DRAFT

EIFAC WORKING PARTY ON FISH MONITORING IN FRESH WATERS

Guidelines for Fish Monitoring in Fresh Waters

i. OVERVIEW

- Fishing methods range from those which require only simple gear such as spears and rakes to the use of ocean-going vessels with enormous trawls or encircling nets. Gill netting, seine netting, electric fishing and angling are probably the most common techniques used for scientific purpose and all involve fish capture. However, observation using divers, electronic fish counters or echo sounding equipment is an option. The sampling of fish populations can be very efficient in small rivers and pools, and most freshwater research has been undertaken in such habitats. Nonetheless, the larger aquatic ecosystems are invariably of great importance as fishery resources and these have received more attention in recent years. The matrix below shows the principal methods used for stock assessment survey work in freshwater systems and their most common applications:

Method	Fish capture	Rivers	Lakes	Migratory species	Non-migratory species
Electric fishing	Yes	*			*
Netting	Yes		*		*
Trapping	Yes	*	*	*	*
Fishermen's catch	Yes	*	*	*	*
Counters	No	*		*	
Hydro-acoustics	No	*	*		*
Observation	No	*	*	*	*

i.i Capture Methods

Electric Fishing

- To scientists attempting stock assessment of rivers and streams, electric fishing is a method of immense value. Although best suited to smaller watercourses, the method has been adapted for use in all types of inland waters including the littoral zones of large rives and lakes. Efficiency can vary enormously according to a host of different factors and truly quantitative population estimates for large water bodies will probably remain elusive. In general terms, the methodologies for fishing with electricity are well established with little need for continued development, although some further research is needed in relation to the acute and chronic effects on fish of the different types of electric current in use.

Netting

- The use of nets for fish capture employs long-established equipment and techniques which have changed little in the general principles applied. The main types of nets used for survey work are seine, trawl and gill nets. Seine nets operated from the shore have the principal limitation of needing a good bed profile over which to set and haul the net. Purse seines, whilst not limited by the substratum, have less application in the freshwater rather than marine environment because of both the relative shallowness of many lakes and the nature of the target species. Nonetheless, seine netting, especially with micro-mesh nets, is often the only way to catch the smaller representatives of populations.

- Although more usually associated with food fish harvest at sea, trawling can be a successful method for surveying larger freshwater systems, particularly with the smaller, faster mid-water trawls. The major constraints are the cost implications and the difficulty in deriving quantitative assessments of the fish population under study.

- Gill nets, popular worldwide in inland artisanal fisheries , are notoriously difficult to use for quantitative stock assessment. Not only do they show inherent selectivity for size of fish but mesh shape and type of materials used to make the net can influence efficiency of capture. Although this selectivity can aid the setting and enforcement of net specifications in the management of commercial fisheries, difficulties arise with scientific survey work unless all factors are into account. The development of a standard gill net for each key target species should assist.

Trapping

- Entrapment devices essentially fall into two categories, those such as baskets, pots and fyke nets, baited or otherwise, used for non-migratory fish and those traps used to intercept upstream or downstream migrants. Whilst traps are used by many artisinal and commercial fishermen worldwide, with the gear often manufactured from locally available materials, their application to stock assessment survey is more limited.

- Non-interceptory fish traps, like any other passive capture gear, are absolutely dependent upon the behaviour of the fish in relation to the type of trap used. Thus, trapping for non-migratory fish can generally be considered unsuitable as a method of quantitative assessment of populations. However, in other work relating to individual target species, such as estimating age-structure, growth or condition of the fish, traps may prove convenient. However, notwithstanding the difficulties with quantitative appraisal, traps remain popular for studies on juvenile fish which may be below the size that can be taken by other methods such as netting or electric fishing.

- For those species that migrate, either to and from the marine environment or within inland systems, interceptory traps can be a convenient way of catching fish for analysis or tag and release. In particular, in-river trapping has been regularly used during research on both salmon and eels. A classic situation might be a weir trap to take downstream migrating salmon smolts with a trap chamber in a fish ladder to reclaim the returning adults.

Fishers' Catch

- The collection and use of catch information from fishers gives access to a vast amount of data, albeit the primary reason for the actual fishing activity being commercial gain, subsistence or leisure. Problems associated with the use of catch data include the difficulties of estimating abundance, the ability and willingness of the fishers to make accurate returns, species bias and the quantification of effort. Such disadvantages have to be balanced against the cost effectiveness of data collection and the fact that observation of fish landings is the only way to sample many of the fisheries under study.

- A variety of methods can be used to collect angler catch data. Roving creel census is likely to be the most accurate, as it involves face to face contact with the fisherman, but is relatively labour intensive. Methods relying on third party reporting include the use of log books, postal questionnaire and newspaper reports.

- Although both commercial and recreational catch data collection can be straightforward, analysis and interpretation of results can be problematical, usually with regard to the appraisal of effort.

i.ii Non-capture methods

Counters

- Electronic fish counters are usually used for counting migratory salmonids in rivers. The technology is more or less understood and, in general, if the civil engineering of the structure is correct then the counter is likely to work efficiently with up to 90% of the fish passing over the electrodes being successfully counted. The principal constraint is the cost of the associated structure, such as a weir or dam, but the opportunistic installation in existing structures can prove relatively inexpensive. It is difficult to enable the counter to differentiate between sizes of fish, such as large sea-trout and small salmon, but the complementary use of photographic equipment can be helpful where conditions permit.

- The design criteria for combined fish passes and counting units is established whereas devices for counting across wide weir crests requires further research. Another development need is for counters where no structure exists. Some progress is being made with weir-less counters but, although upstream counts can be quite good, downstream ones remain poor. In terms of data capture and transfer, recent advances in telemetry systems have proved invaluable.

Hydro-acoustics

- Recent developments in the use of hydro-acoustics for freshwater survey work have been significant. Quality of output has progressed from not much more than flicks on a recorder chart to the computation of biomass based on target strengths. This can, however, introduce the danger of inappropriate confidence in the results obtained whereas it is crucial to recognise the complex nature of the data analysis, and the assumptions that have to be made. The biggest problem is truthing in relation to fish behaviour and the calibration of target strengths. Also the equipment is very expensive. The advantage of sonar is that it provides access to some fish populations that cannot be conveniently sampled in other ways, providing high precision and good spatial distribution of effort. The ability of hydro-acoustic equipment to count fish is good, although working better in deep, open water with few species present.

Observation

- Observational methods can be used both for survey work itself and for the calibration of gear. The human observer can either watch and count the fish directly or deploy remote control camera systems. Fish shoals in shallow water have been successfully counted from a boat whilst in other cases diving (using snorkel, scuba or mini-submarine) has been used. The obvious constraint is the need for good water clarity but other problems include the cost, training and safety considerations when divers are used. Observation is likely to best suit situations where traditional sampling methods are either inefficient or result in unacceptable disturbance of the fish population, especially where repeat estimates of biomass are sought.

i.iii Conclusion and recommendations

- Sometimes it is appropriate to use more than one sampling technique in a complementary way so as to enhance the accuracy of stock assessment overall. For example, hydro-acoustics and boom-boat electric fishing or salmon anglers' catch and fish counters could be successfully used in combination.

1. ORGANISATION AND PREPARATION

1.1 Site Selection

Background

- The selection of suitable sample sites is essential to the success of the chosen monitoring programme.
- The suitability of a site will be determined in part by the purpose of the site or larger survey of which the site is a component.
- Application of the tenets of this section will help to achieve consistency and statistical robustness of the monitoring programmes.

Detail 1: Location

- The site selected must allow all persons involved in sampling to work in a safe and efficient manner. Site specific risk assessments should be carried out.
- Fish sampling sites must be located according to the purpose of the survey and in accordance with monitoring programme design.
- The site must adequately represent the habitat or biome of that part of the watershed being sampled.
- Consideration should also be given to the feasibility of access to the site for personnel and equipment.

Detail 2: Site dimensions

Physical dimensions of sites that are likely to be suitable for the various elements of the core monitoring programme are given in Table 1.

Table 1: Dimensions of monitoring sites sampled for various purposes

Survey type	**Monitoring programme element**	**Min site length, m**	**Max site length, m**	**Timed**
Quantitative e/f by wading	Salmonid: Quantitative sites (at least 10 x stream width) Coarse: Temporal & Index sites	30 75	100 150	–
Semiquantitative e/f by wading	Salmonid: Semiquant sites Coarse: Spatial & Sentinel sites	30 75	100 150	–
Timed electric fishing by wading	Salmonid: Fry surveys in rivers >10m wide	–	–	≥ 5 minutes
Quantitative e/f by boat	Coarse: Temporal and Index	100	300	–
Semiquantitative e/f by boat (incl boom boat)	Coarse: Spatial and Sentinel Large river Temporal & Index	100 250	300 unlimited	–
Quantitative netting	Coarse: Temporal & Index	100	up to 250m,	–
Semiquantitative netting	Coarse: Spatial and Sentinel	100	up to 120m,	–
Micromesh seining	Coarse: Fry surveys	$50m^2$	$150m^2$	-

1.2 The Use of Stop Nets in Fisheries Survey Work

Background

- The use of stop nets is essential in fishery surveys where the intention is to produce a numerical estimate of fish abundance.

- Mathematical procedures used to estimate fish abundance from catch data rely upon a set of assumptions that must be satisfied if the estimates are to be valid. One of these assumptions is that the sample population of fish is 'closed' and that no individuals enter or leave the sample site during sampling operations. This assumption is usually met by using stop-nets across a river to delimit the sample site and prevent fish movement into or out of the site.

- In order to work effectively, stop-nets must be fixed firmly in place for the duration of sampling and must form an effective seal with the river banks and bed

General principles

- Stop nets are used whenever it is necessary to delimit a riverine fish sample site. The most common instances will be where a multiple-catch sample is to be taken or where a single catch is to be used to estimate abundance from known probability of capture.

- As a general rule, stop nets should be used during all electric fishing surveys.

- Exceptions to this general rule can be made:

    1. where fishing is in an upstream direction and is between two relatively impassable barriers such as shallow riffles (< 5 cm depth)

    2. when fishing long stretches of the margins of a large river on a catch per unit effort basis

3. when fishing for target groups with limited mobility or cryptic behaviour such as coarse fish fry, minor species (eg bullheads, stoneloach) juvenile salmonids or eels.

- For semi-quantitative sampling of fish, the use of stop nets is strongly recommended, especially if it is intended to use probability of capture as a population estimation method

- Where stop nets are used they should be of knotless material with dimensions and mesh size suited to the species and sizes of fish anticipated and to the depth and velocity of the river. As an approximate guide stop nets should be a minimum of twice the depth of the water and 1.5-2.0 x the width of the site, in order to permit diagonal setting, with stretched mesh sizes of between 20 and 25mm. Specialist applications (eg fry surveys) may demand other net specifications. The leadline of stop nets should be heavy enough to ensure close adherence to the river bed. Weighting in the order of 2.5kg m^{-1} can be used successfully but very high velocity sites may need greater weights. Detachable weights or, in the last resort, stones may be useful in some circumstances where velocity is very high.

- In all but very low water velocities, stop nets should be set diagonally across the flow in order to reduce pressure on the net and its fixings

- Location of stop nets should take advantage of natural features of the river channel. Nets set on shallow riffles or in low water velocities will be easier to fix and work more effectively than those in deep, turbulent flows.

- Use of removable weights on the leadline (aka footline) should be considered where there is a risk of the flow lifting the net.

Deployment of nets

- Nets need to be carried from the arrival point to the point of use. To avoid disturbing fish in the sample site unduly and thus compromising the survey objective, nets should be carried alongside the channel as far back from the bankside as feasibly possible and then set across the river in a quick and quiet manner.

- In slow-flowing, lowland streams inhabited by shoaling cyprininds it is advisable to set the up- and down-stream nets at the same time to minimise the possibility of driving fish out of the site.

Fixing stop nets

- Stop nets will normally be fixed to the river bank by means of ropes extending from the floatline (aka headline). Methods of fixing stop nets are given below, in order of preference.

