SAMPLING BENTHIC AND DEMERSAL FISH POPULATIONS IN SUBTIDAL ROCK HABITATS

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Part 2. Procedural Guidelines

SAMPLING BENTHIC AND DEMERSAL FISH POPULATIONS IN SUBTIDAL ROCK HABITATS

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Introduction

There have been few detailed and systematic quantitative investigations of mobile macrofauna carried out in the UK rocky sublittoral zone. Rocky habitats make up approximately 35% of the UK coastline (Anon, 1993) yet rocky sub-littoral habitats are difficult areas in which to observe and quantify animal abundance. Benthic species present, particularly fish, are often small and cryptic, whilst hyperbenthic species may only be transient occupants. Quantifying abundance in such an environment is often a compromise between being invasive enough to obtain reliable quantitative information without disturbing or altering abundance patterns.

There are three techniques detailed in these guidelines for sampling benthic and demersal fishes in the rocky sub-littoral zone. A fourth method using underwater television (UWTV) is also included, but costs of equipment and associated analysis make it an unlikely choice for routine survey work. The method selected will depend on the objectives of the survey and the species of interest. Interspecific differences in sampling efficiency make comparisons among species difficult. For example, the absence of a fish species in a trap does not necessarily indicate that it is absent at that site, simply that it did not enter the trap at the time of trapping. Despite these restrictions, the methods detailed in these guidelines are suitable for monitoring temporal changes in fish populations as long as the quality assurance procedures outlined below are followed.

Common rocky sub-littoral species

Cod (*Gadus morhua* (L.)) first year juveniles, two spot goby (*Gobiusculus flavescens* (Fabricus)) and leopard-spotted goby (*Thorogobius ephippiatus* (Lowe)) are commonly seen by SCUBA divers, although the two spot goby moves into shallow (intertidal) weedy areas during the summer. Goldsinny wrasse (*Ctenolabrus rupestris* (L.)) adults are territorial and relatively easily seen by diver as is the rock cook (*Ctenolabrus exoletus* (L.)) although during summer months the latter species tends to shoal over weedy subtidal areas making quantification difficult.

Recommended Methods

1. Fyke nets
2. Traps
3. SCUBA diver observation

1. Fyke nets

Overview: Fyke nets consist of a one or more leader nets which direct fish into a conical shaped net held open by metal rings. The conical net comprises a series of interconnecting nets with one-way entry doors which trap the fish (Van der Veer *et al.*, 1992). Although they can be used singly, fyke nets are usually sold in pairs. Fleets of fyke nets can be joined together into a line and sample a much larger area. In some circumstances it may be desirable to distinguish fish that have encountered the leader net from different directions; the net described by Baelde (1990) could easily be modified to produce directional information. To prevent otters entering the net and drowning, otter boards should be attached. Fyke nets are not suitable for use in areas of strong currents. Where the net is likely to be exposed to moderate currents it should be very firmly attached to metal stakes hammered into the substratum by diver (where possible) or heavily weighted. Currents are likely to interfere with the performance of the leader net (by pushing it over) and may cause the net funnel to roll over the substratum. Fyke nets can be used for short periods and where strong tidal currents are likely to be encountered nets should be used during slack water.

Staff required
- At least two staff (plus a boat skipper)

Equipment required
- Fyke net (Collins Nets, Bridport, Dorset) + otter boards
- Boat
- Shot weight (at least 10 kg per pair of fyke nets)
- Protective and safety clothing (gloves, oilskins, buoyancy suits, lifejackets etc.)

Method
Sew the otter boards into the mouth of the net funnel as directed by the manufacturer. Attach the shot weight to the closed end of one of the nets and then lower it to the bottom using the net (there is no need to attach an additional length of rope). When the weight reaches the bottom the rest of the fleet can be payed out as the boat slowly reverses. Most fish in the rocky subtidal move parallel to the shore and, therefore, the net should be orientated perpendicular to the shore. It is useful to survey the site visually, prior to deploying the fleet, to check for obstacles. Areas with large boulders, very steep slopes/ cliffs and detritus which could become entangled in the net should be avoided. If deploying the net on a steeply sloping substratum attach an extra long shot line and use a larger buoy. This layout reduces the chances of losing the net if it is deployed slightly off site and where the weight of the fleet pulls the marker buoy under the water. Recovery is achieved by lifting the buoyed rope and fish can be removed from the end compartment by untying the ends of the net (see Figure 1).

