ENVIRONMENT AGENCY

South West Region.

Restormel Fish Counter.

Annual Report 1999.

Cornwall Area Fisheries Science Team
March 2000.

Executive Summary

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Executive Summary

- The following report presents the daily upstream counts of migratory salmonids recorded at Restormel Weir counting station (SX 107 613) in 1999. The counter data covers the period of the commercial migratory salmonid net buy-back scheme, which was in operation between 2 March to 15 June 1999.

- The fish counter at Restormel is installed on the compound 'Crump' weir situated on the River Fowey, approximately 2-km upstream of the tidal limit. The fish counter is a resistivity based system (Logie 2100A – Aquantic limited) and operates over all three channels of the weir at Restormel.

- The 1999 upstream count for salmon / large sea trout was 1262. The minimum salmon count estimate was 497, which is 25% higher than in 1998 (387) over the same period. This count estimate was made using counts recorded between January to February and September to December 1999, effectively excluding the majority of the large salmon sized sea trout. Counter data from previous years suggests that since 1996 there has been a general decline in the overall size of the salmon runs over successive years on the River Fowey. However, the salmon / large sea trout count data for 1999, after elimination of the large sea trout, suggests a 22% increase in the estimated minimum run size for salmon.

- The 1999 upstream count for sea trout was 6590. This equates to a 45% increase in the total number of sea trout when compared to 1998 (3590).

- The run pattern observed for salmon and sea trout in 1999 is generally consistent with that of previous years. However, the total combined annual count of salmon and sea trout migrating upstream on the River Fowey in 1999 was 43% higher, when compared with the 4-year average.

- Flows on average were half those of 1998 during September, October, and November. It is interesting to note that an extended period of low flows over the same period was observed in 1995, a drought year, and corresponds to the movement of an almost identical number of salmon.

- The detection efficiency of the counter for upstream migrating salmonids in 1999 was calculated as 87.5% for fish > 45 cm and 32.4% for fish <45 cm (excluding non-directional fish events). The efficiency for fish <45 cm rises to 75% if non-directional fish events are included. These results are comparable to the results of the initial validation study conducted in 1997. We are presently in discussion with Aquantic and other Logie fish counter users to find a way of reprogramming the fish counter to recognise the non-directional fish events as upstream fish.

1. Introduction

The following report presents upstream salmon and sea trout counts with respect to daily mean flow (cumecs) recorded during 1999 at Restormel fish counting station (SX 107 613) on the River Fowey. The flow data reflects the residual flow that exists at Restormel weir following abstraction at Restormel Water Treatment Works (WTW) by South West Water (SWW).

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 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 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.

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 1 (Page 26).

3. Net Buy-Back

National byelaws to protect stocks of 'spring' salmon were introduced on the 15 April. The implementation of these byelaws restricted the netting season for salmon on the River Fowey from 1 June – 31 August, inclusive. 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 netting season for sea trout, therefore, ran from 2 March – 31 August, inclusive.

As in 1997 and 1998, South West Water (SWW) operated a buy-back of commercial migratory salmonid netting time from 1 March – 15 June, inclusive. This put a further limit on the times available to net and effectively restricted the salmonid netting season to between 16 June and 31 August. 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 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 2 (Page 27).

Data from fish trapping studies undertaken between 1979 and 1984 – Sambrook (1985), supports the relationship between fish length and deflection size that has been established independently using counter data and video footage from the Restormel fish counter site. It also supports the use of deflection sizes to differentiate between salmon / large sea trout and sea trout - Restormel Fish Counter Annual Report (1998).

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 fish counter work at Restormel and gives confidence in the accuracy of the data that the fish counter is producing.

5.1. Video Validation Strategy.

Video footage is collected over all three channels of the weir and is usually collected between April and July, when the greatest numbers of fish are seen. All tapes are quality checked before the operator leaves the site to highlight any potential problems with poor picture quality or equipment failure.

The aim is to watch videos within 7 days of collection. When videos are watched the "viewer" is required to complete a "video session recording sheet" which provides a record of

each video session that the person has viewed and other relevant details, such as picture quality, camera orientation etc.

5.2. Video Viewing Sessions

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.

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.

5.3. 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 – Appendix 3.

5.4. 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

Comparing the numbers of salmon / large sea trout and sea trout recorded by the counter with the numbers on the video footage an estimate of counter efficiency can be made.

6. Results

The migratory salmonid counts obtained for the River Fowey recorded at Restormel fish counting station in 1999 are presented as follows:

6.1. Upstream Fish Counts

Figure 1: This presents the monthly upstream counts for salmon / large sea trout recorded at Restormel weir in 1999. The total number of salmon / large sea trout counted moving up the river in 1999 was 1262 (Table 1).

Figure 2: Presents the monthly upstream counts for sea trout recorded at Restormel weir in 1999. The total number of sea trout counted moving up the river in 1999 was 6590 (Table 2). This equates to a 45% increase in the run size when compared to last years figures.

Figures 3 & 4: Presents the daily upstream counts for salmon / large sea trout and sea trout, in relation to monthly mean flow (cumecs) at Restormel weir in 1999.

Figures 5 – 28: Each of these figures presents daily upstream counts for salmon / large sea trout and sea trout, for each month, in relation to daily mean flow (cumecs) recorded at Restormel weir.

Figures 29 – 40: Displays monthly fish deflection values recorded by the counter during 1999.

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 1995 – 1999.

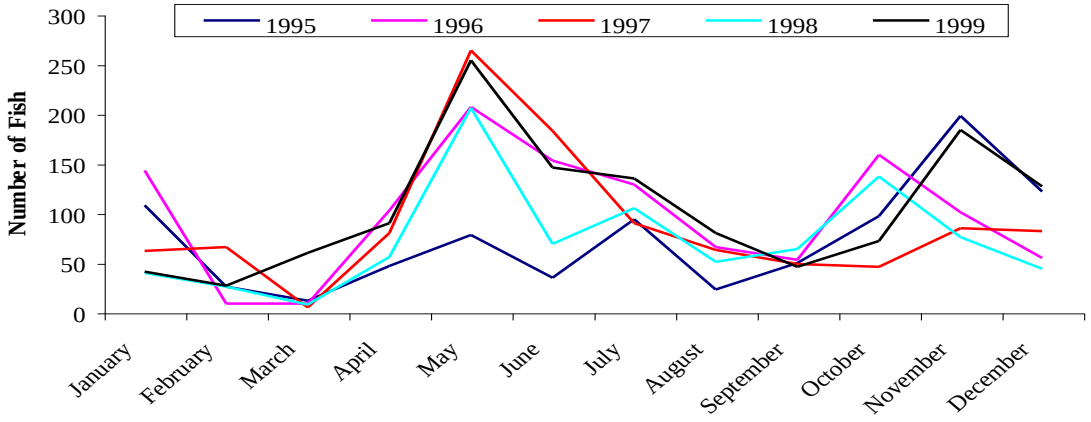


Table 1 – Monthly Upstream Counts for Salmon / Large Sea Trout at Restormel Weir 1995 – 1999.

Month	1995	1996	1997	1998	1999
January	108	143	62	40	41
February	26	9	66	26	27
March	12	9	5	8	60
April	47	103	80	56	90
May	78	207	264	206	254
June	35	153	183	69	146
July	94	129	90	105	135
August	23	66	63	51	80
September	50	53	49	64	46
October	97	159	46	137	72
November	198	101	85	76	184
December	122	55	82	44	127
Totals	890	1187	1075	882	1262

Figure 2 – Monthly Upstream Counts for Sea Trout at Restormel Weir 1995 – 1999.

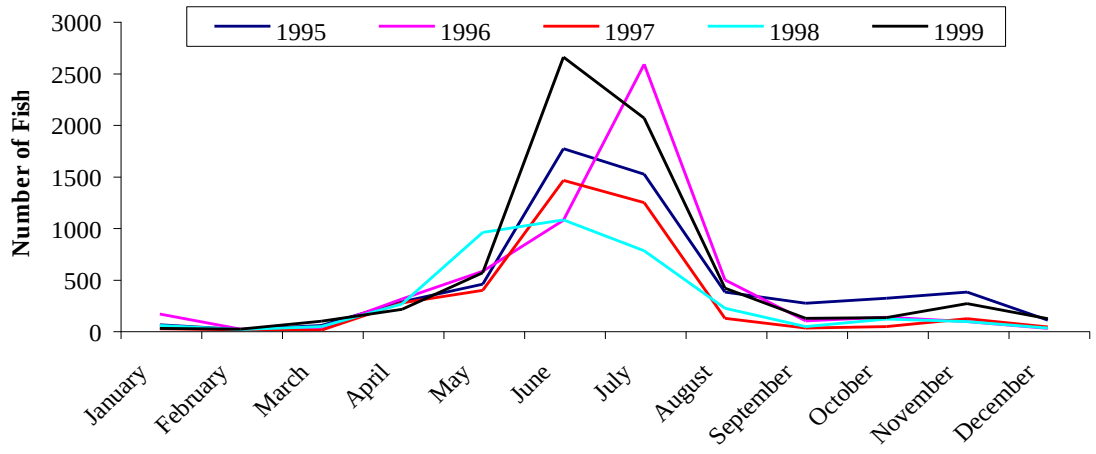


Table 2 – Monthly Upstream Counts for Sea Trout at Restormel Weir 1995 – 1999.

Month	1995	1996	1997	1998	1999
January	52	156	13	46	18
February	8	10	4	6	9
March	47	18	1	35	87
April	274	303	264	256	203
May	446	573	388	948	556
June	1759	1065	1454	1070	2649
July	1513	2578	1237	770	2056
August	368	489	116	214	408
September	263	92	21	36	114
October	310	125	36	107	121
November	368	84	113	82	259
December	98	18	30	20	110
Totals	5506	5511	3677	3590	6590

6.2. Validation

6.2.1. Video Validation and Counter Efficiency.

Table 3– Analysis of Video Validation Data (Channel 1) for Restormel Fish Counter 1999.

Total Video Recorded (Hours)	516.1
Total Video Reviewed (Hours)	151
Video Collection Period	11/5/99 - 6/8/99
Number of Upstream Fish Recorded on Video	
• > 45 cm	32
• < 45 cm	284
Counter / Video Matches	
Fish > 45 cm	
• Upstream Counts	28
• Events	0
• Unmatched Fish*	4
Fish < 45 cm	
• Upstream Counts	92
• Events < 45 cm	120
• Unmatched Fish*	72

*Unmatched fish are classed as fish that could not be matched to both counter and video data and can therefore not be included in any calculation for efficiency.

The detection efficiency of the counter for upstream migrating salmonids in 1999 was calculated as 87.5% for fish > 45 cm and 32.4% for fish <45 cm (excluding non-directional fish events). The efficiency for fish <45 cm is 75% if non-directional fish events are included.

7. Discussion

Figures 1 and 2 indicate that seasonal run patterns observed for salmon and sea trout on the River Fowey in 1999 are consistent with previous years. However, there is a 43% increase in the combined annual total count for upstream migrating salmonids on the River Fowey when compared to previous years.

7.1. Salmon / Large Sea Trout counts recorded on the River Fowey 1995 - 1999.

- The upstream counts obtained during March - June indicate that a large number of salmon sized fish are entering the river at this time. Deflection values over the period March – June (Figures 29 - 31) confirms this. Traditionally salmon, predominantly one sea-winter fish (grilse) are known to enter the Fowey from the end of June with a further late run of salmon occurring from October – January.

- Historic rod catch and trapping data indicates that only small numbers of salmon enter the River Fowey prior to the end of June. It is therefore highly likely that large sea trout account for the majority of this count especially in view of the fact that it has been an exceptional year for sea trout. Analysis of video data taken in June, July and August (channel 1) and anecdotal evidence tend to confirm this. Counter data from previous years indicates a general increase in the number of these larger fish over the last four years, with the exception of 1995, which was a drought year. Bearing this in mind, counts recorded for salmon between September and February probably provide a more reliable minimum estimate of the salmon run size, as this would effectively remove the majority of the larger sea trout from the count. The estimated minimum count for salmon between September and February in 1998 was 321; the count over the same period in 1999 was 429, an increase of 25%.

- Analysis of fish deflections (Figures 29 - 31) allows us to breakdown the data into discrete size classes. 52% (225) of the fish counted over the period (Jan - Feb and Sept – Dec) had deflections equal to or greater than 80 deflection units, equivalent to a fish of 80 cms or larger, and would almost certainly be salmon. The remaining (204) fish within this class i.e. greater than or equal to 50 deflection units, in this period had deflections of between 50 – 80.

- The estimated minimum counts for salmon during the early part of the year (Jan/Feb) are consistent with those recorded in 1998, however, figures for the latter part of the year (Nov/Dec) are roughly double those recorded over the past 3 years (1996, 1997 and 1998).

- Counter data from previous years suggests that since 1996 there has been a general decline in the overall size of the salmon runs over successive years on the River Fowey. However, the salmon / large sea trout count data for 1999, after elimination of the large sea trout, suggests a 22% increase in the estimated minimum run size for salmon.

