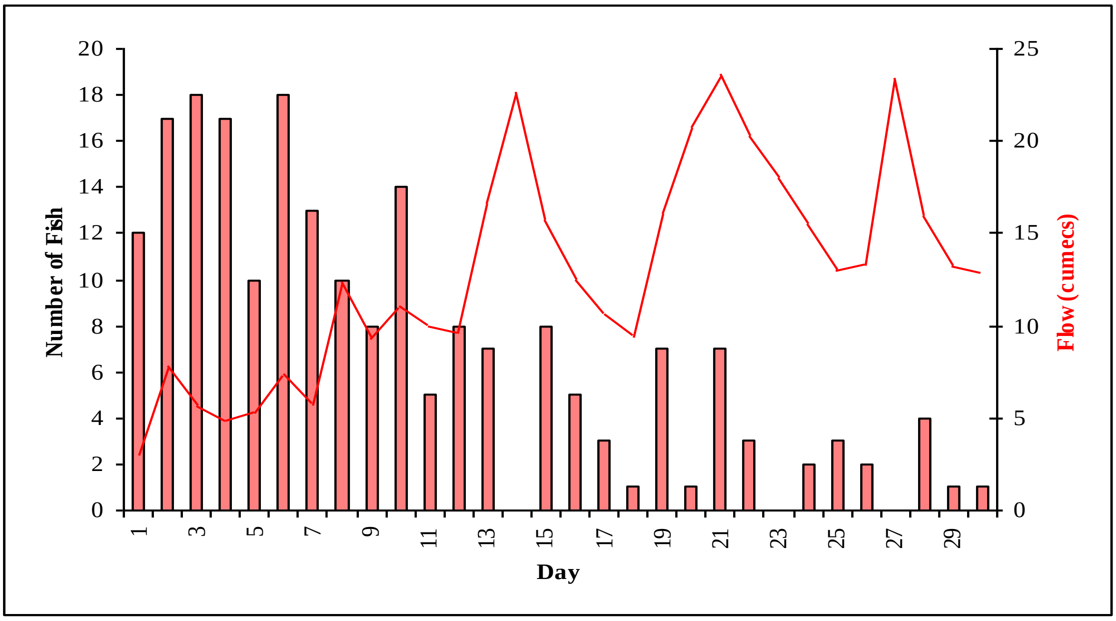


Figure 33 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – November 2002.

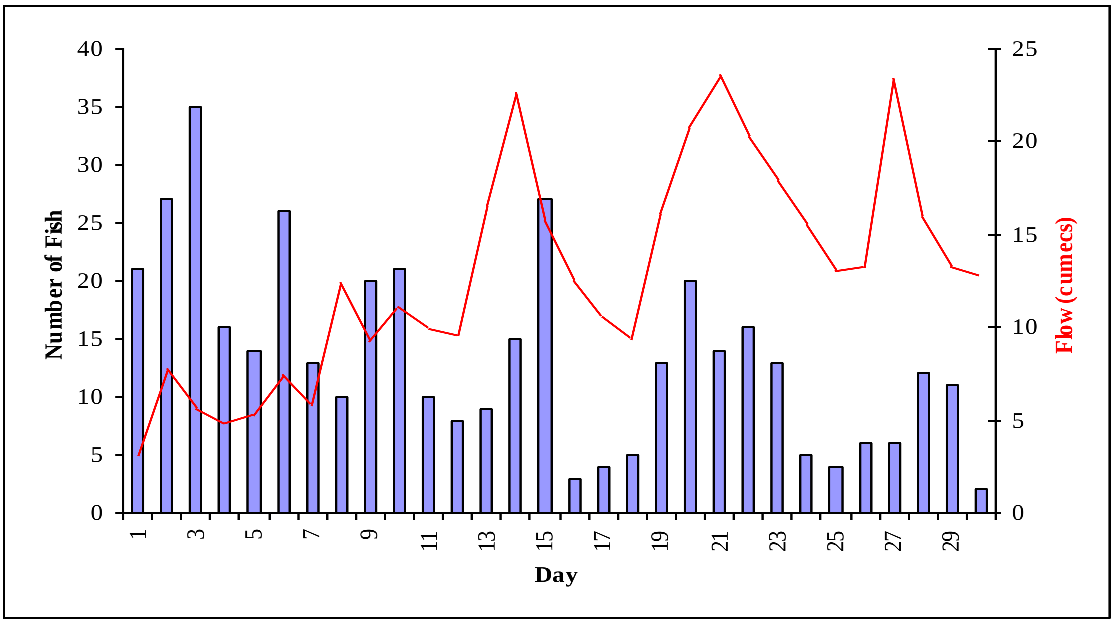


Figure 34 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – December 2002.

