Newport Research Facility

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Report for the year ended 31st December 2010

This report follows in sequence from the Annual Reports of the Salmon Research Agency of Ireland Inc. and the Salmon Research Trust of Ireland Inc.

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Summary

1. The Salmon Research Agency of Ireland merged with the Marine Institute on the 1st July 1999 into Aquaculture & Catchment Management Services. This report provides a continuation of the data records for the Burrishoole facilities.

2. The total rainfall recorded in Furnace in 2010 was 1311.6 mm. Months of relatively high rainfall in 2010 were July, August, September and November with low rainfall from January to June.

3. The year started with a cold period in January and finished in December with another bitterly cold period of frost, snow and ice.

4. The total release of micro-tagged salmon smolts of Burrishoole reared origin into L. Furnace amounted to 33,995. Smolts were released as five core and one SLICE treated groups, ranging in mean weight from 58g to 64g. An experimental group of 10,110 smolts, derived from wild Owenmore and wild Burrishoole parents, were released into Lough Furnace on 30th April 2010.

5. In 2007, the Irish Government introduced a cessation of drift netting for salmon at sea and this was continued in 2010.

6. A total of 686 wild grilse were recorded moving upstream through the permanent traps during the season. The number of spring fish recorded was 17. The total run of wild grilse, including the Furnace rod catch (0), was 686.

7. Returning adults were checked for net mark damage; 3.8% (n=684) of wild grilse and 2.6% (n=899) of reared grilse had net marks recorded.

8. The maximum spawning escapement was 617 wild and 35 reared fish.

9. A total of 7123 wild salmon smolts were recorded in the downstream trap in 2010. The wild return of 2009 smolts as wild grilse in 2010 was 8.9%. The ova to smolt survival at 0.67 – 0.75%.

10. Wild kelt survival was 33.5% and kelt return as previously spawned grilse later in the year was 10.1%.

11. The return to freshwater of the Burrishoole reared grilse recorded was 2.7%, up from 1.2% in 2009.

12. A total of 72 wild sea trout and a further 104 non-silvered trout migrated upstream through the traps in 2010. Of the sea trout, 35 were adults and 37 (51%) were finnock.

13. The 2010 sea trout smolt run amounted to 213 smolts.

14. The percentage of smolts returning as finnock in the same year has historically ranged from 11.4% to 32.4%. In 1989 it collapsed to a minimum of 1.5%. There has been a saw-tooth pattern of finnock return in the 1990's between 4 & 10%,

rising to 16.7% in 1999. Finnock return in 2010 was 17.5% – the second highest return rate since 1999 and comparable to 2009.

15. Silver eel trapping continued with the total run amounting to 2137 with the run mainly in September, October and November. The run dropped off in November and few eels were recorded in December or in early 2011.

16. A total of 104 salmon were caught in the Fishery in 2010. The catch consisted of 26 wild fish and 78 reared salmon. All wild fish were returned alive. There was a minimum of 22 sea trout caught on L. Furnace and 1 on L. Feeagh and these were returned alive. 120 brown trout were also caught on L. Feeagh in 2010.

17. 2010 marked the completion of 20 years of catchment electrofishing surveys for juvenile salmonids and eel.

18. Intensive eel fyke net surveys of Bunaveela and Feeagh were undertaken in conjunction with IFI in 2009 and 2010. The data from these surveys were included in the National eel database.

19. Invertebrate surveys were carried out in 2010 on the Owengarve and Burrishoole catchments.

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1 Introduction

The Salmon Research Agency merged with the national Marine Institute on the 1st July 1999. The staff of the Agency were absorbed into the Aquaculture and Catchment Services Group of the Institute and the research facilities at Furnace have undergone a programme of upgrading and improvement. The core monitoring work of the Agency will continue but its unique experimental facilities, both in relation to aquaculture and wild fisheries, will be fully utilised within the context of the Marine Institutes published Research, Technology, Development and Innovation Strategy. The merger has resulted in an increased national role for the work of the Agency and a consolidation of the trap and laboratory facilities at Newport.

This report represents a continuation of the Annual Reports published by the Salmon Research Agency of Ireland. The data presented creates a unique record of fish rearing and wild fish census data for the past 41 years. This data is an essential component in the local, regional and national management of salmon, sea trout and eel and is becoming ever more valuable in the light of increasing pressures on natural stocks, such as exploitation, habitat degradation and global climate change scenarios. The fish monitoring facilities in Newport, along with the reared and ranched salmon stocks held in Burrishoole, are also essential for the evaluation of novel enhancement techniques, alternative stocks and ranching and evaluation of interactions between farmed, ranched and wild strains.

2 Environmental Data

2.1 Mill Race Data

2.1.1 Rainfall

Daily meteorological data were collected during 2010 at the manual Met Station in Furnace. The monthly rainfall figures for 2007, 2008, 2009 and 2010 are given in Table 2.1, along with the annual totals for the years 1977 to 2010. Months of relatively high rainfall in 2010 were July, August, September and November. Low rainfall was recorded in the first six months of the year and December. The total rainfall was 1311.6 mm in 2010. The year started with a very cold period in January and February with hard frosts and spells of snow. December was unusually cold with considerable accumulations of snow in Burrishoole for most of the month. Air and water temperatures were low and many streams and lakes froze, with L. Furnace almost totally covered in a thick ice cover. Daily rainfall amounts are shown in Figure 2.1.

Table 2-1: Monthly rainfall totals (mm) for the Furnace Station in 2006, 2007, 2008 and 2009 and the annual totals for 1977 to 2010.

Month	2007	2008	2009	2010	Year	Total	Year	Total
January	202.9	227.0	143.8	86.0	1977	1579.7	2000	1833.2
February	116.6	137.5	61.8	69.1	1978	1592.2	2001	1298.7
March	122.0	230.2	124.9	82.5	1979	1653.3	2002	1715.9
April	55.7	67.6	92.8	48.8	1980	1792.1	2003	1353.2
May	129.7	29.1	128.8	48.2	1981	1646.8	2004	1641.3
June	121.1	95.8	67.5	44.3	1982	1609.6	2005	1608.2
July	191.7	62.0	243.8	129.3	1983	1495.9	2006	1550.7
August	87.4	218.9	254.7	100.2	1984	1556.6	2007	1576.8
September	120.4	178.9	87.1	262.4	1985	1584.1	2008	1805.0
October	92.0	249.4	132.3	130.9	1986	1886.9	2009	1793.9
November	131.8	179.3	322.6	240.1	1987	1373.6	2010	1311.6
December	205.5	129.3	133.8	69.8	1988	1715.2		
					1989	1583.9		
Total	1576.8	1805.0	1793.9	1311.6	1993	1473.4		
					1994	1757.1		
					1995	1382.5		
					1996	1286.6		
					1997	1351.6		
					1998	1830.9		
					1999	1949.1		

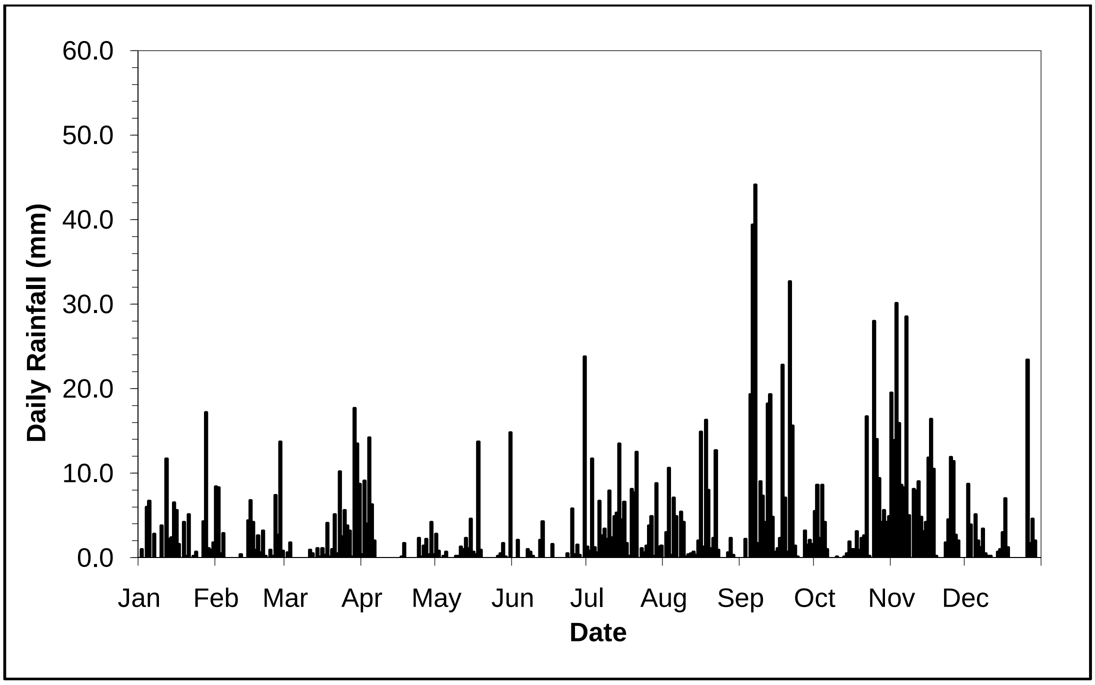


Figure 2-1: Daily rainfall amounts (mm) recorded in the Mill Race manual weather station.

2.1.2 Water Level and Temperature

Water Level: Difficulties were experienced in 2003 with the automatic water level chart recorder. An OTT Orphimedes automatic water level recorder was installed in late January 2004. Water levels are recorded every 15 minutes and are presented in Figure 2.2 recorded at 23.45 hrs. This approximates to the previous mid-night readings from the chart recorder.

Water Temperature: In 2004, a TidbiT temperature logger was installed along with the chart recorder and this records water temperature every 30 minutes. The temperature logger data is presented in Figure 2.3, recorded at the closest time to midnight (<30mins).

Water temperatures (recorded at midnight) fell to a minimum of 3.7^{O}C on the 15th January. There was an increase in temperature from the middle of March through to a peak of 15.4^{0}C in late May followed by a further increase to the 20th June to a maximum of 16.7^{O}C, a full 3 degrees lower than in 2009. The temperature dropped fairly steadily from early September for the rest of the year to a minimum of 2.2 ^{O}C on the 25th of December.

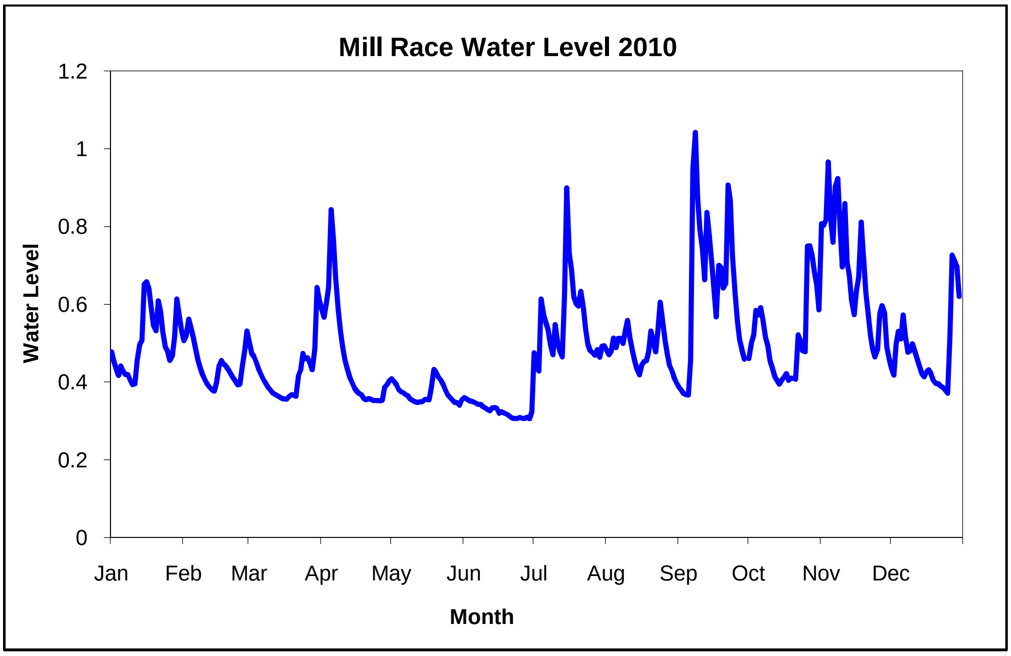


Figure 2-2: Water levels recorded at mid-night for the Mill Race using an OTT Orphimedes automatic water level recorder.

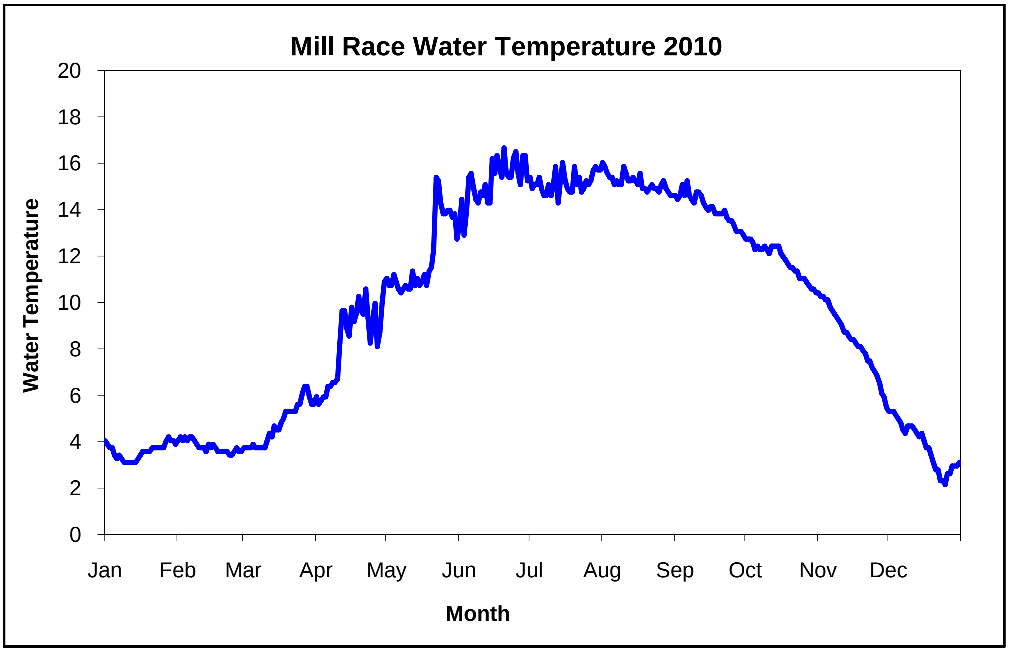


Figure 2-3: Water temperatures recorded, by TidbiT data logger, at mid-night for the Mill Race.

2.2 Catchment Programme

2.2.1 Background

In recent years, the combined effect of extreme weather events with impacts of land use, have had a significant effect on the erosion rates recorded in many upland areas. Since 1995 the Marine Institute has operated a series of automatic monitoring stations to monitor these impacts, the influence of weather patterns and to attempt to quantify the transport of suspended sediments in the Burrishoole catchment. These automatic stations, funded under EU LIFE and National programmes, include two lake stations (AWQMS – installed under EU LIFE 93 and ERDF 2008), which have various meteorological instruments included with a suite of underwater temperature and water chemistry sensors, and three river stations, (ARMS – installed under EU LIFE 98), which are equipped with sensors for measuring water temperature, water level, pH, conductivity, dissolved oxygen, and turbidity. The automatic monitoring stations are also equipped with a telemetry system for relaying high-resolution data back to the laboratory.

In addition the Institute has also deployed additional core-funded instrumentation in the catchment including temperature loggers, water level recorders and seventeen data-logging rain gauges in the Burrishoole and Owengarve catchments and two in the Owenduff catchment, which will assist in building up a detailed profile of precipitation in a mountainous catchment.

Also located within the catchment are a series of OTT Orphimedes water level recorders which measure water level at fifteen-minute intervals. These data can be used to calculate water volumes on an hourly or daily basis. An important feature of the monitoring network is the ability to simultaneously collect data from river, lake, and climatic instruments. The continuing integration of this data with ongoing fish population surveys is an important component of the research programme.

In 2007, the Burrishoole catchment became a member of the Global Lake Ecological Observatory Network (GLEON: http://www.gleon.org), an association of limnologists, information technology experts and engineers whose goal is to establish a persistent network of lake ecology observatories (http://www.gleon.org). Data from these observatories (of which Lough Feeagh and Lough Furnace, both located in the Burrishoole, are included) will allow a better understanding of key processes, such as the effects of climate and land use on lake function, episodic events and carbon cycling within lakes. The research involvement in GLEON is a continuation of the work carried out under various national and internationally funded projects.

Previous research identified a scientific gap in knowledge in terms of understanding the implications of present and projected future changes in stream flow, water temperature, pH levels and DO concentrations on fish productivity in the catchment. To address this, in 2008 and 2009 a multidisciplinary team of scientists, funded within the SSTI Climate Change programme, from the National University of Ireland Maynooth (NUIM), TCD and the Marine Institute, undertook an analysis of both present and likely future climate impacts on the catchment with a view to furthering the understanding of the interlinkages between climate, climate change, and the freshwater ecosystem. This report, entitled *RESCALE: Review and Simulate Climate and Catchment Responses at Burrishoole*, builds on the wealth of scientific endeavours previously undertaken on the catchment and represents the collaborative efforts of the multidisciplinary research team.

2.2.2 The Black River

The main river flowing into Lough Feeagh is the Black River. A water level recorder is installed approximately 500m above the lake. Figure 2.4 shows the average daily water level and Figure 2.5 shows the average monthly water levels from 2001 to 2010. The high rainfall event in July 2009, mentioned in Section 2.1.1 of the 2009 report, can be seen reflected in the water level in the Black River followed by the unusually dry winter/spring period in 2010.

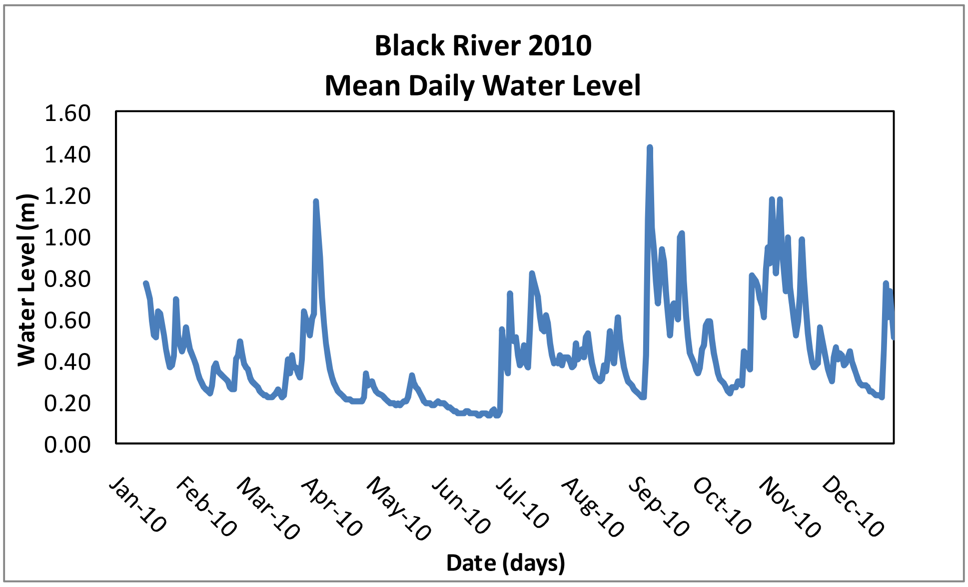


Figure 2-4: Daily mean water level for the Black River, 2010

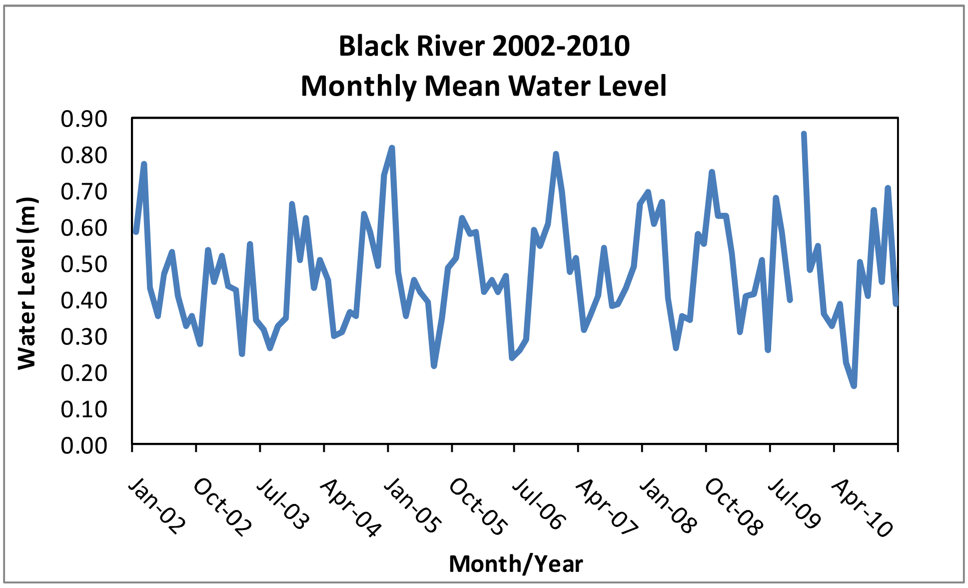


Figure 2-5: Monthly mean water levels for the Black River, 2002-2010.

2.2.3 Lough Feeagh

Lough Feeagh is situated in the Burrishoole catchment in the west of Ireland close to the Atlantic coast and is therefore strongly affected by the temperate oceanic climate that predominates in the region. The water is soft (pH range 5.7-6.9 in 2007, alkalinity 6mgl-1 CaCO3) and highly coloured (2007 mean of 82 mgl-1 PtCo), and is oligotrophic, with Chlorophyll "a" ranging between 1 and 2 µg l-1. Mean annual Total Phosphorous is 11 µg l-1 (2006) and Total Nitrogen is 0.69 mgl-1 (2006). The Lough Feeagh AWQMS measures various parameters using a Hydrolab datasonde 5, two Chelsea scientific minitrackas and a Seapoint fluorometer (pH, dissolved oxygen, temperature and conductivity, turbidity, Chl *a* fluorescence and CDOM fluorescence). These parameters are measured every five minutes and an hourly average is calculated for all the parameters. There is also a thermister chain and various weather instruments continually monitoring variables such as barometric pressure, wind speed and wind direction. Lake water temperature ranged from 2.1-17.8 °C (2010) and the lake usually stratifies between May and October each year (Fig. 2.6 & 2.7).

The temperatures (max and min) were approximately 2° lower than in 2009 and the effect of the cold winter in 2009/2010 and 2010/2011 can be clearly seen in (Fig. 2.6 & 2.7).

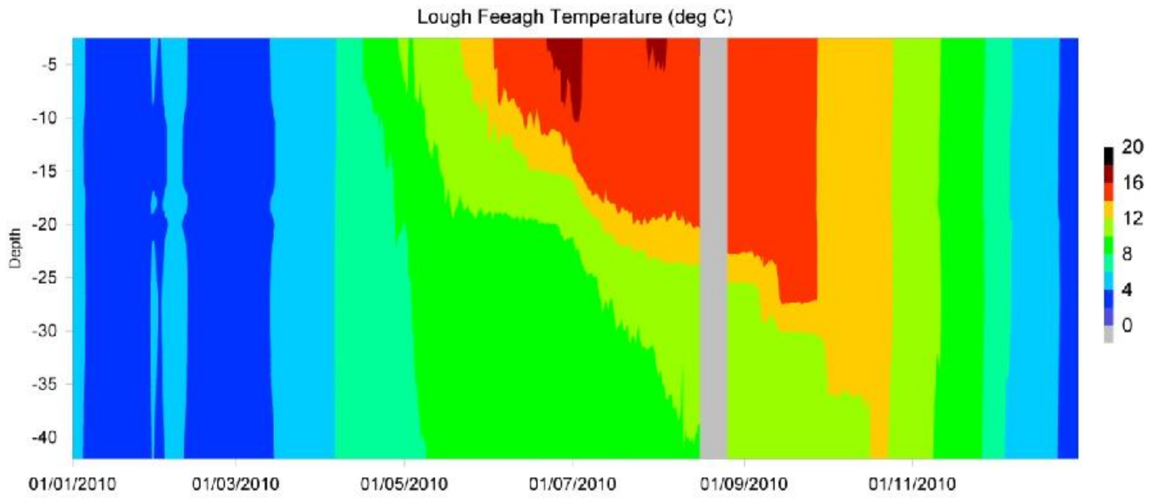


Figure 2-6: Temperature profiles for L. Feeagh measured using PRT sensors on the AWQMS for 2010. The grey denotes missing data.

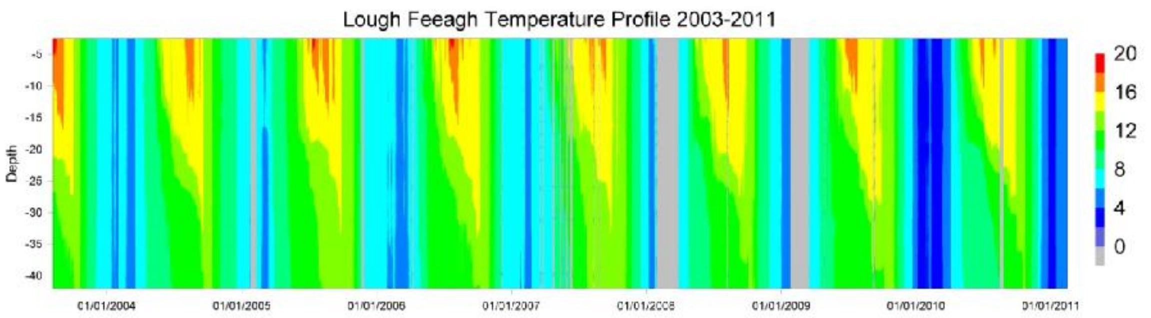


Figure 2-7: Temperature profiles for L. Feeagh measured using PRT sensors on the AWQMS for 2003-2011. The grey denotes missing data.

2.2.4 Lough Furnace

Lough Furnace is situated in the lower end of the Burrishoole catchment. Lough Furnace, (2km from north to south at its widest point, covering an area of 170ha, max depth is 21m with an average depth of 7m) is a cryptodepression tidal lagoon lake. Sea water enters the lake during spring tides but the freshwater exchange ensures relativity low salinities at the surface throughout the year. Initial results indicate that in 2008 the pH ranged from 7.0- 8.1 and dissolved oxygen levels decrease dramatically below 3m of the lake. The lough is thermally stratified throughout the year with spring and autumn inversions with accompanying halo- and oxyclines (Figure 4.8). Monitoring of L. Furnace commenced in the early 1970s and automatic daily monitoring commenced in May 2008. This AWQMS has a Datasonde DX5 attached to a profiling winch, enabling temperature, conductivity, dissolved oxygen (% and mg/l), salinity and pH profiles of the lake to be taken. The winch profiles the lake 4 times a day (6am, noon, 6pm and midnight), taking four hours to run a profile and is parked for two hours. There is also a nephlometer and fluorometer positioned one meter below the water column. All parameters are measured every 2 minutes and an hourly average is then calculated. A weather station is also fully functional on the AWQMS measuring wind direction, wind speed, radiation, relative humidity and barometric pressure.

