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FACTORS AFFECTING SALMON PRODUCTION IN IRISH CATCHMENTS

By

M.F. O'Grady and P.G. Gargan

ABSTRACT

This paper outlines the range of salmon habitats in Ireland and illustrates the extent of baseline data available in relation to this resource. The range of problems which are adversely affecting/eliminating wild salmon production are illustrated. Programmes are underway to offset the difficulties which are outlined.

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1. INTRODUCTION

A review of all research programmes concerned with Irish salmon stocks up to the 1980's has been presented in Bracken and O'Grady (1992).

Detailed surveys concerned with establishing the physical/ecological nature of Irelands salmonid catchments only commenced on a large scale in the 1980's. Most of these programmes were undertaken by the staffs of the Central and Regional Fisheries Boards. The survey data compiled in these studies is used here to illustrate the problems facing this resource within the freshwater environment in Ireland and the research/development exercises currently underway to maintain/enhance salmon production.

2. SURVEY PROCEDURE

Given adequate resources, the authors would suggest that the compilation of the following data bases are required to understand the major factors influencing salmon production. In physical terms the availability of longitudinal sections and cross-sections at regular (100 yard) intervals for all channels is most desirable. A comprehensive data base on the physical nature of substrates over entire channel lengths is also critical. This information has been compiled for all Irish channels which have been subject to arterial drainage and is also available for some undrained rivers. An example of the type of data available is illustrated (Fig. 1). Obviously all available hydrological data should be reviewed. Ideally comprehensive information on water chemistry, aquatic plant and macro-invertebrate communities and the nature of the riparian zone should be compiled. We would consider the compilation of a quantitative data base on fish stocks as being essential. Since these survey programmes commenced techniques used to quantify fish stocks have been modified. Initially fish stocks were often quantified over long (≤ 4km) channel lengths using Petersen tag/recapture methods (Robson and Regier, 1964). Experience has shown that stocks in shorter channel sections equally reflect the situation over long distances provided that physical, hydrological and general ecological conditions do not change.

The authors would contend that the selection of sampling locations throughout a catchment should be dictated by a combination of physical, hydrological and ecological factors. A preliminary survey of all channels with the physical data base to hand will allow one to select representative habitat types. Locations selected will be determined principally by reference to channel gradient, basewidth, substrate type, summer Q values and the nature of the riparian zone with additional sites being added to the programme as one or more of these factors changes significantly over a channels length. The level of sampling intensity required to comply with this procedure in one Irish catchment is illustrated (Fig. 2). Generally in physically undisturbed salmon spawning/nursery zones a physical sampling unit would consist minimally of one riffle/glide/pool sequence in Irish rivers. The authors experience indicates that in Irish rivers the electrofishing aspects of these surveys should not commence before July because of fry (0+ year-old) sizes. Our fish stock assessments have been confined to the July-September period thereby allowing reasonable comparison of all available data bases. The type of procedure outlined here is similar to that specified by Rosgen (1985). The importance of adopting such an approach has been reviewed recently by Kershner and Snider (1992).

An example of the type of survey sheet now being completed at each sampling location for data, other than fish figures is provided (Fig. 3). In the last three years a more detailed physical and hydrological survey has also been undertaken for a sub-sample of sites in individual surveys. This involves the measurement of flows, channel cross-sections, reach gradient, detailed substrate analysis (after Fluskey, 1989), bank full width and netted perimeter.

A depletion electro-fishing technique involving two or three successive fishing in enclosed sites is employed to quantify fish numbers (after Seber and Le Cren, 1967 or Zippin, 1958) as appropriate. Usually at least (≥50) all of the fish captured in the first fishing are measured and a proportion (10 per site) are scaled for subsequent age and growth analysis.

3. THE EXTENT OF SURVEY DATA AVAILABLE

The salmon catchments surveyed by the C.F.B. to-date are listed (Table 1). It should be stressed that the range of comprehensive information, now considered desirable, is not available for all of these waters.