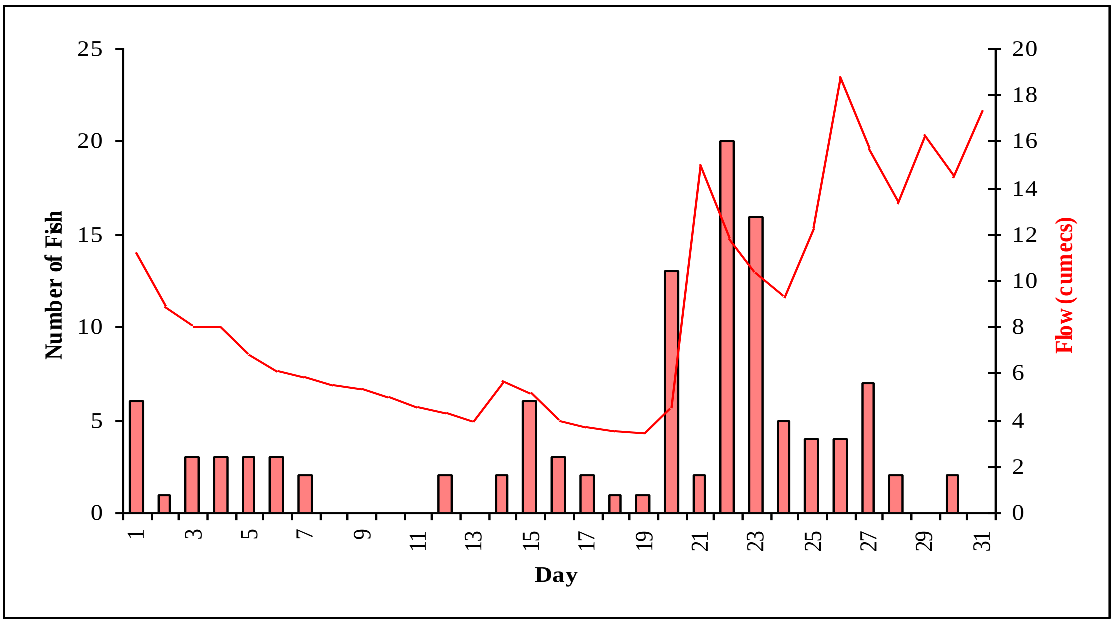
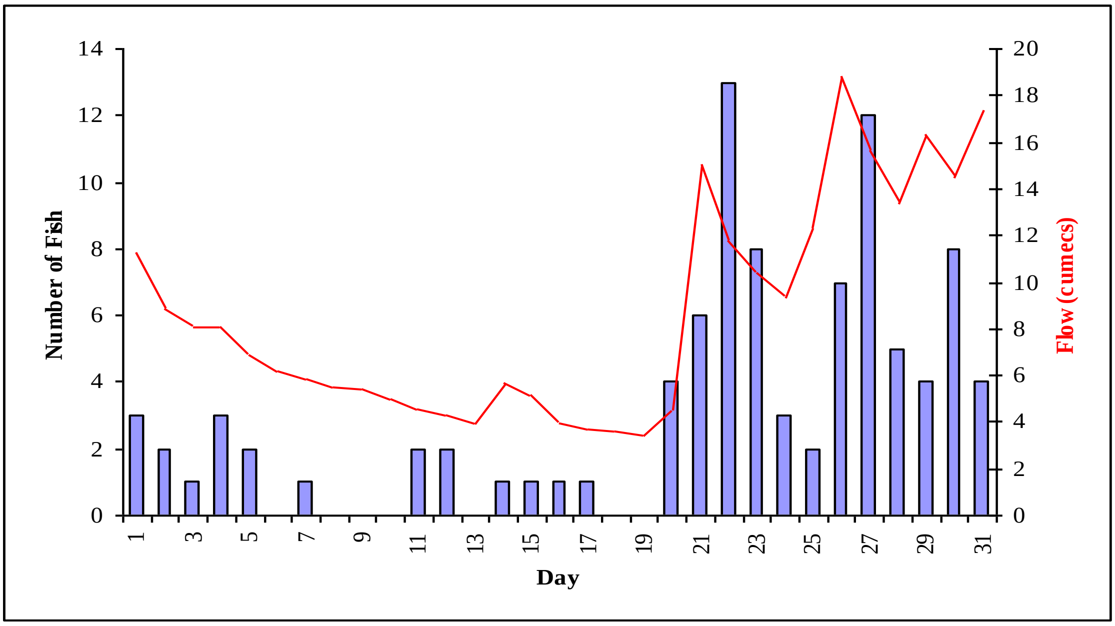