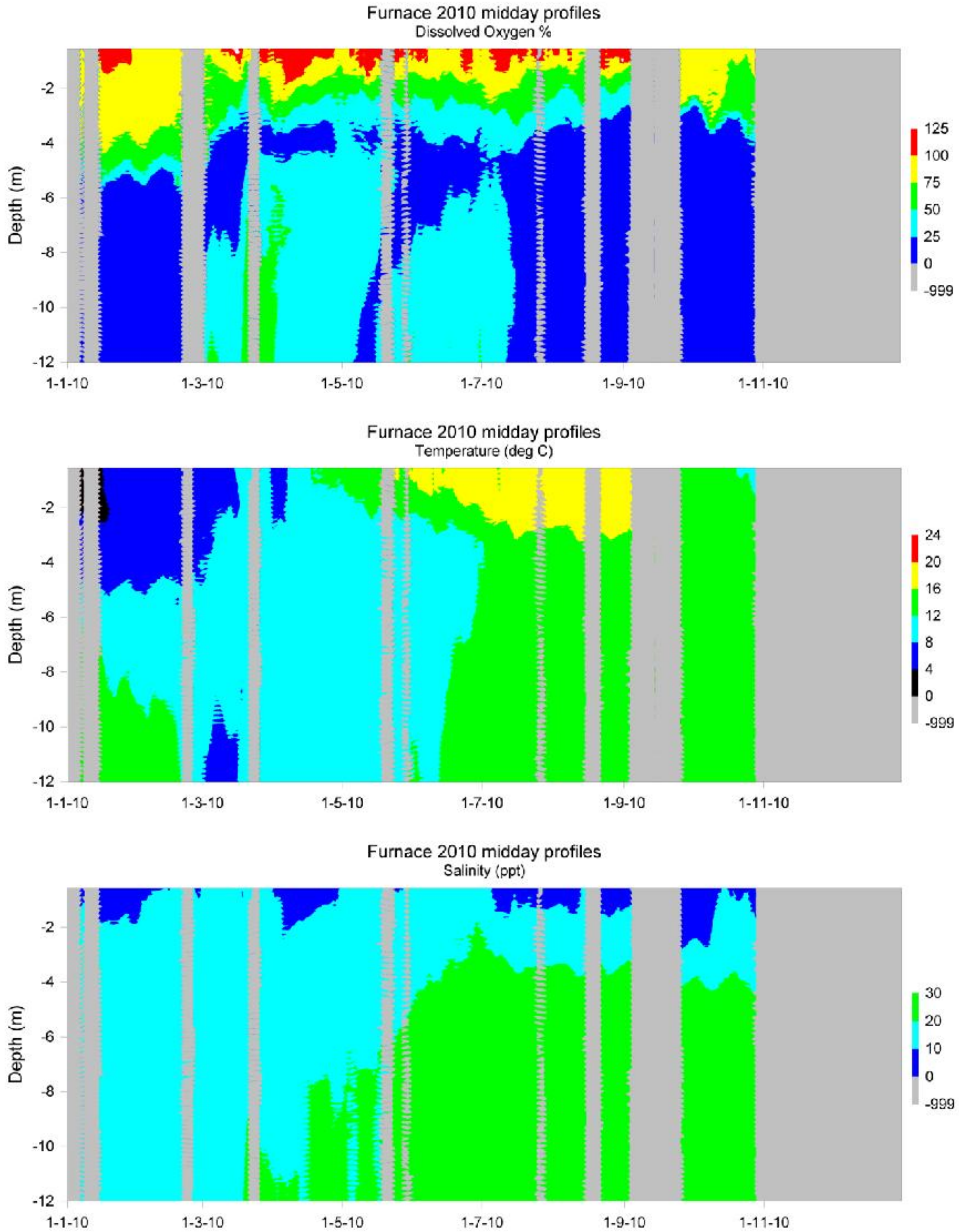


Figure 2-8: Oxygen (top), temperature (middle) and salinity (bottom) profiles from Lough Furnace in 2010. The grey areas indicate missing values.

3 Salmonid Rearing

3.1 Salmon Stocks 2009

3.1.1 Ranching

The total release of microtagged smolts of ranched Burrishoole grilse origin into Lough Furnace was 33,995. Six groups, including one group treated with 'SLICE' for protection against lice infestation during the early weeks at sea, were released on 29th and 30th April 2010. Mean weights ranged from 58 to 64gms.

An additional experimental group of 10,110 smolts, derived from wild Owenmore and wild Burrishoole parents, were released into Lough Furnace on 30th April 2010. Smolts were microtagged and branded as part of the collaborative Beaufort local adaptation research programme.

Tag code details are shown in Table 5.1.

3.2 Salmon Stocks 2010

Burrishoole ranch broodstock numbers were significantly lower than usual in December 2009 and therefore, in addition to Burrishoole ranch salmon, Burrishoole wild and Burrishoole MSW (ex Delphi)/grilse crosses were hatched in 2010. There was no commercial production in 2010.

Growth and survival were good with a particularly high survival rate of 93% to July. Despite icy weather conditions in January, first feeding commenced on April 21st when water temperatures were optimal at 10^{0}C. Grading was carried out during August and in October the progeny of the earliest and latest stripping groups (1st and 5th stripping dates) were retained as separate groups and all other groups were mixed (2nd, 3rd, 4th stripping dates).

Parasite levels were low and few formalin treatments were required. Stocks remaining in December 2010 comprised 35,132 Burrishoole ranch, 6,318 Burrishoole wild and 9,023 Burrishoole MSW (Delphi origin) crossed with Burrishoole ranch grilse.

3.3 Salmon Stocks 2011 (Grilse ova laid down in 2010)

An estimated 58% of all returns were processed during July and August. In view of the unusual pattern of returns in 2009, when there was an abrupt reduction in the number of adult returns from mid-August onwards, broodstock collection commenced earlier than usual, from August 12th onwards. Salmon were held in ponds until transfer to the broodstock holding pond on 2ndSeptember 2010 (53 males, 67 females). Broodstock collection continued into December and in total, 365 ranch adults (184 females, 181 males) were held during the stripping period. A small number of 'thin' salmon (6 females, 4 males) were removed from the broodstock when the fish were examined in November. In addition, 27 wild Burrishoole salmon (13 females, 14 males) were collected (15 Rough river, 7 Goulaun river, 5 Salmon Leap downstream trap) and held for experimental purposes.

Water temperatures in early December were lower than usual (5^{0} - 6^{0}C) following a period of severe frost in late November. Stripping commenced on December 13th 2010 and extended over a period of six weeks to January 24th 2011. An estimated 436,800 green ova were produced by 144 females (128 males). The average fecundity value was 3,019 ova per grilse female and 5,459 ova per 2SW female. Ova from parents with no tag or from experimental groups, as indicated by microtag, were removed. Forty females were not used for ova production, including 21 samples and 14 females which failed to strip; ova were retained within the egg membrane and included some over ripe ova. A proportion of each family, from confirmed Burrishoole stock, was retained in the hatchery from each of the seven stripping dates, totalling 82,841 eyed ova from 109 females and 107 males. Females stripped on the first (13.12.10) and sixth (17.1.11) stripping dates were crossed with

the same group of males, as in the 2008/09 season, for a study to examine the heritability of spawning time. A sample of each family was retained in the hatchery to monitor survival and development to the first feeding stage.

An experimental population (67,232 green ova), consisting of 221 pure and 159 hybrid (Erriff x Burrishoole) families, was produced using eggs and milt from Burrishoole wild (9 females, 13 males) and Erriff wild (18 females, 10 males) salmon. Scale samples and fin samples (stored in alcohol) were taken from all parents for aging and genotyping respectively. Wild Burrishoole and Erriff broodstock were collected and held in MI Newport and Erriff hatcheries respectively. Eggs and milt were transported from the Erriff on 30th December 2010 and 4th January 2011. Burrishoole wild females were stripped on 30th December 2010 and 14th January 2011. The average number of ova produced per grilse female was estimated to be 1,908 for Burrishoole hens and 2,503 for Erriff hens. In this collaborative project with the Beaufort Genetics Group and Western Regional Fisheries Board, the objective is to assess the importance of local adaptation at small geographical scales by comparing the relative fitness of the progeny of Burrishoole and Erriff salmon and their hybrids in alternate local common environments, namely the Srahrevagh river in the Burrishoole system and the Glendavock river in the Erriff system. Experimental populations were produced with a view to sending eyed ova to Cong Hatchery for smolt production and retaining a similar group in the hatchery for the production of an experimental group of ranch smolts. The release of experimental populations from the Erriff and Burrishoole systems would have provided data on marine survival. However, unfortunately there was a positive IPN detection in one pool of five Burrishoole wild broodstock tested and it was necessary to cull all ova associated with this project in February 2011 and to initiate a sampling programme for IPN testing of wild salmon in Burrishoole.

Broodstock condition was good throughout the holding period. Six fish (5 males, 1 female) were screened for the presence of *Anasakis* on 20th October and although *Anasakis* was noted in all fish, levels were considered to be low. Ranch salmon broodstock were sampled and tested by the Marine Institute Fish Health Unit in January 2011 and subsequently were found to be disease free. Ova quality and survival was good.

3.4 Rainbow Trout 2010

An estimated 5279 0+ rainbow trout (Seven Springs NI) were stocked into Ballinlough Fishery in October and November 2010 and 2166 trout were retained for stocking in 2011.

3.5 Acoustic Tracking 2010

Three acoustic temperature/depth tags (VemcoV13TP) were provided by CEFAS for a pilot study to examine behavioural differences and environmental preferences of wild and ranch adult salmon in Lough Feeagh. Three receivers (VemcoVR2W) were moored in Lough Feeagh, positioned to the North, Middle and South of the lake and downloaded monthly. One ranch and two wild female adult salmon returns were tagged in the Salmon Leap upstream trap in August 2010. Two salmon were recovered in the Salmon Leap downstream traps in November 2010 and one wild female remained in the system into 2011. A more extensive programme is planned for 2011 and data should provide novel insights into fish behaviour and inform important thematic research areas on 'interactions of wild and cultured salmon' and 'climate change'.

4 Wild Salmon Census Programme

The salmon census and stock assessment programme was continued in 2010 with a full upstream and downstream census of migrating wild salmon. The data provides a valuable index of salmon survivals and stock dynamics for the freshwater components of the stock.

4.1 Wild Salmon and Grilse

A total of 686 wild grilse were recorded moving upstream through the permanent traps during the season (Table 4.1). The upstream migration of wild grilse during 2010 showed a similar pattern as in 2009 with the run commencing in the first week of July. Although water levels were generally low in June the majority of the fish recorded in the upstream traps in July were silvered suggesting that the low water conditions had not prevented fish moving upstream in June but rather, as occurred in 2009, fish were again returning later to freshwater.

The main upstream grilse migration was recorded in the Salmon Leap trap with 575 grilse, compared to 111 grilse in the Mill Race trap.

The total number of spring fish recorded in the upstream traps was 17.

No wild fish were retained in the rod catch of wild grilse on Lough Furnace and therefore the total wild grilse return to freshwater was **686**.

Table 4-1: Monthly wild grilse totals for the Salmon Leap and Mill Race traps, 2010.

Month	Mill Race	Salmon Leap	Total
June	6	0	6
July	78	442	520
August	10	96	106
September	16	30	46
October	1	6	7
November	0	1	1
December	0	0	0
Total	111	575	686

The monthly proportion of the upstream migration of wild grilse observed in 2010 was similar to the previous year with the main migration occurring in July and August. There was an increase in the proportion of later running fish, September to December, with 7.8% recorded in 2010 compared to 1.6% the previous year.

Table 4-2: Monthly proportions (%) of the wild grilse run timing 2004-2010.

	2004	2005	2006	2007	2008	2009	2010
May	0.0	0.4	0.5	0.3	0.0	0.0	
June	36.0	23.9	1.4	7.7	9.1	4.6	0.9
July	41.0	13.2	40.1	56.3	17.9	78.7	75.8
August	9.8	39.1	31.9	17.5	62.6	15.5	15.5
September	10.9	14.8	22.8	14.9	7.3	0.9	6.7
October	1.0	5.5	2.5	1.0	2.9	0.2	1.0
November	0.7	3.0	0.5	1.3	0.2	0.2	0.1
December	0.5	0.2	0.3	0.8	0.0	0.0	0.0

Table 4-3: Wild salmon and grilse totals in the upstream traps, 1970-2010.

Year	Total Salmon	Total Grilse
1970-74	14	1145
1975-79	36	703
1980-84	35	449
1985-89	22	492
1990-94	16	421
1995-99	12	509
2000	6	568
2001	6	368
2002	2	648
2003	18	544
2004	28	580
2005	9	532
2006*	31	530
2007*	12	1049
2008	23	548
2009	37	549
2010	17	686

* years where the grilse count was raised to account for loss in the traps.

4.2 Net marked fish in upstream traps

In 2007, the Irish Government introduced a cessation on drift netting in Irish coastal waters. The overall incidence of net marks recorded since the cessation in 2007 remains very low. The incidence of net marks on wild grilse has continued to show an increase, increasing from 0.2% in 2007, 2.3% in 2008, 2.7% in 2009 and 3.8% in 2010. The incidence of net marks recorded on reared fish showed an increase from 1.0% to 2.6% in 2010. The majority of net marks were observed in July and August (Table 4.4).

Table 4-4: Percentage occurrence of net marks on wild and reared grilse, 2010.

	Wild Grilse	n for wild/month	Reared Grilse	n for reared/month
May	0	0	0	0
June	0	6	100	1
July	4.1	518	1.7	424
August	3.8	106	5.1	294
September	2.2	46	0	144
October	0	7	0	23
November	0	1	0	13
December	0	0	0	0
n =		684		899

4.3 Wild Spawning Stock

The spawning stock (escapement) represents the number of fish available for spawning. It is calculated by subtracting rod caught fish and downstream-displaced fish as well as losses due to poaching, disease and predation, which have been estimated at 5% for wild fish and 10% for reared fish.

In both 2006 & 2007, an additional number of fish, reared and wild, escaped upstream undetected (see previous reports). It is likely that the wild grilse count for those years were minimum figures and this was taken into account for all calculations based on the 2006 & 2007 spawning escapements.

4.3.1 Spawning escapement and stock

The total spawning stock in 2010 consisted of 637 wild fish and 38 reared fish (Table 4.5). As a precautionary measure, due to the poor return of reared fish the previous year, additional reared fish were released upstream. The reared component was derived from 133 reared fish which were released upstream between June and September. The majority of these fish had moved downstream again prior to the spawning season, 91 were recaptured in the downstream traps and were retained as broodstock. Therefore despite the additional reared fish released upstream the reared component of the spawning stock was low (5.6%).

Table 4.6 gives the annual total escapement, the wild escapement and the reared fish component. In the last 15 years, the spawning escapement in 2007 was the only one that stands out higher than the rest. Particularly poor escapement was recorded in 2001.

Table 4-5: Spawning stock of salmon and grilse, 2010.

	Wild grilse (1SW) & previously spawned grilse	Wild Salmon (2SW)	Ranched fish released upstream
Counted in trap	686	17	130
Rod Feeagh	--	--	1
Culled	0	--	0
Broodstock	22	--	0
Estimated Mortalities	33	1	4
Displacement	28*	2	91
Spawning stock	**603**	**14**	**35**

* Includes 5 taken for broodstock

Table 4-6: Spawning escapement, 1970-2010.

	Maximum spawning escapement	Wild fish component	Reared fish component
1970-74	1126	986	140
1975-79	725	683	42
1980-84	474	430	44
1985-89	662	428	232
1990-94	603	348	254
1995-99	519	428	95
2000	567	527	40
2001	370	349	21
2002	570	562	8
2003	517	506	11
2004	554	528	26
2005	503	472	31
2006	552	520	32
2007	1038	958	80
2008	512	495	17
2009	517	489	28
2010	652	617	35

4.3.2 Wild salmon broodstock stripped December 2009/2010

Wild broodstock were again collected in 2010 from the downstream traps and in the catchment for a Beaufort breeding project. A total of 5 fish were removed from the downstream traps and an additional 22 were captured in the catchment. Of these 27, five were not used in the broodstock. All fish were transferred to the broodstock ponds. Ten females were stripped, 5 from Goulaun, 3 from the Downstream traps and 2 from Shrarevagh. Subsequently due to a disease risk all eggs were destroyed.

For all wild broodstock collected in 2008, 2009 and 2010, the average number of eggs stripped is given in Table 4.7. The number of ova produced by 2SW was significantly higher than that for 1SW (P<0.0001).

Table 4-7: Average and range of ova stripped from 1SW and 2SW wild salmon, 2008, 2009 and 2010 combined.

Sea Age	Average number of ova stripped	Minimum	Maximum	n stripped
1 SW	2520	1600	3764	34
2 SW	4334	3033	6714	9
Total	2900	1600	6714	43

4.4 Survival from Ova to Grilse

The relevant brood year for the 2010 grilse was 2006 with ova hatch in 2007 and smolt migration in 2009 (Table 4.8). As in previous years, it has been assumed for the purpose of estimating survival that ranched grilse spawned naturally. Specific data are not currently available on differential survival rates of wild and ranched stocks spawned in the wild. All relevant calculations are based on parameters set out in the Ann. Rep. No. 19, 1974.

Table 4-8: Survivals from ova to smolt and smolt to grilse.

Spawning escapement in 2006	530
No. of females*	265 - 292
Ova deposition	1,006,000 – 1,199,523
No. of smolts in traps 2009	7980
No. of smolts released	7749
Survival ova to smolt	0.8 – 0.7
No. returning grilse 2010	686
Survival smolt to grilse	8.9%
Survival to grilse per grilse female	***2.4 – 2.6***

* two estimates of the % females in the run using 50% and 55%

4.5 Ova to Smolt Survival

The survival of ova to smolt ranged from 0.67 to 0.75 (Table 4.8) based on the two estimates of proportion of females in the run (see Table 4.8).

There was an increase in both the number and percentage return to freshwater during 2010. Wild grilse numbers increased from 550 in 2009 to 686 in 2010 and the percentage return for the same period increased from 8.2% to 8.9%.

The survival to grilse per grilse female was 2.4 – 2.6 (Table 4.9).

Table 4-9: Percent survivals for ova to smolt and grilse per female grilse spawner; comparative data for 5-year averages from 1970-1989 and values for the individual brood years from 1990 onwards.

Brood year-class	% survival rates ova to smolt	survival rates to grilse per grilse female spawner
1970-74	0.48 - 0.62	1.4 - 1.7
1975-79	0.63 - 0.73	1.5 - 1.7
1980-84	0.61 - 0.69	1.7 - 1.9
1985-89	0.44 - 0.45	1.4 - 1.5
1990	0.47 - 0.54	1.8 - 2.0
1991	0.47 - 0.53	1.8 - 2.0
1992	0.48 - 0.54	1.3 - 1.5
1993	0.39 - 0.45	1.5 - 1.6
1994	0.36 - 0.41	1.3 - 1.4
1995	0.83 - 0.93	1.9 - 2.1
1996	0.53 - 0.61	1.8 - 1.9
1997	0.52 - 0.59	1.4 - 1.5
1998	0.58 - 0.60	2.4 - 2.6
1999	0.79 - 0.70	1.8 - 2.0
2000	0.56 - 0.64	1.9 - 2.1
2001	1.30 - 1.10	2.9 - 2.6
2002	0.56 - 0.64	1.7 - 1.9
2003	0.68 - 0.76	3.7 - 4.1
2004	0.53 - 0.60	1.8 - 2.0
2005	0.69 - 0.61	2.0 - 2.2
2006	0.75 - 0.67	2.4 - 2.6

4.6 Wild Salmon Smolts

In contrast to 2009 when conditions were ideal for smolt migration, the very low water conditions during April and May 2010 resulted in the majority of salmon smolts migrating in a four day period (Fig. 4.1). Of the 7123 salmon smolts recorded during the smolt migration, 5795 (81%) were recorded from the 19th to the 22nd of May inclusive (Table 4.10). Although the total numbers of wild salmon smolts decreased from 7980 in 2009 to 7123 in 2010, the total smolt output was similar to the average recorded for the previous three years (Table 4.11).

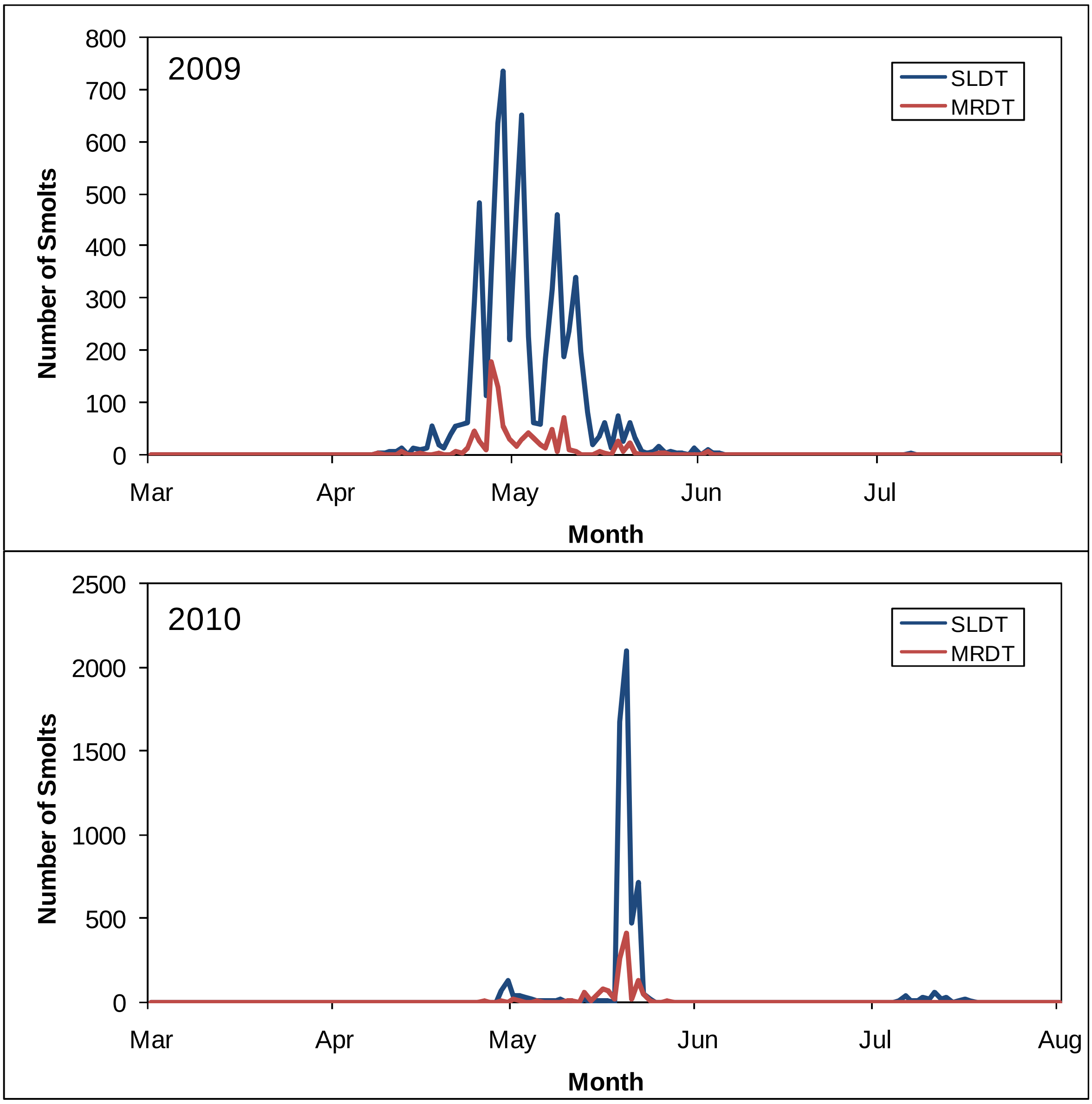


Figure 4-1: Timing of the 2009 and 2010 wild salmon smolt runs in the Salmon leap and Mill Race traps.

Table 4-10 : Number of wild salmon smolts counted in 2010.

Month	Salmon Leap Down Trap	Mill Race Down Trap	Total
March	0	0	0
April	224	49	273
May	5261	1271	6532
June	6	8	14
July	289	13	302
August	1	1	2
TOTAL	5781	1342	7123

Table 4-11: Annual numbers of wild salmon smolt recorded in the downstream traps.

Year	1990-94	1995-99	2000-04	2005-09	2005	2006	2007	2008	2009	2010
Smolts Counted	5618	7052	7490	7351	7261	7918	6685	6909	7980	7123
Smolts Released		6967	7340	7138	7030	7701	6518	6691	7749	6979

4.7 Wild Salmon Kelts

4.7.1 Census

Kelts migrate downstream after spawning. The highest monthly percentage of migrating salmon kelts were recorded in March when 50% of the total migration was recorded (Table 4.12). The percentage recorded during April and May was 29.9% and 12.2% respectively.

The overall survival of kelts from the spawning stock was 33.5% of which 86.5% were females and 13.5% were males. The majority (98.1%) of fish were in very good condition (Table 4.13).

Table 4-12: Numbers of wild salmon kelts counted in 2010.

	Salmon Leap	Mill Race	Total
December '09	4	0	4
January '10	6	0	6
February	4	0	4
March	81	1	82
April	40	9	49
May	19	2	21
June	0	0	0
July	2	0	2
Total	156	12	168

4.7.2 Tagging of wild kelts

Following the cessation of drift netting during 2007 and the corresponding increase in the wild spawning stock at Burrishoole tagging of the wild kelts recommenced during 2008. Tagging of wild salmon kelts continued in 2010 and a total of 165 tagged kelts were released from the downstream traps. During the summer of 2010 a total of 17 of these fish were recorded as previously spawned grilse in the upstream traps, a recovery of 10.1% (Table 4.13).

One of the recoveries was a second spawner which had initially been tagged as a kelt on 29/3/09 and was recorded in the upstream trap in July of 2009 and again in August 2010. A second fish which was taken from the Rough river in 2009 as potential broodstock, was not used in the hatchery as it was over ripe, was tagged BL 1913 and released into Lough Furnace on 21st January 2010. This fish was recaptured in the upstream trap on the 14/8/10.

Table 4-13: Comparison of annual salmon kelt runs.

Year	Kelt Quality Grade				
	A	B	C	D	E
1975-79	75	18	14	30	8.1
1980-84	82	18	6.7	48.7	9.7
1985-89	88	21	5.1	43.2	8.4
1990-94	92	31	4.8	61.4	6.6
1995	74	28	18.3	59.9	2.3
1996	88.1	27	10.1	53.1	4.0
1997	93.7	33.5	6.3	58.9	*
1998	94.3	30.8	5.7	67.6	*
1999	90.6	38.5	4.5	76	*
2000	92.5	44.5	5.5	62.1	*
2001	97	38.5	2.8	72.5	*
2002	91.3	40.9	7.8	49.6	*
2003	95.5	37	3.5	42.3	*
2004	89.9	36.3	9	53.2	*
2005	83.3	35.5	15.3	57.6	*
2006	82.2	36.1	16	54.4	*
2007	95	37.3	4.1	**	*
2008	93.2	26.9	6.8	**	5.6
2009	96.1	20.8	3.3	43.8	4.9
2010	98.1	13.5	1.3	34.2	10.1

* no kelt tagging

** see section 4.7 (2007 report)

A = % healthy kelts in kelt run

B = % males in kelt run

C = % lightly marked

D = % survival from wild spawning escapement

E = % recapture of previously spawned grilse in first year

5 Reared Salmon Census Programme

A programme of rearing and releasing tagged salmon has been carried out in Burrishoole since the early 1960s. The stock was based originally on donor wild salmon from the Burrishoole system and the stock has been closed since using returning tagged fish as broodstock. Additional experimental groups are sometimes released and these are freeze branded and differentially tagged so as to avoid mixing these with the core ranched stock. The ranched stock facilitates data collection and comparison with the wild stock without putting undue stress or mortality on the wild stock – in this report the ranched stock are known as reared grilse and reared 2SW salmon.

5.1 Coastal Returns

Details of coastal returns of Burrishoole fish are available in the Marine Institute 'National Report for Ireland - The 2010 Salmon Season' report.

5.2 Return rate of reared and wild grilse

A total of 943 tags were recovered from reared fish returning to Burrishoole in 2010. Of the total recovery, 891 were identified as Burrishoole core fish, of which 880 were grilse and 11 2SW.

The average return rate of reared Burrishoole grilse to freshwater, as determined by microtags, showed an increase in 2010 from the previous year. The return rate, of core Burrishoole ranched grilse, increased from 1.2% in 2009 to 2.7% in 2010 (see National Report). However the same level of increase did not occur in the wild population which changed from 8.2% to 8.9% between 2009 and 2010.

The majority of these fish were in very good condition with many weighing over 2kg. The abrupt end to the upstream migration observed during August 2009 was not repeated during 2010.

5.3 Recapture of Reared 2SW Fish

The total number of microtagged 2SW reared fish recorded in Burrishoole during 2010 was 11, comprising 5 release groups. The largest 2SW fish was 2.9kg.