- It is interesting to note that the counter recorded an almost identical number of salmon/large sea trout over the same period in 1995 – Table 1. Flow conditions in both years over the same period also followed a similar pattern i.e. a long period of low flows

extending into November followed by a number of small spates. It is possible that this period of low flows may have delayed the upstream migration of the salmon and may have subsequently deterred them from moving as far upstream as usual and into areas where they may have been subjected to exploitation by the rod fisheries. This long period of low flows almost certainly accounts for the low numbers of salmon counted during September / October, in comparison with previous years.

7.2. Sea Trout Counts Recorded on the River Fowey 1995 - 1999.

- Historically, the main sea trout run on the River Fowey is consistent with that of many other rivers in the South West and is concentrated predominantly in the months of June and July. The peak movement of smaller school peal sea trout takes place in July. Smaller runs of larger sea trout occur in April, May and August with numbers declining sharply near the end of August with only small numbers moving upstream thereafter.

- The counter data indicates that 1999 was an exceptional year for sea trout (6590). The minimum run estimate shows a 45% increase on the 1998 estimate (3590) and is the largest count recorded over the last 5 years of counter operation. The previous highest count was in 1996 (5511). The majority of the run was concentrated in June and July, which is consistent with previous years. It is also interesting to note that the pattern is of the run is almost identical to 1995.

- The counts in January are likely to be slightly lower than expected as the counter was out of action from the 15 December 1998 to the 8 January 1999. This was due to a faulty internal power supply unit. The counts around this period were not considered to be consistent enough to make a reliable estimate for the lost count data. However, the counts after and prior to the counter being out of action, together with data from previous years suggests that the numbers of fish traversing the weir are likely to be low and would therefore have little effect on the overall run patterns.

- A point of interest in the 1999 data (Table 1 & 2) is the significant increase in the number of salmon and sea trout counts recorded during March. A large proportion, 32 and 42 respectively, of these counts can be attributed to the last four days in March, and more particularly on the 29 March, 13 fish for both salmon/large sea trout and sea trout. Flow rates are fairly consistent with those in the pervious 4 years. It is therefore likely that the reason for this early run of fish may have been due to higher water temperatures around this period, which encouraged the fish to move earlier than normal.

- Flow data for 1999 indicates that suitable flows for upstream migration on the side channels were available for 98% of the year. Past studies have shown that the minimum level on the side channels for successful upstream migration is 5 cm on the crest, equivalent to a flow of 1.16 cumecs - Sambrook (1985). These same studies have also shown that salmonids show greater preference for the side channels (channels 2 & 3) of the weir during spate / high flow conditions. This would be expected, as fish would preferentially select the best available flows for traversing the weir.

7.3. Video Validation and Counter Efficiency

All the video footage taken at Restormel was taken during the hours of daylight due to the poor quality of the night-time footage, which was due to a number of factors including:

- Condensation on the camera lenses at night.

- Resources were not available to clean the weir at regular intervals, which allowed the build up of a dense algal mat. This resulted in a reduction of picture quality particularly during the hours of darkness.

The lighting and camera system at Restormel is currently being upgraded to minimise these problems in the future and should improve the quality of night-time and day time footage.

The counter efficiencies (Table 3) are based on the number of fish that have been seen on video and recorded by the counter during daylight hours over the period (11/5/99 – 6/8/99).

The overall detection efficiency of the counter for fish >45cm (87.5%) and fish <45cm (32.4%) was comparable to the validation study conducted in 1997. As indicated in the 1997 validation report, a better estimate for fish <45 cm can be obtained using the non-directional fish passage "events" (42.3%). If we include these events together with the upstream counts the efficiency for detecting fish < 45cm rises to 75%.

Slight losses in efficiency, when compared to the 1997 validation study, were due 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-directional fish" events. We are presently in discussion with Aquantic and other Logie fish counter users to find a way of reprogramming the fish counter to recognise the non-directional fish events as upstream fish.

8. Data Processing

The data presented in this report represents final adjusted counts, which takes into account such things as maintenance work on the weir i.e. cleaning, which may have caused false counts. Weir cleaning was initiated in May 1998 and so data 1998, and from previous years, was not affected by this activity.

The original monthly summary reports were intended to give a general indication of salmonid movements and to provide an estimated minimum salmonid count for the month. Any data contained within the original monthly summary reports has been superseded by this report.

9. Update

- A Y2K compliant counter was installed on the 14 July 1999. The software and PC were tested for compliance, 14 May and 29 September respectively, and verified as compliant. No problems have been found with the counter during the roll over into 2000.

- Telemetry was installed at the beginning of 1999, which has enabled the counter to be remotely downloaded and operational conditions to be closely monitored. It has also

allowed us to quickly identify and rectify faults with the counter, which is reflected in the drastic reduction of enforced downtime for 1999.

10.Future Work

- Video validation will be carried out during the summer months to assess the efficiency of the counter.

- Replacement of the existing camera array 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.

- Incorporation of anti-condensation heaters into the camera housings to reduce the risk of the camera lenses misting over during the collection of night-time footage.

- An upgrade of the 12V infrared lighting system to a more powerful 240V system is in progress and should be completed by the end of February 2000. The new system consists of six 300-Watt infrared lights, two per channel, which should give us good light penetration of the water and will enable us to collect good quality night-time footage.

- It is hoped that an experimental surface-skimming camera will be installed in the centre channel at Restormel sometime during 2000. This will allow side view footage to be collected, which will improve species identification and apportionment. A similar system has been trialled at the Gunnislake fish pass with promising results.

- Two sensors / data-loggers, to measure and record changes in temperature and barometric pressure, will be installed at the counter site in March 2000. These are being installed to investigate the effects of temperature and pressure on the movements of salmonids. These will provide valuable additional data, which can be used in conjunction with the counter, flow and video data to improve our knowledge of salmonid movements on the River Fowey.

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

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

11.Downtime

The counter was operational for 8567 hours out of a possible 8760, approximately equivalent to 357 days out of a total of 365 days. The majority of this downtime can be attributed to a fault in the power supply at the end of December 1998, which was not rectified until the 8 January 1999. The downtime is broken down as follows:

Table 4 – Breakdown of Counter Downtime in 1999.

Item	*Downtime*		*% Downtime*	
	Enforced	*Routine*	*Enforced*	*Routine*
Weir cleaning (gate shut)		10.56		5.18
Counter Maintenance		0.58		0.28
Camera Maintenance		0.00		0.00
Counter Fault	192.58		94.43	
Other		0.23		0.11
Total Downtime (Hours)	192.58	11.37		
Expected Operational Hours	8760.00			
% Time Operational	97.67			

12.References

01. Environment Agency (1998). A preliminary assessment of the ability of Restormel fish counter to enumerate the passage of migratory salmonids on the River Fowey; Environment Agency, South West Region, September 1998.

02. Sambrook, H. T. "Upstream Migration of Salmonids into the River Fowey Catchment, Restormel Trap 1979 – 1984. South West Water, Dept. of Env. Serv., Environmental Section – West, Vol II, 1985.

03. Environment Agency (1997). Design and Use of Open Channel Resistivity Fish Counters (Advisory Manual). Fisheries Technical Manual No. 2. Environment Agency North West Region. R&D Technical Report W23.

Figure 3 - Daily Upstream Counts of Salmon / Large Sea Trout in Relation to Flow (cumecs) at Restormel Weir – January – December 1999.

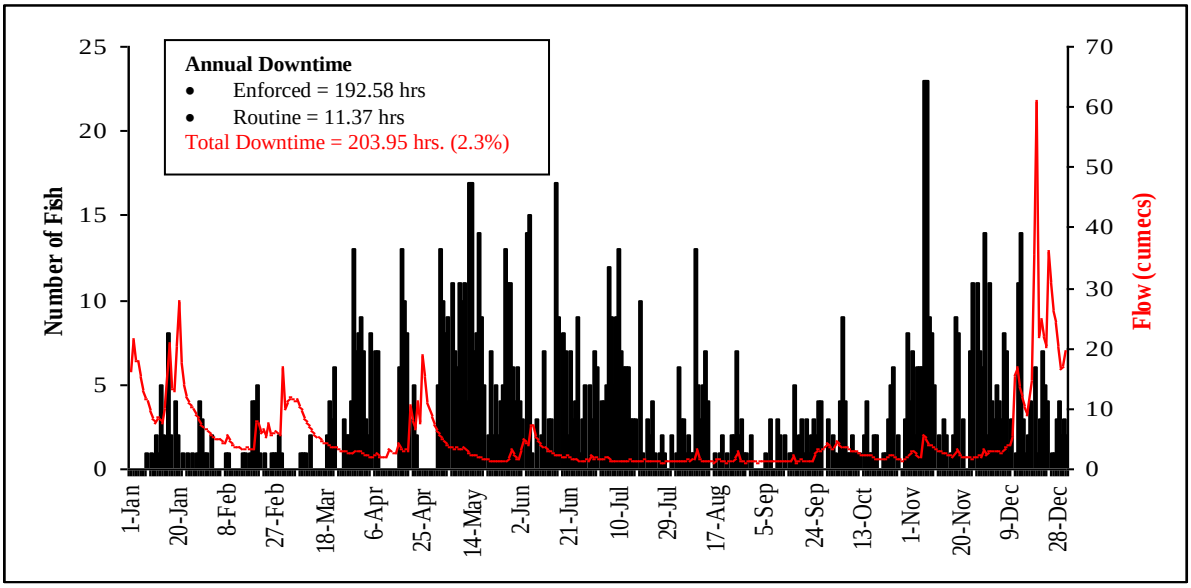


Figure 4 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Restormel Weir – January – December 1999.

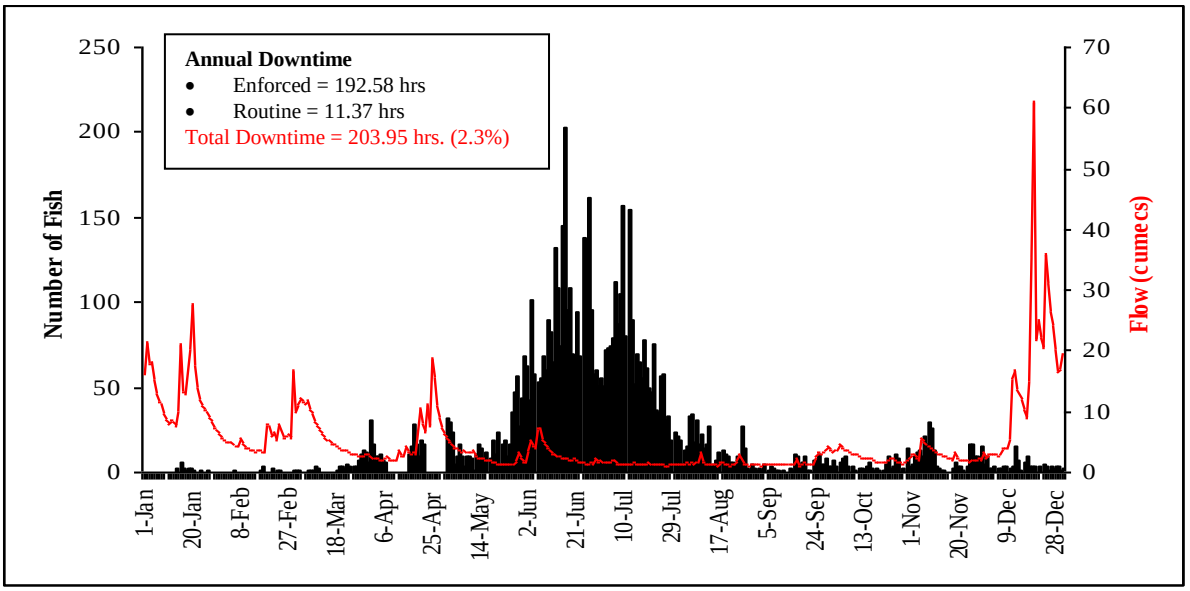


Figure 5– Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – January 1999.

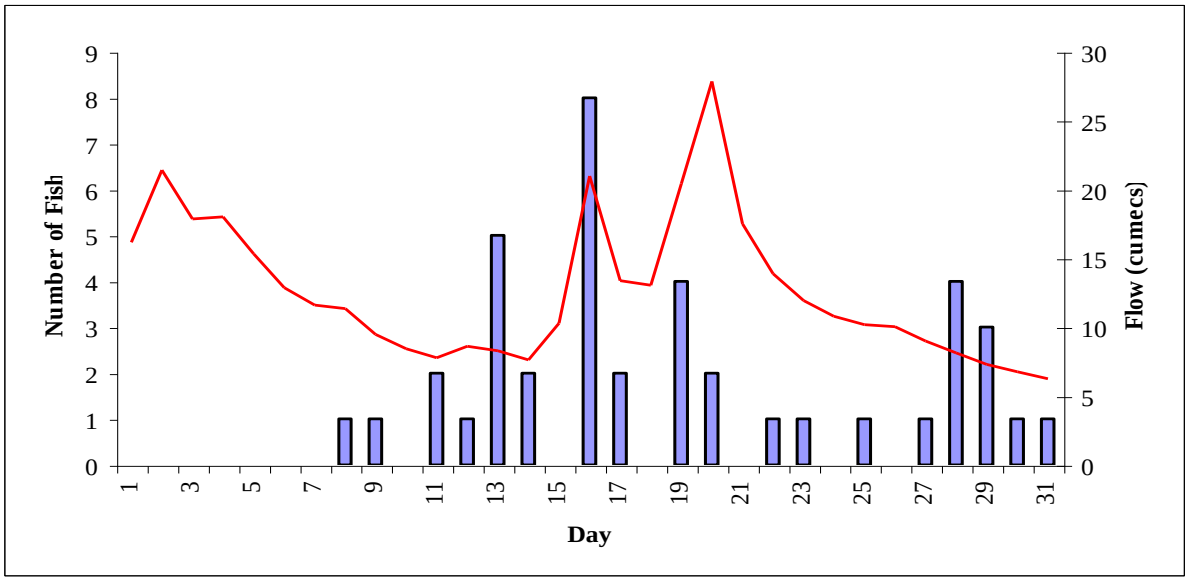


Figure 6 – Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – January 1999.