Figure 35 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – December 2002.



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.

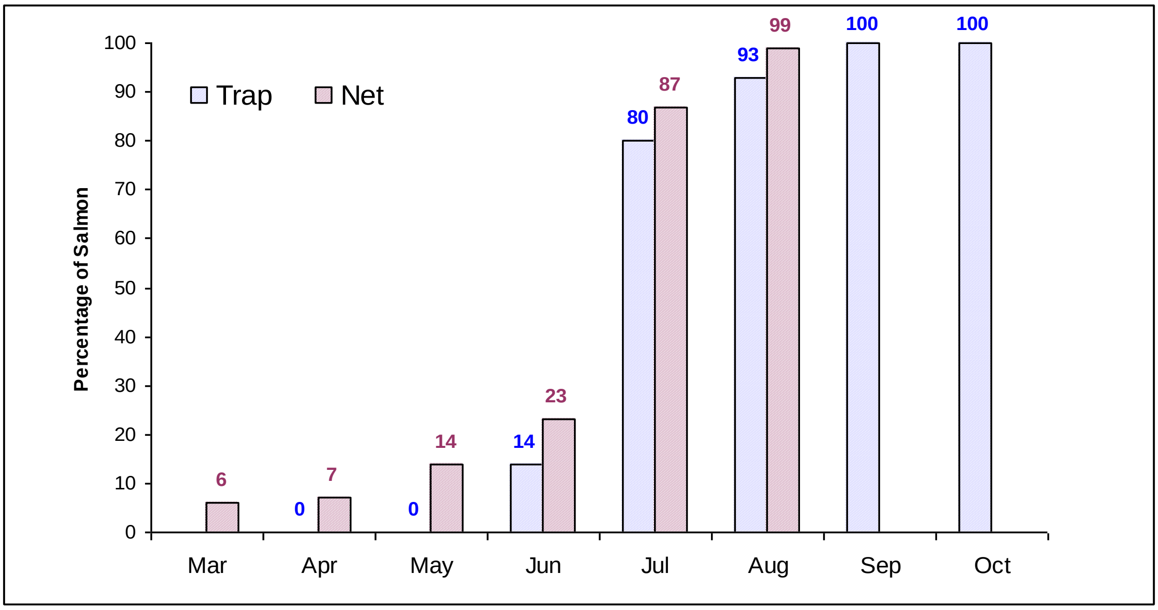
Appendix 7 - Separation of salmon and large sea trout at Restormel using historic Fowey Net catch (1990 – 1991) and Trap data (1984 – 1984).

The considerable overlap in sizes between salmon and sea trout populations on the River Fowey makes species apportionment based on size harder than for rivers such as the Tamar. The Tamar has a fairly distinct size split between the two species with only a small degree of overlap.

Smaller sea trout are relatively easy to separate out of the overall counts as data has indicated that these tend to produce deflections of less than 50, roughly equivalent to 50 cms. Trapping data, rod and net returns all suggest that salmon less than 50 cm in length are very rare on the Fowey.

The difficulty arises when trying to separate the larger sea trout (>50cm in length) from the salmon. As stated before the considerable overlap in size between the two species means that fish length or deflection size can not be used to distinguish between the two groups. However examination of historical net catch data on the Fowey reveals that the two groups (salmon and large sea trout) exhibit distinct differences in run timing. Small sea trout are effectively removed from the net catch data due to the sampling bias associated with the mesh size of the Fowey nets.