    - Fix ropes/nets to existing bankside features. Examples include trees, shrubby vegetation, fence posts, boulders.
    - Take advantage of artificial bankside features, *e.g.* vehicles or trailers. It is possible to use large weights taken for the purpose but this may pose manual handling risks to the operators
    - Use purpose-built net support structures. In some circumstances, especially small, low-energy rivers, it is feasible to fix nets using portable structures in the stream channel. If such structures are used, they must be constructed of non-conductive material. (Contact author for sample design).
    - Use of short (max length 400mm, max penetration 300mm) wooden pegs.

- Warning: On many occasions it has been common practice to use metal stakes for anchoring stop nets but, especially close to habitation or roads, there are potential hazards of ground penetration attendant upon this practice and utility search procedures should be carried out.

1.3 Competence and Training Needs

- Text needed -

2. FIELD DATA CAPTURE METHODS

2.1 Electric Fishing

Detail 1: Optimum Team size

- Field team size will vary according to gear used and purpose of a particular sampling occasion as shown in Table 1.1 below. Team composition is assumed to be one Leader with specialist knowledge of fisheries science and *n* x staff with appropriate competence and related training. Team composition must also comply with the Electric Fishing Code of Practice

Table 1.1 Minimum and optimum team sizes for electric fishing operations

Method/Purpose	Minimum Team size	Optimum Team Size
Backpack	3*	4
Wading: single anode	3	4
Wading: double anode	4	5
Boat Handheld	4	5
Boom Boat	3	4
Boom Boat + Catcher Boat	5	6

*Two person teams are acceptable for backpack fishing <u>only</u> if all of the following conditions are met: 1) sampling with a single backpack electric fishing machine; 2) Risk assessment carried out to ensure suitability of watercourse; 3) both operators as 'experienced'; 4) mobile telephone communications with base established and reliable.

Detail 2: Gear Selection

- The approach to a given electric fishing site should be determined by the nature of the site. Appropriate equipment should be selected according to the prevailing conditions at the time of sampling. General guidance is given in Table 2.1.

- Where depth of a site is variable and includes water that may be waded but also has parts that require a boat, it may be necessary to use boat-mounted gear with operators embarking and disembarking as needs dictate.

Table 2.1 Selection of suitable electric fishing gear according to site specifications.

Site Details		Suitable Gear						
Width, m	Mean Depth, m*	Wade	Boat	Single Anode	Two Anodes	Lane Nets	Boom Boat	Multi-boat***
<5	**<0.8**	Y		Y				
5-10	**<0.8**	Y		Y	Y			
10-15	**<0.8**	Y			Y**			
>15	**<0.8**	Y			Y**	Y		
<15	**>0.8**		Y		Y		Y	
>15	**>0.8**		Y		Y	Y	Y	Y
Canal			Y		Y		Y	

* - When gauging depth for wading, account should be taken of soft sediment which may increase effective depth.

** - In certain circumstances more than two anodes might be used when wading but this is permissible only where all electrodes are operated via a single control unit.

*** - Concurrent use of more than one boat for electric fishing is only permissible where all electrodes on all craft are operated by a single control unit.

Detail 3: Selection of electrical output

- Selection of the most appropriate electrical output from the equipment used is an important part of ensuring optimum capture efficiency and fish welfare in electric fishing operations. Factors that may influence the choice of output include:

  - Conductivity
  - Target fish species and size
  - Width
  - Depth
  - Turbidity
  - Temperature
  - Presence of rare or vulnerable species

- and optimum electrical output may be achieved by varying:

  - Output type and waveform
  - Voltage
  - Frequency
  - Power output (pulse width settings)
  - Anode size and shape
  - Cathode size and shape

- *Detailed guidance is given in the separate document "Electric Fishing Best Practice".*

Detail 4: Electric fishing by wading

- Electric fishing by wading, whether wearing dry-suit or chest/waist waders, should only be undertaken where water in the majority of the site is less than thigh deep. Depth estimation should take account of soft sediments which may render the effective depth of the river channel much greater.

Choice of sampling strategy

- Electric fishing may be undertaken by wading using one of three strategies:

1. Backpack fishing. **NB** Backpack units should only be used with a single anode. Two independently operated backpack units should be used simultaneously during an operation

2. Using hand–held electrodes fitted with long cables connected to a bank-based control box and generator

3. Placing the generator, box and fish-bins in a small boat which can be towed or pushed behind the fishers by one of the team.

General procedures

- Fishing may be undertaken by operatives holding an electrode in one hand and a handnet in the other, or by units of two people with a net and electrode between them. The former method will give a greater coverage of the river for a given team size when using generator-based, multi-socket control boxes, but in deeper water, stronger flows and where there are numerous obstacles, the latter may present the safer option. In both cases, the presence of a person with a fish-holding receptacle is assumed

- When electric fishing by wading, the sampling team should proceed in an upstream direction to avoid obscuring the fish- catching area by disturbing sediment that drifts downstream.

Typical electric fishing procedure with suggested mode of operation for wading in a river using a single anode in a narrow stream is shown in Figure 1. With more anodes, operators fish in unison, as illustrated in Figure 2.

Detail 5: Electric fishing from a boat.

- Electric fishing from a boat must be carried out from a suitable vessel when mean water depth is greater than thigh depth over the majority of the site being fished.

Options available

- A number of options is possible for boat electric fishing depending on flows, depths, widths and target species:

1. Boat propelled by outboard motor – suitable when depths are over 1 m. and where currents are strong, > 0.7 m/s.

2. Boat propelled by oars or paddles – good when currents are gentle and the habitat is more varied, a good oarsperson can enable very fine control of the operation. This can also work well when fishing in a downstream direction in a stronger current.

3. Boat drawn back and forth across the current using ropes pulled by operatives on the bank, gradually working along the length of the survey site. Good for achieving systematic coverage of wider watercourses which are relatively uniform and with relatively unobstructed banks and gentle current.

- Direction of fishing with a boat depends on substrate type, current and depth.

- Upstream fishing has a number of advantages. Fish driven ahead of the boat will tend to tire and either come back downstream to the boat or seek cover in the margins. Fish that are missed are not repeatedly stunned as the boat drifts over them. Sediment drifts downstream away from the fish catching area. Stunned fish do not become entangled in the downstream stopnets, which might expose them to repeated stunning. Boats propelled by outboard motors are easier to manoeuvre against the flow

- In very swift current, stunned fish may come past the boat so rapidly that it is not possible to pick them up. Damage to fish by outboard motor propeller in this situation is also likely and downstream fishing may be the only practical option.

- For large rivers, boats using boom-mounted electrodes should be considered.

- Possible strategies for electric fishing sites of various widths by boat are shown in Figure 3.

2.2 Seine Netting in Rivers

General

- The use of nets as a fish sampling technique almost invariably involves the use of boats to deploy the gear. Nets are most often landed from the bank but may be landed in boats.

Detail 1: The Wrap-around technique

- This technique is suitable in rivers up to 40m wide where the mean water velocity is less than 3km h^{-1} ($<0.83 m.sec^{-1}$) and the substrate is primarily mud or silt.

- Nets should be of suitable dimensions for the site. Net length is dependent on river width as described below. Depth, or draw, of the nets should be at least 1.5 times the depth of the water to be sampled. Leading (weighting) of the nets should be adequate to ensure a good seal between the leadline and the substrate; 500g m^{-1} is suggested as a guide. Mesh must be knotless and of an appropriate size for the anticipated stock of fish. 7.5 to 12.5mm bar mesh is probably an adequate range for most occasions. Mixed-mesh nets may also be used in some circumstances.

- The sequence of operations is shown in Figure 4 and described below:

- Two pairs of beach seines are laid on the river bank between 100 and 250m apart, depending on the width of the river. Each of the downstream pair of nets should be at least three times as long as the width of the sample site.

- Ropes are run across the river upstream and downstream of the section to be sampled and then walked down to the nets taking care that the ropes are pulled tight and do not touch the water.

- The two sets of nets are then pulled simultaneously across the river and anchored in position. (At present there should no use of stakes for anchoring stop nets, unless the necessary ground penetration and utility search procedures have been followed.)

- The excess of the inner downstream net (Seine 2 in Fig 4) is laid along one edge of the river. At this point Fig 4a applies.

- The inner upstream net (Seine 1 in Fig 4a) is pulled slowly downstream at a pace not exceeding 2km h^{-1} until it meets Seine 2. (Fig 4b)

- Seine 2 is now wrapped around Seine 1, thus containing it and Seine 1 is removed, leaving the fish from the sampled area enclosed in Seine 2. (Fig 4c)

- Seine 2 is landed in the normal manner for a beach seine and the captured fish are removed to a storage facility. (fig 4d)

- A sample of 100 fish >100mm from the first catch is batch-marked (eg with a ‘Panjet’ inoculator) and released back into the sample section.

- Seine nets 1 & 2 are repositioned as safety nets outside the sample area enclosed by Seine nets 3 & 4.

- A second haul, using nets 3 & 4, is performed in the same manner as the first.

- The proportion of marked fish recaptured provides an indication of netting efficiency. Should this proportion be <50% then it is advisable to perform a third haul using the repositioned nets 1 & 2 from the first effort.

Detail 2: Seine netting between stop nets

- Where the river to be sampled exceeds 40m in width the wrap around technique may be inoperable due to the difficulties of pulling long nets along the river. In this situation a simpler technique may be employed.

- Net dimensions and specifications are the same as for the wrap around technique.

- Netting procedure is illustrated in Figure 5 and follows the procedure below:

- The area to be sampled is demarcated by two stop nets. There is currently a presumption against using metal stakes to anchor stop nets.

- A seine net is laid inside and adjacent to the stop nets and along the intervening bank and is then landed in the normal way.

- Hauls of the seine net may be repeated to permit catch-depletion estimates to be made.

Detail 3: Isolated area netting

- Where the width of the river exceeds 90m and the wrap around technique and normal seining between stop nets are both impractical, the use of an encircling net may be a feasible way of sampling. This technique is unlikely to be practical in anything other than the most minimal of water velocities

- Net dimensions and specifications remain as previously.

- Procedure for this method is shown in Figure 6 and is as below:

- An encircling net, minimum length 120m, is set by boat in a roughly circular shape thus enclosing the area to be sampled. (A suitable method of estimating the netted area is necessary to produce population density estimates. It is probably not adequate to assume that the encircling net is mathematically circular.)

- A seine net is laid inside and adjacent to the encircling net and is then drawn and landed in the normal way, with two or more fishings made to allow catch-depletion techniques.

- Finally, the encircling net can be drawn and landed as a final 'catch' but attention should be paid to possible changes in efficiency if the two nets are not of very similar specifications, especially in regard to mesh size and leadline weighting.

Detail 4: Netting for coarse fish fry

- Seine netting for coarse fish fry requires specifically adapted equipment and techniques. The most appropriate approach is likely to vary from site to site but the general procedure should be as below, with the basic approach of sampling a known area of habitat:

- As fry are normally found in marginal habitats and different species often inhabit specific microhabitats, the choice of sample site is very important.

- Dimensions of a typical fry-seine would be 25m long by 3m deep with a knotless mesh of 3-5mm. Weighting of leadlines and bouyancy of floatlines may vary to suit the substrate.

- The net should be set in a semicircle from the bank, either by wading or by boat in deeper water. Once the net has been set the area enclosed may be determined. This may be done in a variety of ways but it is unlikely that the net will have formed a perfect semicircle and $\pi r^2/2$ will be inadequate.

- Sites with abundant submerged vegetation may be better sampled using electric fishing techniques or may be netted by setting the net and then cutting and removing the vegetation before drawing and landing the net. It is likely that even this approach may not entirely remove the problem of vegetation lifting the leadline and allowing fish to escape.

2.3 HYDROACOUSTICS

Detail 1: Technique limitations

- Mobile hydroacoustic sampling of fish populations is limited to "large" watercourses (average width >20m; depth >2m). Additional criteria that need to be met are outlined in "Detail 5: Sampling strategy".