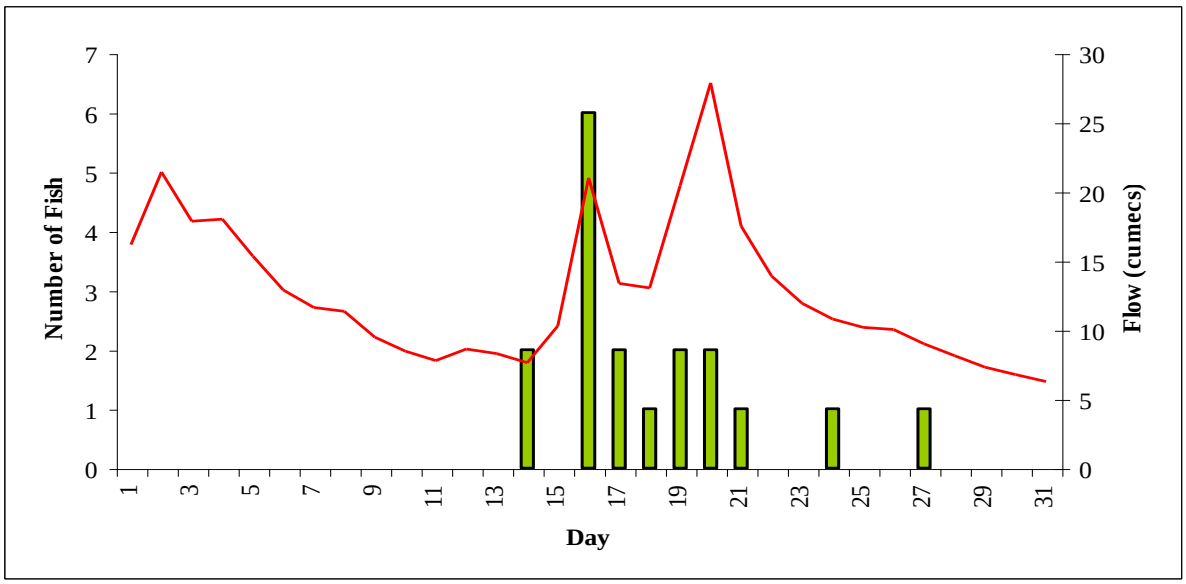


Figure 7 – Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – February 1999.

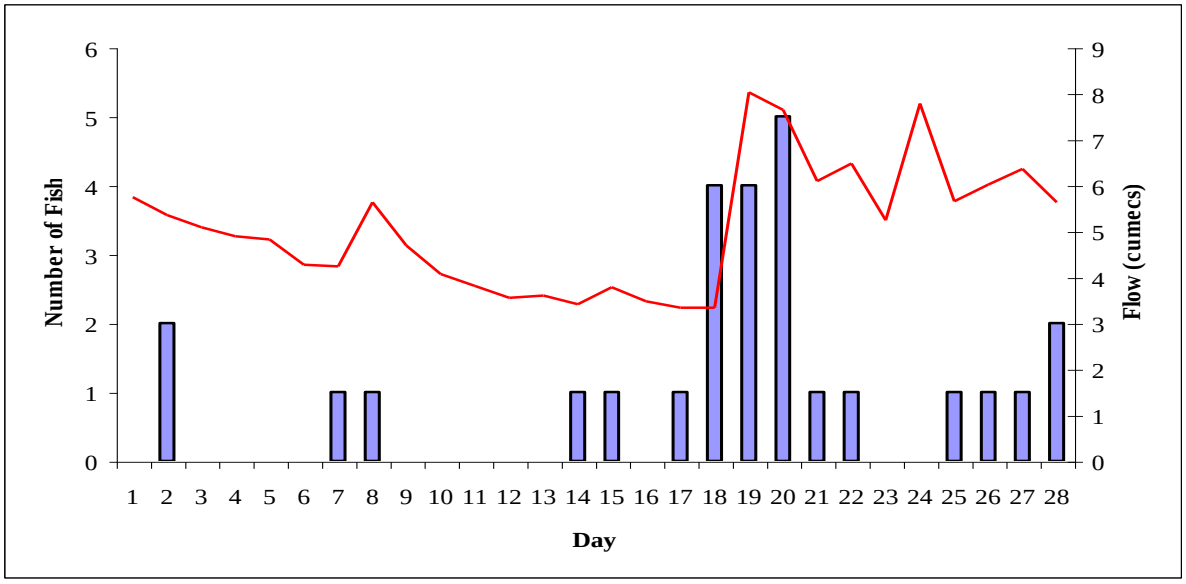


Figure 8– Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – February 1999.

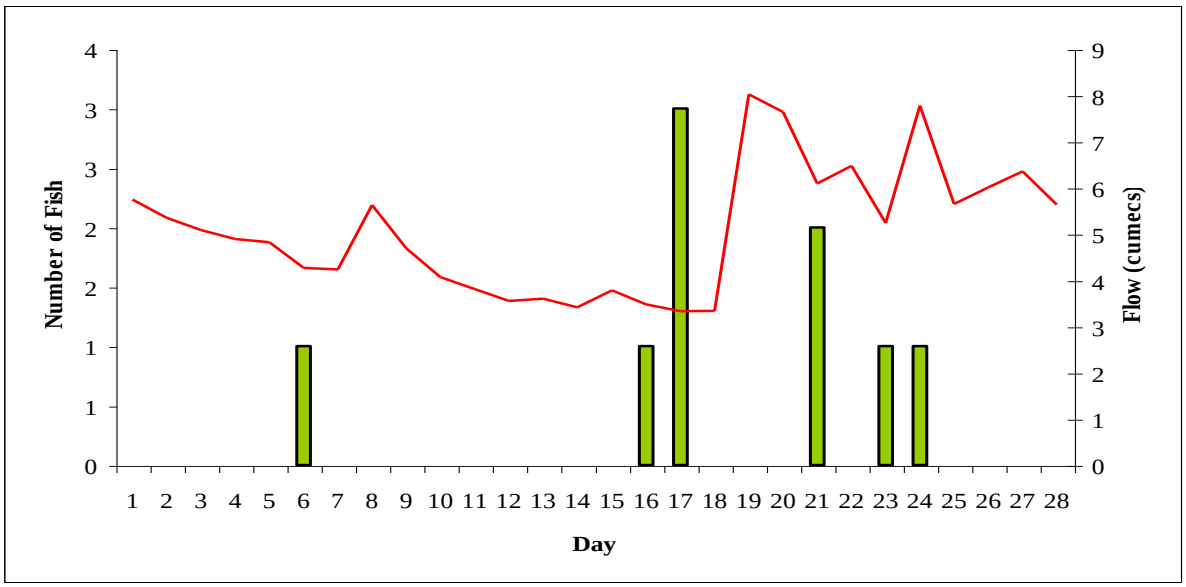


Figure 9 – Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – March 1999.

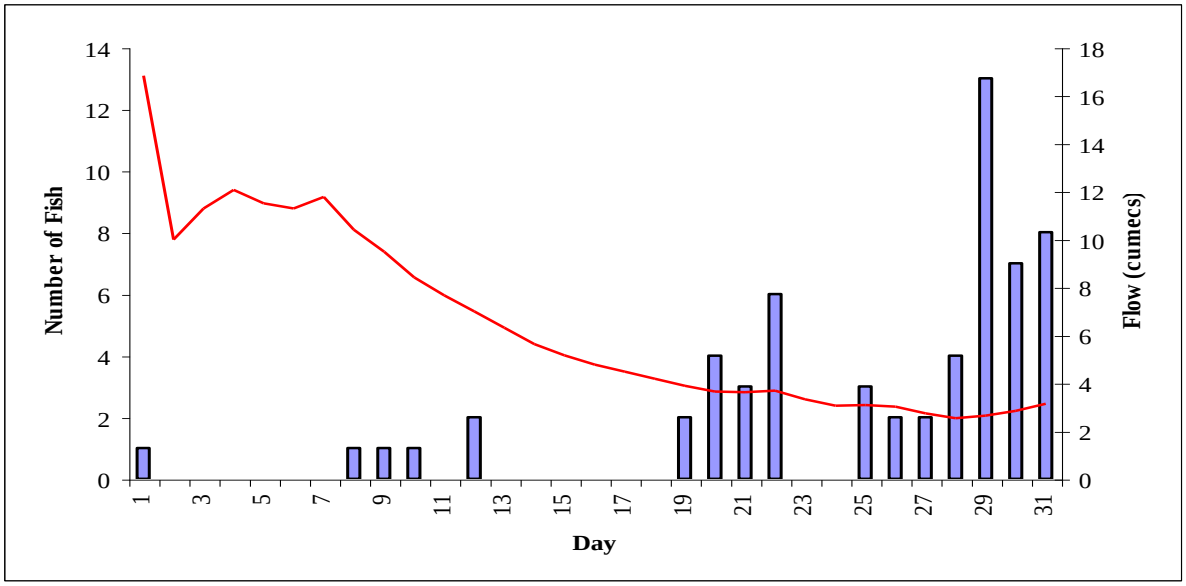


Figure 10 – Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – March 1999.

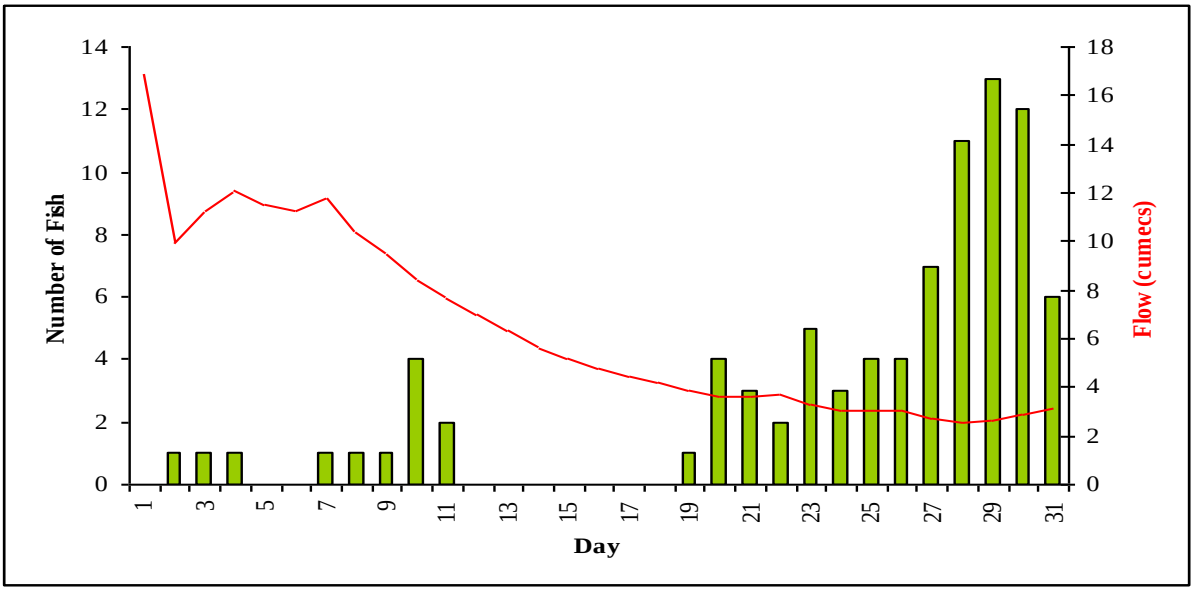


Figure 11 - Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – April 1999.

