Marine Institute
Foras na Mara

Newport Research Facility

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Report for the year ended 31st December 2003

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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Marine Institute – Newport Research Facility

Report for the year ending 31st December 2003

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SUMMARY

1. The Salmon Research Agency of Ireland merged with the national 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 was 1353.2 mm in 2003 – Months of relatively high rainfall in 2003 were January, May, July and November with low rainfall in February, March, April, June, August and September.

3. The total release of microtagged salmon smolts of Burrishoole reared origin into L. Furnace amounted to 25,100. Smolts were released as six groups, averaging 60g in weight. A further 37,900 smolts were released as six 'experimental' groups. The groups were part of a contract study with NUIG

4. In association with Cong, Delphi and Parteen hatcheries the MI co-ordinated the sale of 724,000 salmon ova to Germany for the Rhine Rehabilitation Programme.

5. A total of 544 wild grilse were recorded moving upstream through the permanent traps during the season. The number of spring fish recorded in the upstream traps was 18. The total run of wild grilse, including the Lough Furnace rod catch, was 547.

6. A total of 7248 wild salmon smolts were recorded in the downstream trap in 2003. The return to freshwater of the Burrishoole reared grilse recorded was 3.0%. The wild grilse return, at 6.5%, was lower than that recorded in 2002 (10.2%), but the same as in 2001.

7. The ova to smolt survival at 0.70 – 0.79, was similar to that recorded in 2001.

8. A total of 78 wild sea trout and a further 40 non-silvered trout migrated upstream through the traps in 2003. Of the sea trout, 19 were adults and 59 (76%) were finnock. The 2003 smolt run amounted to 787 smolts.

9. The percentage of smolts returning as finnock in the same year has historically ranged form 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 – the highest return rate since 1986. Finnock return in 2003 was at 5.1%.

10. Silver eel trapping continued with the total run amounting to 3919 with 70% of the run trapped in October.

11. A total of 59 salmon were caught in the Fishery in 2003. The catch consisted of 37 wild fish and 22 reared salmon. Of the 37 wild fish caught, 34 were returned alive to the water and 3 were killed. There was a minimum of 16 sea trout caught on L. Furnace and returned alive.

12. Two invertebrate surveys were carried out in 2002 and 2003. In 2002, a comparison was made between surveys in the 1950's & 60's with data from 2002. There were significant differences between the two periods with the sites in 2002 showing significant impact from afforestation.

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 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 33 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.

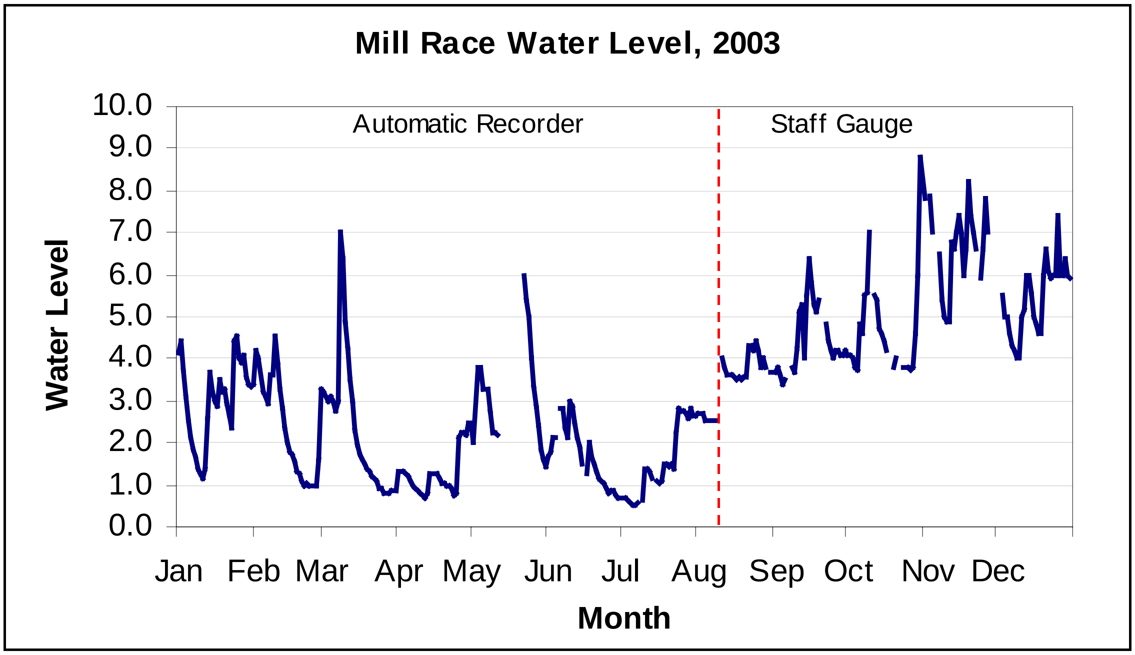


Figure 1. Water levels recorded in the Mill Race.

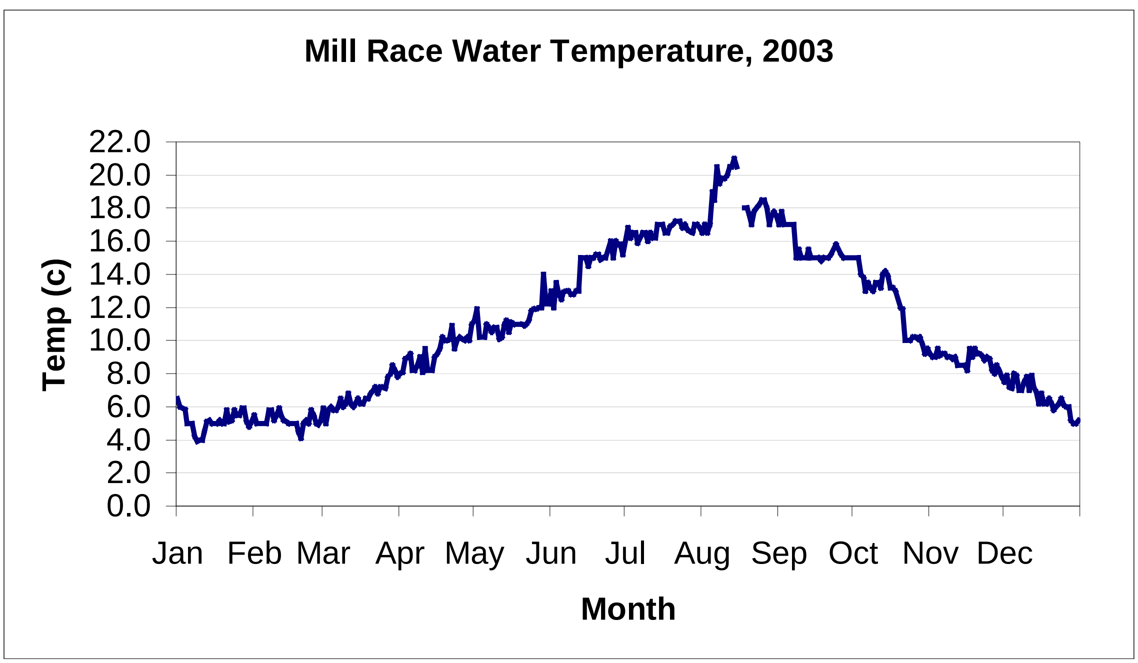


Figure 2. Water temperatures recorded in the Mill Race at midnight.

2 Meteorological Data
2.1 Mill Race Data

Daily meteorological data were collected during 2003 at the Met Station in Furnace. The monthly rainfall figures for 2000, 2001, 2002 and 2003 are given in Table 1, along with the annual totals for 1977 to 2003. Months of relatively high rainfall in 2003 were January, May, July and November with low rainfall in February, March, April, June, August and September. The total rainfall was 1353.2 mm in 2003.

Table 1. Monthly rainfall totals (mm) for the Furnace Station in 2000, 2001, 2002 and 2003 and the annual totals for 1977 to 2003.

Month	2000	2001	2002	2003	Year	Total
January	133.2	93.4	163.8	130.7	1977	1579.7
February	223.6	90.8	261.2	90.4	1978	1592.2
March	123.2	94.0	97.4	90.2	1979	1653.3
April	115.9	97.8	111.5	66.2	1980	1792.1
May	80.2	51.3	118.9	168.8	1981	1646.8
June	87.4	110.2	152.0	72.7	1982	1609.6
July	56.6	100.9	78.5	102.0	1983	1495.9
August	182.9	169.0	115.8	53.5	1984	1556.6
September	150.0	62.3	38.6	96.6	1985	1584.1
October	299.8	154.5	203.9	110.7	1986	1886.9
November	211.7	170.0	230.3	194.8	1987	1373.6
December	168.7	104.5	144.0	146.6	1988	1715.2
					1989	1583.9
					1990	1805.9
					1991	1549.6
					1992	1771.1
					1993	1473.4
					1994	1757.1
					1995	1382.5
					1996	1286.6
					1997	1351.6
					1998	1830.9
					1999	1949.1
					2000	1833.2
					2001	1298.7
					2002	1715.9
					2003	1353.2

Difficulties were experienced in 2003 with the automatic water level chart recorder. Readings were taken from the end of July using a staff gauge on the upper bridge over the Mill Race. The staff gauge will also be used for quantifying a new OTT water level recorder to be installed in February 2004. Water levels in 2003 largely reflected the monthly rainfall with high flows particularly in early March, late May and November. Levels were low in late March through April, late June, August and September. Water temperatures (recorded at midnight) fell to a minimum of only 3.9^{o}C in late January and hovered between 5 and 6 ^{o}C for January to early March.. There was a steady increase in temperature from early March to a maximum of 17.2^{o}C in early July. A hot spell in August saw water temperatures rise to 21^{o}C at night and 23^{o}C during the day. Temperature began dropping steadily for the rest of the year from the end of July back to a minimum of 5.0 ^{o}C in late December.

2.2 Catchment Programme

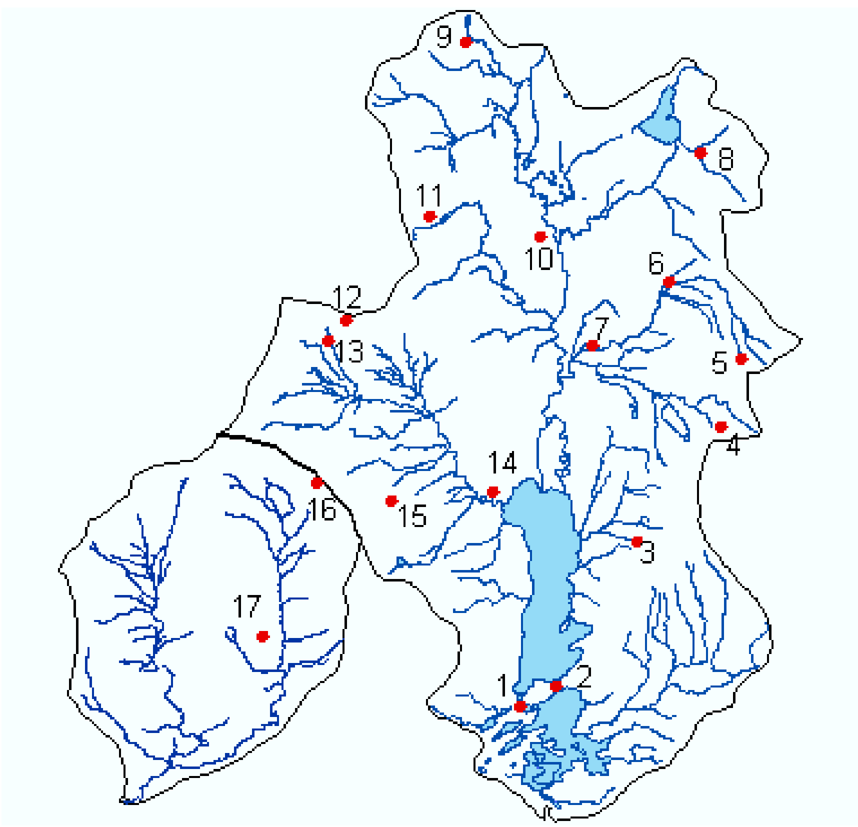
In recent years, the combined effect of extreme weather events, with impacts of land use, have had a significant effect on the erosion rates recorded in many upland areas. Since 1995 the Marine Institute has installed a series of automatic monitoring stations to monitor these impacts, and to attempt to quantify the transport of suspended sediments in the Burrishoole catchment. These automatic stations, funded under EU LIFE programmes, include a lake station (AWQMS – installed under EU LIFE 93), which has 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. These include seventeen data-logging rain gauges (Figure 3), which will assist in building up a detailed profile of precipitation in a mountainous catchment. Figure 4 shows annual total rainfall for the same stations. Even allowing for days when the gauges were not operating, the data clearly show the considerable variation in recorded rainfall between locations within relatively short geographic distances.

Also deployed 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.

A water level recorder and a rain gauge were installed in the Owengarve catchment, adjacent to Burrishoole, as part of a joint programme with Coillte. Coillte plan to begin harvesting timber from the Glendahurk valley in 2004 and this will provide baseline data pre-harvest. It is also planned to replant with a considerable proportion of native trees and the Institute will monitor the future changes in the flow regime.

Table 2 summarises rainfall for sixteen of the rain gauges. The data include the maximum daily rainfall recorded at each site. The maximum figure recorded was 69.8mm at the Altahoney gauge. This compares with 29.4mm for the Salmon Leap, 29.8mm for the Mill Race, and shows the variation that can be expected in a mountainous catchment. The Mill Race also houses a Met Eireann rain gauge. The table also notes the number of days each unit did not sample due to technical problems. Figure 4 shows the rainfall totals for the sixteen rain gauges. Locations with an asterisk are gauges that were installed in 2003, and so do not reflect the full year.



1.	Salmon Leap	10.	Altahoney
2.	Mill Race	11.	Maumaratta
3.	Buckogh	12.	Glenamong 1
4.	Lodge *	13.	Glenamong 2
5.	Srahrevagh 1	14.	Glenamong 3
6.	Srahrevagh 2	15.	Glenamong 4 *
7.	Srahrevagh 3	16.	Ridge
8.	Gaulaun	17.	Glendahurk *
9.	Namaroon *		

Figure 3. Rain gauge sites in the Burrishoole and Owengarve systems.

Table 2. Summary rainfall data for 16 rain gauge stations in the Burrishoole and Owengarve catchments.

Date	Total (mm)	Mean (mm)	Max (mm)	No. dry days	No. wet days	No. days not sampled	
Altahoney	**2143.8**	5.9	69.8	85	280	0	
Namaroon	**1513.2**	5.8	51.8	57	202	106	Installed 17/04/2003
Buckogh	**1472.6**	4.0	48.4	95	270	0	
Gaulaun	**1540.2**	4.2	44.6	83	282	0	
Glenamong 1	**1081.3**	4.0	60.8	72	195	98	
Glenamong 2	**1531.8**	4.5	41.0	81	257	27	
Glenamong 3	**1572.6**	4.3	37.4	105	260	0	
Glenamong 4	**1072.4**	5.8	35.6	38	146	181	Installed 01/07/2003
Glendahurk	**724.4**	4.2	27.0	43	128	194	Installed 14/07/2003
Maumaratta	**1667.4**	4.6	35.2	91	274	0	
Srahrevagh 1	**1438.8**	3.9	48.8	77	288	0	
Srahrevagh 2	**1307.8**	3.6	48.6	86	279	0	
Srahrevagh 3	**1043.6**	3.8	53.8	77	198	90	
Lodge	**832.6**	4.5	40.0	37	147	181	Installed 01/07/2003
Salmon Leap	**1052.4**	2.9	29.4	87	278	0	
Mill Race	**1088.0**	3.0	29.8	93	272	0	

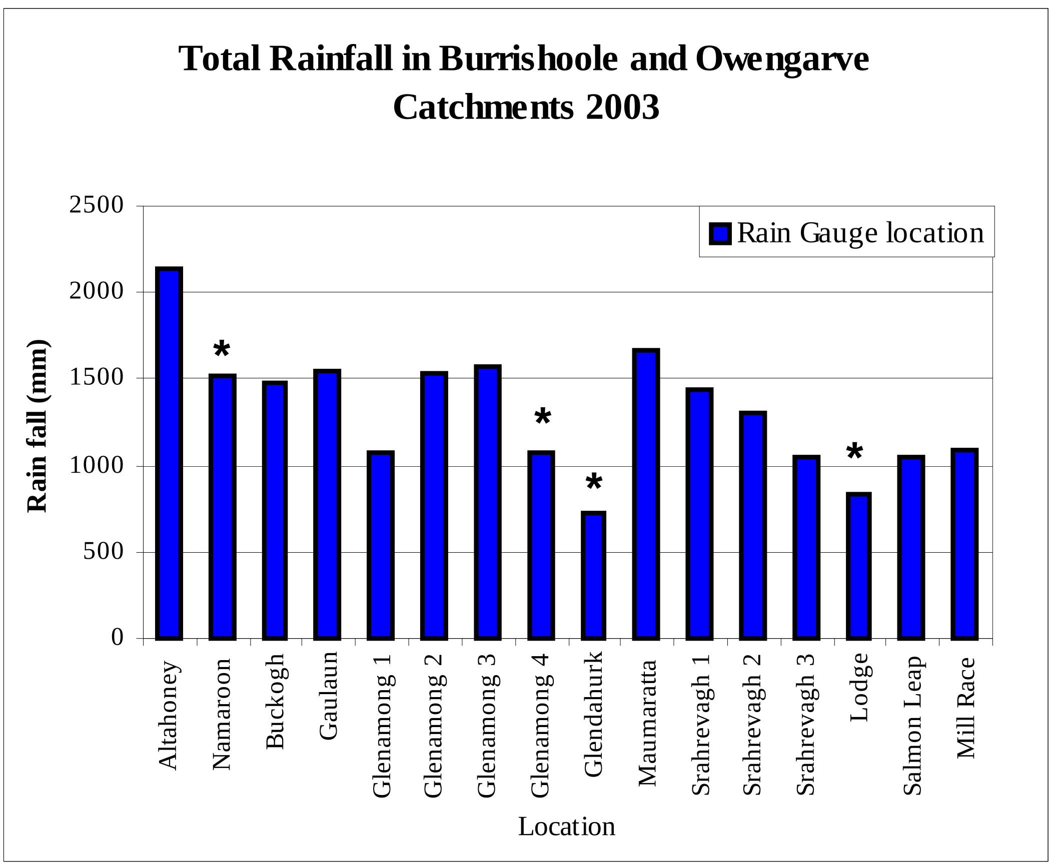


Figure 4. Rainfall totals for 16 rain gauge sites in the Burrishoole and Owengarve catchments.

