THE RIVER CLYDE FISHERY MANAGEMENT PLAN 2009-2015

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Cover Photograph: The Falls of Clyde

The Clyde River Foundation is a registered charity, which researches the ecology of the Clyde and its tributaries, and promotes environmental education throughout the catchment.

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1 Introduction

This River Clyde Fishery Management Plan (RCFMP) has been produced by the Clyde River Foundation (CRF) using Scottish Government (SG) funding obtained via the Rivers and Fisheries Trusts of Scotland (RAFTS). It is the third of three documents, the previous two of which have described the physical structure of the catchment, what the CRF knows of its fish and fisheries resources (and the pressures acting upon them) and the fishery management structure currently in place (McColl *et al.* 2007 & 2008). This document is a digest of the information from its predecessors and describes the Foundation's proposed activities over the next five years to help deliver evidence-based environmental improvement and increased community involvement.

1.1 The Clyde River Foundation – what is it for?

The Clyde River Foundation is a registered Scottish charity (SCO29602) and a company limited by guarantee (SC196438) which researches the ecology of the Clyde and its tributaries, and promotes environmental education throughout the catchment (http://www.clyderiverfoundation.org). The Foundation was incorporated in 1999 and employed its first member of staff in 2002. The CRF currently employs four full-time scientists and is based in the Division of Ecology and Evolutionary Biology at the University of Glasgow (http://www.gla.ac.uk/faculties/fbls/eeb). The Foundation receives no routine core funding and is therefore reliant upon grant aid, project-based funding and contract work for much of its revenue. In the absence of steady income it has proven impossible thus far to avoid having to work where and when funding becomes available; much of our data collection has therefore been piecemeal and opportunistic. It is hoped that one of the outcomes of the RCFMP process will be a more strategic approach to survey work, and the realisation of the environmental improvements stemming from it.

The activities of the CRF could be described conceptually by the "conservation quartet" (http://www.wildcru.org) (Figure 1). Our *research* (including surveying) is designed to increase understanding of the Clyde system, to identify the magnitude of perceived problems and to contribute to their mitigation and resolution. We undertake *education* projects to promote and disseminate the knowledge we accrue, and we work with educational establishments to provide placement opportunities. Our primary foci for *community involvement* are schools and angling clubs, which are the end users of much of our data and information. We employ an Education Outreach Officer to co-ordinate and undertake work with educationalists, and a Fishery Management Planner to interface with the angling clubs and associations. This plan is the first stage towards the integration of what we know (there is still much to do) and the *implementation* phase of identifying mechanisms and projects to maintain and restore the ecology of the Clyde system and to increase public engagement with the river.

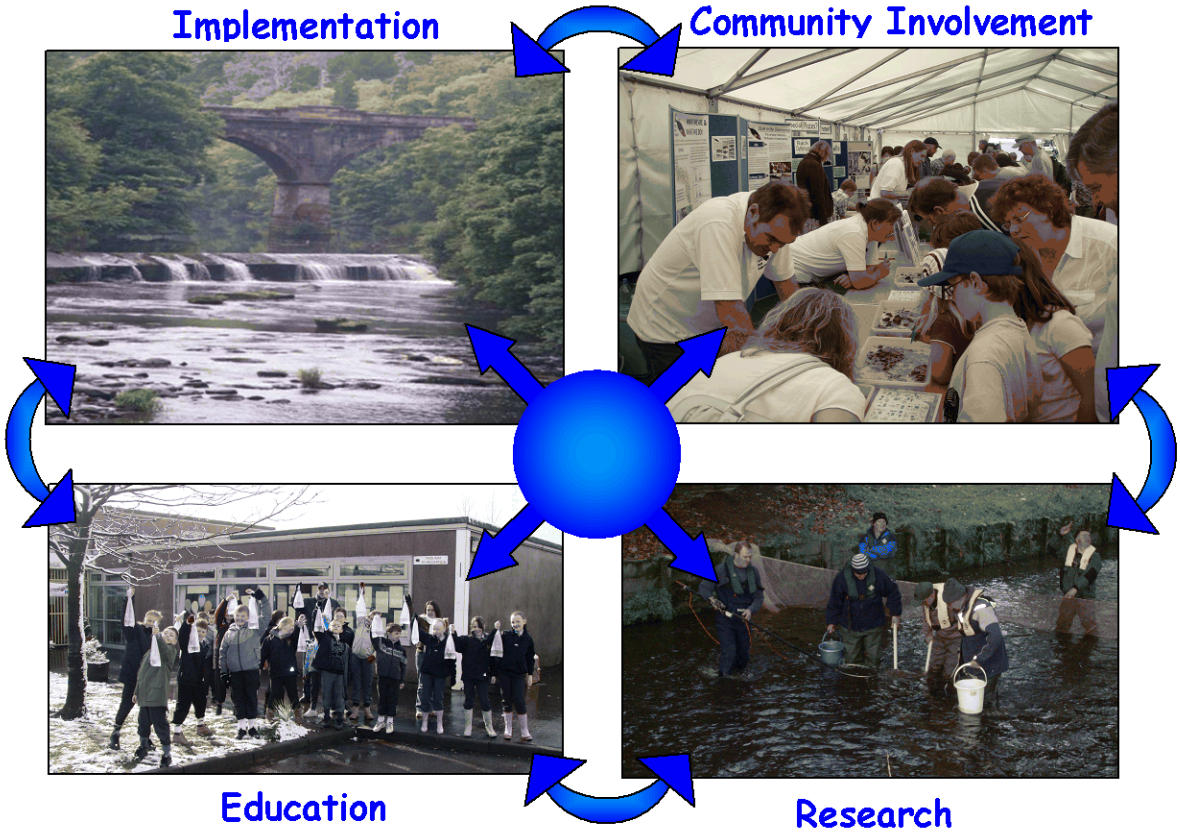

Figure 1 : The Conservation Quartet (http://www.wildcru.org)

Science to support environmental management…..

The Clyde River Foundation is not a statutory body and has no formal fishery management responsibilities; rather it works to support environmental managers by providing evidence-based scientific advice on fisheries science and freshwater biology. Our approach has been to remain strictly independent but willing to work with all potential users of the freshwater resource for the public benefit.

To date, much of our fishery science has been necessarily descriptive (literally trying to find out what lives where), so poorly was the Clyde fisheries resource known but this has evolved and established a framework of monitoring sites across the catchment, where high quality fishery data are collected annually. We have concentrated our scientific efforts on ensuring that the CRF is established as a credible source of information. Since 2002, we have collected fishery data by standard methods on 881 occasions from 555 different sites. We now expect to survey somewhere in the region of 250 sites per annum – this effort concentrated in a field season running from June-October – largely working on specifically-funded projects but maintaining a core network of sites which are monitored annually. The fisheries data are collected for local management purposes (e.g. to determine the inter-annual variation in salmon, trout or grayling production; to research the distribution of non-native species like bullhead and signal crayfish; to assess the requirement for, or efficacy of, fish passes; or as baseline surveys for a number of types of development).

The Clyde is a recovering river and water quality can still be an issue affecting the biota in some areas; the Foundation has therefore developed skills in water quality monitoring, primarily using invertebrate community analysis and employs a full-time biologist on various invertebrate projects.

The CRF can, therefore, undertake impact assessments using both fish and invertebrates and pursues both planned and *ad-hoc* research (and surveys) on various components of the biota. In areas where water quality is no longer the major limiting factor in fish production, fish communities have been demonstrated to recover naturally but man-made barriers to the passage of migratory species (salmon, sea trout, eel and lampreys) and physical alterations to the banks and beds of rivers are still having significant effects. There is considerable scope for river restoration across the RCFMP area and the CRF has initiated a programme of habitat surveys to describe the physical state of our rivers as a prelude to remediation.

The fisheries management structure present in the Clyde catchment is unusual. There is no statutory District Salmon Fishery Board covering the River Clyde and the CRF links the catchment to several national bodies and initiatives (i.e. Rivers and Fisheries Trusts Scotland; the Scottish Fisheries Co-ordination Centre; Fishery Management Planning; River Basin Planning). The CRF works closely with most of the riverine angling clubs in the Clyde and acknowledges their co-operation (and that of their umbrella body, the River Clyde Fisheries Management Trust) in the undertaking of the work leading to the production of this plan.

Education to increase public engagement**.....**

Since 2001, the Clyde River Foundation has undertaken several education initiatives; most notably "Clyde in the Classroom" with primary school and special needs children (and a small number of Secondaries) but also involving young adults with the Princes Trust, adult education initiatives and eco-day activities with charities, Councils and schools. We also give seminars to angling clubs and community groups to disseminate the findings of our scientific work.

Clyde in the Classroom, however, has so far been the cornerstone of our efforts to increase public engagement and is now extremely important to the survival and aspirations of the Foundation. The project has now involved 271 schools among the eight local authorities across the Clyde catchment (46.2% of the total number of primary schools in the river catchment). Some schools have participated several times; one in six different years. Since 2001, a total of 9423 children have participated in Clyde in the Classroom and a total of 10 293 children in all of our primary school education projects.

The CRF is currently addressing the need for a secondary school project to follow-on from Clyde in the Classroom, and also a direct development of the primary school project called "Meet Your River" which will involve more detailed study than is possible with the introductory project.

To encourage and support the current high level of interest by anglers in monitoring river water quality, the CRF is developing a programme of informal workshops to demonstrate sampling methods and fly life identification. We currently host a British Trust for Conservation Volunteers (BTCV) Natural Talent Apprentice who is studying riverflies and

who will make a contribution to these workshops, they will generate information on stoneflies, mayflies and caddis flies from the Clyde catchment.

We are hosted by the University of Glasgow and offer a number of undergraduate and postgraduate student projects annually, on any aspect of freshwater biology and/or fisheries science relevant to our work on the Clyde. The CRF currently supports and part-supervises a PhD student working on crayfish in Scotland and has previously researched potential crayfish control methods with Stirling University scientists.

The CRF also promotes appropriate training for volunteers from local angling clubs and associations who assist us in our survey work and we now have a pool of approximately 20 SFCC-qualified electrofishing personnel. We feel it is important that the anglers engage with our fisheries science and first-hand involvement in the act of surveying allows the volunteers to experience the process and to understand its advantages and shortcomings. Involved and interested anglers assist in the dissemination of our fisheries science.

All of our work aims to describe, protect and improve the ecology of the Clyde, firstly by ensuring that the CRF remains on a stable financial footing to enable progress to be made in turning scientific knowledge into environmental benefit and, in parallel, either initiating or contributing to projects designed to make a positive difference to the rivers and the people who live in the catchment.

1.2 Context and Scope:

The Clyde and its tributaries are slowly recovering from centuries of human impact, the major legacies of which for the biota are the effects of pollution, alterations to water flow and physical alteration of banks and beds. Many of the watercourses are heavily modified and there is considerable scope for environmental improvement across the catchment. This RCFMP covers the entire freshwater River Clyde and its tributaries (including the Carts and Kelvin), plus the smaller watercourses known as the Glasgow and Inverclyde Coastal Burns. The Clyde system has no specific conservation designation for any of its fish species, nor is there the money involved in angling and fishery management of the order seen elsewhere in Scotland but there are significant commercially and culturally important fisheries for salmon, trout, grayling and coarse fish across the catchment.

There is no District Salmon Fishery Board (DSFB) on the Clyde. There are a small number of salmon fishery proprietors throughout the catchment. Almost all of the salmon fishing rights are owned by the Crown Estate and are leased to a network of angling clubs, which manage the fisheries. These "water holding" angling clubs have the River Clyde Fishery Management Trust as their umbrella body. There are a small number of other riverine angling clubs which do not hold leases for migratory fish, and a currently unknown number of stillwater fisheries (game and coarse). There is a Protection Order in place on much of the main stem of the River Clyde upstream of Bothwell Bridge in Lanarkshire, overseen by a local liaison committee (McColl *et al.* 2008). A total of more than 20 sub-catchment fishery management units have been identified within the River Clyde catchment (McColl *et al.* 2008). There is, therefore, considerable heterogeneity in the fishery management structure and scope for harmonisation across the Clyde system.

1.3 Development:

Scotland's freshwater fisheries are a major contributor to the socio-economic and recreational well being of the country. Strategic management of this resource has been identified as a priority: "Scotland will have sustainably-managed freshwater fish and fisheries resources that provide significant economic and social benefits for its people" (The Scottish Government 2008). There is strong recognition by Government and the private sector that effective catchment-based fisheries management is key to ensuring fish stocks and fisheries are managed and developed sustainably (The Scottish Government 2008).

This RCFMP has been prepared using the Scottish Fisheries Co-ordination Centre template (http://www.sfcc.co.uk/index.asp). While the CRF has no direct responsibility for fisheries management, it has an important role in providing scientific information to support management of fish stocks in the Clyde catchment and will make recommendations for management actions where accrued knowledge warrants it. Additionally, as one of the few bodies working catchment-wide, the CRF is well-placed to provide informed comment on the state of its fish and fisheries.

The RCFMP has evolved over three years. In 2006 the CRF was contracted to provide information on the local distribution of salmon, salmon stocking and obstacles to salmonid migration to the Scottish Government via Fisheries Research Services (FRS) (now Marine Scotland).

In 2007, the CRF followed this up with an inventory of resources, information and current fish and fishery management activities on the Clyde (McColl *et al.* 2007). An updated report was produced which contained additional information on factors limiting fish production and fishery performance, potential management actions, data and research requirements, personnel management and available resources, and budgets (McColl *et al.* 2008) again under contract to FRS. The information was obtained from face-to-face meetings and a questionnaire survey to the majority of major practical fishery management stakeholders in the Clyde catchment between November 2007 and February 2008.

The key themes which were identified by the fishery managers in 2007/08 and the proposed activities of the CRF to address them (subject to funding becoming available) are presented in this document. The RCFMP will provide a focus for sustainable fishery management across the Clyde catchment. Essentially, the RCFMP will draw together relevant local information about the current status of the resource and recommend actions to improve management, develop sustainable practices and ensure conservation of fish stocks.

1.4 Implementation:

Monitoring of the RCFMP is vital to the successful implementation and the delivery of its objectives. The RCFMP will be reviewed annually by the CRF, with a major review once every three years; necessary modifications shall be made when appropriate (including at short notice to take advantage of funding or partnership opportunities). Priorities for action are likely to change over time as new issues arise and as progress is made towards implementing the recommendations. We currently envisage the RCFMP planning cycle as that shown in Figure 2.

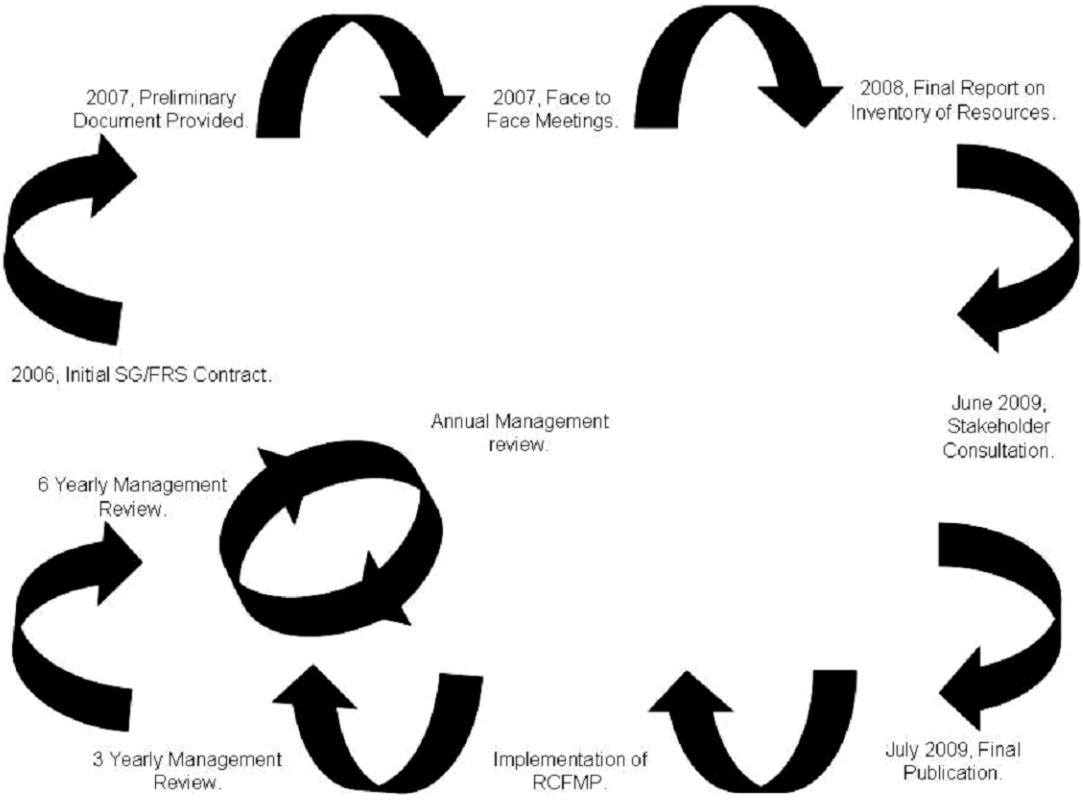

Figure 2: The RCFMP Development and Planning Cycle

1.5 Other Plans

It is acknowledged that this fishery management plan does not exist in isolation; there are several major planning initiatives underway throughout the region, as well as the operating procedures of major stakeholders, which will impact upon possible outcomes from the RCFMP. Local authority initiatives include the Glasgow and Clyde Valley Structure Plan, Local Development Plans and the Glasgow and Clyde Valley Green Network. Land use issues are dealt with by the Scottish Rural Development Plan and Forestry Management Plans. The Quality and Standards Plans produced by Scottish Water deal with water management issues through planned programmes of work.

The draft Clyde Area Management Plan, co-ordinated by SEPA and a sub-plan of the draft River Basin Management Plan for the Scotland River Basin District (Water Framework Directive) have informed the development of the RCFMP; the CRF is represented on the Clyde Area Advisory Group and the RCFMP planning cycle is aligned to that of the Water Framework Directive.

Salmon, lampreys, brown trout and sea trout, eels and freshwater habitats are important in conservation and biodiversity terms. We will continue to work where possible with Local Biodiversity Action Partnerships to help inform and prioritise their project planning and implementation processes. The relevant plans for the Clyde area are: the Inverclyde, Renfrewshire and East Renfrewshire LBAP; the Glasgow City LBAP, Dunbartonshire LBAP, and North and South Lanarkshire LBAPs.

Several of the water holding angling clubs have management plans in place or in preparation. Any made available to the CRF will contribute to the annual assessment of the RCFMP.

1.6 Aims and Objectives:

The aim of this RCFMP is to describe an aspirational programme of works covering an initial three year period from 2009-2012, which will then be critically reviewed before the final three year period of work is completed in 2015. Development of the plan subsequent to 2015 will be guided by the progress made during this initial period. The aim of the implementation phase of the RCFMP is to ensure that resources are focused on areas likely to deliver measurable outcomes (e.g. providing passage for migratory species or generating baseline data where none exists). While we remain focused on long-term goals, we recognise the importance of detailed planning in the shorter term and the RCFMP aims to prioritise requirements for action and outline necessary actions to safeguard the Clyde's freshwater fishery resources by addressing primarily the concerns of the fishery stakeholders.

For example, a key aim of the CRF recognised within the RCFMP is the promotion of the scientific management of fish stocks. While our work to date (funded from a large number of, mainly private, sources) has increased knowledge of certain species and geographical areas, we still have considerable work to do to complete the catchment baseline survey initiated in 2002. Scientific management of the fishery resource will only be possible when its extent and magnitude are documented and understood. Some of the information held by the CRF and has been described in two previous documents (McColl *et al.* 2007 & 2008). The value of the data we already possess will be significantly enhanced when funding is secured to complete the task.

Objectives have been grouped as "organisational", "scientific" and "educational". These objectives are evolving and their description, priority and status are shown in Tables 1-3. Organisational objectives are those necessary to ensure that the CRF continues to participate fully in both catchment-based and national initiatives (Table 1). Scientific objectives relate to the work necessary to generate information on the rivers and fish populations across the catchment (Table 2). Educational objectives refer to projects which will increase public understanding of the River Clyde and its ecology (Table 3). The delivery mechanisms for the scientific and educational objectives are described in Section 5.

1.6.1 Organisational Objectives

We believe strongly that the best interests of the RCFMP will be served by evidence-based fishery management backed up by high quality data collected by trained, experienced scientists. It therefore follows that maintaining the current establishment and status of the CRF is key to progressing the Scientific and Educational objectives within the RCFMP. The Organisational objectives necessary for this are shown in Table 1.