5.4 Smolt Releases 2010

A total of 33,995 ranched smolts were released from Burrishoole into Lough Furnace during April 2010. They consisted of 27,993 smolts released as part of the on-going core ranching programme and 6,002 smolts for an ongoing SLICE project.

In addition to the release of Burrishoole smolts an additional 10,110 smolts were also released for a Beaufort experiment. All of the smolts were H-branded and released in Lough Furnace. For further details on the experimental groups see Section 3.1.1.

Table 5-1: Details of microtag codes and smolt release groups 2010.

Group ID	Tag Code	Mean Wt	Mean Length	No. Released	Date released
Slice	54773	61.48	17.34	6,002	29/04/2010
Core	54771	61.3	17.5	7,017	29/04/2010
Core	54775	58.62	17.09	6,895	29/04/2010
Core	54774	61.53	17.36	6,180	29/04/2010
Core	54776	64.41	17.66	5,301	30/04/2010
Core	54793	62.46	17.54	2,600	30/04/2010

5.5 Reared kelts

During 2009 a total of 83 reared fish were recorded in the downstream traps from a total of 115 released upstream during the summer '09. A further 7 were recorded in 2010 as kelts. The total recovery from the 115 reared fish released upstream in 2009 was, therefore, 90 (78%).

During 2010 a total of 91 reared fish were recorded in the downstream traps from a total of 133 released upstream during the summer. They included nine fish in the Mill Race trap and 74 fish in the Salmon Leap, all of which went to the broodstock pond.

6 Wild Sea Trout Census Programme

The sea trout research and monitoring programmes were continued in 2010.

6.1 Upstream Movements: Timing and Numbers.

A total of 72 wild silvered sea trout and a further 104 non-silvered trout migrated upstream through the traps in 2010. Of the silvered trout, 35 were adults and 37 (51%) were finnock. The numbers are compared with other years in Table 6.1. Of the total run of migratory trout (176), 59% were unsilvered. For the purposes of this report, the unsilvered trout are not included with the sea trout. Table 6.1 shows that the numbers of sea trout have not recovered in the Burrishoole system and have shown a ten-fold drop since the 1970s.

Table 6-1: Annual runs of sea trout recorded in the traps.

Year	Mill Race	Salmon Leap	Total	Amended Total
1970-74	1365	762	2127	
1975-79	829	1775	2604	
1980-84	458	780	1238	1719 *
1985-89	386	590	978	
1990-94	134	72	206	
1995-99	86	91	177	
2000-04	32	64	97	
1995	90	90	180	
1996	112	85	197	
1997	65	72	137	
1998	56	50	106	
1999	107	157	264	
2000	33	78	111	
2001	31	58	89	
2002	26	89	115	
2003	45	33	78	
2004	26	64	90	
2005	5	10	15	
2006	16	22	38	
2007	35	59	94	
2008	4	36	40	
2009	45	93	138	
2010	10	62	72	

* See Table 34, Ann. Rep. XXX (1985); p. 43.

The timing of the sea trout run in 2010, and in previous years, expressed in monthly percentages, is given in Table 6.2. The highest proportion of sea trout, both finnock and adults, moved upstream in July. Almost half the unsilvered trout moved upstream in July with the remained moving throughout the rest of the year.

Table 6-2: Timing of the Burrishoole (a) silvered sea trout run and (b) unsilvered trout run (in monthly percentages). (n = no. of trout).

(a) Silvered Trout

	1970-'79	1980-'84	1985-'89	1990-'94	1995-'99	2000-'04 (483)	2005 (15)	2006 (38)	2007 (94)	2008 (40)	2009 (138)	2010 (72)
May	-	0.2	0.5	0.1	3.1	2.0	6.7	0.0	0.0	0.0	0.0	0.0
June	13.1	24.6	9.4	8.4	8.6	16.7	26.7	0.0	16.1	0.0	2.2	0.0
July	54.4	44.9	62.2	55.0	42.4	37.5	0.0	10.5	53.8	10.0	88.4	85.9
Aug	15.8	10.3	18.4	16.5	19.3	26.4	60.0	26.3	15.1	82.5	6.5	8.5
Sept	7.6	14.8	3.7	8.5	9.8	5.7	6.7	44.7	10.8	5.0	0.7	5.6
Oct	6.4	3.5	4.1	7.9	12.2	10.2	0.0	15.8	3.2	2.5	2.2	0.0
Nov	2.4	1.5	1.5	2.9	4.3	1.5	0.0	2.6	1.1	0.0	0.0	0.0
Dec	0.3	0.2	0.2	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(b) Unsilvered Trout

	2005 (86)	2006 (61)	2007 (94)	2008 (76)	2009 (91)	2010 (104)
April	0	0	2.2	2.6	2.2	0.0
May	4.7	16.4	5.4	3.9	5.6	1.0
June	10.5	9.8	19.4	13.2	8.9	0.0
July	4.7	16.4	25.8	21.1	23.3	44.2
August	43	11.5	4.3	31.6	12.2	16.3
September	12.8	13.1	6.5	7.9	7.8	17.3
October	9.3	27.9	7.5	9.2	24.4	7.7
November	10.5	3.3	20.4	2.6	14.4	11.5
December	4.7	1.6	8.6	7.9	1.1	1.9

6.2 Spawning Escapement

With the continuation of the catch and release bye-law into the 2009 fishing season, no sea trout were reported killed by anglers on L. Feeagh in 2010. Using the upstream fish counts through the traps, the total maximum spawning escapement of migratory trout to the L. Feeagh catchment was 176, of which 104 were non-silvered sea trout.

Table 6-3: Annual spawning escapement of sea trout into freshwater, 1970-2010.

	1970-'79	1980-'84	1985-'89	1990-'94	1995-'99	2000-'04	2005	2006	2007	2008	2009	2010
Max. Escap.	2090	1146	906	231	289	156	101	99	187	116	228	176
Revised	1622											

6.3 Downstream Movements, Sea Trout Smolts

The 2010 smolt run amounted to 213 smolts, of which 211 were released downstream to the wild (Table 6.4). Few smolts were recorded from January to April due to low water temperature and water level. The main migration occurred in May and was strongly regulated by water level (Fig. 6.1). The 2010 smolt run was much lower in number compared to the previous years (Table 6.5).

Table 6-4: Monthly numbers of Burrishoole sea trout smolts recorded through the traps.

Month	Salmon Leap	Mill Race	Total	%
January	0	0	0	0.0
February	0	0	0	0.0
March	2	0	2	0.9
April	33	13	46	21.6
May	132	15	147	69.0
June	1	0	1	0.5
July	11	6	17	8.0
Total	179	34	213	
Number Released Downstream			211	

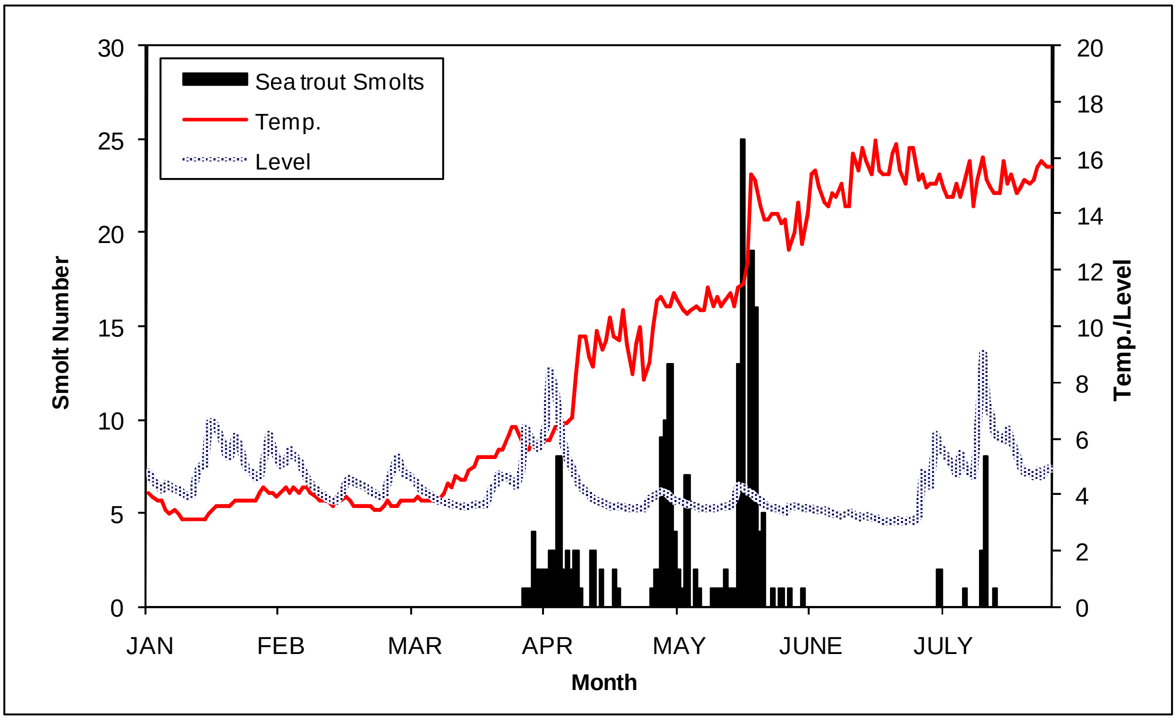


Figure 6-1: Timing of the 2010 wild sea trout smolt migration with daily midnight water level (m x 10) and midnight temperature (^{0}C).

Table 6-5: Annual sea trout smolt numbers in Burrishoole for 1970 to 2010.

	1970-79	1980-84	1985-89	1990-94	1995-99	2000-04	2005	2006	2007	2008	2009	2010
Number	4176	4038	4119	1531	1361	816	777	626	593	393	657	213

A total of 66 wild smolts were measured in 2010. Length measurements were taken to facilitate an estimated age breakdown of the smolt run. The estimated statistics for the 2010 smolts were a mean length of 20.8 cm and a range from 14.0 to 27.8 cm and the length frequency is presented in Figure 6.2. This gave an estimated age of 66.7% 2 year old and 33.3% 3 year olds.

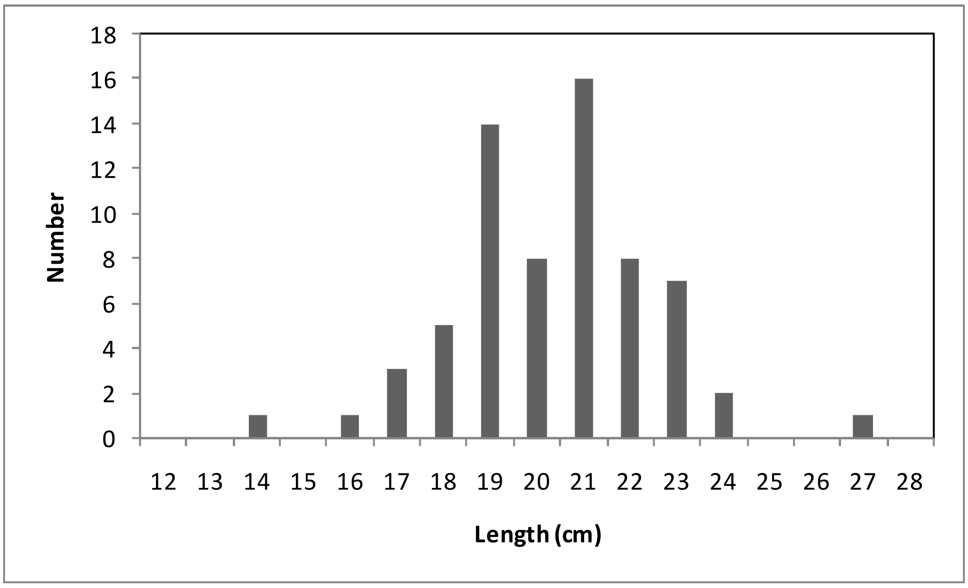


Figure 6-2: Length distribution for smolts in the Burrishoole system, 2010 (n=66).

6.4 Autumn Migrating Smolts

These are juvenile trout (*Salmo trutta* L.) which generally move downstream through the traps from August to December. It is not clear whether these are true sea trout or part of the resident trout stock, should a difference exist. These runs of trout would appear to becoming more prolonged with substantial numbers of un-silvered 0+ and 1+ trout continuing to migrate downstream in the early months of the year.

A total of 769 trout entered the traps between July and December 2010 and up to May 2011 (Table 6.6). The percentage of 0+ trout that migrated over the period was 34.9% (Table 6.7).

Table 6-6: Numbers of migrating autumn juvenile trout in 2010, to the end of May 2011.

	0+		1+		Total	
Month	Salmon Leap	Mill Race	Salmon Leap	Mill Race	Salmon Leap	Mill Race
July	4	0	9	1	13	1
August	6	0	3	1	9	1
September	75	10	156	26	231	36
October	23	2	93	2	116	4
November	66	2	138	9	204	11
December	56	0	19	1	75	1
January '11	1	2	6	0	7	2
February '11	7	0	1	1	8	1
March '11	9	0	6	0	15	0
April '11	5	0	22	0	27	0
May '11	0	0	6	1	6	1
Total	252	16	459	42	711	58
Overall Total	268		501		769	

Table 6-7: Percentage of 0+ juvenile trout in the trapped autumn migrating trout.

Year	% 0+	Year	% 0+
1982	50.0	1997	18.7
1983	N/A	1998	33.5
1984	55.8	1999	42.0
1985	30.3	2000	47.8
1986	16.1	2001	56.3
1987	35.3	2002	32.8
1988	60.9	2003	48.9
1989	37.2	2004	35.5
1990	35.2	2005	37.3
1991	26.0	2006	51.2
1992	38.2	2007	27.9
1993	27.6	2008	28.2
1994	16.8	2009	25.0
1995	25.3	2010	34.9
1996	34.0		

6.5 Total Recruitment

The 0+ autumn trout will not be large enough to become sea trout smolts in the following spring. The remainder, predominantly 1+ year olds, could contribute to the overall recruitment of sea-run trout the following year. The exact proportion of 1+ autumn trout that become smolts in any given year is not known. It is only since 1982 that the proportion of 0+ trout amongst the autumn migration has been estimated. Thus the figures for total recruitment up to this time are over-estimated (Table 6.8).

From 1982, total recruitment was calculated by adding the number of sea trout smolts produced in any one year to the total of 1+ autumn trout the previous year (Table 6.9). The assumption is made that all the 1+ autumn trout will become sea trout smolts and that no 0+ trout from the two years previous will be recruited as smolts. The fate of 1+ unsilvered juveniles migrating downstream in January to May is unknown but it would seem unlikely that these will contribute to the 2 year old spring smolt migration.

Table 6-8: Estimates of total migrant trout recruitment up to 1981.

Year	Smolt Total	Autumn trout (preceding year)	Total Recruitment
1970-74	4450	2870	6746
1975-79	4314	3186	7489
1980	2337	2351	4688
1981	6710	2631	9341

Table 6-9: Estimates of total migrant trout recruitment from 1982.

Year	Smolt Total	1+ Autumn trout (preceding year)	Total Recruitment
1982-84	3714	1203	4917
1985-89	3706	1063	4778
1990-94	1788	399	2187
1995-99	1361	498	1860
2000	769	358	1127
2001	530	218	748
2002	1272	910	2100
2003	787	976	1763
2004	723	426	1149
2005	777	590	1367
2006	628	251	879
2007	593	377	970
2008	393	534	927
2009	657	495	1152
2010	213	267	480

6.6 Marine Survival

An estimate of sea trout survival to first return to freshwater can be more accurately calculated by the use of trap census data rather than rod catch returns of tagged or marked fish. Small numbers of stray fish are captured in other systems and it is not known whether these fish would have returned to their natal systems to spawn. Finnock are known to wander between river systems and are therefore not as reliable for assessing survival.

The pattern of marine survival found is similar whether the number of smolts is used or the combined total recruitment of smolts and autumn 1+ trout. The percentage of smolts that return as finnock in the same year historically ranged from 11.4% to 32.4% (Fig. 6.3). In 1988 it fell below the previous recorded minimum to 8.5% and in 1989 to a minimum of 1.5%. There has been a saw-tooth pattern of finnock return in the 1990's rising to 16.7% in 1999, 18.1% in 2009 and 17.5% in 2010 – the highest return rates since 1986. These increases were not, however, always sustained in subsequent years and there was a collapse in 2005 down to 1.5%. This was associated with the heaviest infestations of sea lice observed in the Burrishoole area since 1992.

The total survival of smolts to their first return to freshwater as finnock in the same year and one year old sea trout in the following year (always an over-estimate as a proportion of finnock re-entering freshwater in year 1 return as sea trout in year 2 (Mills *et al*, 1990)) also shows a drop in survival from 1987 to 1989 (Fig. 6.4).

Historically, the total survival to first return ranged from 19% to 66%. This collapsed to 1.8% in 1989 but rose to 12.1% in 1990. However, little further improvement was recorded in 1991 (12.8%). Marine survival fell to the second lowest level in 1992 but returned to 13.1% for the 1993 year class of smolts. There was a further increase in 1994 to 18.2% but a drop in 1995 to 8.1%. There were marginal improvements again in 1996 (12.8%) and 1997 (13.3%), a drop to 8.3% in the 1998 year class and a marked improvement in the 1999 year class where marine survival was 20%, the highest recorded in 12 years and back within the pre-collapse historical range. Total survival increased for the 2009 cohort to the highest recorded level since 1988 of 23%.

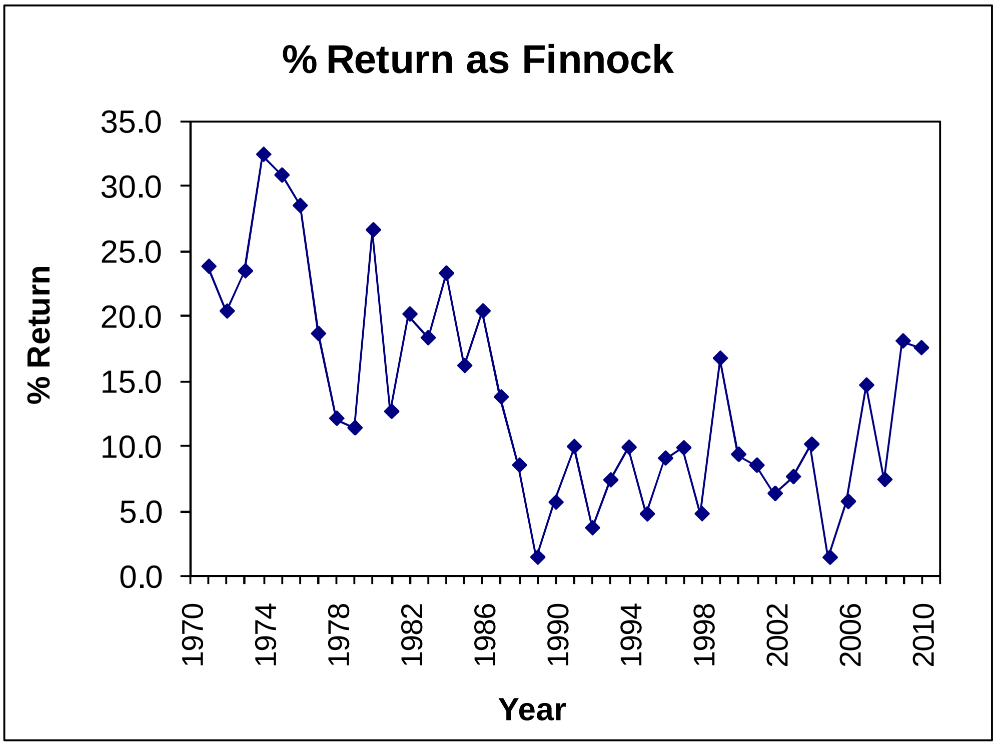


Figure 6-3: Annual percentage return of smolts returning as finnock to the Burrishoole system.

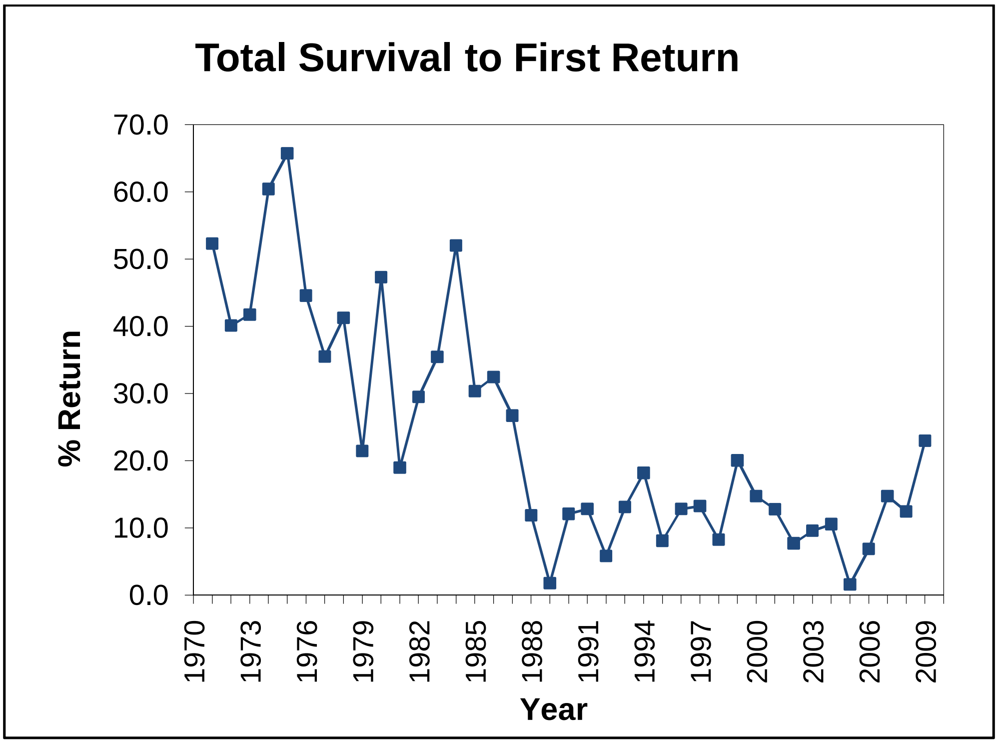


Figure 6-4: Annual marine survival of smolts to first return (as finnock and 1+ sea trout) to the Burrishoole system.

6.7 Sea Trout Kelts

Table 6.10 gives the numbers of sea trout and brown trout kelts, both spawned and immature, counted downstream in the winter of 2009 and spring of 2010.

The freshwater survival of kelts is given in Table 6.11. In some years, the number of kelts migrating downstream has exceeded the number of upstream migrants. This occurred in the early '80s when the screen allowed finnock to escape. This was rectified. More recently, the difficulty in separating small finnock and large smolts has led once again to a discrepancy as shown in Table 6.11. In addition to the size overlap, trout counted upstream as unsilvered migrants may be counted downstream as silvered kelts, causing difficulties in making survival estimates.

Since 1987, only one survival rate has been given for all sizes as it has been shown that a proportion (at least 33%) of the sea trout population may over-winter in freshwater. These fish do not spawn and continue to grow. There is also the additional complication of larger smolts and reduced sea growth mentioned above. Thus the comparisons of the proportion of fish in different year classes between the upstream migrants of one year and the downstream migrants of the next are invalidated.

The kelt survival dropped to 59.4% in 2010 and for finnock only to 51%. This is the lowest survival recorded in over 20 years and may be due, at least in part, to the disruption caused by the flood in July 2009.

Table 6-10: Timing and numbers of sea trout kelts for the 2009/2010 season.

Month	Large ST	Small ST	BT	Total ST	Total Trout
October '09	2	2	6	4	10
November	1	6	50	7	57
December	1	6	19	7	26
January '10	0	3	9	3	12
February	0	1	0	1	1
March	3	4	0	7	7
April	6	18	4	24	28
May	9	20	3	29	32
June	0	0	0	0	0
Total	22	60	91	82	173

Table 6-11: Annual survival rate to sea trout kelt, as % of the upstream escapement of the previous year.

Year	Larger (> 30.0 cm)	Small (< 30.0 cm)	Year	Larger (> 30.0 cm)	Small (< 30.0 cm)
1976	79	66	1995	96.20%	“ *
1977	63	45	1996	127.70%	" *
1978	50	66	1997	97.00%	" *
1979	33	107*	1998	140.10%	" *
1980	50	82	1999	110.40%	" *
1981	44	345*	2000	70.10%	"
1982	53	203*	2001	82.00%	" *
1983	63	177*	2002	129.60%	" *
1984	74	210*	2003	66.10%	"
1985	70	98	2004	120.50%	"*
1986	66	72	2005	142.20%	"*
1987	58.7% (combined)		2006	110.50%	"
1988	65.50%	"	2007	228.90%	"**
1989	68.70%	"	2008	98.90%	"**
1990	79.00%	" *	2009	107.50%	"*
1991	98.70%	" *	2010	59.40%	
1992	89.50%	" *			
1993	96.70%	" *			
1994	104.60%	" *			

* Years when the number of finnock kelts counted downstream exceeded the number counted upstream during the previous season.

7 Silver Eel Census Programme

7.1 Numbers

Silver eel trapping was continued in 2010. The main run occurred in September, October and November (Table 7.1). The run dropped off in November and only four eels were recorded in December probably due to very low water temperatures. Few eels were recorded in January to March after water temperature increased. Figure 7.1 shows the daily counts of silver eels.

The total run amounted to 2137 eels. As in other years, the highest proportion of the total catch (82%) was made in the Salmon Leap trap.

Table 7-1: Timing and numbers of the 2010 silver eel run.

	Salmon Leap	Mill Race	Total	%
June	0	1	1	0.0
July	62	10	72	3.4
August	61	30	91	4.3
September	451	131	582	27.2
October	839	169	1008	47.2
November	341	34	375	17.5
December	4	0	4	0.2
Jan. 2010	4	0	4	0.2
Feb. 2010	0	0	0	0.0
Total	1762	375	2137	

7.2 Size

Sampling of individual eels (n = 960) gave an average length of 45.2 cm (range: 28.7 – 96.4 cm) and an average weight of 192 g (Table 7.2). The length frequency distribution is presented in Figure 7.2 along with those for 2008 and 2009 for comparison.

Catches of silver eel between the years 1971 (when records began) and 1982 averaged 4,400, fell to 2,200 between 1983 and 1989 and increased again to above 3,000 in the '90s (Fig. 7.3). There was an above average catch in 1995, possibly contributed to by the exceptionally warm summer. The catch in 2001 of 3875 eel was the second highest recorded since 1982. The average weight of the eels in the catches has been steadily increasing from 95 g in the early 1970s to 216 g in both the 1990s and the 2000s (Fig. 7.3).

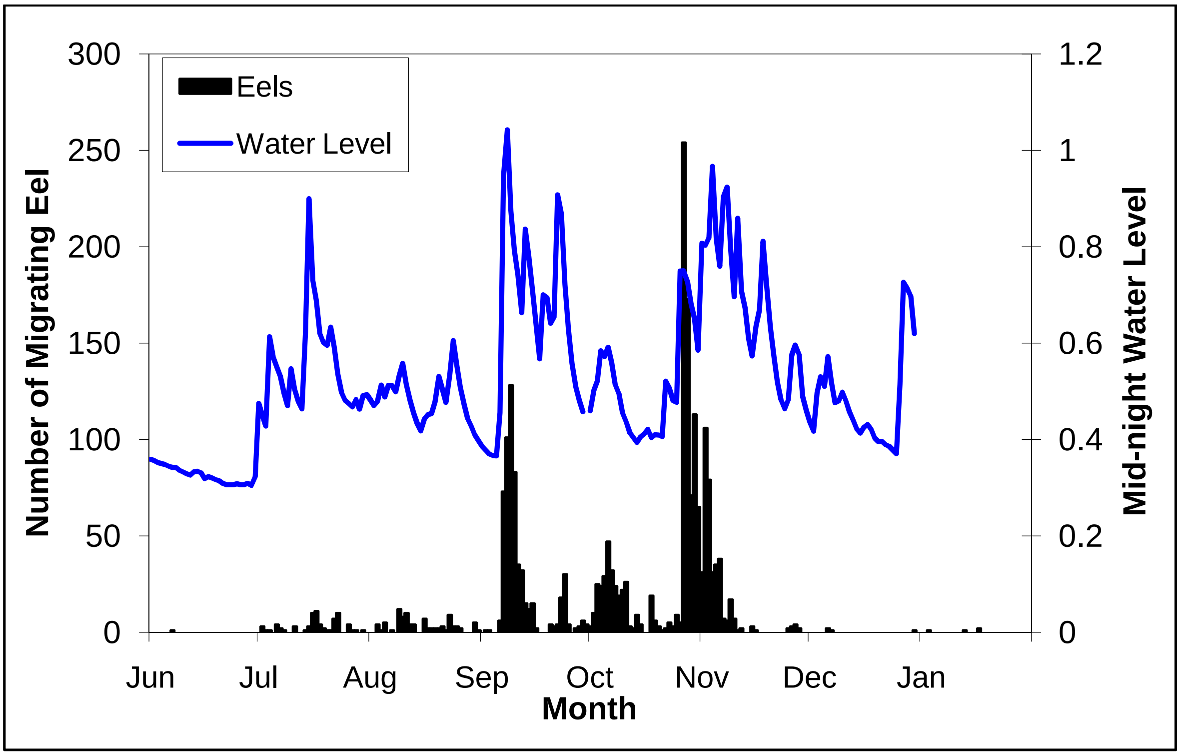


Figure 7-1: Daily counts of downstream migrating silver eel and mid-night water levels.