Detail 2: Gear Selection

- The approach to a given hydroacoustic survey should be determined by the nature of the reach. Appropriate equipment should be selected according to the requirements of the survey and the nature of the site. General guidance is given below but there cannot be absolute prescription of the most appropriate equipment in all circumstances and the person in charge during the survey has ultimate responsibility for equipment selection and appropriate deployment.

- Boat design – vessel stability is the most important factor and where possible a twin hulled vessel eg. catamaran should be used.

- Echosounder type – scientific, with constant signal amplitude.

- Transducer type - split beam and dual beam units are available although the former is the preferred option. Single beam transducers are available but are not recommended for monitoring purposes.

- Transducer mounting arrangement and positioning - the transducer MUST be placed as far as possible away from outboard engines, the preferred location being 1m forward of the bow at a working depth of 0.5-0.8m.

Detail 3: Selection of acoustic output

- Selection of the most appropriate acoustic output from the equipment used is an important part of ensuring optimum and appropriate acoustic data collection. Factors that may influence the output include:
  - ping rate
  - frequency
  - pulse width settings
  - Time Varied Gain (TVG) settings
  - Background noise levels (Signal:Noise ratio)

Detail 4: Calibration

- In order to collect accurate information about fish size all sonar equipment must be calibrated prior to data collection. Calibration involves placing a standard acoustic reference (usually a copper or tungsten sphere) of known target strength into the sonar beam.

- Calibration should be conducted prior to each survey, following the equipment manufacturer's instructions and specifically where environmental parameters have changed notably since the previous survey. The ease of calibration is greatly increased with the use of a remotely operated pan and tilt mounted transducer.

Detail 5: Sampling strategy

- An appropriate sampling strategy for mobile hydroacoustic surveys is essential to obtain accurate data that can be used both in isolation and also for temporal comparison with other appropriate acoustic data. The list below should be considered as the most desirable sampling strategy, and local planning should be undertaken to meet this.

- All hydroacoustic surveys relating to the core monitoring programme should be conducted over a minimum survey reach length of 5km, and ideally greater than 10km. The reach length covered by investigation surveys cannot be prescriptive and will depend on the aims and objectives of the study.

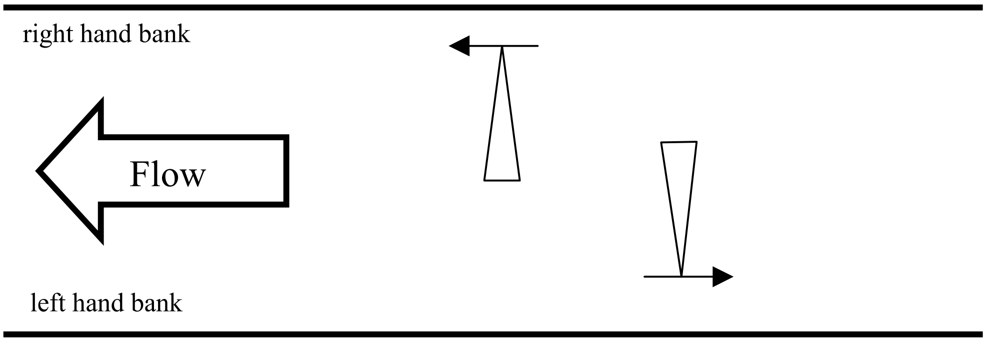
- Desirable channel characteristics are:
  >20m width
  >2m depth
  Laminar flow – Steady flow, no turbulence, avoiding entrained air (e.g. weirs)
  Well defined channel with limited macrophyte growth (timing)

- Other requirements are:
  Survey June to October
  Survey between 1 hour after sunset and 1 hour before sunrise
  Max boat speed 5 kph^{-1} (slow ping rates of ~5 pings s^{-1} will dictate a slower optimum boat speed)
  Boat noise and roll should be minimised
  Survey both banks (upstream and downstream)
  Avoid periods of high rainfall, high flow and high winds
  Avoid full moon/ aim to conduct surveys around new moon if possible.

Repeat surveys should be conducted, where possible, under same time, date and environmental conditions.

Mobile hydroacoustic survey sampling methodology

- Mobile surveys are carried out by directing the acoustic beam perpendicular to the flow in the horizontal plane. Insonification of the watercourse is from the near bank towards mid-river. For narrower watercourses (20-40m) the beam may span the width of the river). In all cases orientation of the acoustic beam MUST be optimised for the fish distribution in each specific watercourse.



All surveys should take account of local navigation instructions. In most circumstances the upstream transect is to be conducted from the left hand side of the river and the downstream transect is to be conducted from the right hand side of the river. (The normal convention of handedness of banks as seen looking downstream applies.)

2.4 TRAPS FOR MIGRATORY SALMONIDS

Background

- Specific details of trap design and use, and the nature of fish handling, will vary with individual site characteristics and the objectives of each sampling programme. Hence only general instructions are provided here.

- To gain a full appreciation of the practical aspects of trapping, and ensure any proposed programme makes the best use of available knowledge, direct contact with experienced staff and ‘hands-on’ visits to established facilities are strongly recommended.

- The effects of trapping on fish welfare are also important. All trapping programmes are likely to cause a degree of stress and handling damage to the target species. These need to be minimised through good trap design and handling procedures. Note that trapping programmes are unlikely to meet their objectives if released fish are more susceptible to death and disease than their contemporaries in the population at large.

- Before embarking on any trapping programme it should be clearly established that it will address the monitoring objectives. It is not usually desirable or possible to capture all fish entering or leaving a river system and, in any event, upstream or downstream traps are rarely 100% efficient. If the aim of trapping is to measure run size, then this may need to be achieved indirectly, e.g. using mark-recapture or radio-tracking techniques. Similarly if trapping is being carried out to provide biological information (e.g. size, age and species composition) then the user needs to be aware of potential selectivity problems.

- Whatever the broad aim of a trapping programme, minimum sample sizes will be required to fulfil specific needs (e.g. precision requirements for run estimates will dictate numbers of fish which need to be marked and recaptured). These should be identified at the outset to evaluate the feasibility of each trapping scheme and assess the risk (and associated cost) of failing to deliver the programme objectives.

Detail 1: Upstream trapping of adult salmon and sea trout

- Upstream adult traps, either permanent or temporary structures, have a number of common features/requirements:

- Fish are encouraged into the trap by a combination of

    1. the flow of water through the trap relative to the whole river flow and

    2. the ease of upstream passage via the trap compared to alternative routes. The latter is usually ensured by siting the trap alongside some existing barrier to migration e.g. a weir, or by creating a barrier eg. from fencing.

- The entrance to the trap normally comprises a 'V'-shaped 'inscale' or similar structure which 'funnels' fish into the main body of the trap through a narrow opening. Sometimes this opening is set above the floor of the trap and this arrangement, as well as the size of the opening and the instinct of fish to face upstream against the flow, helps ensure they are retained in the trap.

- The trap construction usually incorporates steel bars or grid work at a spacing which retains the target species while allowing sufficient flow of water to serve as an attractant to the fish. Bar or grid spacing will determine the selectivity of the trap as will the size of the inscale opening. Temporary alterations to spacings, e.g. by fixing finer plastic mesh to the existing structure, can be used to obtain un-biased samples of smaller run components when seasonally abundant (ie. fish which would otherwise pass between the bars).

- Trap design should take account of fish welfare as well as operator safety. A large trap will lessen the chance of fish overcrowding and damage, although too large, and fish may prove difficult to remove from the trap. The timing and frequency of sampling and number of samplers must also be gauged to prevent overcrowding and minimise retention time and associated stress to the fish. This may require some flexibility in operation to accommodate daily and seasonal patterns of fish abundance and movement.

- The method by which fish will be caught and handled also needs to be considered in the design. Hand nets are normally used to capture fish, use of anaesthetic might be necessary prior to tagging or collection of biological information (e.g. scales, length, weight), and recovery from anaesthetic is required prior to release. The design of the trap may allow these 'processing' activities to take place at or close to water level and so avoid having to transport the fish outside the trap structure.

- Some method of controlling the water flow/level in the trap (e.g. automated penstocks, stop-boards, pump etc.) may also be necessary to ease fish capture and handling.

Detail 2: Downstream trapping of juvenile salmon and sea trout

- Two types of 'smolt' trap are discussed here:

    2. fixed traps

    3. portable 'rotary screw traps' (RSTs).

- Fixed traps normally operate by creating a vertical barrier to downstream migrants – forcing fish to move, via a by-pass channel, into a retaining box or pool. The barrier usually comprises narrow spaced bars or grid work designed to retain most or all migrants while allowing through-flow of water. In addition, some traps may also incorporate a horizontal screen set over a natural or man made fall in the river (e.g. a weir) to allow a downward flow of water.

- Rotary screw traps comprise a pontoon mounted, cone-shaped drum and holding box. Water flowing into the drum mouth causes it to rotate by acting on an internal, helical vane. Downstream migrating fish are carried with the water into the drum and through to a rear holding box. The drum is constructed of perforated sheet or mesh to allow some through-flow of water, but the design is such that water is always present to carry fish into the holding box (i.e. fish are not damaged by being left dry on the drum walls).

- RSTs are easily assembled and relatively light to transport (constructed predominantly of aluminium). The diameter of the drum can vary – but normally ranges from 1.8-2.5m. Pontoons range from 5-7m long by around 0.6m wide and 0.3m deep. When operational, half the drum is submerged – meaning that wherever the trap is located a sufficient depth of water must be present (e.g. 1.3m depth for an 2.6m diameter drum). When not operating, a winch and 'A'-frame arrangement are used to lift the drum clear of the water.

- RSTs are kept in place in the river channel using ropes or steel cable. The latter may be winch operated to allow flexibility in positioning the trap. The nature of the anchorage will depend on the size of the trap and expected loadings.

- Site selection is important to the success of the RST. Generally, the greater the proportion of the flow passing through the trap the greater its effectiveness at catching downstream migrants. For example, positioning at locations where the flow is focussed e.g. at the start of a run, will help to maximise capture efficiency.
-

2.5 CATCH MONITORING

- Different techniques are necessary for capture fisheries (e.g. commercial netting or salmon rod fishing) and catch-and-release fisheries (e.g. coarse angling).

Detail 1: Commercial catches

- Commercial catch data is best collected using some type of mandatory catch return system associated with the licences issued by the appropriate authority.

Detail 2: Rod catch of salmon and migratory trout

- Data should be collected in a similar way to that for commercial fisheries using some type of mandatory catch return system associated with the licences issued by the appropriate authority.

Detail 3: Coarse fish - Angler Census

- The primary purpose of angler census is to collect data on species, size and rate of capture of fish by anglers fishing individually or in matches that cannot be monitored by postal questionnaires.

- For coarse fish, creel census techniques are recommended and can be used to form long term data sets. Careful organisation of census programmes is necessary if serious problems are to be avoided. Logbooks have been found to be unsuccessful for coarse fish (but see Detail 6 for guidance on logbook schemes for trout and grayling).

- Detailed data on effort and catch are best collected by bankside interview (see detail 4.3) and direct observation of fish retained in keepnets.

- A proportion of catches should be sampled for length-frequency and age composition by length measurement and scale sampling. This can be achieved directly from cooperative pleasure anglers or by retaining some catches in nets after the weigh-in of matches, so that data collected from all catches in the match in general size categories can be calibrated.

- In addition to catch data, information may be collected on:

    1. Spatial distribution and other behavioural patterns of anglers, angling methods used and details of the individual anglers;

2. Spatial distribution of fish, distribution of fish amongst anglers, behavioural responses of fish as expressed in catches and vulnerability to capture by different methods, relationships between stock and catch at index sites;

3. Biological parameters of fish captured from samples taken (age, growth, health status, etc.).

Detail 3.1: Sampling strategy

- Census programmes should be designed to reduce variability arising from sampling procedures and fishing methods. Site selection may need to be on the basis of angling effort rather that catchment or geographical features

- Specific census programmes that differ from those recommended here may need to be designed to examine particular aspects of fishery performance, e.g. the impact of seasonal fish movements.

- The following are guidelines that could be followed in a 'standard' census programme:

- Sampling period – end of June to end of September for rivers – to maximise the likelihood that fish will be spread out in summer feeding patterns rather than in spawning or overwintering aggregations. Angling activity is also relatively high in most localities at this time.