Table 1: Organisational Objectives

Objective	Description	Priority	Status
1.1	To secure sufficient funds to maintain the Clyde River Foundation as a going concern throughout the period of the RCFMP.	Highest	Ongoing
1.2	To maintain an appropriately trained and skilled workforce throughout the period of the RCFMP.	High	Ongoing
1.3	As a consequence of Objective 2, to maintain continuity and the "corporate memory" of the CRF so that it might contribute to catchment-based and national initiatives throughout the lifetime of the current RCFMP and beyond.	High	Ongoing
1.4	To maintain continuity of tenure and accommodation at the University of Glasgow.	High	Ongoing
1.5	To maintain membership by subscription of Rivers and Fisheries Trusts Scotland and the Scottish Fisheries Co-ordination Centre, thereby ensuring that the Clyde catchment is represented in national fora and accrues the benefits of representation by these bodies.	High	Ongoing
1.6	To maintain a RAFTS presence on the Clyde Area Advisory Group for the Water Framework Directive River Basin Management Plan.	High	Ongoing
1.7	To formalise the relationship between the CRF and the major stakeholders in the RCFMP area by establishing and providing a Secretariat for a "River Clyde Fishery Management Partnership".	Medium	No progress.
1.8	To produce a CRF Operations Manual.	Medium	Ongoing.
1.9	To produce an annual scientific report.	High	Ongoing.
1.10	To work in partnership with all potential users of the freshwater fisheries resource to secure the best environmental outcome for RCFMP area.	High	Ongoing

1.6.2 Scientific Objectives

Scientific fishery management relies upon up-to-date information on the relevant stocks being available. Collecting and disseminating this information is time consuming and expensive work but can deliver significant environmental benefits. The RCFMP provides a structure for delivering management actions from its scientific objectives, which are described in Table 2. **The rationale for each scientific objective is described in Section 5.1.**

Table 2: Scientific Objectives

Objective	Description	Priority	Status
2.1	To complete a comprehensive spatial survey of the fish communities and populations of the River Clyde catchment, Glasgow Coastal Burns, and Inverclyde Coastal Burns.	Highest	Ongoing
2.2	To establish and maintain a network of core temporal fishery survey sites across the RCFMP area.	High	Ongoing
2.3	To ensure that each subcatchment management unit, once surveyed comprehensively, is re-surveyed in full at least once every five years.	High	Ongoing
2.4	To undertake comprehensive fish habitat surveys throughout the RCFMP area, and to determine the quality and quantity of habitat available.	High	Ongoing
2.5	To use data accrued from spatial and temporal fishery surveys and habitat surveys to drive environmental improvements throughout the RCFMP area.	High	Ongoing
2.6	To develop and maintain an awareness of riverine fishery resources throughout the RCFMP area (salmon, sea trout, trout, grayling and coarse fisheries).	Medium	Ongoing
2.7	Develop and maintain an awareness of the still water fishery resources throughout the RCFMP area (trout and coarse fisheries).	Medium	Ongoing
2.8	To develop and maintain an awareness of fishery performance (migratory and non-migratory) throughout the RCFMP area.	Medium	Ongoing
2.9	Develop co-operative studies on stillwater fish populations and provide management advice upon request.	Low	Ongoing
2.10	Generate improved knowledge of the life cycles, production and stock structure of salmon and sea trout across the RCFMP area.	Medium	Ongoing
2.11	To disseminate the findings of our routine monitoring to angling clubs annually.	Medium	Ongoing
2.12	To develop and retain in-house knowledge of invertebrate community ecology, including the use of macroinvertebrates, especially riverflies, as indicator organisms.	Medium	Ongoing
2.13	To develop and retain in-house knowledge of aquatic and riparian plant biology, with a view to better understand its	Medium	Ongoing

	role in the production of fish species and also to quantify the occurrence of invasive, non-native riparian plants (Japanese knotweed, Himalayan balsam, giant hogweed and skunk cabbage) with a view to their possible control.		
2.14	To increase our knowledge of invasive, non-native animal species and their effects on the native biota of the catchment. This work will lead to the development of a biosecurity plan for the Clyde catchment as part of a RAFTS/SNH national initiative.	Medium	Ongoing
2.15	To develop and retain in-house knowledge of survey techniques for mammals (particularly otter, mink and water vole) to allow us to contribute to wider riparian surveys.	Low	No progress
2.16	To ensure that our surveying activities are co-ordinated with those of SEPA.	High	Ongoing

1.6.3 Educational Objectives

Successful fishery management outcomes are achieved by a well-informed and engaged local community across all age and stakeholder groups. The educational objectives shown in Table 3 represent a systematic campaign of awareness raising and provide opportunities for community involvement in the RCFMP.

Table 3: Educational Objectives

Objective	Description	Priority	Status
3.1	To deliver a programme of education projects across eight local authority areas (Glasgow City, West Dunbartonshire, East Dunbartonshire, North Lanarkshire, South Lanarkshire, East Renfrewshire, Renfrewshire and Inverclyde).	Highest	Ongoing
3.2	To seek sponsorship to develop and deliver Objective 3.1	High	Ongoing
3.3	To continue to increase community involvement in our work by increasing the number of volunteering opportunities.	High	Ongoing
3.4	To continue to increase community involvement by raising awareness of the work of the CRF at public events and by giving presentations.	Medium	Ongoing
3.5	To mentor the BTCV Natural Talent Riverfly Apprentice	Medium	Ongoing
3.6	To develop an efficient method for disseminating progress reports to members and beyond.	Medium	Little progress.
3.7	To develop an interactive website to allow online delivery of education projects.	Medium	No progress.

2 Catchment Description

2.1 Management Units:

The geographical extent of the RCFMP area is shown in Figure 3. The major subcatchments of the RCFMP area are shown in Figure 4 and the 20 angling clubs responsible for river management in the area are shown in Figure 5 (there is one additional angling club – Hosier AC – which manages fishings between New Lanark to Easter Sills Farm on the River Clyde but we have been unable to establish contact with a representative). The fine-scale management of the system is complicated in some areas by the presence of several angling clubs in a single subcatchment, sometimes with different management philosophies. The CRF has always worked to the hydraulic boundaries of the subcatchments, and these are considered here as the "management units" for the purpose of the RCFMP (Figure 4). This does not compromise the practical fishery management boundaries of the angling clubs. There is a significant unit boundary among the areas above and below Stonebyres Falls (the limit of penetration by migratory species) on the main stem of the River Clyde (Figure 4).

Little is known of the areas of the RCFMP which are not managed by angling clubs (i.e. the Glasgow and Inverclyde Coastal Burns); they may be fished to some extent, and some may contain significant fish populations. One of the aims of the RCFMP is to gather comprehensive information on these watercourses.

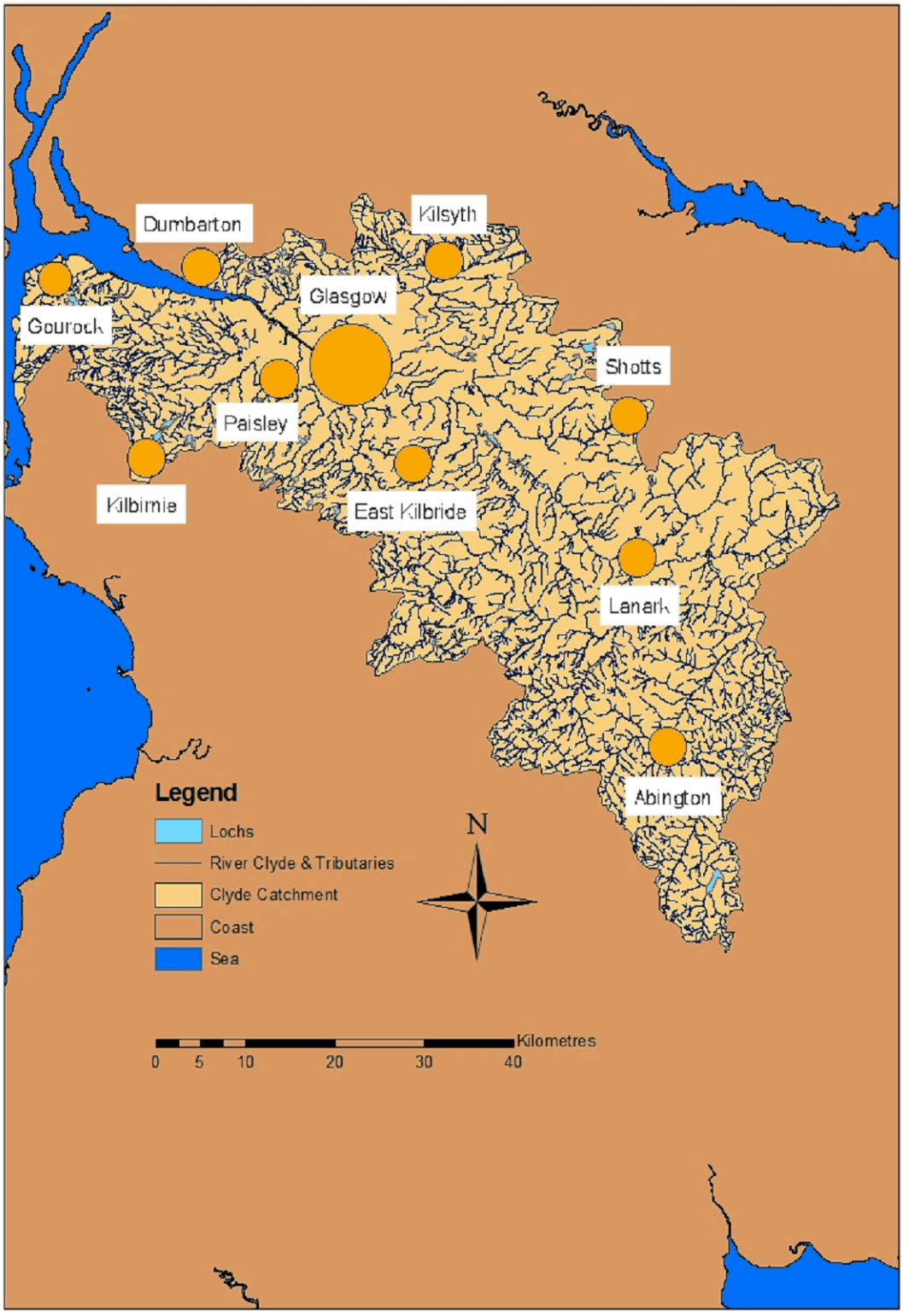

Figure 3: The Geographical Area covered by the RCFMP

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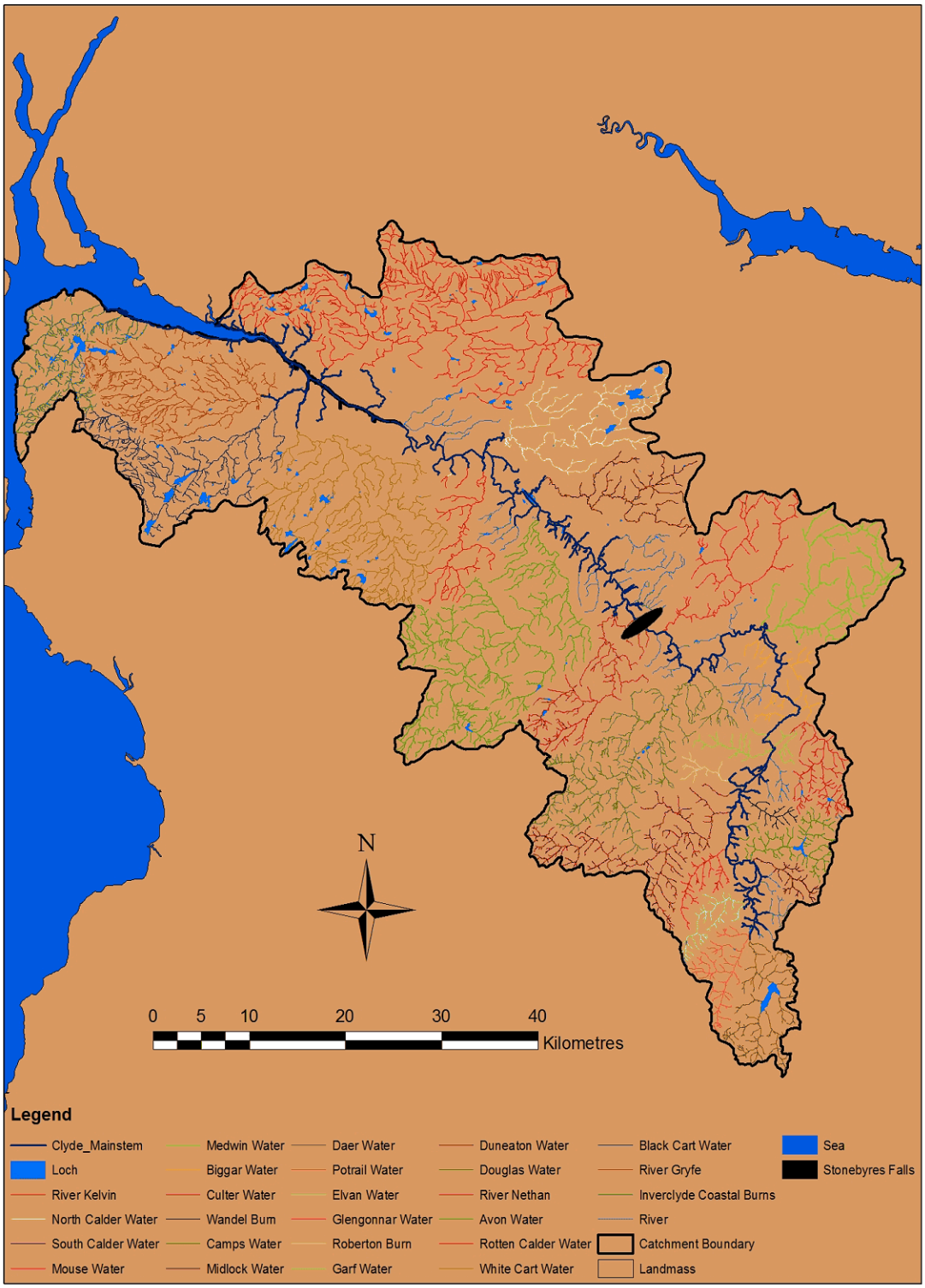

Figure 4: The Major Tributary Systems Covered by the RCFMP (key to rivers to be read clockwise from the Kelvin, at top)

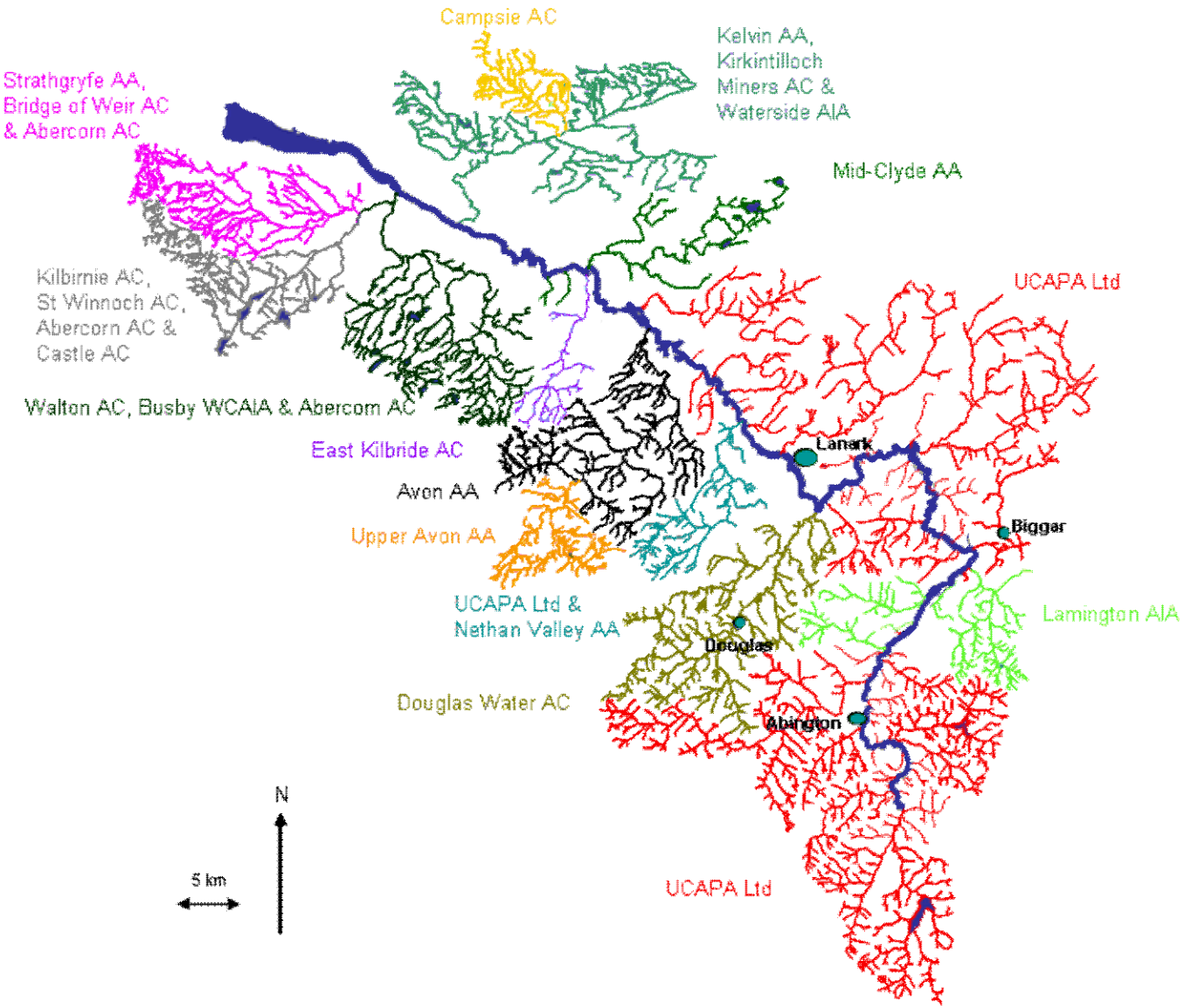

Figure 5: Angling Clubs with Riverine Fishery Management Responsibility

2.2 Topography:

The River Clyde, at 170 km, is the third longest river in Scotland (Figure 3). The catchment has a surface area of 3,200 km^2 (of which 26.3 km^2 is freshwater lochs and reservoirs), and a total river length of 4,244 km. The River Clyde catchment crosses the boundaries of ten Council areas: East Dunbartonshire, East Renfrewshire, Glasgow City, Falkirk, Inverclyde, North Ayrshire, North Lanarkshire, Renfrewshire, South Lanarkshire and West Dunbartonshire; and these are home to 34.3% of Scotland's human population (2005 figures) (McColl *et al.* 2008).

The source of the River Clyde has at least four potential locations, depending upon the perspective and purpose of the determination. Historically the source of the River Clyde was taken to be that of the Clydes Burn, which rises at an altitude of 460m in the vicinity of Beattock summit in South Lanarkshire. However, since this small watercourse joins the more substantial stream formed by the confluence further south of the Daer and Potrail Waters many geographers now regard the Daer Water as the source of the Clyde (Martin 1999). The Daer Water rises at an altitude of 550m in the north-east slope of Gana Hill (http://www.geo.ed.ac.uk/scotgaz/features/featurefirst3510.html). Culturally the River Clyde appears in name only where the Daer Water, the main stream, is joined by the Clydes Burn near Crookedstane Farm, south of Elvanfoot (Macleod & Gilroy 1991). The altitude of this possible source of the River Clyde is 270m. The source for biological purposes is regarded by the CRF (Dodd *et al.* 2005) and others as that of the Potrail Water because (unlike the Daer Water) it suffers no impoundment and is the most typical burn to consider as the source for ecological modelling (MacPhee 1969; Maitland 1980).

Over its course, the Clyde is joined by tributaries of various sizes and qualities. It flows through greatly contrasting landscapes, from afforested uplands, over the fertile farmlands of Clydesdale and finally through industrialised areas such as Glasgow.

The River Clyde meanders from Elvanfoot to Crawford and Coulter, around Tinto Hill to Thankerton, northwards toward Carstairs and then south-west to Hyndford Bridge. After passing Hyndford Bridge the Clyde turns north and accelerates into and over the Falls of Clyde near Lanark; Dundaff Linn, Corra Linn and Bonnington Linn and Stonebyres Falls (Macleod & Gilroy 1991). Stonebyres Falls are the natural upstream limit of salmon, sea trout, eels and migratory lampreys in the main stem of the River Clyde. Below the falls, the river crosses a landscape of market gardens, garden centres and orchards between Crossford and Garrion Bridge (Martin 1999).

The course of the river was altered to create the artificial loch within Strathclyde Park between Motherwell and Hamilton. The river then flows through Blantyre and Bothwell. Below Uddingston and into the southeast of Glasgow the river begins to widen, meandering a course through Rutherglen, the limit of tide near Dalmarnock, and into Glasgow city centre. Flowing past Glasgow Green and the tidal weir, the river is artificially straightened and widened through the city. From there, it flows west past Govan, Partick, Whiteinch, Scotstoun and Clydebank. Further west, the river flows past Renfrew, under the Erskine Bridge and past Dumbarton on the north shore to the sandbank at Ardmore Point between Cardross and Helensburgh. Oppposite, on the south shore, the river continues past Port Glasgow to Greenock where it reaches the Tail of the Bank as the river merges into the Firth of Clyde. The major tributaries of the River Kelvin (from the north) and the Carts (from the south)

enter in the tidal section, and the River Leven carrying the outflow from Loch Lomond flows in from the north at Dumbarton.

2.3 Rainfall, Hydrology and Flows:

River flows are determined by rainfall, catchment area and topography. There are some impoundments in the headwaters of the Clyde and Carts in particular that are of sufficient magnitude to alter river flows, either by abstracting water or by balancing flows to reduce flashiness in times of high rainfall. Average rainfall across the Clyde catchment is in excess of 1000mm/year, and the annual totals for the Meteorological Office rain gauge at Paisley between 1959 and 2008 are shown in Figure 6. The mean annual rainfall for this site is approaching 1200mm.