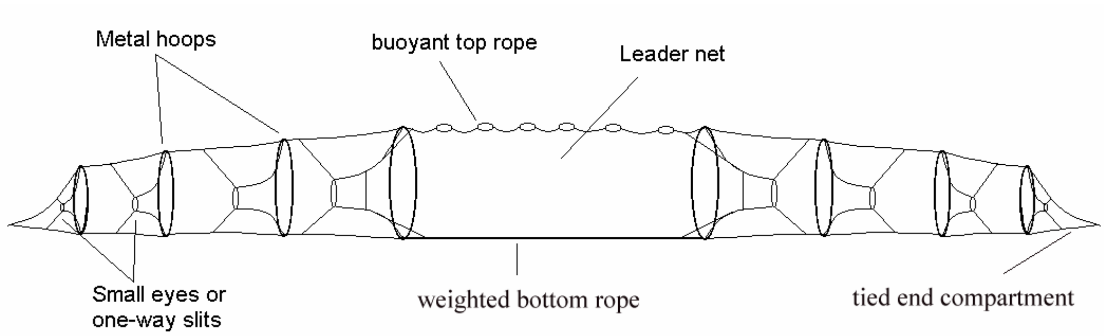

Figure 1. Fyke net

Time Required
Boat deployment and recovery takes around 5 minutes per net pair (Sayer *et al*., 1996). Removing the fish takes ca. 10 minutes. Fishing time depends on the survey objectives but fyke nets are commonly left in position for one day or one tidal cycle (Treasurer, 1996).

Advantages:
1. More objective than visual census
2. Cost effective
3. Easy to use
4. Non destructive (fish are maintained alive)

Disadvantages:

1. Restricted depth range (ca. 15 m maximum)
2. There are problems relating catch with the actual population; the catching power is unknown for most species and may vary with season and other factors (Darwall *et al*., 1992)
3. Cannot be successfully used in areas subject to even moderate currents

2. Traps

Overview: The target species and objectives of the survey will dictate the optimum trap type to use. Traps are very species-selective and without a thorough understanding of relative catch efficiency the data generated should not be used to predict relative abundancies of different fish species. Traps for use in fish surveys are often modified commercial traps and can be deployed from either a boat or from the shore. For species such as wrasse modified *Nephrops* creels can be used. Although smaller traps are manufactured (e.g. for crayfish) they do not seem to be effective for small fish such as gobies. Cheap, effective traps can be made from plastic mesh (Kruuk *et al*, 1988). Bait can be used to encourage certain fish species to enter the trap. Baits commonly used include crushed mussels, crab, salted fish and broken sea urchin. The use of baits can, however, result in biased results because one bait may attract a particular species to the exclusion of others. In addition, it is not known if territorial fish, such as goldsinny, will move across adjacent territories to enter a trap. Trapping efficiency is governed by a number of factors including bait type, fish activity/behaviour (depends *inter alia* on season) and where, in relation to fish territory, the trap is deployed. Consequently, accurate abundance estimates using trap data are difficult to make. However, for a given species, date, time of day, location and tide, the catch efficiency should be similar. Data thus generated indicate relative numbers and can be used to monitor yearly changes in population. Traps are quite robust and can be deployed in areas of moderate current and over rough ground. However, they can foul on detritus and it is advisable to have some indication of the substratum type and the presence of detritus at the proposed site. Traps can be moved by other users in the area so avoid placement close to anchorages or areas subject to fishing activity.

Staff required

- Two staff

Equipment required

- Traps (Gael Force Marine Equipment, Stornaway or Caithness Creels Ltd., Wick), rope and buoys
- Boat
- Buckets
- Scales/ measuring board if required
- Bait (if required)
- Protective clothing (gloves, boots, survival suits, oilskins, life jackets, survival suits etc.)

Method

To avoid entanglement the fleet should be rigged as shown in Figure 2. Throw the first trap of the fleet into the water, over the chosen site, and lower by the rope attached to the other traps, deploying these as necessary. Attach a rope and buoy to the ground rope and lower this to the bottom. Reverse the boat away after throwing in the first trap whilst deploying the others. Where access permits, traps can be deployed from the shore/ pier. In water deeper than 10 m, retrieval should be relatively slow to reduce the risk of fish damage through pressure changes. For a fleet of five traps the ground rope should be ca. 30 m with a 3 - 5 m trap rope separating each trap from the ground rope (Figure 2).