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4 SALMONID REARING

4.1 Salmon Stocks 2002

4.1.1 Ranching

The total release of microtagged smolts of ranched Burrishoole grilse origin was 25,100. Smolts were released as six groups on 1st May 2003, averaging 60g in weight.

A three year partnership was initiated with the Department of Fisheries and Oceans, Canada to examine the effect of exposure of Atlantic salmon smolts to the endocrine disrupting substance nonylphenol, on their return as adult salmon to the Burrishoole system. Nonylphenol, and the larger group of nonylphenol ethoxylates, are in use in almost all commercial, industrial and domestic sectors. These compounds are members of the second largest class of non-ionic surfactants in use today, the alkylphenol polyethoxylates. Concentrations of these compounds occurring presently in the environment have been shown to have endocrine disruptive effects on fish in rivers and estuaries downstream of municipal sewage treatment works. Nonylphenol ethoxylates are also used in about 20-25% of all pesticide and herbicide formulations available today. Nonylphenol itself (4-nonylphenol) has been used in the past as a major constituent in certain pesticide formulations, some of which were applied in Canada. The current research indicating estrogenic effects on fish at low 4-nonylphenol levels (10 ug/L range) raises the potential that pesticide formulations containing nonylphenol ethoxylates and leaving residues in water may be capable of affecting fish. In salmon, endocrine hormones play an integral part in the smoltification process. Additional stress or modification of endocrine function at this crucial life stage may pose problems for growth and survival of smolts as they enter salt water. In the first of two releases, 13,500 smolts were released as 3 microtag groups.

Other ongoing programmes include use of the lice prevention treatment ‘SLICE’ to increase the smolt’s resistance to lice infestation in the first weeks at sea and a further release of smolts to Lough Feeagh to monitor fish survival and migration through the traps. A small number of salmon smolts were tagged with data storage tags and 102 fish were released. The tags used, weighing approximately 5g, were modified I-buttons temperature loggers manufactured by Alpha Mach, Quebec, Canada. The tags measure 2048 observations with a sampling interval of an hour and log measurements for three months. They can therefore log temperature information through the first few weeks at sea, thought to be crucial in terms of post smolt survival. The recovery of these fish carrying the DST should provide important information on Sea Surface Temperatures (SST) encountered by the fish during their migration in the North East Atlantic.

A further 37,900 smolts were microtagged, branded and released as six 'experimental' groups on 31^{st} April 2003, averaging 65g in weight. The groups were part of an on-going research programme with the National University of Ireland, Galway (NUIG) using pedigreed lines of multi-sea winter (MSW) and grilse Shannon stock, developed by the ESB since 1991. This long term programme commenced in 2000 and returns of MSW salmon to the traps are expected up to 2006. The programme aims to look at the influence of parent genotype on return habit by testing the hypothesis that MSW males have a higher genetic liability for the MSW trait and examining the impact of precocious male parr parentage on the return habit of adult salmon. DNA micro-satellite work is in progress at NUIC with a view to examining family effects.

4.1.2 Aquaculture

An estimated 58,200 vaccinated salmon smolts of Scottish origin, averaging 90g, were successfully transferred to a commercial sea farm in March 2003. Smolts were part of an ongoing programme to evaluate Norvax mono PD vaccine. Unfortunately, these salmon smolts were lost prior to any viral challenge.

4.2 Salmon Stocks 2003

Burrishoole grilse, Shannon and commercial 2SW Scottish stocks were hatched in 2003. Growth and survival was satisfactory throughout the year, despite particularly high temperatures and notably high parasite loadings during August. Grading was carried out in August and September and commercial pre-smolts were vaccinated in October/November 2003 and January 2004 using two vaccines (Norvax Compact 4 and Mono PD vaccines) and two vaccination strategies.

Stocks remaining in December 2003 were 27,600 Burrishoole grilse , 59,800 commercial 2SW and 38,800 Shannon.

4.3 Salmon Stocks 2004 (Grilse ova laid down in 2003)

450 broodstock were held for stripping in November and December. The majority of microtags were read on the day of stripping and 55 broodstock were identified as Shannon grilse. Shannon stock had been cold branded as pre-smolts, in order to distinguish them from Burrishoole stock and to facilitate their removal as grilse from the traps. Non recognition of brand marks in the Shannon stock was high and ova and milt from these fish were excluded from the programme.

Broodstock were stripped during December and an estimated 870,000 green ova were produced by 205 Burrishoole hens. The average fecundity value was 4,250 per female.

Broodstock condition was good throughout the holding period. Fish were tested by the Marine Institute Fish Health Unit in December and subsequently salmon ova were certified disease free. Ova quality and survival was good. The Marine Institute ACMS co-ordinated the sale of 724,000 ova to Germany for the Rhine programme. 80,000 Burrishoole ova were retained in the hatchery.

4.4 Rainbow Trout 2003

An estimated 5,600 rainbow trout (Seven Springs NI) were stocked into Ballinlough Fishery, from August to October. 1200 trout were retained in December 2003 for stockings in 2004.

4.5 EU Triploid Programme EU AIR CT94 2216

The results of research carried out by Irish partners in this EU programme were presented as a Ph.D thesis by Deirdre Cotter 'Triploid Atlantic Salmon (Salmo salar L.): Growth, Maturation and Migratory Behaviour'.

Abstract: In triploid fish, each cell nucleus contains three sets of chromosomes rather than the two sets found in normal diploid fish. Although mitotic cell divisions can proceed normally in triploids, meiotic processes are disrupted, resulting in functionally sterile fish. The effects of triploidisation on growth, maturation and migration in Atlantic salmon were examined.

The performances of mixed-sex (MS) and all-female (AF) diploid (2N) and triploid (3N) Atlantic salmon were compared in fresh water, under commercial production conditions in two year classes (1995YC & 1996YC). The performance of AF2N and AF3N salmon (1996YC) was also assessed for 14 months in a commercial sea farm.

Freshwater mortality was higher in the triploid groups. The majority of losses occurred in the early stages of egg development and during the first feeding period. In growth studies, although diploid fry were significantly heavier during first feeding there were no significant differences in weight between groups thereafter. Smolting rates were high (ranging 89.5-95.3%) and the incidence of deformities was low (< 1%) in all groups.

Marine survival was lower in the triploid group, largely as a consequence of higher losses sustained during a period of chronic stress, when triploid losses were 9% higher. Growth patterns were similar for the first 11 months in sea water, but differences emerged as a consequence of the increased growth rate in diploids, associated with early maturation. Overall yields of triploid salmon in salt water were lower due to inferior survival. However, it was not possible to maintain the triploids beyond the diploid harvest date and thereby quantify their potential advantage over diploids.

The migration behaviour of groups of triploid salmon was investigated through the controlled release of microtagged triploid and diploid stocks of ranched grilse origin. Mixed-sex and all-female 2N and 3N smolts were ranched from the hatchery of origin and two groups of post-smolts were released from cages in a marine site. The return of adult salmon from these groups to the coastal fisheries and to fresh water was monitored as part of the Irish national coded wire tag recovery programme. The return of triploid salmon was significantly reduced compared to

diploid salmon. The return of a small number of hormonally deficient, sterile triploid female fish suggests that migration to fresh water is not inextricably linked with reproduction. The substantially reduced return of hormonally competent triploid males, to the coast and to fresh water, indicates that other factors may have an effect on their marine survival.

Ovarian development in triploid salmon was severely retarded. The mean gonadosomatic index of ranched salmon (1995YC) returning to fresh water in September 1997 was 0.2 in triploids compared to 11.8 in diploids. In triploids the majority of germ cells failed to progress beyond the primary growth phase and therefore somatic tissues important for steroid synthesis failed to complete development. Steriod hormone (estradiol-17β (E) and testosterone (T)) levels remained low in triploids (<1.0 ng/ml plasma) in contrast to maturing diploid females where hormone levels peaked within six weeks of spawning (E 38.4ng/ml, T 19.67ng/ml). Gonadotropin I (Gth I) levels in triploid females were similar to those in diploid females some 7-12 months prior to spawning. However, major differences in plasma Gth I and II were evident in triploid and diploid females within six months of the normal spawning time. The higher Gth I levels observed in triploid females may be a consequence of the affect of low gonadal steroid concentrations on the feedback mechanisms controlling gonadotropin release. In contrast to females, the testes of triploid males developed at the same rate as diploid males and steroid hormone and gonadotropin levels did not vary significantly.

Triploidisation resulted in differences in the reproductive physiology of Atlantic salmon, particularly females. The reduced return of triploid salmon, together with their inability to produce viable offspring, demonstrates the potential for triploidy as a means of eliminating genetic interactions between cultured and wild populations, and of reducing the ecological impact of escaped farmed fish. Triploidisation of commercial stocks may be found to have a useful role in the conservation of wild Atlantic salmon stocks.

4.6 SalCo-Op

The SalCo-Op research project was carried out on behalf of the NASCO/ISFA Liaison Group to establish the level of co-operative projects between aquaculture and wild fisheries interests. The report 'Inventory of co-operative projects between salmonid aquaculture and wild fisheries' (Poole, Cotter & Whelan, 2003) was presented to NASCO in January 2003 and is published as a report of the sub group on salmon co-operation (SalCo-Op) SLG (03)4.

4.7 Molecular biology of the Atlantic salmon

This three year study (2003 – 2006) aims 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 will provide materials and services in support of this programme, which is funded by the HEA programme for research in third level institutions (PRTLI).

5 SALMON CENSUS PROGRAMME

5.1 Wild Salmon and Grilse

A total of 544 wild grilse were recorded moving upstream through the permanent traps during the season (Table 3). The run commenced in May and was completed in November (Table 4). The main upstream migration was recorded in the Salmon Leap trap with 463 wild grilse and 81 in the Mill Race trap.

The number of spring fish recorded was 18 (Table 5).

The retained rod catch of wild grilse on Lough Furnace was 3 fish. Therefore, the total wild grilse return, including the Furnace rod catch and the upstream count, was **547**.

Table 3. Monthly wild grilse totals for the Salmon Leap and Mill Race traps.

	Mill Race	Salmon Leap	Total
May	3	2	5
June	5	53	58
July	41	230	271
August	3	59	62
September	0	47	47
October	8	51	59
November	21	21	42
December	0	0	0
Total	81	463	544

Table 4. Monthly proportions (%) of wild grilse run 1999 –'03.

	1999	2000	2001	2002	2003
May	1.2	1.8	0	0.9	0.9
June	26.3	31.5	60.1	53.4	10.7
July	44.6	4.9	20.7	32.3	49.8
August	16.9	45.1	11.1	7.3	11.4
September	9.6	11.6	0.8	0.3	8.6
October	1.2	3.5	5.2	4.9	10.8
November	0.2	0.0	1.1	0.6	7.7
December	0.0	0.4	1.1	0.3	0.0

Water levels in the upstream traps were low during May and much of June. Increased water levels at the end on July resulted in 49.8% of the total wild run being recorded in July. Water levels were also low during August and September and a late run of wild grilse was recorded in October and November.

The wild grilse return to freshwater at 6.5% is a decrease from 10.2% in 2002. This poorer return of wild fish is also reflected in the overall national salmon catches.

The reported national commercial catch in 2003 was 168,819. This was 13,181 below the Total Allowable Catch (TAC) of 182,000. All District catches were below the District TAC's set. There was a reduction in the commercial salmon catch in 2003 from 2002 of 40,025 fish (19.3%).

Table 5. Wild salmon and grilse totals in upstream traps 1970-2003.

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	15	582
1996	18	409
1997	6	538
1998	4	516
1999	16	502
2000	6	568
2001	6	368
2002	2	648
2003	18	544

5.2 Net marked fish in upstream traps

The occurrence of net marks on both wild and reared fish in the upstream traps during 2003 was low in 2003 (Table 6).

Table 6. Percentage occurrence of net marks on wild and reared grilse

	Wild Grilse n = 424	Reared Grilse n = 743
May	0.0	0.0
June	1.2	1.2
July	6.4	1.6
August	2.8	0.0
September	0.0	1.2
October	0.0	0.0
November	0.0	0.0
December	0.0	0.0

5.3 Wild Spawning Stock

The spawning stock 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.

The maximum spawning escapement decreased from 599 in 2002 to 517 in 2003. (Table 7 & 8). The reared component of the spawning stock (11) was 2.1%.

Table 7. Spawning stock of salmon and grilse

	Wild grilse(1SW) & previously spawned grilse	Wild Salmon (2SW)	Ranched fish released upstream
Counted in trap	544	18	87
Rod Feeagh*	--	--	--
Culled	6	--	0
Broodstock	15	--	0
Estimated morts.	26	1	1
Displacement	19	--	75
Spawning stock	**489**	**17**	**11**

* No angling on L. Feeagh during 2003.

Table 8. Spawning escapement 1970 - 2003

	Maximum spawning escapement	Wild fish component	Reared 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	464	376	102
1996	594	355	239
1997	494	466	28
1998	498	456	42
1999	547	485	62
2000	567	527	40
2001	370	349	21
2002	570	562	8
2003	517	506	11

5.4 Survival of Ova to Grilse

The relevant brood year for the 2003 grilse was 1999 with ova hatch in 2000 and smolt migration in 2002 (Table 9). As in previous years, it has been assumed for the purpose of estimating survival that ranched grilse spawned naturally. Specific data are not 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 9. Survival ova to grilse

Spawning escapement in 1999	547
No. of females	274 - 301
Ova deposition	1,096,000 – 1,238,615
No. of smolts in traps 2002	8627
No. of smolts released	8423
Survival ova to smolt	0.70 - 0.79
No. returning grilse 2003	547
Survival smolt to grilse	6.5%
Survival to grilse per grilse female	2.0 – 1.8

5.5 Ova to Smolt Survival

The survival of ova to smolt range of 0.7 to 0.8 was higher than in recent years.

The survival of smolt to grilse decreased from 10.2% in 2002 to 6.5% in 2003. Low water conditions were recorded during much of the summer of 2003 and led to a delay in the upstream migration of wild fish. This delay may have resulted in these fish being vulnerable to seals which were observed in the lake during this period.

The survival to grilse per grilse female was just above the value required to sustain the population of four years earlier (Table 10).

Table 10. Comparative data for the five-year averages from 1970 - 1989 and the 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	0.70 – 0.79	1.8 – 2.0

5.6 Wild Salmon Smolts

A total of 7248 wild salmon smolts were recorded in the downstream traps during 2003 (Table 11). This is a decrease from 8627 recorded the previous year.

Table 11. Numbers of wild salmon smolts counted in 2003.

MONTH	SLDT	MRDT	TOTAL
March	1	0	1
April	2541	0	2541
May	4528	146	4674
June	29	0	29
July	1	0	1
August	2	0	2
September	0	0	0
October	0	0	0
TOTAL	7102	146	7248

Table 12. Annual numbers of wild salmon smolt recorded in downstream traps

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
5429	5971	5998	6148	6331	9588	7197	5791	6466	8627	7248
			5854*	5960*	8937*	7118*	5689*	6387*	8423*	7081*

* Number of smolts released to sea from traps when mortalities and samples were deducted.