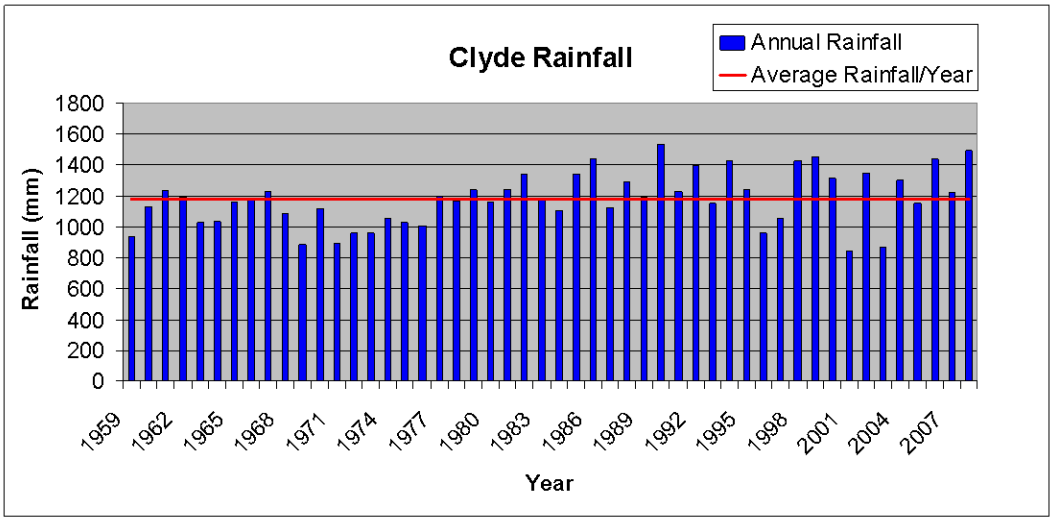

Figure 6: Rainfall totals for Paisley, 1959 - 2008

SEPA operates a network of river gauging stations across the Clyde catchment and example data are shown for the River Clyde at Daldowie (Figure 7). The flow pattern is typical of temperate, rain-fed rivers, i.e. the wettest months are December and January and the driest months are June and July, and these are reflected in river flows.

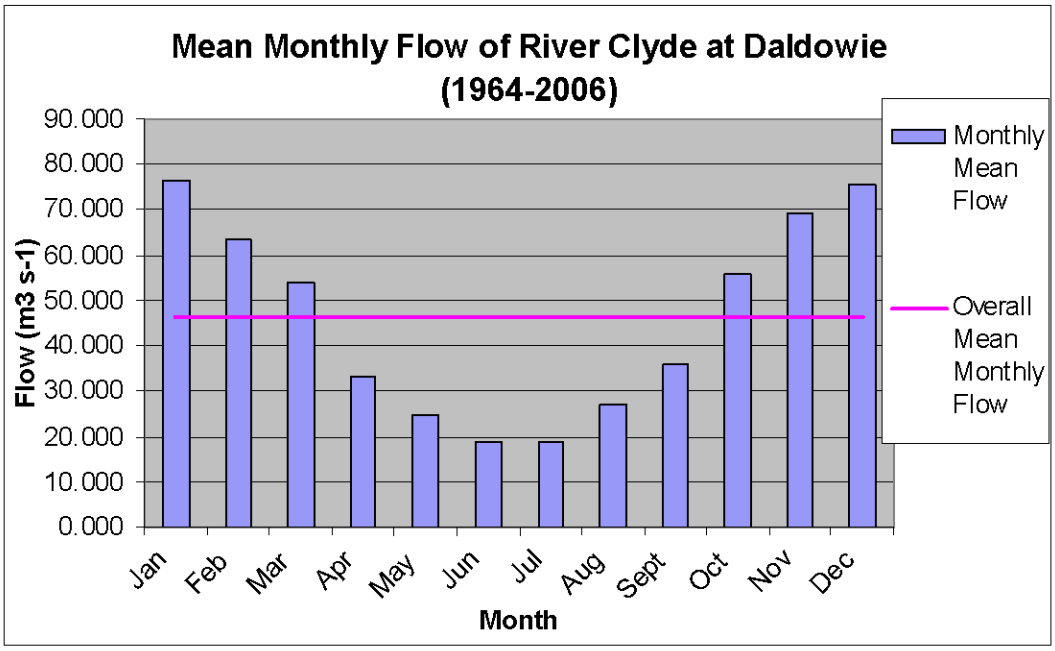

Figure 7: Example flow pattern – River Clyde at Daldowie

The rainfall and mean and low flows from five gauging stations towards the foot of the catchment are given in Table 4. The key issue concerning flows relevant to fisheries are the extremes; very high flows in winter may destroy spawning habitat or wash out eggs and/or alevins and very low flows in summer which may reduce fry and parr habitat greatly, as well as causing difficulties with high temperatures and low oxygen levels leading to fish mortalities.

Table 4: Long-term Mean Water Flow at Five SEPA Gauging Stations in the Lower Clyde Catchment.

Gauging Station	Catchment Area (km^2)	Mean rainfall (mm)	Mean Flow (m^3/s)	Q95 (Low water flow) (m^3/s)
River Clyde @ Daldowie	1903.1	1129	47.87	9.712
River Kelvin @ Killermont	335.1	1257	8.45	1.625
White Cart Water @ Hawkhead	234.9	1314	6.73	0.851
Black Cart Water @ Milliken Park	103.1	1788	4.70	0.422
River Gryfe @ Craigend	71.0	1824	4.22	0.269

2.4 Altitude:

The most elevated sections are to the far north (Campsie Fells), and south of the catchment (small areas in excess of 600m) (Figure 8). The majority of the catchment north of the southern upland fault is below 300m altitude, with most of land in proximity to the main stem below 100m. The northern periphery of the catchment rises steeply to 500m+ and this is the northern edge of the Scottish Midland Valley (McColl *et al.* 2008).

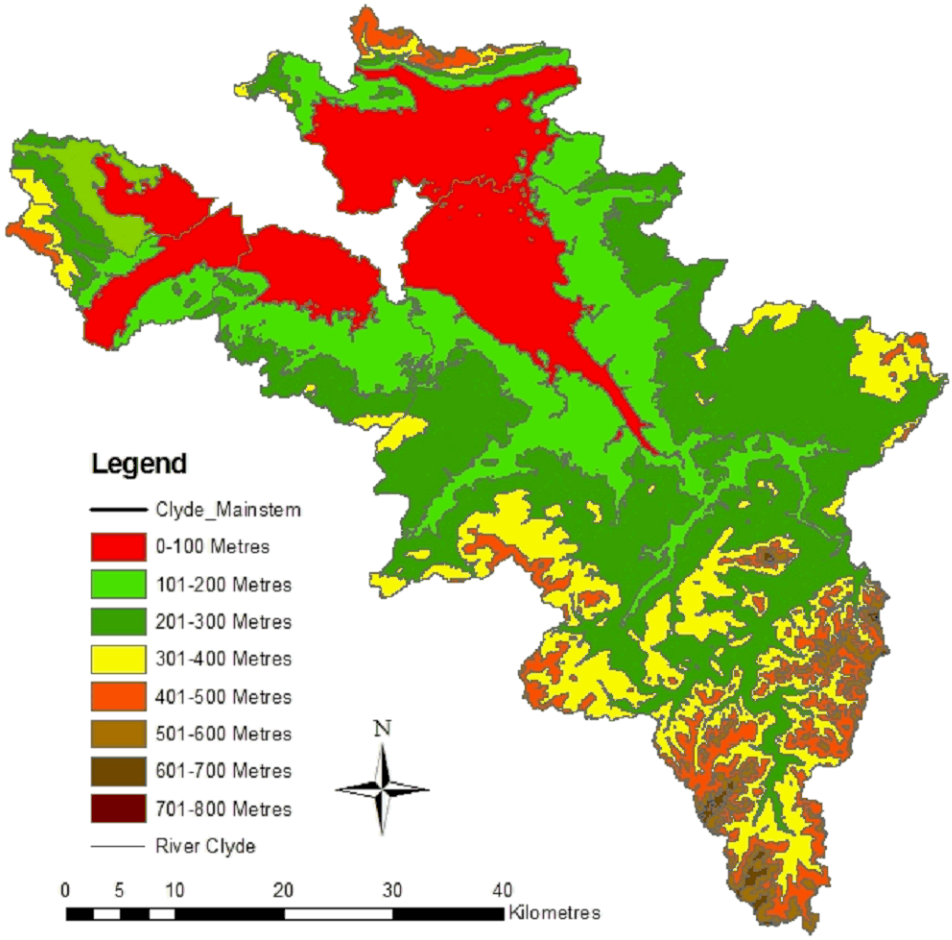

Figure 8: Altitude of the Clyde Catchment

Derived from OS 1:50,000 Panorama data with the permission of the controller of Her Majesty's Stationery Office © Crown copyright).

2.5 Geology and Soils:

Outcrops of Old Red Sandstone are common in the Scottish Midland Valley (Figure 9). Closer to the northern and southern margins Old Red Sandstone rocks are thick and very coarse, typically boulder beds and conglomerates. Toward the centre of the Midland Valley, the grain size decreases and conglomerates give way to finer sandstones and siltstones (Gillen 2003). Extensive deposits of glacial sand and gravel; found in Lanark, Carstairs and Carnwath, made Clydesdale a major producer of sand and gravel (Martin 1999).

In the Midland Valley, Carboniferous rocks form important landscape features such as the Campsie Fells, Kilpatrick Hills, Renfrewshire Heights and the Gargunnock Hills. Equally important are the volcanic plugs that now form prominent landmarks such as Dumbarton rock. The volcanic rocks, together with the widespread sandstone, limestone and coal deposits, mean that Carboniferous rocks underlie most of the Midland Valley. They cover the Old Red Sandstone and Devonian rocks, except near the Highland Boundary Fault and the Southern Upland Fault (Gillen 2003).

The geology of the northern section of the catchment, from Lanark towards Kilsyth and Glasgow is dominated by Westphalian coal. The Southern Uplands have weathered into rounded hills, covered in most places with grass. Much of this land is used for sheep farming, but on the lower slopes more intensive agriculture is carried out. The Clyde estuary, the underlying carboniferous rocks (containing coal and iron) and the fertile agricultural soil have combined to make this a very densely populated area

The overlying "soft" geology (i.e. soils) of the catchment is dominated by glacial till with areas of raised marine deposits. There are some mosaics of alluvium, glacial sand and gravel. The extremities of the catchment have significant areas of superficial peat (Figure 10).

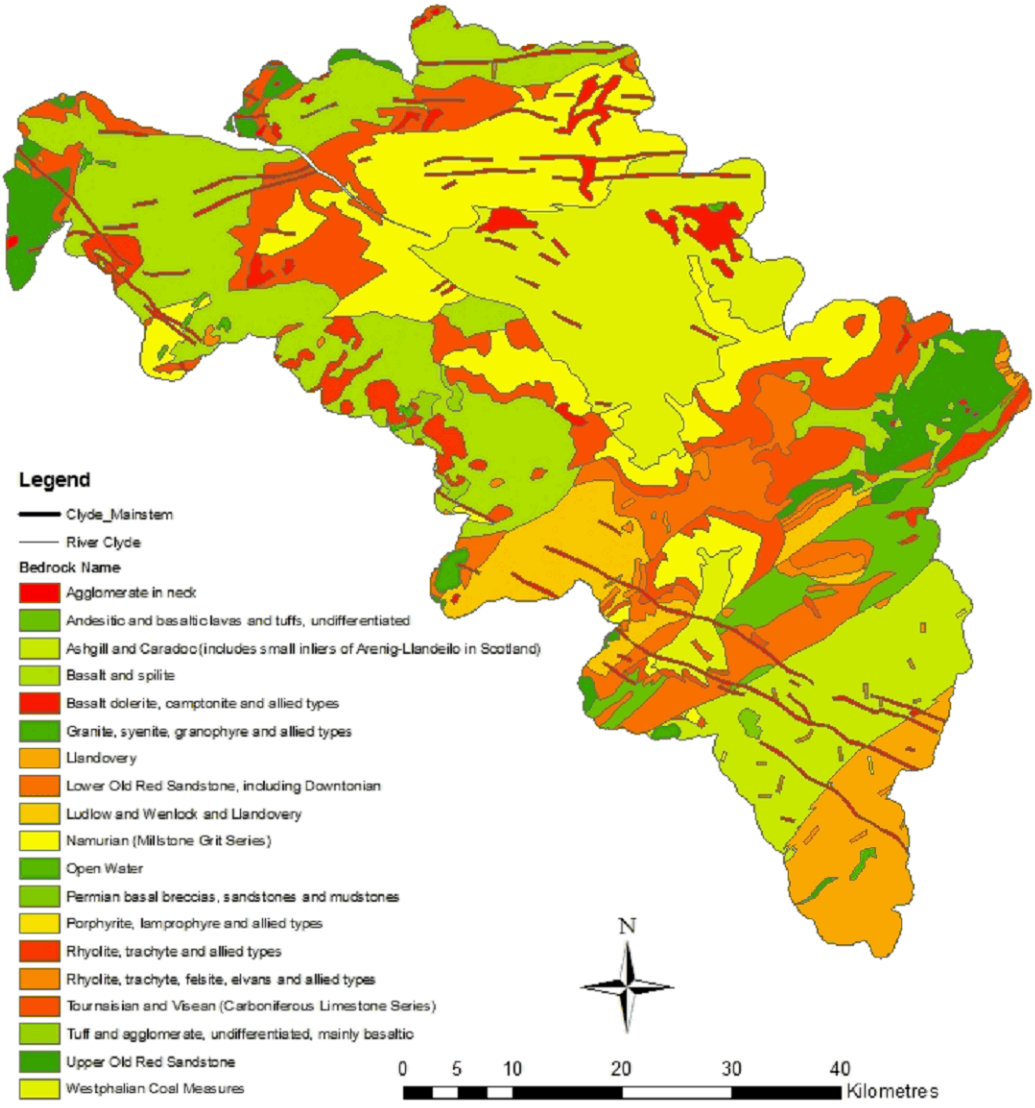

Figure 9: Geology of the Clyde Catchment

'Geology, BGS 1:625,000, © NERC.'

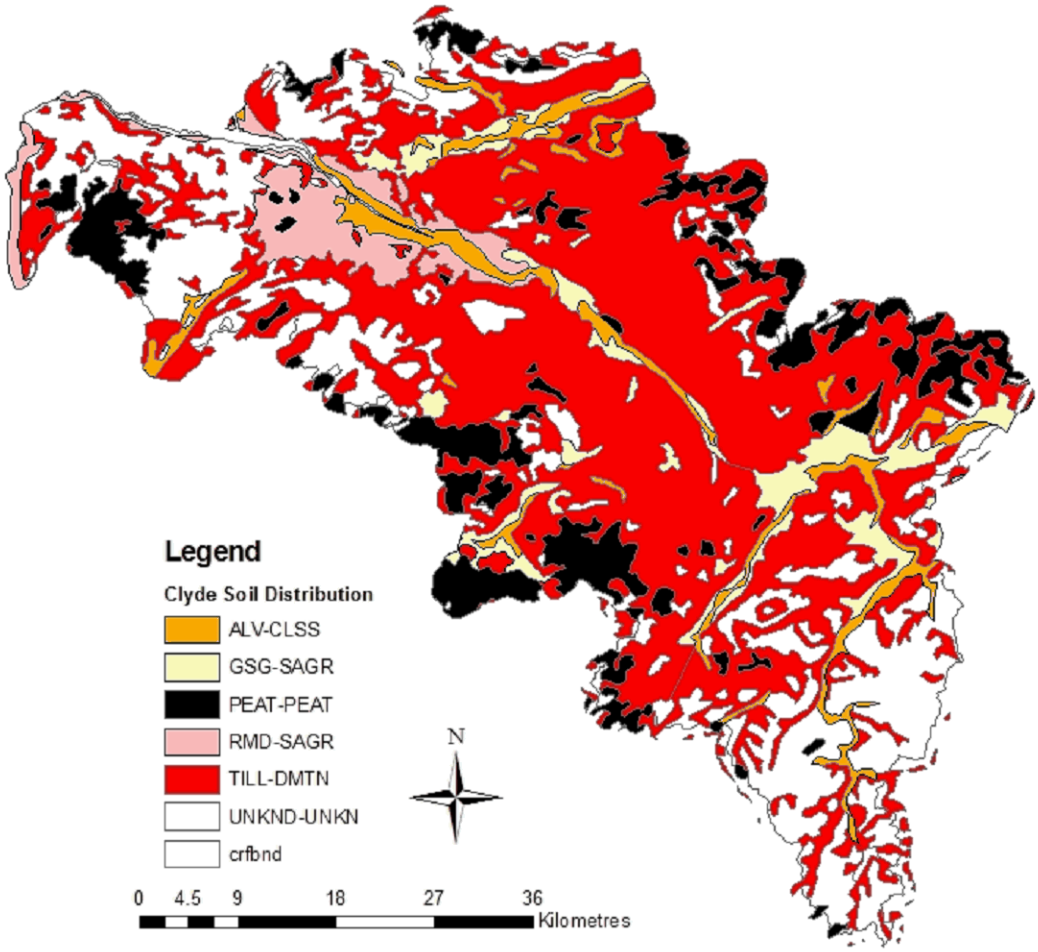

Figure 10: Soils of the Clyde Catchment

'Geology, BGS 1:625,000, © NERC.'

2.6 Climate:

Scotland's temperature records indicate average spring, summer and winter temperatures rising by more than 1ºC since 1961. This has been particularly prevalent in southern and eastern Scotland. Average temperature increases are smallest in autumn (SEPA 2007).

Scotland over a whole year is on average 20% wetter than it was in 1961. Winter precipitation shows a clear upward trend since this time, with a 58% increase recorded across the country. This is most marked in the north (nearly 70% increase) and less marked in the east (36% increase). There is less variability in precipitation across the other seasons and patterns are less clear. The key trends for non winter months appear to be that the east has become slightly drier during the summer and the west wetter in spring. There has been a trend of increasing heavy rainfall in winter, particularly in the north and west. There is a link between the number of days of heavy rain and overall rainfall (SEPA 2007).

2.7 Land-use

Improved grassland dominates the Clyde catchment (72.6% of the total area) (Table 5 & Figure 11). Rough grassland, urban areas, conifers, heather moor and peat land are the only other categories to exceed 1% coverage. Much of the upper Clyde is dominated by poor rough grassland and heather moor with small mosaics of peat land and conifer woodland. As the Clyde flows toward Lanark improved grassland becomes the dominant landuse with small regions of mixed woodland, arable land and urban areas. The urban areas of Lanarkshire and the Glasgow conurbation dominate the lower Clyde valley and the Inverclyde coast, surrounded by improved grassland in many places, along with small areas of arable land. From Renfrew to Greenock the dominant land use is once more improved grassland with large areas of arable farmland, peatland, good rough grassland and some sporadic urban areas. The extremities of the catchment are dominated by a combination of heather moor, peatland, recent plantations and conifer woodlands.