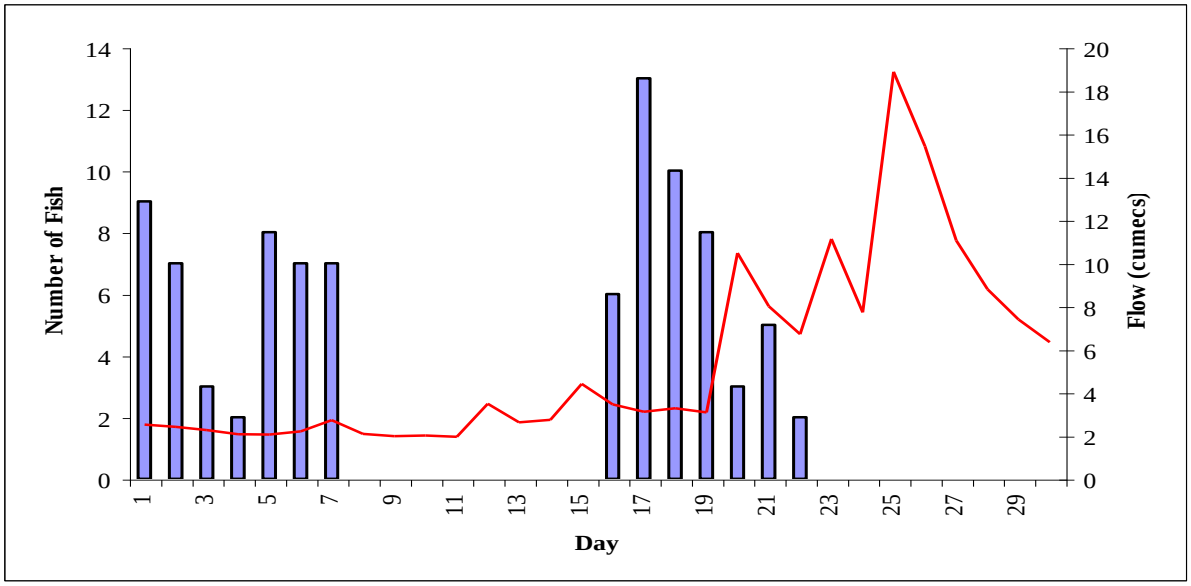


Figure 12 - Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – April 1999.

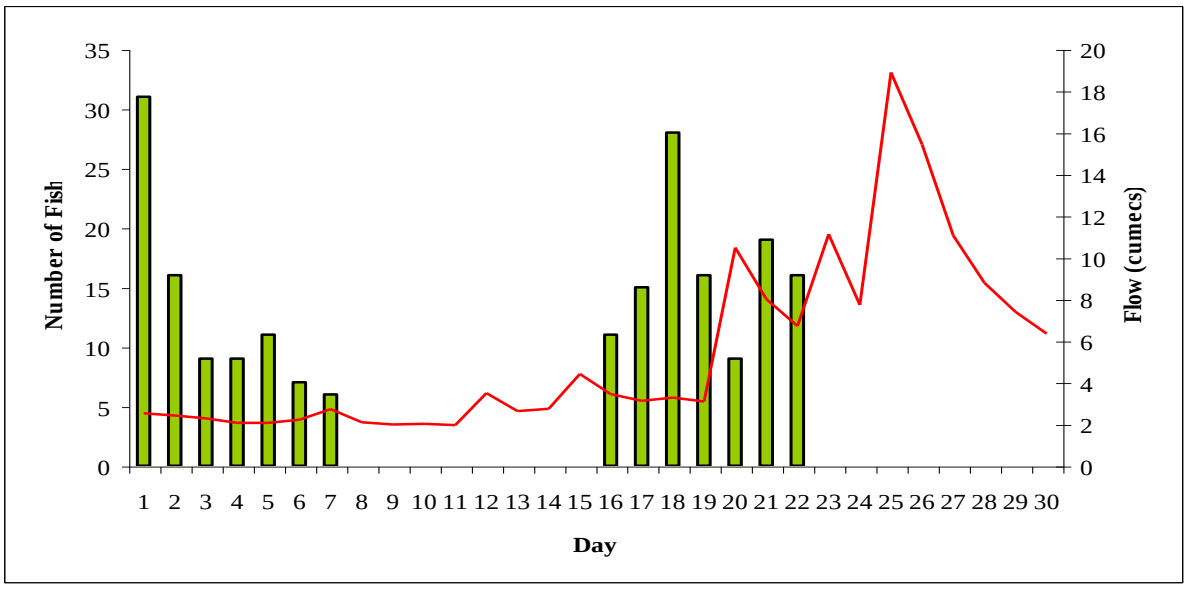


Figure 13 - Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – May 1999.

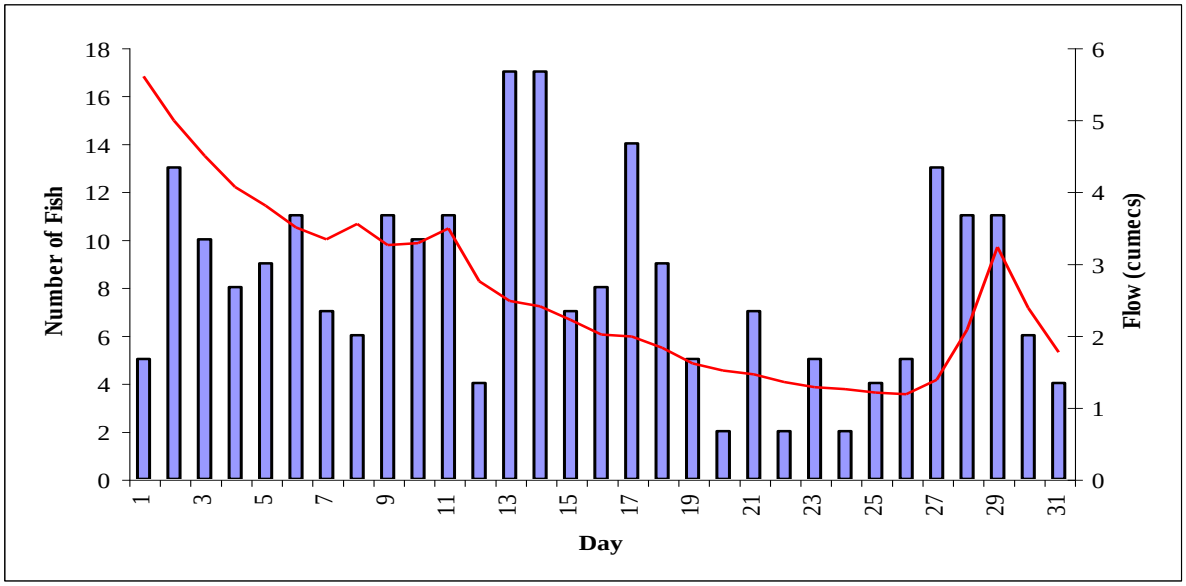


Figure 14 - Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – May 1999.

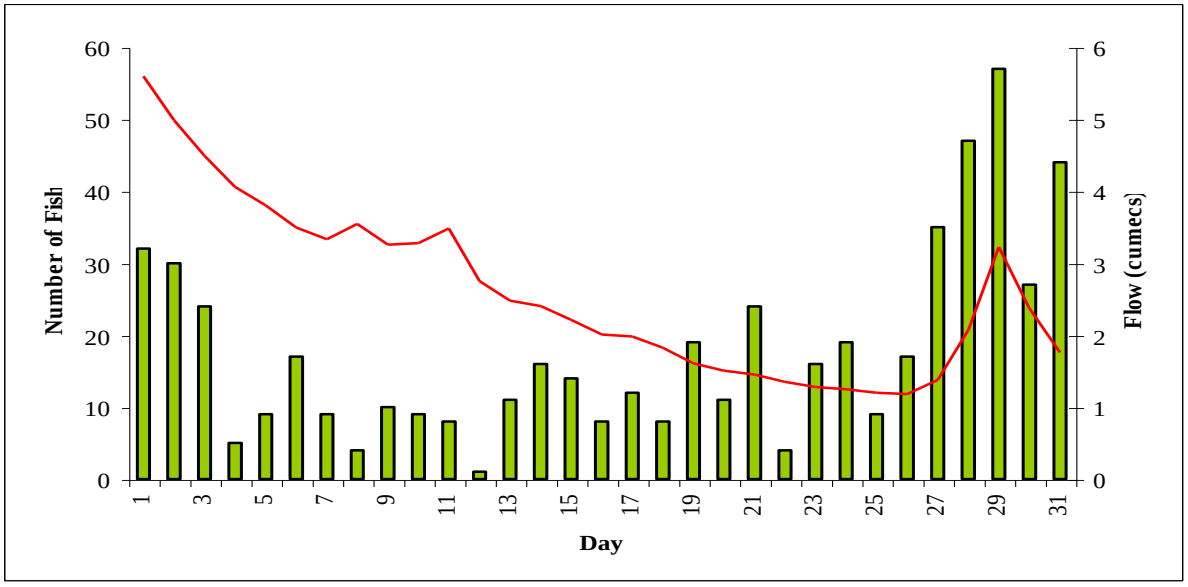


Figure 15 - Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – June 1999.

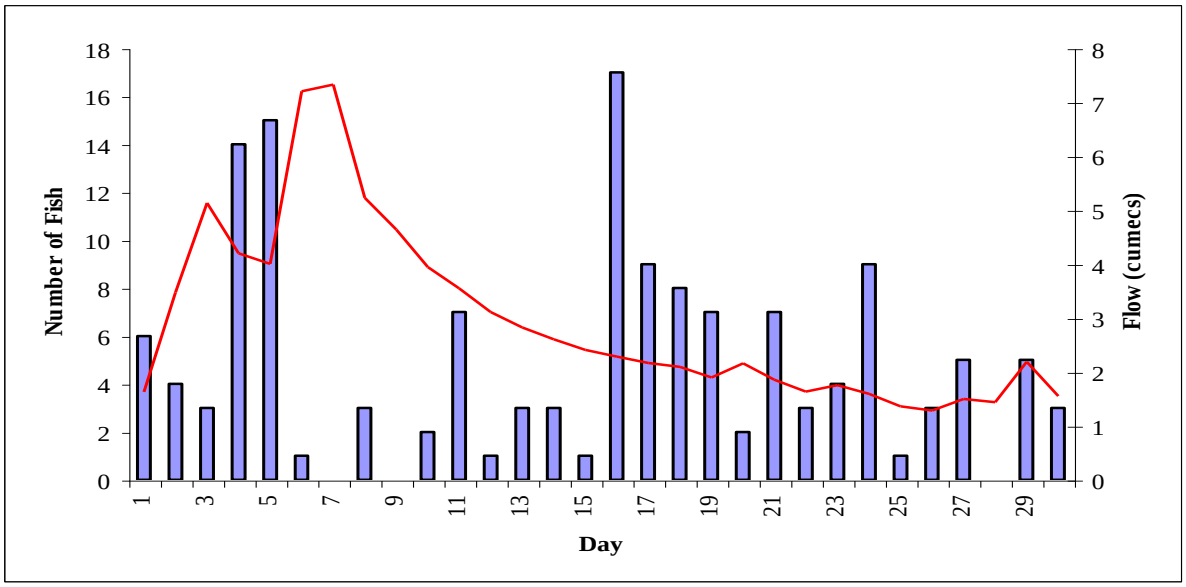


Figure 16 - Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – June 1999.

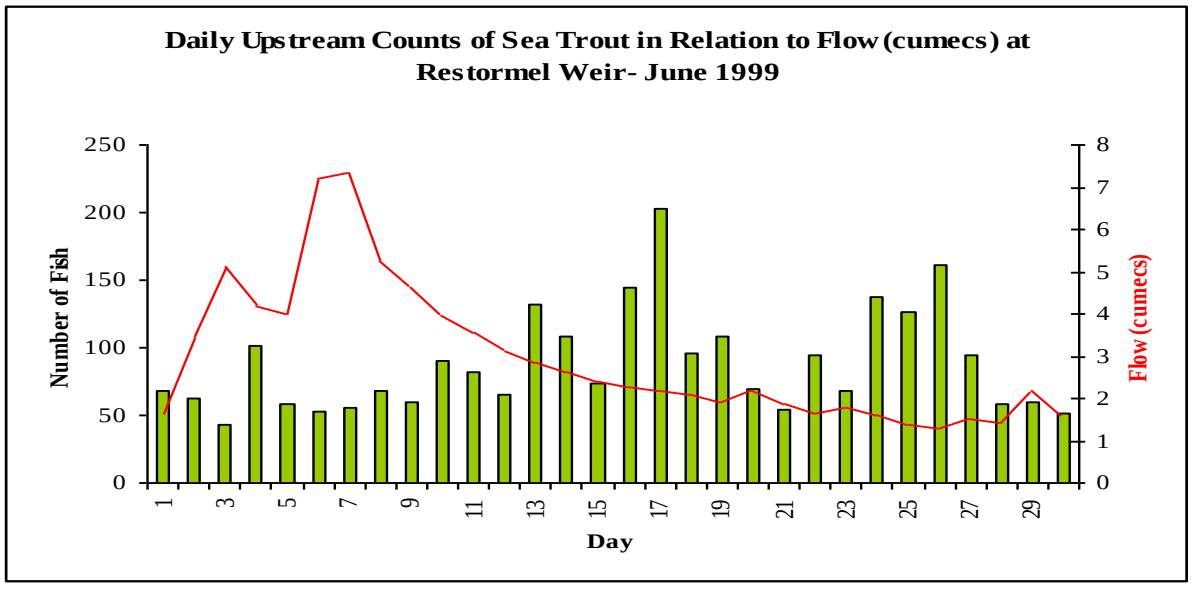


Figure 17 - Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – July 1999.