Table 7-2: Comparative data for the silver eel runs since 1971.

Years	Number Sampled	Mean. Weight (gm)
1971 - '75	4465	84
1976 - '80	4023	115
1981 - '85	2678	171
1986 - '90	11658	196
1991 - '95	3441	227
1996 - '00	3958	212
2001	850	238
2002	732	207
2003	650	177
2004	382	216
2005	587	237
2006	493	225
2007	571	201
2008	796	234
2009	220	209
2010	982	192

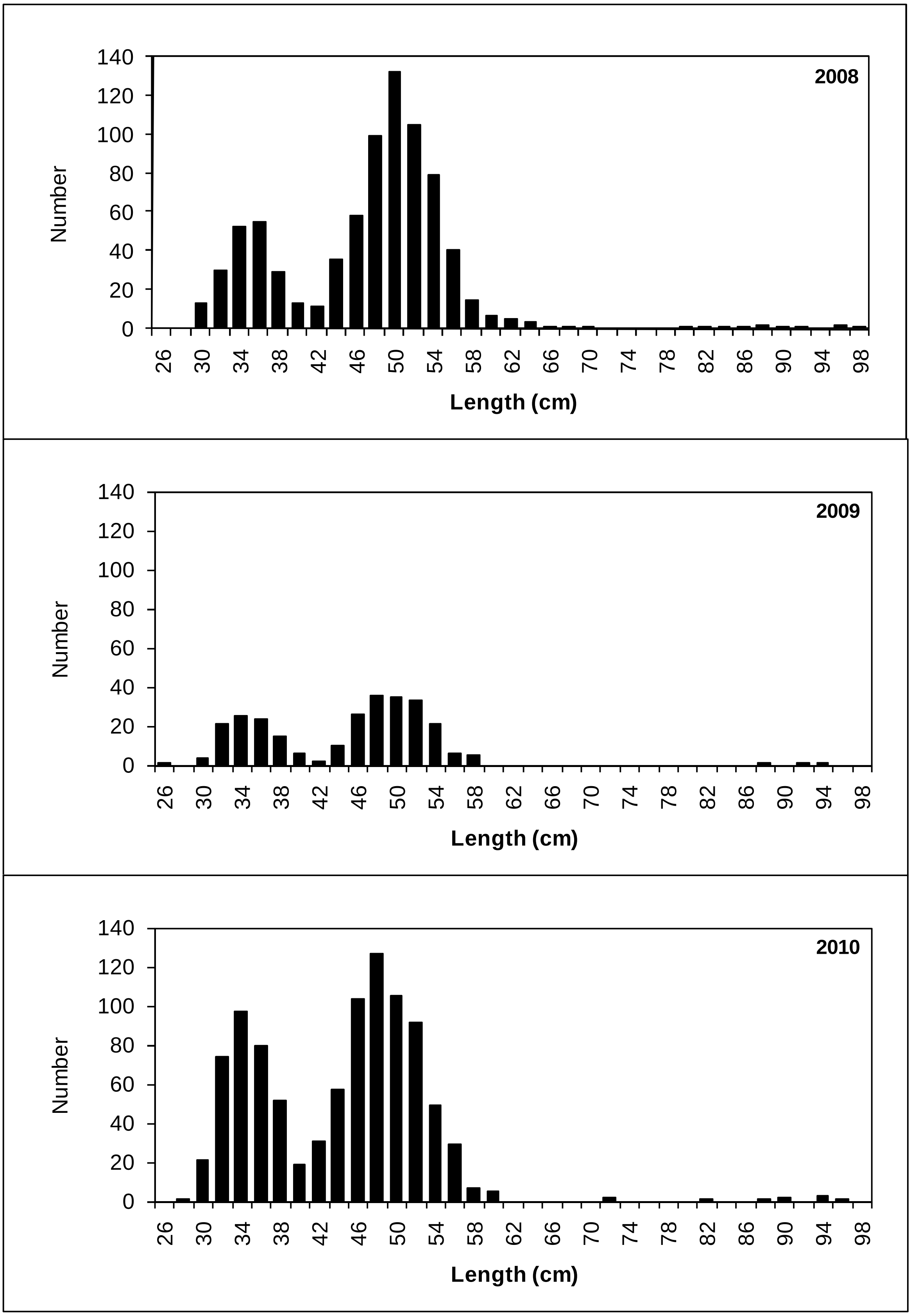


Figure 7-2: Length frequency of sub-samples of silver eels trapped in the downstream traps, 2008 (n=800), 2009 (n=273) and 2010 (n = 960).

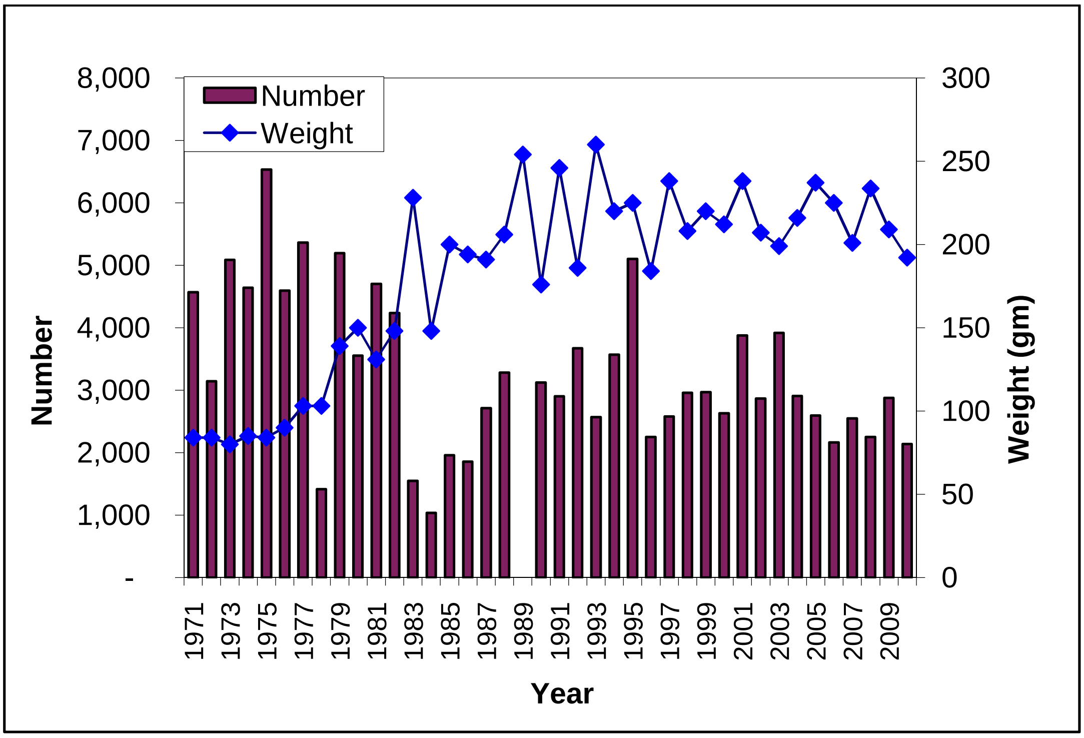


Figure 7-3: Annual number and mean weight of silver eels trapped in the downstream traps.

8 Fishery Report - Catch Data

The Burrishoole Fishery is a valuable part of the overall stock census programme and is run as an integral part of the monitoring programme. As part of the conservation of the Burrishoole wild stock, changes to the active season and to the parts of the catchment being fished have caused differences, or gaps, in the data being collected. Lough Feeagh, which had been closed to angling since 1997 for conservation reasons was opened to angling for the month of September in 2008, on a catch and release basis for wild fish. During 2009 and 2010 Lough Feeagh was open for angling on a catch and release basis from August to the end of September.

8.1 Numbers and Average weight of Rod Catch

There was an increase in the total catch of both wild and reared salmon in 2010 compared to the previous year. The catch of wild salmon increased from 12 to 26 and the catch of reared salmon increased from 7 to 78. For conservation purposes all of the wild fish were returned alive.

The Lough Furnace catch consisted of 18 wild fish and 77 reared fish and the Lough Feeagh catch consisted of 8 wild grilse and 1 reared fish.

The average weight of reared salmon was 1.6 kg (n=74); the heaviest reared fish 2.8 kg. No lengths or weights are available for wild fish.

A total of 22 sea trout were caught on Lough Furnace and 1 on Lough Feeagh. Regulations remained in place whereby all rod caught sea trout were returned alive.

In addition to the sea trout caught on Lough Feeagh, a total of 120 brown trout were also caught on the lake in 2010.

8.2 Timing of Catch and Rod Effort

There was a significant increase in the rod catch at Burrishoole in 2010 compared to the previous year and increased catches were also recorded in other rivers on the Bangor District. Although water levels were generally low during May and June, water levels increased for the remainder of the season.

The better fishing conditions during 2010 were also reflected in the rod effort which increased from 588.5 hrs to 1280 hrs on Lough Furnace.

Table 8-1: Wild and reared salmon rod catch and rod effort (hours) for the 2010 season for L. Furnace and L. Feeagh.

Furnace

	Salmon Catch		Effort in hours
	Wild	Reared	
May	0	0	0
June	3	3	27
July	12	64	722
August	3	9	509
September	0	1	22
Total	18	77	1280

Feeagh

	Salmon Catch		Effort in hours
	Wild	Reared	
May	0	0	0
June	0	0	0
July	0	0	0
August	2	0	60
September	6	1	28
Total	8	1	88

8.3 Exploitation Rates of Rod Fishery

Rod exploitation rates for Lough Furnace and Lough Feeagh from 1990 to 1996 are shown in Table 8.2. From 1997 onwards Lough Feeagh was closed to angling. Exploitation rates are only available for Lough Furnace since 1997. The cessation of angling on Lough Feeagh was due to the continuing low stock level of wild fish. Following the cessation of drift netting in 2007 and the increased return of wild fish it was decided to open Lough Feeagh in 2008 to angling for the month of September only on a catch and release basis for both wild and ranched fish. No sea trout angling was permitted on L. Feeagh since 1997.

Anglers fishing on Lough Furnace were requested to return wild fish alive to the water. Injured or damaged wild fish were permitted to be retained; therefore, the rod catch on Lough Furnace consists of a total catch which includes released fish and a retained catch which are fish that have been killed.

Rod exploitation rates for Lough Furnace and Lough Feeagh from 1990 to 1996 are shown in Table 8.2.

Table 8-2: Rod fishing exploitation rates (2002-2010).

	2002	2003	2004	2005	2006	2007	2008	2009	2010
WILD SALMON									
Lough Feeagh									
"Available" fish by end of fishing season	*	*	*	*	*	*	531	585	691
Total rod catch							18	5	8
Rod catch retained							0	0	0
Angling success %[1]							3	0.85	1.15
Exploitation rate %[2]							0	0	0
WILD SALMON	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Loughs Feeagh & Furnace									
Total stock of wild fish	651	565	610	542	566	1063	572	587	703
+ 10% addition for L. Furnace population	716	622	671	596	623	1169	629	646	773
Total catch of wild fish	12	37 3	10	27	48	26	52	12	26
Rod catch retained	1	2		1	5	2	1	1	0
Max. angling success %	1.8	6.5	1.6	5.0	8.5	2.4	9.1	2	3.7
Min. exploitation rate	0.14	0.5	0.3	0.2	0.9	0.2	0.2	0.2	0
Max. exploitation rate	0.15	0.5	0.3	0.2	0.8	0.2	0.2	0.2	0
REARED SALMON	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Lough Feeagh									
"Available" fish by end of fishing season	*	*	*	*	*	*	98	115	130
Total rod catch							1	1	1
Rod catch retained							0	0	0
Angling success %[1]							1.0	0.9	0.8
Exploitation rate %[2]							0.0	0	0
Loughs Feeagh & Furnace									
Total stock	860	1178	902	952	954	2624	1865	456	940
Total rod catch	10	22	64	28	66	169	116	7	79
Exploitation rate %	1.2	1.9	7.1	2.9	6.9	6.4	6.2	1.7	8.4
WILD SEA TROUT	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Lough Feeagh									
"Available" fish by end of fishing season	*	*	*	*	*	*	39	135	71
Rod catch							3	12	1
Exploitation rate %							0	0	0

8.4 Angling Success

Table 8-3: Catch per unit effort (CPUE) and effort per unit catch (EPUC) for the Burrishoole Fishery.

	Lough Furnace				Lough Feeagh			
	Salmon		Sea Trout		Salmon		Sea Trout	
Year	CPUE	EPUC	CPUE	EPUC	CPUE	EPUC	CPUE	EPUC
'80-'84	0.13	9.92	0.85	1.35	0.23	4.47	0.63	2.10
'85-'89	0.24	4.89	0.46	5.09	0.24	4.57	0.29	70.30
'90-'95	0.20	6.10	0.17	16.80	0.20	5.40	0.10	14.00
'96	0.22	4.40	0.10	10.50	0.83	1.20	0.30	2.90
'97	0.17	6.00	0.10	9.60	*	*	*	*
'98	0.44	2.30	0.08	13.20	*	*	*	*
'99	0.09	10.80	0.05	20.80	*	*	*	*
'00	0.30	3.31	0.06	16.50	*	*	*	*
‘01	0.15	6.70	0.12	8.40	*	*	*	*
’02	0.12	8.30	0.07	15.30	*	*	*	*
’03	0.13	7.60	0.06	17.70	*	*	*	*
’04	0.22	4.60	0.16	6.30	*	*	*	*
’05	0.26	3.80	0.08	13.00	*	*	*	*
’06	0.44	2.30	0.04	23.50	*	*	*	*
’07	0.49	2.10	0.14	6.90	*	*	*	*
’08	0.35	2.89	0.05	21.60	0.46	2.18	0.07	13.80
’09	0.18	5.66	0.24	4.09	0.21	4.75	0.42	2.38
’10	0.60	1.66	0.14	7.27	0.82	1.22	0.09	11.00

9 Collaborative Research Programmes

9.1 National University of Galway: Molecular biology of the Atlantic salmon

This research, funded by HEA PRTLI (2003-2006), aimed to characterise gene expression profiles during the key life stages of Atlantic salmon, particularly smoltification and maturation, using functional genomics tools. In partnership with the Molecular Biology Group, National University of Ireland Galway, ACMS provided materials and services in support of this programme. Postgraduate students continue to work towards completion of theses and publications.

Samantha L. White 'Examination of novel differentially expressed transcripts of the neuro-endocrine system of Atlantic salmon (*S. salar*) during the parr-smolt transformation' Ph.D. November 2008.

Patrick F Forde 'Differential expression in the head kidney and spleen during the parr-smolt transformation of Atlantic salmon (*S. salar*)' Ph.D. in progress.

Aoife Guiry 'Gene expression during sexual maturation in the Atlantic salmon (*S. salar*)' Ph.D. in progress.

9.2 Beaufort Fish Population Genetics

MI Newport is committed to supporting a number of agreed projects that are facilitated and undertaken as part of the Beaufort Fish Population Genetics Programme. The Marine Research Award in Fish Population Genetics was granted by the former Department of Communications, Marine and Natural Resources to University College Cork and Queens University Belfast in June 2007. Management of the Beaufort Research Awards is the responsibility of the Marine Institute.

A series of work programmes are in progress, which aim to determine the scale of biologically important local adaptation at small geographical scales, in Atlantic salmon and brown trout, using a common garden experimental approach:

- 2008/9 broodstock - To assess the importance of local adaptation at small geographical scales by comparing the relative fitness of the progeny of Burrishoole and Owenmore Atlantic salmon parents and their reciprocal hybrids in a common natural environment (Partners: MI Newport , Beaufort Ph.D. studentship UCC).
- 2009/10 broodstock - The establishment of a common garden experiment in the Srahrevagh (Burrishoole) and Tawnyard (Erriff) experimental rivers for the study of local adaptation in Atlantic salmon (Partners: MI Newport, WRFB, Beaufort).
- 2009/10 broodstock - To assess the importance of local adaptation at small geographical scales by comparing the relative fitness of the progeny of Burrishoole and Bunavela brown trout parents and their reciprocal hybrids in a common natural environment (Partners: MI Newport, Beaufort)

9.3 Prevent Escape

The Prevent Escape project (2009-2012) is a research project funded by the European Community under FP7. Escapes of fish from sea-cages have been reported for almost all major species cultured across Europe, including Atlantic salmon, sea bream, sea bass, Atlantic cod and rainbow trout. The project is specifically designed to conduct and integrate biological and technological research on a pan-European scale to improve recommendations and guidelines for aquaculture technologies and operational strategies that reduce escape events. Prevent Escape involves 11 partners from six countries (Norway, Greece, Spain, Malta, Scotland and Ireland) and is led by SINTEF Fisheries and Aquaculture. The Marine Institute are involved in two work packages and as project leaders for

Map Escape, are responsible for carrying out a Europe wide survey of escape events and their causes.

9.4 SALSEA

The Marine Institute is one of 20 partners from 9 countries involved in a three year research programme (2008-2011) ‘Advancing understanding of Atlantic Salmon at Sea: Merging Genetics and Ecology to Resolve Stock-specific Migration and Distribution patterns’, funded by the European Community under FP7. In June/July 2009 over 800 post-smolts were taken in three surveys, carried out by scientists from Ireland, the Faroe Islands and Norway. Over 1,700 contemporary samples have been taken from the surveys in 2008 and 2009 and these will be tested for a broad range of genetic and biological parameters. A wealth of other biological material and oceanographic data was also collected. A full update on the work of SALSEA merge is available on www.salmonatsea.com. Analysis is ongoing to determine the origin of each individual salmon captured at sea, and to link this with the marine growth dynamics, survival and feeding of specific river stocks of Atlantic salmon. Work continues on mapping the migration routes of the salmon post smolts at sea.

9.5 Fisheries Induced Evolution (FinE)

The Institute is part of an FP6 European research network working on a programme entitled ‘Fisheries Induced Evolution’ (July 2007-June 2010). Staff from all sections of MI Newport have worked with Dr. Philip Bacon, FRS Scotland, to integrate Burrishoole ranch stock databases and facilitate an assessment of fisheries induced selection on size at maturity and the evidence for associated fisheries induced evolution.

9.6 Brackish lakes Study

Palaeolimnological assessment of recent ecosystem disturbance / regime shifts in sediment cores from ecotonal brackish lake systems

A postgraduate student from Mary Immaculate College, Limerick, has commenced a 36 month PhD Study 'Palaeolimnological assessment of recent ecosystem disturbance / regime shifts in sediment cores from ecotonal brackish lake systems'. The aim of this EPA funded fellowship is to examine the recent palaeolimnology of two brackish lake systems, one of which is Lough Furnace. Specifically the project will quantify the salinity and nutrient response in the fossil diatom, cladoceran and foraminifera records. These results will be supplemented by quantification of the organic isotope ratio (C:N) in the sediment record in an effort to establish changes in allochthonous and authochonous sediment inputs. Analysis of the cores is complete and the project is on schedule for completion in 2011..

Limno- and palaeo- limnological responses to lake water dissolved organic carbon (DOC)

This PhD project by Mary Immaculate College, Limerick, aims to provide a clearer understanding of the special features of dystrophic lake waters from a neolimnological and paleolimnological (surface sediments) through quantification of the response in bacterial and algal populations of Lough Feeagh, Co Mayo. Monthly sampling is currently underway and sediment traps have been installed in Lough Feeagh.

9.7 Climate Change

As part of the SSTI Climate Change Initiative, ACMS is engaged in workpackages on fish growth and survival, the analysis of climate and environmental datasets collected from the Burrishoole catchment and forecasting future local climate scenarios using downscaled climate models (see RESCALE below). An automatic water monitoring station was installed (funded by ERDF) on a buoy in L. Furnace, which includes a profiling winch, and this has commenced monitoring the tidal influxes and stratification in the lough. Significant outputs are now being received from the buoy and the station has been included in the international GLEON network.

9.7.1 RESCALE, Review & Simulate Climate and Catchment Responses at Burrishoole

RESCALE is a multi-partner project involving the Marine Institute, NUI Maynooth and Trinity College Dublin funded by the SSTI Climate Change programme. The project will analyse, evaluate and integrate environmental data from Burrishoole with high-resolution climate scenarios and catchment–based models to assess the likely changes in key aquatic processes in the catchment.

There are several components to the project:

- Collation, evaluation & insertion of data into a centralised database
- Downscaling of Global Climate Models (GCM's) to a regional level
- An assessment of the impacts of projected changes in stream-flow, soil and groundwater storage on the Burrishoole catchment.
- An assessment of predicted changes in river and lake temperature, dissolved organic carbon, oxygen levels, pH and dissolved oxygen resulting from climate change
- To integrate the above with inshore and coastal monitoring data and examine the implications for fish growth and survival under various downscaled climate scenarios.

The project began at the beginning of May 2008 and data collection, evaluation and collation, is progressing well. Downscaling of GCMs using data from the Burrishoole catchment at NUI Maynooth is complete and data exchanges between workpackages is now taking place for the modelling, analysis and report writing. The project reported in Feb 2010 with presentations to the Minister for Agriculture, Fisheries and Forestry in September and the Minister for State for Inland Fisheries and natural Resources in October.

9.7.2 Diadromous Fish Growth and Survival Workpackage

The project is tracking changes in salmonid and eel growth and survival from the 1950's in the Burrishoole catchment, using archived scale and otolith samples along with environmental and meteorological data. The aim of this workpackage is to correlate salmonid and eel growth and survival data with downscaled weather data, to predict how these parameters may change under various climate scenarios. Results and predictions from the project were included in the Marine Institute's Ocean Status Report 2009. Ageing and growth work on both salmonids and eels is being carried out on a digital analysis system, which will provide a digitised archive of all scales and otoliths examined during the study. Laboratory work and analysis is complete. The first draft report has been received and this was integrated with the RESCALE report in 2010.

9.8 EU EELIAD

The FP7 funded EELIAD Programme focuses on improving our knowledge of the life history of eels both in the marine and freshwater environments. The project will assess the possible reasons for recruitment failure in eels and identify the characteristics of those eel-producing areas which

produce silver eels of sufficient quality to achieve successful migration to the spawning grounds. The proposed research will facilitate the development of models that can be used by managers to identify the most effective and appropriate measures to improve the quality of silver eel escapement and contribute significantly to the objectives of the EU's Eel Recovery Plan. Silver eels and technical support were provided to the project in late 2008 and 2009 for the satellite and data storage tag tracking of silver eels in the ocean. Burrishoole eels were used as *Anguillicola* free individuals. The Marine Institute also provide technical support to EELIAD and act as a linkj between the project, ICES and the EU. The annual meeting of the project was held in Gothenburg, Sweden, in June 2010.

9.9 SANIFAC

SANIFAC is funded by the Department of Agriculture, Food and Fisheries STIMULUS fund for NUIG and the MI to work on two catchments for 4 years from 1st December 2007 to the 30 Nov. 2011

In order to protect the water quality, good management practices have been introduced in forest industry in Ireland, which include: (i) sizing the harvesting area using the dilution capacity in the receiving waters to limit concentrations, (ii) buffer zone development and (iii) whole-tree harvesting. However, these practices may not always be suitable for upland peat forests. Dilution sizing of the harvesting area can reduce the concentrations of the nutrients in the receiving water but will not reduce the nutrient load releases. Buffer zones can be efficient in removing suspended solids and particulate nutrients. However, there are concerns about the effectiveness of buffer zones in upland blanket peat catchments - such as the Burrishoole Catchment - where: (i) most of the phosphorus (P) release occurs in soluble form during storm events, (ii) some of the buffer zone soils have low permeability and (iii) the land slopes in the catchment are steep. Whole tree harvesting removes the nutrients and base cations from the catchment, which could be essential for the next rotation since the fertility of the original blanket peat is very low. While the overall objectives of the SANIFAC project are to comprehensively assess the impact of blanket peat forest harvesting activities on water quality and to evaluate the performance and feasibility of the three different mitigation methods mentioned above, another, novel, mitigation method – grass seeding – is also proposed and will be examined in this study.

SANIFAC mainly focuses on the assessment and mitigation of soil and nutrient losses from acid-sensitive forest catchments. Dr. Michael Rodgers was the original Principal Investigator. After his retirement at the end of November 2009, Professor Padraic O'Donoghue took over the PI role. Dr. Liwen Xiao is the project co-ordinator and research fellow. Mr. Mark O'Connor is the research assistant. Connie O'Driscoll and Zaki-ul-Zaman Asam are the two postgraduate students. The field study of this project is carried out in four sub-catchments in Burrishoole Catchment. Liwen Xiao and Zaki-ul-zaman Asam are based in NUI Galway. Mark O'Connor and Connie O'Driscoll are located in Marine Institute, Newport.

9.10 HYDROFOR

HYDROFOR is funded by the Environmental Protection Agency's STRIVE fund for UCD, UCC and NUIG to work on six catchments (3 in higher details than others) for 5 years commencing on 1/5/2008 and will end on 30/4/2013. The NUIG component of the work is based in Newport.

The HYDROFOR project aims to compare nutrient and sediment release from forest clearfelling operations. Two sites are being examined: (1) in Glenamong, sediment and nutrient release from two 8-ha sites (a study site and a control site) are being examined; (2) in Altahoney (Altahoney), the effectiveness of naturally revegetated riparian buffer zones - clearfelled in 2006 – in mitigating the

particulate and nutrient releases from forest harvesting activities upslope that are due to take place in January/February, 2011 are also being investigated.

Work in the Glenamong micro-catchment of the Burrishoole forest is currently being conducted by NUI Galway. A number of baseline and storm events sites have been monitored in the Glenamong study and control site. Each site is fully instrumented with a H-Flume for measuring the flow and a data-sonde for measuring pH, temperature, conductivity and dissolved oxygen. Clearfelling of the 8-ha study site is due to take place in January/February, 2011. In January/February 2011, approximately 2 ha of forest in Altahoney will also be clearfelled. A buffer zone - clearfelled in 2006 – is in place to capture nutrients and sediment from the clearfelled site. The site is reasonably well vegetated and is instrumented with piezometers to monitor water table changes and sampling tubes to enable subsurface water samples to be collected and analysed.

HYDROFOR mainly focuses on the assessment and mitigation of soil and nutrient losses from acid-sensitive forest catchments. Dr. Mark Healy is the project co-ordinator. Mr. Mark O'Connor is the research assistant (funded through SANIFAC). John Regan is a Research Assistant and Joanne Finnegan is the postgraduate student. The field study of this project is carried out in two sub-catchments in the Burrishoole Catchment. Mark Healy, John Regan and Joanne Finnegan are based in NUI Galway and make regular visits to Burrishoole. Mark O'Connor is located in Marine Institute, Newport.