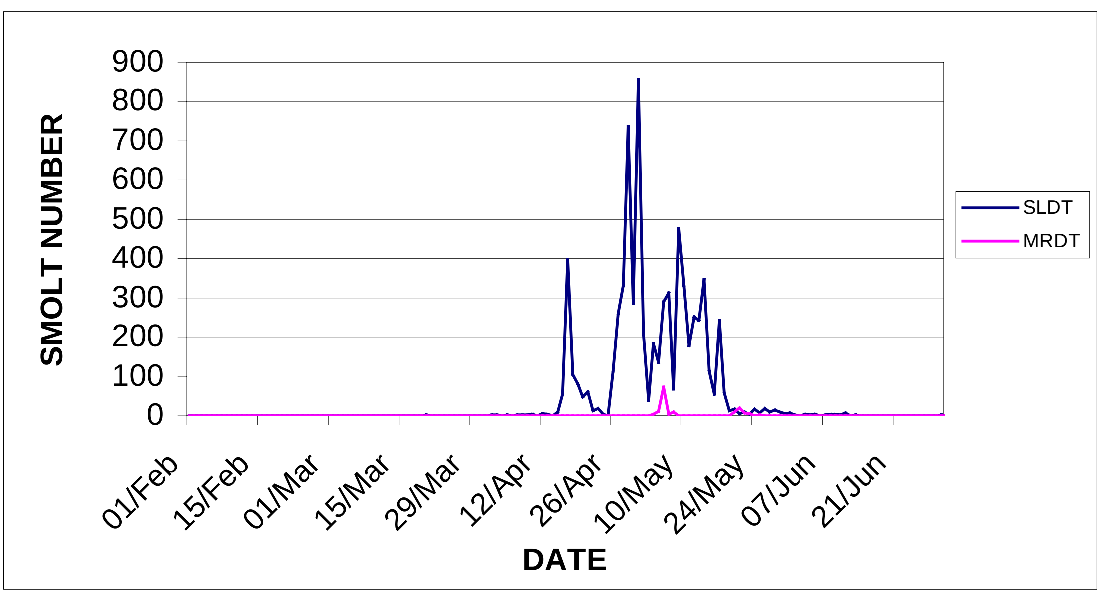

Figure 5. Timing of the 2003 wild salmon smolt run in the Salmon Leap & Mill Race traps.

5.7 Wild Salmon Kelts

The wild kelt run commenced in December 2002 and the peak of the run occurred during March 2003 (Table 13). There was a late run of kelts during May when 27% of the total run was recorded. As in recent years the kelts recorded in the downstream traps were in very good condition. The survival from the spawning stock continues to show a decrease, decreasing from 72.5% in 2001 to 49.6% in 2003 and 42.3% in 2003.

Table 13. Numbers of wild salmon kelts counted in 2003.

	SLDT	MRDT	TOTAL
Dec ’02	4	0	4
January ‘03	15	1	16
February	6	6	12
March	108	2	110
April	46	0	46
May	59	9	68
Total	238	12	250

Table 14. Comparison of annual kelt runs:

	A	B	C	D	E
1975-79	75	18	14.0	30.0	8.1
1980-84	82	18	6.7	48.7	9.7
1985	94	26	3.0	56.0	7.7
1986	93	31	3.4	55.3	9.2
1987	68	15	10.8	22.6	9.7
1988	88	24	4.6	55.0	8.7
1989	96	11	3.7	27.0	6.6
1990	94	35	5.6	48.6	7.6
1991	98	39	3.4	82.3	9.7
1992	92	39	7.0	59.3	6.9
1993	83	5	3.2	52.7	7.4
1994	91	37	4.7	64.3	1.6
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	76.0	*
2000	92.5	44.5	5.5	62.1	*
2001	97.0	38.5	2.8	72.5	*
2002	91.3	40.9	7.8	49.6	*
2003	95.5	37.0	3.5	42.3	*

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

6 REARED SALMON CENSUS PROGRAMME

6.1 Coastal Returns

Details of coastal returns of Burrishoole fish are available in the Marine Institute ‘National Report for Ireland – The 2003 Salmon Season’ report.

6.2 Return rate of reared and wild grilse

As in recent years the return of reared fish to the Burrishoole system consists of both Burrishoole native ranch fish and experimental Shannon strains.

The total adult return of reared fish to Burrishoole in 2003 was 1178 fish. Microtag readings were obtained from 1091 fish and of these 682 fish (62.5%) were identified as Burrishoole ranch grilse. This was a minimum return rate of 2.8% from a release of 24,740 smolts in 2002. As the number of Burrishoole ranch grilse identified by microtag was 62.5% of the total number of fish identified by microtag in 2003 the maximum return rate of Burrishoole grilse is calculated by assuming that 62.5% of returning adults from which tags were not retrieved (98) were also Burrishoole grilse. Therefore the maximum return of Burrishoole reared grilse in 2003 was 743 (3.0%), increased from 2.3% in 2002. However, the wild grilse return decreased from 10.2% to 6.5%.

6.3 Recapture of Reared 2SW Fish

A total of nine 2SW reared Burrishoole stock was identified by microtag during 2003.

An increase in the number of wild 2SW fish was also recorded during 2003.

6.4 Smolt releases 2003

A total of 25,103 reared smolts of Burrishoole origin consisting of six groups were released during 2003 (Table 15). Five microtag groups were released directly into L. Furnace. A sixth group was transferred to Lough Feeagh for a predation study. All fish migrating from this group were counted in the downstream traps.

Table 15. Burrishoole smolts released in 2003.

Release Date	1/5/03	1/5/03	1/5/03	1/5/03	1/5/03	1/5/03
Release Site	Furnace	Furnace	Furnace	Furnace	Furnace	Feeagh
No. Released	4484	4468	4539	4738	4897	1977
Weight (g)	60	55	56	59	63	54
Length (cm)	17.1	16.6	16.7	17.1	20.5	17.6
Microtag Code	24771	24772	24773	24774	24777	194735

7 Wild Sea Trout

7.1 Upstream Movements: Timing and Numbers.

A total of 78 wild silvered sea trout and a further 40 non-silvered trout migrated upstream through the traps in 2003. Of the silvered trout, 19 were adults and 59 (76%) were finnock. The numbers are compared with other years in Table 15. Of the total run of migratory trout (118), 35.7% were non-silvered. For the purposes of this report, the non-silvered trout are not included with the sea trout. Table 15 shows clearly that the numbers of sea trout have not recovered in the Burrishoole system and have shown a ten-fold drop since the 1970s. The sea trout count for 2003 was the lowest ever recorded.

Table 15. 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	
1985	479	976	1465	
1986	277	1110	1387	
1987	528	422	950	
1988	497	366	863	
1989	147	77	225	
1990	101	54	155	
1991	180	162	342	
1992	123	28	151	
1993	130	43	173	
1994	136	74	210	
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	

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

The timing of the sea trout run in 2003 and in previous years, expressed in monthly percentages, is given in Table 16. The highest proportion of sea trout, both finnock and adults, moved upstream in July. No sea trout moved upstream in August, due to low water levels.

Table 16. Timing (%) of the Burrishoole sea trout run. (n = no. of sea trout).

	1970-'79	1980-'84	1985-'89	1990-'94	1995-'99	2000 (111)	2001 (89)	2002 (115)	2003 (78)
May	-	0.2	0.5	0.1	3.1	0.9	2.3	0.9	2.6
June	13.1	24.6	9.4	8.4	8.6	7.2	23.6	3.5	18.0
July	54.4	44.9	62.2	55.0	42.4	9.0	30.3	57.4	55.1
August	15.8	10.3	18.4	16.5	19.3	72.9	16.9	23.5	0.0
September	7.6	14.8	3.7	8.5	9.8	7.2	0.0	0.9	12.8
October	6.4	3.5	4.1	7.9	12.2	1.8	24.7	9.5	11.5
November	2.4	1.5	1.5	2.9	4.3	0.0	2.2	4.3	0.0
December	0.3	0.2	0.2	0.7	0.7	0.0	0.0	0.0	0.0

7.2 Spawning Escapement

With the continuation of the catch and release bye-law into the 2003 fishing season and the closure of L. Feeagh to angling, no sea trout were reported killed by anglers on L. Feeagh in 2003. Using the upstream fish counts through the traps, the total maximum spawning escapement of migratory trout to the L. Feeagh catchment was 118, of which 40 were non-silvered sea trout (Table 17).

Table 17. Annual spawning escapement of sea trout into freshwater.

	1970-'79	1980-'84	1985-'89	1990-'94	1995-'99	2000	2001	2002	2003
Max. Escap,	2090	1146	906	231	289	174	143	183	118
Revised		1622							

7.3 Downstream Movements, Sea Trout Smolts

The 2003 smolt run amounted to 787 smolts, of which 771 were released to the wild (Table 18). The smolt run in 2003 was well spread out over time (Fig. 6). A small number of silver smolts were migrating downstream as early as the start of January. The first peak of activity occurred at the end of February/early March. Low water affected the run until late April after which two main peaks of migration occurred in conjunction with rises in water levels.

Table 18. Monthly numbers of Burrishoole sea trout smolts recorded through the traps.

	Salmon Leap	Mill Race	Total	%
January	8	0	8	1.0
February	0	1	1	0.1
March	75	2	77	9.7
April	159	0	159	20.2
May	506	20	526	66.8
June	15	0	15	1.9
July	1	0	1	0.1
Total	764	23	787	
Number Released Downstream			771	

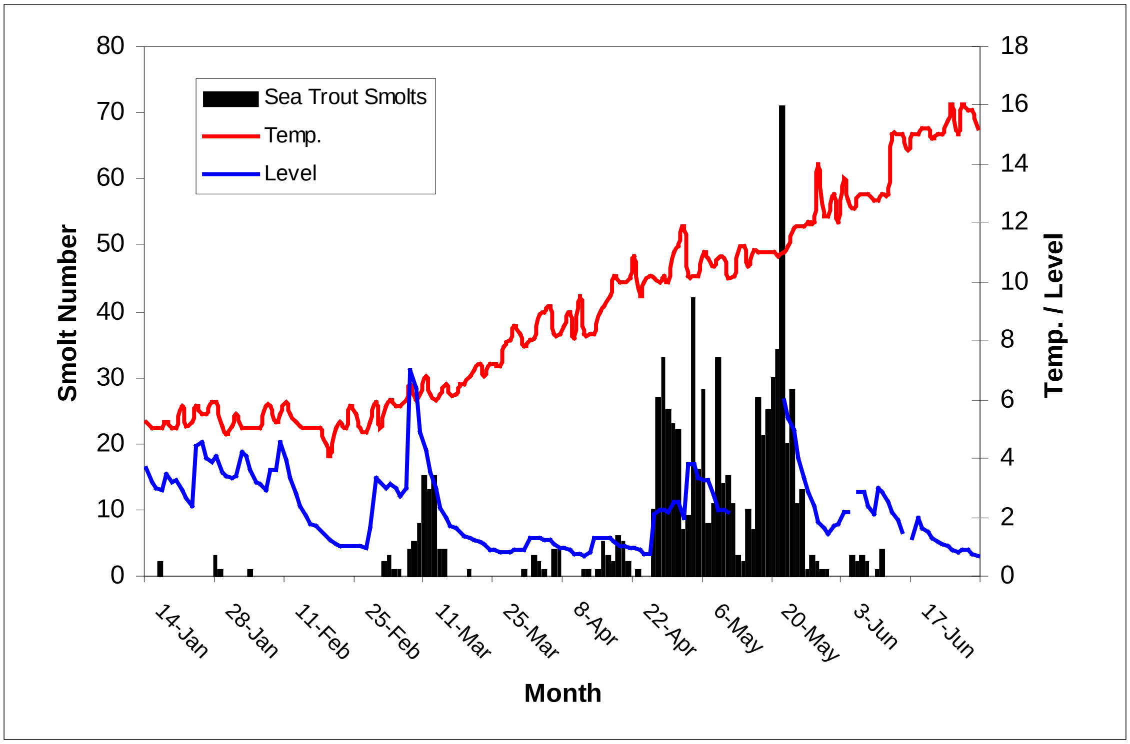

Fig. 6. Timing of the 2003 wild sea trout smolt migration with daily water level and temperature.

Table 19. Annual sea trout smolt numbers in Burrishoole for 1970 to 2003.

	1970-79	1980-84	1985-89	1990-94	1995-99	2000	2001	2002	2003
Number	4176	4038	4119	1531	1361	769	530	1272	787

LENGTH

The wild smolts had an average length of 20.5 cm and ranged from 14.8 cm to 26.4 cm in length. However, only 33 smolts were measured in 2003 so it wasn't possible to plot a length frequency distribution.

7.4 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 834 trout entered the traps between July and December 2003 and up to May 2004 (Table 20). The percentage of 0+ trout that migrated over the period was 48.9% (Table 21).

Table 20. Numbers of migrating autumn juvenile trout, to the end of January 2004.

Month	0+		1+		Total	
	SL	MR	SL	MR	SL	MR
July	7	0	3	0	10	0
August	1	0	1	0	2	0
September	47	0	47	0	94	0
October	77	0	53	0	130	0
November	123	0	200	4	323	4
December	76	2	51	0	127	2
January 2004	16	1	11	3	27	4
February 2004	28	0	18	0	46	0
March 2004	13	0	14	1	27	1
April 2004	17	0	12	1	29	1
May 2004	0	0	6	1	6	1

Total	408	426	
Overall Total			834

Table 21. Percentage of 0+ juvenile trout amongst trapped autumn migrating trout.

1982	50.0
1983	N/A
1984	55.8
1985	30.3
1986	16.1
1987	35.3
1988	60.9
1989	37.2
1990	35.2
1991	26.0
1992	38.2
1993	27.6
1994	16.8
1995	25.3
1996	34.0
1997	18.7
1998	33.5
1999	42.0
2000	47.8
2001	56.3
2002	32.8
2003	48.9

7.5 Total Recruitment

The 0+ autumn trout will not be large enough to become sea trout smolts in the following spring. The remainder, predominantly 1+ years old, 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 22).

Table 22. 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

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 23). 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 23. Estimates of total migrant trout recruitment from 1982.

YEAR	SMOLT TOTAL	AUTUMN TROUT 1+ & Older (preceding year)	TOTAL RECRUITMENT
1982	3907	1300*	5207*
1983	4852	1109	5961
1984	2383	1200*	3583*
1985	4238	611	4894
1986	3454	1472	4926
1987	3371	1726	5097
1988	4290	949	5239
1989	3179	556	3735
1990	2022	634*	2656*
1991	2137	636	2773
1992	1936	234	2170
1993	1720	183	1903
1994	1127	306	1433
1995	1821	282	2103
1996	1300	336	1636
1997	817	513	1330
1998	1608	717	2325
1999	1260	644	1904
2000	769	358	1127
2001	530	218	748
2002	1272	910	2100
2003	787	976	1763

* estimated

7.6 Marine Survival

WILD

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. 7). 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 – the highest return rate since 1986. This increase has not, however, been sustained in subsequent years.

The total survival of smolts to the 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. 8).

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 in recorded in 12 years and within the pre-collapse historical range.

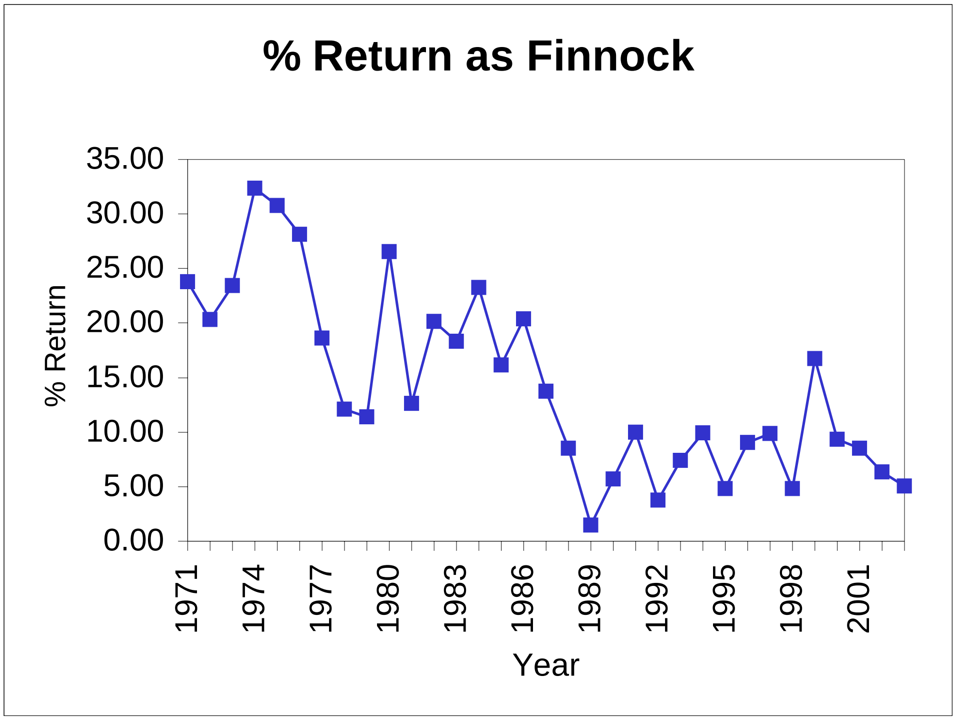

Fig. 7. Annual percentage return of smolts returning as finnock to the Burrishoole system.