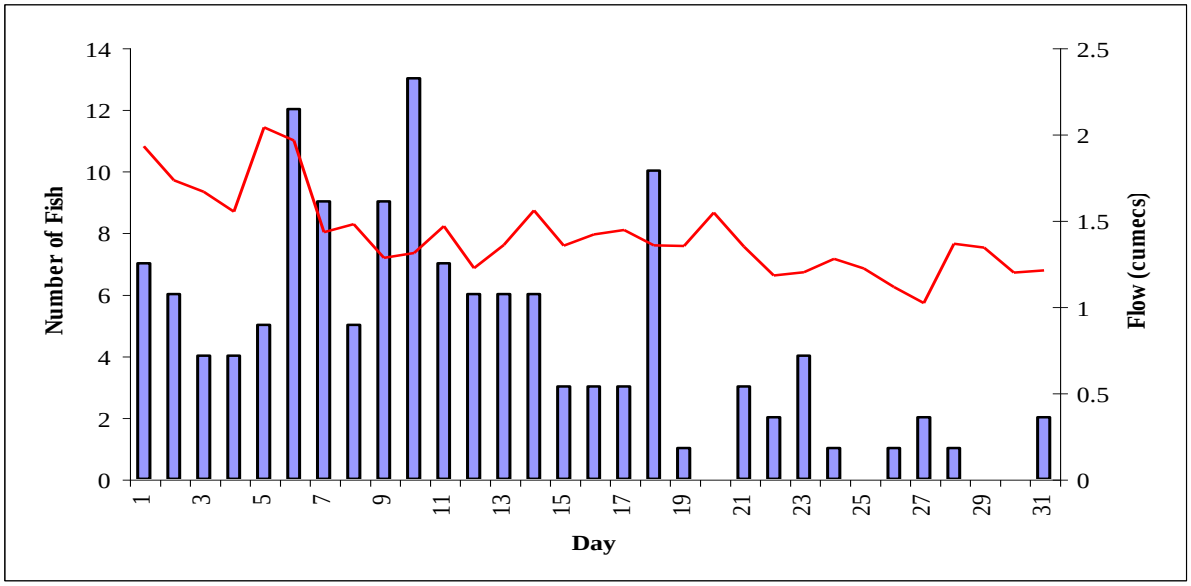


Figure 18 - Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – July 1999.

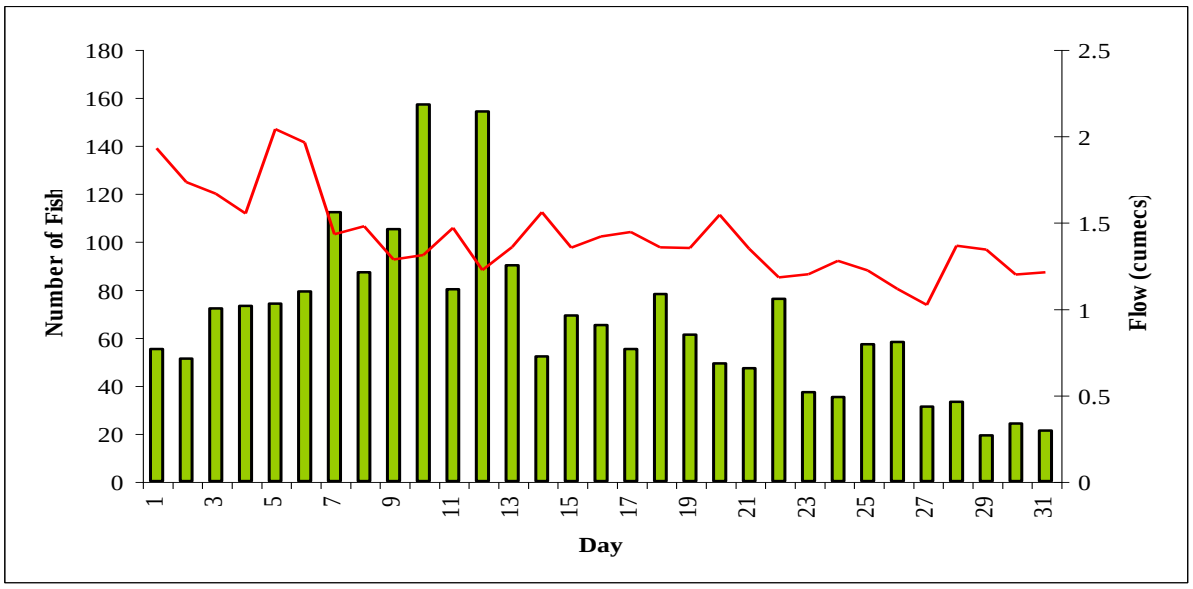


Figure 19 - Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – August 1999.

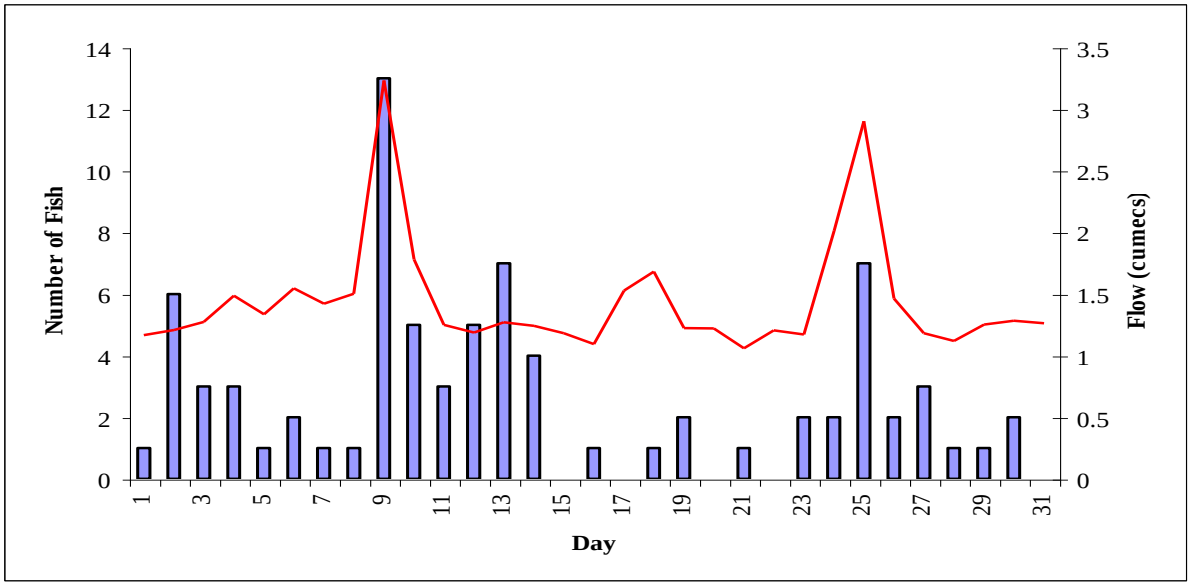


Figure 20 - Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – August 1999.

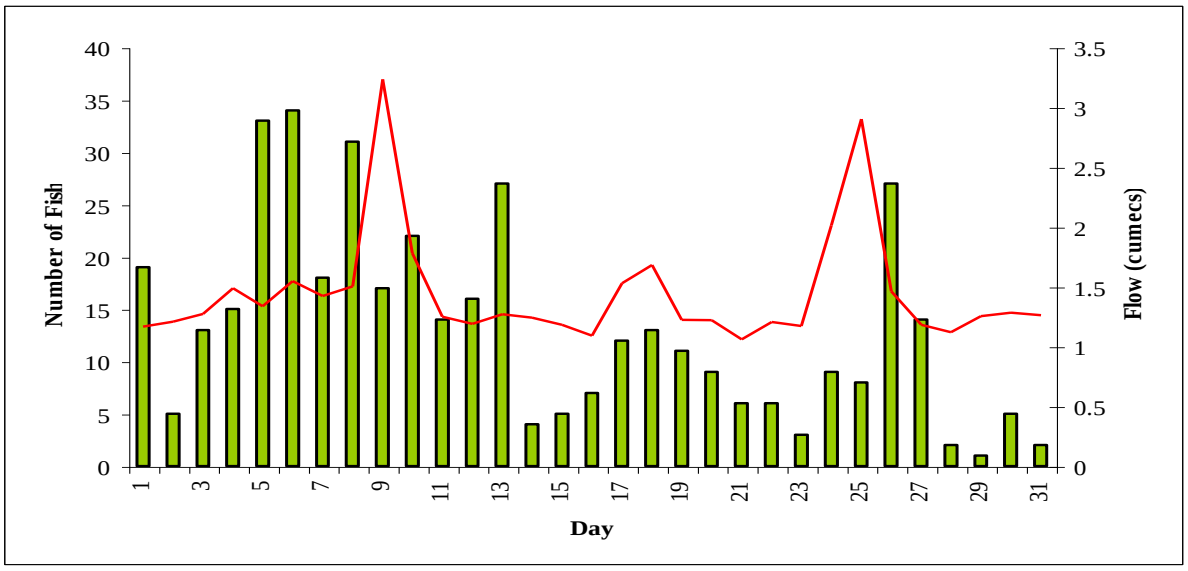


Figure 21 - Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – September 1999.

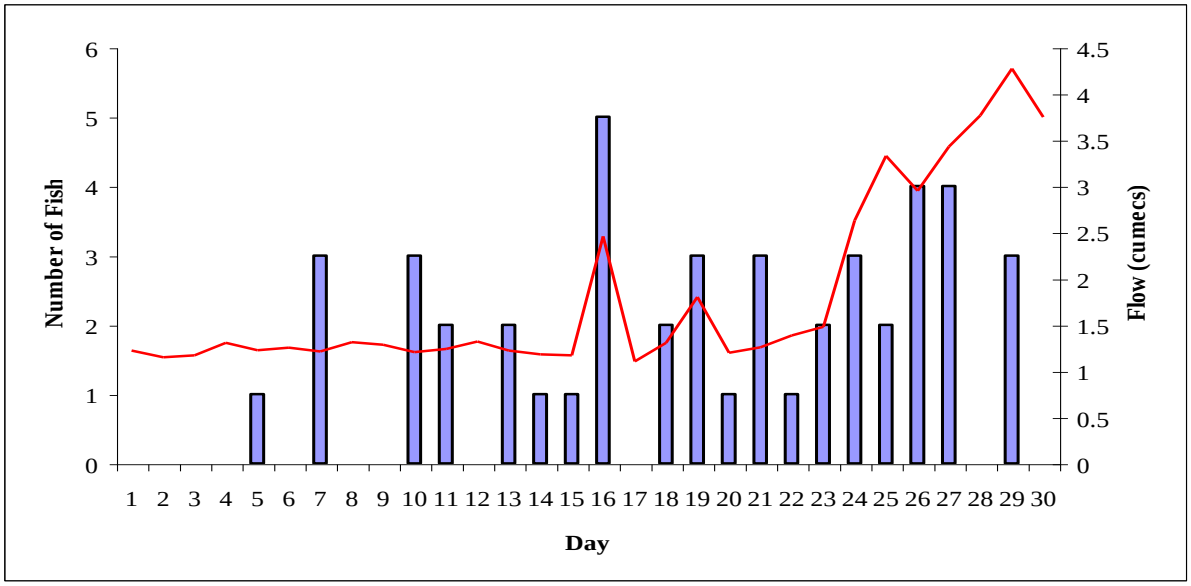


Figure 22 - Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – September 1999.

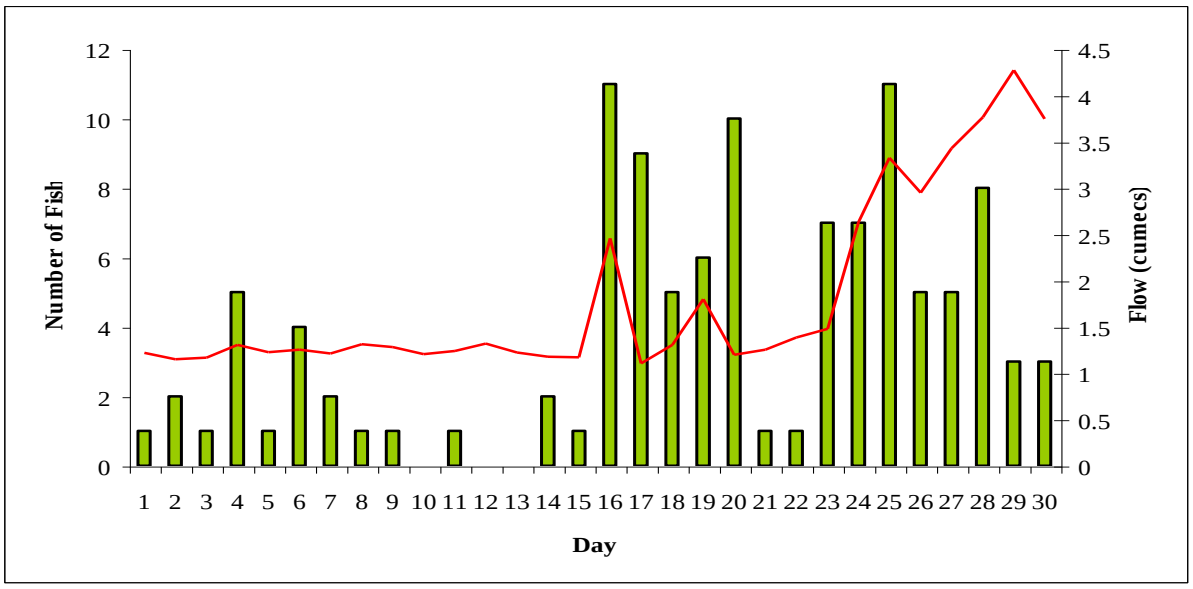


Figure 23 – Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – October 1999.