- Sampling days – spread throughout period, preferably when angling activity is high and likely to be of similar form – to enable long-term comparisons of catch per unit effort to be like-for-like. Sixteen weekend days of census per annum are recommended.

- Number of interviews – about 30 or more per sampling day on average – to reduce variance of total catch rates. Likely effects of increasing or decreasing interview numbers on variance around mean catch rates should be examined against monitoring objectives after one season.

- Interview timing – late afternoon or at the end of matches - to obtain maximal fishing hours. During matches, an initial check of numbers and locations being fished may be necessary in order that effort of anglers with no catch can be assessed.

Detail 3.2: Interview techniques

- The interview – fishery owners should be advised of the purpose of the census, who will operate it and how data will be gathered. Brief introductions may be necessary to each angler until they are familiar with being interviewed.

- Interviews should not be obtrusive and no record of the identity of individual anglers should be kept. No obligation should be placed on individual anglers to provide any particular detail. Catches of each individual angler should be recorded to the prescribed level of detail. Measurement of biological parameters of individual fish can be taken from batch samples retained.

- The interview should take the following form and should elucidate details of the trip and catch;

    a) Times of fishing (start and end);

    b) Baits and methods used;

    c) Baits and methods that caught fish;

    d) Examination of the catch.

Detail 3.3: Data to be collected

- General:- venue, date, river and weather observations and any other factors that may affect the representative nature of the records, e.g. match for pike or other target species.

- Fishing trip data:- individuals' fishing times, numbers of fish of each species in each size category caught by each method, other methods used unsuccessfully, type of fishing (pleasure, match) or target species and whether or not fish were seen.

- Direct data capture in electronic form would be preferred, but no ready-made British system is known to exist. An example of a suitable recording card is shown in Figure 7.

Detail 3.7: Data analysis

- Data analysis summaries should include:
  a) catch rates (g angler h^{-1}) for all species combined,
  b) individual species and each size category of each species;
  c) numbers of anglers and proportion without catch.
  d) trip statistics, eg average time spent fishing

- Additional analyses can be made to meet local needs, e.g. hot pegs, weather effects, bait preferences.

- Note : The angler catch census is of particular use for establishing long term trends. The inherent variability of the data means that useful feedback cannot be made until after each complete sampling season.

Detail 4: Coarse Fish – Contest Catch Monitoring

- Monitoring catches of coarse fish made by anglers in organised competitions offers a successful method for assessing fishery performance in large rivers and stillwaters with relatively little sampling effort.

- Match catch monitoring provides an opportunity to instigate or improve liaison with local angling organisations and anglers.

- Site selection for match catch monitoring depends on assuring an adequate volume of data:-

- Earlier work on this topic suggests that, where angler catch alone is used to monitor a stretch of river, results from 60 matches per year, with a minimum of ten anglers per match, are needed to generate robust catch data that will permit reliable detection of a trends in performance (as mean catch) for matches of any size at any time of year. Smaller numbers of matches may be equally valuable where data is gathered from a restricted time-period, eg June to October.

- Where possible, match catch monitoring should be carried out on river stretches where complementary sampling (hydroacoustics, qualitative boom-boat electric fishing) is also planned as part of the monitoring programme. In this situation, smaller volumes of catch data can be of great value in supplementing the results of the other techniques.

- There is no guidance on physical dimensions of a suitable match catch monitoring site as angler effort is the defining criterion. Intensively fished waters will obviously lead to shorter river lengths producing the required number of matches. However, care should be taken to avoid a situation where the site is so large that major impacts (eg large WRW effluent discharges) affect a proportion of the fishing locations in the site.

- It is suggested that coarse fish angler catch data from rivers are collected in the period June to October inclusive in order to reduce the influence of adverse river and climatic conditions upon angling success. For stillwaters with no close season a suitable sampling period would be April to October inclusive. Where this is not possible then data maybe collected throughout the year. Rivers which host 'winter leagues' are also useful.

- Fisheries that are permanently pegged are often the source of good quality catch data.

- Fisheries that are fished by the same group of anglers on a regular basis (eg an angling club) are valuable data sources.

Detail 4.1: Coarse match catch data: data to be recorded.

- In terms of data collection, the minimum set of parameters that is of use is:
- Date of match
- Venue fished and location
- Duration of match (h)
- Start time
- Number of competitors
- Number of competitors catching fish (or weighing in but this underestimates the true number catching)
- Individual catch weights of winning, second and third competitors (units need not be metric – can be converted if necessary by spreadsheet).
- Total weight caught by all anglers combined
- Species of fish caught in:
    1. greatest numbers
    2. second greatest numbers
    3. other species caught
- In addition to actual catch information, records of environmental parameters, especially water temperature and flow (discharge), should be obtained where possible from Agency hydrometric records for the flow monitoring station nearest to the match fishing venue. At present, water temperature is not routinely monitored at all hydrometric stations across England and Wales but such monitoring can usually be arranged by request.
- Data on climatic and perceived river conditions on the fishing day may also be collected but often vary widely on any given day and so are not easy to interpret in relation to catches.
- Collection of data may be by various means but the two most common approaches are to use either the standard Agency prepaid postal return cards as shown in Figure 8 or to establish liaison with angling clubs that regularly hold matches on the same waters and arrange to gather copies of the match results sheets.
- Postal questionnaires employing the form below are the preferred method for data collection on fisheries that are controlled by a large angling organisation but are visited by numerous angling clubs (which may be affiliated to the controlling organisation) during the season. On this type of water angling clubs wishing to fish a match must book well in advance and the booking process can be used to send forms to appropriate clubs. Timing of the delivery of the forms can be important. If possible the forms should reach the angling clubs 2-3 weeks prior to the match date. A longer interval might lead to poor returns as the request for data can easily be forgotten.

Detail 5: Angler logbook schemes

- Some species (e.g. brown trout and grayling) support important recreational fisheries in situations where options for monitoring are limited because the main fisheries are difficult to sample effectively using techniques such as electric fishing or netting.
- Use of angler logbooks is a relatively low cost/low risk option for monitoring which, potentially, can provide numerous pieces of information. These include: (i) measures of catch, fishing effort and catch per unit effort – by angler, by visit, and by location; (ii) numbers of fish killed/released (iii) size of fish caught (iv) method of capture; etc. Once a core of support is secured for each scheme it may also be possible to persuade participants to collect other data, e.g. scale samples, return tags, etc.

- For both schemes to deliver sufficient information, they must attract adequate numbers of participants. Successful schemes take time to establish and it is recommended that a pilot scheme is always carried out prior to a full launch. n trailed for the last two years).

- Catch returns can be expected from 30-40% of participants.

2.6 Habitat assessment

- Text needed -

2.7 *Point-abundance Sampling*

- Text needed -

2.8 Monitoring Stillwaters

- Text needed -

2.9 Monitoring Canals

- Text needed -

3. DATA ACQUISITION AND MANAGEMENT

3.1 Fish Handling

Detail 1: Care during capture

- Ensuring that fish captured remain alive and in good condition is a primary requirement of any sampling method.

- Best practice will vary with the sampling method and the size, number and species of fish involved:

- Eels require separate treatment during and after capture, see Detail 1.4

Detail 1.1 For fish caught during electric fishing by wading:

- This method of sampling demands that fish are held temporarily in containers carried by members of the electric fishing team during the capture operation.

- Non-conductive materials must be used for construction of fish-holding containers used to hold fish during sampling. Plastic buckets (10-15l capacity) with non-conductive or insulated handles are most commonly used but have obvious limitations regarding the number of fish which can be held satisfactorily

- During electric fishing, anode operators should make every effort to minimise the length of time that fish are held in the active electric field before netting.

- Every effort must be made to ensure that narcotised fish are removed from the influence of electricity as quickly as possible. To do this, hand-net operators need to be alert and in a good position relative to the anodes at all times during sampling and have hand-nets of the correct shape, mesh size and length of handle for the habitat and size of fish likely to be captured. Nets made from knotless material are must be used, unless their use is considered to generate a greater potential risk to the operator *eg* using a large net in very fast-flowing water where the greater flow-resistance of knotless netting could increase the risk of muscular strain. Netspersons also need to be able to transfer netted fish to temporary holding containers rapidly to avoid fish being out of water for an excessive time or repeat electrocutions of the fish.

- Usually, relatively little water is held in the bucket to avoid fatigue due to carrying excess weight. This in itself limits the quantity of fish that may be held without undue distress. It is not possible to give absolute figures of a 'safe' quantity of fish as conditions on the day, especially water temperature and the size of fish, will exert considerable influence. Whilst it may be possible to hold 20-30 0+ trout for a short while in a bucket with 2l of water, the same container would be overloaded with a single 300mm chub.

- Fish held in buckets should be transferred to a container at the measuring station holding tanks well before they begin to show signs of physiological distress through lack of oxygen. In sites with high fish densities this may mean transferring fish several times during a fishing run.

Detail 1.2 For fish caught during electric fishing by boat (Hand-held or boom electrodes):

- Fish captured by electric fishing from a boat usually need to be held for longer periods before processing than those captured when wading. Fortunately, it is normally possible to use a much larger receptacle than a bucket in a boat.

- Fish-holding tanks in boats must be constructed of non-conductive materials. Glass-reinforced plastics or rigid PVC tanks are commonly employed in capacities up to $1m^3$. The facility to aerate holding tanks would be beneficial to the fish and is strongly recommended. If aeration is not possible then care must be taken to ensure that water in the tank is frequently replenished or replaced.

- As with wading, an important factor in fish welfare is the minimisation of time for which the fish are subject to a live electric field and the anode operator(s) or boom controller should work to this end.

- Hand net operators must use nets appropriate to the sampling site and size of fish anticipated and should aim to transfer fish from the river to the holding tank as quickly and smoothly as possible, avoiding multiple shocking of fish by repeatedly sweeping a net containing a few fish in order to catch more from a group of narcotised specimens. (See also comments re knotless nets in Detail 1.1)

- Where fish are abundant it is likely that the on-board tank will become full and need emptying of fish before the sampling run is completed. This can significantly interfere with the efficiency of the sampling operation and should be avoided if possible but the welfare of the fish should take priority.

Detail 1.3 For fish captured by seine netting:

- Fish captured by netting face different threats from those presented by electric fishing. Specifically, the major risks are gilling in the meshes of the net, crushing/abrasion when large catches are made and asphyxiation from disturbed sediments at the landing site.

- The use of knotless material for the construction of seine nets is strongly recommended at all times to minimise fish damage unless there are overbearing operational reasons for reverting to knotted mesh. All new nets purchased must be constructed of knottless material, again unless there are over-riding operational reasons for continuing to use knotted nets.

- Selection of appropriate mesh size can reduce the problems of gilled fish but is not always feasible. Drawing the net very slowly can help reduce this problem but it is rarely eliminated.

- Physical damage to fish can be reduced by exercising care in the final stages of landing the net. If the landing-site has been selected carefully it should be possible to land the lead-lines well in advance of the float-lines and so trap the catch in a 'hammock' of netting with a sufficient depth of water to ensure that large fish are not stranded and that smaller fish are not crushed by the larger. At this point, most of the fish can be removed by hand nets, constructed of knotless material, to a floating keep net or similar container for processing. There should be very few fish in the seine when it is finally completely landed.

- The problem of disturbed sediments causing difficulties for fish can only be reduced by careful selection of the landing site so as to avoid organic or very fine sediments. Frequently, however, such avoidance is not possible and rapid removal of the fish from the net to a holding facility with clean water is the only way to limit the problem.

Detail 1.4 Handling and storage of eel

- Eel require different treatment from other species of fish during sampling and processing. If significant numbers of eel are expected at a sampling site, arrangements should be made accordingly.

- Considerations should be given to retaining eel in a container separate from other species of fish. The reason for this is that the copious amounts of mucus produced by stressed eel can increase the viscosity of the water in a bucket or tank to the point where other species are unable to respire satisfactorily.

- Because of their ability to climb and otherwise escape, eel should be held in containers large enough to make escape unlikely; tall bins are often used. Containers for eel should ideally have lids but if this is not possible, they should not be filled with water beyond ¼ full.