4. RESULTS

The data compiled to-date relate solely to the rivers surveyed and as such may not necessarily reflect the extent of problems in other Irish catchments. The following is a review of the relative extent of problems identified. It should be noted that, unlike many other European countries, Ireland has not lost a single salmon fishery to-date. However, the list of problems outlined indicates the nature and extent of our difficulties and reflects some of the freshwater problems responsible for reduced salmon runs to these rivers in recent decades.

The distribution and extent of problems in individual catchments is outlined in Table 1 and the magnitude of individual problems in the twenty-seven catchments surveyed is outlined in Table 2.

4.1. Organic Pollution

Table 1 illustrates that organic pollution is one of our more serious problems. Both localised de-oxygenation and the more subtle effects of cultural eutrophication are evident in some of our larger salmon catchments (Nore, Suir and Boyne). These problems are primarily a consequence of inadequate sewage treatment and run-off from intensively farmed land. It is hoped that pending E.C. legislation (Anon, 1991) will help to alleviate the sewage problem. Agricultural scientists in collaboration with relevant fisheries personnel are reviewing the problems in this area with a view to re-organising slurry management practice in order to resolve this problem.

4.2. Unbalanced Riparian Zones

O'Grady (In press) has shown that where incident light to Irish rivers is significantly reduced the whole aquatic ecology suffers with depressed salmon and trout production as a consequence. In all the listed rivers the excessive shade is primarily a consequence of overhanging deciduous vegetation. Initial observations (O'Grady, unpublished) has shown that partial shrub clearance can quickly (2 years) restore significant fish productivity levels. The Regional Fisheries Boards have now adopted partial shrub clearance as a standard development practice to resolve this problem.

In contrast, a lack of fencing, in combination with over-grazing by cattle and/or sheep, has resulted in the elimination of virtually all bankside vegetation on some rivers (Tables 1 and 2). In some channels this has lead to bank instability, excessive erosion and reduced juvenile salmon stocks because of an elimination of the thalweg and the collapse of the natural riffle/glide/pool sequence. Such channels are often braided i.e. too broad and shallow and only support small numbers of 0+ year-old salmon.

Many Irish rivers which have stable banks, without a significant level of bankside vegetation, still support very substantial juvenile salmon populations. Consequently the role of a developed riparian zone on Irish rivers, in terms of maintaining optimum juvenile salmon stocks, is still unclear.

Erosion problems are also evident in Irish rivers as a consequence of commercial gravel removal (R. Feale) and land drainage schemes (R. Nore).

4.3. Impassable Barriers

The position of impassable barriers within a system obviously determines their relative importance. In Irish rivers surveyed to-date the majority of such structures are located in headwater areas of catchments (Crana, Easkey, Ilen and Claddy). In two systems, the Shannon and Nore man-made structures (weirs or sand traps) are limiting upstream salmon migration in important salmon tributary sub-catchments. In two catchments, the Mill and Melvin systems, natural waterfalls constitute either a serious impassable barrier (Melvin R.) or a very formidable barrier (Mill R.) to the upstream passage of salmon to extensive catchment areas.

4.4. Afforestation

This is a limited problem in selected small catchments where planting of coniferous trees too close to stream banks has resulted in excessive shade and subsequent bank erosion and siltation as described by Mills (1967) and Smith (1980). It has been a particular problem in a number of sea trout fisheries in the west of Ireland where fish rely on very small channels (2-3m summer channel basewidth) to spawn.

Recent collaboration between forestry and fisheries interests have drawn up guidelines which, have been put in practice and should resolve these problems (Anon, 1992).

4.5. Hydro-Schemes

The impact of large hydro-electric schemes on the passage of migratory fishes is well documented. There are four such schemes in Ireland, the Shannon, Erne, Lee and Liffey. In the context of salmon management the principal problems are related to the impedance of smolt migration, the upstream movement of returning adults and free passage for descending kelts. In the Irish context this problem is now being studied in great detail and progress is being made in relation to resolving some of the difficulties particularly relating to smolt migration (O'Farrell, pers. comm).