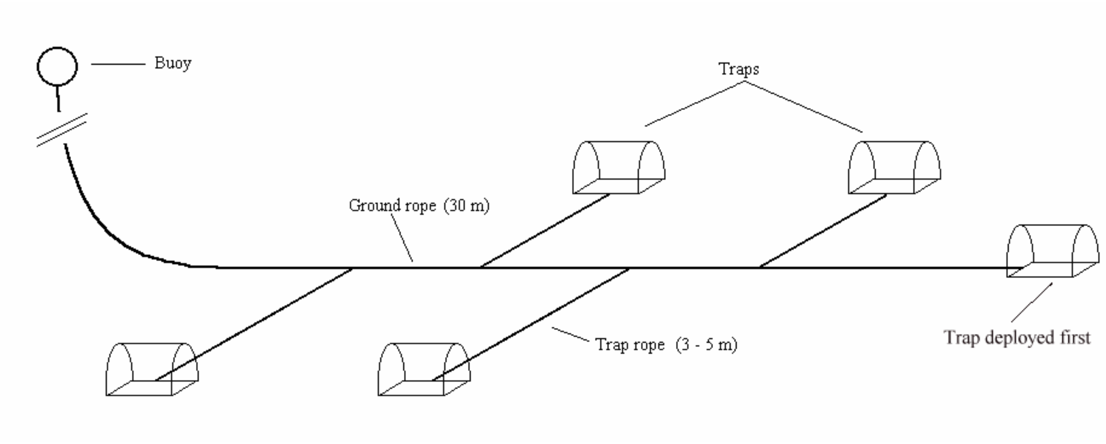

Figure 2. Suggested layout of a fleet of five traps

Time Required
A fleet of five traps can be deployed in 10 minutes. Recovery time is similar. Fish are easily removed by opening the trap. Any measurements, as dictated by the sampling protocol, can then be made.

Advantages:
1. More objective than visual census
2. Cost-effective
3. Easy and quick to deploy
4. Can be deployed for short periods (ca. one hour)

Disadvantages:
1. Very species- and size- selective (some common species cannot be sampled using traps)
2. Perceived as competition by local fishermen
3. There are problems relating catch with the actual population; the catching power is unknown for most species and may vary with season and other factors (Darwall *et al*., 1992)

3. SCUBA diver observation

Overview:- SCUBA technology allows direct observation, identification and counting of fish. However, the close presence of SCUBA divers can affect fish behaviour and must be considered when using such techniques (Chapman & Atkinson, 1986; Costello, 1992). Censuses by SCUBA diver using transects or point counts can be a useful way to monitor long term fish population changes. However, the efficiency of this technique is dependent *inter alia* on species, diver, season, underwater visibility and weather. This technique is, therefore, subject to considerable experimental error and cannot accurately be used, for example, to compare relative abundance of different species. Transects used in fish survey research are usually permanently fixed belt-transects and accurately delineate a finite area. Where the establishment of rope transect is impractical (i.e. because of the presence of very large boulders or if the site is used for other purposes) point counts can be undertaken. These can be in the form of fixed, marked stations where a diver stops and counts the fish, or a series of short (1 - 5 m) fixed transects. In certain circumstances individual fish refuges can be marked and monitored. This technique applies particularly to territorial fish where individuals can be identified and recorded over extended periods. Fixed belt-transects should be used in preference to simple line transects or point counts whenever practical and are described in these guidelines.

General guidelines

The following points should be considered when initiating a visual census

- Depth (can the work be adequately carried out within depth-imposed restrictions on diving time? Ideally, transects should be less than 20 m deep).
- Exposure (are windy/rough conditions likely to restrict access?)
- Tide (is enough slack water time available even during spring tides?)
- Ease of access (is a boat required, if so where will it be launched?)
- Is the site representative of the area of interest?
- Is the area subject to heavy traffic, fishing or to boats anchoring?
- Is the site convenient for the deployment of transect lines ? (boulders over 1m diameter should be avoided)
- Species (less abundant species will require a longer search)
- Deployment method (is a boat available?)