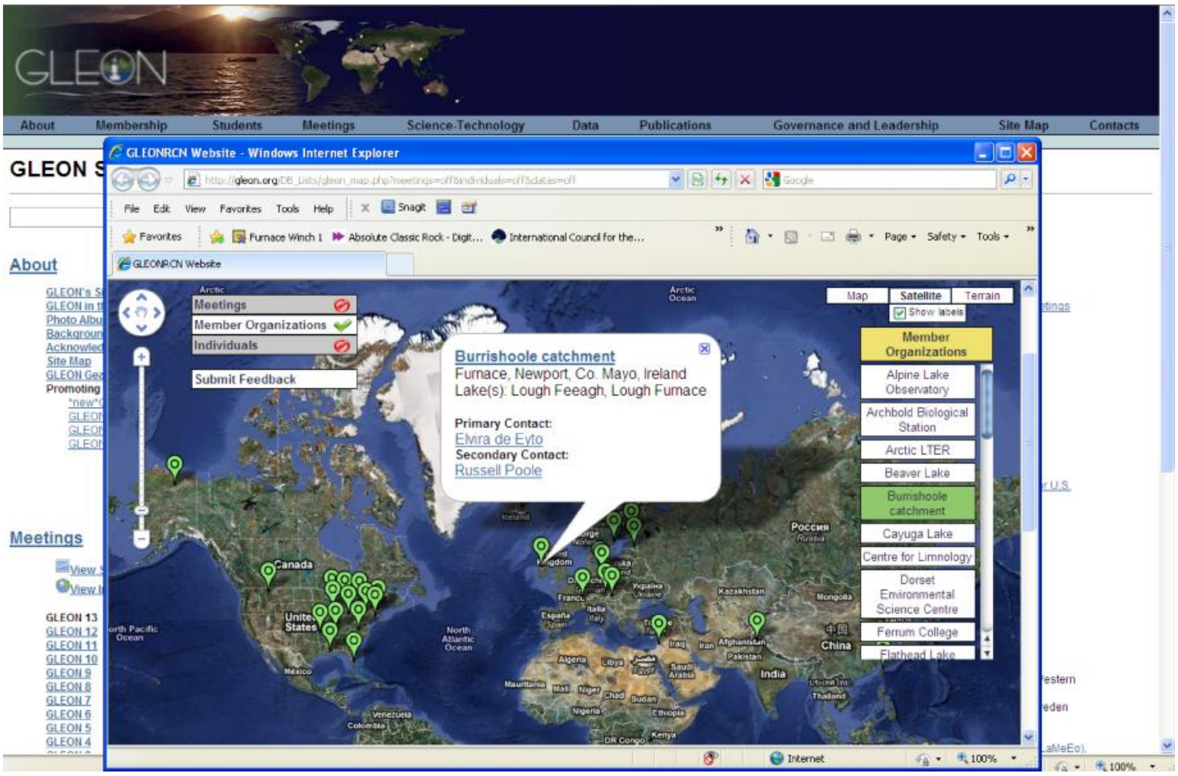
9.11 Estimating carbon pools and processing in a humic Irish lake.

This study is being carried out by Liz Ryder of Dundalk IT on Lough Feeagh in the Burrishoole system. The catchment has a history of Dissolved Organic Carbon research and investigations into lake dynamics (Life, Reflect, Life II and Clime project, 1996-2004). The project is designed to address gaps in current knowledge as to how the carbon pool in humic lakes is processed. The AWQMS on Lough Feeagh will greatly enhance the study owing to the high frequency nature of the fluorescence measurements. This PhD study is building on considerable work conducted during the CLIME, ILLUMINATE and RESCALE projects, which have indicated that processing of DOC is likely to be impacted as a result of future climate change, due to changes in catchment soil moisture levels and the impact of temperature on decomposition. While more information is becoming available on characterisation of carbon pools, few studies place these data within the context of whole lake systems and none to date model changes in these pools under projected changes in climate. Future climate conditions, particularly warmer temperatures and more seasonal precipitation than present have been predicted for the Burrishoole catchment as a result of global warming. Through an approach that integrates empirical data with output from dynamic models, this project will examine how climate change is likely to impact on in-lake carbon dynamics in Lough Feeagh, in particular on the pools of available carbon in both phytoplankton and DOC and the processing of this carbon by higher trophic levels. Aquatic ecosystems play an important role in regional carbon budgets, particularly in areas such as the west of Ireland where peatlands are extensive and lakes are numerous. In addition, the leaching of highly coloured water from peatland catchments has important implications for the use of this water for public consumption. Work on Lough Feeagh, therefore, provides a useful test catchment for assessing the management implications of climate change with respect to carbon budgets, and water usage.

9.12 GLEON

The Burrishoole Catchment is now a member of GLEON – a grassroots network of limnologists, ecologists, information technology experts, and engineers who have a common goal of building a scalable, persistent network of lake ecology observatories worldwide. In 2010, GLEON met in May

in Brazil (MI was represented by Liz Ryder (DkIT)) and in October in Nanjing China and the meeting was attended by Elvira deEyto and Liz Ryder (DkIT).



9.13 Publications

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10 Catchment Stock Assessment

10.1 Introduction

The Burrishoole catchment, upstream of the main fish traps, has been monitored since 1990 with surveys of the salmonid and eels stocks taking place in the rivers and the main lakes. Electrofishing, with 3 fishing depletions, is used for salmonids and eels in the streams, fine mesh beach seines are used for salmonids in the lakes and summer fyke nets are used for eels in the lakes.

10.2 Electrofishing Surveys

2010 marks the completion of 20 years of consistent electrofishing surveys in the Burrishoole and Owengarve catchments. The 2010 annual surveys of fish stocks in the Burrishoole and Owengarve rivers took place between the 26th August and the 15th of October. Weather conditions were not ideal in September, with a lot of rain in the middle two weeks preventing electrofishing. Nevertheless, 41 sites were fished, and a total of 1165 fish were caught, identified and measured. Summary data are presented in Figures 10.1 – 10.6, and these show the distribution of fish densities around the catchment for eel (Fig. 10.1), 0+ salmon (Fig. 10.2), 1+ salmon (Fig. 10.3), 0+ trout (Fig. 10.4), 1+ trout (Fig. 10.5) and 2+ trout (Fig. 10.6). Densities were calculated using three pass removal sampling.

Eel densities are generally below 0.02 eel per m^2 and were absent in 24 of the sites fished. Highest densities were recorded at the base of the Maumaratta River (0.0484 /m^2) and in the Glenthomas side of the Owengarve catchment (0.0508 /m^2).

Salmon densities were generally higher on the east side of the Burrishoole catchment, although it should be noted that numbers in the bottom section of the Shrarevagh River are owing to stocking of both 0+ and 1+ fish. Apart from those stocked populations, the highest densities of 0+ salmon were recorded in the Goulaun River (1.08/m^2 for 0+ and 0.31/ m^2 for 1+ fish).

Trout densities were also generally higher on the east side of the catchment, particularly in the two streams feeding into Lough Feeagh (Streams A and C), the Fiddaunnahoilean and in the Fiddaunveela. In all the streams, 0+ densities were in excess of 0.5/m^2, with Stream A recording 2.39/m^2. 1+ trout were also high in Stream C, a site on the Fiddaunveela and a site on the Fiddaunahoilean, where 0.2/m^2 was recorded. In contrast, the highest numbers of 2+ trout were recorded in the top of the Shrarevagh River, above the waterfall, where numbers of fish were 0.09/m^2.

10.3 Beach Seine Surveys

Due to high water levels and poor weather conditions, beach seine surveys were not conducted in 2010.

10.4 Fyke Net Surveys

Fyke net surveys of yellow eels have been conducted in the 1970s and 1980s as parts of previous studies. The Burrishoole lakes Feeagh and Bunaveela have been incorporated into the National Eel Survey in 2009-2011.

Yellow-eel stock monitoring is integral to gaining an understanding of the current status of local stocks and for informing models of escapement. Such monitoring also provides a means of evaluating post-management changes and forecasting the effects of these changes on silver eel escapement. The monitoring strategy aims to determine, at a local scale, an estimate of relative stock density, the stock's length, age and sex profiles, and the proportion of each length class that migrate as silvers each year.

Fyke net surveys carried out between 1960 and 2008 will provide a useful bench mark against which to assess the changes in stock. The yellow eel monitoring strategy will rely on the use of standard fyke nets. Relative density will be established based on catch per unit (scientific-survey) effort.

Lough Feeagh has a surface area of 395ha and an average depth of 14.5m (with several areas >35m in depth). Lough Feeagh was sampled by IFI and the MI for six nights (3 nights per session) during the summer of 2010 (Fig. 10.7). In total, 496 eels were caught with a catch per unit effort (CPUE) of 1.65 (Table 10.1). The eels ranged in length from 26.6cm to 89.1cm and in weight from 0.026kgs to 1.656kgs, with a total weight of 73kgs caught over the 6 nights (Table 10.1 and Fig. 10.8).

Bunaveela Lough is located in the upper reaches of the catchment. It has a surface area of 42ha and a maximum depth of 23m. It was sampled by the MI for one night over two occasions (coinciding with the L. Feeagh surveys dates). In total 11 eels were caught with a catch per unit of effort of 0.22. The eels ranged in length from 36.2cm to 58.3cm.

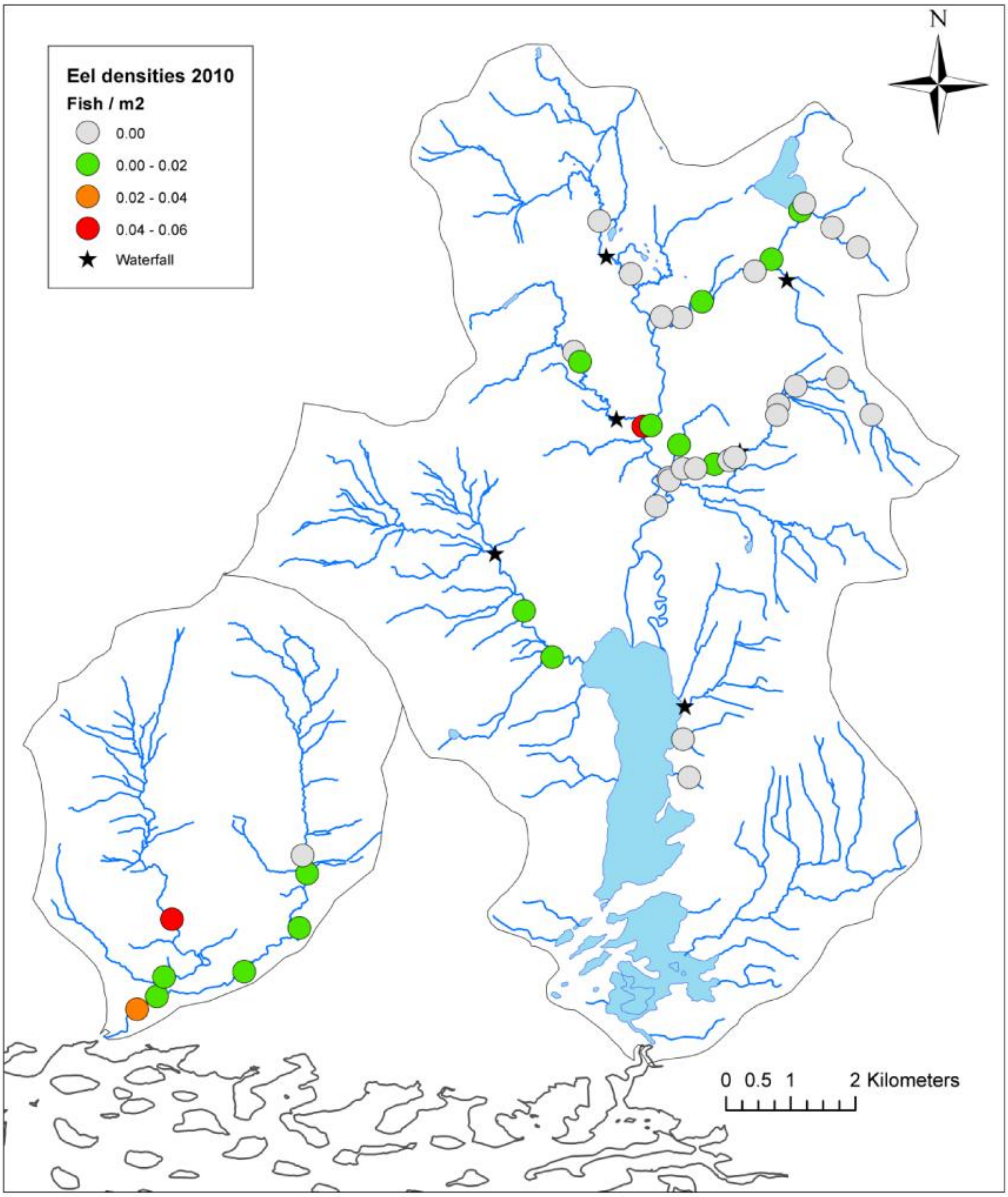

Figure 10-1: Densities of eel calculated from the 2010 electrofishing survey of the Burrishoole and Owengarve catchment.

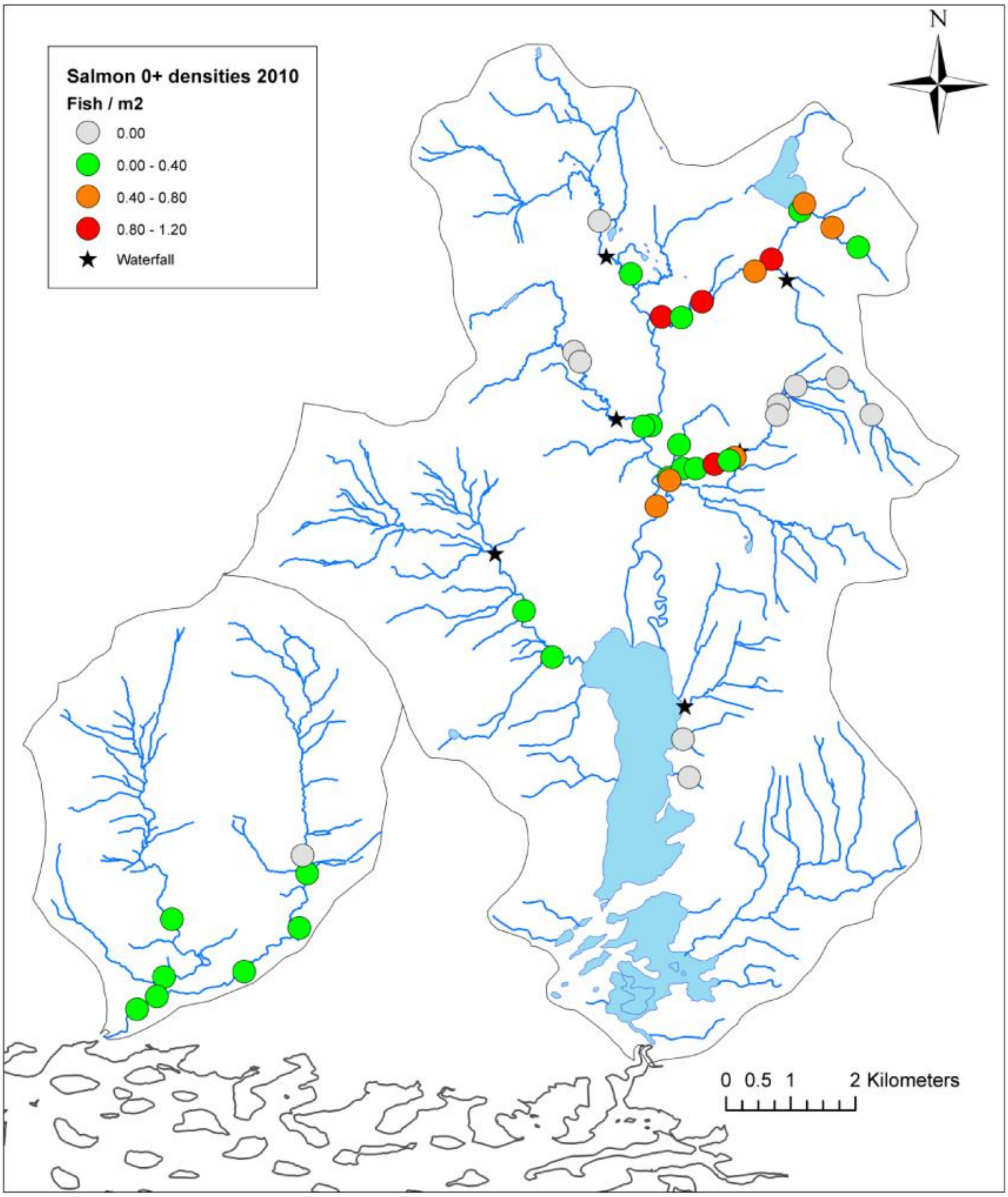

Figure 10-2: Densities of 0+ salmon calculated from the 2010 electrofishing survey of the Burrishoole and Owengarve catchment.

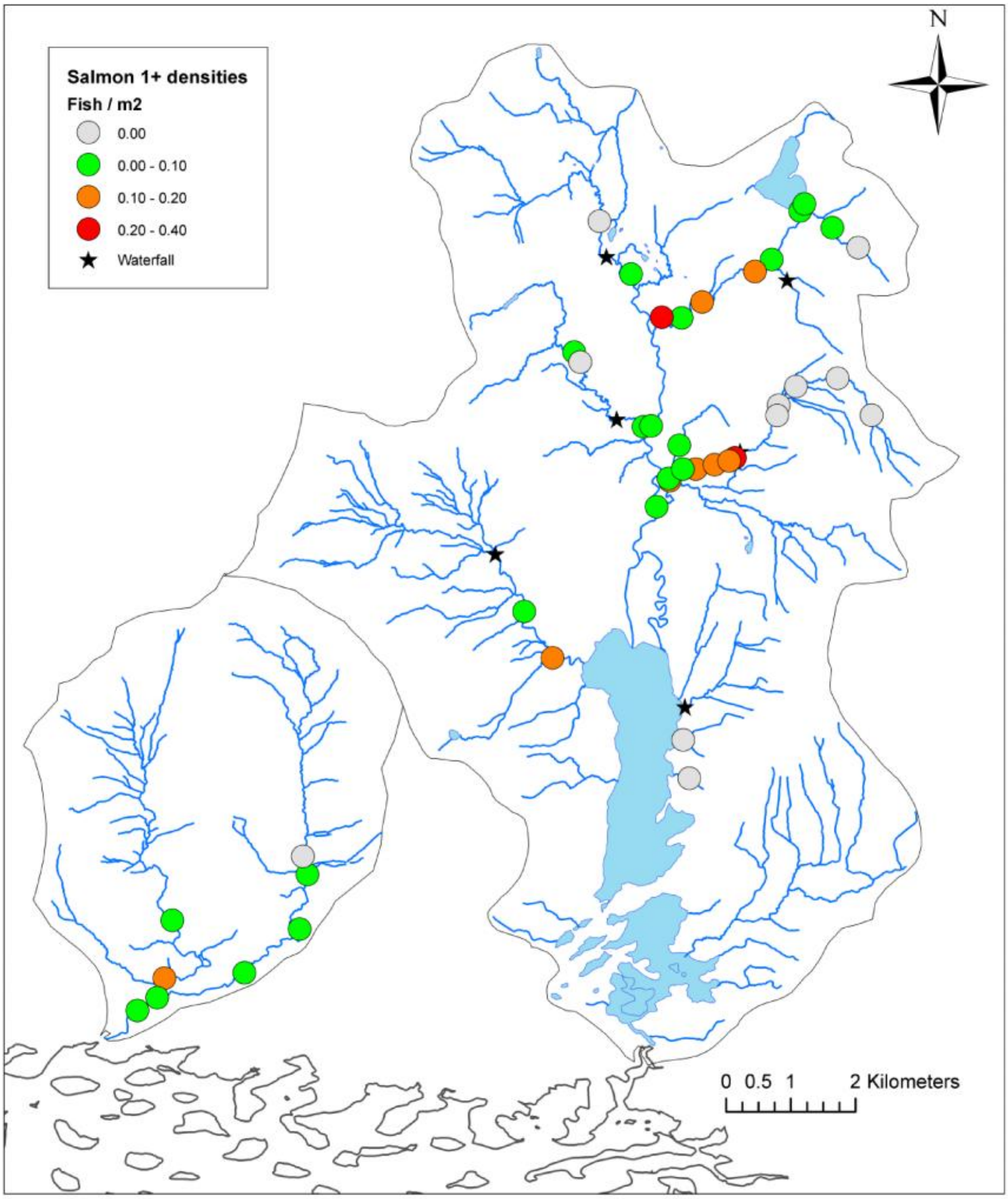

Figure 10-3: Densities of 1+ salmon calculated from the 2010 electrofishing survey of the Burrishoole and Owengarve catchment.

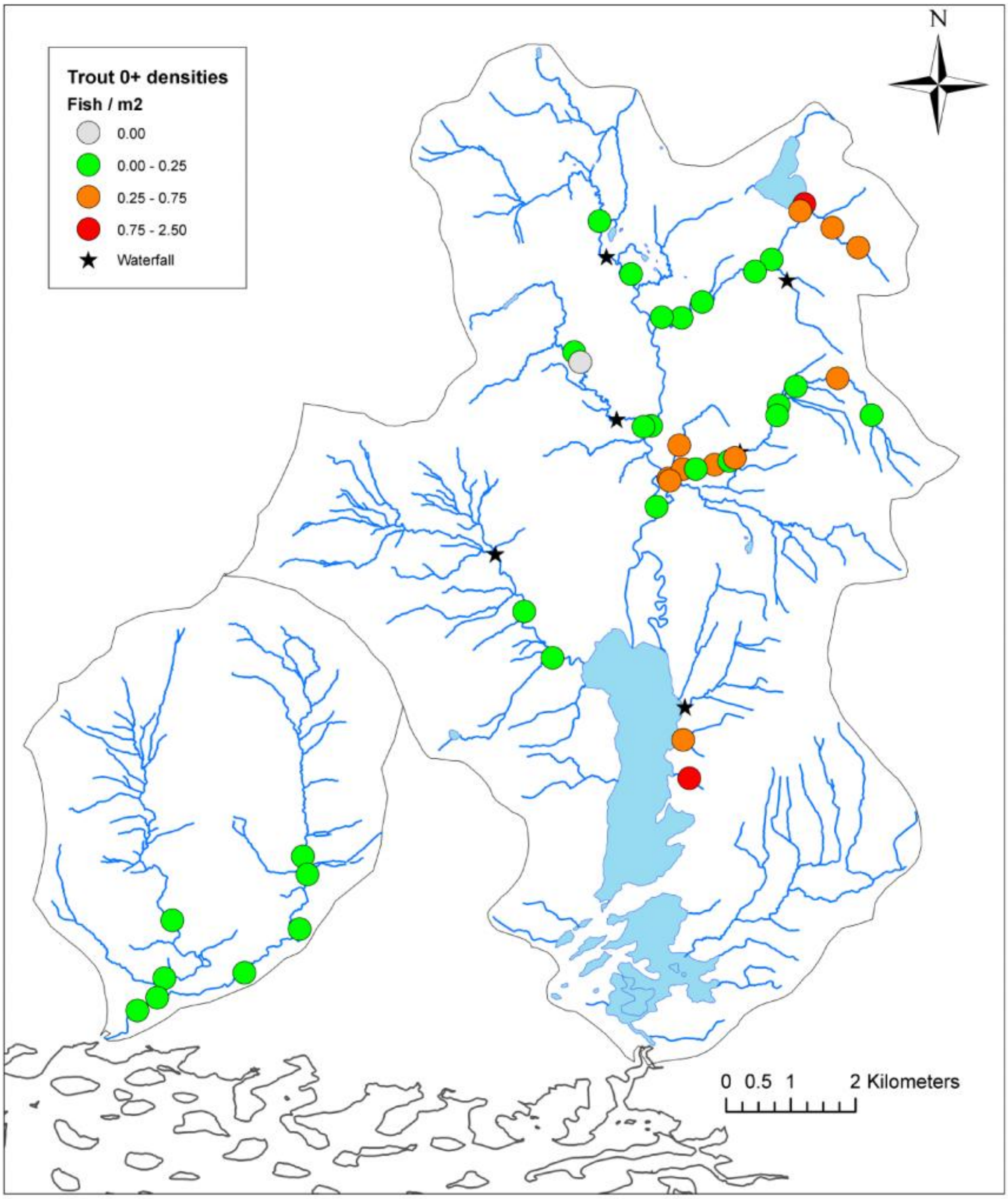

Figure 10-4: Densities of 0+ trout calculated from the 2010 electrofishing survey of the Burrishoole and Owengarve catchment.

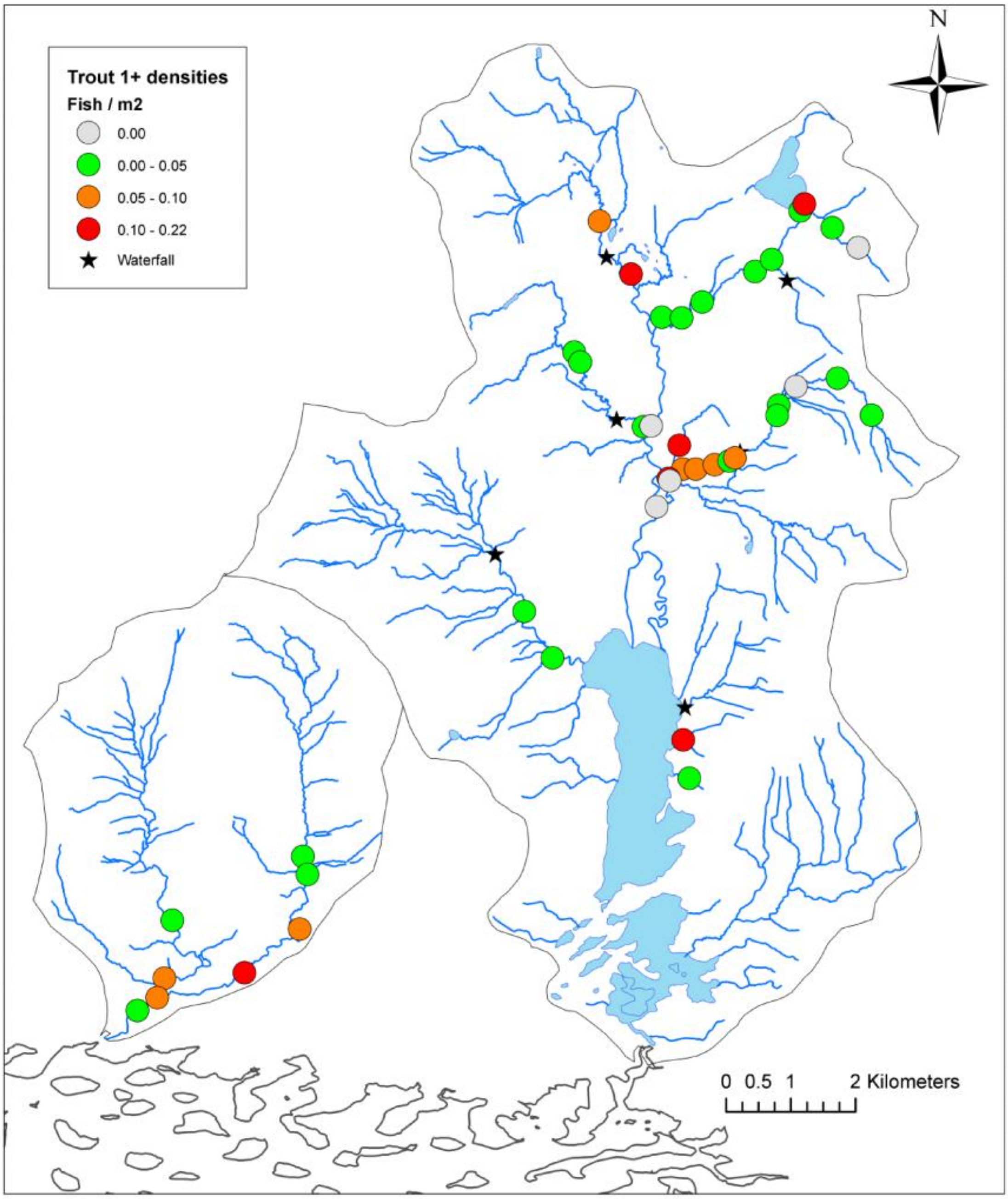

Figure 10-5: Densities of 1+ trout calculated from the 2010 electrofishing survey of the Burrishoole and Owengarve catchment.