Detail 2: Storage of fish

- Fish captured during an individual sampling effort need to be retained until they can be processed. In the case of catch-depletion surveys, processed fish will, in most cases, need to be retained until the final sampling effort has been completed before being returned to the sample site.

- Fish storage facilities need to be located in an area out of direct sunlight and as near to the actual sampling site as possible but must be such that they are part of a safe and stable work area for processing fish. This is likely to be a level part of the bank for sites fished by wading but can be in a boat in some circumstances.

- Tanks used for holding fish must be constructed of non-conductive materials. They should be of sufficient capacity for the sizes and numbers of fish likely to be caught

- Fish holding tanks should be filled with water from the sample site and temperature should subsequently be monitored to ensure it remains close to the site ambient water temperature. Elevation of temperature by 2^{o}C or more may be dangerous or stressful to fish. Sensitivity to thermal shock varies with species.

- Oxygenation or aeration of holding tanks is recommended, especially in warmer weather. Delivery of compressed oxygen through a flow-meter and ceramic diffusers is probably the most efficient.

- If oxygenation or aeration equipment is not available then water in holding tanks must be replenished or changed at regular intervals to avoid low-DO problems and possible accumulation of ammonia.

- Floating cages may also be used for holding fish whilst processing.

Detail 3: Measuring fish

- Fish lengths are to be recorded as Fork Length.

- Millimetres will be used as the unit of measurement.

- Subsampling of length measurements should be used for large sample sizes

- Anaesthetics should be used in connection with fish measurement only when absolutely essential and then in compliance with relevant protocols.

- Fish should be measured on a suitable board. Special boards might be needed for measuring particularly small or large fish.

- Any necessary collection of scales for fish should be undertaken at the same time as length measurement to avoid double-handling of fish.

Detail 4: Post-processing care of fish

- When fish have been captured and processed they must be retained alive until the end of the sampling occasion when they should be returned to the water as near to the sample site as possible. Mortalities should be recorded and dead fish disposed of appropriately

- Separate containers should be used for processed fish, to keep them separate from captured fish that are yet to be processed.

- Containers for processed fish need to be large enough to accommodate all of the fish likely to be captured by the total sampling effort; in some cases of catch-depletion estimates this may be four or five catches of fish.

- Non-conductive tanks, with suitable aeration or oxygenation facilities, are most frequently used for this purpose. If no aeration facility is available then the water in holding tanks must be replenished or changed at regular intervals.

- Floating keep-cages, with removable lids, may be useful where large numbers of fish need to be retained. Where electric fishing is the sampling method, the cages must be located well outside any possible influence of the electric fishing gear.

- As with retention of fish prior to processing, care should be taken to monitor water temperature in land-based storage facilities to prevent thermal shock.

Detail 5: Collection and preservation of samples for later analysis

- When samples of fish fry are collected by seine netting, electric fishing or point-abundance sampling, there is often the need, especially for coarse fish, to kill and preserve samples of the catch to allow identification of species in the laboratory

- Fish to be preserved should be killed in an approved manner as soon as possible after capture to minimise stress

- Killing and preservation of fry should follow recognised principles.

- The following protocol is recommended:

    1. After capture, place live fry in water in a white plastic tray and leave in the light for ten minutes. Exposure to light is important as it influences the size and appearance of melanophores. Light-exposed melanophores aid identification.

    2. After ten minutes light-exposure, tip the water and fish into a fine meshed net and immediately fix the fish in 4% formaldehyde.

- Alternatively, fry can be killed by overdose of a suitable anaesthetic.

- Preservation of samples killed by overdose can be with IMS (Industrial Methylated Spirit) or 4% formaldehyde (10% ‘formalin’). Samples intended for long-term storage may be better preserved in formalin.

- When the samples are to be processed in the laboratory the preservative should be thoroughly washed from the samples before processing takes place in accordance with the relevant laboratory safety regulations.

- Preservation of samples of fish other than fry may be required on occasion although it is not anticipated that preservation of samples will be a frequent occurrence. When the need arises the technique used should be the most appropriate to the purpose of the sample but generally the provisions above should apply.

3.2 Sub-sampling Fish Lengths

- The accepted measurement of fish will be Fork Length.
- Millimetres will be used as the unit of length for all fish.
- For species of primary interest, 300 fish per species captured at a site should be measured. The measured fish must include specimens from each catch of the sample and should be representative of the complete size range captured. Judgement will need to be exercised as to the most suitable balance of fish from each catch; it is not possible to be prescriptive. For species caught in excess of 300 individuals, the excess fish will be sub-sampled by measuring approximately 50%. Unmeasured fish should then be counted by species. The length frequency of the unmeasured fish is estimated through interpolation with the length frequency of the measured fish.
- For species of secondary interest, measure 100 fish per species, including specimens from each catch across the entire size range. Excess fish will be counted.
- If length data are required for species of tertiary interest, measure 50 fish per species, including fish from each catch. Excess fish will be counted.
- Where the sample consists predominantly of a single age-class of a single species – for example 0+ salmon – it will be acceptable to measure the 50 (including fish from each catch) individuals of that species/ year class if that meets local requirements with additional fish counted. Other age groups or species in this type of sample should be measured according to the above protocol.

3.3 Collection of Scale Samples

Background

- Determination of age, growth and other statistics of fish populations from sites sampled is necessary to meet the requirements of the monitoring programme. Determination for most species will be by means of analysis of scales and the collection of scales in the field should follow a common protocol to ensure consistency and robustness of output. Sub-sampling may be necessary for efficient and effective data handling when large samples of fish are collected and avoids the collection of excessive data whilst ensuring that the data remains statistically robust.

Detail 1: Collecting scale samples

[For survey definitions refer to Section 4:Guidance]

- For **Coarse Fish Index Zone Surveys**: Scales from a maximum of 5 fish per 5-mm length increment should be collected for each target species sampled. Scale samples can be combined across sites within a zone but care should be taken to ensure that no individual site is over-represented. When low numbers of individuals per species are sampled in the zone, the minimum acceptable sample size for a species comprises scales from 15 fish, representing at least five 5mm length increments.
- For **Coarse Fish Temporal, Spatial and Sentinel Surveys**: Scales from a **maximum of 3 fish per 10-mm length increment** should be collected from target species. As with Coarse Fish Index Zones, scales should be combined from across sites whenever possible. When low numbers of individuals per species are sampled, the minimum acceptable sample size for a species comprises scales from 15 fish, representing at least five 10mm length increments.
- For **Brown Trout Surveys:** Scales from a maximum of 10 trout per 5mm length increment should be collected. Higher numbers of trout scales are required per increment to account for the greater proportion of replacement scales in trout than coarse fish. When low numbers of trout are sampled,

the minimum acceptable sample size comprises scales from 20 fish, representing at least five 5 mm length increments.

- For Brown Trout captured in Salmonid Sentinel Surveys or any type of coarse fish survey: Scales from a maximum of 10 trout per 5mm length increment should be collected. When low numbers of trout are sampled, the minimum acceptable sample size comprises scales from 20 fish, representing at least five 5 mm length increments.

- For **Trap Samples of Adult Migratory Salmonids:** Scales should be collected from all adult salmonids trapped.

3.4 Use of Fish Anaesthetics in Fish Monitoring

- Text needed –

3.5 Salmon Catch Returns – Nets

- Text needed –

3.6 Salmon Catch Returns – rods

- Text needed –

3.7 Eel Catch Returns – nets

- Text needed –

3.8 Habitat Evaluation for Fisheries Monitoring

- Text needed –

3.9 Fish Counters

- Text needed –

3.10 Hydroacoustic Data Processing

- Text needed –

3.11 Monitoring Angler Participation

- Text needed -

4. GUIDANCE

4.1 Programme rationale

- Historically, most monitoring programmes were designed to meet to meet locally perceived needs and priorities and this led to a situation where data could not readily be aggregated across larger geographical areas - an application required increasingly to meet current needs.

- Modern programmes can be built from the bottom up using a series of statistical models to determine ideal sampling regimes.

- One key issue in developing the revised fisheries monitoring programme has been an awareness of the potential needs of the WFD. Considerable debate continues about just what data the WFD will demand to quantify ecological status for designated waters. It would appear that the any programme's temporal monitoring element should provide data appropriate for the highest level surveillance monitoring for rivers. Stillwaters are a development area in this context.

- Monitoring requirements will need to be developed for fish species only when appropriate reference states for the defined range of ecosystems under the Directive have been determined and where fish are deemed to be the biological element most sensitive to the environmental pressure in question.

4.2 Programme elements

- Four basic types of data need are specified for each type of fishery although the balance and emphasis between them varies. These are:

Index Monitoring

- Effective fisheries management requires an in-depth understanding of the ecology of fish species and populations, and the way these change. This can only be achieved by detailed studies that are affordable only at a limited range of locations.

Temporal Monitoring

- Temporal elements of the programme will provide long term time-series data about specific places. Collectively, the information from these sites can be used to show trends or patterns over a larger area. Temporal monitoring requires a frequent sampling regime as return period drives the statistical power. Sites should be sampled annually. Even at this frequency it is likely to be 30 years or more before significant trends can be demonstrated although this does not preclude interim investigations in response to identified issues.

- Many temporal sites fall within, and therefore contribute to, index reaches – they also contribute to spatial datasets.

Spatial Monitoring

- Spatial surveys are aimed principally at comparing groups of sites (for example between habitat types or sub-catchments). In contrast to temporal monitoring, spatial survey power is driven by sample size (number of sites) rather than sampling frequency. Sites in the Spatial surveys should be sampled at five-year intervals. Over very long time-scales, >60 years, it may be possible to use data collected through spatial surveys in a temporal context.

Sentinel Monitoring

- There are many waters where a full, statistically based, sampling programme cannot be justified on grounds of cost effectiveness. In these waters there is, nevertheless, a need for awareness of the general status of their fish populations to satisfy duties to e.g. Conservation and Sustainable Development.

- Sentinel monitoring aims to address the question:

  - *"Is there any reason to believe that this fish population is not self-sustaining or might not be so in the near future?"*

- Consequently, there will be a reliance on instantaneous assessments, rather than statistically valid comparisons. Data from index zones will also be useful in this context. Age and population structure, growth rate and species composition will be important parameters to assess in order to address the specific question being asked.

- Typically one or two well placed sites per reach or sub-catchment, with a five-year return period, will satisfy the data need.

- Coarse fish communities are complex and are subject to high annual variations in abundance. Consequently, the statistical power of any given coarse fish programme will be less than it would be for the equivalent salmonid programme. In particular, spatial discrimination is relatively weak and consequently coarse fish monitoring is best focussed where it is most cost-effective - temporal monitoring of principal fisheries.

- Salmonid populations are very dependent upon smaller tributaries for breeding and nursery areas although the resulting fisheries are usually in the larger tributaries or main-river. Smaller tributaries are often those most at risk from pollution or other impacts such as acidification, upland drainage or erosion. Power calculations indicate that, unlike coarse fish, juvenile salmonid populations tend to be more stable so that spatial comparisons are feasible. This type of information is essential for fishery assessment and diagnosis. However, it is also very important to study population changes over time, for example to relate to catches, so a strong temporal element is also required.

4.3 Generic principles of monitoring fish in rivers.

This guidance describes principles applying to both Quantitative and Semi-Quantitative surveys. The principal sampling method used for both is likely to be electric fishing although, in some rivers, seine netting might be a more appropriate method and other methods may be used, particularly in large rivers and for some Semi-Quantitative surveys.

Detail 1: Definitions

Quantitative surveys make use of conventional catch depletion sampling and population estimation techniques. To satisfy the conditions of these estimation methods, the isolation of the site with stop nets (and/or natural barriers) is essential. Sites must be fished at least three times except and unless "the 2nd catch is very much smaller that the 1st and the field estimates of population size indicate (a) that the population size exceeds 200, and (b) that the probability of capture of an individual fish is greater than 0.6. Under these circumstances a third fishing need not be carried out.". Irrespective of the number of catches in the sample, it is essential that fishing effort remains constant for each catch.