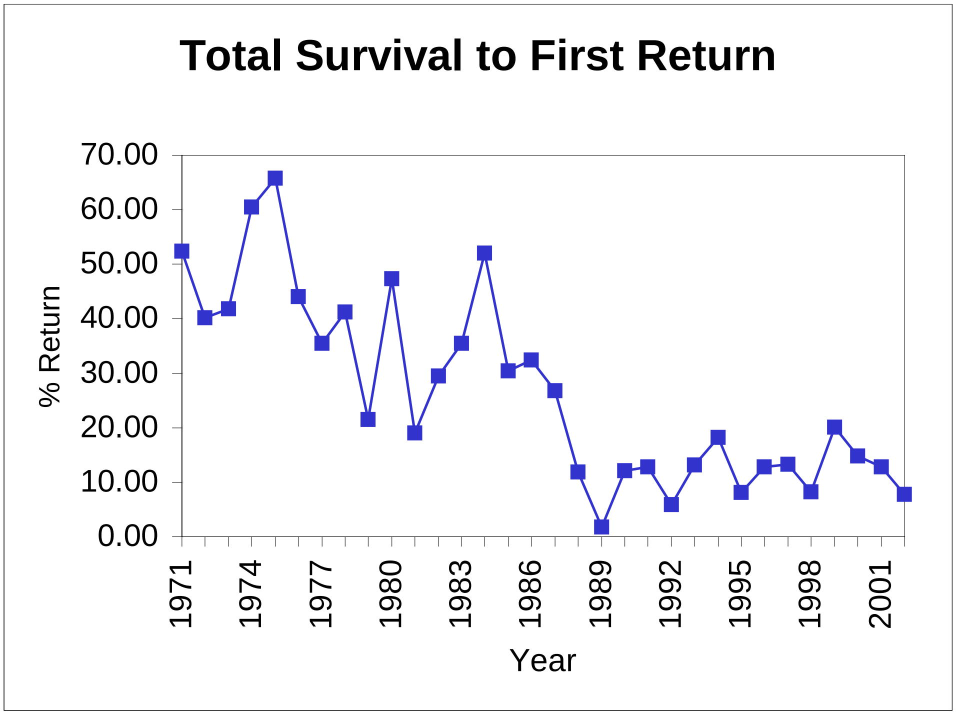

Fig. 8. Annual marine survival of smolts to first return (as finnock and 1+ sea trout) to the Burrishoole system.

7.7 Sea Trout Kelts

Table 24. Timing and numbers of sea trout kelts for the 2002/2003 season.

Month	Large	Small	Total
October	0	1	1
November	4	6	10
December	5	6	11
January	5	1	6
February	0	0	0
March	4	11	15
April	7	8	15
May	4	14	18
Total	29	47	76

The freshwater survival of kelts is given in Table 25. 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 25. 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.

Table 25. 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)
1976	79	66
1977	63	45
1978	50	66
1979	33	107*
1980	50	82
1981	44	345*
1982	53	203*
1983	63	177*
1984	74	210*
1985	70	98
1986	66	72
1987	58.7% (combined)	
1988	65.5% "	
1989	68.7% "	
1990	79.0% " *	
1991	98.7% " *	
1992	89.5% " *	
1993	96.7% " *	
1994	104.6% " *	
1995	96.2% " *	
1996	127.7% " *	
1997	97.0% " *	
1998	140.1% " *	
1999	110.4% " *	
2000	70.1% "	
2001	82.0% " *	
2002	129.6% " *	
2003	66.1% "	

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

8 SILVER EEL CENSUS PROGRAMME

Silver eel trapping was continued in 2003. The run timing was similar to that in 2001 & 2002 with almost 70% of the migration in October (Table 26). A drought in August and September reduced the count for those months to minimal numbers. A flood in October triggered a mass migration and 54% of the annual count occurred on the night of 30th October with 67% over a three day period.

The total run amounted to 3919 eels. As in other years, the highest proportion of the total catch (96%) was made in the Salmon Leap trap.

Table 26. Timing and numbers of the 2003 silver eel run.

	Salmon Leap	Mill Race	Total	%
July	43	4	47	1.2
August	24	0	24	0.6
September	235	11	246	6.3
October	2641	63	2704	69.0
November	704	73	777	19.8
December	63	7	70	1.8
January 2004	34	17	51	1.3
Total	3766	175	3919	

Sampling of individual eels (n=650) gave an average length of 45.1 cm (range: 29.2 – 93.9 cm) and an estimated weight of 177 g (Table 27).

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. 9). 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 215 g in the 1990s (Fig. 9).

Table 27. 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
1986	1856	194
1987	2713	195
1988	3283	206
1989 *	685	254
1990	3121	176
1991	266	246
1992	523	186
1993	181	260
1994	468	220
1995	2003	225
1996	1172	184
1997	1022	238
1998	845	208
1999	577	220
2000	342	212
2001	850	238
2002	732	207
2003	650	177

* Incomplete due to flood damage

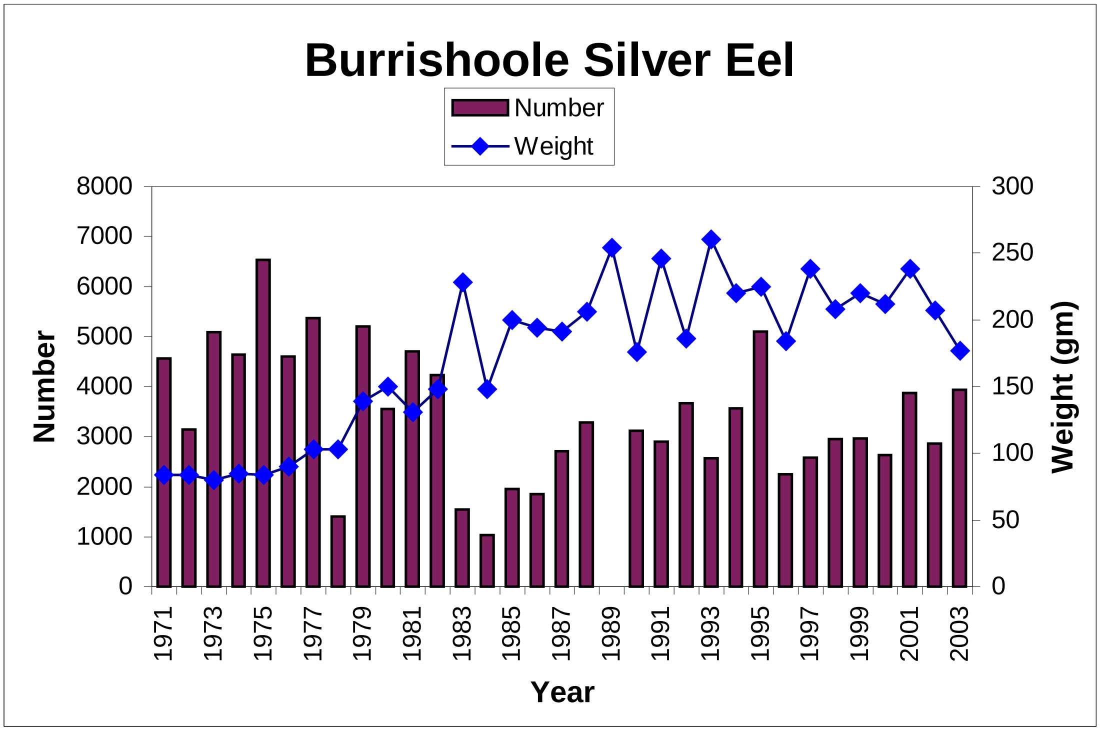

Fig. 9. Annual number and mean weight of silver eels trapped in the downstream traps.

9 FISHERY REPORT - CATCH DATA

9.1 Numbers and Average weight of Rod Catch

A total of 59 salmon were caught in the Burrishoole Fishery in 2003. The catch consisted of 22 reared fish and 37 wild fish. For conservation purposes 34 of the wild fish were returned alive.

The average weight of reared fish was 3.2kg (n = 19), the heaviest reared fish was 5.5kg. No lengths or weights were available for wild fish.

The total trout rod catch was 16 fish. Regulations remained in place whereby all rod caught sea trout were returned alive.

9.2 Timing of Catch and Rod Effort

Angling was again confined to Lough Furnace during 2003, as Lough Feeagh remained closed as a conservation measure. Unlike 2003 when reduced availability of fish during the angling season resulted in low rod catches, there was an increase in fishing effort due in part to fish being observed in Lough Furnace during the fishing season. The rod effort on Lough Furnace increased from 183 rod days in 2002 to 282 rod days in 2003.

Table 28. Wild and reared salmon rod catch and rod effort (hours) for the 2003 season.

	SALMON CATCH		EFFORT/ HRS.
	WILD	REARED	
May	0	0	0
June	1	3	430
July	28	12	1455
August	5	7	245
September	3	0	132
Total	37	22	2262

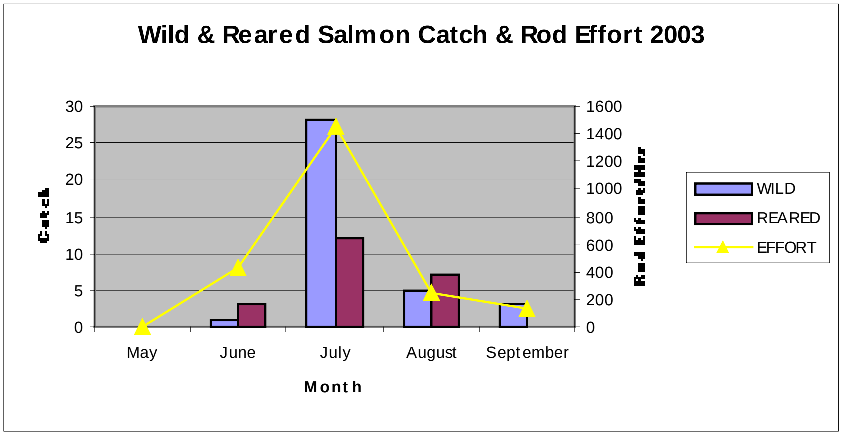

Fig. 10. Wild and reared salmon rod catch and rod effort (hours) for the 2003 season.

9.3 Exploitation Rates of Rod Fishery

Rod exploitation rates for Lough Furnace and Lough Feeagh from 1990 to 1996 are shown in Table 29. From 1997 onwards Lough Feeagh was closed to angling. Exploitation rates are only available for Lough Furnace for these years. The cessation of angling on Lough Feeagh was due to the continuing low stock level of wild fish. Anglers fishing on Lough Furnace were requested to return wild fish alive to the water. Injured 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.

Table 29. Rod Fishing Exploitation Rates (1990-2003)

	1996	1997	1998	1999	2000	2001	2002	2003
WILD SALMON								
Lough Feeagh								
"Available" fish by end of fishing season	167	*	*	*	*	*	*	
Total rod catch	**11**							
Rod catch retained	**8**							
Angling success %[1]	6.6							
Exploitation rate %[2]	4.8							
WILD SALMON								
Loughs Feeagh & Furnace								
Total stock of wild fish	406	544	520	524	580	375	651	565
+ 10% addition for L. Furnace population	447	598	572	576	638	413	716	622
Total catch of wild fish	119	125	80	40	70	17	12	37
Rod catch retained	35	25	11	6	6	1	1	3
Max. angling success %	29.3	23.0	15.4	7.6	12.1	4.5	1.8	6.5
Min. exploitation rate	7.8	4.2	1.9	1.0	0.9	0.2	0.14	0.5
Max. exploitation rate	8.6	4.6	2.1	1.1	1.0	0.3	0.15	0.5
REARED SALMON	1996	1997	1998	1999	2000	2001	2002	2003
Lough Feeagh								
"Available" fish by end of fishing season	150*	*	*	*	*	*	*	*
Rod catch	1							
Exploitation rate %	0.7							
Loughs Feeagh & Furnace								
Total stock	1032	848	1682	395	1257	834	860	1178
Total rod catch	176	93	560	35	129	43	10	22
Exploitation rate %	17.1	11.0	33.3	8.9	10.3	5.2	1.2	1.9
WILD SEA TROUT								
Lough Feeagh								
"Available" fish by end of fishing season	82*	*	*	*	*	*	*	*
Rod catch	5							
Exploitation rate %	6.1							

* No Fishing on Feeagh

9.4 Angling Success

The wild salmon catch increased from 12 fish in 2002 to 37 in 2003. There was also a corresponding increase in the reared salmon catch. Fishermen reported a lot of salmon showing in Lough Furnace during the fishing season but that they were reluctant to take. Movements of wild salmon through the upstream traps confirm the presence of these fish in Lough Furnace, with only 73% of the total run recorded by the end of August compared to 94% the previous year. This also resulted in an increase in rod effort, which increased from 1462 rod hours in 2002 to 2262 in 2003.

Table 30. Catch per unit effort (CPUE) and effort per unit catch (EPUC) for the Burrishoole Fishery

YEAR	L. FURNACE				L. FEEAGH			
	SALMON		SEA TROUT		SALMON		SEA TROUT	
	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	14.0
'96	0.22	4.4	0.10	10.5	0.83	1.2	0.30	2.9
'97	0.17	6.0	0.10	9.6	-----	-----	-----	-----
'98	0.44	2.3	0.08	13.2	-----	-----	-----	-----
'99	0.09	10.8	0.05	20.8	-----	-----	-----	-----
'00	0.30	3.31	0.06	16.5	-----	-----	-----	-----
‘01	0.15	6.7	0.12	8.4	-----	-----	-----	-----
’02	0.12	8.3	0.07	15.3	-----	-----	-----	-----
’03	0.13	7.6	0.06	17.7	-----	-----	-----	-----

Appendix 1.

A historical comparison of the invertebrate fauna of the Cottage, Altahoney and Glenamong rivers, Burrishoole catchment.

Elvira de Eyto, Derek McLoughlin and Terry Rooney

Introduction

The use of macroinvertebrates in assessing river quality is well established and forms the basis for the EPA's Q index, which is used for monitoring Irish rivers (McGarrigle, Bowman et al. 2002). The macroinvertebrate assemblages of the Altahoney, Glenamong and Cottage rivers in the Burrishoole catchment have been studied several times over the last fifty years. The resulting large data sets provided us with the opportunity in 2002 to resample these rivers, with a view to comparing current assemblages with those recorded since the 1960's, and to assess the impact that habitat change has had on the macroinvertebrates.

The Glenamong and Altahoney rivers are situated on the western side of the Burrishoole catchment, and the Cottage River on the east. The base geology of the Glenamong and the Altahoney sub-catchments is schist, gneiss and quartzite, making them acidic in nature, with poor buffering capacity. In contrast, the Cottage River has some amount of limestone and sandstone in its catchment, which provides some buffering to acid conditions. 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. This has led to severe hillside erosion in some parts of the catchment as a result of overgrazing, particularly in the Glenamong sub-catchment. About one third of both the Altahoney and Glenamong sub-catchments is under active coniferous forestry plantations, which were planted in batches starting in the 1970's. However, none of these trees have been harvested as yet. The Cottage River subcatchment contains no forestry, but has some hardwood in its lower reaches. The historical invertebrate data therefore predates the planting of forestry, and probably represent reference or baseline conditions against which change can be quantified.

Methods

The three rivers chosen for the 2002 study, the Altahoney, Glenamong and Cottage, were all sampled quantitatively at least once in the 1960's. These rivers have been sampled several times over the intervening years, but as the methods were not comparable, we are not including them in this report (Table 1).

In 2002, the rivers were sampled at approximately the same sites as were sampled in the 1960's, and using the same methods (SRT, 1961; 1964; 1966) (Fig. 1, 2 & 3). A surber sampler with a one-foot square cross-sectional area was used to sample the bottom fauna. The substrate within the wire square was disturbed and rocks and cobbles overturned, and all animals were washed into the net. Five replicate samples were taken from riffle areas of each site, and physical and chemical measurements recorded (Table 2).

Abundances of animals were standardised to individuals per square foot, for all years, rivers and sites to enable historical quantitative comparisons. Species lists were also compiled at the most detailed taxonomic level possible, allowing for the fact that some studies reported higher taxonomic resolution than others did. Shannon diversity ($J = -\sum(P_i \text{Ln} P_i)$, where P_i = the proportional abundance of the *i*th species) and Berger-Parker dominance ($d = N_{max}/N$, where N_{max} = the number of individuals of the most abundant species and N = total number of individuals) were calculated for all sites. The Q index (McGarrigle, Bowman et al. 2002) and BMWP scores (Hawkes 1997) were also calculated for each site. The total numbers of sensitive taxa (Ephemeroptera, Plecoptera and Trichoptera) were also calculated for each set of samples. A dissimilarity matrix using euclidean distances (a measure of how dissimilar assemblages are) was constructed using SPSS 11.0 to assess which sites had undergone the most change between sampling.

Results

Three sites were sampled in the Cottage River in 1964, and again in 2002. At all three sites, we found much lower invertebrate abundance and species richness in 2002 than was reported in 1964 (Table 3, Fig. 4). A similar pattern was found for the five sites sampled in 1961 and 2002 in the Glenamong River, (Table 3, Fig. 5). In the Altahoney, only one site was sampled in 2002 that could be paired with a quantitative sample from the 1960's, and at this site, lower taxa richness was found in 2002, but abundance was slightly higher. The consistent trend of decreases in species richness across the three rivers is not matched by a similar decrease in diversity. Indeed, the Shannon diversity index increased in several sites between the 1960's and 2002 (Fig. 6). This particularly true for the Glenamong river, where diversity increased at four out of the five sites sampled. A corresponding drop in dominance (as measured by Berger-Parker dominance) was noted in sites where diversity increased (Fig. 7).