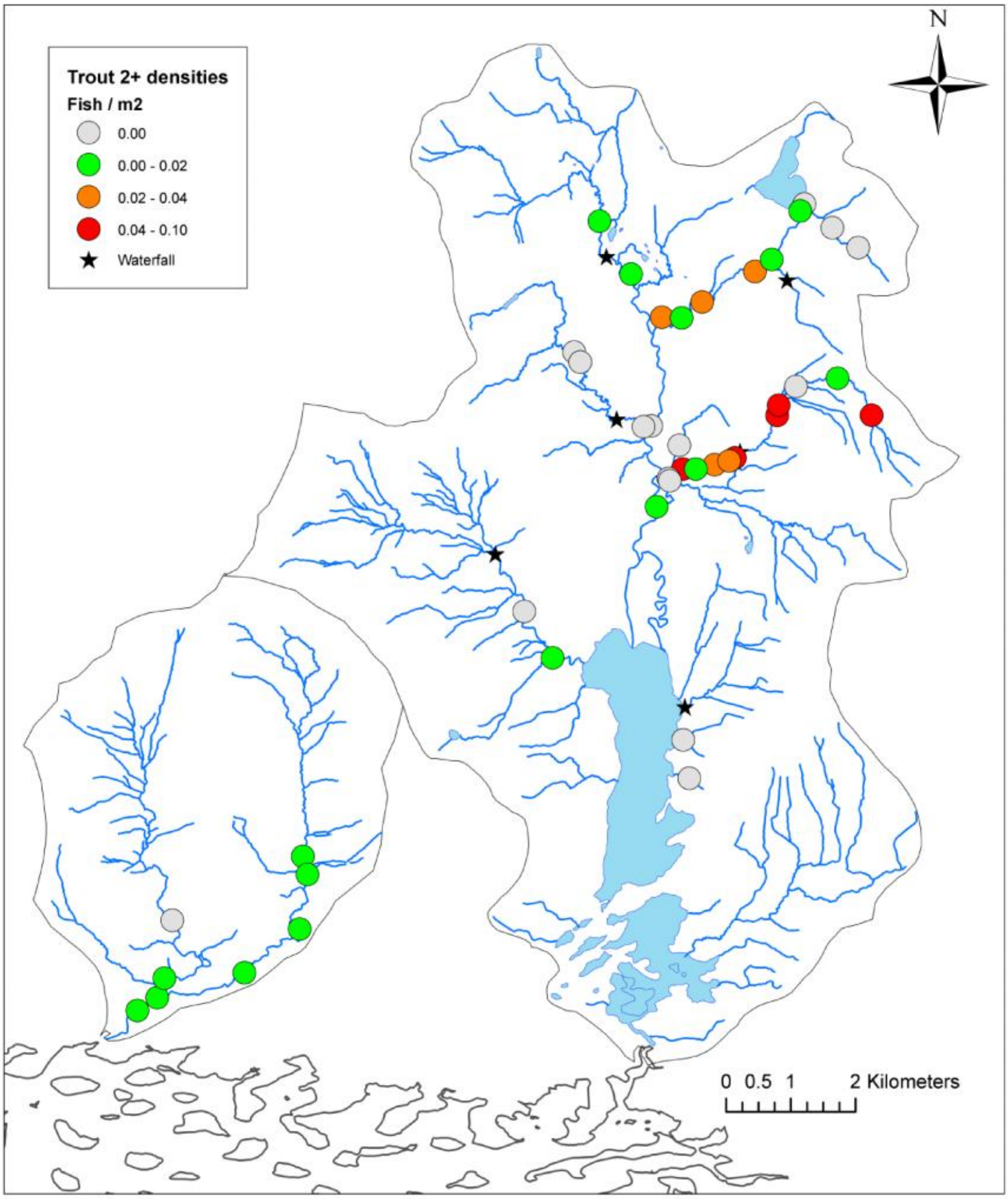

Figure 10-6: Densities of 2+ trout calculated from the 2010 electrofishing survey of the Burrishoole and Owengarve catchment.

Table 10-1: Catch details of the yellow eel survey carried out in 2010.

Lake	Dates	No. Eels	Nets* Nights	CPUE	Total weight (kg)	Mean length (cm)	Mean weight (Kg)
Feeagh	25/05/2010	130	50	2.60	17.864	43.5 (30.8-59.2)	0.153
	26/05/2010	83	45	1.84	12.116	41.7 (28.8-69.0)	0.151
	27/05/2010	40	55	0.73	5.843	42.1 (28.6-68.8)	0.146
	04/08/2010	95	50	1.90	16.357	42.6 (26.6-89.1)	0.174
	05/08/2010	79	50	1.58	12.423	43.6 (33.2-78.4)	0.159
	06/08/2010	69	50	1.38	8.562	40.3 (30.2-55.8)	0.128
	2010	**496**	**300**	**1.65**	**73.165**	**42.5 (26.6-89.1)**	**0.154**
Bunaveela	02/06/2010	5	25	0.2	-	46.7 (36.2-58.3)	-
	29/07/2010	6	25	0.24	-	48.9 (36.7-53.6)	-
	2010	**11**	**50**	**0.22**	**-**	**47.9 (36.2-58.3)**	**-**

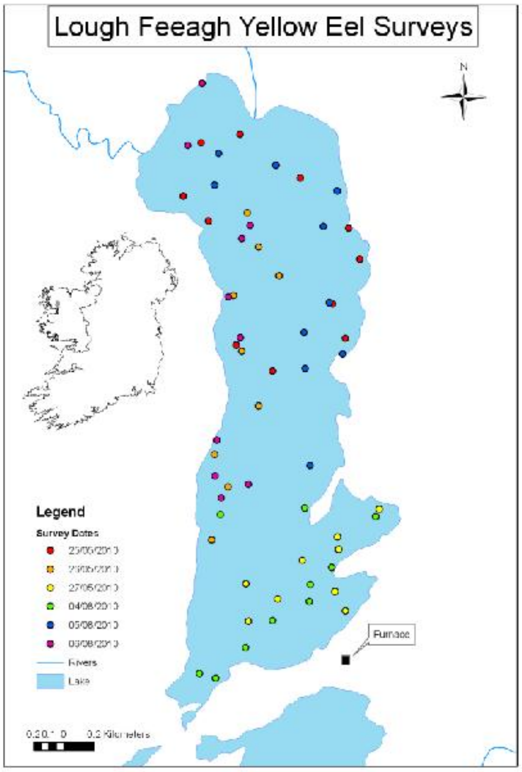

Figure 10-7: Locations of fyke nets sampled on L. Feeagh, 2010.

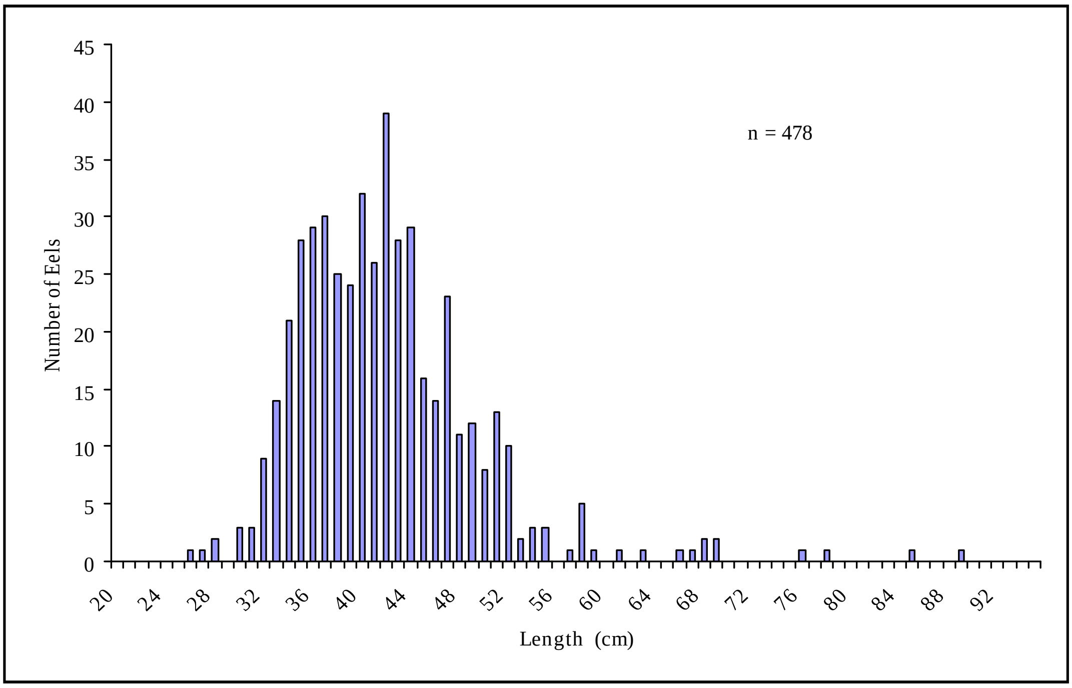

Figure 10-8: Length Frequency of yellow eels captured at Lough Feeagh, 2010.

Annex 1: Macro-invertebrate Survey of rivers in the Burrishoole and Owengarve catchments, 2009 & 2010

Elvira de Eyto, ACMS, Marine Institute

Introduction

The research facility in Furnace is ideally placed for the collection and analysis of data applicable to the long term monitoring of lotic and lentic freshwater habitats. In 2003, a formal, consistent macroinvertebrate monitoring plan was implemented, which will hopefully be continued long term to enable annual trends in water quality to be captured. Eight years of continuous data are now available.

The main land uses in the Burrishoole catchment are forestry and agriculture. The agriculture is mainly hillside subsistence farming, with large numbers of mountain sheep. About 18% of the Burrishoole catchment and 7% of the Owengarve catchment is under active coniferous forestry plantations, which were planted in batches starting in the 1970's. The base geology on the west side of the Burrishoole catchment (Glenamong, Altahoney and Maumaratta subcatchments) is predominantly quartzite/schist, making them acidic in nature, with poor buffering capacity. On the east side of the catchment (Rough, Lodge, Goulaun and Cottage subcatchments) , the geology is much more complex and while there is also quartzite/schist, it is interspersed with veins of volcanic rock, dolomite, wacke and pure schist, which means that the buffering capacity is higher as is the aquatic production. The Owengarve catchment is split in half with quartzite/schist in the northern half, and sandstone in the southern half (Fig. 1).

In July 2009, one month after the 2009 samples were taken, there was a significant flood event which affected the east side of the Burrishoole catchment (Annual Report 2009, Ch. 2.2.5). The west side of the catchment appeared to be generally unaffected. The 2010 samples, therefore offer an opportunity to assess whether this flood had medium or long term affects on the macroinvertebrate communities in the Rough, Lodge, Cottage and Goulaun rivers.

Methods

Macroinvertebrate samples were sampled in May 2009 and 2010 from two sites in each of the main Burrishoole sub-catchments, and two sites in the Owengarve catchment (Fig. 2). Three replicate 1ft sq surber samples were taken from riffle / stony areas. Samples were stored in >70% IMS and sorted and identified using standard keys in the laboratory. Data were collated at both taxa and order level and were combined with data from 2003 - 2008. Biotic indices (ASPT, BMWP, Q index, No. of taxa, No. of EPT taxa, acidity index) were also calculated for each site.

Results and discussion

A total of 1931 and 1587 individual macroinvertebrates, representing 63 and 57 taxa, were sorted and identified from the 2009 and 2010 samples respectively (Table 1). The number of taxa identified from rivers in the west side of the catchment was generally similar to that recorded in the previous six years (Fig. 4 top). On the east side of the catchment, however, numbers of taxa were particularly low in 2010 in the Rough river (top and bottom) and the top site on the Lodge river. As in previous years, the macroinvertebrates on the Burrishoole and Owengarve catchments

in 2009 and 2010 were dominated by Ephemeroptera, Diptera, Plecoptera, Coleoptera and Trichoptera (Fig. 5).

The use of biotic indices helps to condense all the taxa and assemblage information into single values, and indices were calculated for the six years data to date (2003-2010). Several of these indices are specifically designed to monitor nutrient enrichment (Q index, ASPT, BMWP) (Hawkes, 1997; McGarrigle *et al.*, 2002) while the acidity index is used to monitor acidification (Henrikson and Medin, 1986).

The Shannon diversity index gives an overall view of the diversity at each site (Fig. 6), and ranged between 1.2 and 2.3 in 2009, and between 0.52 and 2.1 in 2010. The diversity was slightly lower in the rivers in the west of the catchment (Fig. 6 top) when compared with those on the east (Fig. 6 bottom). Several of the sites had low diversity in 2010, especially the Rough river top and bottom and the top of the lodge.

The number of EPT taxa (Ephemeroptera, Plecoptera and Trichoptera), which are indicative of high water quality, ranged from 3 to 15 in 2009 and 3 to 13 in 2010 (Fig. 7). Many of the rivers showed an increase in EPT taxa between 2008 and 2009, but then a decrease again in 2010, particularly in the rivers affected by the flood.

The BMWP (Biological Monitoring Working Party) score showed a similar trend, with values being higher in 2009 than in 2008, but dropping back down in 2010 in some rivers. The BMWP score ranged from 42 to 125 in 2009, and from 44 to 98 in 2010 (Fig. 8). A BMWP score of greater than 100 are associated with clean rivers, while heavily polluted rivers would score less than 10, so the BMWP scores for our sampling sites suggest that our rivers are not been impacted by nutrient enrichment.

The ASPT scores (which are calculated by dividing the BMWP score by the number of taxa, to standardise for sample size) ranged from 6.2 to 8.1 in 2009 and 6.2 to 7.9 in 2010 (Fig. 9). The BMWP, ASPT and Q index (rivers were either 3, ¾ or 4 – Fig. 10) generally do not tell us much about our rivers, except to show that nutrient enrichment is not really an issue at the moment in these rivers. It is also worth noting that the sampling methodology that we use (surber samples) is not strictly consistent with the calculation of Q, BMWP and ASPT indices (which employ kick sampling). Nevertheless, as our sampling methodology is consistent over the years, the calculation of these indices allows trends to be assessed.

The acidity index ranged from 1 to 8 in 2009 and from 1 to 10 in 2010 (Fig. 11). The rivers in the west of the Burrishoole (and the Owengarve) generally have a lower acidity index than those in the east, indicating that the macroinvertebrates assemblages in these rivers are a good reflection of the acid nature of the water. The acidity index ranges from 0-14, and the Swedish EPA recommends that a river that is unaffected by acidity (in reference conditions) would have an acidity score of at least 6. Some of the rivers in the Burrishoole and Owengarve catchments are well below this, and while it is largely a reflection of the underlying geology, it seems likely that the very low scores (1-3) are a reflection of the impact of afforestation.

It was recorded in the 2008 annual report that several of the rivers were showing signs of some kind of impact, in particular the Glenthomas, the Goulaun and the Rough rivers. On closer examination, there has been a drop in the number of taxa sampled, and a decrease in the number and abundance of sensitive species (Fig. 12). In 2008, no sensitive species (class A) were recorded in the Glenthomas, and the main abundance of macroinvertebrates comprised dipteran larvae (Chironominae, Orthocladinae and tanypodinae). In 2009 and 2010, there was an improvement in these conditions, with all indices exhibiting an increase over the values observed in 2008.

There were no amphipods or acid sensitive EPT species found at the site at the bottom of the Goulaun river in 2008, and generally the species richness and abundance of sensitive species was low (Fig. 13). As with the Glenthomas, conditions improved in 2009 and 2010, and diversity in

2009 was particularly high. While the Goulaun was probably affected by the 2009 flood to some extent, the macroinvertebrate community seems to have recovered well.

With regard to the Rough river (Srahrevagh), 2008 showed a continuing decline in ecological quality at the bottom of the river, which was first observed in 2006 (Fig. 14). The absence of amphipods in samples taken in 2006 and 2008 is the main contributing factor to the low acidity score, but the absence of many of the sensitive species in 2008 was also worrying. Like the two sites mentioned above, the 2008 samples were dominated by tolerant beetles and dipterans. The acidity index was also low at the top site on the Rough owing to an absence of acid sensitive species. There were signs of an improvement in 2009 at both the top (Fig.15) and the bottom of the rough, with all the biotic indices increasing. However, both sites had quite different invertebrate communities in 2010, probably as a result of the flood which was centred on the Rough river catchment. At both the top and bottom sites, *Baetis rhodani* were dominant in 2010, indicating that this mayfly may be very good at exploiting new habitats, where the flood waters had left gravels and cobbles exposed.

As the flood seems to have had a significant physical impact on some of the rivers, additional analysis was conducted to ascertain which rivers were affected and to what degree. A multivariate analysis of the macroinvertebrate taxa was carried out, using multidimensional scaling on Bray Curtis similarity measures between samples (Fig. 16). Where the flood had an impact, it would be expected that the 2010 samples would be quite different in terms of composition when compared with other years. This appears to be the case in the Lodge, Rough and Cottage rivers, where the 2010 samples cluster separately to all other years. The diversity in these three rivers was lower in 2010 than in previous years, with *B. Rhodani* being the dominant species in all rivers (Fig. 17).

Acknowledgements

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Table 1. Macroinvertebrate taxa sampled from the Burrishoole and Owengarve catchments, 2003-2010

Order		2003	2004	2005	2006	2007	2008	2009	2010
Total Taxa		**61**	**83**	**62**	**37**	**44**	**40**	**63**	**57**
Acari	Hydracarina	x	x	x		x			x
Amphipoda	Gammarus duebenii	x	x	x	x	x	x	x	x
Coleoptera	Coleoptera			x			x	x	x
	Colymbetinae							x	
	Dryopidae		x			x			x
	Dytiscidae	x	x			x		x	
	Elmis aenea	x	x	x	x	x	x	x	x
	Esolus parallelepipedus	x	x	x		x	x	x	x
	Gyrinidae		x						x
	Helodidae	x	x	x	x	x		x	x
	Hydraenidae	x		x					x
	Hydroporinae		x	x	x	x		x	x
	Hygrobiidae		x						x
	Laccophilus sp.							x	
	Limnius volckmari	x	x	x	x	x	x	x	x
	Noteridae						x		
	Oulimnius tuberculatus	x	x	x		x		x	x
	Stenelmis canaliculata		x						
Collembola	Collembola	x	x					x	
Diptera	Chironomidae	x	x	x		x	x	x	x
	Chironominea	x	x	x	x	x	x	x	x
	Culicidae	x	x	x	x				
	Dicranota	x	x	x	x	x	x	x	x
	Diptera	x		x				x	x
	Orthocladinae	x	x	x	x	x	x	x	x
	Ptychopteridae		x						
	Simulidae	x	x	x	x	x	x	x	x
	Tabanidae		x	x					x
	Tanypodinae	x	x	x	x	x	x	x	x
Ephemeroptera	Baetis atrebatinus	x				x			
	Baetis rhodani	x	x	x	x	x	x	x	x
	Baetis sp.					x	x	x	
	Caenidae			x				x	
	Caenis macrura	x							
	Caenis rivulorum	x	x		x	x			
	Caenis horaria		x						
	Centrophilum luteolum		x	x					
	Ecdyonurus	x							x
	Ecdyonurus insignis	x	x						
	Ecdyonurus dispar		x	x				x	
	Ecdyonurus torrentis			x					
	Ecdyonurus venosus	x	x	x	x	x		x	

Table 1. (Cont.)

Order		2003	2004	2005	2006	2007	2008	2009	2010
Ephemeroptera	Ephemerella ignita	x	x	x	x	x		x	x
	Ephemerella notata		x	x					
	Ephemeroptera			x				x	x
	Heptagenia			x	x	x	x	x	x
	Heptagenia lateralis	x	x	x				x	
	Heptagenia sulphurea		x					x	x
	Heptagenidae		x				x		
	Leptophlebia	x	x					x	x
	Rhithrogena germanica			x			x		
	Rhithrogena semicolorata	x	x	x	x	x	x	x	x
Hemiptera	Veliidae		x					x	
Hirudinea	Hirudinea		x						
Mollusca	Ancylus fluviatilis	x		x					
	Hydrobia ulvae	x					x		
	Hydrobiidae			x					x
	Mollusca								x
	Pisidium			x	x		x		x
	Potamopyrgus jenkinsi	x	x		x	x			x
	Prosobranchia						x		
Odonata	Anisoptera			x					
Oligochaete	Oligochaete	x	x	x	x	x	x	x	x
Ostracoda	Ostracoda		x						
Platyhelminthes	Platyhelminthes	x							
Plecoptera	Amphinemura sulciollis	x	x	x	x	x		x	x
	Chloroperla torrentium	x	x	x	x	x	x	x	x
	Diura bicaudata	x							x
	Isoperla grammatica	x	x	x	x	x	x	x	x
	Leuctra hippopus	x	x	x	x	x	x	x	x
	Leuctra inermis	x	x					x	x
	Leuctra fusca		x	x				x	
	Nemoura cinerea		x		x	x		x	x
	Perla bipunctata		x					x	
	Perlodes microcephala		x						
	Perlodidae		x						
	Plecoptera			x					x
	Protonemura meyeri							x	x
Trichoptera	Agrypnia obsoleta						x		
	Allotrichia						x		
	Athripsodes		x				x		x
	Beraeidae	x							
	Cheumatopysche lepida		x						
	Cyrnus trimaculatus	x						x	
	Diplectrona felix	x	x					x	x
	Ecnomus tenellus		x						
	Economidae	x		x				x	x
	Glossosoma	x	x						

Table 1. (Cont.)

Order		2003	2004	2005	2006	2007	2008	2009	2010
Trichoptera	Glossosoma boltani	x							
	Glossosomatidae		x	x					
	Goera pilosa							x	
	Halesus radiatus							x	
	Holocentropus sp.							x	
	Holocentropus dubius	x	x	x	x			x	
	Hydropsyche contubernalis	x	x					x	x
	Hydropsyche siltalai	x	x	x	x	x	x	x	x
	Hydropsychidae			x					
	Hydroptila	x	x	x	x	x	x		x
	Lepidostomatidae		x		x	x	x	x	
	Limnephilidae		x	x			x		x
	Lype phaeopa	x	x			x		x	
	Metalype fragilis	x	x	x	x		x		x
	Odontocerum albicorne		x						
	Philopotamidae			x					
	Philopotamus montanus	x	x						
	Phryganea			x					
	Phryganeidae			x					
	Plectrocnemia	x	x						x
	Plectrocnemia conspersa				x	x	x	x	
	Polycentropidae		x	x				x	
	Polycentropus flavomaculatus	x	x	x	x	x	x	x	
	Polycentropus kingi	x	x				x	x	x
	Polycentropus irroratus		x						
	Psychomyia pusilla	x	x	x	x	x	x	x	
	Psychomyidae	x	x	x					
	Rhyacophila dorsalis	x	x	x	x	x	x	x	x
	Rhyacophila munda		x						
	Rhyacophilidae			x					
	Sericostomatidae		x			x			
	Silo pallipes	x	x	x	x	x		x	x
	Tinodes dives		x						
	Tinodes muculicornis		x						
	Tinodes sp.					x			
	Tinodes waeneri		x		x	x		x	
	Trichoptera	x	x	x	x	x	x	x	x
	Wormaldia occipitalis								x
	Neureclipsis bimaculata						x	x	

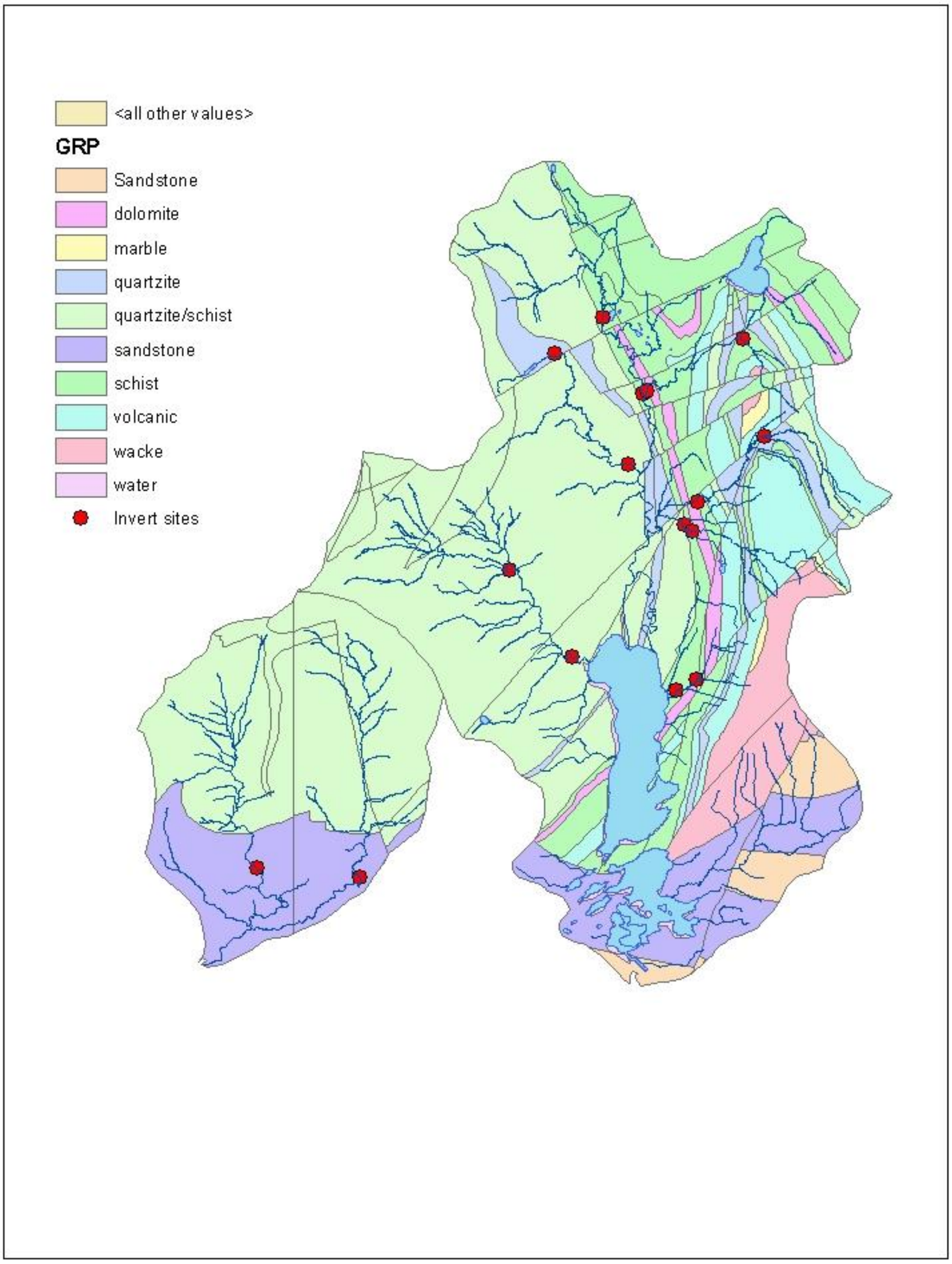


Figure 1: Geology of the Burrishoole and Owengarve catchments, and location of macro-invertebrate sampling sites.