Over the last decade there has been a growing number of "micro-hydro" schemes on Irish rivers. They are causing a number of problems. The weir structure built to generate the "head of water" often causes increased difficulty for salmon movements and ponds upstream areas eliminating habitat. In addition smolts are often attracted into the headrace and subsequently destroyed. Adult salmon often lie below the tail race and remain there for long periods at a time when they should be migrating upstream. While Irish fishery law demands the presence of adequate screens to prevent the aforementioned fish movements, the experience on the ground has been that such screens are not always maintained adequately.

4.6. Overgrazing

E.C. subsidies have lead to a significant increase in the sheep numbers grazing poor mountain heathlands in the west of Ireland. This has resulted in serious overgrazing on both hillside and river valley areas. In the authors opinion the elimination of heathland has lead to increased run-off rates in watercourse resulting in higher Q values during flood periods. Silt run-off has also increased because of the lack of vegetation. These factors, in combination with the same level of overgrazing along river banks, have resulted in significant increases in bank destabilisation leading to siltation and channel braiding. This type of problem was clearly evident to the authors in the Erriff, the Easkey and Ballinahinch Rivers. It has also been reported from the Burrishoole system (K. Whelan, pers. comm). Land management programmes in North America have shown that controlled seasonal grazing patterns in combination with limited livestock numbers can eliminate this problem (Chaney et al 1990).

A failure of landowners to fence river banks in Irish lowland areas has lead to similar problems in terms of bank stabilisation and lack of shade. However, in these areas the proper agricultural management of entire valley areas, with no overgrazing, means that the bankside problems here are of a more localised nature. It is hoped that more extensive bankside fencing programmes will lead to the elimination of this problem. The importance of an undisturbed riparian zone in the context of river management has been highlighted by many authors (Petersen et al, 1992; Boon, 1992; White and Bryndilson, 1967; Hunt 1979 and Binns 1986 and others).

In the immediate future it is the Irish Government's intention to grant aid farmers in relation to fencing off watercourses, 20 year "set aside" of river bank areas and a lowering of stocking rates on hillside areas. This measure should resolve most of these problems.

4.7. Siltation/Compaction of Gravels

This has arisen as a consequence of man's activities in a number of different circumstances. The most serious problems of siltation and compaction of gravels has arisen where large scale peat harvesting has allowed the escapement of large quantities of silt into watercourses. This has a number of serious consequences. Compacted gravels can no longer function as salmonid spawning areas and it has also been shown that eggs laid in clean gravels (i.e. Owenmore River) which have subsequently been silted over by peat have failed to hatch. Settlement of peat particles on the river bed can seriously reduce both the diversity and abundance of the aquatic flora and invertebrate fauna. Such peat discharges can lead to an accelerated rate of secondary bank formation thereby creating long uniform glides where heretofore there had been a riffle/glide/pool sequence. In state owned peat harvesting operations, more attention is now been paid to the entrapment of loose peat particles with the provision of an adequate number, and regular maintenance, of effective silt traps. Attention is also being paid to the entrapment of wind blown peat particles. In this regard consideration is being given to the planting of deciduous hedgerows along bog drains to minimise this problem.

Another example of compaction of gravels results as an indirect consequence of cultural eutrophication. In a number of zones in Irish rivers (Liffey, Suir and lower Shannon) this phenomenon has lead to the generation of extensive beds of the macrophyte species *Potamogeton pectinatus* (Caffrey, 1990). This plant can grow on loose gravel beds and over a period of years entraps silt to a point where these gravel deposits can no longer function in salmonid spawning terms.

Gravel beds can sometimes become compacted by silt generated from arterial drainage programmes. Studies on the Boyne and Bonet have shown that subsequent tossing or sieving of compacted deposits can resolve this problem (Fluskey pers. comm).