The euclidean distances between sampling occasions indicated which sites have undergone the most change with respect to their macroinvertebrate assemblages (Fig. 8). The macroinvertebrates found at site 1 in the Cottage River appear to have changed the most since they were sampled in 1964, with a euclidean distance between sampling occasions of 148. The change in the macroinvertebrates at all the Glenamong sites ranges from 25 to 75, with the most change being observed at site 4.

The major change in the Altahoney, site 2 between 1966 and 2002 is an increased dominance of Plecoptera (Fig. 9), with a resulting decrease in diversity of other taxa (Fig. 6). Plecoptera increased from a relative abundance of 40% to one of 87% between the two years. The main plecopteran species found in 2002 was *Leuctra hippopus*, although there were a few individuals of *Isoperla grammatica*. Ephemeroptera, which constituted almost 20% of the samples in 1966 (all *Baetis rhodani*) were not found in 2002. Hydracarina also were not recorded in 2002, although they were found in 1966. The proportion of coleoptera stayed approximately the same between both years.

The macroinvertebrates recorded at site 1 in the Cottage River have changed very dramatically between 1964 and 2002 (Fig. 10). Chionomids (Diptera) constituted just over 50% of the samples in 1964, but dropped to 5% in 2002. Ephemeroptera were the most dominant taxa in 2002 (60% proportional abundance). About one third of the Ephemeropterans in 2002 were *Ecdyonurus* species, and two thirds were *Baetis rhodani*. In contrast, only 8% of the macroinvertebrate assemblage in 1964 were Ephemeroptera, when *B. rhodani*, *Ephemeralla ignita* and *Heptagenia sulphurea* were identified. Also notable from this site is the proportional abundance of the Amphipod *Gammmarus duebenii*, which increased from 4% to 37% between 1964 and 2002. The other two sites sampled on the Cottage River did not show quite as much change as Site 1, with euclidean distances between macroinvertebrate assemblages of 18 and 28 (in comparison to 147 from site 1). Although taxa richness and abundance was much lower in 2002, the proportional abundance of the main groups is relatively similar (Fig. 8). Specifically, Ephemeroptera was the most dominant group at both sites in 1964 and in 2002. In 2002 the most common species was *B. rhodani* followed by *Ecdyonurus* sp. *Ephemerela ignita*.. Both *Heptagenia lateralis* and *Rithrogenia semicolorata* were recorded in 1964, but not in 2002. The proportions of Diptera remained relatively constant at both sites between the two sampling years, as did the Coleoptera. Molluscs were not found in 2002 at either site, even though both *Ancylastrum fluviatile* and *Limnea pereger* were present in 1964.

The five sites sampled on the Glenamong River all show a similar shift from a dominance by Diptera (especially chironomids) to a high proportion of Plecoptera (Fig. 11). *Leuctra hippopus* constituted a large proportion of the samples in 2002, with an average abundance of 7 individuals per square foot over all five sites. *Baetis rhodani* was the dominant ephemeroptera in 1964, when it was found at all sites. However, it was only found in small numbers in site 5 during the 2002 survey. Significantly, an *Ecdyonurus* sp. was recorded from two sites in 1960, but was not found at all in 2002. In addition, *Ancylastrum fluviatile* was not found at all in 2002, even though it was found in fair numbers at all sites in 1960. Coleoptera were found to have a slightly higher relative abundance in 2002 than in 1960, while plecopterans had a lower relative abundance in 2002.

In the Altahoney River, The Q index remained the same between 1966 and 2002, with a rating of 3-4. A higher rating could not be assigned to this site, owing to the lack of sensitive Group A species. Only one stone fly species was recorded at this site in the years sampled (*Amphinemura sulcicollis* in 1966 and *Isoperla grammatica* in 2002). The BMWP score dropped from 61.4 to 44.4, and the number of EPT taxa from 5 to 3. All the biotic indices indicate a drop in ecological quality at sites 2 and 3 in the Cottage River. The Q ratings dropped from 4 to 3-4 at both sites, the BMWP scores decreased from 108 to 39 at site 2 and 121 to 36 at site 3 and the EPT taxa dropped from 10 to 5 at site 2 and 13 to 4 at site 3. Site 1 was slightly different in that the Q index increased from 3-4 to 4 owing to the presence of *Ecdyonurus* in 2002. However, the BMWP dropped from 131 to 20 and the EPT taxa also decreased from 11 to 3. The Glenamong River was assigned a Q rating of 3 for four out of five sites in 2002. Site 5 was assigned a rating of 3-4 in 2002, owing to the presence of small numbers of *Isoperla grammatica*. The presence of small number of *Ecdyonurus* at site 1 and site 3 in 1960 meant they could be assigned a Q rating of 3-4. All others were assigned a Q rating of 3.

Discussion

The most startling difference between the surveys in the 1960's and 2002 is the significant decrease in taxa richness and abundance at all sites (paired t-test, $P<0.05$, d.f. = 8). While there may have been some unintentional differences in sampling and sorting techniques owing to the time lapse between surveys, we feel that this could not account for the three or four fold difference in taxonomic richness that was recorded. The decrease in taxa richness, as well as the drop in diversity and the changes in the biotic scores indicate that the macroinvertebrate assemblages of all three rivers have been detrimentally impacted, and that the ecological quality of the rivers has changed dramatically.

In the case of the Altahoney and Glenamong rivers, the changes noted between the 1960's and 2002 are consistent with acidification resulting from afforestation. Acid streams tend to have low taxa richness and diversity, be dominated by plecopterans and have low (if any) numbers of ephemeropterans and molluscs (Wade, Ormerod et al. 1989; Smith, Wyskowski et al. 1990; Ventura and Harper 1996; Kelly-Quinn, Tierney et al. 1997). Plecopterans dominated almost all sites surveyed in the Glenamong and Altahoney rivers in 2002. The loss of the acid sensitive species *Baetis rhodani* from both rivers also suggests that acidification is the cause of the observed changes. (*Baetis* has been recorded in the Glenamong River in the last decade, in the area of site 2, so it has not been totally wiped out. M.McGarrigle, *pers. comm*.) Another acid sensitive species, *Ancylastrum fluviatile* was also not recorded from the Glenamong River in 2002. A survey of the Altahoney River in 1994 also concluded that the river has undergone severe change as a result of acidification (Kroes 1994). We have not included these results in this report, as the invertebrates were sampled in the winter, and are therefore not directly comparable. However, all the evidence from this survey is in agreement with that published in 1994, and it can be safely assumed that the main impact affecting the macroinvertebrate fauna in the Glenamong and the Altahoney rivers is acidification.

While it seems that the changes in the macroinvertebrate assemblages in the Altahoney and Glenamong rivers can be attributed to the effects of acidification, it is harder to understand the changes in the Cottage river. This river was thought to have undergone little change in comparison to the other two, owing to the lack of afforestation in its catchment. However, the results from this survey indicate that this river has undergone a fair degree of change, particularly at site 1. In 1960, the Salmon Research Trust of Ireland had fish rearing facilities in the vicinity of this site, and it is on record that the effluent from the ponds did enter the Cottage river (Anon. 1964). It seems likely that the dominance of chironomids in 1964 reflects this situation, although the water quality cannot have been very bad, given the presence of *Heptagenia sulphurea* in the samples. Although the Q rating for this site changed from 3-4 in 1964 to 4 in 2002 (owing to a greater proportion of ephemeroptera in 2002), the other biotic indices and the decrease in taxa richness and diversity do indicate that has been some detrimental impact on the river. This is reflected in the results for sites 2 and 3, which also indicate a decrease in ecological quality. Acidification is not a likely cause for this change, given that acid sensitive species are still present. It is more likely that the change is a result of land use practices in the catchment.

In conclusion, these results provide a very useful comparison of pre and post impact macroinvertebrate assemblages in three rivers in the Burrishoole catchment. The data from the 1960's can be considered reference conditions for what the rivers should be like, and the fact that the 2002 data deviate so significantly from these baselines indicate that the rivers have been severely impacted. In the case of the Glenamong and the Altahoney, acidification, as a result of coniferous afforestation, is the most likely cause. It is harder to explain the impacts on the Cottage River, but even the most conservative analysis leads to the conclusion that there has been significant change. It is likely that the changes observed in macroinvertebrate taxa richness and abundance in all three rivers has had implications for the food supply of the fish populations of the river. In addition it is very likely that the ecological changes that resulted in the macroinvertebrate changes have also affected the spawning and success of salmon and trout. The fact that we have data that can be equated to reference conditions is of huge benefit to amelioration efforts, as it is apparent that the macroinvertebrate fauna provides a very useful tool for monitoring ecological change in this catchment. Regular invertebrate sampling in the future will be useful in determining whether these amelioration efforts are successful in the long term.

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Table 1. Macroinvertebrate studies carried out in the Burrishoole catchment, 1959 to 2002

River	Date	Qualitative	Quantitative
Altahoney	1959	x	
Altahoney	1966	x	x
Altahoney	1970	x	
Altahoney	1994	x	x
Altahoney	2002	x	x
Cottage	1959	x	
Cottage	1964	x	x
Cottage	2002	x	x
Glenamong	1959	x	
Glenamong	1960	x	x
Glenamong	2002	x	x

Table 2. physical and chemical variables measured in the Burrishoole catchment as part of a macroinvertebrate survey, 25th –27th June, 2002.

River	Site	Date	Location	Water Temperature °C	Width (m)	Substrate	Dissolved Oxygen (mg/l)	pH	Conductivity (µS/cm)
Cottage	1	25-Jun-02	F974 012	15.7	2	Boulders and Cobble	10.8	6.5	60
	2	25-Jun-02	F977 014	14.5	1.5	Small Boulders and Gravel	10.6	4.7	160
	3	25-Jun-02	F980 020	15	<1	Gravel	10	4.9	200
Altahoney	2	26-Jun-02	F961 080	12.8	7	Boulders & Gravel	11	5.1	77
Glenamong	1	25-Jun-02	F954 018	19.1	7	Cobbles & Gravel	10	6.5	66
	2	25-Jun-02	F948 025	18.8	14	Cobbles & Gravel	9.7	6.6	63
	3	27-Jun-02	F947 028	12.5	9	Boulders & Gravel	9.6	6.9	70
	4	27-Jun-02	F944 034	12.2	4	Boulders & Gravel	10.9	6.6	69
	5	27-Jun-02	F930 038	11.1	7	Boulders & Gravel	11.2	6.7	65

Table 3. Total taxa and abundances **per sq. foot (0.1m²)** recorded in the Burrishoole catchment in the 1960's and in 2002.

		Total Individuals			Total Taxa		
River	Site	1960's	1994	2002	1960's	1994	2002
Altahoney	2	26	92	33	12	21	7
Cottage	1	300		13	29		6
Cottage	2	60		7	23		8
Cottage	3	73		6	26		8
Glenamong	1	64		21	24		7
Glenamong	2	74		10	23		7
Glenamong	3	55		10	27		7
Glenamong	4	119		10	24		7
Glenamong	5	35		9	18		7

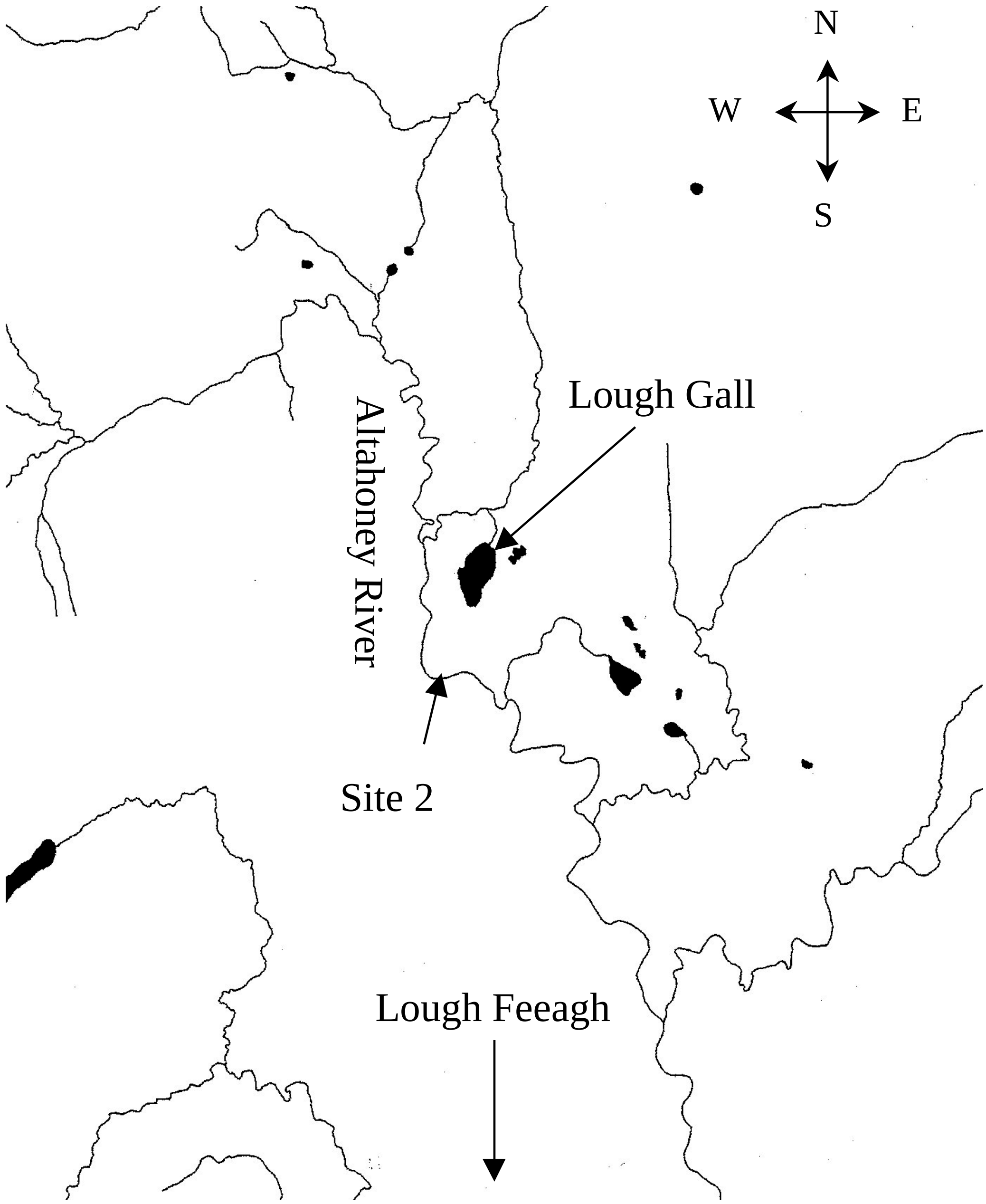

Figure 1. Location of sampling site on the Altahoney River, Burrishoole catchment where macroinvertebrates were sampled in 1966 and 2002.

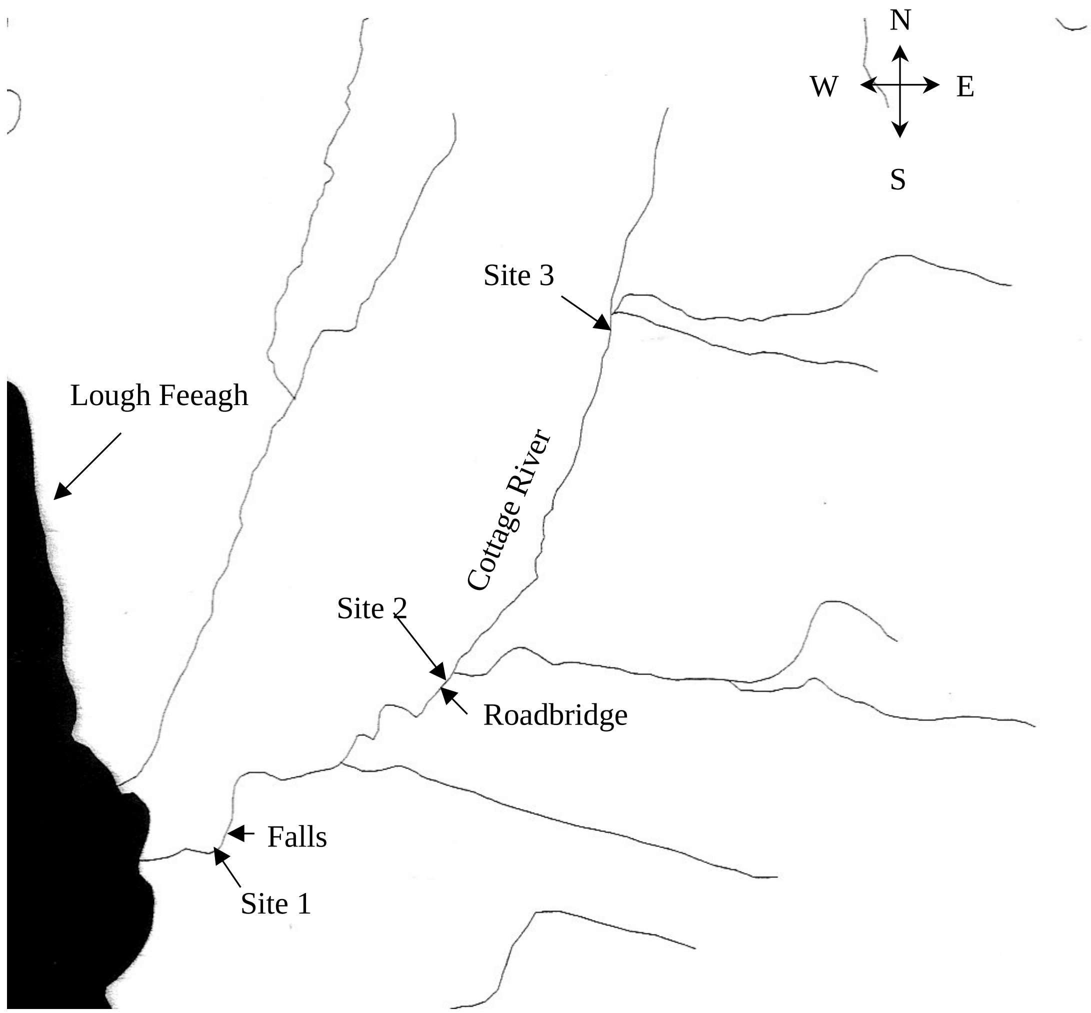

Figure 2. Location of sampling sites on the Cottage River, Burrishoole catchment where macroinvertebrates were sampled in 1964 and 2002.