Staff required

- Suitably qualified, experienced and equipped diving team (Dean *et al.*, 1997). At least one diver must be experienced in identifying the fish species found in the rocky sub-littoral zone.

Equipment required

- Weighted rope
- shot weights (redundant chain is ideal)
- tape measures, marker buoys
- 30 - 45 mm diameter rigid plumbing pipe

Method

(i) Transect Manufacture

Ten to 15 mm diameter negatively buoyant, brightly coloured, polypropylene rope should be used for the transect. Form the transect width by attaching 30 - 45 mm diameter plastic pipe cut to the desired width of the transect to both pieces of the transect rope (Figure 3). This will act to help maintain the desired transect width during and after deployment. Dividing the transect length into sections can yield additional within-transect variability data.

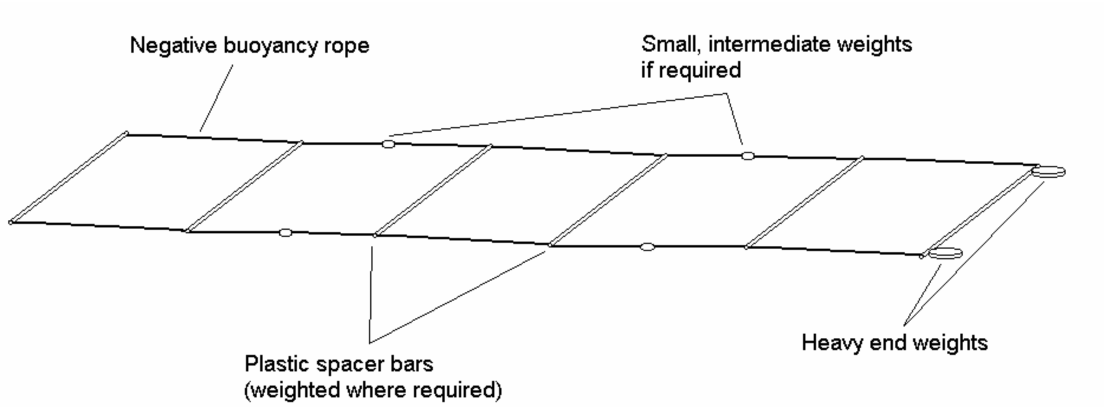

Figure 3 - Suggested design for a belt transect

(ii) Deployment
The preferable method of deployment requires a boat. Attach steel or concrete weights (ca. 50 kg) to one end of the transect and lower it to the bottom over the bow of the boat. By pulling against the weight the transect can be deployed taut, the weights can be recovered after deployment if necessary. Keep the rope from twisting and with the boat in slow reverse pay out the transect. At regular intervals (at points marked by the pipe is recommended) attach weights (5 - 10 kg) to the rope. When the whole length is deployed attach a buoy, if desired, and lower the end of the transect to the bottom. After deployment, divers should remove twists and ensure that the transect width is correct. Where appropriate, and especially in areas of strong current, divers can deploy further ballast or, where practical, stake the rope to the substratum using stout posts.

Shore deployments can be achieved, where pipe spacers and weights are not used, but are difficult and time consuming.

(iii) Surveying
The amount of time spent surveying each transect should be standardised and is species dependent; surveying small benthic fish will require a certain degree of searching. More active, visible species can be counted whilst swimming a standard speed (commonly ca. 4 m min^{-1}). As each fish is seen it should be recorded on a pre-prepared species list written on a white plastic board with a soft lead pencil (underwater tape recorders or surface communications have also been used). The use of underwater torches is recommended when surveying species inhabiting crevices. To assist in quantifying fish in complex areas the anaesthetic quinaldine can be used. However, this is a complex underwater task which should only be undertaken by experienced divers (Sayer *et al*., 1994).

Time required
Commonly transects are 30 - 100 m long, 2 - 3 m wide and can take up to 1 hour to survey (although a dive time of 30 - 40 min. is more practical). Access time to the diving site will depend on location.