Semi-quantitative sampling consists of

Either: a single electric-fishing run, using the methods above (Stop nets need not be used but if it is intended to use probability of capture as a population estimator then the use of stopnets is strongly recommended. Advantage may be taken of natural obstacles, *eg* riffles, waterfalls).

or (for salmonids only): Timed electric-fishing targeted at riffle areas in streams of greater width than 10m. This method focuses on fry, and is typically used to assess the spatial distribution of juvenile fish in main stem rivers.

Detail 2: Data to be recorded

- At all sites sampled, the following data **must** be recorded for each sampling effort (electric fishing run or net haul). Metrics specified are the minimum requirement and not an exhaustive list; additional data will be recorded where necessary to meet the needs of a particular sampling occasion.

- Species of fish captured

- Lengths of individual fish will be recorded in accordance with the protocol outlined in 3.2 "Sub-sampling Fish Lengths".

- Scale samples appropriate to the number and size-range of fish captured will be taken in accordance with 3.3 "Sampling Fish Scales for Age and Growth Determination".

- For eel, the preferred data to be recorded is individual length of eel captured (subject to subsampling protocols), with or without bulk weights. Alternatively, a count of individuals ≤99mm and >99mm, together with the bulk weight of all individuals >99mm caught per sampling effort, will be recorded.

- For non-target an estimated total number per species for the site, will be recorded unless there is a specific reason to exceed this level of precision. It is recommended that numbers are recorded as follows:
- 1<9,
- 10<99,
- 100<999, and so on.

- Routine recording of individual fish weights for target species is not normally required as adequate biomass information can be derived from established length/weight relationships. In some circumstances, however, weighing of individual fish may be justified, for example where a river-specific length-weight relationship is required.

- Site- and survey-specific variables e.g. habitat descriptors.

- Habitat variables capable of affecting performance of electric fishing gear, particularly conductivity and temperature.

Detail 3: Timing of survey work

- What is important in terms of survey timing, for samples intended to provide time-series information, is that each sample at a site must be taken, as near as possible, at the same time of year as other samples at that site in order to ensure continuity. As long as individual sites or groups of sites are sampled at the same time each year, time series comparisons will be valid.

- Sample the site(s) for the first time at a time which is appropriate to the purpose of the survey and main species concerned.

- The date of the first sample becomes the target date.

- The sampling window for future data collection is then six weeks either side of the target sampling date

4.4 Large River monitoring strategy

- The information presented in this section of guidance begins with the decision to monitor fish in a large river and end with the formulation of an appropriate sampling strategy for the river or section of river in question

Detail 1: Theoretical considerations

- In large rivers, the problems of catching fish in order to estimate fish population parameters are compounded by the uneven distributions of many species, particularly shoaling fish. For guidance on how best to monitor fish populations in these rivers, it is useful to look at how similar monitoring problems are handled for extremely large rivers or the sea. In both these circumstances, population estimates from individual site surveys are only used if a large proportion of a fish population is concentrated in the site area. More attention is paid to overall catch per unit effort from large parts of the fisheries, coupled with data on the size and age distribution of fish stocks. Separate, routine fish population monitoring surveys are not carried out by monitoring personnel, but commercial catches are used. The only time that fish population monitoring surveys are carried out is to use techniques that can efficiently sample a good proportion of the population, e.g. trawling for juvenile flatfish in nursery areas, or hydroacoustics.

Detail 2: Information Requirements

- Before defining sampling methods for large rivers, it is essential to determine the management information requirements from the surveys and to what extent it is practical to meet these with the accuracy and precision desired.

- The minimum requirements are those needed to provide some understanding of the species present, their relative abundance and their population age and size structures, so that their dynamics can be followed in the fisheries. The emphasis is usually on following temporal changes, so it is most important that the selected parameters are monitored in a consistent and accurate manner. Species and sizes of fish constituting the bulk of angling catches will be of most interest, along with those species and sizes of fish that may be highly prized by anglers, such as specimen barbel.

Deatail 3: Information available versus sampling difficulty

- It is desirable for management purposes to monitor stock abundance in a quantitative manner rather than just in relative terms. However, in large rivers this may not be practicable due to sampling difficulties and costs. For example, it would be very difficult to get an accurate quantitative estimate of fish population density from deep, turbulent water full of tree branches. Spatial variance in riverine coarse fish population numbers is usually very high, making it very difficult to estimate those population parameters likely to have high spatial variance, such as population density or biomass, with high precision or accuracy within river reaches from a series of surveys at individual sites.

Detail 4: Recommended sampling regime

- Angling catch data have special value as they are directly related to the purpose for which a fishery is managed. Results from a large amount of effort can be relatively cheaply collected and bias due to the selectivity of the method is of less relevance to the usefulness of the results if angling methods have remained relatively constant. Thus, any multiple method sampling regime should include collection of data from anglers' catches .

- The main objective of monitoring large river coarse fisheries is to detect and quantify temporal changes, at the reach level, in relative abundance, population and age striker of major species present. This needs to be done in a cost-effective manner. If the abundance data can be made quantitative for no significant additional cost, then the relevant methods should be adopted.

- Large British rivers are of an intermediate size in relation to the efficiency of population sampling techniques between the efficient techniques for small streams and the inadequacy of these techniques in large environments, as noted above. It is therefore necessary to weigh the benefits of using familiar quantitative techniques for estimation of population densities and biomasses against the additional costs, difficulties and risks to fish stocks involved in scaling up techniques from small rivers.

Detail 5: Survey decision making

- A possible procedure for deciding on a suitable sampling strategy for monitoring fish in large rivers is shown in Figure 9.

Detail 6: Suitable combinations of survey techniques

- Since a comprehensive picture of fish stocks is required against which to compare fishery catches, sufficient effort is required from any method that will enable the relative abundance and identity of a stock component to be identified. Stock components identified from fishery catches are the most important consideration.

- For example, if angling catches showed the presence of large bream shoals that significantly affected overall catch weights or other measure of fishery performance, such as winning weights, then the most effective techniques for ascertaining their relative abundance and age and size structure should be employed. These might entail hydroacoustics to show overall abundance of fish in a size range and locations where shoals occur, angling to catch some of these for radio tagging and then seine netting to get a large sample for age and size structure.

- If eels are common in angling catches, then fyke nets and special electric fishing surveys might be needed to determine relative abundance and size structure.

- Capture efficiencies by different methods will vary greatly with habitat and thus it will be very difficult directly to compare relative abundance between waters, but trends in relative abundance, population size and age structures should be largely comparable between waters. If methods and effort are standardised for a particular water body, then temporal comparisons should be valid. Angling catches may provide the nearest to a standardised method enabling countrywide spatial comparisons for large rivers where quantitative estimates cannot be obtained. Each Region should go through the same process in considering the methods to use for surveying large rivers, but the chosen methods should represent the most cost-effective means of data collection compatible with the required data quality. Effort required in sampling of any particular population parameter should be gauged by that necessary to stabilise mean values within a particular range of confidence. For example, in many cases it is likely that growth rates and population size structure will show less spatial variance between sites than population density.

- If existing non-angling survey methods give an effective picture (quantitative estimates of major components) of all stock components, can this be more efficiently obtained (e.g. combination of seine netting and hydroacoustics for density and biomass estimates)?

- If an effective picture is not obtained from existing non-angling survey methods, then use combinations of methods that will provide overall quantitative estimates (e.g. seine net for open water and electric fishing of shallow, weedy areas using mark-recapture or catch depletion.

- If these do not provide quantitative estimates, then use catch per unit effort of most cost effective method of data collection. Use sufficient effort with each method to provide catches of all major species in the fishery (usually roach, dace, chub, bream) in proportion to their appearance in angling catches, if >5% by weight. Standardise these efforts into a repeatable programme for future temporal comparisons. (Angling catch census may be the best technique).

- Any changes to the combination of methods should include a period of overlap between the new method and that to be replaced in order to allow continuity of data comparisons.

4.5 Advantages and disadvantages of various techniques

Angling catches

- Match returns

Advantages- Cheap to collect, but may need a lot of data to control variance.
Disadvantages - No anglers, no data, selective according to angling methods used, little control over effort and may be difficult to collect data. Data errors. No data on individual fish.

- Angling census

Advantages – Individual anglers sampled in areas where match fishing does not take place. Less scope for data errors if clerks well trained.
Disadvantages – relatively expensive data collection, depends on finding enough anglers.

Hydroacoustics - side scan sonar

Advantages – Cheap to collect a lot of data. Rapid picture of variation in population densities.
Disadvantages – Expensive data capture equipment. High temporal variance and causes uncertain. Requires sampling by other methods to determine species and sizes of targets recorded. Most effectively sampled at night when fish are dispersed in open water. Interference by entrained air from weirs or boat propellers. River needs to be deep and wide to sample sufficient volume. Experienced practitioners required for survey and analysis of data. Some species poorly sampled (benthic).

Seine netting
Advantages – Quantitative data in suitable habitats for efficient sampling. Simple and relatively inexpensive equipment. Simple capture technique effective for most species.
Disadvantages - Poor sampling efficiency in some habitats (fast flow, uneven bed, snags, weed beds), but precision at a site may appear to be high. High manpower or vehicle requirements to pull nets. Obstruction to navigation. May be high mortality of small, scaled fish.

Gill netting
Advantages – Passive technique requiring little manpower.
Disadvantages - Highly selective for active swimming species and having body shape vulnerable to mesh entanglement. Affected by water-borne debris. High mortality rate of captured fish in some cases.

Other nets (cast, trammel, fyke)
Advantages – Specific applicability, some passive techniques.
Disadvantages – Selective, can be destructive. Require skill sets not normally resident in Agency staff for efficient operation.

Trawling
Advantages – Active capture,
Disadvantages - Suitable for large, navigable rivers with relatively even bed.

Electric fishing
Advantages – Active technique giving high efficiency in habitats where seine net efficiency is low. Can be scaled up in power and number and size of electrodes. Most species vulnerable.
Disadvantages - Cannot be scaled up sufficiently to cover the width of large rivers at one pass. Some species have low capture efficiency. Some environments poorly sampled (high conductivity, very low conductivity). Avoidance behaviour in open water. Some increased mortality of larger fish. High manpower requirement of trained operatives. Equipment moderately expensive. Low efficiency in deep, open water.

4.7 Recommended combinations of survey methods other than angling

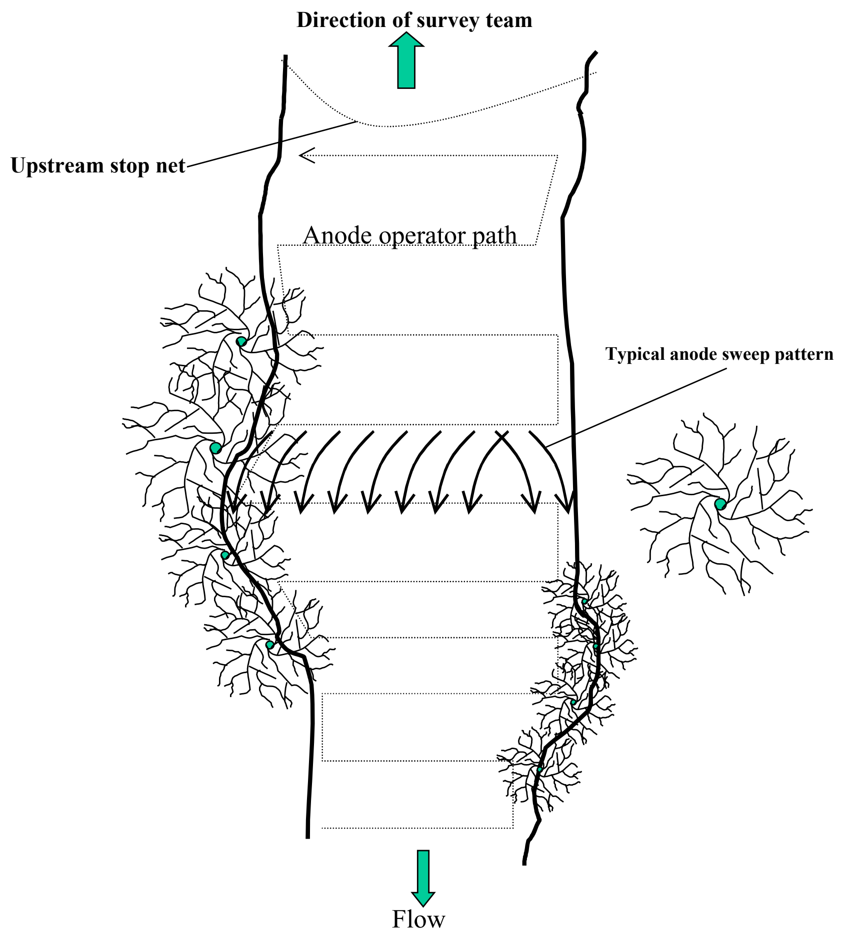
- Shoaling species in deep or open water - targeted seine netting and hydroacoustics, possibly gill netting.