Table 5 Land-use in the Clyde Catchment

Land-use	% Area Coverage
Arable	0.0054
Bracken	0.0033
Broadleaves	0.1043
Cliffs	0.0037
Conifer plantation	4.0738
Felled woodland	0.0879
Fresh waters	0.2924
Good rough grassland	1.8685
Heather moorland	3.5844
Improved grassland	72.6467
Marshes	0.0277
Mixed woodland	0.5355
Montane	0.1232
Other mosaics	0.8289
Peatland	2.8202
Poor rough grass	5.6439
Recent Planting	1.6259
Rural Development	0.8563
Salt Marsh	0.0076
Scrub	0.1276
Seminatural conifers	0.0006
Tidal waters	0.0364
Urban	4.1616

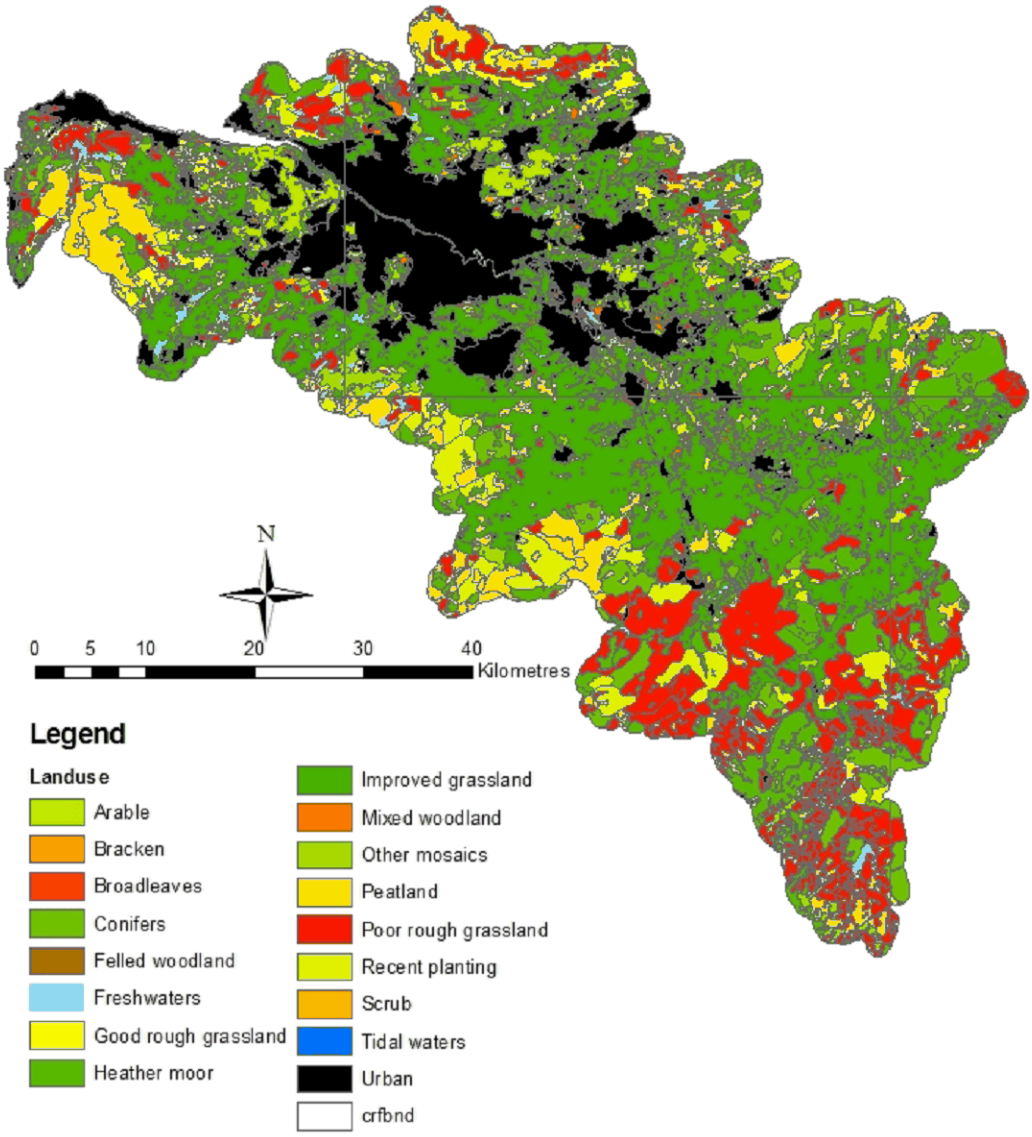

Figure 11: Land-use in the Clyde Catchment

'LCS88, MLURI 1993'

2.8 Water Quality:

Water quality plays a key role in the performance of a fishery. In the headwaters of the Clyde and many of its tributaries, water quality has always been high. This is not the case in some of the more urban or post-industrial parts of the catchment (Figure 12) where the effects of high density human settlements sees the rivers utilised for polishing effluents from sewage treatment works or receiving the flow from septic tanks, wrong drainage connections or combined sewage overflows (CSOs). In more rural areas, diffuse pollution from intensive livestock farming has degraded some watercourses and industrial uses (e.g. open cast coal mining, and gravel extraction,) have apparently caused problems by reducing water quality. Water quality in some areas is compromised by surcharging waters from former deep mines and there are concerns regarding forestry and bog stripping.

Figure 12: Dye Pollution in the Shirrell Burn, North Lanarkshire

Water quality over the catchment has generally improved in recent years; however some sections are not expected to reach good ecological status by 2015 and beyond. The EC Water Framework Directive River Basin Management Plan will drive improvements in water quality throughout the area. Numerous impacts were identified during the drafting of the plan (e.g. sewage treatment works effluents, metal pollution, rural diffuse pollution, road runoff, resurgent minewaters), and it is to be hoped that these will be dealt with by the river basin management planning process (McColl *et al.* 2008). There are still large numbers of man-made pollution incidents in our urban watercourses and there have been recent catastrophic silt pollutions from poorly operated reservoir drawdowns. Development pressures also still exert an influence on water quality (e.g. overloaded sewage treatment works).

2.9 Habitat Quality:

There is little doubt that the instream and riparian habitats of many of the rivers in the RCFMP area have been degraded, sometimes severely, leading to the decline or loss of fish populations. Land drainage and flood defence works have altered the physical structure of banks and beds and there remain significant problems for fish with the post-industrial legacy of weirs and impoundments which block migration and fragment linear habitats. While some of these issues have been addressed (e.g. provision of fish passes on the Kelvin system) there is a huge amount of work to be done throughout the RCFMP area. There are significant concerns among fishery managers that current development pressures may impact upon fish habitat quality (e.g. micro-hydropower schemes, windfarm construction, flood defence works).

The RCFMP area also plays host to three high profile non-native plants (Japanese knotweed, Himalayan balsam and giant hogweed) which are known to degrade riparian habitats and negatively affect the angling experience of those encountering them. One "new" invader seems to be the skunk cabbage, which has been found in Dunbartonshire and Renfrewshire and forms dense growths along riverbanks. Additionally, the instream habitat of the upper Clyde is now under pressure from the burrowing activities of American signal crayfish, which are also impacting upon the local invertebrate communities.

3 Fish Populations

3.1 Fish species present in RCFMP Area

The Clyde and its tributaries are slowly recovering from centuries of human impact. The Clyde catchment is home to 33 species of freshwater fish (Maitland 2004) and supports valuable fisheries for salmon, sea trout, resident brown trout, grayling and "coarse" species. A number of scientifically important and endangered species are also present (lamprey (*Petromyzon marinus*, *Lampetra fluviatilis* and *Lampetra planeri*) and eel (*Anguilla anguilla*) respectively. Of the 33 species, the Clyde River Foundation has encountered 19 (57.6% of the total) during its survey work since 2002 (Table 6 – those species in red). Fourteen non-native fish species (42.4% of the total) have become established - for example the bullhead (*Cottus gobio*) is common in one sub-catchment and the main River Clyde contains probably the most northerly population of barbel (*Barbus barbus*) in the world (McColl *et al.* 2008). One particularly interesting initiative underway is the ongoing attempt to establish a safeguard population of vendace in the Daer Reservoir (this species not included in Table 6).

Table 6: Freshwater Fish Species of the Clyde Catchment (Maitland 2004)

River Lamprey	Atlantic Salmon	Common Minnow
Brook Lamprey	Brown/Sea Trout	Roach
Sea Lamprey	Grayling*	Rudd*
European Eel	Thick-lipped Grey Mullet	Tench*
Common Bream*	Three-spined Stickleback	Stone Loach
Barbel*	Ten-spined Stickleback	Pike
Goldfish*	Common Bullhead*	Rainbow Trout*
Crucian Carp*	Sea Bass	Smelt, possibly extinct
Common Carp*	Ruffe*	Dace*
Common Gudgeon*	European Perch	Flounder
Chub*	Common Goby	Orfe*

* = Introduced species

Brook lampreys are regularly encountered during survey work throughout the catchment (the species appears widespread above the Falls of Clyde), and river lampreys were detected from the main stem of the Clyde during the national survey of

2003/2004. The European eel is still relatively common and widespread in the accessible parts of the catchment. The barbel is a relatively recent introduction which appears to be colonising the main stem of the Clyde – our very young specimens were captured while electrofishing in the margins for lampreys. Single specimens of common carp and rudd were recorded during the netting of a stillwater coarse fishery in North Lanarkshire. Common minnow, three-spined stickleback and stone loach are all widespread and common in our electrofishing samples. Roach and pike are usually found in samples taken in the vicinity of stillwaters (where they are both common across the catchment). Perch are usually associated with on-line stillwaters but are encountered in larger rivers. Common gudgeon appear sporadically in electrofishing samples and are surprisingly widespread.

Of the salmonids, the recolonisation of the system by Atlantic salmon is now largely a matter of barrier removal, although water quality remains an issue in some areas. The brown trout is the most common and widespread fish in the Clyde system, although the current state of sea trout populations is poorly known. Grayling are widely distributed but relatively rare in electrofishing samples.

Ten-spined stickleback and bullhead have only been recorded from the White Cart subcatchment in Renfrewshire; the former with very restricted distribution, the latter very common in areas downstream of its original introduction.

Of the species present in the catchment but not yet recorded by the Clyde River Foundation, sea lamprey have been seen in the Clyde at Blantyre Weir in recent years and spawning was recorded during 2009 in the River Kelvin, the coarse species are likely to be present only in stillwaters or areas of rivers where safe electrofishing is impossible (bream, goldfish, crucian carp, chub, orfe, dace, tench and ruffe); rainbow trout are likely to be largely restricted to stillwaters; others are basically estuarine or marine fish (mullet, sea bass, common goby); and the smelt is possibly extinct.

There are a number of publications detailing the importance of freshwater fisheries to the Scottish economy but relatively few with any substantial detail on the economics of fishing the freshwater Clyde. The most recent and comprehensive review of the economic impact of angling in Scotland (Radford *et al.* 2004) grouped the Clyde catchment together with the Forth catchment, Fife and Ayrshire into a region described as "Central Scotland". Central Scotland was described as one of the three most important regions for angler effort (the others being "Highlands" and "North East") partly due to the amount of rainbow trout angling in the region. A total of 473,233 angler days were estimated annually for Central Scotland, with 48.9% of the total effort being expended on rainbow trout, 28.4% on brown trout, 13.0% on salmon and sea trout, and 9.6% on coarse fishing (including grayling). It is reasonable to assume that a fair proportion of this effort was expended in the Clyde catchment, signalling important fish and fishery management issues in all four sectors.

3.2 The Fishery

3.2.1 Migratory Fish: Atlantic salmon and Sea Trout

Declines in salmon catches have been observed across the range of the species over the last few decades and this has led to the closure or restriction of many commercial and recreational fisheries (ICES, 2006). Salmon and sea trout (sea running brown trout) were historically widespread in the Clyde catchment (Doughty & Gardiner 2003). Both species became extinct during the industrialisation of the Clyde catchment but salmon returned in number in 1983 following water quality improvements and the recovering system now supports fisheries for both species.

Migratory salmonids are chiefly caught on the main stem of the River Clyde but fisheries also exist on the Kelvin, the Carts and the Gryfe. The Crown Estate migratory salmonid catch return for the River Clyde (1996-2007) displays an overall upward trend for salmon and downward trend for sea trout (McColl *et al.* 2008) (Figure 13).

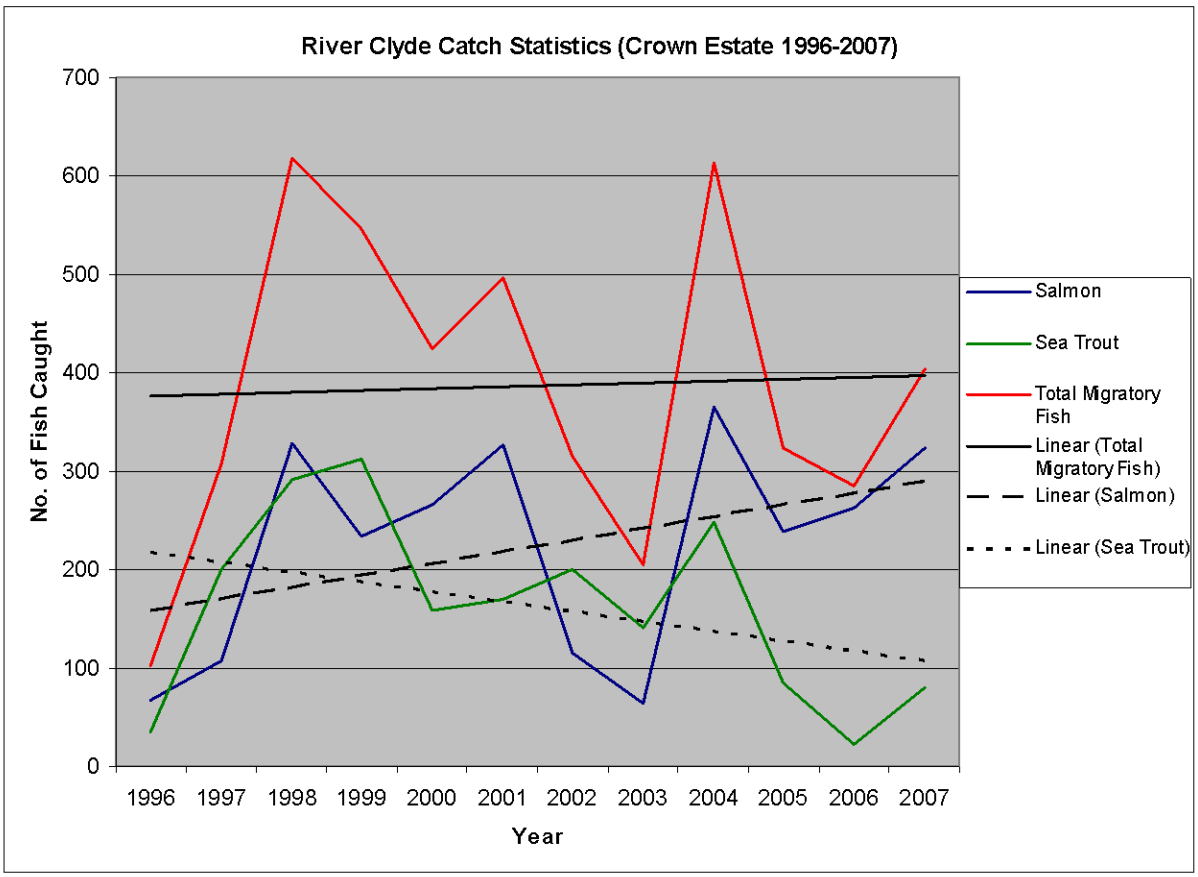

Figure 13: Salmon and Sea Trout Catches from the Clyde System

Adult salmon and sea trout spawn in freshwater; their young develop as fry, then parr. Atlantic salmon parr from the River Clyde usually remain within the system for two years before migrating to sea as smolts. The maximum output of smolts is governed by the quantity of suitable habitat within the catchment. Post-smolts migrate to the seas around Faroe Islands and Greenland, where they feed for one or more years before maturing and returning to their natal river to breed. Genetic analysis is

required to determine whether stocks consist of discrete sub-populations derived from different areas of the catchment.

Many factors affect the abundance of salmon, but most attention has been directed towards marine influences (Crozier *et al.* 2003) where recruitment to fisheries has been observed to be both variable and, crucially, lower than in the past (Friedland *et al.* 2005). Several factors threaten the freshwater populations of migratory fish, including the effects of man-made barriers to fish migration, water quality, water quantity, habitat degradation, predation, poaching, and non-native species. If migratory fish populations are to be managed sustainably, then some assessment of these threats is essential. A programme of research and monitoring is underway to establish the status of migratory stocks and the measures required to protect and enhance them.

Very little is known about the sea trout of the RCFMP area. A specific programme of research on the adults (catches, scale reading) would generate useful information on growth rates in freshwater and the sea and basic stock parameters like age at migration to sea.

3.2.2 Brown Trout:

Brown trout are the mainstay of the Clyde fishery, and are probably angled for in every major subcatchment. Catch return schemes are, however, rare and data few. The economic importance of the River Clyde brown trout fishery is therefore difficult to assess.

Brown trout are widespread and common throughout the Clyde catchment but there are some areas where poor water and/or habitat quality is preventing development of self-sustaining riverine trout fisheries (McColl *et al.* 2008) (Figure 14). There is a Protection Order on the River Clyde. The order encompasses the part of the River Clyde comprising the main stem of the River Clyde and its banks from the Daer Water, downstream to the upstream side of Motherwell Bridge. The Protection Order liaison committee comprises angling clubs, individual anglers and riparian owners. A Protection Order may be granted where a proprietor or tenant offers appropriate access to anglers. Under these circumstances it becomes a criminal offence to fish without legal right or written permission. One intention is to make it easier for anglers to be controlled and the water to be managed.

Despite the significance of the fisheries, the biology of trout from the River Clyde is poorly understood. Marine Scotland - Science research suggests that there may be several races of trout ranging from those which have free access to the sea, to those totally isolated above natural barriers. Trout have similar biological requirements to those of salmon; including clean oxygenated water, access to suitable spawning habitat and an adequate supply of food either in freshwater, or in coastal waters for sea trout. Many of the factors that can potentially affect salmon in freshwater also have an impact on trout. Actions to address these issues will be beneficial for both species.

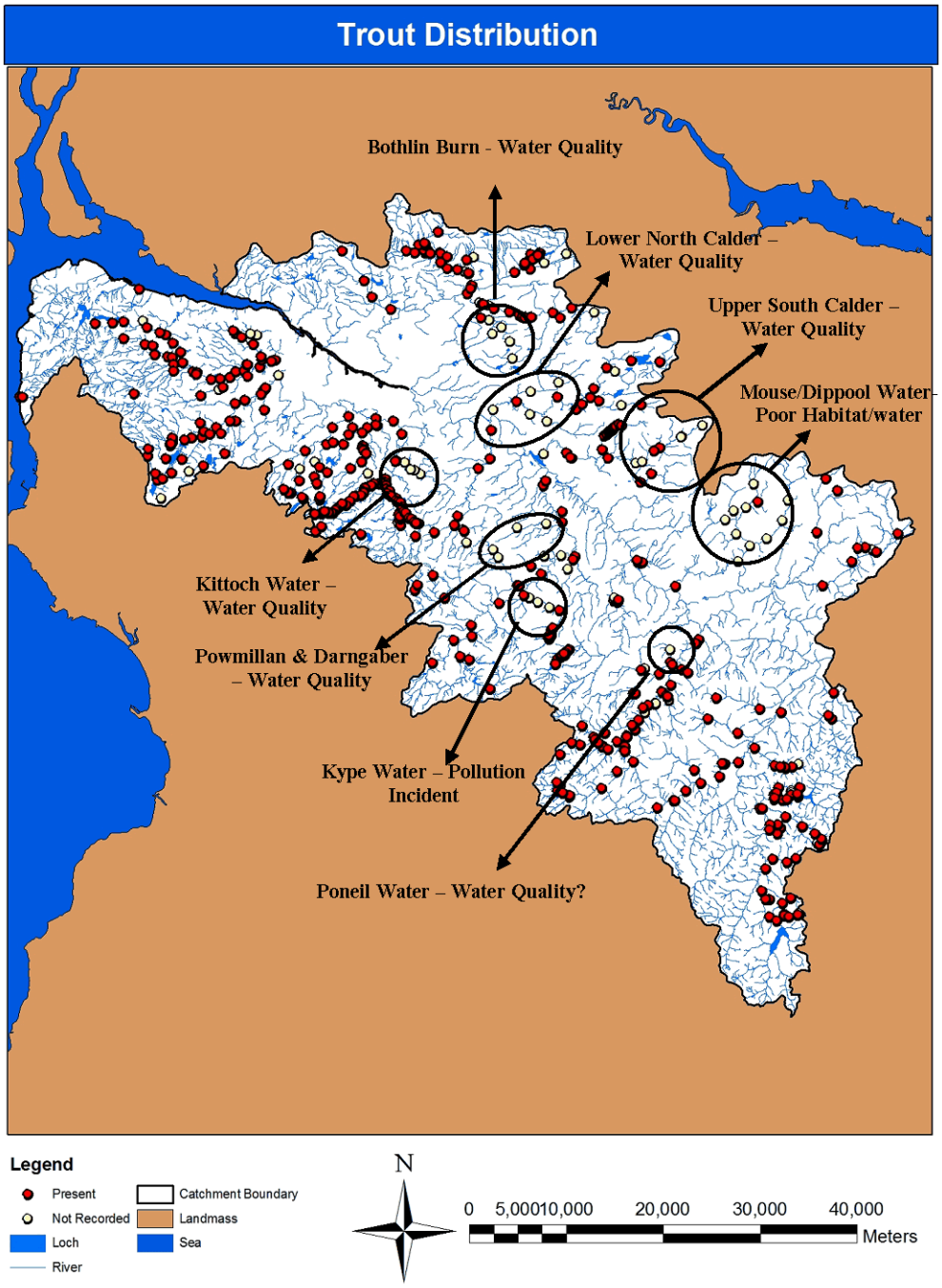

Figure 14: Distribution of brown trout and areas of concern revealed by Electrofishing

Derived from OS 1:50,000 Panorama data with the permission of the controller of Her Majesty's Stationery Office © Crown copyright).

3.2.3 Grayling:

The grayling fishing season on the Clyde starts when the salmon and trout seasons are over, allowing the angler the opportunity to fish all year. Grayling were introduced to the Clyde in 1855 (Gardiner 1993) and provide significant fisheries throughout the main stem of the Clyde and its upper tributaries, the Avon Water and the River Gryfe. The Environment Agency holds some catch data via The Grayling Society / Environment Agency log book scheme but this probably significantly underestimates the extent of the fishery. Again, nothing is known of the economic value of the Clyde grayling fishery (McColl *et al.* 2008).

The CRF catches very few grayling during routine surveying – the species tends to prefer water which is of greater depth than that which can be electrofished safely. Repeated observation of one population in the South Calder Water prompted the establishment of an annual survey of a long (180-250m approximately) section of this river in Calder Park, Motherwell in 2007 (Figure 15). This project has been supported in 2008 by the Scottish Government via RAFTS and the Grayling Research Trust; it is hoped to extend it to the Gryfe and Avon catchments if further suitable sites can be found.

Fish from the South Calder Water were also sampled by the CRF in 2008 to assist with a Grayling Research Trust genetics study; a small number of volunteer anglers from Lamington AIA, UCAPA Ltd. and the Bridge of Weir Angling Club also contributed several hundred samples to this initiative.

The CRF is also supporting a joint initiative with UCAPA Ltd. which holds a grayling fishing match around Mauldslie Bridge on the middle Clyde each October/November. Our input is to collect scientific data from the grayling caught and to tag some of the fish to allow the angling club members to assess recapture rates. This may represent a cost-effective mechanism for monitoring grayling in large rivers. The CRF encouraged Clyde anglers to participate in the joint Grayling Society/Environment Agency grayling logbook scheme but we understand this is now being discontinued. If demand justifies it, the CRF would consider running a local version of this scheme.