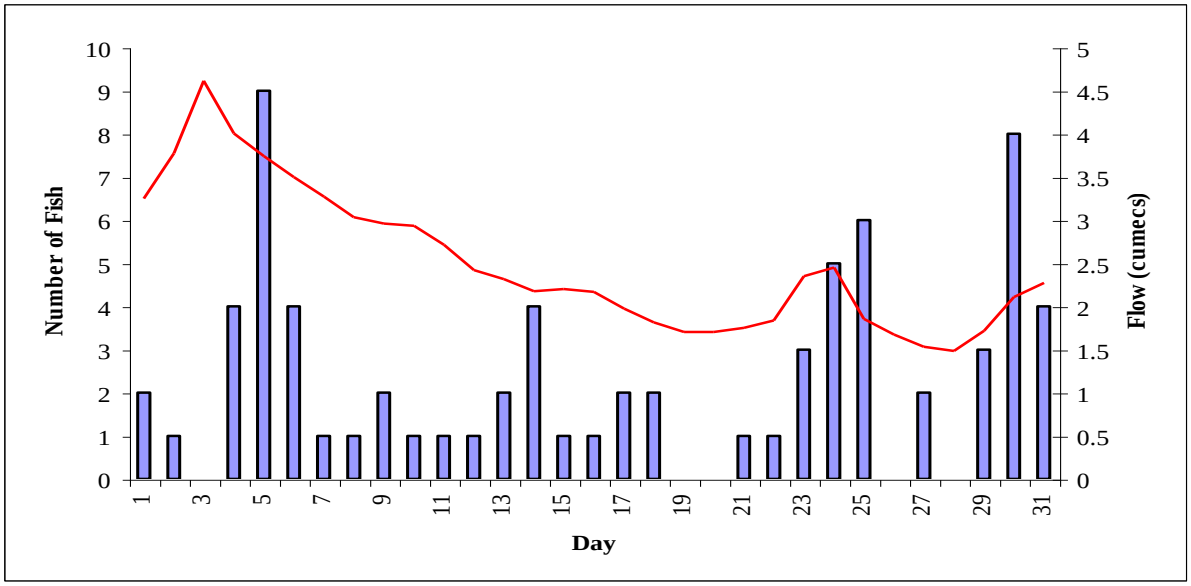


Figure 24 – Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – October 1999.

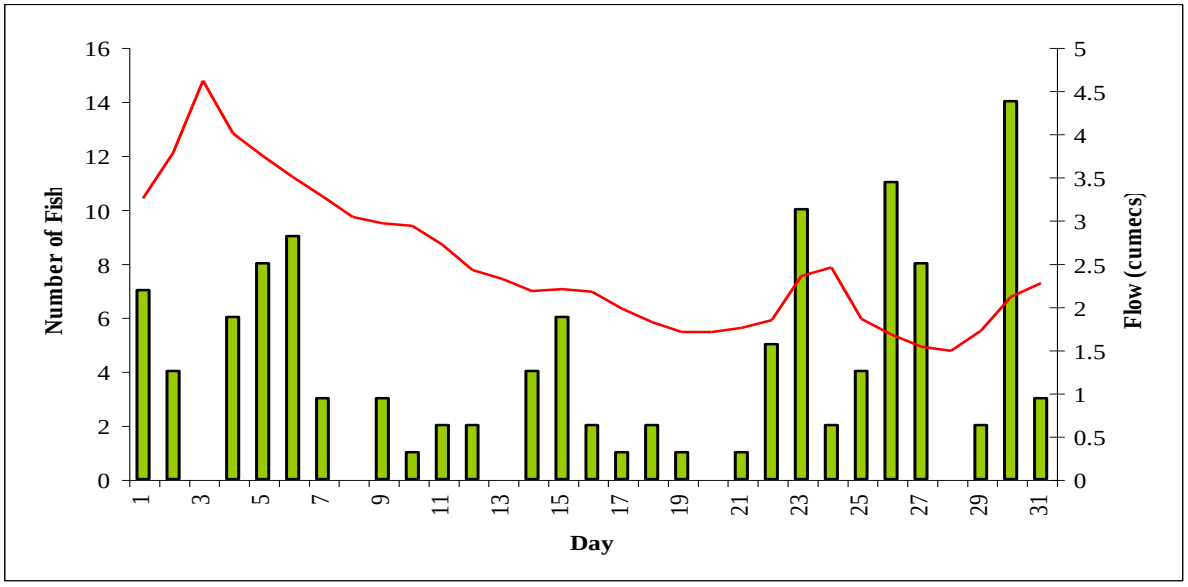


Figure 25 – Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – November 1999.

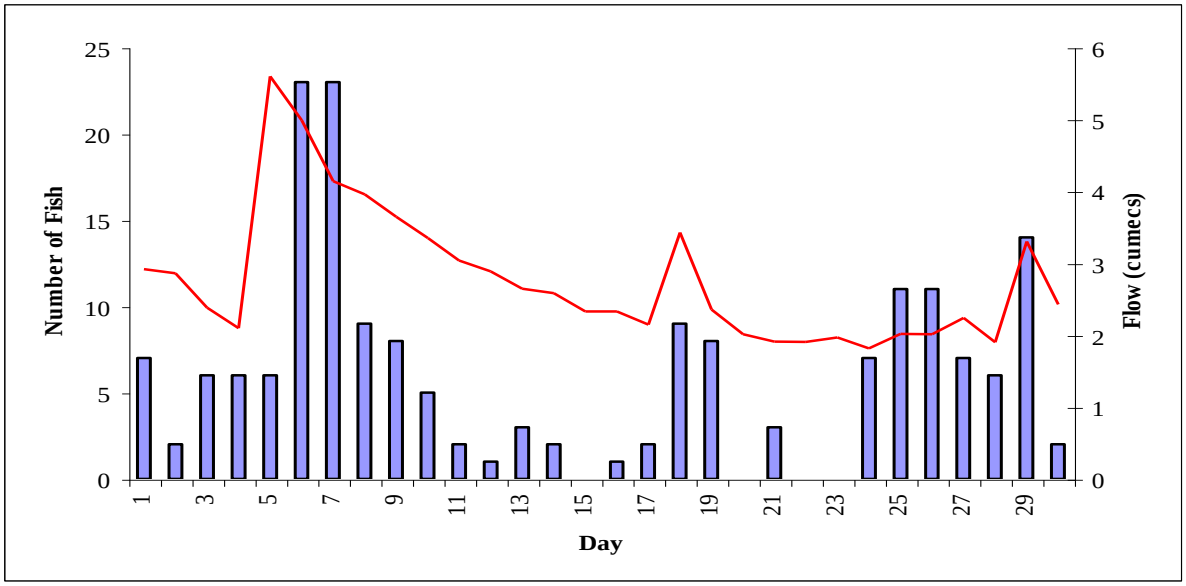


Figure 26 – Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – November 1999.

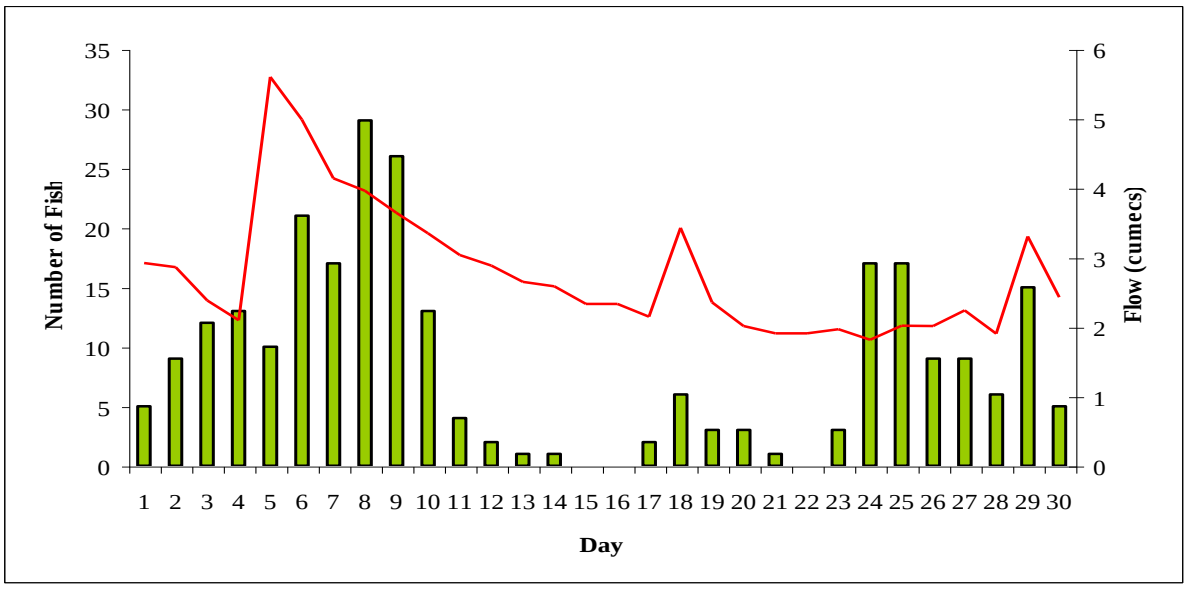


Figure 27 – Daily Upstream Salmon / Large Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – December 1999.

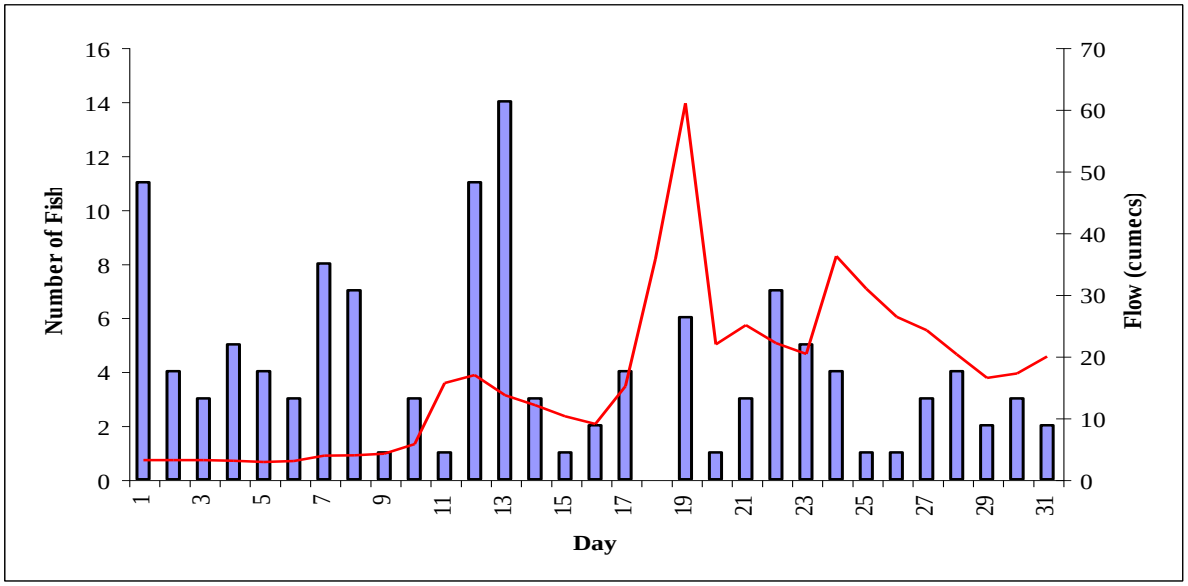


Figure 28 – Daily Upstream Sea Trout Counts in Relation to Flow (cumecs) at Restormel Weir – December 1999.