- Snaggy or weedy areas - boom boat or multi-anode electric fishing.

- Benthic species - Electric fishing if clear and shallow, fyke nets if deep and/or turbid.

Electric fishing by wading with a single anode.

FIGURE 1



Electric fishing by wading with two anodes

FIGURE 2

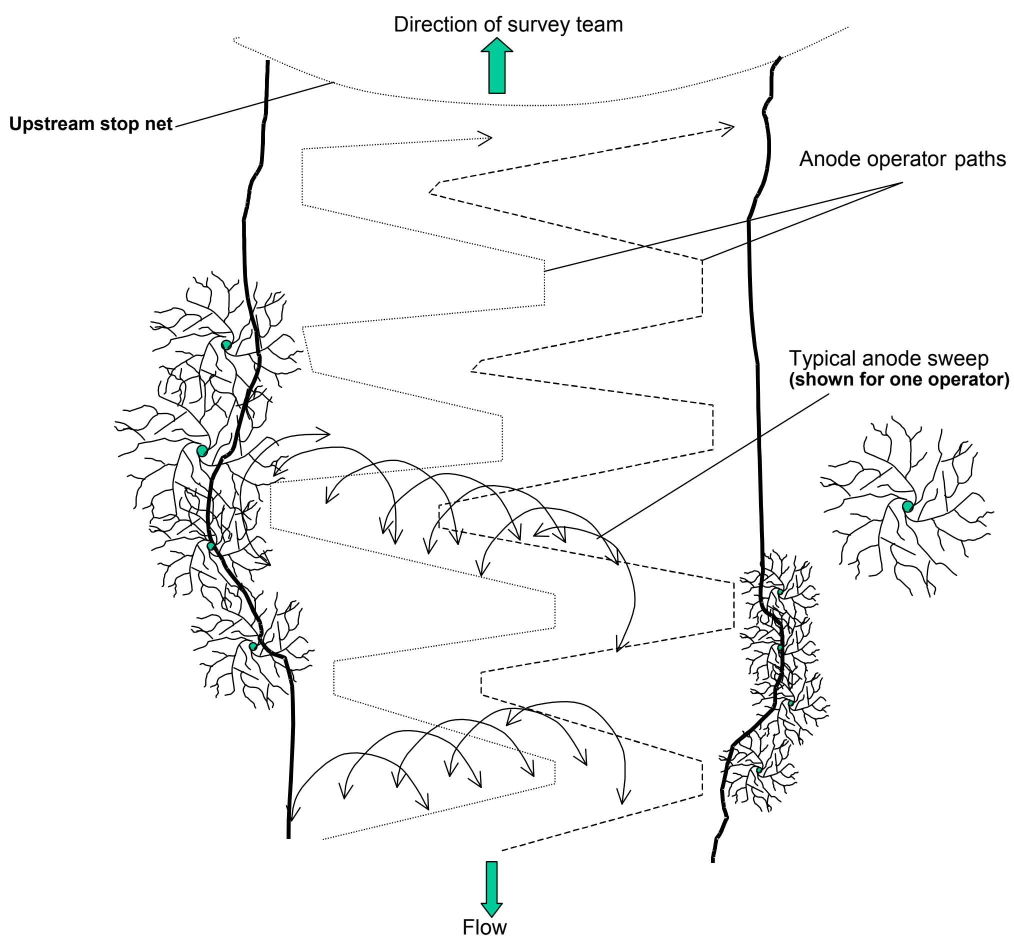
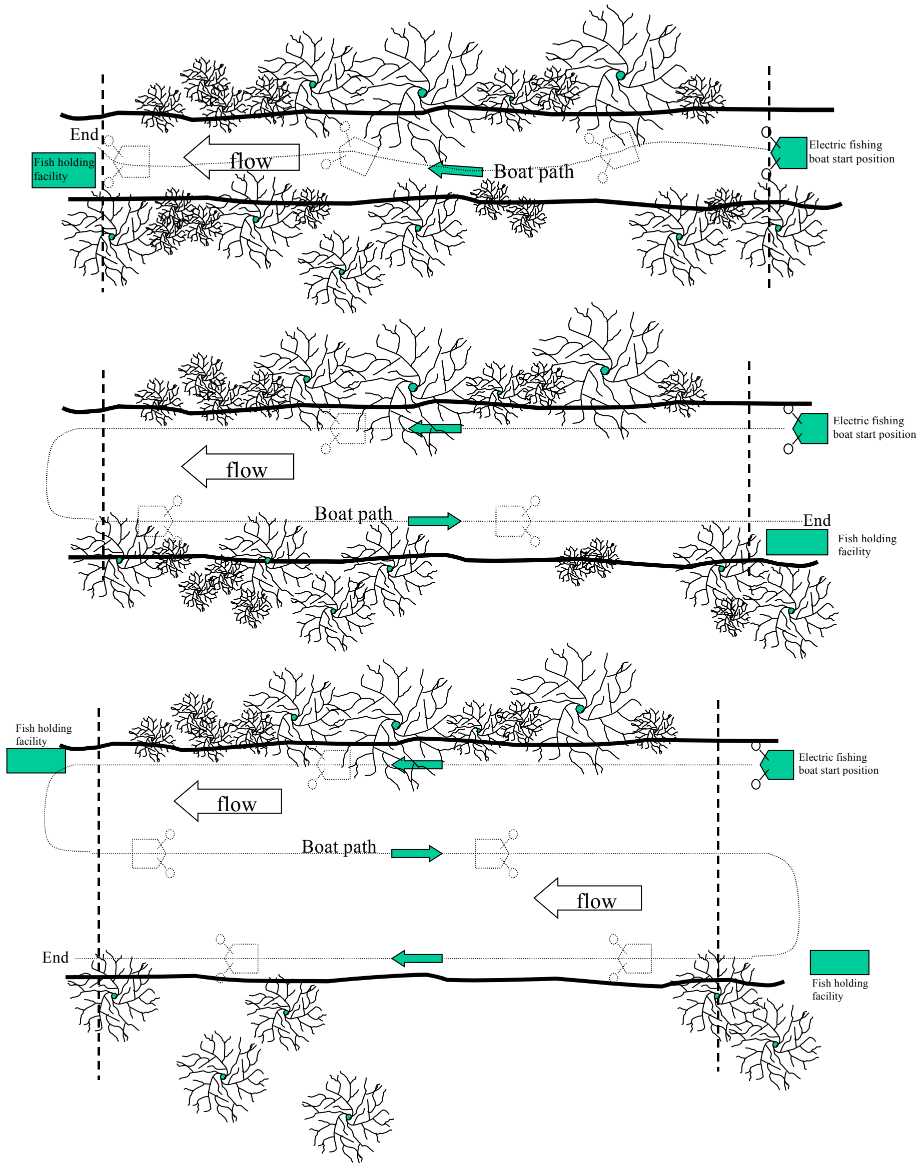


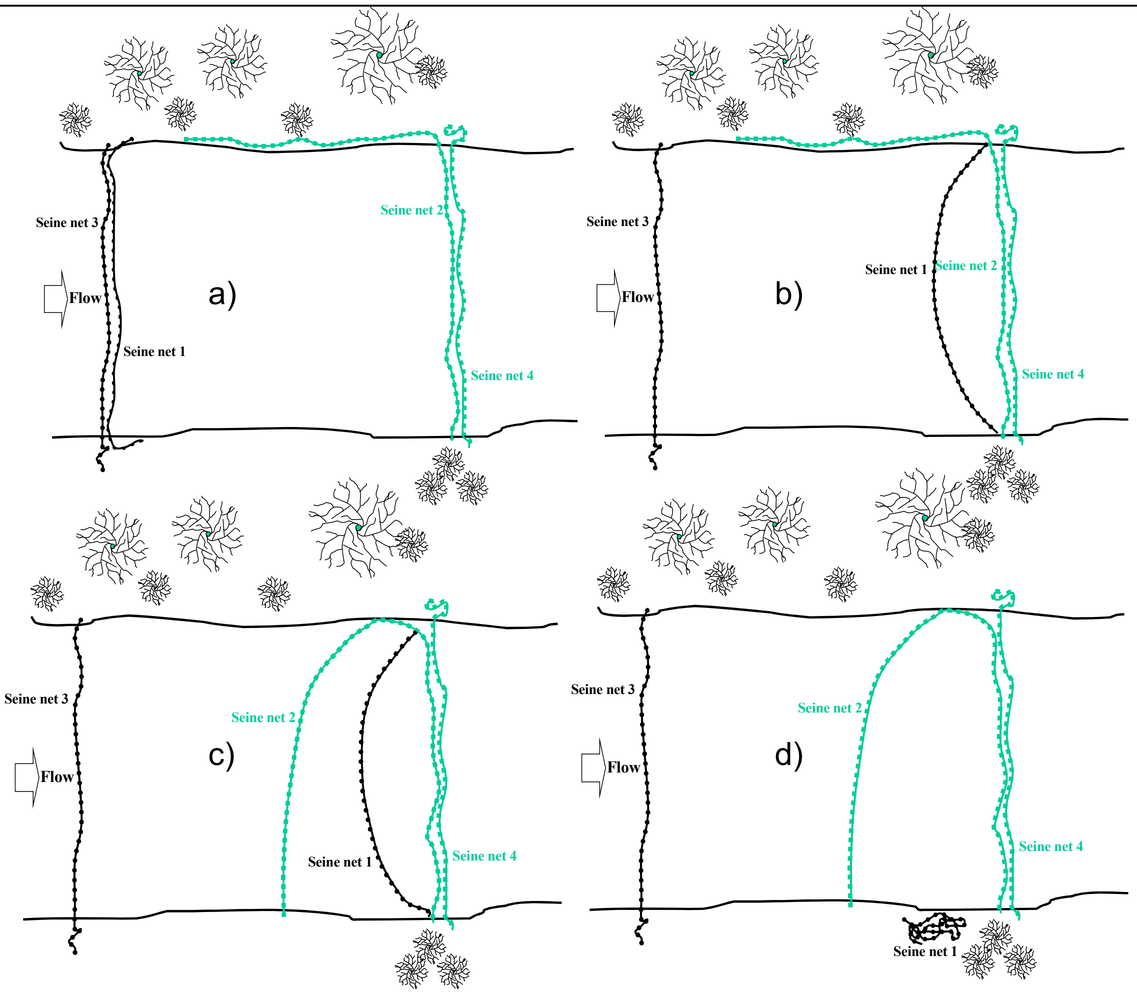
FIGURE 3

Electric fishing by boat in rivers of various widths A single sampling effort is shown in each case.