4.8. Arterial Drainage Schemes

A majority of Ireland's salmonid catchments have been subjected to arterial drainage schemes at some time between 1840 and 1980. The more major mechanised schemes took place from the 1950's onwards. While the short-term impact of these schemes was very detrimental to salmonid stocks, recent studies have shown that the long-term impact has been very varied and complex ranging from positive, to neutral, to negative in relation to salmon stocks (O'Grady 1991(a), 1991(b); O'Grady 1993; O'Grady and King 1992 and O'Grady and Curtin, In press). Many of the Central Fisheries Board's salmonid riverine surveys have been carried out in drained catchments with one objective being the identification of poorly productive areas in salmonid terms. Subsequently enhancement schemes have been designed and implemented. Over the last decade circa 100,000 tonnes of stone and gravel have been used to enhance salmonid habitat in a number of catchments.

4.9. Competition/Predation

Apart from competition and predation by brown trout (*Salmo trutta* L.), an indigenous species, the salmon faces problems in this sphere from a number of species. Since the 1970's there has been an alarming spread of roach (*Rutilus rutilus* L.) throughout many salmon catchments (Fitzmaurice, 1984) with roach occupying salmonid nursery areas. The authors feel that pressure for space and food by roach may have resulted in a reduced salmonid carrying capacity in such channels. A similar problem may have resulted from the introduction of Dace (*Leuciscus leuciscus*, L.) to the Cork Blackwater earlier this century.

This species has also recently been found in the Nore system where a rapid expansion of the stock can be expected.

Many of Ireland's larger salmonid catchments encompass some low gradient riverine channel zones and/or large lakes both of which can support substantial pike stocks. Investigations have shown that pike consume substantial numbers of smolts (C.F.B., internal reports). Where resources are available it is established policy to control pike numbers in such waters. Predation by cormorants is a problem on all Irish salmon catchments to a varying degree, but is particularly heavy on the Slaney catchment. Kennedy (1987) has reported very heavy cormorant predation on salmon smolts in the River Bush in Northern Ireland.

4.10. Ponding

Over the last two hundred years a large number of stone weirs have been constructed on Irish rivers to harness the rivers power for milling purposes. In many instances, in channels of moderate gradient, individual weirs have ponded up to 1km length of channel thereby eliminating salmon spawning and nursery areas and creating suitable habitat for cyprinids and pike (*Esox lucius* L.). Most of these mills are now derelict but the weirs and their ponding effects are still in place. It is hoped that many of these derelict structures can be removed to restore the natural ecological conditions.

4.11. Water Abstraction

This is a relatively minor problem in Irish waters to-date because of our extensive aquatic resources, limited population and lack of industrialisation. However, the undesirable impacts of this problem have been observed, to a limited extent, in five of the catchments surveyed (Table 2).

4.12. Calcification

In Irish limestone river systems substantial amounts of calcium carbonate often precipitate out of solution and in the process compact gravel deposits to a point where they can no longer be used by salmonids for spawning purposes. This has been recognised as a problem in parts of four major Irish salmon catchments. Decompaction of such gravels using hydraulic machines has provided a short term solution to this problem (O'Grady and King, 1993).

4.13. Reservoir Creation

The damming of rivers to create reservoirs for water supply has resulted in loss of habitat for salmonids similar to that caused by ponding. However, river dams have also severely impacted on the migratory movements of smolts, kelts and spawning fish. The creation of lothic habitat can also lead to the establishment of large cyprinid populations and increase predation on salmonid smolts by pike. Such problems are currently evident in the Liffey and may arise following construction of the Owenasop dam on the Crana River.

4.14. Gravel Removal

This is a particular problem on two rivers in the south-west of Ireland - i.e. the Inny (Waterville) and the R. Feale where gravels are removed annually principally for road construction. This has had the effect of eliminating well defined adult salmon pools and generally destabilising the physical topography of long sections of channel. Legislation is now being prepared to prohibit the ongoing large scale removal of gravels in these and all other Irish rivers.