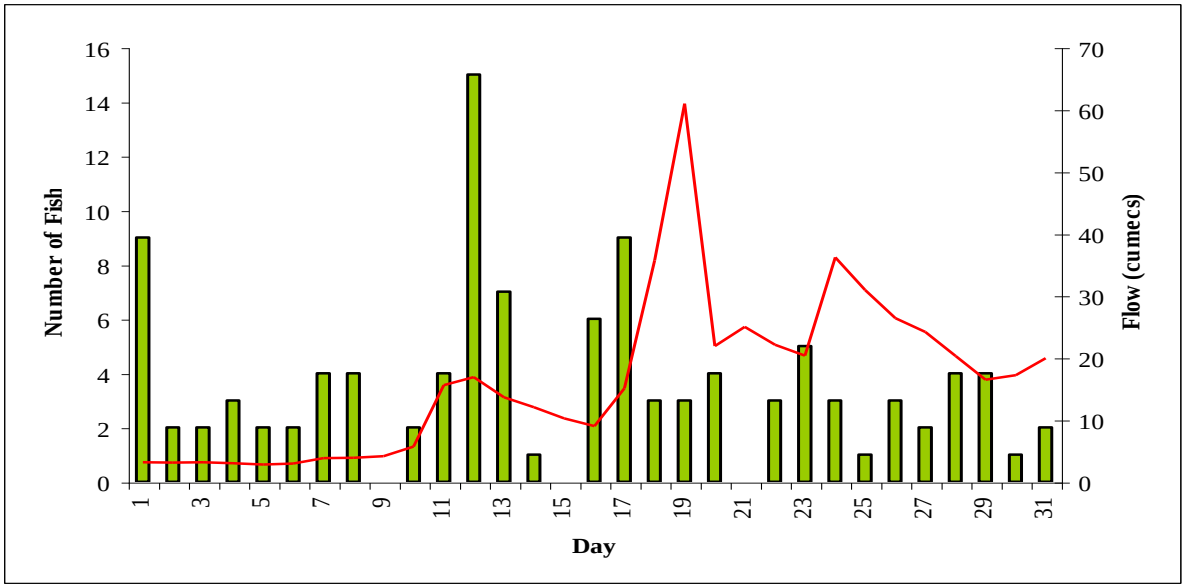


Figure 29 - Fish Deflection Values Recorded at Restormel Fish Counter - January 1999.

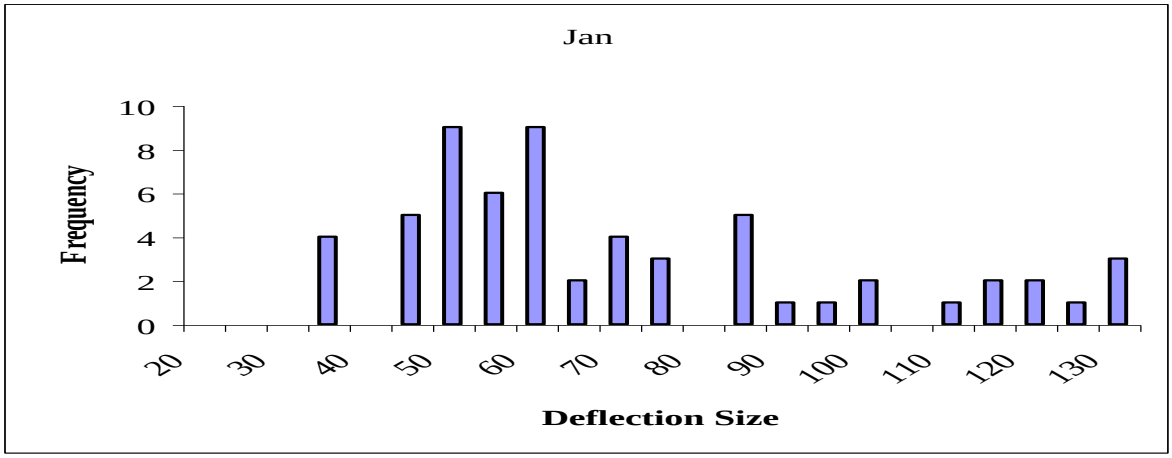


Figure 30 - Fish Deflection Values Recorded at Restormel Fish Counter - February 1999.

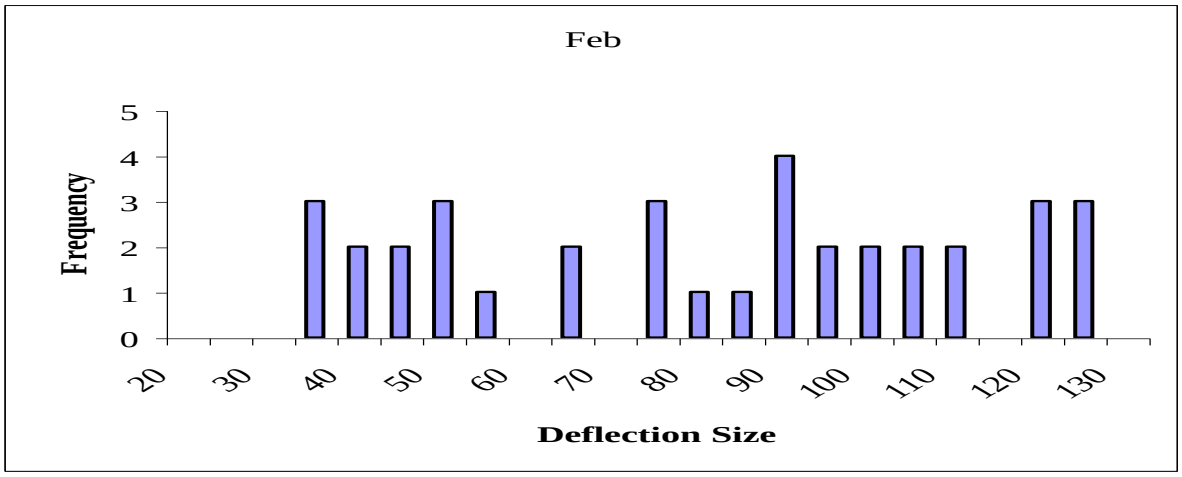


Figure 31 - Fish Deflection Values Recorded at Restormel Fish Counter – March 1999.

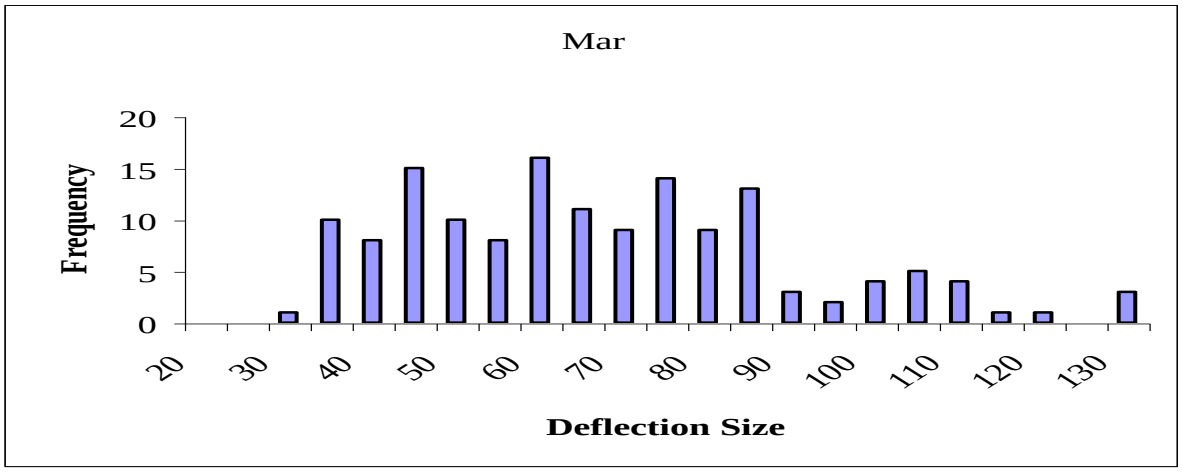


Figure 32- Fish Deflection Values Recorded at Restormel Fish Counter - April 1999.

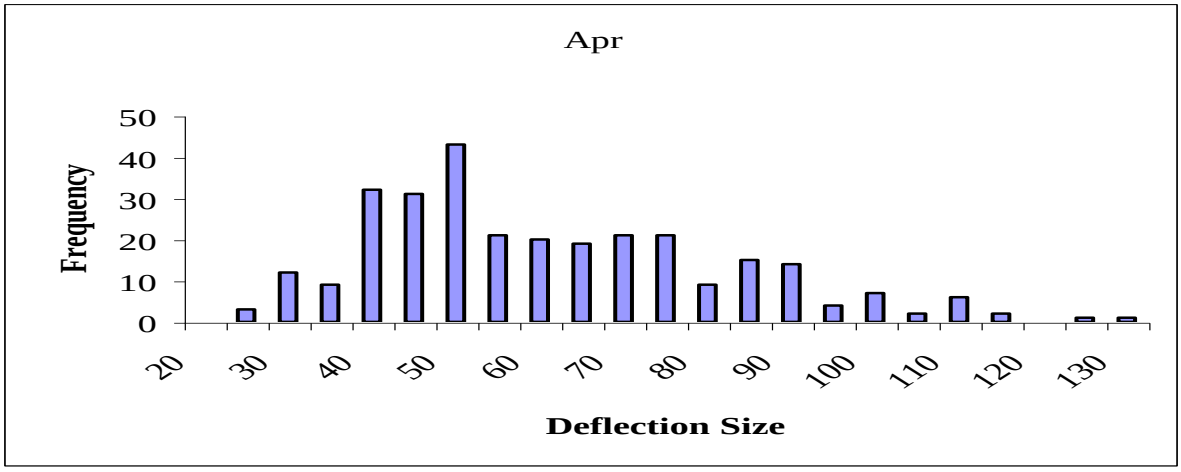


Figure 33 - Fish Deflection Values Recorded at Restormel Fish Counter - May 1999.

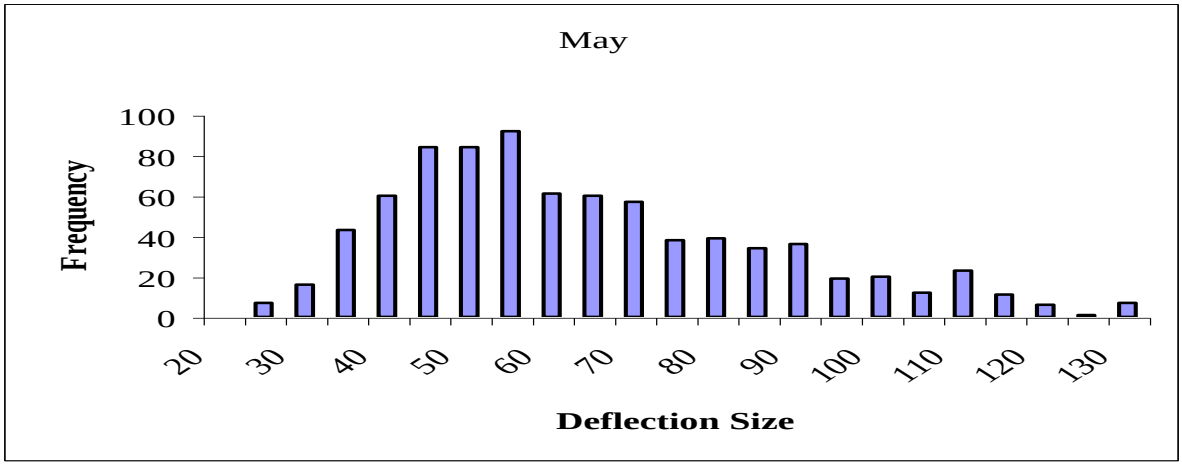


Figure 34 - Fish Deflection Values Recorded at Restormel Fish Counter - June 1999.

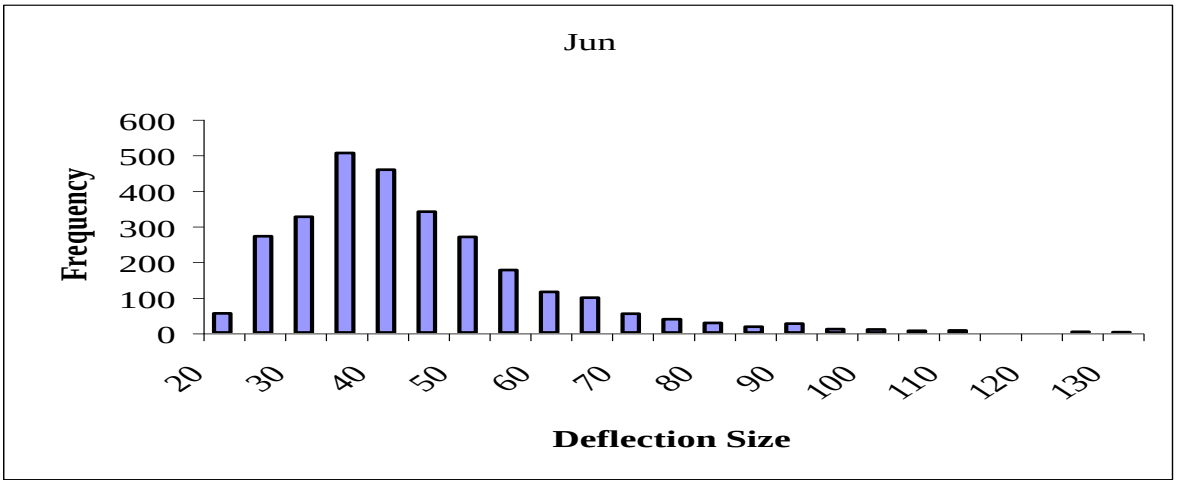


Figure 35 - Fish Deflection Values Recorded at Restormel Fish Counter - July 1999.