Figure A – Percentage of salmon and sea trout caught netted and trapped on the River Fowey.
[Trap (1979 – 1984) and net catch (1990 – 1999) data]



Interpretation of the graph: the graph is separated into trap and net caught salmonids. The bars show the percentage of salmon caught by the various methods. The distance from the top of the bar to the 100% level (y-axis) indicates the percentage of sea trout in the catch. Values of 0 indicate that no salmon were caught in that month – if no value is displayed then no data was available for that month.

The net catch data suggests that the upstream migration of large sea trout on the River Fowey is almost completely over by the end of June whilst the upstream migration of salmon does not commence until the beginning of July. The timing of the runs of these two species is also remarkably consistent between years, which gives a high level of confidence in predicting the timing of the upstream migrations in future years.

The timing of the salmon and large sea trout run on the River Fowey inferred from the net catch data is strongly supported by trapping data collected on the Fowey at Restormel from 1979 to 1984, inclusive (Figure A). The trapping data also shows that the upstream migration of large sea trout on the River Fowey is almost completely over by the end of June. The upstream migration of salmon does not commence until the beginning of July.

Appendix 8 - Minimum salmon run estimates for July and August

Over recent years attempts have been made to produce a minimum run estimate for salmon on the River Fowey. To ensure that large sea trout are effectively excluded for this count only the salmon / large sea trout data from September to February has been utilised. Trapping, net and rod catch data suggests that it is highly unlikely that large sea trout would still be running over this period.

Discrimnant analysis, of salmonid lengths caught in the River Fowey nets during July between 1990 and 1999, indicated 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. In July 2001 the counter recorded 238 upstream movements by salmon sized fish (>50 cm). 87 of these fish were observed on video and their lengths calculated. 54/87 (62%) had a length greater than or equal to 55-cm suggesting they were salmon. Applying this rationale to the salmon / large sea trout counts in July and August we can be fairly confident that all fish with a deflection of 70 or greater will be salmon.

Appendix 9 - Minimum large sea trout run estimates for the period March – June.

The trapping and net catch data (Figure A) has again been used to produce a minimum run estimate for large sea trout (>50 cm). The data implies that the main run of large repeat spawning sea trout is between March and June with only small numbers moving upstream thereafter. It can therefore be assumed that the majority of the salmon / large sea trout count over the period March – June consists of large sea trout. The figures for large sea trout in this report are based on these assumptions.

Appendix 10 - 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.

	Confidence	90%	95%	99%
Precision	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

Appendix 11 – Table B: Fish deflection values for upstream migrating salmonids recorded at Restormel Weir in 2002.

Deflection	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	1	0	0	0	0	0
10	0	0	0	0	0	1	2	1	0	1	1	0
15	0	0	0	0	0	0	18	7	0	0	1	1
20	8	1	2	3	16	67	365	92	7	37	43	9
25	22	1	3	3	46	195	533	136	25	103	95	15
30	23	2	2	7	75	340	440	74	9	90	80	19
35	16	2	2	12	88	428	300	37	8	51	65	16
40	9	3	7	46	98	434	171	12	6	44	49	10
45	4	2	5	72	111	281	108	11	3	30	46	12
50	5	0	2	111	120	227	72	12	4	26	29	16
55	6	1	2	96	91	144	33	3	1	25	30	20
60	4	2	2	89	111	137	33	5	1	24	27	18
65	2	1	0	92	98	94	28	6	1	28	30	13
70	5	0	1	79	85	56	12	9	2	29	18	7
75	1	0	1	64	63	30	8	4	1	19	19	9
80	9	1	0	43	57	30	4	6	0	13	16	8
85	3	0	0	23	50	26	4	8	2	21	9	7
90	4	0	0	18	38	7	4	7	1	21	5	4
95	5	0	1	25	26	12	5	8	1	11	2	4
100	1	0	0	17	15	9	2	12	8	17	4	6
105	2	0	0	13	16	5	3	8	1	14	5	2
110	4	0	0	4	17	9	3	9	3	6	6	2
115	5	0	0	1	13	3	1	14	8	10	4	3
120	2	0	0	1	7	3	0	7	3	10	9	4
125	4	0	0	3	9	8	0	12	9	23	13	2
<130	11	1	0	4	8	4	1	8	7	16	5	2

Appendix 12 - Daily Movements of Salmon and Sea Trout Recorded at Restormel Fish Counter in 2002.