4.15. Lack of Gravels

In a number of sub-catchments in Irish rivers, a bedrock substrate and no erosion of gravels from banks leads to insufficient gravel deposits for spawning. This problem exists on sections of the Waterville, Melvin and Annagheeragh fisheries and is a localised problem on other rivers. Input of gravels in these areas is seldom successful because of the scowering effects of floods.

5. DISCUSSION

The authors would be optimistic in relation to the future management of Ireland's freshwater salmon resource. While there are a range of freshwater management problems we would contend that the important first step has been taken - i.e. a detailed evaluation of the type, extent and relative impact of the various difficulties has been assessed for many rivers. It is hoped that, over the next five years, a similar census will be completed for all of

Ireland's major salmon rivers.

In recent years tourism has ben a rapidly growing industry in Ireland. There is a political commitment to maintaining and, where necessary, improving water quality standards and the inland fisheries resource as an integral part of servicing this industry. As outlined many of the problems identified have already or will shortly be incorporated in management programmes.

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TABLE 1. The distribution and extent of problems in the individual catchments surveyed.

Catchment	Arterial Drainage (see footnote)	Lack of gravel	Bank erosion	Calcification	Compaction/Siltation	Gravel removal	Ponding	Impassable barriers	Organic pollution/ Eutrophication	Over-grazing (entire catchment area)	Competition (Roach, Dace)	Water abstraction	Hydro-Schemes	Afforestation	Reservoir creation	Unbalanced riparian zone: Excessive shade	Unbalanced riparian zone: Lack of bank cover	Pike predation
Dee	+	-	-	-	-	-	-	-	*	-	*	-	-	-	-	**	*	-
Boyne	+	-	-	*	*	-	*	-	**	-	*	-	*	-	-	-	**	*
Liffey	-	-	-	-	*	-	**	-	**	-	*	*	*	-	**	-	-	*
Slaney	-	-	-	-	-	-	-	-	*	-	-	*	*	-	-	-	-	-
Owenavaragh	+	-	-	-	-	-	-	-	**	-	-	-	-	-	-	-	-	-
Nore	+	-	**	*	-	-	*	**	*	-	*	-	*	-	-	**	*	-
Suir	-	-	*	*	*	-	*	-	**	-	-	-	*	-	-	*	-	-
Upper Cork Blackwater	-	-	-	-	-	-	-	-	*	-	*	-	-	-	-	*	*	-
Ilen	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	**	-	-
Waterville	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inny, Co. Kerry	-	-	-	-	-	**	-	-	-	-	-	-		-	-	-	-	-
Feale	+	-	**	-	*	***	-	-	-	-	-	*	-	*	-	-	-	-
Shannon	+	-	-	*	*	-	*	*	**	-	*	*	**	-	-	**	*	**
Doonbeg	+	-	-	-	*	-	-	-	*	-	-	-	-	-	-	*	-	-
Annagheeragh	-	*	-	-	-	-	-	-	*	-	-	-	-	-	*	-	-	-
Inagh, Co. Clare	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Erriff	-	-	***	-	-	-	-	*	-	***	-	-	-	*	-	-	*	-
Ballynahinch	-	-	*	-	-	-	-	-	-	*	-	-	-	**	-	*	*	-
Owenmore Co. Mayo	-	-	**	-	***	-	-	-	-	*	-	-	-	**	-	-	*	-
Easky	-	-	*	-	-	-	-	*	-	*	-	-	-	*	-	-	-	-
Bonet	+	-	*	-	-	-	-	*	-	-	-	-	-	-	-	*	-	*

Table 1 Contd.