Figure 15: Grayling from the South Calder Water being tagged with a visible implant tag as part of a Stock Investigation in conjunction with the Grayling Research Trust

3.2.4 Coarse Fish Species:

Coarse fisheries exist on the main stem of the Clyde (pike, cyprinids, and perch); at a small but growing number of club or commercial stillwaters (many species) and also in the central Scotland canals. The true extent and economic value of these fisheries are unknown to us at present (McColl *et al.* 2008). The management of the riverine coarse fisheries is largely informal but this sector is known to be growing in central Scotland and the RCFMP would benefit from a more informed perspective on these species.

3.2.5 Rainbow Trout:

The rainbow trout is not native to Scotland, but has been introduced for fishery and aquaculture purposes. While direct contact has been limited to date, the Clyde River Foundation has collated preliminary information on the stillwater fishery resources of the Clyde catchment (McColl *et al.* 2008). Rainbow trout fisheries are widespread throughout the Clyde catchment (FRS 2003) and it is likely that this sector is the most commercially valuable in the locality (Radford *et al.* 2004).

There are several potential issues for wild fish associated with the introduction and/or escape of rainbow trout from still waters. Although the CRF have no evidence of any self sustaining populations within the catchment, rainbow trout may disrupt indigenous freshwater ecosystems via competition, disease and/or predation. The stocking of rainbow trout is now regulated but there is no co-ordination of their introduction or distribution throughout the catchment. As with coarse fisheries, the RCFMP would benefit from formal interaction with representatives of those stocking rainbow trout.

3.2.6 Other Fish Species:

The remaining 11 indigenous fish species likely to be found (sea lamprey, river lamprey, brook lamprey, eel, stone loach, thick-lipped grey mullet, three-spined stickleback, ten-spined stickleback, sea bass, smelt (possibly extinct), flounder and common goby) are probably of limited interest to freshwater fishermen (although there was once a small commercial fishery for eel in the Clyde, recent legislation prohibits the taking of the species). Our interest in these species is primarily to assess their distribution and flag up their conservation interest. Relatively little is known of their distribution and abundance in the Clyde catchment.

The three lamprey species are, however, of particular conservation importance (listed in Annex 2 of the EC Habitats Directive). As such their distribution and status within the catchment requires better understanding. The abundance of European eel is known to be at an all time low throughout its range and therefore exploitation should be avoided and research increased.

3.3 Fish Hatcheries and Stocking

There is a long history of stock manipulation by stocking eggs and fish on the Clyde. Many of the riverine angling clubs have routinely stocked their waters, some for over 100 years. The vast majority of stocking exercises have involved brown trout, either purchased from commercial facilities or reared in angling club hatcheries. Very few of these exercises have had their efficacy assessed but there is a common belief that if angling clubs cease stocking, permit sales decline. There are currently three brown trout hatcheries in operation in the Clyde catchment, those run by the Avon Angling Club, the Upper Avon Angling Association and the Nethan Valley Angling Association. It is important to ensure that these facilities are operating to best practice.

Other species were (or appear to have been) stocked specifically to create fisheries, including the best known case, that of grayling, and several species of coarse fish (eg. barbel). Additionally, there is probably a significant number of rainbow trout stocked annually to the many stillwater fisheries in the catchment.

The precise role of hatcheries in the return of salmon to the Clyde is unclear. There was at least one stocking event of salmon in the 1980s but it appears that the salmon in the Clyde and its tributaries are largely there naturally. The influence of straying fish from adjacent catchments (eg. the River Leven) on the re-establishment of the Clyde salmon stock remains unknown but ongoing genetic studies should provide some indication of their origin.

Stocking is a legitimate fisheries management activity under carefully considered conditions. Socio-economic, scientific and educational benefits can accrue from stocking of fish. However, there are significant risks associated with stocking. The stocking event may not be successful, it could introduce disease, increase competition and/or predation, impact upon other organisms of conservation value and cause a reduction in genetic fitness in resident/wild populations (Aprahamian *et al* 2003 and references therein; Maitland 2007). Before any stocking event fishery managers should question its necessity and potential impact. The stocking of fish in the RCFMP area is regulated by Marine Scotland and it is an offence to intentionally

introduce any live fish or spawn of any fish into inland waters (or to possess either with the intention of introduction) without the previous written agreement of the regulator.

3.4 Predators and Competing Species

Cormorants and goosanders are of sufficient concern in one area for the local angling club to have received the necessary permissions to shoot a small number of birds to protect the fishery from serious damage. Other significant predators of Clyde fish include the American mink, which has been controlled in some localities.

Competition between species is a normal part of ecosystem functioning. The components of natural ecosystems have usually evolved together over long periods of time and there is usually a degree of balance and resilience, depending upon the diversity and relationships between the species present. Aquatic systems are very vulnerable to the introduction and establishment of non-native species and the Clyde catchment as a whole has had a large proportion (42.4%) of its total freshwater fish species introduced from elsewhere (Table 6). Clearly, only a small proportion of the total species in the catchment will be present at any given location and some (particularly the non-natives) may be restricted to very few sites.

There are, however, serious issues with introduced species altering the balance of our fisheries; put simply, non-native species require food and shelter and they are likely to have to predate upon and compete successfully with our native species to get them if they are to persist. It is, however, often difficult to determine the extent of the changes but observations like those summarised in Figure 16 are cause for concern. Bullheads were introduced into the White Cart system during the 20th century and are now becoming very common in the lower reaches. In the Earn Water, which we suspect to be the original site of introduction, the bullhead now dominates the fish community to a huge extent (Figure 16) and appears to be negatively affecting the native species, such as brown trout and stone loach. The reaches surveyed were habitats where brown trout would almost certainly dominate in the absence of bullhead, based upon our observations elsewhere in the catchment.

Another serious cause for concern is the introduction to the upper Clyde of the American signal crayfish. The crayfish were introduced near Crookedstane Farm at least ten years ago and have been spreading since then (Figure 17). The CRF has been involved in the long-term trapping programme carried out by UCAPA Ltd. and funded by SNH. The distribution of signal crayfish in some upper Clyde tributaries is now known to a resolution of less than 100m and options are now being assessed to prevent their spread across the watershed into the Annan catchment. The likelihood is that signal crayfish will never be eradicated from the Clyde system and that the effects of predation and competition on the native plants and animals will become clearer as the population spreads. We have already shown impacts upon aquatic invertebrates (i.e. fish food) near the original site of introduction and it seems inevitable that there will be considerable downstream spread of the crayfish population.

The crayfish are also spreading upstream and their approximate limits in the Daer Water, Blakehouse Burn, Crookedstane Burn and Clydes Burn have been identified. Recent investigations by the Annan DSFB did not record crayfish in the headwaters of that catchment. There is potential for overland spread of crayfish from the Clyde to the Annan, the possibility of entry to the Daer Reservoir, and spread to the Tweed

catchment further downstream in the Biggar area. This highlights the importance of a biosecurity plan in order to tackle this particular issue.

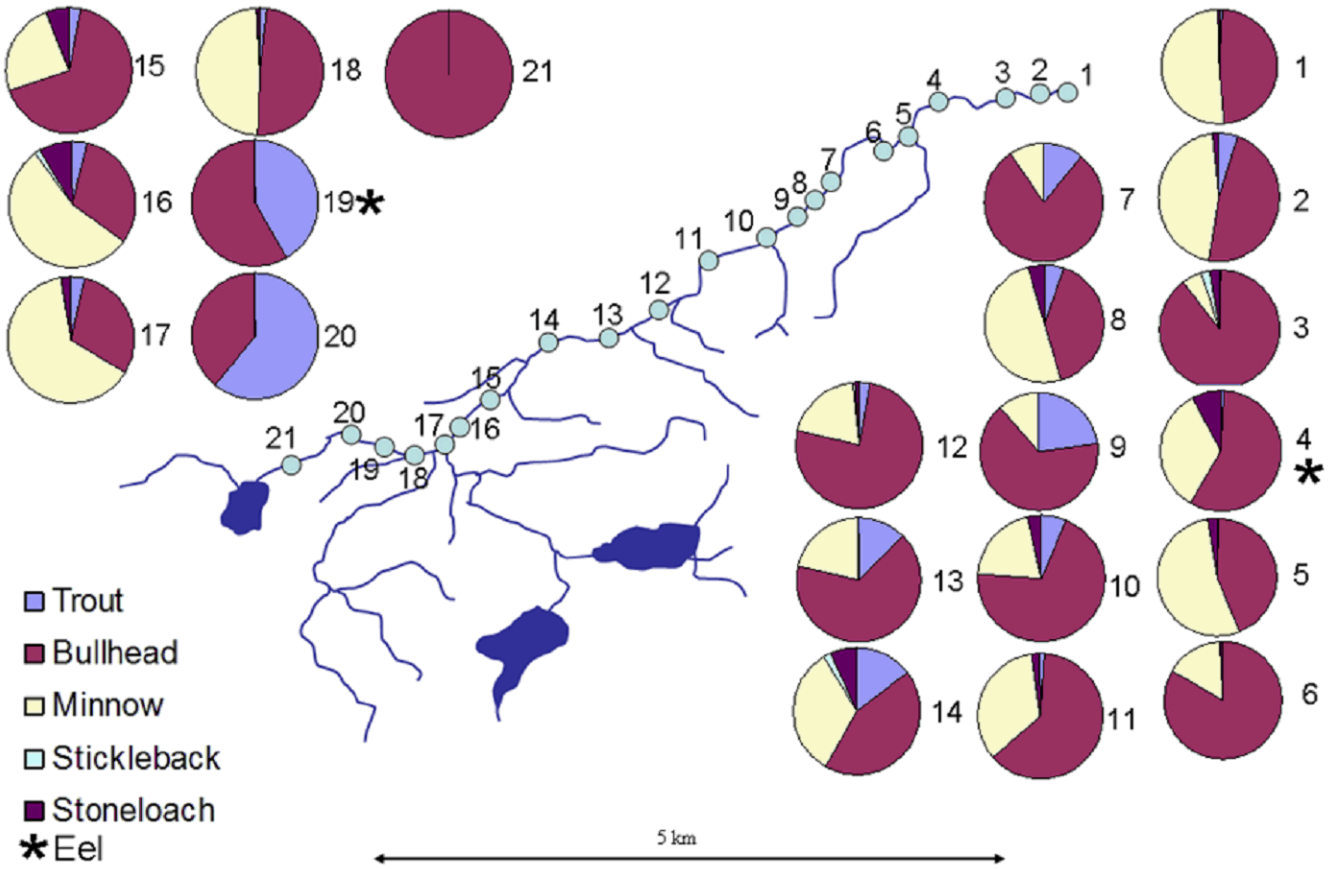

Figure 16: Composition (numbers) of the fish community of the Earn Water, East Renfrewshire in 2006

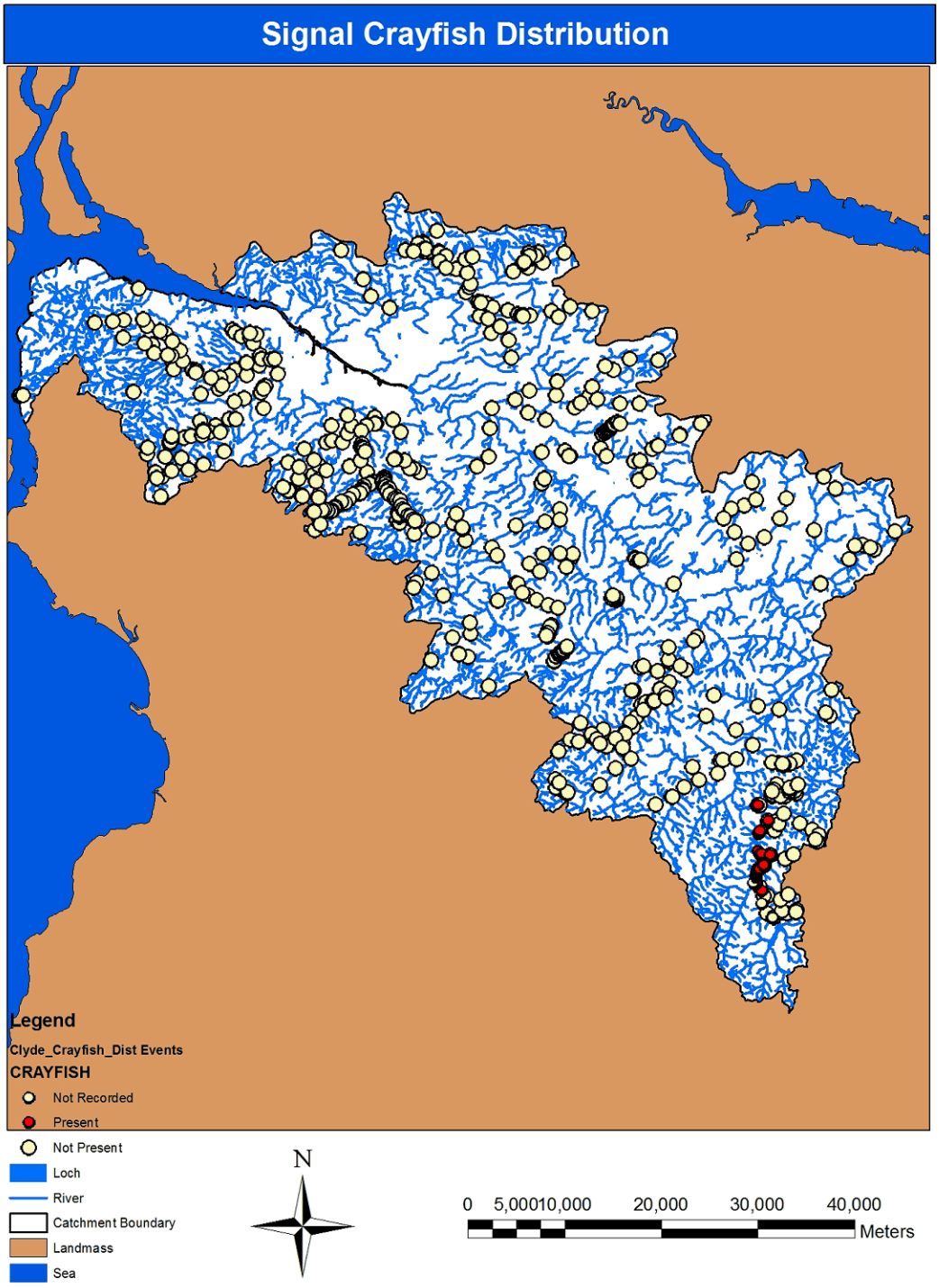

Figure 17: Distribution of Non-native, Invasive Signal Crayfish in the Clyde Catchment

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4 Analysis and Evaluation

4.1 Limiting Factors in Freshwater

There are a large number of factors affecting the production of fish in freshwaters, both salmonids (eg. Armstrong *et al.* 2003) and coarse species (eg. Cowx 2001). The health of the ecosystem may not, however, always be directly reflected in the performance of the fishery. The current River Basin Management Planning initiative (co-ordinated by SEPA) has identified some of the significant physical, and chemical constraints to fish production in the Clyde catchment and suggested positive management actions, although it excludes small catchments (Table 7). It should be noted however, that smaller catchments are excluded from the RBMP, and such watercourses can be very important to local fisheries. Damage to fisheries can result from unsympathetic management of smaller waters (e.g. flood defence works or gravel extraction).

Fishery performance can only be assessed with reference to those actually exploiting the resource. The biggest issues identified by the fishery managers are detailed in Table 8.

Table 7: Significant Water Management Issues across the Clyde Catchment

River	Issue	Action	Expectation
Clyde Mainstem	Abstraction (Daer Res.)	Negotiate supplementary flows & clarify abstraction regime Controlled Activities Regulations (CAR)	Increase Flow & decrease likelihood of fish kills in summer
	Impoundment (Daer Res.)	CAR licence	Water quality and quantity maintained
	Poor water quality (d/s Daer Res.)	Reduce contamination of watercourse	Better habitat
	Non-native species	Habitat assessment	Control
	Diffuse pollution	Better agricultural practices (NFU 4 point plan)	Local water quality improvements
	Morphological alteration	Habitat restoration	Better habitat
	Power stations	CAR	Maintain flow
	Point Source Pollution	CAR	Improved water quality
	Impoundment	Better passage up and downstream	Improved passage available to migratory fish
	Poaching	Better enforcement	Increased egg deposition and better stocks of juvenile fish
	Predatory birds	Assessment of impact	Monitor effect on fish populations
River Kelvin	Low flow in summer	Investigate supplementary flow from reservoirs	Increase Flow & decrease likelihood of fish kills in summer
	Numerous Obstructions	Negotiate removal	Increase stock
	Development	Influence development process	Reduce siltation/ increase stock
	Dredging	River restoration	Increased habitat heterogeneity
	Abstraction	Negotiate supplementary flows & clarify abstraction regime (CAR)	Increase Flow & decrease likelihood of fish kills in summer
	Diffuse Pollution	Liase with SEPA and Scottish Water	Local water quality improvements
	Non-native Species	Habitat assessment	Control
North Calder	Poor water quality	CAR	Better water quality

River	Issue	Action	Expectation
Water	Impoundment	CAR	Passage available to migratory fish
	Abstraction	Negotiate supplementary flows & clarify abstraction regime (CAR)	Increase Flow & decrease likelihood of fish kills in summer
	Urban run-off	Better regulation (CAR)	Better water quality
	Mine water resurgence	Better mining practices	Better water quality
	Point Source Pollution	CAR	Better water quality
	Obstructions	Negotiate removal	Increase stock
	Canal off-take	Fish passage	Increased habitat availability for migratory fish stocks
South Calder Water	Point source pollution (Mine water)	Better treatment (Reed beds etc)	Better water quality
	Impoundments	CAR	Passage available to migratory fish
	Diffuse Pollution	Liase with SEPA and Scottish Water	Local water quality improvements
	Access for migratory fish	Provision of fish pass	Increased fish stocks
	Predatory birds	Assessment of impact	Monitor effect on fish populations
Mouse Water	Poor Water quality	Better treatment from mine works (Reed beds etc)	Better water quality
	Resurgent mine water	Better treatment (Reed beds etc)	Better water quality
	Morphological alterations	Habitat restoration	Better habitat
Medwin Water	Morphological alterations (Dredging)	Habitat restoration	Better habitat
	Gravel Quarry	CAR	Reduced siltation
Douglas Water	Poor water quality (resurgent mine water)	Better treatment (Reed beds etc)	Better water quality
	Morphological alterations (Dredging)	Habitat restoration	Better habitat
	Erosion	Habitat restoration	Better habitat
	Effluent from open cast mine	CAR	Improved water quality

River	Issue	Action	Expectation
	Sand/Gravel Quarry	CAR	Reduced siltation
River Nethan	SEPA Gauging station	Provision of fish pass	Increased fish stocks
	Morphological alterations	Habitat restoration	Better habitat
River Avon	Obstructions	Provision of fish pass	Increased fish stocks
	Poor water quality (Sewage works)	CAR	Better water quality and Increased stock
	Diffuse pollution	NFU 4 point plan	Local water quality improvements
	Morphological alterations	Habitat restoration	Better habitat, Increased stock
Rotten Calder Water	Poor water quality	CAR (Industry)	Better water quality and Increased stock
	Diffuse pollution (East Kilbride)	Liase with SEPA and Scottish Water	Local water quality improvements
White Cart Water	Impoundments	CAR	Passage available to migratory fish
	Obstructions	Provision of fish pass	Increased fish stocks (migratory and resident)
	Water quality	CAR (Industry)	Better water quality and Increased stock
	Development (Flood defence)	Habitat restoration	Better habitat, Increased stock
	Non-native species (Bullhead)	Research and educate	Containment
	Diffuse pollution	NFU 4 point plan	Improved water quality
Black Cart Water	Non-native Species	Habitat assessment	Control
	Obstructions	Provision of fish pass	Increased fish stocks (migratory and resident)
	Predatory birds	Assessment of impact	Monitor effect on fish populations
	Predatory fish (Pike)	Assessment of impact	Monitor effect on fish populations
	Morphological Alterations	Habitat restoration	Better habitat, Increased stock

River	Issue	Action	Expectation
	Unstable substrate (Dredging)	Sympathetic river bed maintenance (CAR Licence)	Increased survival of stock
	Flow alterations	CAR	Better flow regime and better fish passage d/s of Castle Semple Loch
River Gryfe	Diffuse pollution (agricultural)	NFU 4 point plan	Improved water quality
	Diffuse pollution (urban)	CAR	Improved water quality
	Morphological Alterations	Habitat restoration	Better habitat, Increased stock
	Abstraction	Negotiate supplementary flows & clarify abstraction regime (CAR)	Increase Flow & decrease likelihood of fish kills in summer