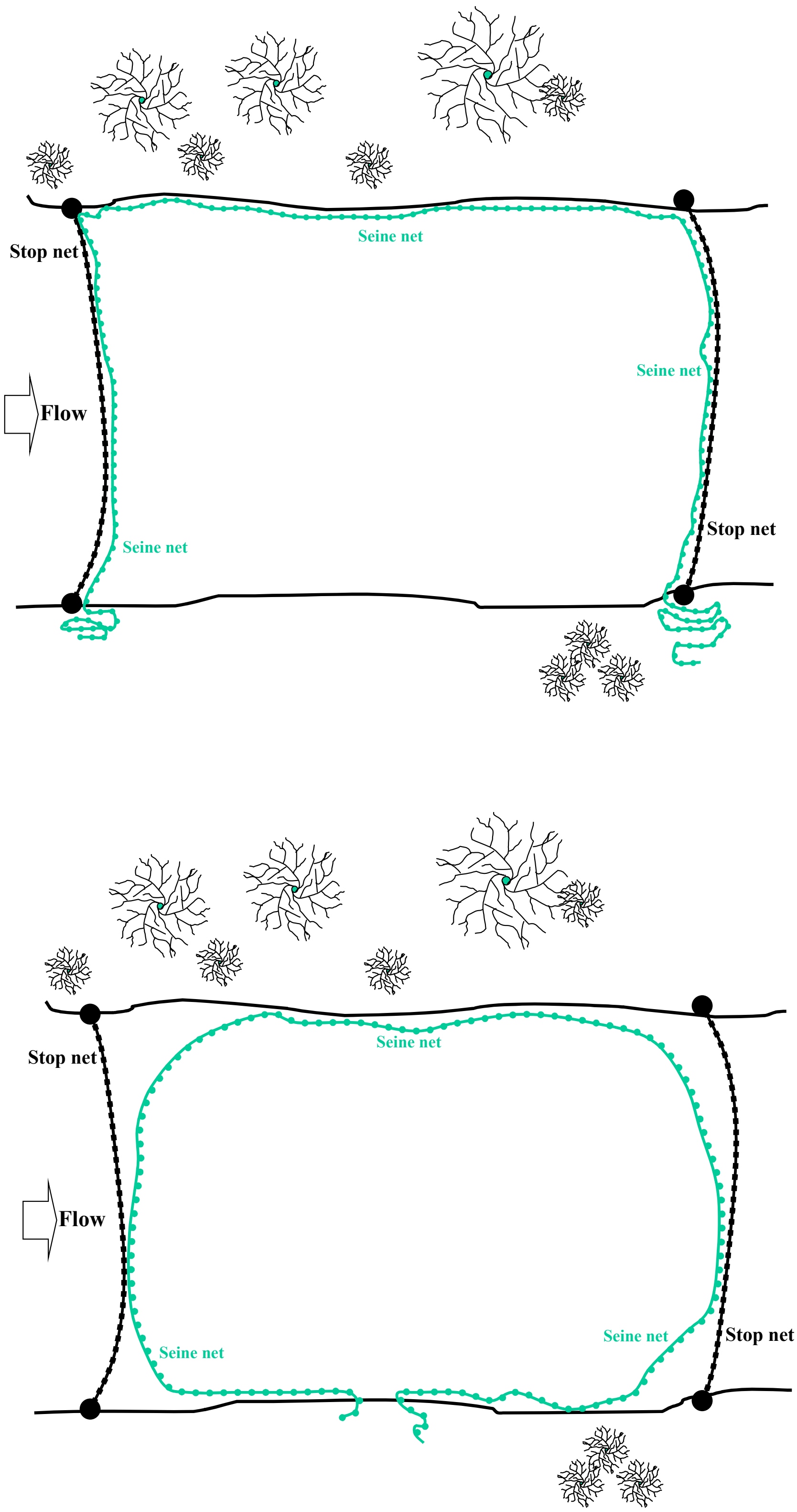
The wrap around netting technique. Time sequence is a)-d)

FIGURE 4



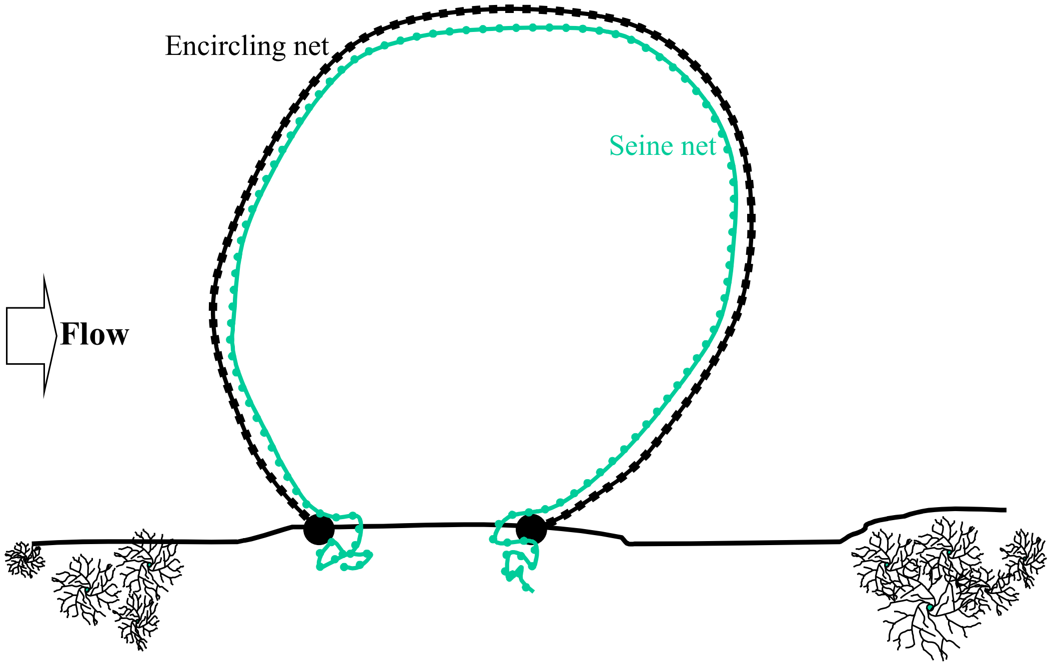
Procedure for seine netting between stop nets

FIGURE 5



Procedure for sampling with an encircling net.

FIGURE 6



Sample of angling census record card

FIGURE 7

ANGLING CENSUS

Date Venue Recorder

	< 5cm	5-9cm	10-14cm	15-19cm	20-24cm	25-29cm	30-34cm	>35cm
Trout								
Grayling								
Chub								
Barbel								
Bream								
Pike								
Dace								
Roach								
Perch								
Bleak								
Gudgeon								
Ruffe								

Record method in each square and tick other methods used

F – Fly
M – Maggot (float)
B – Maggot (ledger)
W – Worm (float)
L – Worm (ledger)
S – Spinner/lure
A – Other bait –state type below

Other species and lengths:

Time spent fishing – mark start & stop times

05….06....07....08....09....10….11….12….13….14….15....16....18….19…

Detail 5: Standard Agency Match Catch postal questionnaire form

FIGURE 8

Environment Agency Match Record

Please complete after each match and return by post (postage prepaid)

Name of Club………

Date of Match…………………………River……………………………Venue…………………………………………..

Number of competitors……………….Start time…………………………Duration of match………………………hours

Section/permanent peg number fished………………….. Total weight caught……..…………………………………..

…………………………………………………………… Winning weight …………...lbs …..……….oz

Number of anglers weighing-in………………………….. 2nd weight ……………..lbs ......……….oz

Species caught in: 3rd weight ………………lbs …. ……….oz

a) Greatest numbers ……………………………………… b) 2nd greatest numbers …..……………………………

c) Other species caught…………………………………………………………………………………………………..

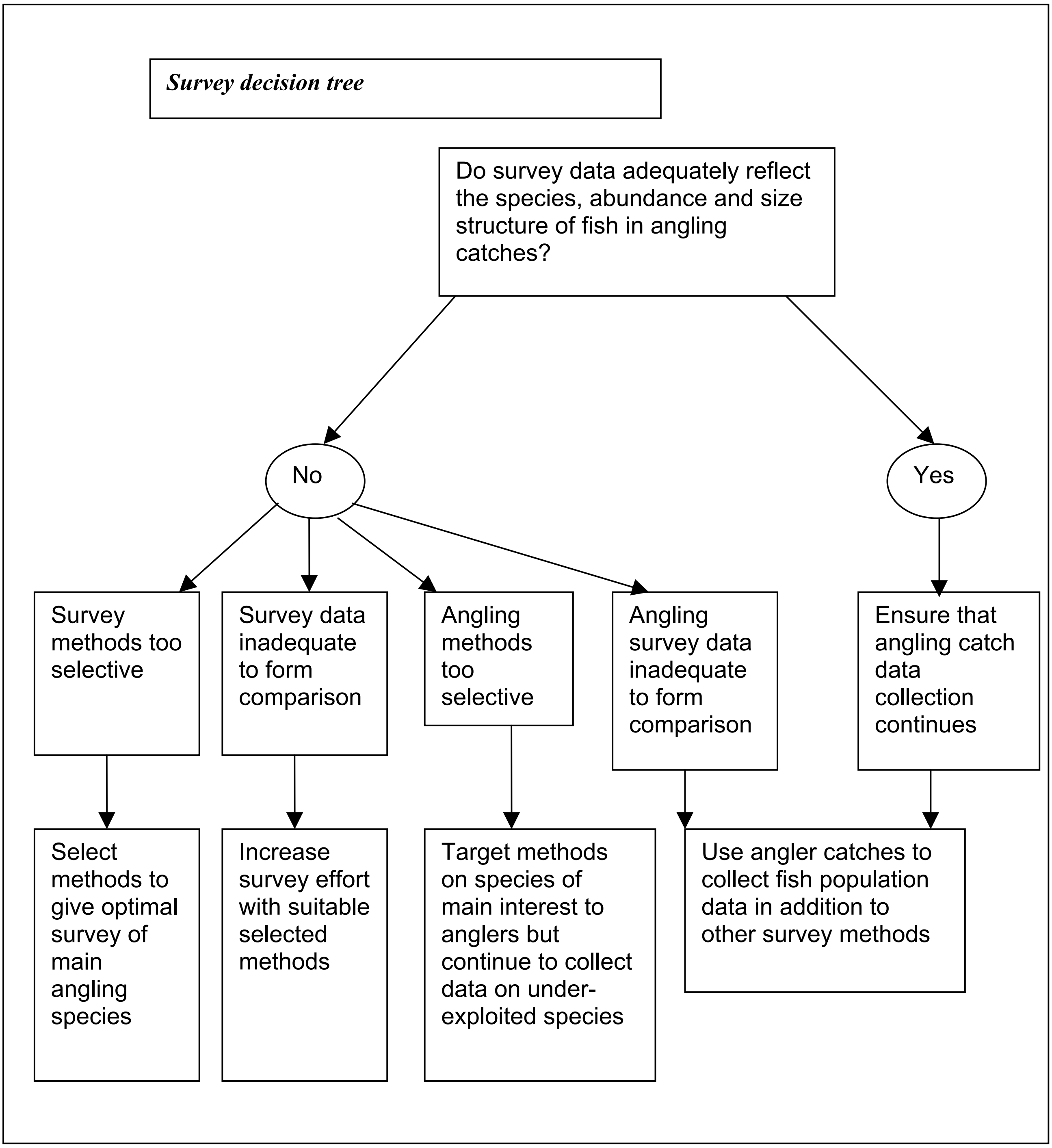
In the table below, please tick the option in each column that best describes conditions at the time of the match.

RIVER						RIVER TEMP FOR TIME OF YEAR		WEATHER CONDITIONS					
Level		Colour		Condition				Brightness		Wind		Rain	
Low		Clear		Falling		Cold		Dull		Still		Dry	
Normal		Coloured		Steady		Normal		Changeable		Light		Drizzle	
High		Green		Rising		Warm		Bright		Moderate		Light	
										Strong		Heavy	

Any other comments?…………………………………………………………………………………………………...

…………………………………………………………….Signed……………………………………….Club Secretary

FIGURE 9


Survey decision tree
Do survey data adequately reflect the species, abundance and size structure of fish in angling catches?
No
Yes
Survey methods too selective
Survey data inadequate to form comparison
Angling methods too selective
Angling survey data inadequate to form comparison
Ensure that angling catch data collection continues
Select methods to give optimal survey of main angling species
Increase survey effort with suitable selected methods
Target methods on species of main interest to anglers but continue to collect data on under-exploited species
Use angler catches to collect fish population data in addition to other survey methods