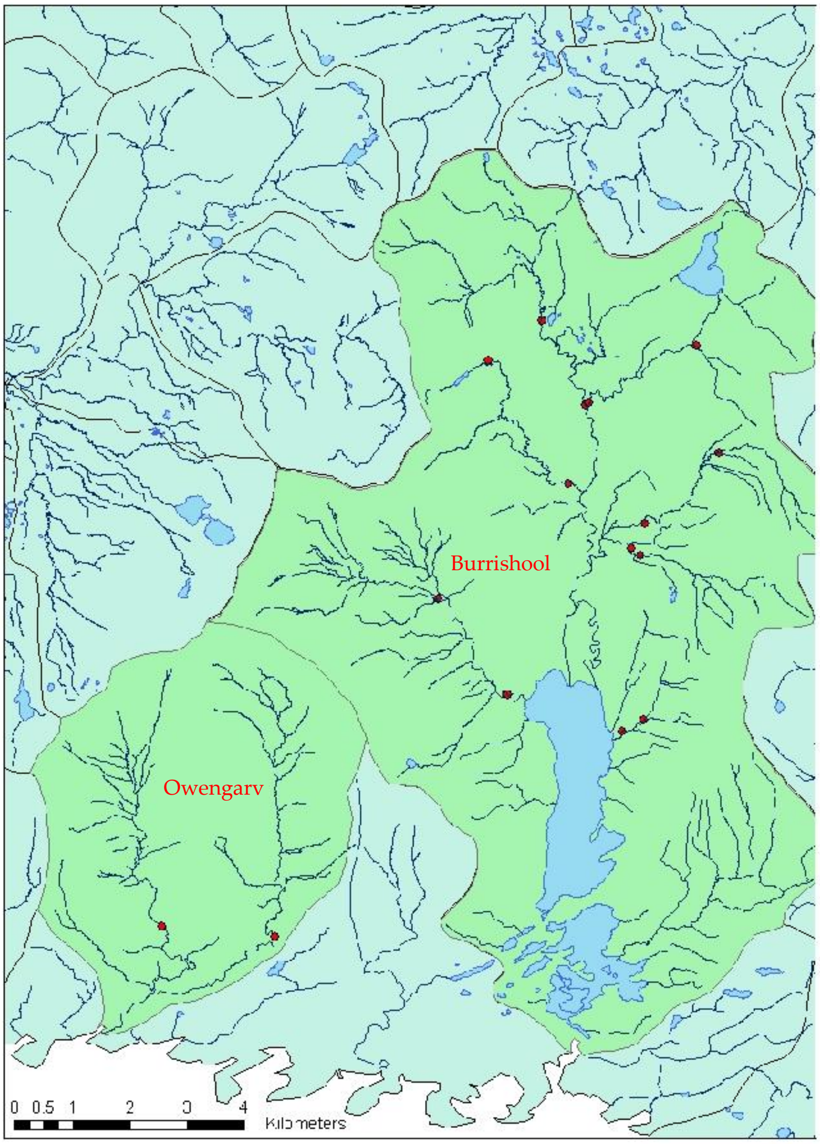


Figure 2: Macro-invertebrate sampling sites in the Burrishoole and Owengarve catchments included in the biological monitoring programs 2003-2007.

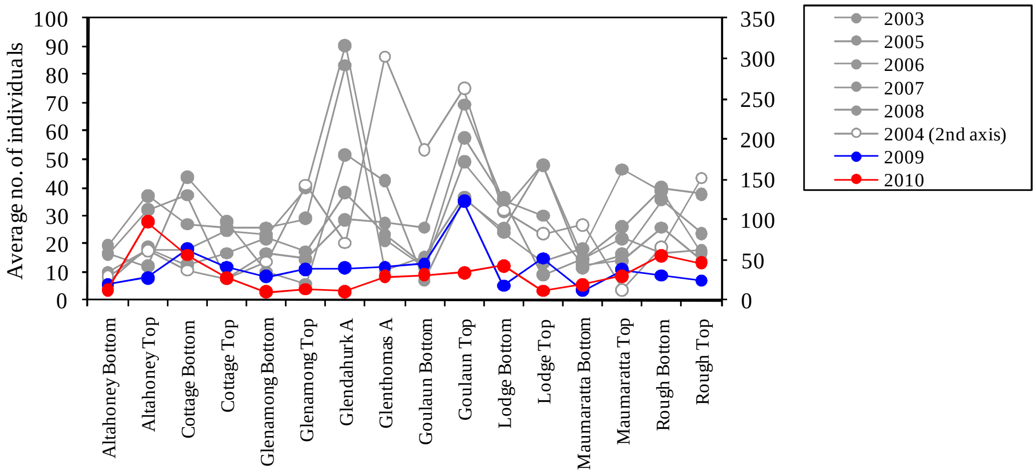


Figure 3: Average number of macroinvertebrates found in a 1ft sq surber sample in the Burrishoole and Owengarve catchments 2003-2010. N.b. 2004 values are on the secondary axis. The average is calculated from 3 replicate samples.

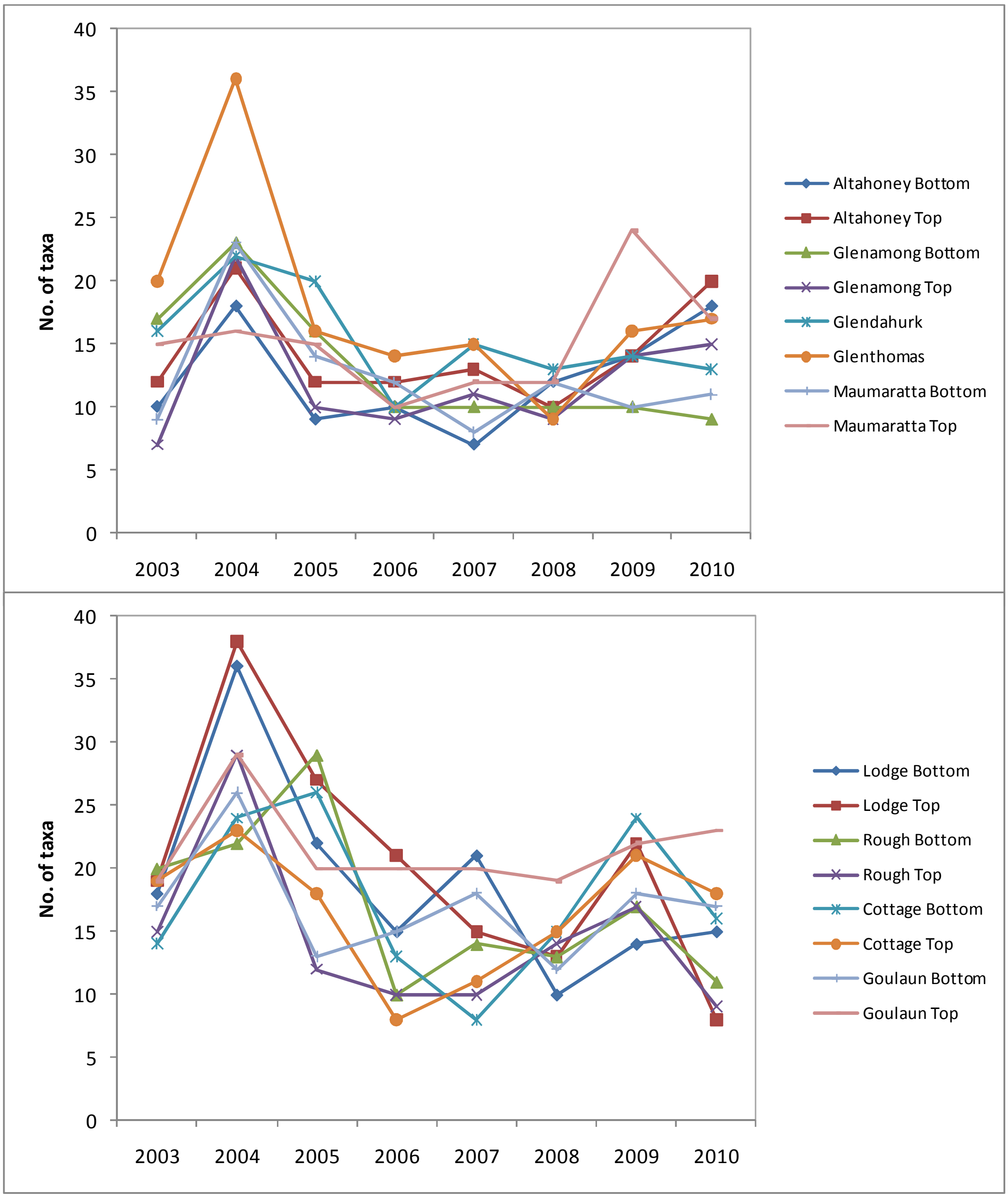


Figure 4: Number of macroinvertebrate taxa found in 1ft sq surber samples in the Burrishoole and Owengarve catchments 2003-2010.

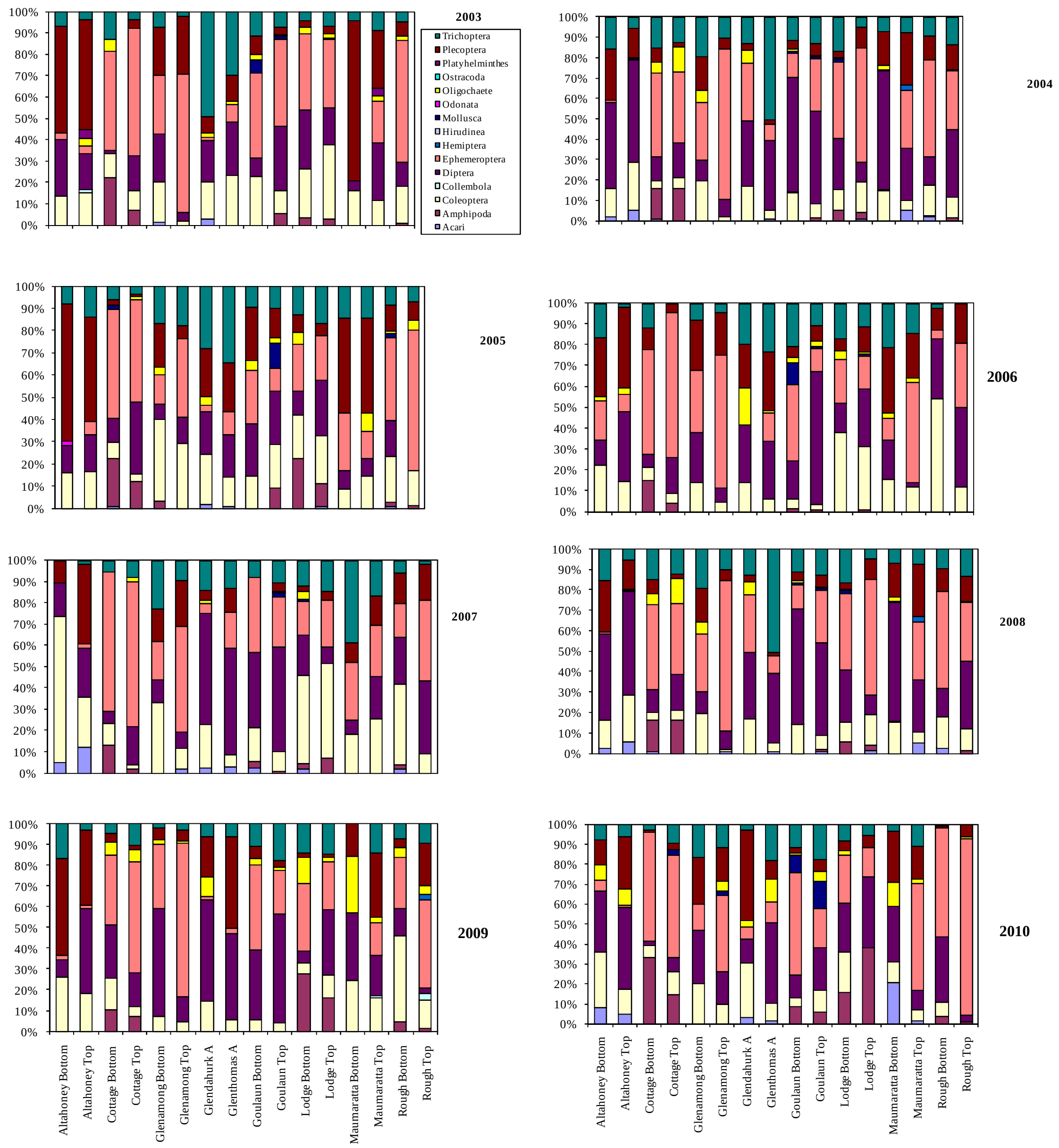
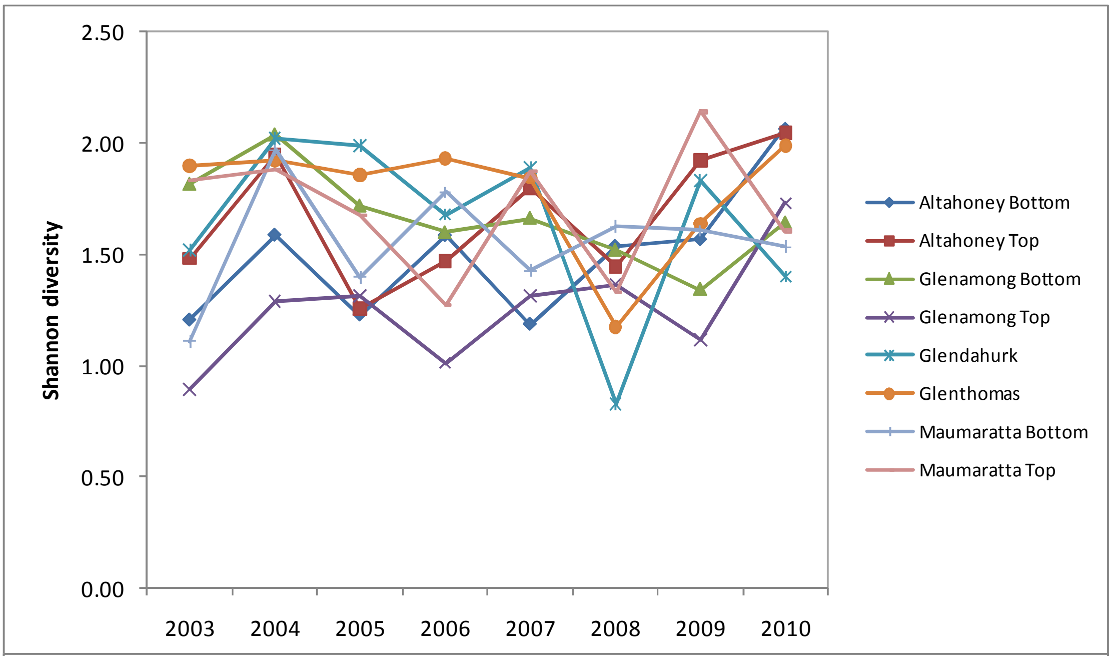


Figure 5: Proportional abundances of the most common orders of macroinvertebrates found in the Burrishoole and Owengarve catchments, sampled between 2003 and 2010



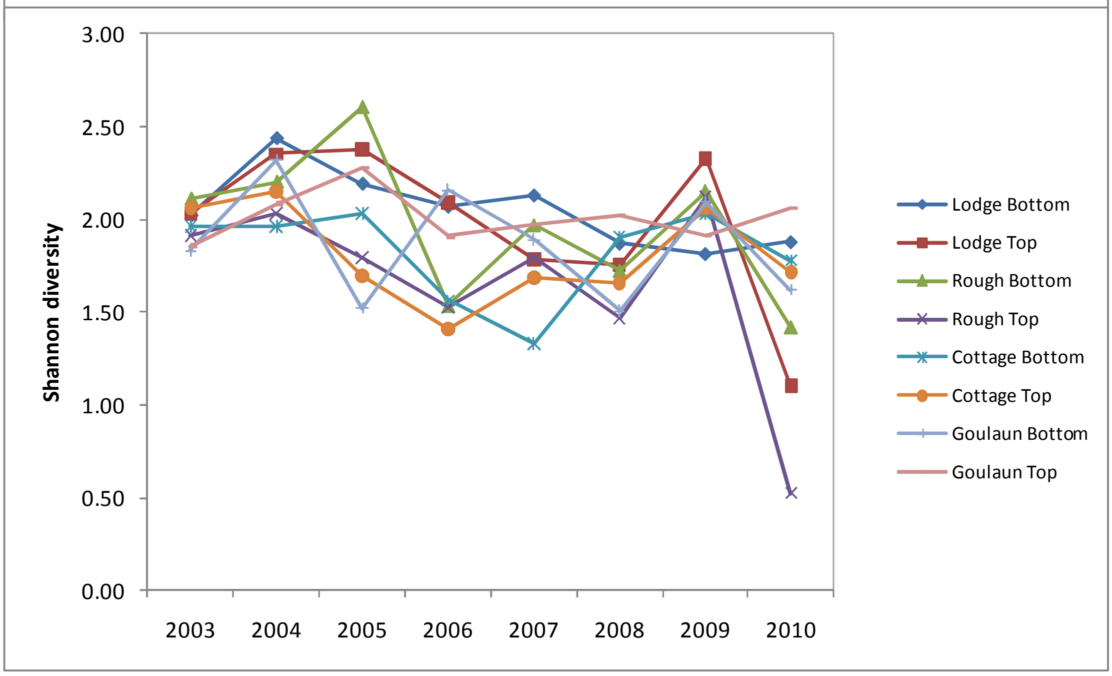


Figure 6: Shannon diversity index calculated for macroinvertebrates sampled from the Burrishoole and Owengarve catchments 2003-2010.

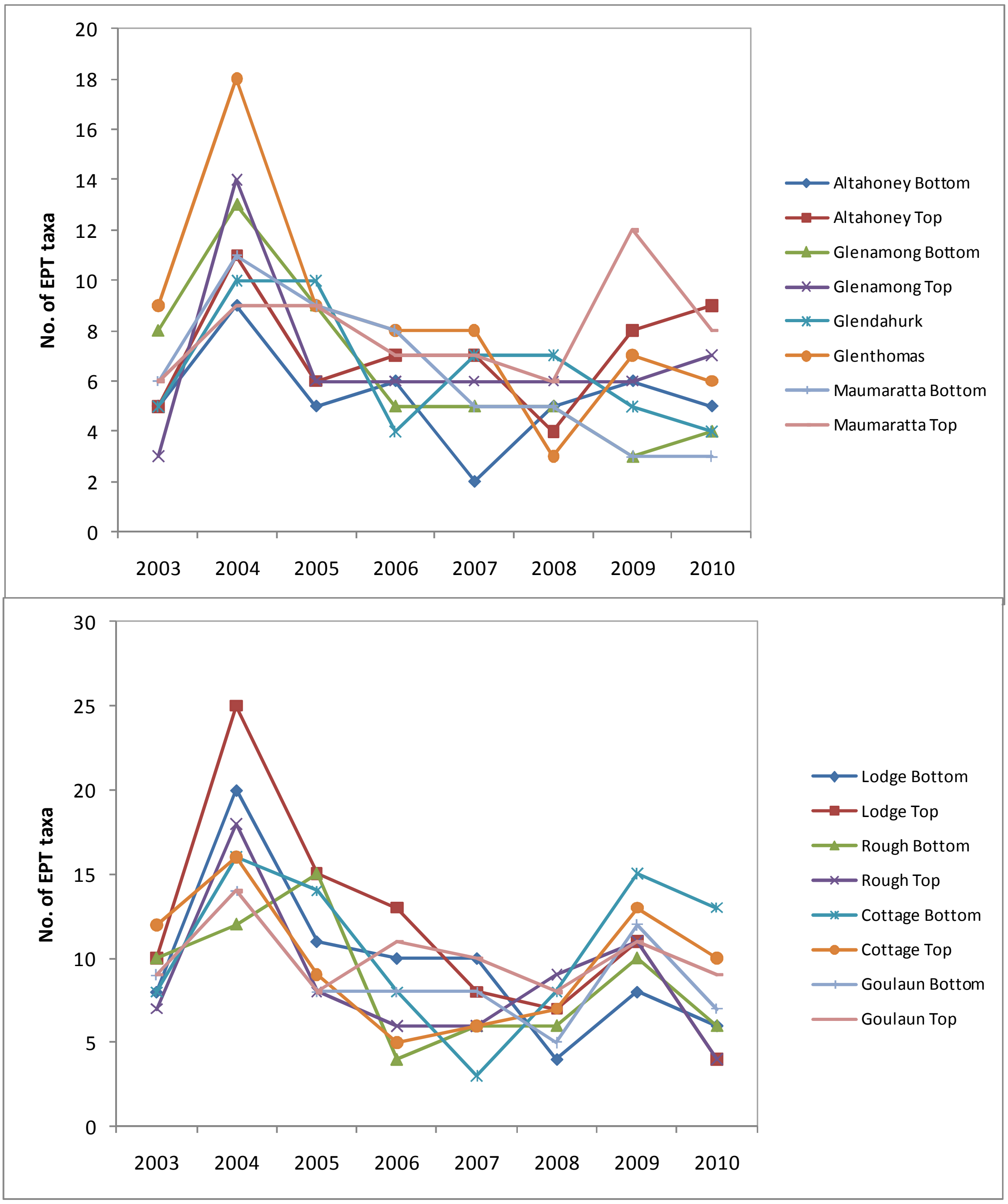


Figure 7: Number of EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa calculated for macroinvertebrates sampled from the Burrishoole and Owengarve catchments 2003-2010.

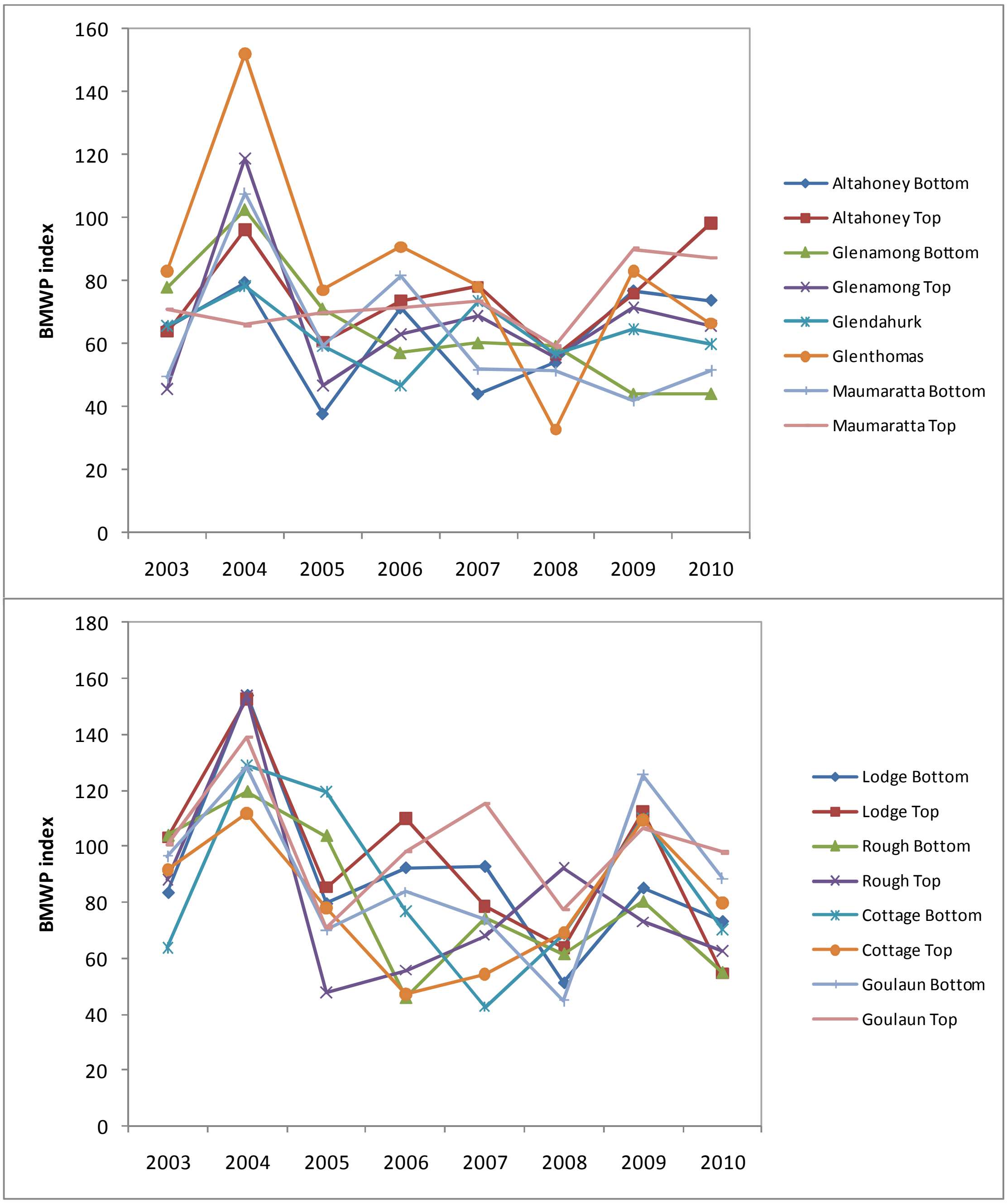
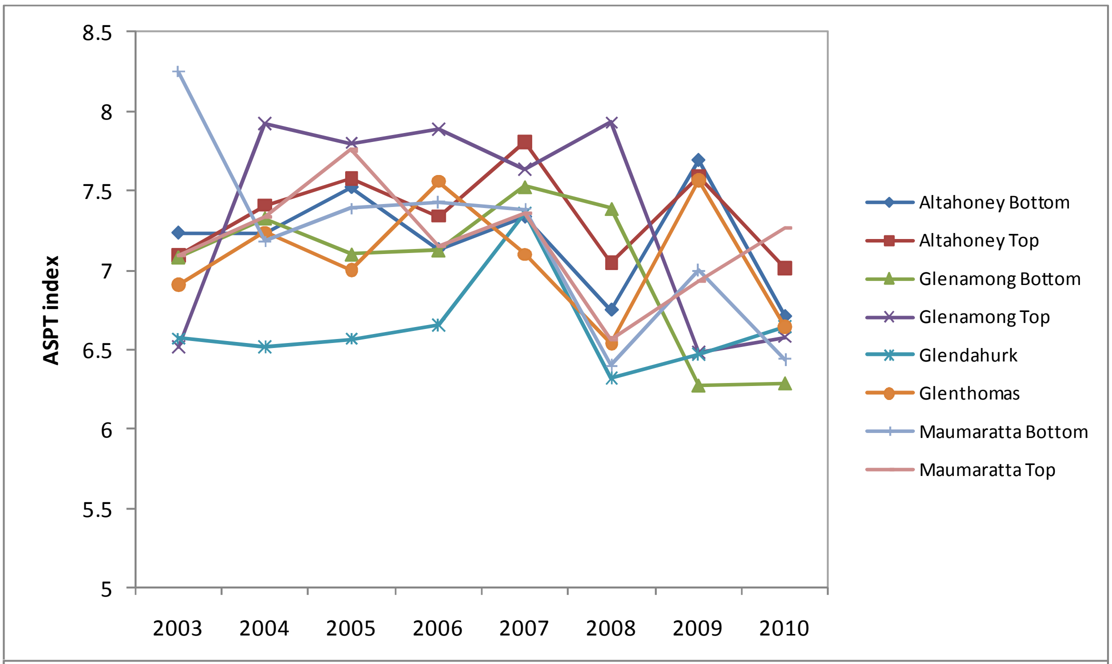


Figure 8: BMWP calculated for macroinvertebrates sampled from the Burrishoole and Owengarve catchments 2003-2010.



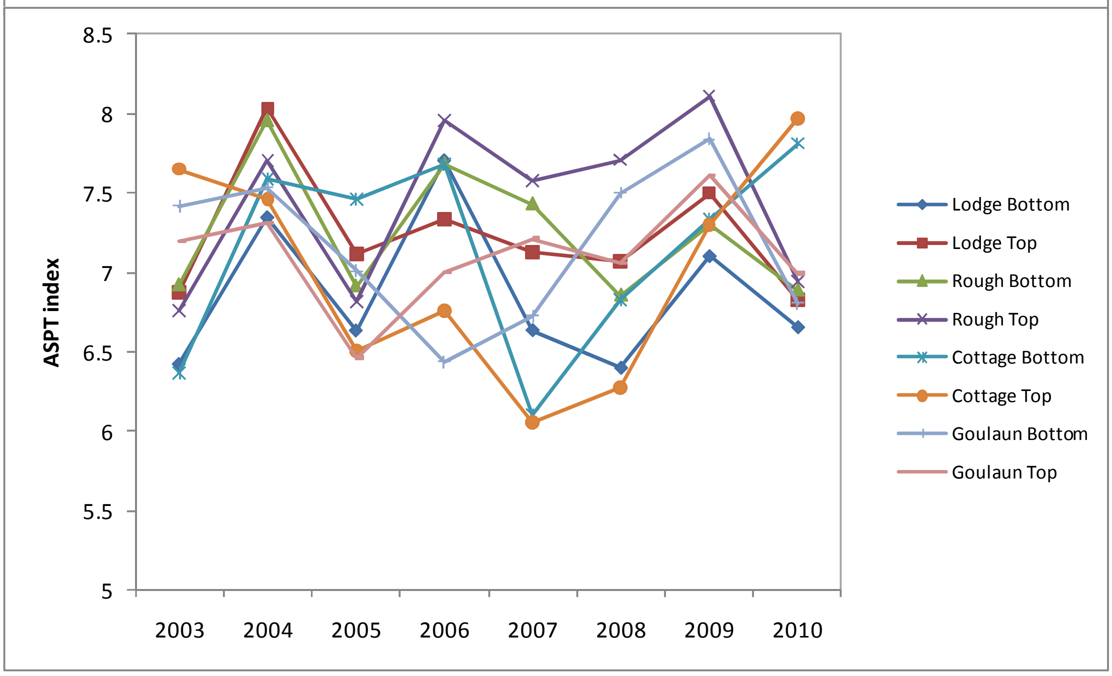


Figure 9: ASPT calculated for macroinvertebrates sampled from the Burrishoole and Owengarve catchments 2003-2010.