Table 8: Factors Limiting Fishery Performance

Factors Limiting Fishery		Status of Impact	Sub-management Unit
Water Quality/Quantity	Domestic Sewage	Episodic	Strathgryfe AA
			Bridge of Weir AC
			Abercorn AC
			Walton AC
		Historic	East Kilbride AC
		Historic & Chronic	Avon AA
	Agricultural	Episodic	Strathgryfe AA
			UCAPA Ltd.
			Walton AC
			East Kilbride AC
			Lamington AIA
		Historic & Chronic	Castle AC
			Bridge of Weir AC
	General	Historic & Chronic	Mid-Clyde AA
			Kelvin AC
			Busby WCIAA
	Minewater Resurgence	Chronic/Historic/ Episodic	Douglas Water AC
	Power Station Operation	Episodic	UCAPA. Ltd
Pollution Events	Landfill site	Historic	Lamington AIA
		Episodic & Increasing	East Kilbride AC
	Opencast Mines	Chronic	Lamington AIA
			UCAPA Ltd.
			East Kilbride AC
		Chronic/Historical/ Episodic	Douglas Water AC
	Runoff	Episodic	East Kilbride AC
			Abercorn AC
	Drainage	Historic	East Kilbride AC
	Farming	Episodic	East Kilbride AC
	Construction	Episodic & Emerging	East Kilbride AC
Predators	Mink	Emerging	East Kilbride AC
			Kelvin AC
			Douglas Water AC
	Otter	Emerging	East Kilbride AC
	Heron	Emerging	East Kilbride AC
	Goosanders	Emerging	Strathgryfe AA
		Chronic	Lamington AIA
	Cormorants	Emerging	Strathgryfe AA
			Douglas Water AC
			East Kilbride AC
		Chronic	Lamington AIA
	American signal crayfish	Emerging	Lamington AIA

Factors Limiting Fishery		Status of Impact	Sub-management Unit
	American signal crayfish	Historic & Chronic	UCAPA Ltd.
	Seals	Emerging	Mid-Clyde AA
Development		Emerging	Mid-Clyde AA
	Flood prevention works	Emerging	Busby WCIAA
		Emerging	Walton AC
	Poorly designed culverts	Historic	Nethan Valley AA
	Gravel Extraction	Emerging	Lamington AIA
Obstructions to Fish Passage	Millheugh Weir	Historic	Avon AA
	Ferniegair Weir		Avon AA
	Gavins Mill		Kelvin AC
	Bishops Mill		Kelvin AC
	"BBC Weir"		Kelvin AC
	Gauging Station		Nethan Valley AA
	Plum Weir	Historic & Chronic	Castle AC
	Tidal Weir	Emerging	Mid-Clyde AA
	Carmyle Weir	Emerging	Mid-Clyde AA
Impoundment		Historic & Episodic	Strathgryfe AA
			Abercorn AC
Water Abstraction		Episodic	Campsie AC
Bank Erosion		Chronic	Strathgryfe AA
			Bridge of Weir AC
		Episodic	Abercorn AC
Flooding		Episodic	Lamington AIA
Competition	With salmon	Emerging	Bridge of Weir AC
Access		Historic	Busby WCIAA
Poaching		Emerging	Kelvin AC
			Mid-Clyde AA

4.2 Distribution of pressures

The River Basin Management Planning initiative has categorised various pressures on the freshwaters of the Clyde catchment. In the absence of comprehensive habitat surveys (to date) this approach broadens the scope of the information currently available. During the summer of 2007, the Clyde River Foundation examined the preliminary SEPA list of the 763 Class 1a waters (i.e. those likely to fail to achieve "Good" ecological status by 2016 under the Water Framework Directive). The CRF held some fishery information on all but 100 of these sites at the time of initial examination; we now have that figure down to 86 sites. These "at risk" sites are therefore a high priority for electrofishing in the coming field seasons.

There was a very strong perception among certain angling clubs that poor water quality is still having a measurable effect upon fishery performance. Unsurprisingly, the areas affected by domestic sewage tended to be concentrated around centres of population (Eaglesham, East Kilbride, Bridge of Weir, Stonehouse, Strathaven and Paisley). Conversely, agricultural pollution was largely a problem in the countryside (upper and middle Gryfe catchment, upstream of East Kilbride, the upper White Cart catchment and in South Lanarkshire). The Water Framework Directive shifts the emphasis in water quality monitoring from water chemistry to the study of the biota but the Clyde River Foundation is concerned at the possible shift of SEPA effort away from routine monitoring of smaller catchments.

Abstractions were usually associated with reservoir storage or industrial use and are largely, but not exclusively, situated on headwaters. Two notable abstractions are those which remove water from the North Calder Water (to supply the Forth and Clyde Canal *via* the Monkland Canal) and, potentially more damaging, the removal of water from the Garrell Burn to supply the lowland canal network. The Garrell Burn is a Kelvin tributary which flows through Kilsyth and is a salmon spawning burn. The British Waterways abstraction causes a section of the Garrell Burn to dry up on occasion. Another British Waterways abstraction on the Bothlin Burn (Kelvin subcatchment) will prevent upstream migration of fish, should the water quality improve sufficiently for them to return in number. In Renfrewshire, total abstraction of the Dargavel Burn occurs within the site of the former Royal Ordnance Factory at Bishopton, where the burn is effectively broken in two by an offtake which was used to feed the former fire ponds. One interesting abstraction from the catchment is that for the bottled water plant in Lennoxtown; this takes water at source, effectively removing it from the headwaters of the Glazert Water in the Campsie Fells. The extent of this abstraction is currently unknown to us as, inevitably, are its ecological effects.

For the purposes of the WFD in Scotland, only four species have been described as "alien" in freshwaters; three plants (Japanese knotweed, Himalayan balsam and giant hogweed) and one animal (the American signal crayfish). It is likely that the number of sites affected is currently underestimated and requires updating. The potential effects of the signal crayfish have been discussed earlier.

Diffuse pollution is, by its very nature, difficult to identify and to deal with. It is noticeable that this category of pressure is largely restricted to the more lowland and urbanised areas of the catchment, presumably because the more intensive farming is practised in lower-lying areas, and urban diffuse pollution covers a multitude of different possibilities (eg. septic tank outfalls, road runoff). Diffuse pollution is a significant issue in the River Kelvin, Douglas Water, Avon Water, Rotten Calder, White Cart and Black Cart catchments, according to the SEPA classification. Resurgent minewater is a particular problem on the South Calder and Douglas Waters.

Flow regulation pressures are largely associated with large-scale impoundments (eg. reservoir dams) or are at the currently known sites of weirs and offtakes. Among the former are the structures on the Cochno Burn, North Calder, Culter Water, Camps Water, Daer Water, Elvan Water, the Logan Water (Nethan subcatchment), Kype and Dargavel Waters (Avon system) the reservoirs at the heads of many of the tributaries of the White Cart Water, and those impounding the Gryfe Reservoirs, and Barcraigs Reservoir on the Roebank Burn (Black Cart subcatchment). The second set of generally smaller flow regulation structures includes the major weir at Blantyre on the mainstem of the River Clyde, British Waterways offtakes on the Garrell Burn and North Calder Water, the weirs at the outfalls of Strathclyde Loch into the Clyde, the SEPA gauging station on the River Nethan, the significant weirs at Millheugh and Ferniegair which prevent salmon ascending the Avon Water, Waterfoot Weir on the White Cart Water, and the Plum Weir on the Black Cart Water. All of these structures, and there are likely to be others, will have a significant impact on the upstream movement of fish.

Morphological alterations are distributed throughout the River Clyde catchment and their effect on the fishery (if any) will require to be assessed on a case-by-case basis. Dredging and flood defence work has certainly altered the habitat of several management units (eg. Glazert Water, almost the entire length of the Black Cart

Water catchment, the Mouse Water and the Medwins). This type of alteration tends to reduce the heterogeneity of habitat and adversely affect salmonids in particular. Other types of morphological alteration include the culverts common around roads and urban areas – most of the Glasgow Burns run underground at some point, some for the majority of their courses. Poorly designed culverts are obviously a hindrance to fish migration. In addition, most of the larger urban rivers are constrained artificially by flood defence walls (eg. White Cart Water, River Kelvin, Luggie Water). The most spectacular single man-made structure in the catchment is arguably the 750m long tunnel which carries the South Calder Water under the former Ravenscraig steelworks site near Motherwell – its effects on the fishery currently unknown.

Point source pollution is generally from sewage treatment works or industrial premises or discharges. Each is regulated by SEPA and, under normal circumstances, their impact should be quantifiable and minimal. Problems are usually restricted to plant or operational failure causing poorly-treated effluent to enter rivers and deplete dissolved oxygen levels; this is particularly troublesome during periods of high temperature and low baseflow (eg. summer in the mainstem of the Clyde downstream of Daldowie STW or in the Clyde estuary, where there are occasional migratory fish kills).

One direct and measurable fisheries problem associated with the Water Framework Directive is that of man-made obstructions to upstream-migrating spawning salmon, which is an artificial limit on freshwater production (Figure 18). Such obstructions are distributed throughout the River Clyde catchment. Given the ease of determining and monitoring successful outcomes, removing these barriers represents a clear ecological gain, although identification of ownership and high costs have limited fish pass construction to very few schemes in the Clyde to date (eg. Blantyre Weir, the Allander Water at Milngavie, Flint Mill Weir on the River Kelvin in Glasgow). Given the lack of comprehensive habitat surveys to date, there may be additional obstructions which do not feature in Figure 18. A catchment-wide programme of habitat surveys will address this issue fully and a prioritised plan for dealing with the known obstructions should be produced. There are currently initiatives underway to address salmon passage on the Avon Water at Ferniegair and Millheugh Weirs, on the Garrell Burn in Kilsyth, and at the SEPA gauging weir on the River Nethan.

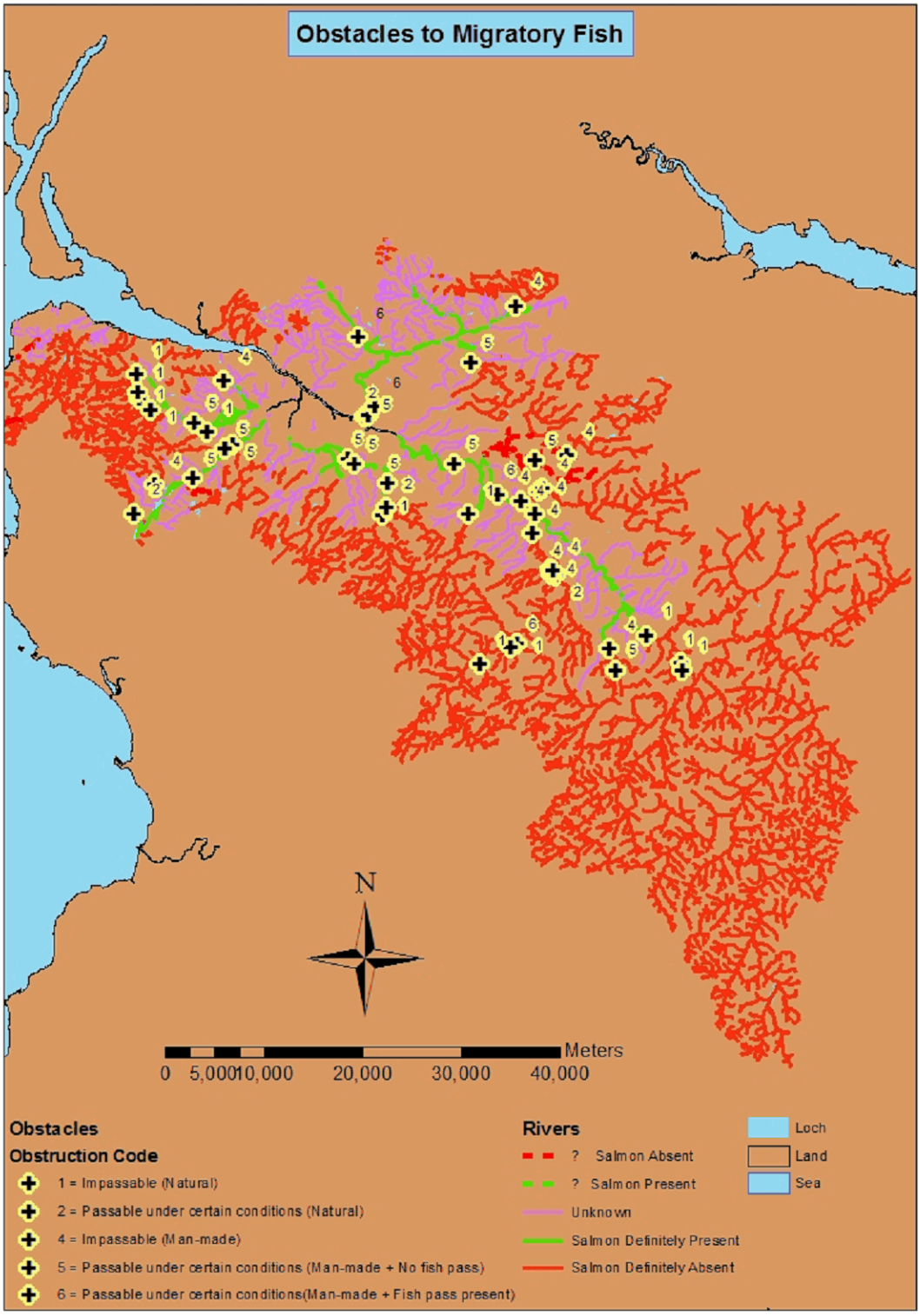

Figure 18: Locations of Known Barriers to Migratory Salmonids

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4.3 Limiting Factors at Sea

Sea trout and salmon catches along the west coast of Scotland have generally been in decline for several years. Sea trout appear to suffer disproportionately from the effects of sea lice from salmon farms and there is aquaculture activity in the Firth of Clyde. There is insufficient information to make any sensible assessment of any effect of fish farming on Clyde sea trout or salmon. There is scope for a pan-Clyde sea trout project involving the Argyll, Lomond, Clyde and Ayrshire Fishery Trusts.

Migratory salmonid catches on the Clyde are still relatively small, which is to be expected in a recovering river and it may take some time before systematic (or explicable) patterns of abundance emerge. The effects of survival at sea may, therefore be masked by changes in abundance and production in freshwater.

4.4 Opportunities and Constraints

The Clyde River Foundation, working closely with our management partners provides a mechanism for taking advantage of opportunities to protect and improve the fish and fishery resources of the Clyde catchment. The production of this RCFMP and the actions suggested for consideration herein provide a tentative framework for scientific fisheries management across the Clyde catchment. There are opportunities which could be taken to strengthen the fishery management structure (i.e. the suggested River Clyde Fishery Management Partnership) as well as to provide increased involvement and awareness for angling clubs regarding the status of the stocks they manage to allow them to make better informed management decisions.

Our priority is to work in partnership to take advantage of opportunities for improvement as they arise. Additionally, there is scope for better communication between the fishery managers and the CRF, hence the suggestion for the RCFMPartnership. We envisage this as being a quarterly or 6-monthly meeting between the fishery managers and the CRF where items of detail pertaining to the RCFMP could be discussed and updated bilaterally. There is agreement between the Clyde River Foundation and the River Clyde Fisheries Management Trust to work closely for the benefit of the fishery and this is an opportunity to use the resources of the CRF as a Secretariat to drive the meetings. Better partnership working with local authority Biodiversity Officers may lead to increased opportunities for environmental restoration.

The constraints we have identified for the CRF are all resource-based, primarily funding for staff, running costs or capital works, although clearly there are sometimes good operational reasons why suggested improvements cannot go ahead (eg. for engineering or financial reasons).

5 Management Actions

One purpose of this RCFMP is to align the activities of the CRF with improved fisheries management. The major operating principles and objectives of the CRF were described in Section 1 and Sections 2-4 deal with the current state of the environment and the fishery. Here, we suggest how the scientific objectives of the CRF can be turned into management actions for the RCFMP.

5.1 CRF Scientific Objectives – Rationale and Examples

CRF Objective 2.1 Spatial Distribution

The distribution of the 555 electrofishing sites shown in Figure 19 indicates that good quality data are probably available for around 60% of the accessible areas of the catchment. There are notable exceptions (e.g. parts of South Lanarkshire, and the main stem of the River Clyde and the larger tributaries in particular) and some of the more vulnerable areas have yet to be described fully (e.g. headwaters and urban burns, both of which are vulnerable to development). These omissions will be addressed by the actions within the RCFMP. While this objective has yet to be completed, the interim data have yielded some useful information. In 2009, we will also give high priority to sites which have been identified by SEPA as being likely to fail to reach "good" ecological status for the Water Framework Directive but have no fishery information to date.

Since 2002, we have identified areas where there are poor or no fish populations. "Poor" fish populations might result from the apparent absence of species which might otherwise be expected to be present. For example, it is now relatively rare to find stretches of river without trout and our data suggest that investigation, mitigation and restoration would be best targeted towards these areas, or to areas where missing year classes from the age structure suggest intermittently stressed populations. The same is true regarding the effects of barriers upon the distribution of migratory salmon and sea trout. For example, there are two weirs towards the foot of the Avon Water in South Lanarkshire which we have shown to prevent the migration of salmon upstream into potentially extensive spawning grounds. Similarly, the distribution of damaging invasive, non-native species such as bullhead and American signal crayfish has been documented.

The importance of this objective is that it allows the formulation of management strategies for the species concerned. Barriers to migration can be removed and the environmental benefits demonstrated immediately by increased geographical distribution of the species concerned.

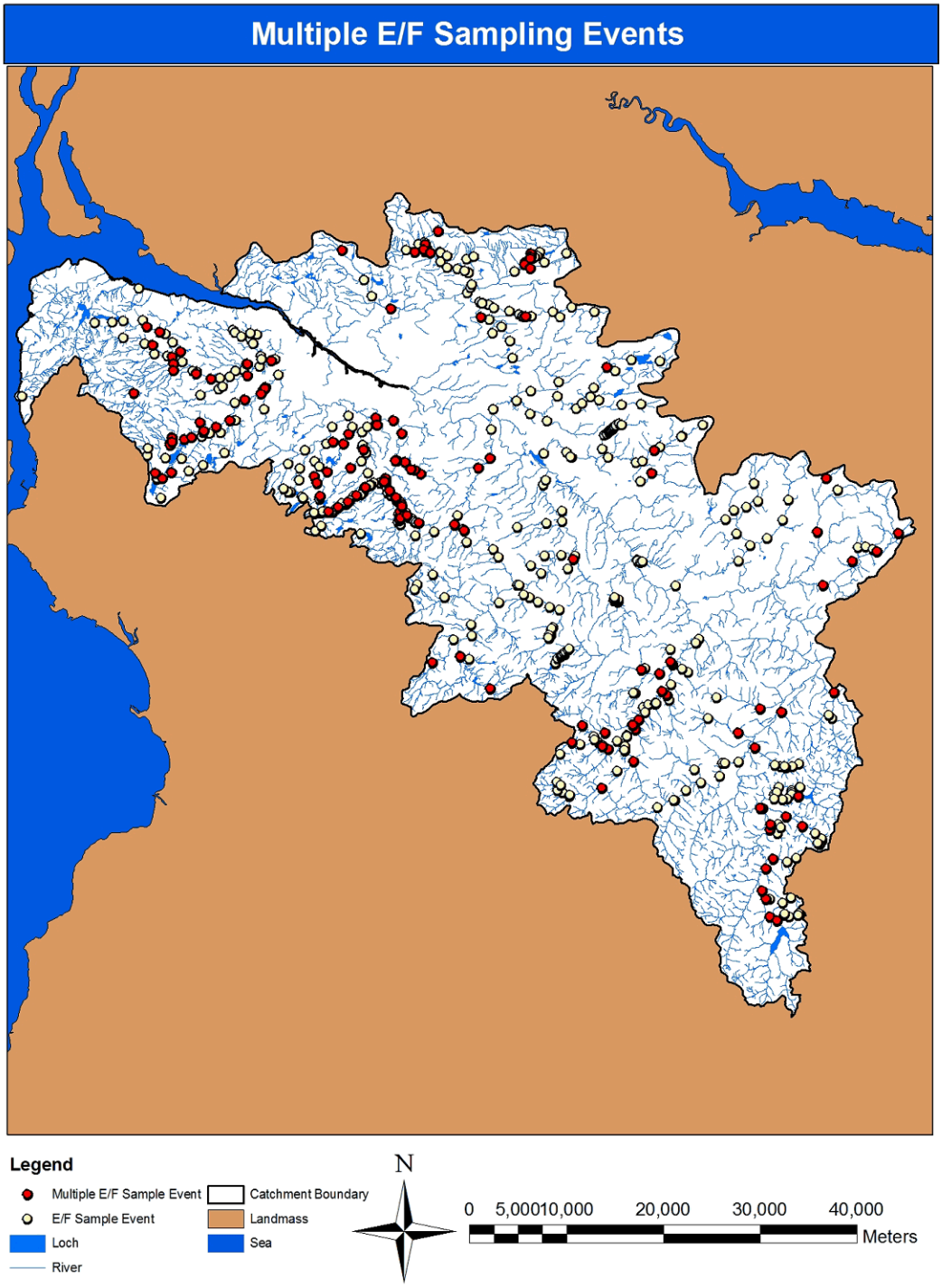


Figure 19: Clyde River Foundation Electrofishing Samples 2002-2008 (white = single samples to date; red = multiple samples)

CRF Objective 2.2 Temporal Assessment

Our initial sampling strategy is to undertake large-scale quantitative electrofishing across a given catchment; this to be repeated at least every five years to detect any broad changes in the distribution of fish species. A smaller number of sites are then selected and revisited annually to generate more detailed information on the local fish populations. Such within site comparison (temporal assessment) is valuable because it sheds light on the amount of variation within fish populations and communities from year-to-year. This can detect improving or declining salmonid populations and may be useful in assessing the carrying capacity of juvenile salmonid habitats in particular.