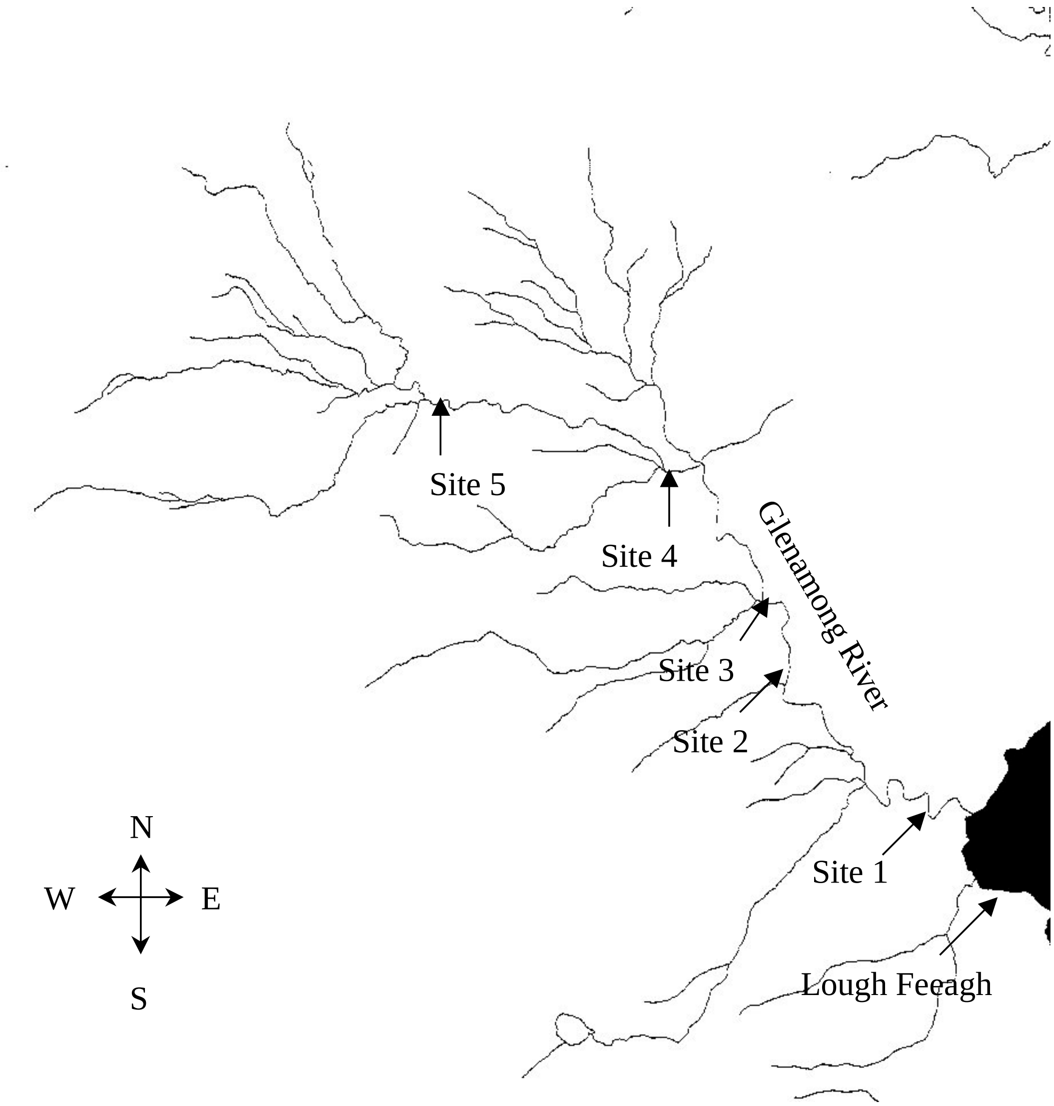

Figure 3. Location of sampling sites on the Glenamong River, Burrishoole catchment where macroinvertebrates were sampled in 1960 and 2002.

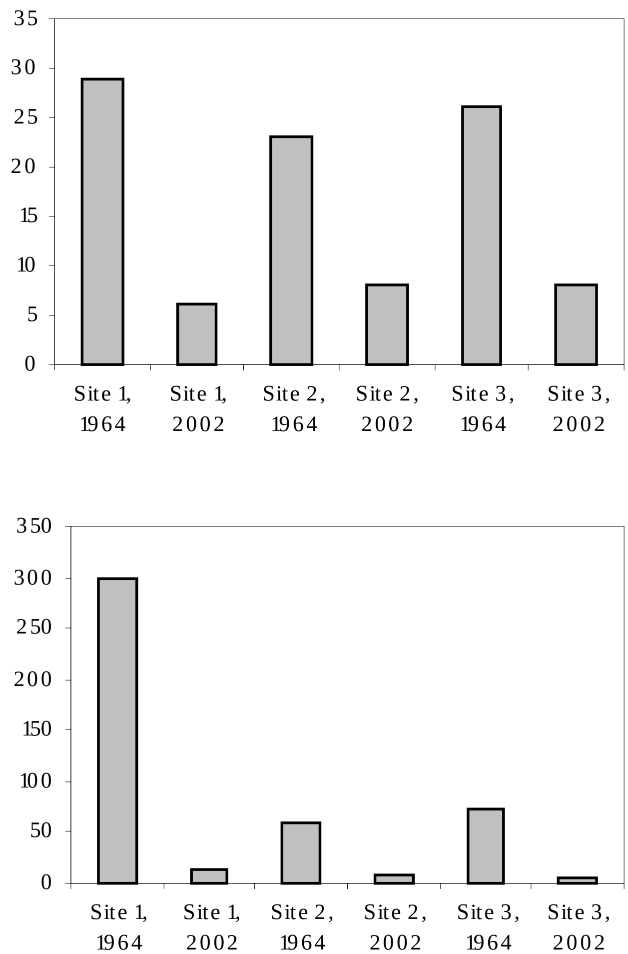

Figure 4. Total macroinvertebrate taxa (top) and abundances (bottom) per $0.1m^2$ sampled from three sites in the Cottage River in 1964 and 2002.

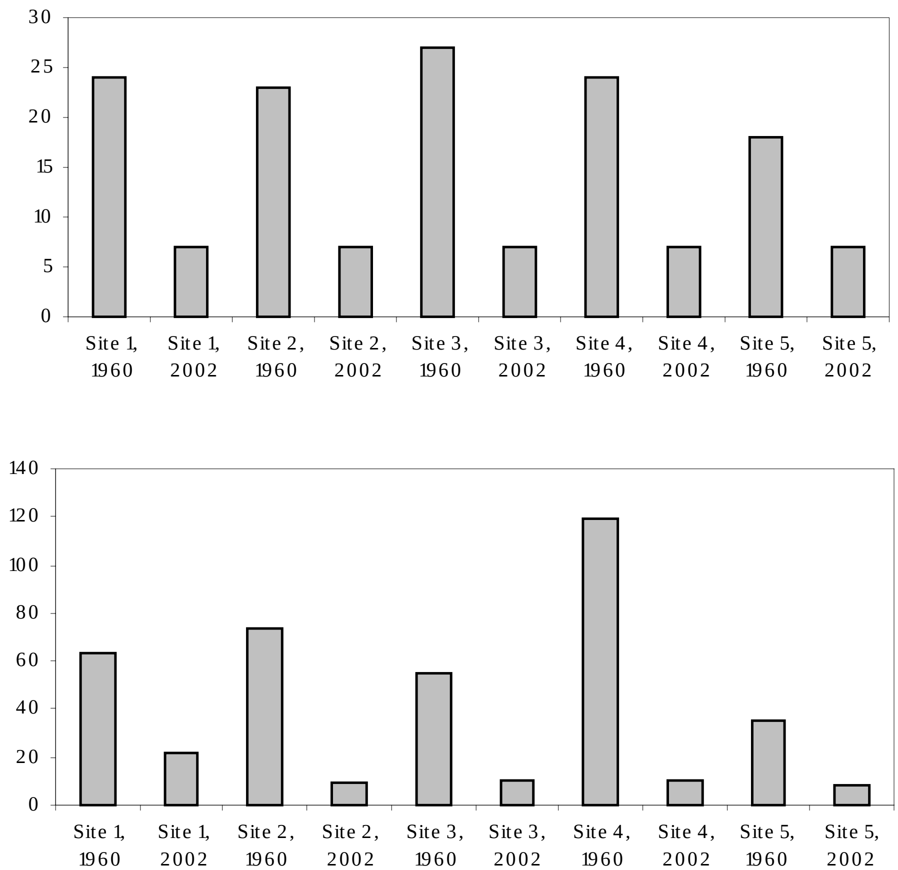

Figure 5. Total macroinvertebrate taxa (top) and abundances (bottom) per $0.1m^2$ sampled from five sites in the Glenamong River in 1960 and 2002.

Figure 6. Total macroinvertebrate taxa (top) and abundances (bottom) per 0.1m^2 sampled from one site in the Altahoney River in 1966 and 2002.

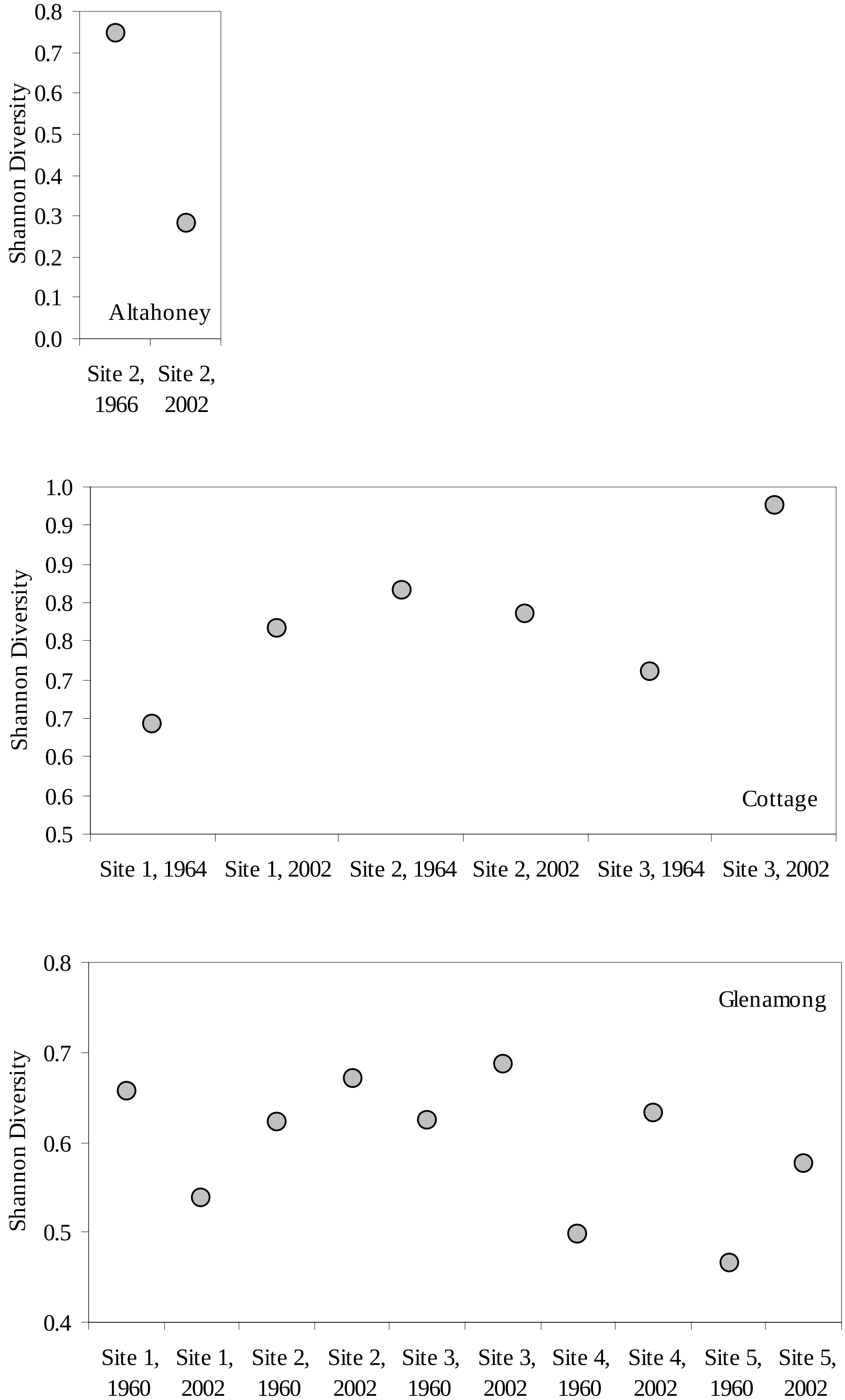

Figure 7. Shannon diversity of macroinvertebrates sampled from rivers in the Burrishoole catchment, 1960 – 2002.

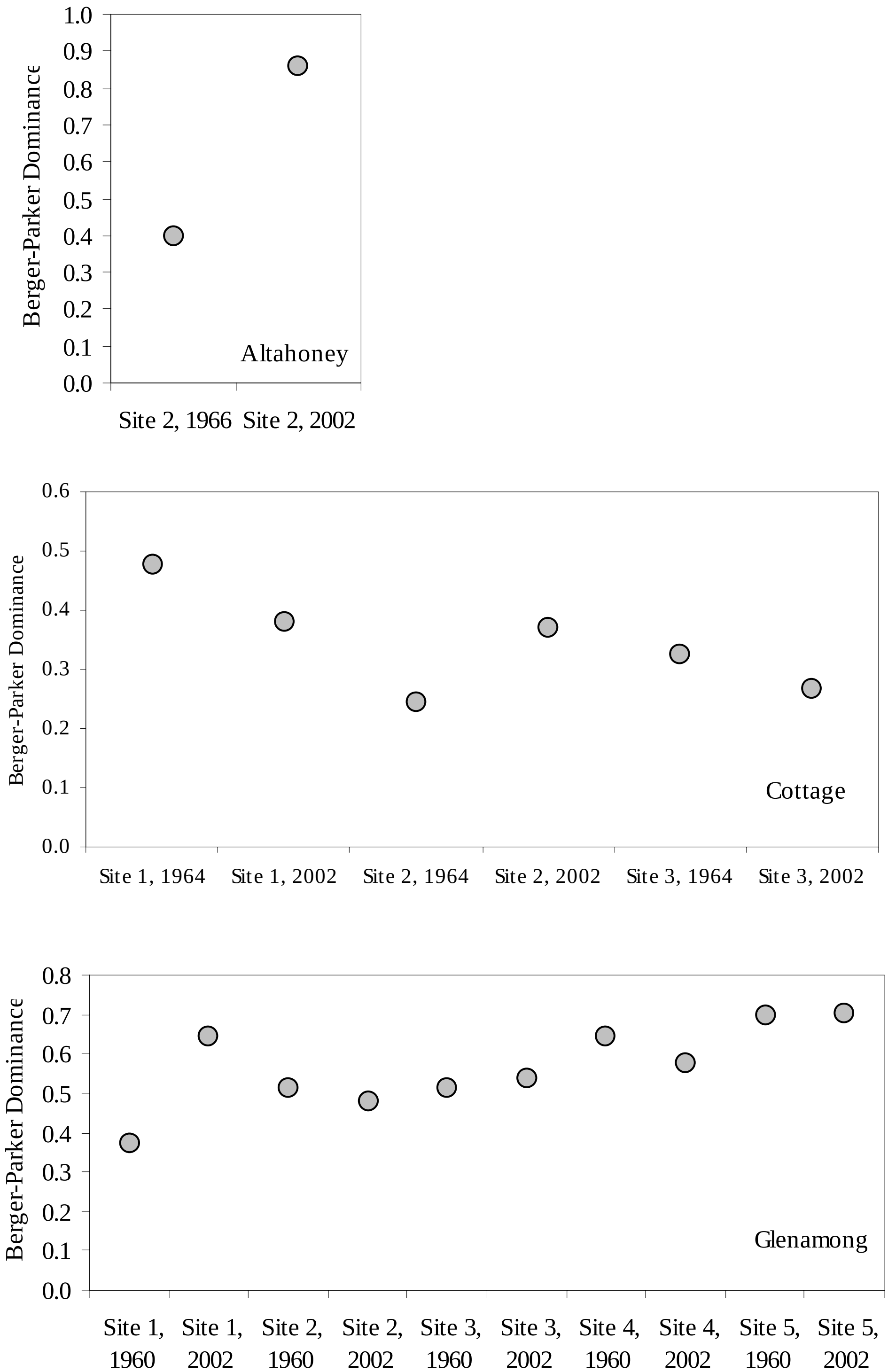

Figure 8. Berger-Parker dominance of macroinvertebrates sampled from rivers in the Burrishoole catchment, 1960 – 2002.