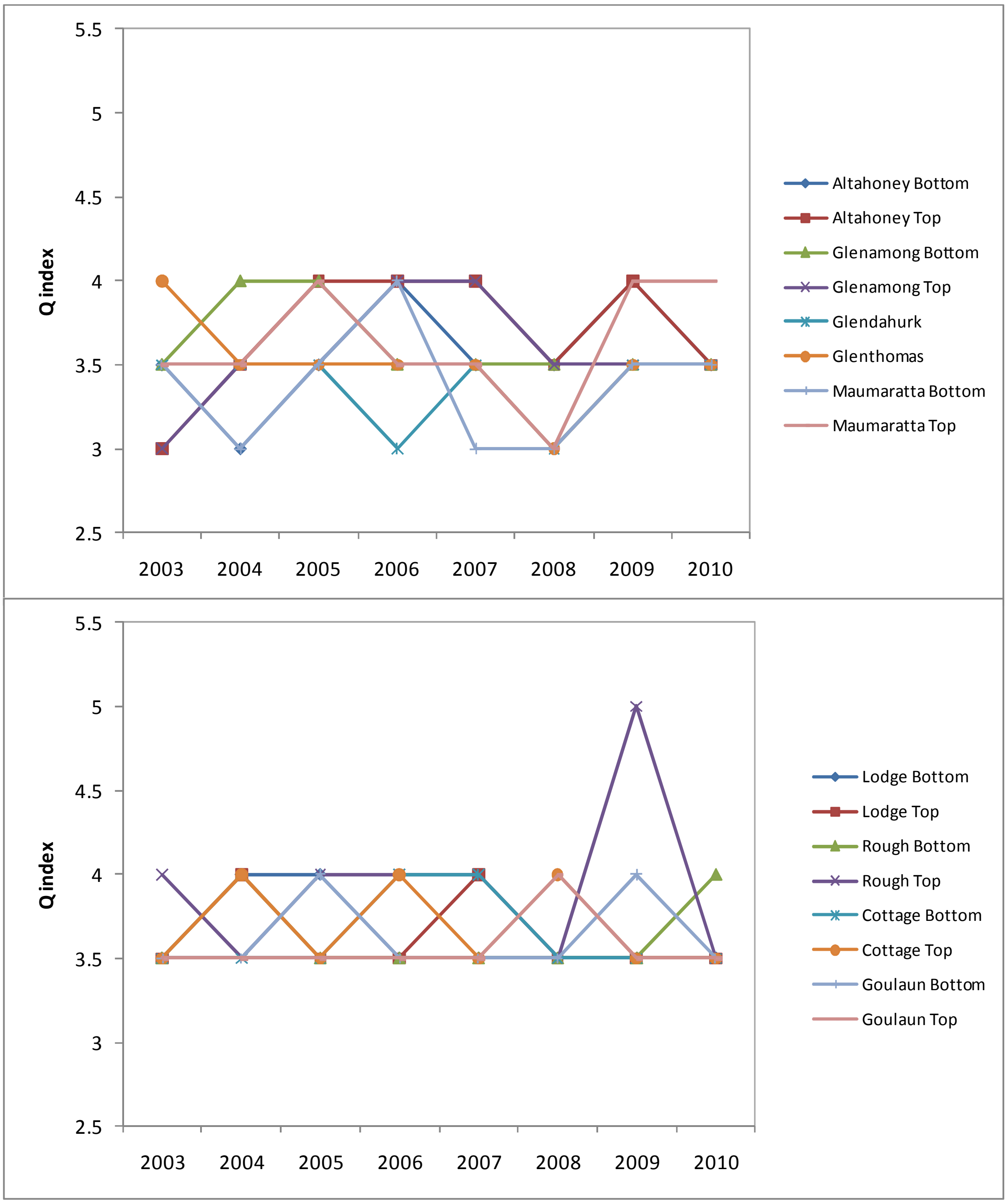
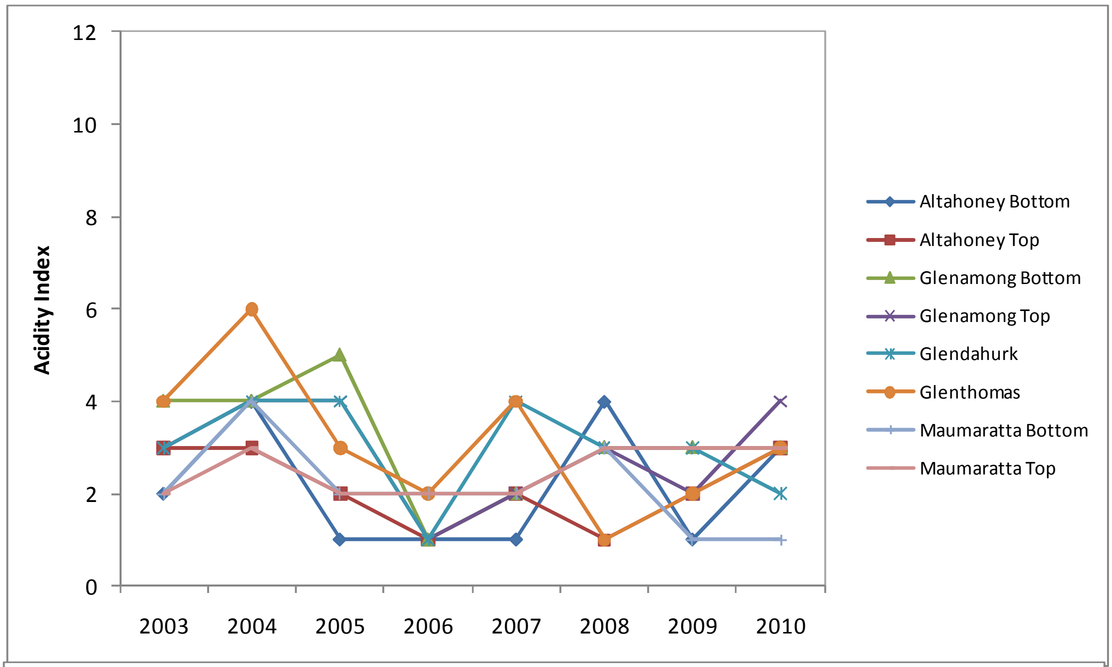


Figure 10: Q index calculated for macroinvertebrates sampled from the Burrishoole and Owengarve catchments 2003-2010.



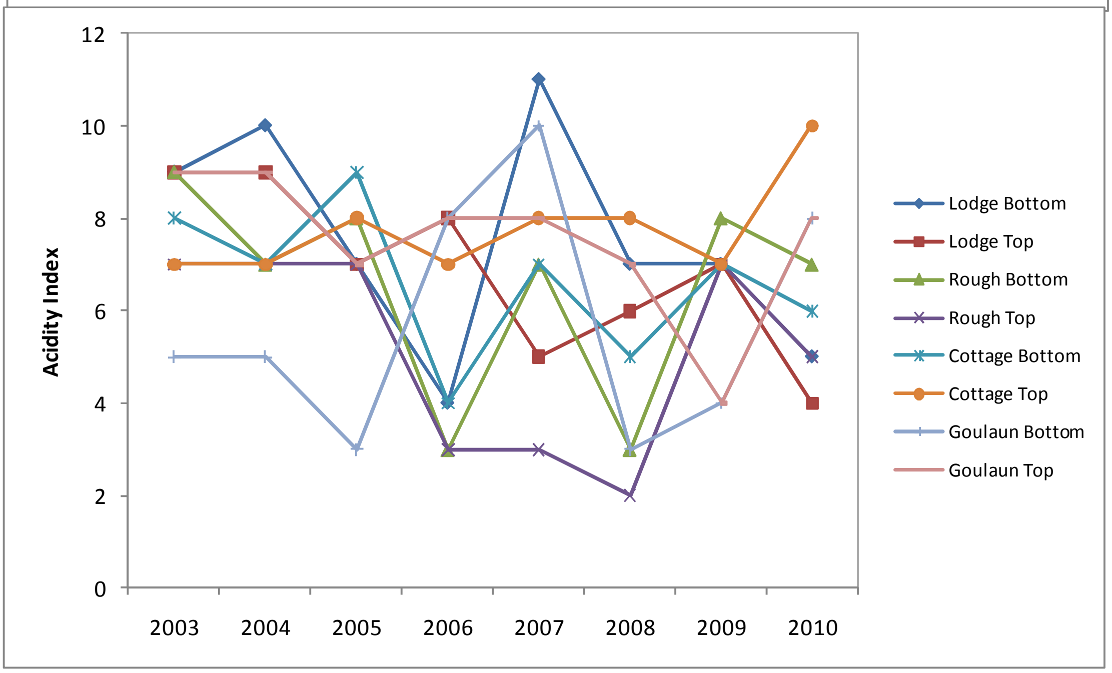


Figure 11: SI acidity index calculated for macroinvertebrates sampled from the Burrishoole and Owengarve catchments 2003-2010.

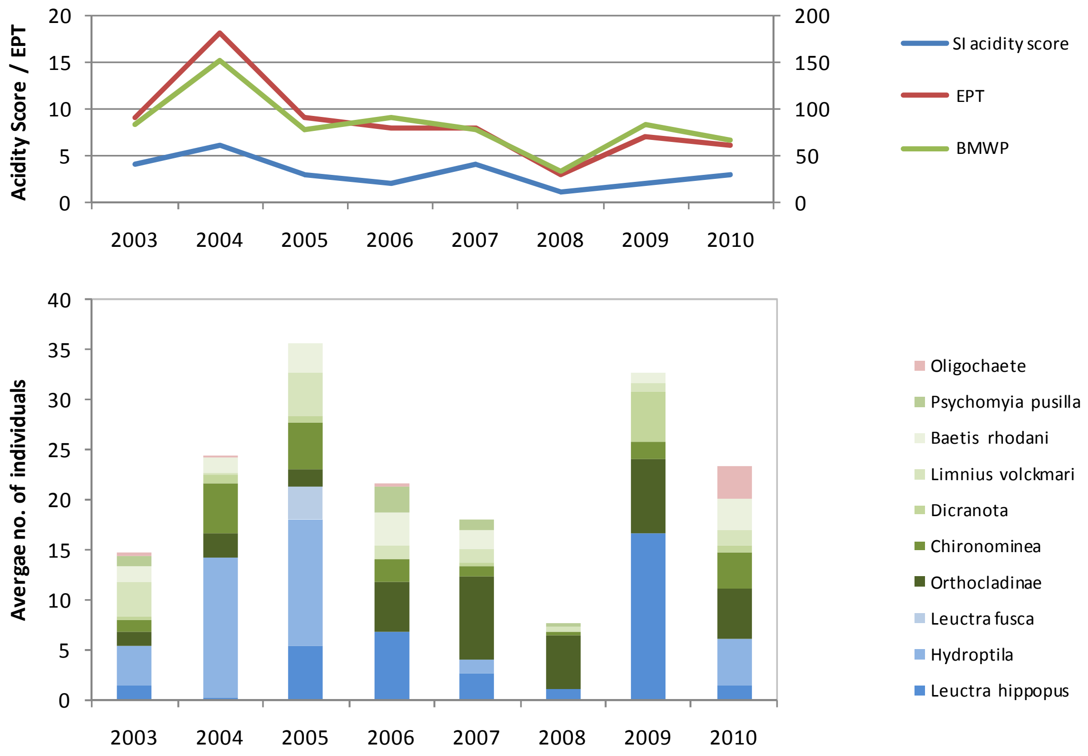


Figure 12: Average abundance of the most common species at the Glenthomas index site 2003-2010 (bottom) and corresponding acidity score and number of EPT taxa (top). The abundance values for 2004 have been divided by ten to allow graphical representation.

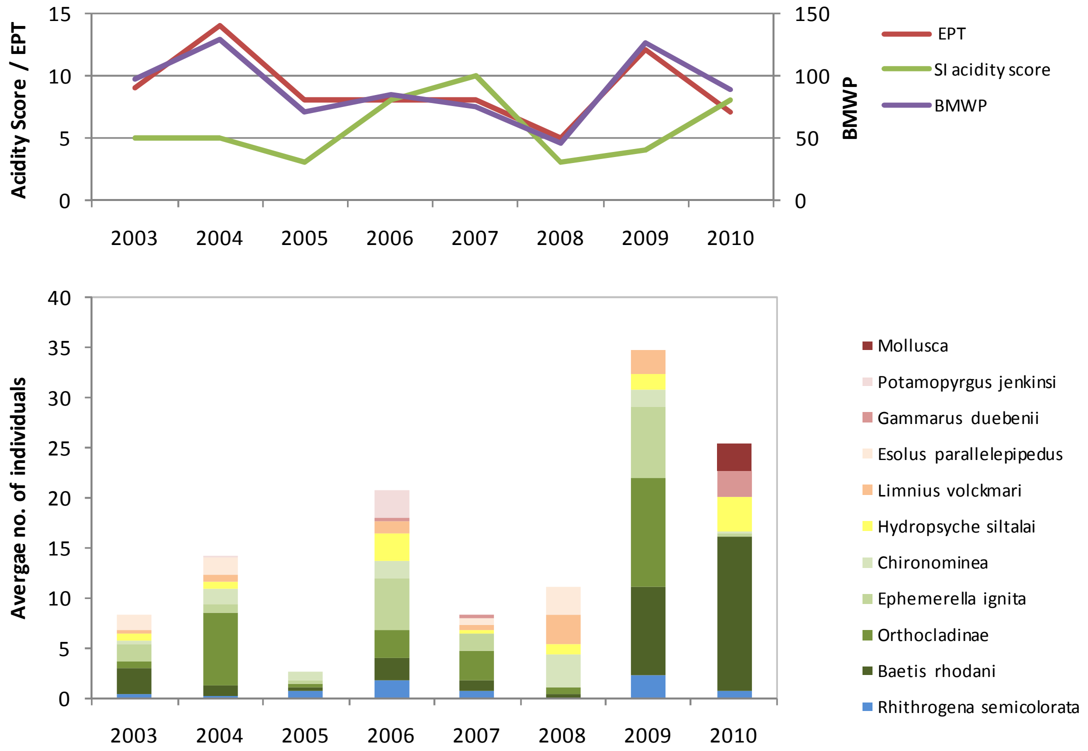


Figure 13: Average abundance of the most common species at the index site at the bottom of the Goulaun river 2003-2010 (bottom) and corresponding acidity score, number of EPT taxa and BMWP index (top). The abundance values for 2004 have been divided by ten to allow graphical representation (red asterix).

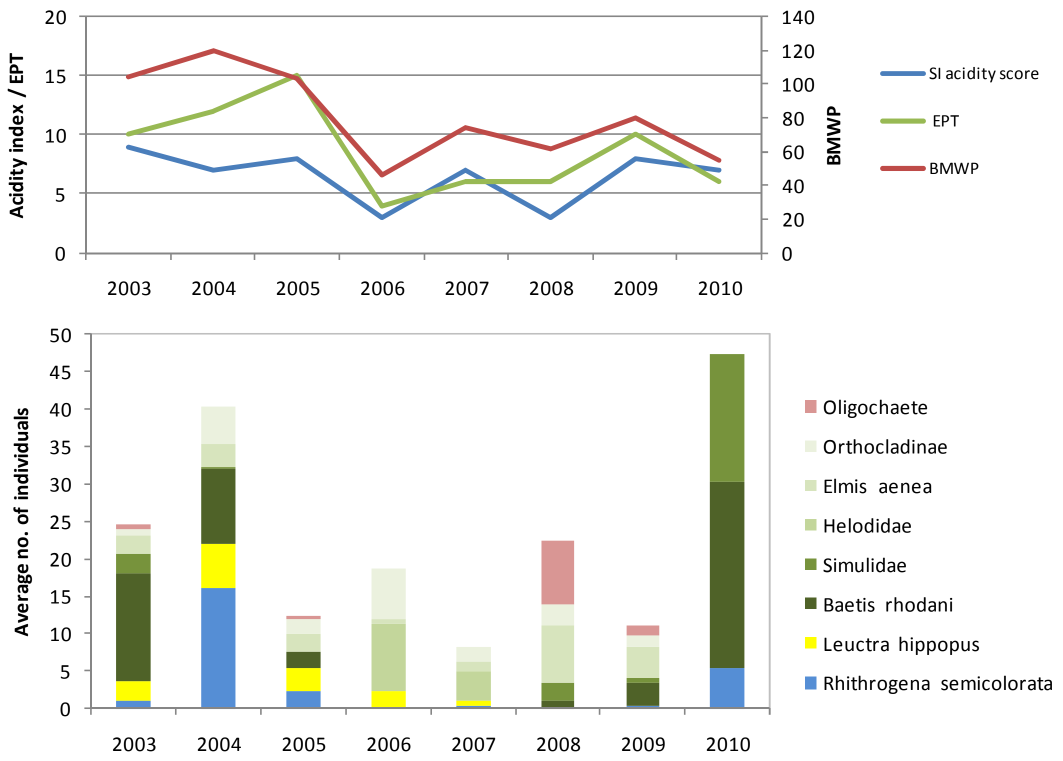


Figure 14: Average abundance of the most common species at the index site at the bottom of the Rough river 2003-2010 (bottom) and corresponding acidity score, number of EPT taxa and BMWP index (top).

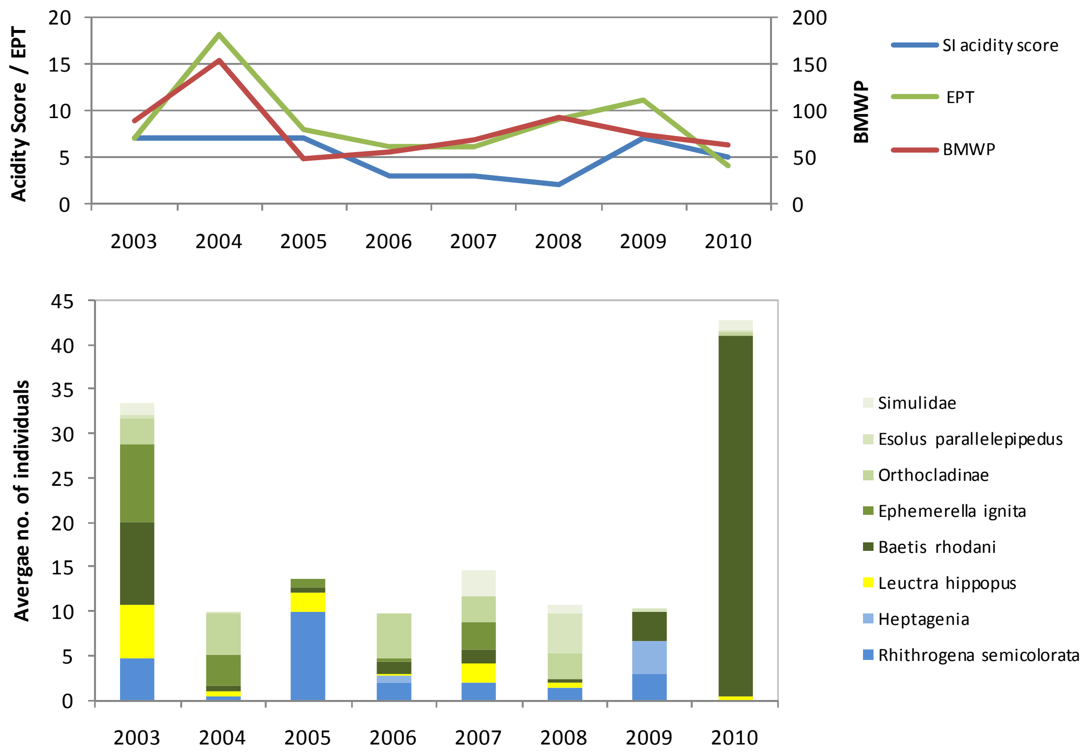


Figure 15: Average abundance of the most common species at the index site at the top of the Rough river 2003-2010 (bottom) and corresponding acidity score, number of EPT taxa and BMWP index (top). The number of individuals in 2004 was divided by ten to allow graphing

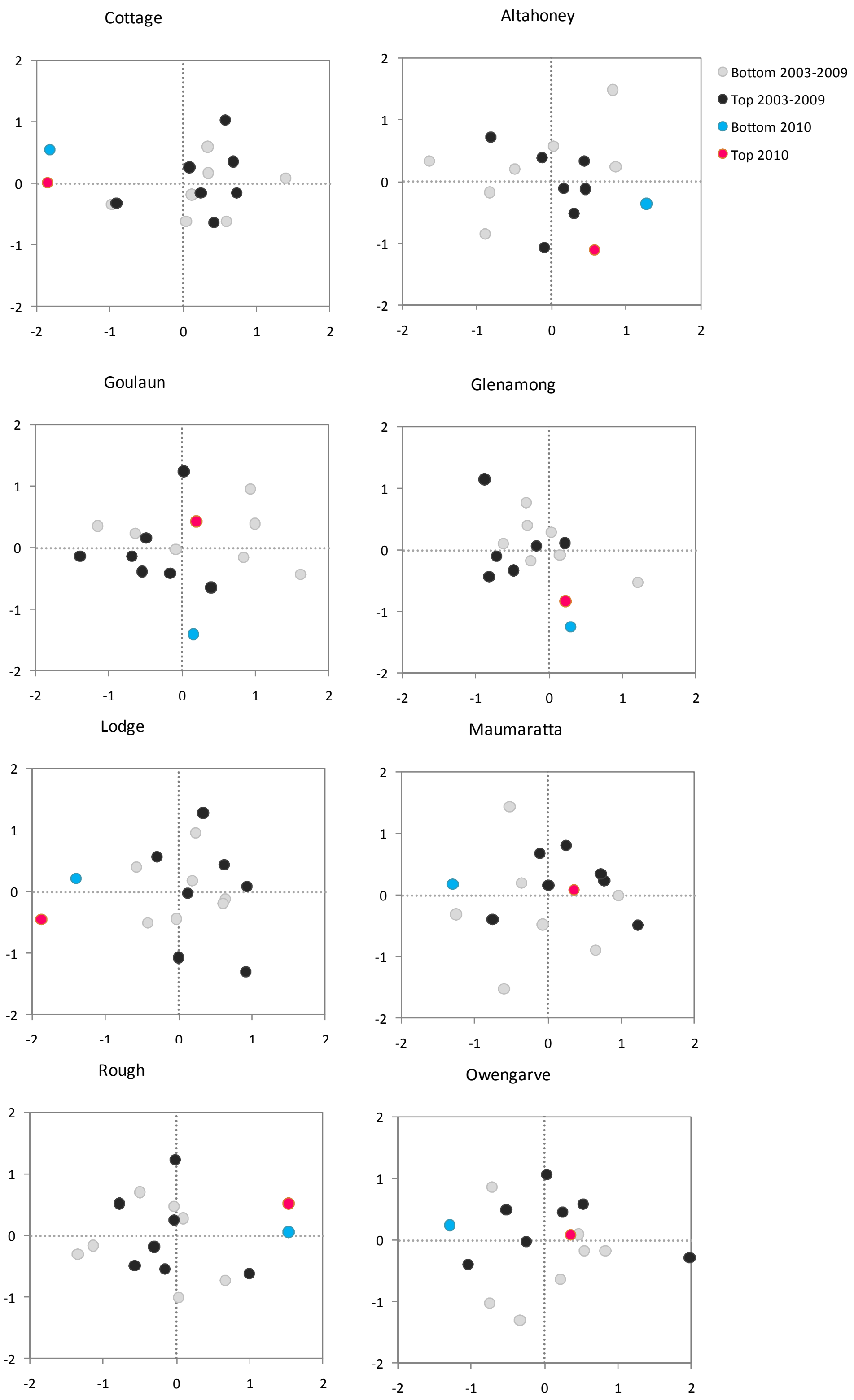


Figure 16: MDS plots of macroinvertebrate samples taken from rivers in the Burrishoole and Owengarve catchments between 2003 and 2010. Each dot represents an average community from three replicates. Abundances were square root transformed and the Bray-Curtis similarity index was calculated between years. Stress was less than 0.2 in all cases.

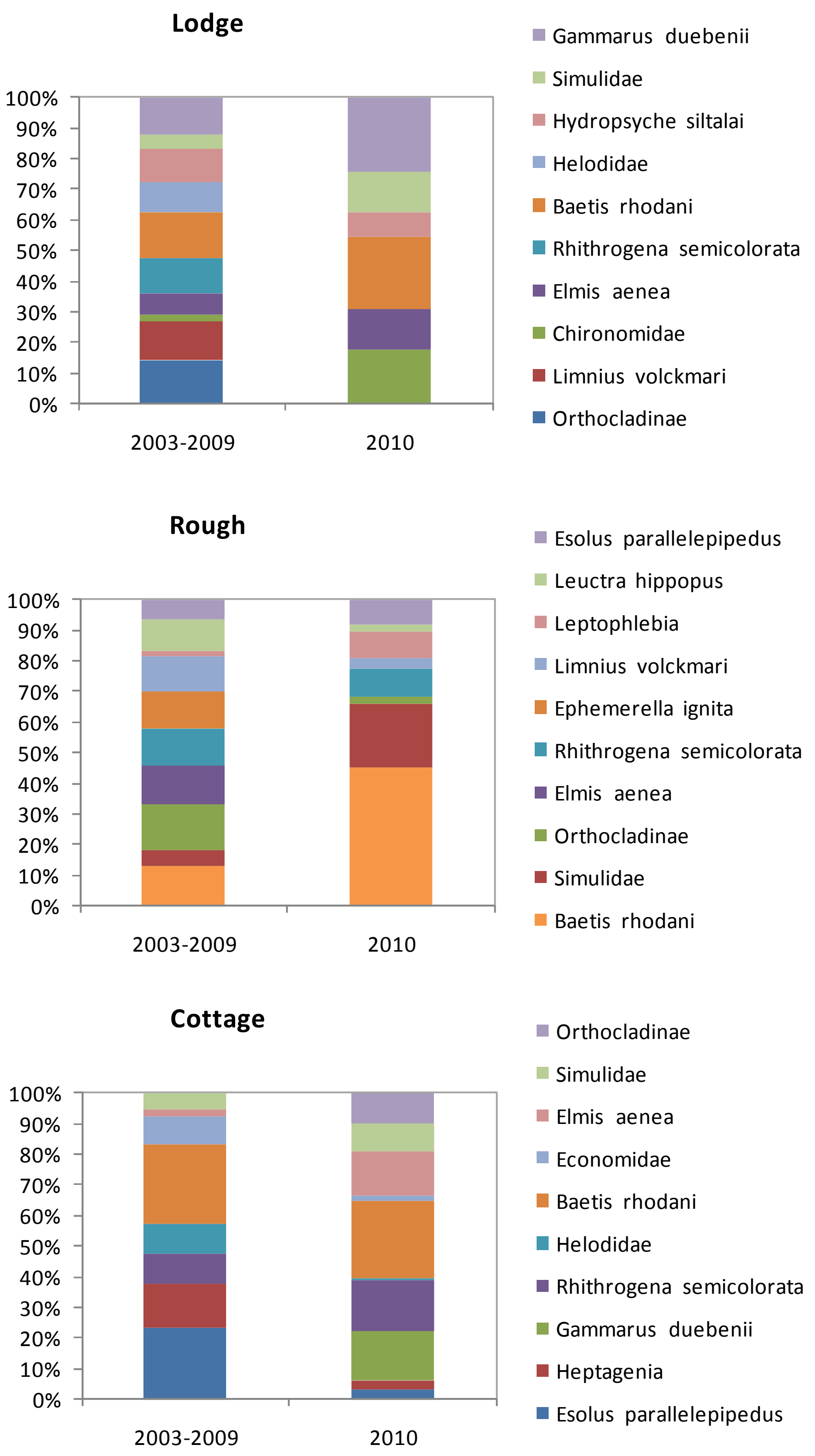


Figure 17: Macroinvertebrates communities occurring in three rivers before (2003-2009 average) and after (2010) a large flood in July 2009.