Catchment	Arterial Drainage (see footnote)	Lack of gravel	Bank erosion	Calcification	Compaction/Siltation	Gravel removal	Ponding	Impassable barriers	Organic pollution/ Eutrophication	Over-grazing (entire catchment area)	Competition (Roach, Dace)	Water abstraction	Hydro-Schemes	Afforestation	Reservoir Creation	Unbalanced riparian zone: Excessive shade	Unbalanced riparian zone: Lack of bank cover	Pike predation
Melvin	-	*	-	-	-	-	-	**	-	-	-	-	-	-	-	**	-	-
Claddy	-	-	-	-	-	-	-	*	-	-	-	-	**	-	-	-	*	-
Leannan	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	*	-
Mill	-	-	-	-	-	-	-	**	-	-	-	-	-	-	-	*	-	-
Crana	-	-	-	-	-	-	-	*	-	-	-	*	-	*	**	*	*	-
Moy	+	-	*	*	*	-	-	*	*	*	-	-	-	-	-	**	*	*

(+) Footnote: Catchments subject to arterial drainage are indicated (+).
The complex impacts of arterial drainage are discussed in the text.

*** A serious problem over extensive channel lengths;
** A serioius problem in limited catchment areas;
* A problem of limited extent.

TABLE 2. The magnitude of individual problems in the twenty-seven catchments surveyed.

	***	**	*
Organic pollution/Eutrophication	-	5	8
Impassable Barriers	-	3	9
Excessive Shade	-	6	7
Bank Erosion	1	3	5
Lack of Bank Cover	-	1	11
Hydro-Schemes	-	2	5
Afforestation	-	2	4
Over-grazing (livestock)	1	-	4
Compaction/Siltation	1	-	7
Competition	-	-	6
Ponding	-	1	4
Pike Predation	-	1	4
Water Abstraction	-	-	5
Gravel Removal	1	1	-
Arterial Drainage	-	-	9
Calcification	-	-	5
Reservoir Creation	-	2	1
Lack of Gravel	-	-	3

*** A serious problem over extensive channel lengths;
** A serious problem in limited catchment areas;
* A problem of limited extent.