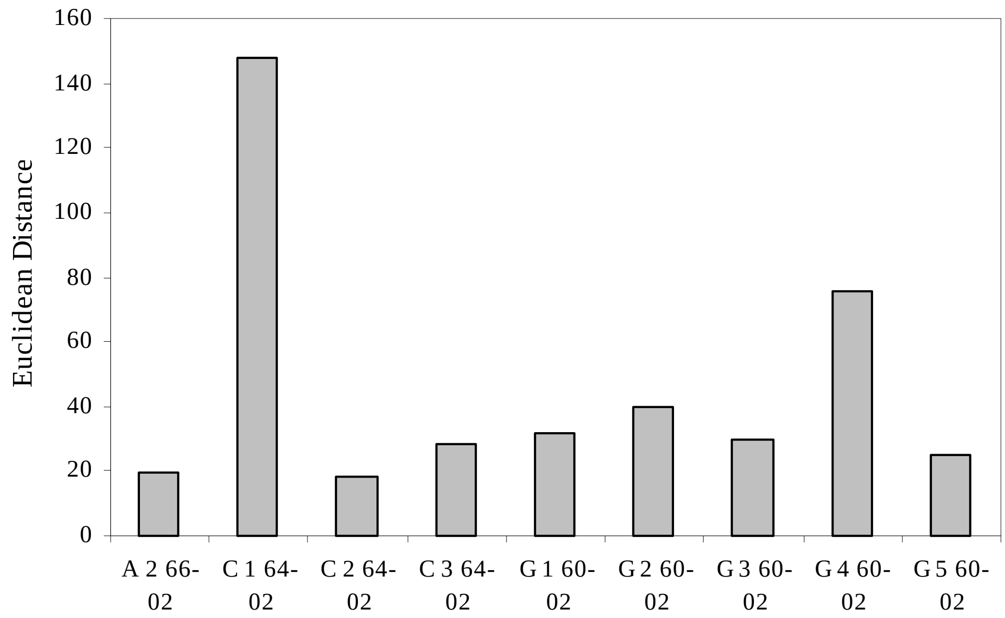

Figure 9. Euclidean distance (measure of dissimilarity) between macroinvertebrates sampled in three rivers in the Burrishoole catchment in the 1960's and 2002 (Altahoney - A, Cottage – C, Glenamong – G).

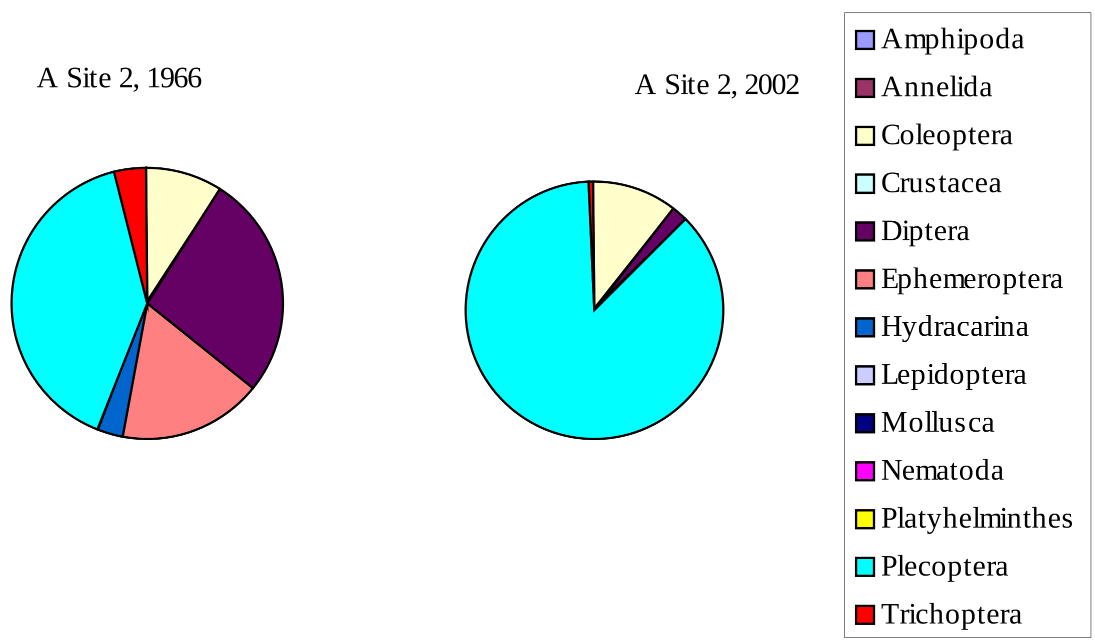

Figure 10. Relative proportions of macroinvertebrate taxa sampled from the Altahoney River in 1966 and 2002

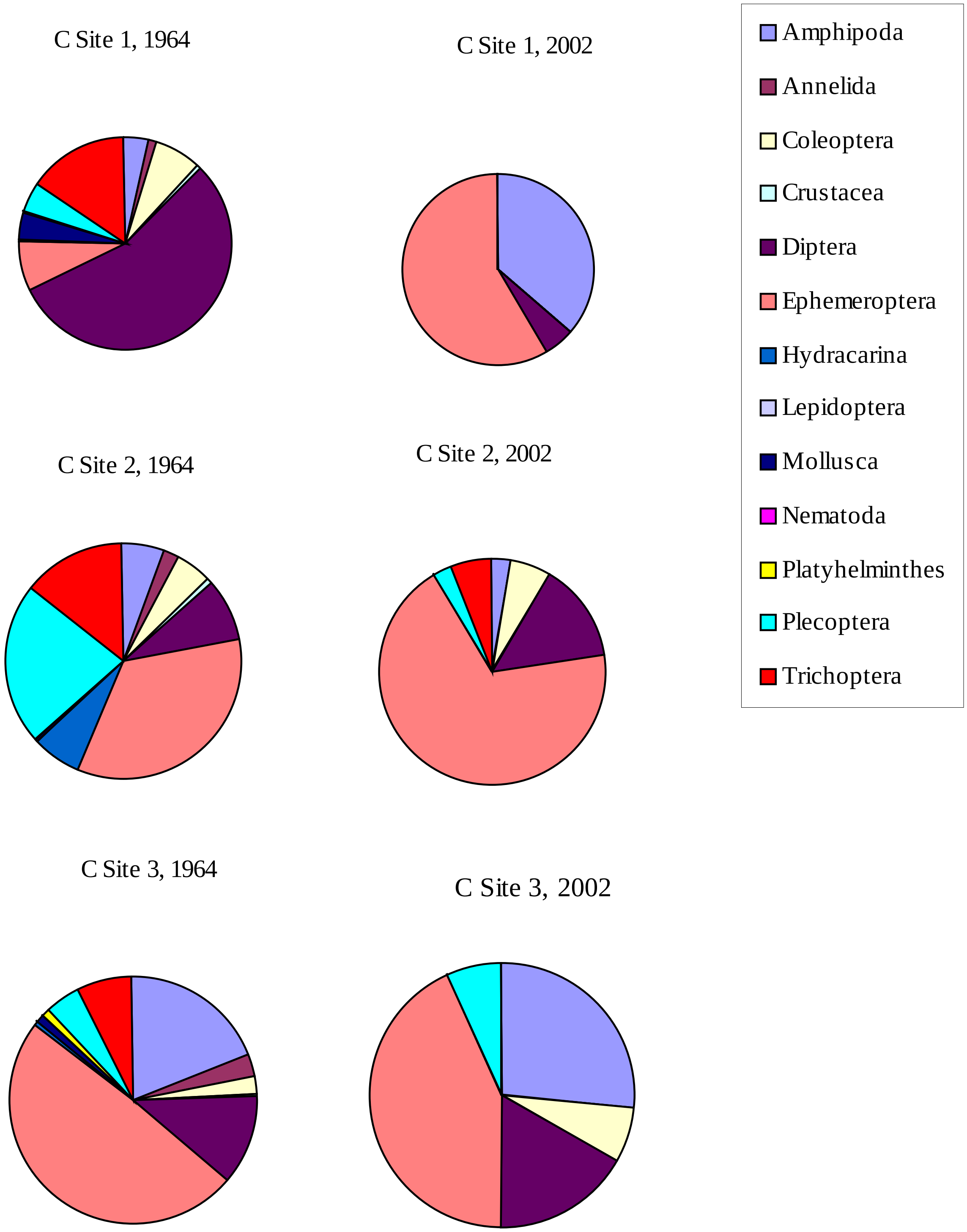

Figure 11. Relative proportions of macroinvertebrate taxa sampled from the Cottage River in 1964 and 2002.

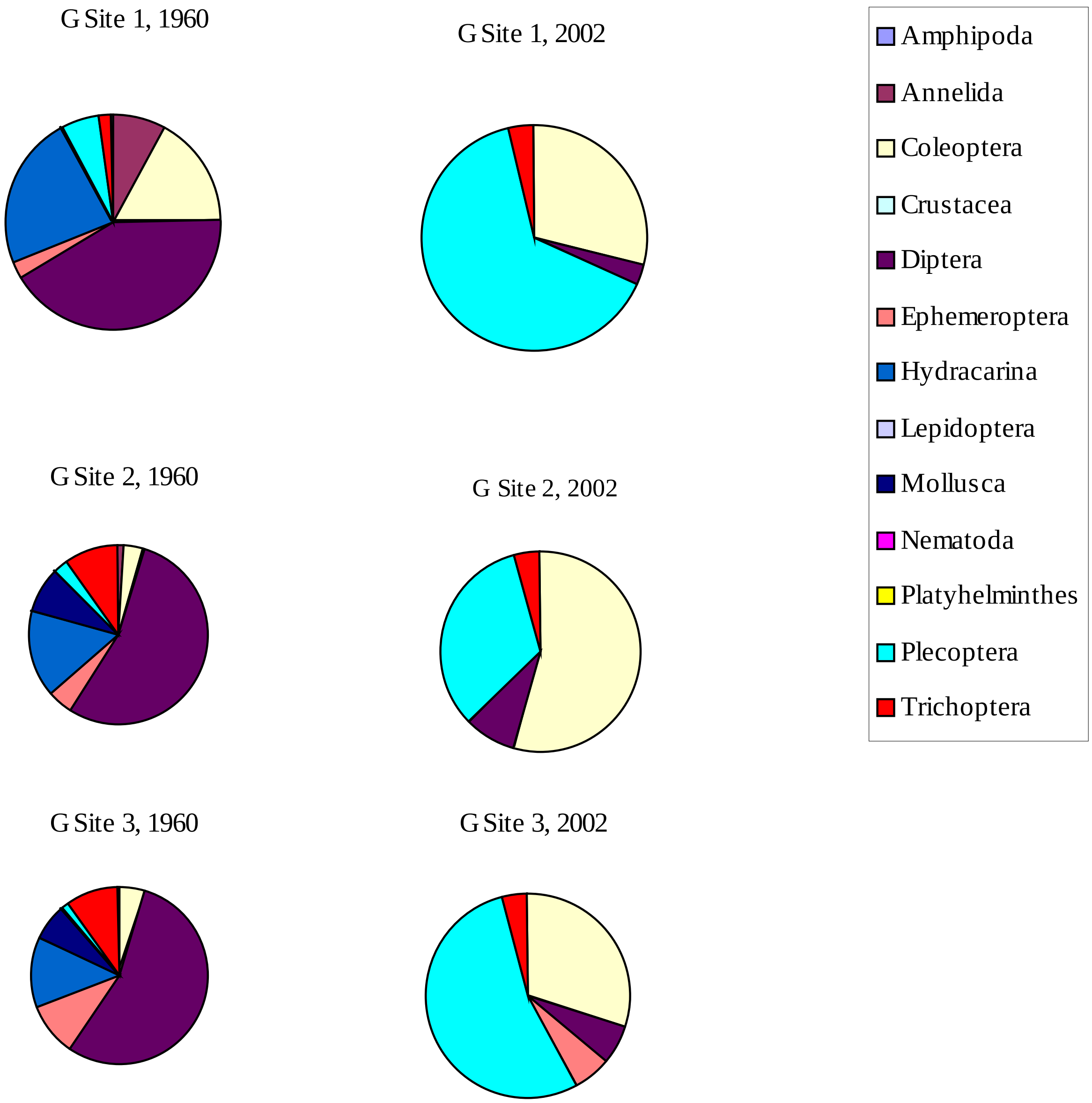

Figure 12. Relative proportions of macroinvertebrate taxa sampled from the Glenamong River in 1960 and 2002.

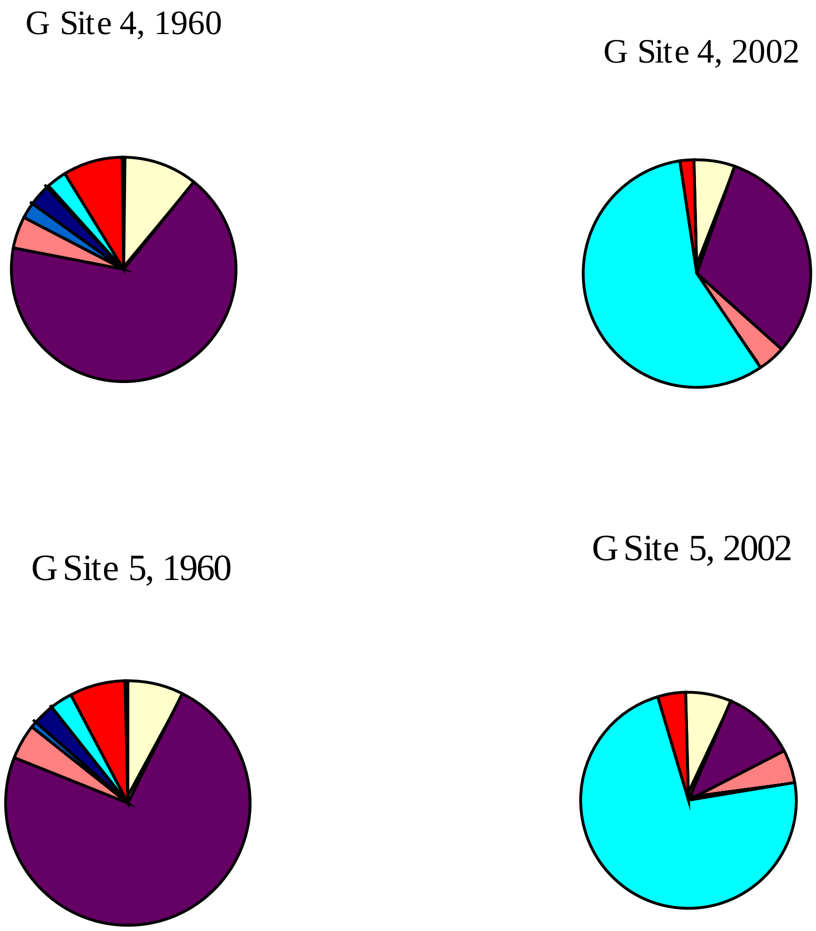

Figure 12 cont.. Relative proportions of macroinvertebrate taxa sampled from the Glenamong River in 1960 and 2002.

Appendix 2.

Macroinvertebrate Survey of rivers in the Burrishoole and Owengarve catchments, 2003.

Elvira de Eyto

Introduction

At the start of 2003, it was decided to formulate and implement a structured biological monitoring plan of the Burrishoole and Owengarve catchments, to complement the fishing surveys and physicochemical work that is carried out on an ongoing basis (*Long term plan for biological monitoring and assessment in the Burrishoole catchment, E. de Eyto, May 2003*). The primary focus of this plan consists of macroinvertebrate surveys of all the major rivers in the catchments, complemented by zooplankton, invertebrate and microcrustacean surveys of five lakes. Up until this year, a large amount of invertebrate work has been conducted in the Burrishoole catchment, albeit on a patchy, ad hoc basis. As a result, there is a lot of historical data and species records for the catchment, dating back to the 1950's. A preliminary survey of three rivers in the Burrishoole catchment (Glenamong, Altahoney and Cottage) carried out in 2002 highlighted major changes in the invertebrate communities between the 1950's and 2002 (*A historical comparison of the invertebrate fauna of the Cottage, Altahoney and Glenamong rivers, Burrishoole catchment, E. de Eyto, D. McLoughlin and T. Rooney, May 2003*). It was felt, therefore, that a long term monitoring programme was warranted, and would provide useful data against which catchment and climate change could be compared over the forthcoming decades. This is the first annual report on the river macroinvertebrate data.