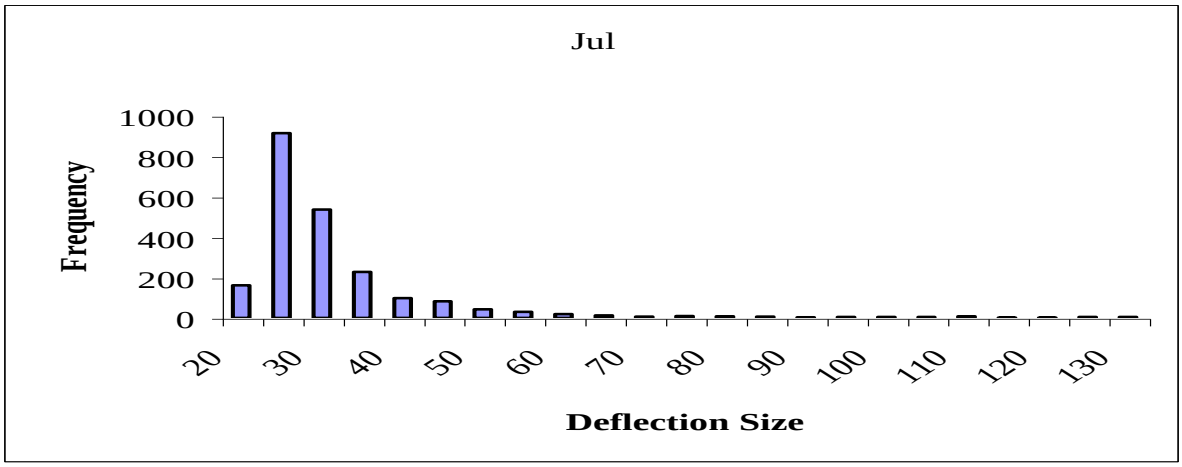


Figure 36 - Fish Deflection Values Recorded at Restormel Fish Counter - August 1999.

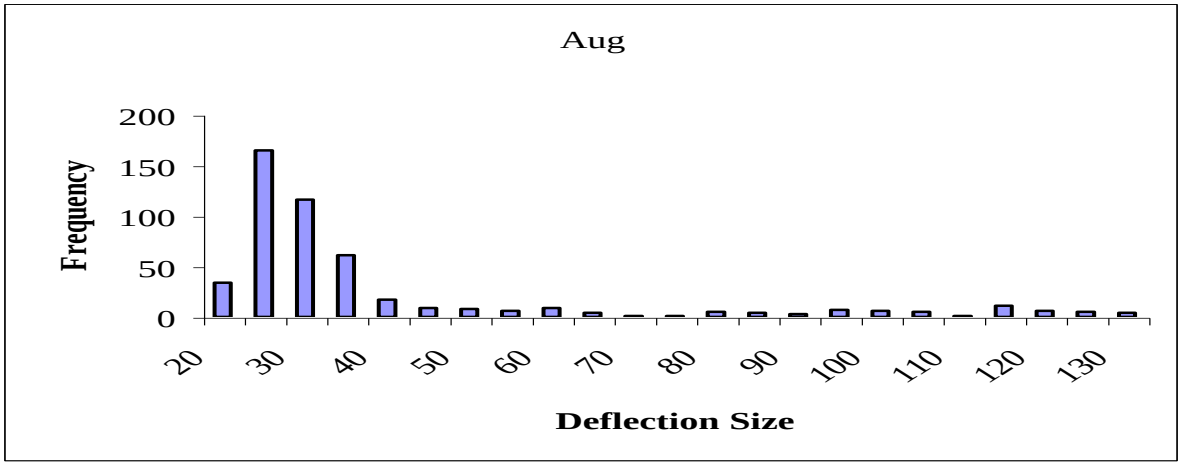


Figure 37 - Fish Deflection Values Recorded at Restormel Fish Counter - September 1999.

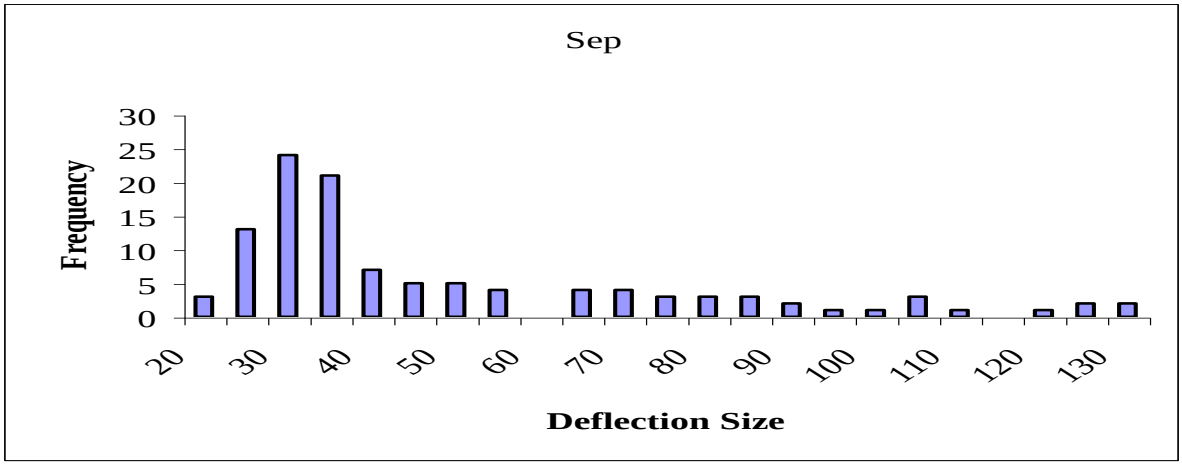


Figure 38- Fish Deflection Values Recorded at Restormel Fish Counter - October 1999.

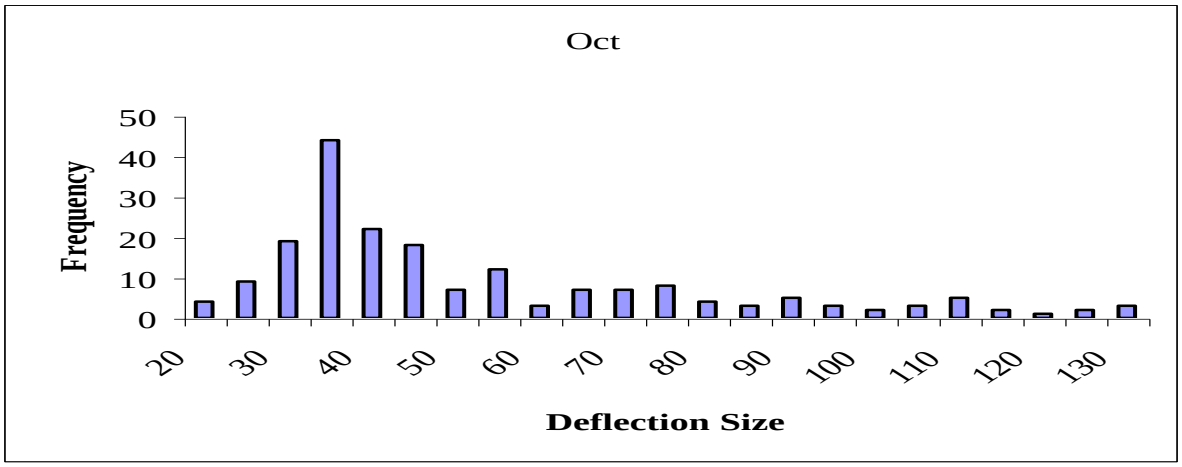


Figure 39 - Fish Deflection Values Recorded at Restormel Fish Counter - November 1999.

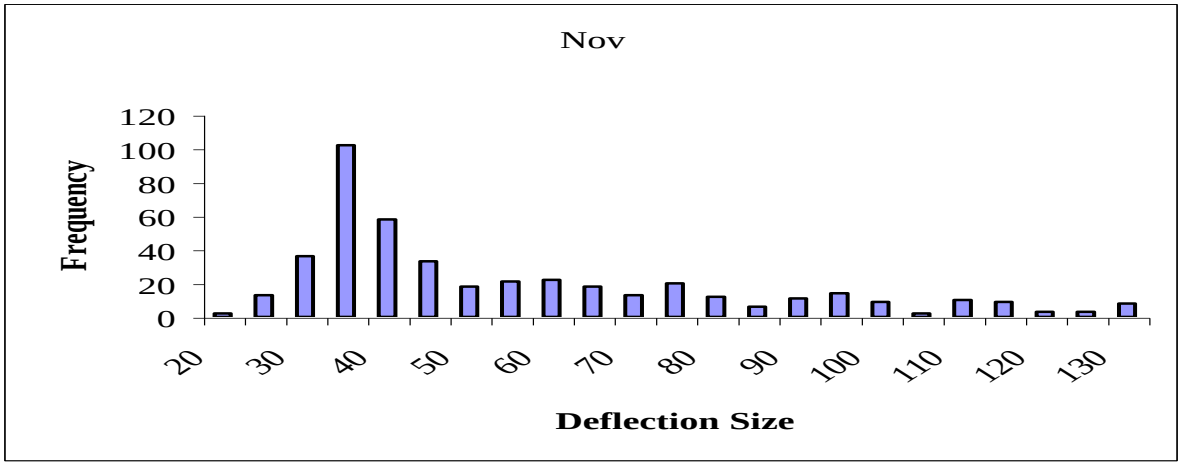
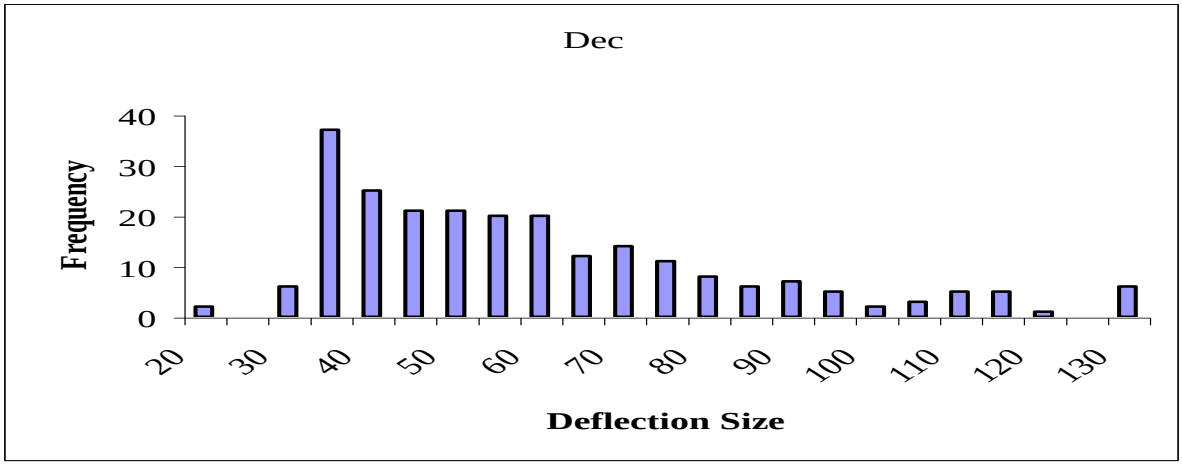


Figure 40 - Fish Deflection Values Recorded at Restormel Fish Counter – December 1999.



13.APPENDICES

Appendix 1 - 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 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 a polythene block to reduce fluctuations in resistivity due to 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 2 - 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 in 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 July and February (88% of all fish greater 50 cm attained a deflection size greater than 50).

Data from previous years indicated that larger sea trout run into the river from March – June. 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.

Appendix 3 - Video Validation – sample size

The following method is used as a guide to assess how many fish are 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%.

For example, if we were only 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).

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 the video 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.

Appendix 4 – Table B: Fish Deflection Values for Upstream Migrating Salmonids Recorded at Restormel Weir in 1999.

Deflection	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20	0	0	0	0	0	54	161	34	3	4	2	2
25	0	0	0	3	7	270	914	165	13	9	13	0
30	0	0	1	12	16	325	537	116	24	19	36	6
35	4	3	10	9	43	504	228	61	21	44	102	37
40	0	2	8	32	60	457	98	17	7	22	58	25
45	5	2	15	31	84	339	83	9	5	18	33	21
50	9	3	10	43	84	268	42	8	5	7	18	21
55	6	1	8	21	92	175	30	6	4	12	21	20
60	9	0	16	20	61	114	19	9	0	3	22	20
65	2	2	11	19	60	98	12	4	4	7	18	12
70	4	0	9	21	57	53	6	1	4	7	13	14
75	3	3	14	21	38	37	10	1	3	8	20	11
80	0	1	9	9	39	27	8	5	3	4	12	8
85	5	1	13	15	34	16	6	4	3	3	6	6
90	1	4	3	14	36	25	3	3	2	5	11	7
95	1	2	2	4	19	10	5	7	1	3	14	5
100	2	2	4	7	20	9	5	6	1	2	9	2
105	0	2	5	2	12	5	4	5	3	3	2	3
110	1	2	4	6	23	6	8	1	1	5	10	5
115	2	0	1	2	11	0	1	11	0	2	9	5
120	2	3	1	0	6	0	2	6	1	1	3	1
125	1	3	0	1	1	2	5	5	2	2	3	0
130	3	0	3	1	7	1	4	4	2	3	8	6

Appendix 5 - Daily Movements of Salmon and Sea Trout Recorded at Restormel Fish Counter in 1999.