Advantages:
1. Good method of showing annual change in abundance at the same site
2. Divers gain a feel for changes and observe potential causes

Disadvantages:
1. Lacks objectivity (different divers see differently)
2. Relatively expensive (requires a full, trained dive team)
3. Requires a boat

4. Underwater television

This technique is non-intrusive and gives a good indication of the behaviour of fish over extended periods (a camera can operate for >24 hours) and observe fish which are either disturbed by diver presence, or not captured remotely. However, the camera system is expensive (£15 - £20,000) and analysis of the video tapes is very time consuming and requires professional analytical video recorders. Underwater television gives a good indication of the presence of fish within the viewable area of ca. 2 - 4 m^2 but is of limited use for assessment over larger scales. This technique is, therefore, unlikely to be suitable for routine fish population quantification over large spatial scales.

Quality Assurance Measures

High natural variability within fish populations and the problems of observation and capture efficiency mean that standardisation of techniques used to assess a fish population is essential if other sources of variation are to be minimised. Apparent changes in abundance may simply be caused by a change in catchability (Beja, 1995; Costello *et al*., 1995; Sayer *et al*., 1994; Sayer *et al*., 1996) or by movements into or out of the sampling area (Allen *et al*., 1992; Claridge *et al*., 1986; Gibson *et al*., 1993; Ross *et al*., 1987). It is, therefore, difficult to link cause and effect unless extensive background data on the behaviour of the fish species of interest are available or intensive surveys with control sites and sufficient replication can be carried out (Barber *et al*., 1995). The techniques described in this section are well suited to detect inter-annual changes because direct comparisons between years are valid when all other factors associated with sampling are standardised. To reduce experimental error and to make the survey as easy and meaningful as possible the following are recommended:

- Chose well-researched common species and familiarise the survey team with the chosen species' behaviour and ecology.
- Utilise survey methods that are simple, that can be undertaken routinely and where access to the sampling site is easy and reliable.
- Standardise the date and time when the survey is carried out. When annual trends are being investigated carry out the survey as nearly as possible on the same date. More importantly, surveys must be undertaken at the same state of the tide and equivalent point in the diel cycle rather than at a specific time. Dusk, for example, may be at 1600 in winter but 2100 in summer. Diving surveys are best undertaken during neap tides because tidal currents are weaker and their influence on fish behaviour is therefore reduced .
- Practice the survey technique (new staff should be trained on 'dummy' sites). Identification skills can be tested using photographs or preserved specimens and, if estimating size visually, using fish models of known length (Costello *et al*, 1995).
- Use, wherever possible, the same survey teams. This is particularly important when conducting visual surveys and manual searches which involve considerable skill.
- Maintain skill continuity during personnel changes by training all members of the survey team in every aspect of the survey technique.
- If spurious results are suspected be prepared to check the fishing gear (if relevant) and possibly repeat the survey. Repeat surveys on successive days to get an indication of day-to-day variability and incorporate these data in any statistical analysis.
- Expect large variation in fish abundance. Where assessing inter-annual variability a minimum of three years data is required.

Data analysis

Survey work will normally generate data on species, abundance and size. Analysis will depend on the experimental protocol and should be analysed done using standard statistical techniques (Sokal & Rohlf, 1995). Fish populations show high inter-annual variability and this must be considered before drawing conclusions regarding cause and effect. Prior to the survey, and depending on the survey objectives, it is advisable to measure the variability of the factors of interest. Carrying out surveys on successive days gives an indication of the reliability of the survey data and these data can be used to predict the number of surveys that will be required to show significant changes (Chapter 9 in Sokal & Rohlf, 1995). Comparisons of abundance between species should always take into account their differing catchabilities. If the results of the survey show a significant change in fish population this may be caused by natural causes (Collette, 1986; [Henderson, 1989 #54; Rogers, 1996 #40] Where a significant fish population change has been shown and tentatively linked to a cause, it is recommended that additional tests be carried out the nature of which will depend on the proposed cause. Where pollution is suspected as a significant factor the relevant authorities should be contacted (Environment Agency, England and Wales or the Scottish Environment Protection Agency).

Health and Safety

Members of staff employed to undertake diving survey work must be suitably qualified and obey the rules and regulations as stipulated by the Health and Safety Diving Operations at Work Regulations (Dean *et al*., 1997). In addition, individual organisation codes of conduct relating to field work must be adhered to. When employing external diving companies to undertake diving work, your organisation will have considerable responsibilities as the diving contractor. If accessing the diving site from the shore care must be taken to avoid slipping. Suitably qualified boatmen must be employed when accessing the site using a boat and all crew must wear appropriate safety clothing.

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