For example, variation in salmon numbers within a single site on the Allander Water between 2002 and 2008 are shown in Figure 20 and broader-scale variation across a large number of sites in the White Cart Catchment in consecutive years is shown in Figures 21 and 22.

This objective is important because multiple-year sampling aids interpretation of survey results and provides context to in which environmental managers can make properly informed decisions. For example, in cases of intermittent access by salmon to spawning streams (Figure 23). In the longer term, the potential for climate change to alter spawning times and fish growth rates might increase the value of such data.

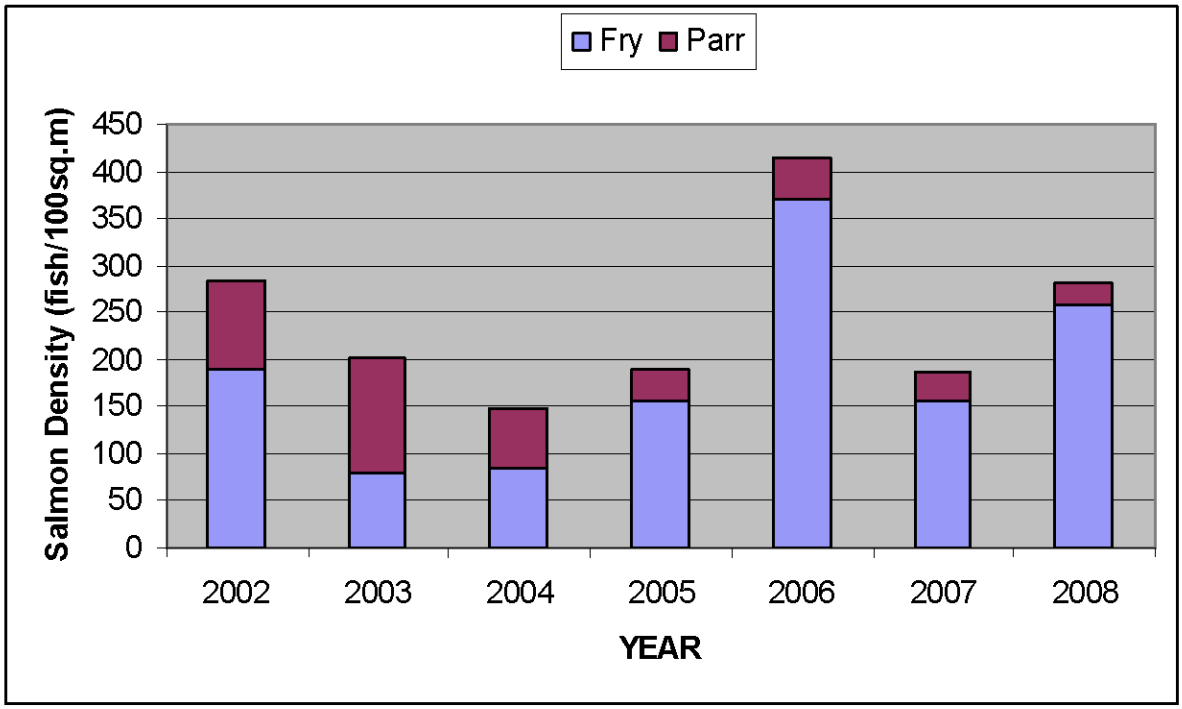


Figure 20: Salmon Density in the Allander Water, Dunbartonshire

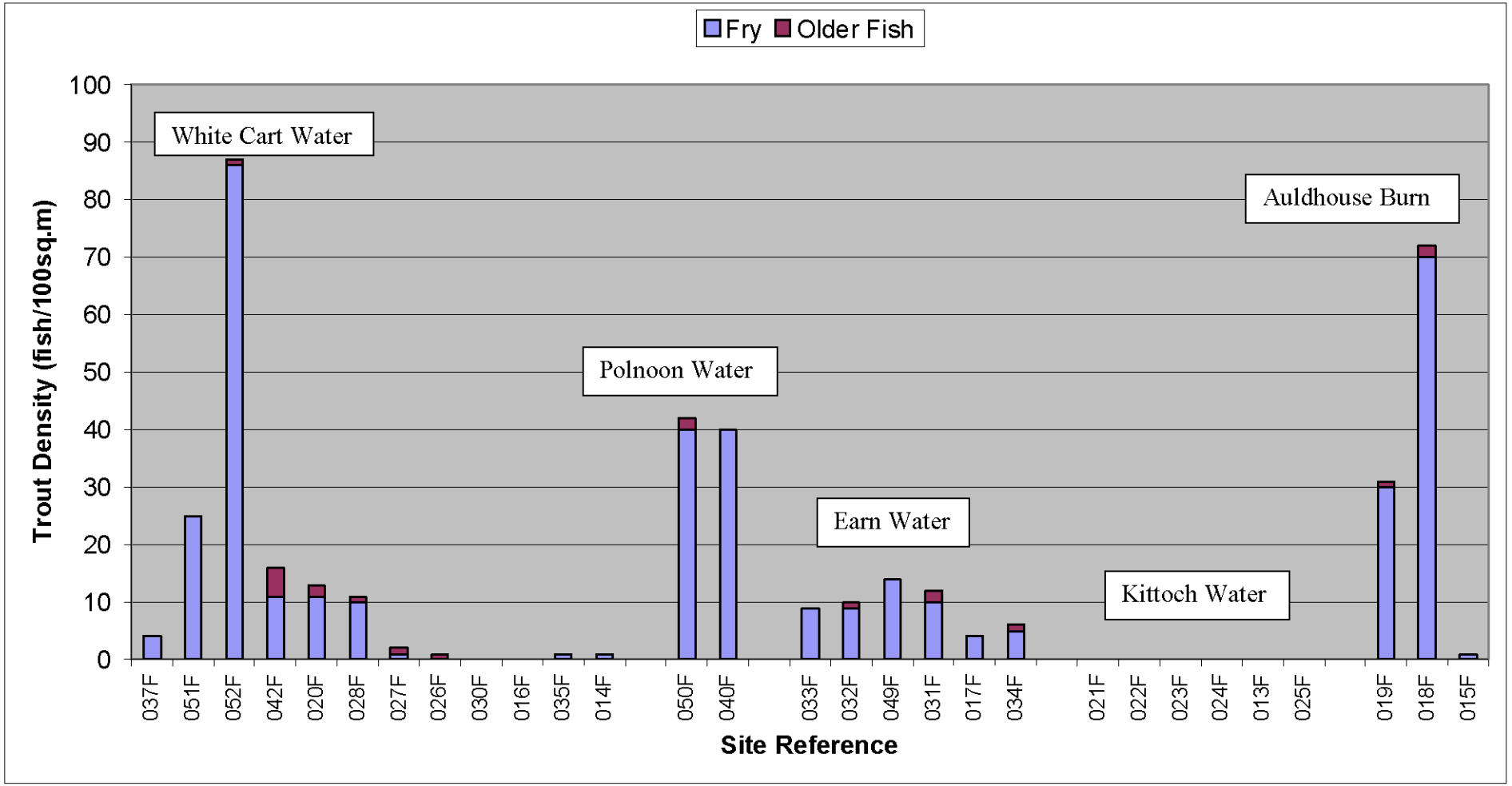


Figure 21: Trout Densities, White Cart Catchment, 2006

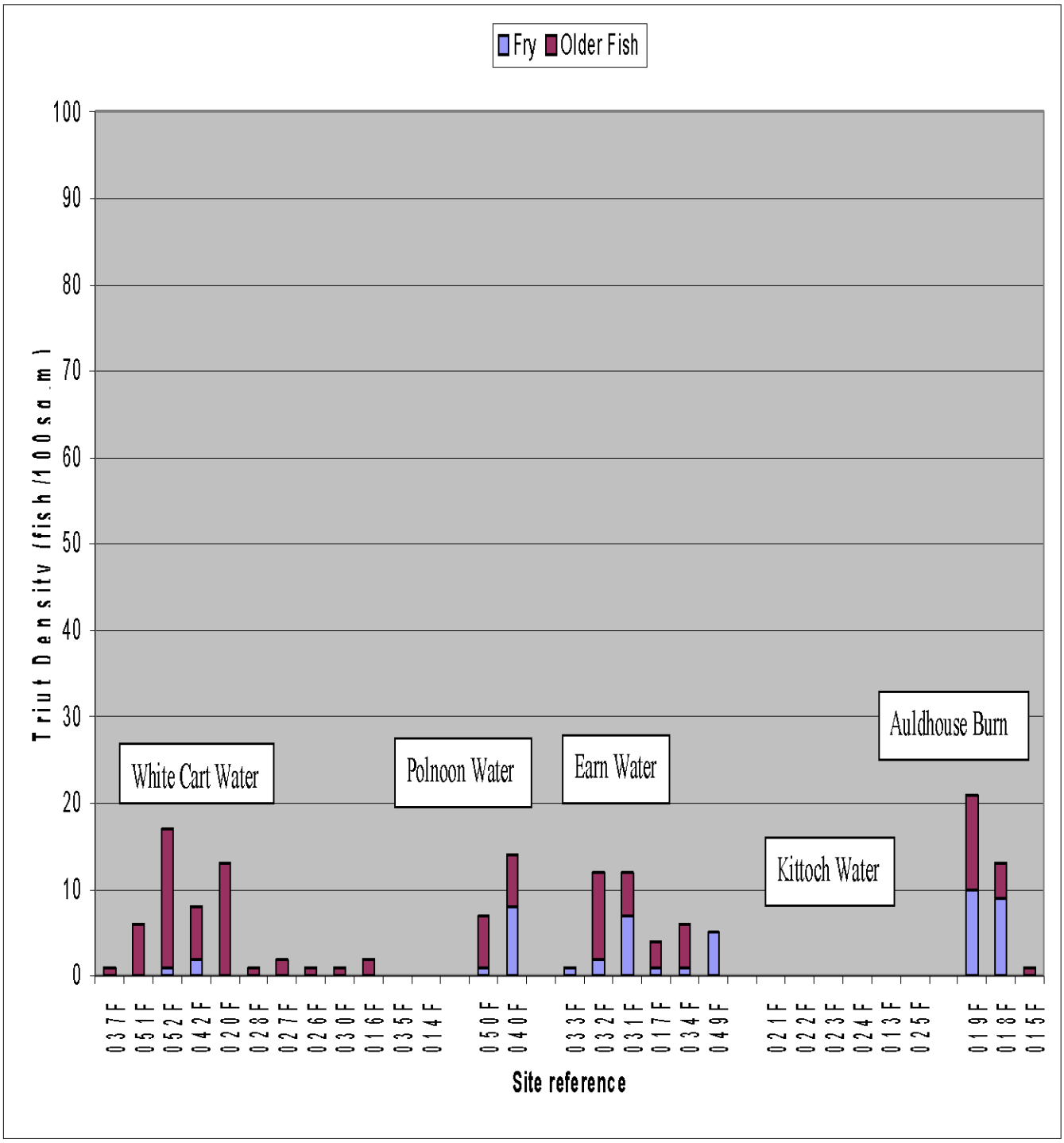


Figure 22: Trout Densities, White Cart Catchment, 2007

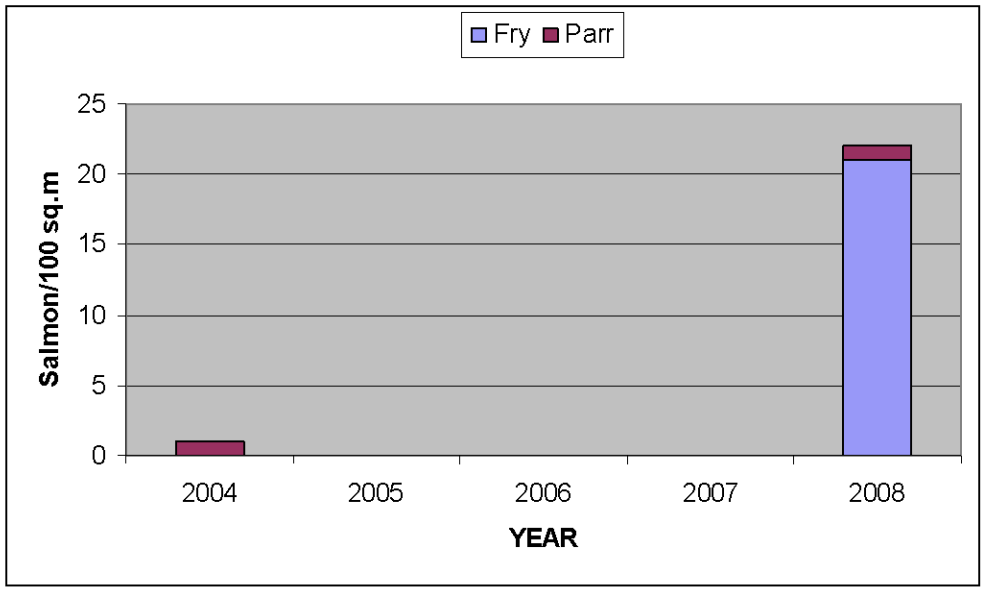


Figure 23: Juvenile Salmon Density in the Roebank Burn, Renfrewshire

CRF Objective 2.3 Surveying Management Subunits

In the absence of catastrophic losses or invasive species being present, broad scale spatial surveys are planned every five years across each of the major subcatchments; this is thought to be manageable at current resource levels. A small number of core temporal sites will be programmed for survey annually in each catchment and data gathering needs will also be reviewed in advance of each field season to allow for reprioritisation, for example if development pressure increases in a particular catchment.

In 2009, we will repeat earlier large-scale spatial surveys of the Gryfe and Duneaton catchments and resurvey approximately 60 core sites.

CRF Objective 2.4 Habitat Surveys

Fish production and habitat availability are closely linked. The suitability of habitats for particular life stages of fish changes with water flow, bed composition, bank form and the combined effects on food and shelter. Habitat niche specialisation allows a wide number of fish species to occupy similar areas, with population size being influenced by the availability of preferred habitat. Physical barriers can prevent fish movement, and behavioural barriers can discourage fish passage through areas of substandard habitat leading to sub-optimal use of habitats and limited fish production.

The Clyde system suffered from massive industrialisation in the past and today is still home to 33% of Scotland's people. Rivers were degraded both chemically and physically and, while much of the most serious chemical pollution has disappeared, alterations to the banks and beds of rivers has left a serious legacy for the fish populations. Impoundment and land drainage/flood defence have caused huge damage to the physical habitat of salmonids in particular and river restoration (or at least preparing for it) is likely to feature large in the work of the CRF over the period of this RCFMP. The CRF has three SFCC-trained habitat surveyors (this will rise to four) and has some experience of undertaking

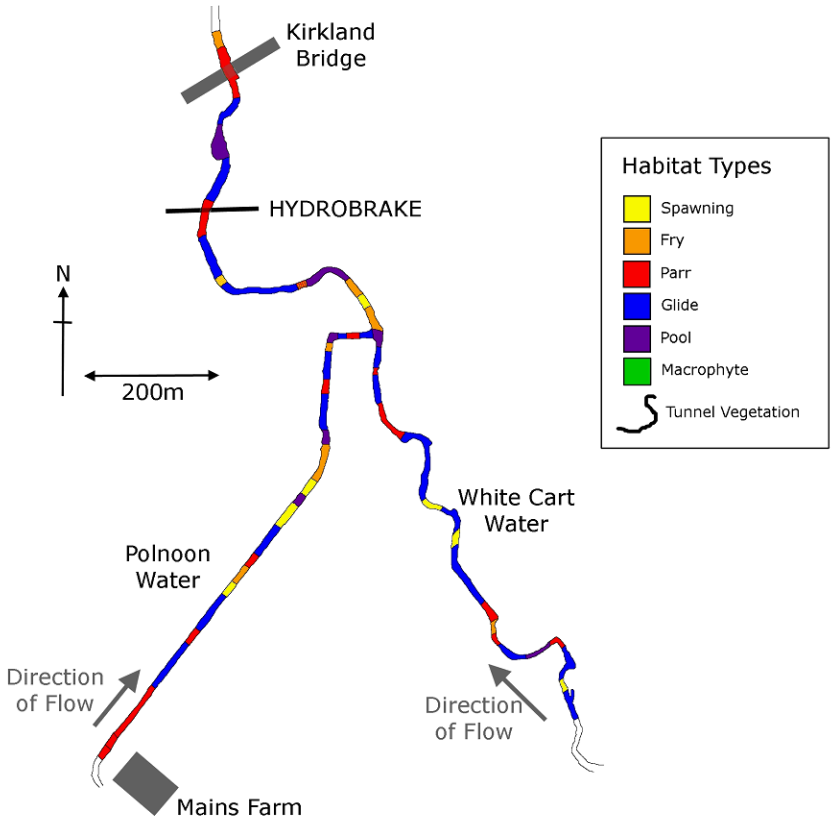
habitat surveys to the full SFCC protocol. Recently, however, we have utilised a more rapid method (Hendry & Cragg-Hine 1997) to demonstrate that lack of spawning habitat is probably responsible for the very poor salmonid numbers encountered in the White Cart system (Figures 21 & 22). This method has also been used to survey much of the length of the Allander Water as part of a study to model smolt production, and it is anticipated that we will survey the bulk of the RCFMP area using it over the next five years.

Habitat surveying helps make sense of electrofishing data and vice-versa and this objective will, by identifying the most degraded reaches, and perhaps habitat bottlenecks, allow the targeting of restoration effort. Habitat surveys also help detect impassable barriers to migratory species and the removal of man-made barriers is key to the full recolonisation of the former range of salmon in the River Clyde (Figure 18). Other species migrate significantly within rivers (eg. grayling and brown trout) and their movement may also be impeded by a range of obstacles.

Habitat restoration programmes have successfully improved fish diversity and production in previously degraded habitats elsewhere. Only a very small proportion of the Clyde system has been surveyed to date and collecting comprehensive habitat data will be a major commitment of the CRF towards the RCFMP over the next five years. Habitat surveys will provide information on the physical state of river banks and bed (including man-made alterations), sediment and pollution sources (including areas affected by diffuse pollution, CSOs and other chronic urban problems), instream and riparian plant communities (including the distribution of alien plant species like Japanese knotweed and Himalayan balsam) and the major land uses surrounding the watercourses. Opportunities for partnership working with local non-native invasive species for a will be investigated.

Information gleaned form habitat surveys will allow us to investigate reasons for habitat degradation and to estimate the total wetted areas of different habitat types and river systems, which will feed into calculations of fish standing stock and production estimates. The production of habitat restoration plans (and their funding) will also be facilitated.

In 2009, we will map the habitat of the Kelvin subcatchment using the Hendry & Cragg-Hine (1997) methodology.



Grid References:
Upstream White Cart Water – NGR 259088 651679
Downstream White Cart at d/s Kirkland Bridge – NGR 258548 652864
Upstream Polnoon Water – NGR 258348 651664

Figure 24: Habitat Map of the White Cart and Polnoon Waters in the Vicinity of Kirkland Bridge, East Renfrewshire

CRF Objective 2.5 Environmental Improvements

Good quality data are key to assessing baseline conditions and, by extension, measuring the benefits of fishery management actions. Our investigative electrofishing has established or confirmed that several man-made structures are currently restricting salmon production in the Clyde system, the prime example being Ferniegair Weir at the foot of the River Avon, which is currently denying pre-spawning fish access to tens of kilometres of potential spawning and rearing habitat. An application has been made to the SEPA habitat restoration fund by South Lanarkshire Council and the Avon Angling Club to address fish passage at this site.

During the lifetime of this RCFMP, we will continue to assess the effects of structures by combining electrofishing and habitat survey information. We are currently preparing a case to assess the options for fish passage at Bridgend Dam, on the River Calder in Renfrewshire and will liaise with angling clubs as this work becomes necessary elsewhere.

CRF Objective 2.6 Riverine Fishery Resources

Access to reliable information on the current status, distribution, abundance and species composition of freshwater fish communities on the Clyde is currently unavailable. While we have a considerable quantity of data for a large proportion of the riverine Clyde system, we acknowledge that there is still considerable work to do to characterise this fully, particularly for the coarse fish species, largely because the riverine species prefer deeper water than that in which we can electrofish effectively. One of the commitments of the RCFMP is that we will research more useful techniques for obtaining fisheries information from larger, deeper rivers. This may take the form of index sampling riffles for salmon and trout fry, or of netting deeper reaches for all species, or angling catch information from catch returns or log books or angling matches for trout, grayling and coarse fish.

An example of this approach is the joint electrofishing study of grayling in the South Calder Water, North Lanarkshire with the Grayling Research Trust and the Scottish Government, where a long section of river is monitored annually to assess the density and population structure of the fish population (Figure 15).

CRF Objective 2.7 Stillwater Fishery Resources

The stillwaters of the central belt of Scotland provide a very significant fishery for trout and coarse fish. During the lifetime of this RCFMP we will undertake to increase our knowledge of the numbers, locations and types of these fisheries in the Clyde catchment and to maintain a database of this information. We will establish and maintain useful contact with individual fisheries and/or their representative bodies.

CRF Objective 2.8 Fishery Performance

While electrofishing can give some idea of the general health of the river, fishery performance must be measured directly, i.e. it is necessary to have some measure of catch and of fishing effort. We consider it essential that angling clubs and fishery managers collate catch statistics as a matter of routine and will promote this in the RCFMP. Better fishery management will be possible when these data are available.