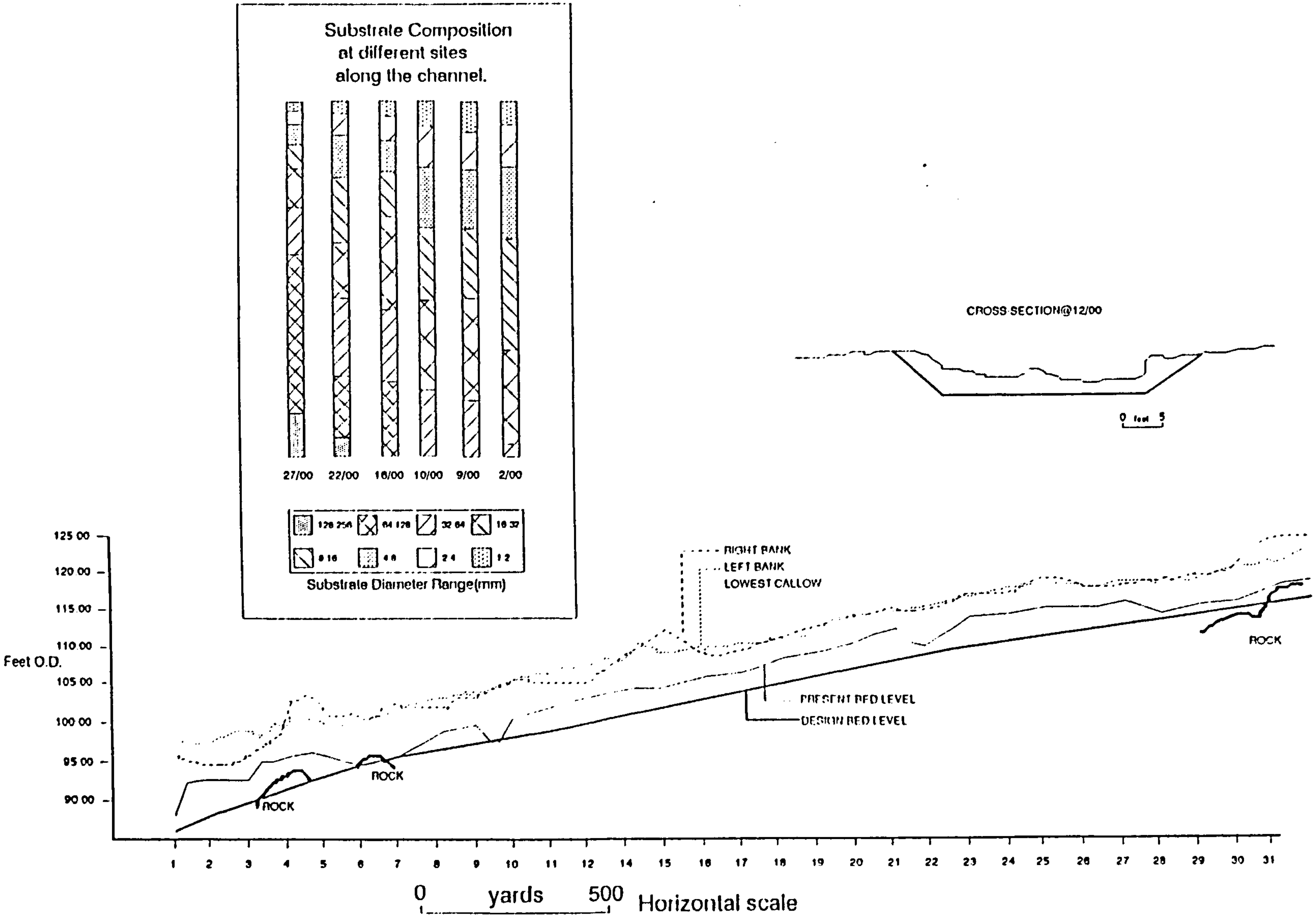

FIG. 1. An illustration of the type of information compiled by Irish drainage engineers at the pre-drainage planning phase.