Materials and Methods

Macroinvertebrate samples were taken from sixteen sites were sampled in May and June 2003. Two sites in each of the main Burrishoole subcatchments, and two sites in the Owengarve catchment were chosen (Fig. 1), and riffle / stoney areas were identified. At each site, measurements of temperature, oxygen, conductivity and pH were recorded (Table 1), as well as a GPS position. To sample the macroinvertebrates, three replicate 1ft sq surber samples were taken. Samples were stored in >70% IMS and sorted and identified using standard keys in the laboratory.

Results and Discussion

A total of 62 taxa were identified from the 16 sampling locations (48 samples in total). 45 of these taxa were identified to at least genera level, while some such as Oligochaetes and

Platyhelminthes were only taken as far as order (Table 2). Coleoptera, Diptera and Trichoptera were found at every sampling site, while Ephemeroptera and Plecoptera were found at all but one of the sites. Acari, Collembola, Mollusca and Platyhelminthes were rare (Table 3) at all sites. When the taxa lists are condensed into data at the level of Order, it is apparent that replication within a site is fairly consistent, with the three replicates from each site clustering close together (Fig. 2). In order to perform a cluster analysis, data was transformed (ln (x+1)), and a similarity matrix between samples was constructed using Bray-Curtis similarities. The replicates clustered even tighter together when the data is viewed at species level (Fig. 3).

Species data was then averaged across replicates for each site to give an overall picture of how the macroinvertebrates differ among subcatchments (Table 3). The only two sites from the same river that clustered together were site A and B on the Rough River. Otherwise, all other pairs of sites were separated on the cluster analysis (Fig. 4). It therefore makes sense to continue sampling at least two sites on each river, as it appears there are significant differences between the top and bottom sections.

There was quite large variation in the number of macroinvertebrates sampled from each location, which ranged from 10 individuals at Altahoney A to 90 individuals at Glendahurk A (Fig. 5). Shannon diversity indices ranged from 0.45 (Glenamong A) to 0.82 (Lodge B) when analysed at the level of Order (Fig. 6). The Shannon indices were obviously higher when calculated using data at the lowest taxonomic level. Some of the sampling sites that had medium levels of diversity at Order level had higher diversity at species level (Fig. 7). This highlights the need for consistent collating of data on an annual basis, which will hopefully be aided by the Access database that has been set up this year. In addition, every effort should be made to identify animals to species if at all possible.

Acid streams tend to have low taxa richness and diversity, be dominated by plecopterans and have low (if any) numbers of ephemeropterans and molluscs. These patterns were found to be true for the 16 sampling sites included in this survey. The sites where low pH was measured generally had lower taxa richness and diversity, and higher percentages of plecopterans (Fig. 8, 9 and 10). This confirms that the use of macroinvertebrates is warranted in monitoring the effects of acidification in these catchments. The 16 sampling sites are clearly split between those from areas of high conductivity (Rough, Lodge and Cottage Rivers) (>150 μscm^{-1}) and those from areas of low conductivity (<100 μscm^{-1}). The macroinvertebrate data reflects this physicochemical split, with significantly different macroinvertebrate assemblages occurring at high and low conductivities (ANOSIM test, global R = 0.265, P = 0.001). This difference is mainly owing to higher abundances of *Ephemeralla ignita*, *Baetis rhodani* and *Esolus parallelepipedus* in the high conductivity sites, and higher abundances of *Leuctra hippopus*, *Orthocladiinae* and *Limnius volckmari* in the low conductivity sites.

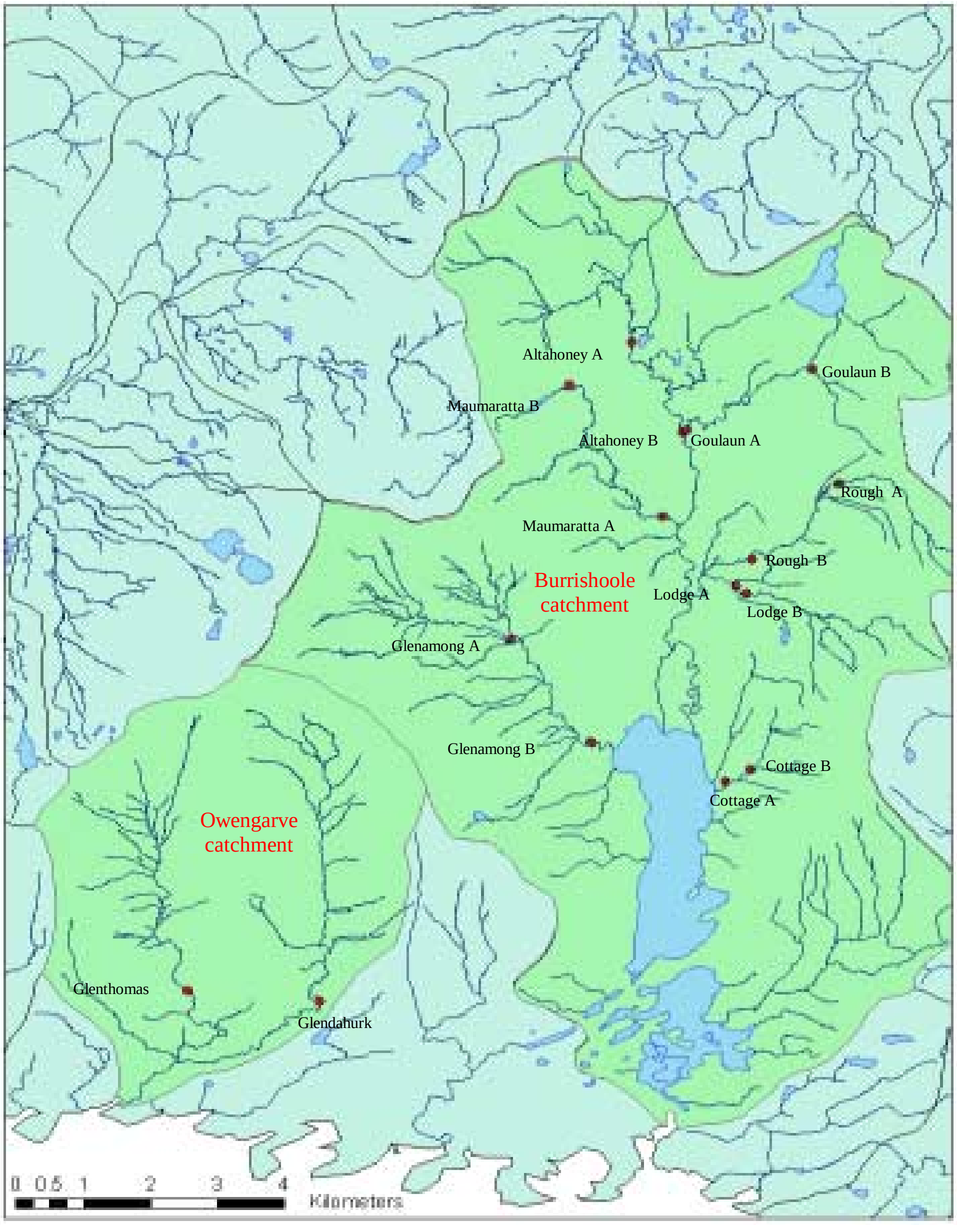

Figure 1. Macroinvertebrate sampling sites in the Burrishoole and Owengarve catchments included in the biological monitoring programs 2003.

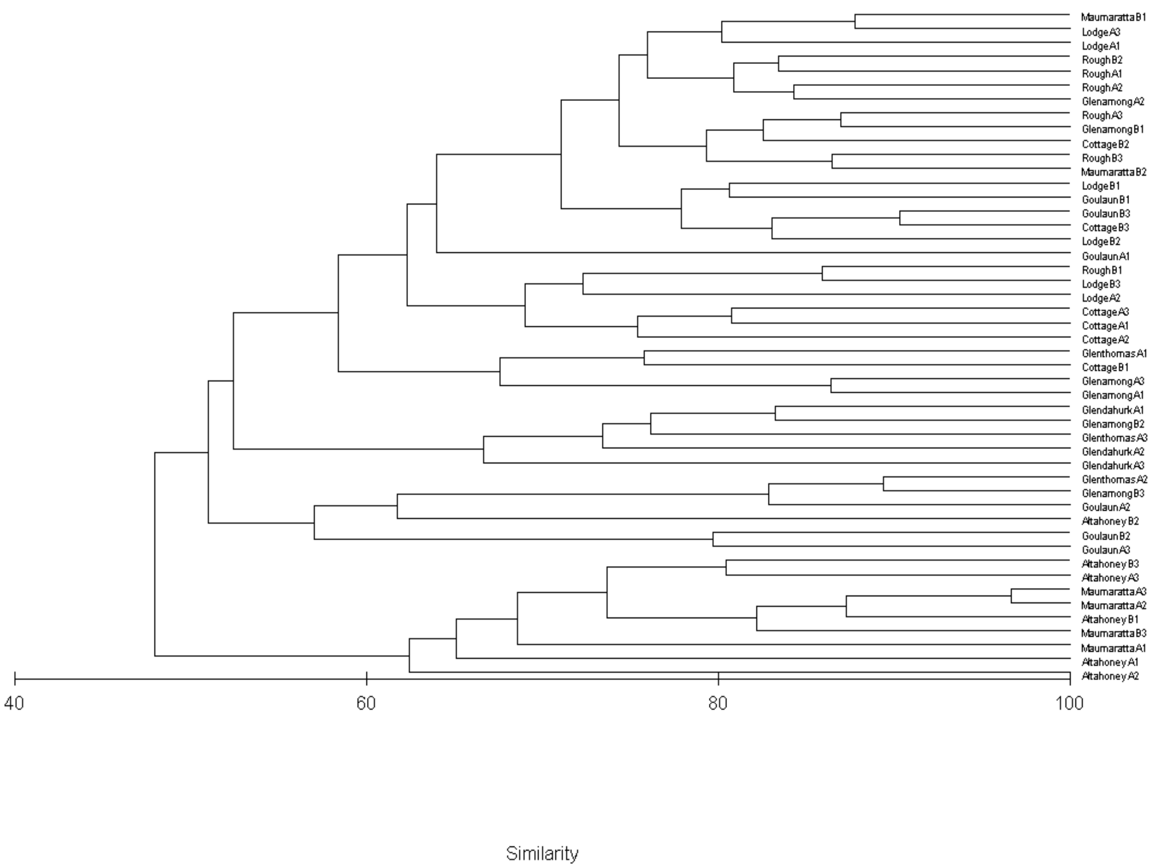

Figure 2. Cluster analysis of invertebrate data (at the level of Order) from 8 subcatchments in the Burrishoole and Owengarve catchments. Replicates for each site are numbered 1, 2 or 3. Similarities were calculated using the Bray-Curtis similarity measurement, on ln (x+1) transformed abundances.

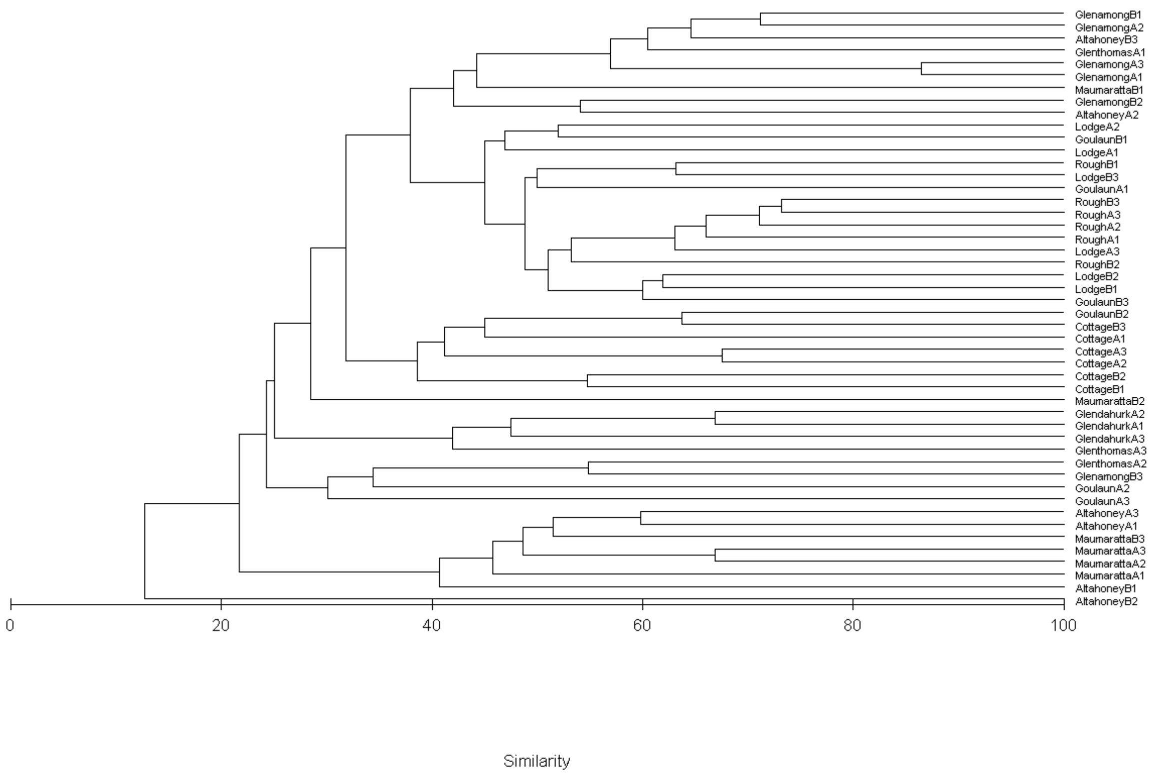

Figure 3. Cluster analysis of invertebrate data (at the lowest identified taxonomic level) from 8 subcatchments in the Burrishoole and Owengarve catchments. Replicates for each site are numbered 1, 2 and 3. Similarities were calculated using the Bray-Curtis similarity measurement, on ln (x+1) transformed abundances.

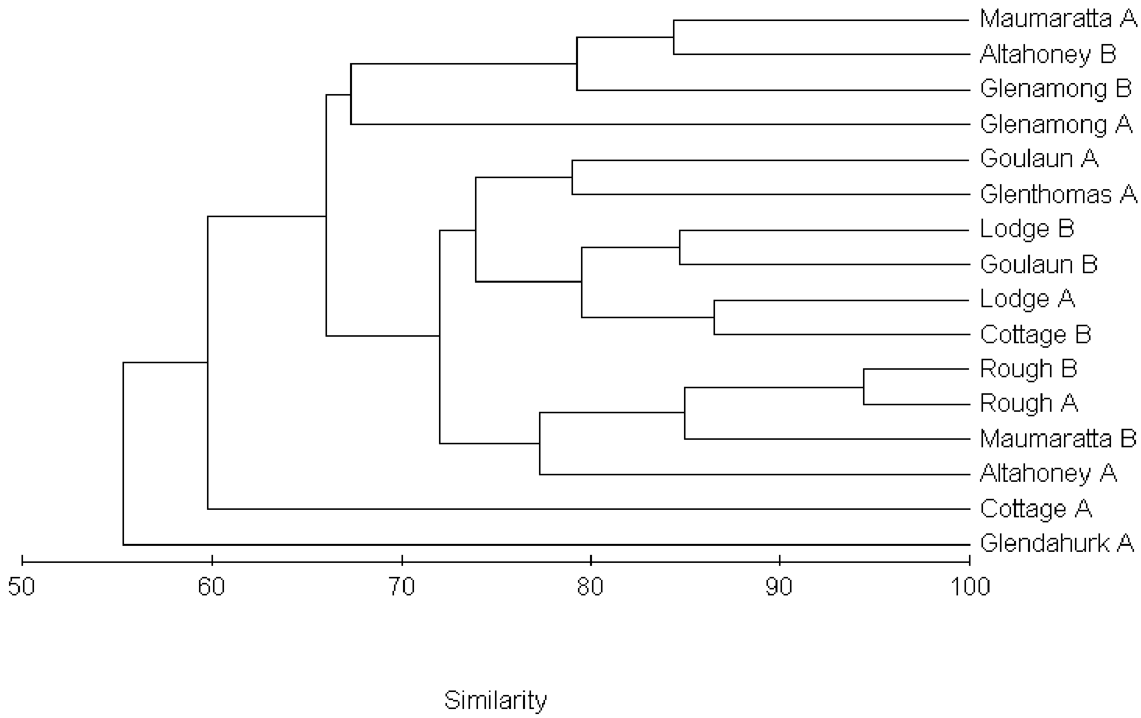

Figure 4. Cluster analysis of macroinvertebrate data collected from sites around the Burrishoole and Owengarve catchments, averaged over three replicates at Order level. Similarities were calculated using Bray-Curtis measurements.