The Walton Angling Club, which controls the fishing in the upper White Cart catchment has instituted an on-line catch return for its members and the CRF has used the information gathered to try to assess the relative performance of the fishery upstream and downstream of an on-line flood prevention structure (Figure 25).

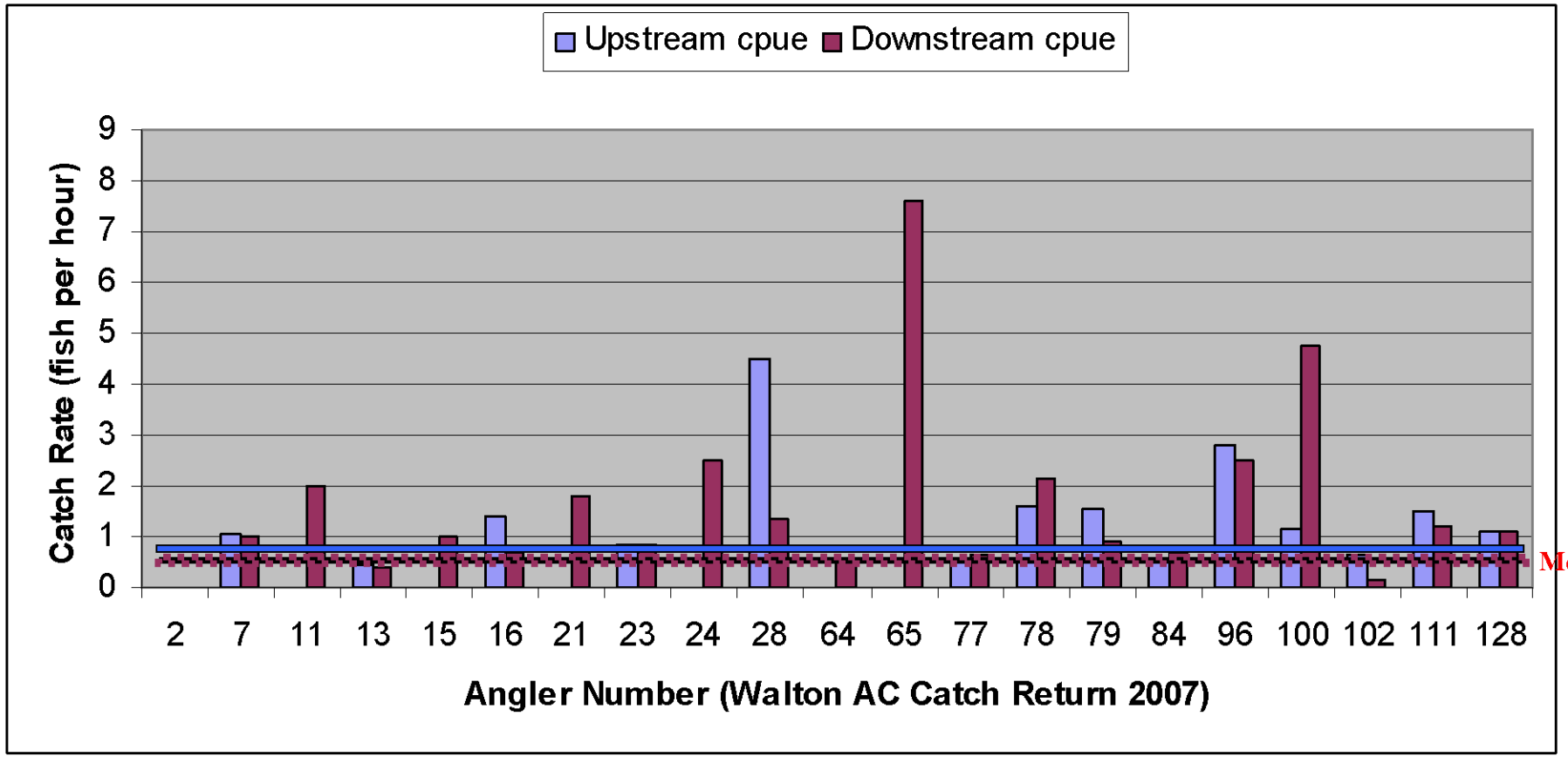


Figure 25: Catch per Unit Effort (trout/hour) from the Walton Angling Club Online Catch Return 2007

CRF Objective 2.9 Stillwater Studies and Management Advice

The CRF has only one member angling club which solely manages a stillwater. During 2009 a study will be initiated in collaboration with the Ballageich Angling Club, looking at the feeding patterns of brown and rainbow trout in the Dunwan Dam and comparing the trout diet with what is potentially available to them (Figure 26). This will be carried out in conjunction with analysis of the club's stocking and catch records over the past ten years. It is hoped to generate sufficient information to generate useful management (stocking) advice for the angling club and we hope to apply lessons learned elsewhere.

Figure 26: Dunwan Dam

CRF Objective 2.10 Salmon Production

Our surveys have extended the known geographical distribution of salmon in each of the seven field seasons to date (including confirmation of breeding within the limits of the City of Glasgow and also in North Lanarkshire). Other than juvenile distribution and density determined from our electrofishing surveys, and rod catch statistics compiled by the angling clubs and collated by the Crown Estate, we have little knowledge of the current status of Clyde salmon stocks.

During the lifetime of this plan we will complete our knowledge of the current distribution of salmon across the RCFMP area. In 2009, we will participate in a joint project with Scottish Natural Heritage and RWE npower renewables to install and operate a VAKI fish counter (Figure 27) at Blantyre Weir on the main stem of the River Clyde (the CRF will be responsible for running the counter once it is installed).

This will give us independent insight into upstream-migrating adult salmon and sea trout (numbers and run timing, etc.).

Figure 27: Vaki Riverwatcher, to be installed at Blantyre Weir, Lanarkshire

The CRF has recently completed a habitat survey of the Allander Water, Dunbartonshire, and we will follow it up this year with an electrofishing survey to determine relative densities of juvenile salmon in the major habitat types. It is hoped to use these data to generate a smolt production estimate for the burn, and to ground truth it by smolt trapping during the lifetime of the RCFMP.

The Clyde system has a recovering salmon population, and its stock structure remains unknown. Fish stocks can show distinct genetic differentiation, even within smaller water bodies. This has been widely studied in salmon populations where the differences are maintained by homing behaviour. The strong homing instinct exhibited by salmon ensures there is reproductive segregation of individuals into distinct groups based on place of origin (Webb *et al.* 2007). Protection of genetic diversity is essential for the health of salmon populations. For example, the wide variations in run timing that occur in salmon populations are explained by genetic variation, which ensures that fresh fish arrive in our rivers from March to November.

Genetic analysis will soon be able to provide information on many vital fishery management issues, including, effective population size, the number of individual populations, relative contribution of tributaries or areas of the river to smolt

production and sources of spring running fish. For these reasons, the CRF considers the collection of genetic material and analysis from across the River Clyde catchment to be an essential management action. Management of the salmon populations should therefore operate on the precautionary principle with conservation of the genetic integrity of stocks given highest priority.

Through participation with RAFTS in the SALSEA project, the CRF hope to be able to produce a fine scale genetic map of salmon populations in the River Clyde. The River Clyde is a recovering river, where salmon spawning is still constrained in some areas by barriers to migration and poor water quality. Numbers of salmon are generally too low to allow efficient sampling to be undertaken but samples were obtained in 2008 from sites in the Kelvin, Black Cart and Gryfe subcatchments. This programme will be extended to cover the mainstem of the Clyde and other subcatchments during the lifetime of this RCFMP.

CRF Objective 2.11 Dissemination of Survey Results to Angling Clubs

The information generated by our science is primarily of use to the local fishery managers. Resource limitations have prevented the CRF from undertaking unfunded reporting of fishery surveys until recently. This year, we have provided summary information on fish community structure and salmonid densities to a small number of our member angling clubs and we will expand this service, updated annually, as funding allows. The angling clubs can therefore access the latest scientific information available for the waters under their control and make better-informed management decisions.

CRF Objective 2.12 Invertebrate Surveys

Although the Clyde system has cleaned up significantly in recent years, water quality is still an issue in several localities, both urban and rural. Issues with poorly treated sewage (Figure 28), CSOs (Figure 29), road runoff (Figure 30), diffuse pollution from land, and silt pollution (Figure 31) mean it is imperative that the CRF maintains independent expertise in freshwater biology and impact assessment. We hold invertebrate data from several hundred sites across the Clyde catchment, mostly collected to the standard kick sampling protocol used by regulatory bodies. These data have been collected during a variety of investigations and in some cases have been used as baseline information following subsequent pollution incidents.

We have also recently undertaken quantitative "Surber" sampling of invertebrate communities to explore whether this might be a better technique for detecting the effects of silt pollution in particular. The recovery of the Logan Water (Figure 31) is now being assessed using Surber sampling and this initial trial of the technique looks promising. Our invertebrate work is also being used to provide proactive baselines against which angling clubs can assess potential damage to the environmental quality of their fisheries. For example, the CRF is assessing invertebrate numbers for the Lamington AIA in an area of the main River Clyde where gravel extraction is being considered immediately adjacent to the fishery (Figure 32).

Figure 28: Sewage Fungus in the Kittoch Water, South Lanarkshire

Figure 29: CSO, Allander Water, Dunbartonshire

Figure 30: Road Runoff, Allander Water, Dunbartonshire

Figure 31: Silt Pollution of the Logan Water, South Lanarkshire

Figure 32: Surber Sampling for Invertebrates on the main River Clyde near Lamington Bridge, South Lanarkshire

CRF Objective 2.13 Aquatic and Riparian Plants

In certain parts of the Clyde catchment (and in many of its still waters) aquatic plants may provide useful cover for fish. Occasionally we see the effects of eutrophication and some areas suffer from an excess of plants which may cause difficulties for the fishery managers (e.g. in the lower Black Cart Water). The CRF is developing skills in identification of aquatic plants in order that we might improve our assessment of river quality.

Extensive stands of Himalayan balsam (Figure 34) and Japanese knotweed occur in parts of the Clyde catchment. Giant hogweed and another species of local concern, skunk cabbage, also appear to be spreading. These plants can make access to the river difficult and negatively affect native biodiversity. During the lifetime of this RCFMP, we will undertake an assessment of the distribution of alien riparian plants across the catchment with a view to assessing the options for eradication where it might be possible.

Figure 33: Himalayan balsam on the banks of the Black Cart Water, Renfrewshire

CRF Objective 2.14 Invasive, Non-native Animal Species

The upper Clyde is blighted by the presence of signal crayfish. The CRF has developed expertise in sampling crayfish, largely in conjunction with colleagues from UCAPA Ltd. and our PhD student, Zara Gladman. We are pursuing various avenues of research which will hopefully be applicable more widely but the CRF is largely involved in impact assessments (looking at the differences in invertebrate

communities in areas with and without crayfish) and in attempting to limit the spread of the crayfish to other catchments (the Annan looks to be particularly vulnerable).

We have clarified the fine-scale distribution of crayfish in the Clyde catchment, and this information will be used for management purposes. This information will be updated regularly during the lifetime of this RCFMP.

A national initiative is currently underway (co-ordinated by RAFTS) to produce biosecurity plans for each catchment; this objective will contribute to the Clyde plan. A programme of awareness-raising will accompany the production of this plan.

CRF Objective 2.15 Mammal Surveys

Otters and water vole are of conservation interest. The CRF undertakes surveys from time-to-time in areas where there are almost certainly one or other of the species present. Knowledge of the key signs of these species would allow us to add value to our routine surveying.

Unlike the other species, we see the occasional mink while sampling. There is a degree of mink control underway on the Clyde and, again, we could add value to our survey data by making a rapid assessment at electrofishing and invertebrate survey sites.

CRF Objective 2.16 Co-ordination with SEPA

SEPA has responsibilities to monitor fish communities for the Water Framework Directive. There is a requirement on both the CRF and SEPA to ensure that fishery sites are not over-sampled. The CRF will therefore co-ordinate its electrofishing programme with that of SEPA where possible to ensure that there is no duplication of effort. SEPA also has lead responsibility for removal of barriers to fish movement and the CRF will assist with such initiatives where appropriate.

5.2 RCFMP Management Actions

The CRF Objectives can be translated into management activities to protect and improve the fisheries of the Clyde system and these are described for each of the major fisheries (migratory, brown trout, grayling, coarse fish and rainbow trout) and the conservation species in Tables 9-16. It is the management actions and timescales in these Tables that require assessment and input from stakeholders.

Table 9: Turning CRF Objectives into RCFMP Management Actions for Salmon and Sea Trout

Objectives	Action No.	Action	Lead	Others	Timescale
2.1, 2.2, 2.3, 2.6, 2.10, 2.16	5.1.1	Monitor spatial and temporal distribution of adult and juvenile salmon and sea trout in the Clyde, and develop stock enhancement policies.	CRF	Local Authorities, RCFMT, Angling Clubs, SNH, AST, Marine Scotland.	2009-2015
2.4, 2.5	5.1.2	Review access to all potential spawning areas and develop a prioritised action plan for removing man-made obstructions and/or facilitating fish passage.	CRF	RWE npower renewables, Riparian Owners, Local Authorities, Angling Clubs, Marine Scotland, RCFMT, SEPA.	2009-2012
2.4, 2.5, 2.12, 2.13, 2.14, 2.15, 2.16	5.1.3	Quantify and protect juvenile habitats; identify and consider options for restoration of those that are degraded.	CRF	Local Authorities, SNH, Riparian Owners, Angling Clubs.	2009-2012
2.10	5.1.4	Contribute to genetic stock discrimination study for management purposes.	RAFTS	Marine Scotland, CRF.	2009-2012
2.6, 2.8	5.1.5	Improve data collection from rod fishery and suggest conservation measures where necessary.	Crown Estate	CRF, Fishery Owners, Angling Clubs, Marine Scotland.	2009-2015
2.1, 2.4, 2.5	5.1.6	Review the management and effects of dams and impoundments in the catchment.	SEPA	Marine Scotland, Scottish Water, British Waterways, Riparian Owners, RWE, SEERAD, CRF, Angling Clubs	2009-2015

Table 10: Turning CRF Objectives into RCFMP Management Actions for Brown Trout

Objectives	Action No.	Action	Lead	Others	Timescale
2.1, 2.2, 2.3, 2.10, 2.16	5.2.1	Monitor the status and distribution of adult and juvenile trout populations in the catchment.	CRF	Local Authorities, Angling Clubs	2009-2015
2.6	5.2.2	Review local stock enhancement and other conservation measures for trout. Produce a local "Code of Practice" for trout stocking.	CRF	Marine Scotland, Angling Clubs	2009-2011
2.6, 2.7, 2.8	5.2.3	Improve data collection from brown trout rod fisheries and suggest conservation measures where necessary.	CRF	Fishery Owners. Angling Clubs, SFCC	2009-2015
2.4, 2.5, 2.12, 2.13, 2.14, 2.15, 2.16	5.2.4	Quantify and protect riverine habitats; identify and assess options for remediation for those that are degraded.	CRF	Riparian Owners. Angling Clubs	2009-2015
2.1, 2.2, 2.4, 2.5, 2.12, 2.13, 2.14, 2.15, 2.16	5.2.5	Investigate trout-free areas and those with poor recruitment	CRF	SEPA, Angling Clubs	2009-2012

Table 11: Turning CRF Objectives into RCFMP Management Actions for Grayling

Objectives	Action No.	Action	Lead	Others	Timescale
2.1, 2.2, 2.3, 2.6, 2.8	5.3.1	Develop methodologies for monitoring the status and distribution of adult and juvenile grayling populations in the catchment.	CRF	Grayling Research Trust, Grayling Society, Angling Clubs	2009-2012
2.2, 2.6	5.3.2	Develop the annual CRF grayling electrofishing survey on the South Calder Water, North Lanarkshire, into a national survey site with assistance from the Grayling Research Trust	CRF	Grayling Research Trust, Grayling Society, Angling Clubs, Scottish Government.	2009-2015
2.1, 2.2, 2.3, 2.6, 2.8	5.3.3	Expand Action 5.3.2 to include sites on the Rivers Avon and Gryfe, and the Douglas Water.	CRF	Angling Clubs, Grayling Society, Grayling Research Trust	2009-2011
2.10	5.3.4	Genetic stock discrimination study for management purposes.	Grayling Research Trust.	CRF, Angling Clubs	2009-2010
2.6, 2.8	5.3.5	Improve data collection from rod fisheries.	Angling Clubs	CRF, Grayling Society .	2009-2015

Table 12: Turning CRF Objectives into RCFMP Management Actions for Rainbow Trout

Objectives	Action No.	Action	Lead	Others	Timescale
2.7, 2.9	5.4.1	Conduct a survey on distribution and abundance of rainbow trout fisheries in the Clyde catchment.	CRF	Trout Fisheries, Angling Clubs	2010-2013
2.1, 2.7, 2.9	5.4.2	Assess the potential presence of rainbow trout in rivers adjacent to stillwater fisheries.	CRF.	Trout Fisheries, Angling Clubs	2010-2013
2.7, 2.9, 2.12, 2.13, 2.14	5.4.3	Improve data collection from rainbow trout fisheries and suggest management measures where requested.	CRF	Angling Clubs, Trout Fisheries	2010-2013

Table 13: Turning CRF Objectives into RCFMP Management Actions for Coarse Fish Species

Objectives	Action No.	Action	Lead	Others	Timescale
2.6, 2.8, 2.9	5.5.1	Integrate management of the coarse fisheries with other Clyde fisheries.	Angling Clubs, SFCA Fishery Owners	CRF	2012-2015
2.1, 2.2	5.5.2	Determine the distribution of coarse fish species in rivers and still waters throughout the Clyde catchment.	CRF.	Coarse Fisheries, SEPA	2009-2012
2.1, 2.2	5.5.3	Develop a monitoring programme for coarse fish species	Angling Clubs, SFCA, British Waterways	CRF	2009-2015
2.12, 2.13, 2.14	5.5.4	Investigate the interactions between introduced species and native fish and invertebrate communities.	CRF	Angling Clubs, SEPA	2009-2015

Table 14: Turning CRF Objectives into RCFMP Management Actions for the Conservation of Non-fishery Species

Objectives	Action No.	Action	Lead	Others	Timescale
2.1, 2.2	5.6.1	Establish the distribution (and abundance where possible) of all non-fishery species	CRF	Local Authorities, SNH	2009-2012
2.1, 2.2	5.6.2	Establish the status of sea, river and brook lamprey populations.	CRF	SNH	2009-2015
2.1, 2.2	5.6.3	Establish the status of the Clyde eel stock.	Marine Scotland	CRF	2009-2015
2.4, 2.5	5.6.4	Identify and protect species of local rarity and/or scientific interest (and their habitats).	CRF	Local Authorities	2009-2103

Table 15: Turning CRF Objectives into RCFMP Management Actions for Education and Awareness

Objectives	Action No.	Action	Lead	Others	Timescale
3.1, 3.2	5.7.1	To continue to deliver "Clyde in the Classroom" across eight local authorities covered by the RCFMP area (i.e. Glasgow City, West Dunbartonshire, East Dunbartonshire, North Lanarkshire, South Lanarkshire, East Renfrewshire, Renfrewshire and Inverclyde)	CRF	SNH, Scottish Government, Local Authorities, Schools, Angling Clubs, Private Sponsors	2009-2015
3.1, 3.2	5.7.2	To develop and deliver "Meet Your River" at a pilot scale across the RCFMP area.	CRF	Scottish Government, Local Authorities, Schools, Angling Clubs, Private Sponsors	2009-2011
3.1, 3.2	5.7.3	To develop a secondary school education project.	CRF	Local Authorities, Schools, Scottish Government	2010-2011
3.1	5.7.4	To continue to provide undergraduate and Masters research projects annually.	CRF	University of Glasgow	2009-2015
3.1	5.7.5	To continue to identify opportunities for PhD students to undertake projects in the RCFMP area.	CRF	University of Glasgow	2009-2015
3.1, 3.2, 3.3	5.7.6	To develop a programme of informal workshops for angling clubs to demonstrate sampling methods and fly life identification.	CRF	Buglife, Angling Clubs	2009-2015
3.3	5.7.7	To train angling club members, where appropriate, to participate in fishery surveys	CRF	Angling Clubs, SFCC	2009-2015
2.11	5.7.8	To continue to present survey results to angling clubs in person and by written report.	CRF	Angling Clubs	2009-2015

Table 16: Turning CRF Objectives into RCFMP Management Actions for Invasive Non-native Species

Objectives	Action No.	Action	Lead	Others	Timescale
2.4, 2.5, 2.13, 2.14, 2.15	5.8.1	Construct a biosecurity plan for the RCFMP area	CRF	RAFTS,	2010-2011
2.4, 2.5, 2.13, 2.14, 2.15	5.8.2	Map the distribution of invasive non-native riparian plants across the catchment with a view to assessing the options for containment or eradication where possible.	CRF	RAFTS, SNH, Local Authorities, Angling Clubs.	2009-2015
2.4, 2.5, 2.14, 2.15	5.8.3	Map the distribution of invasive non-native animal species across the catchment with a view to assessing the options for containment or eradication where possible.	CRF	RAFTS, SNH, Local Authorities, Angling Clubs.	2009-2015
2.4, 2.5, 2.13, 2.14, 2.15	5.8.4	Investigate the impacts of invasive non-native species on the ecology of the RCFMP area.	CRF	RAFTS, SNH, Local Authorities, Angling Clubs.	2009-2015

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