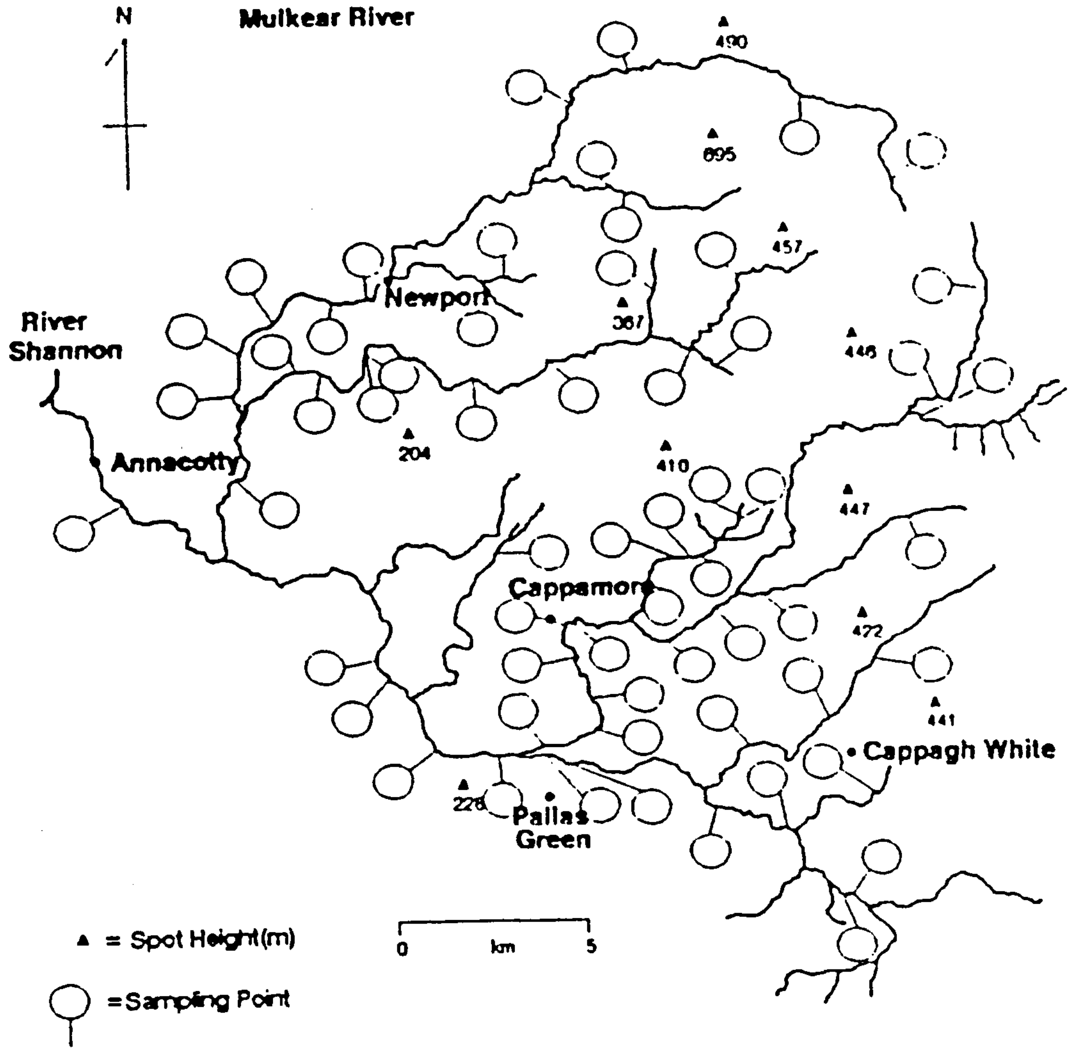

FIG.2. Sampling points for the compilation of physical, floral, faunal and fish stock data, chosen with reference to a knowledge of channel gradient, bed type and the nature of the riparian zone.

CENTRAL FISHERIES BOARD

....QUALITATIVE/QUANTITATIVE FISH STOCK ASSESSMENT SURVEY SHEET

SUB-CATCHMENT:

TRIBUTARY:

SITE No. & Location(exact):

CHANNEL CODE:

CHAINAGE:

POLLUTION STATUS:

DRAINAGE STATUS:
undrained/drained/recently maintained

RIVER:

PHOTOGRAPH:

DATE:

HANDSET: BOAT:

OPERATOR:

WATER LEVELS (or guage reading):

FLOW RATE(m/sec):

Av. channel width*length=AREA
m* m = m

BANK HEIGHT (LHB):
(RHB):

	Yes	No
FENCING:		
TRAMPLING:		
BANK EROSION:		
BANK SLIPPAGE:		

%POOL:	
%RIFFLE:	
%GLIDE:	

THALWEG: none/moderate/well defined

RIVER BED DIVERSITY: uniform/broken;
eroding/depositing

BANK COVER TYPE(%cover)-LHB:
-RHB:

DEPTH:	Riffle	Pool	Glide
RANGE:			
MEAN:			

SHADE: none(0%) light(<25%)
medium(<50%) heavy(<75%)

SURFACE SUBSTRATE TYPES	Riffle	Pool	Glide
exposed bedrock sheet:			
boulder(26-51cm):			
cobble(6-26):			
gravel(0.4-6):			
sand:			
mud/silt:			
Substrate summary:			

LAND USAGE:

MARGINAL VEGETATION(%cover):

INSTREAM VEGETATION(% cover):

INVERTEBRATES:Riffle areas only(State whether Abundant,Common or Present)

OLIGOCHAETES:		E.IGNITA:		CHIRONOMIDAE	
HIRUDINAE:		BAETIDS:		Red:	
ASELLUS:		CAENIS:		Green:	
GAMMARUS:		BEETLES:		SIMULIDS:	
PLECOPTERA:		TRICHOPTERA		SNAILS:	
EPHEMERA:		Cased:			
RHITHROGENA/ECDYNURUS:		Uncased:			

CURRENT STATUS/POTENTIAL:	RECOMMENDATIONS:
Spawning:	
Nursery:	
Angling:	
General comments:	

Fig. 3. Survey information compiled at each sampling location