FISH SAMPLING METHODS IN RIVERS, LAKES, RESERVOIRS ETC...

Key words: Nets, Gear, Habitat, Models

Fig – 4.1

INTRODUCTION

Professional fishermen have usually the greatest experience in catching fish and, as mentioned above, the techniques most often employed for fish sampling are the same as those used in commercial fisheries, but because the purpose is to catch fish according to a programme designed with a certain objective in mind, the use of the gear may differ. Commercial fishermen want to catch as much fish as possible and in the most profitable way, whilst a sampling programme has rather different objectives. Thus, the use of the commercial (as well as sport) fishing gears lies within the scope of this book.

Standardized sampling and data comparison methodologies are used in a wide variety of fields such as medicine, finance, education and agriculture. Standardized sampling methodologies are also extremely important in fisheries and are required to evaluate how a fish population changes over time, or is functioning compared to an "average" in a state or a region. This allows the biologist to identify problem fish populations, discover populations with exceptional angling opportunities, set regulations, or apply various management strategies and monitor their effects.

Effective management of fisheries resources requires knowledge of the fish populations and communities to be managed, and knowledge of the relationships between the populations and communities and their habitats. Information about fish populations and communities is normally acquired through some sort of fish 'sampling'. This sampling usually involves capturing fish, although it may, in some cases, be acquired by simply observing fish in their habitats.

The Sampling Objective

Sampling is undertaken to obtain information about characteristics of fish populations or communities, often in relation to the habitats they occupy. The characteristics that are of interest and the accuracy with which these must be estimated determine the sampling approach that is required.

Many types of fishing gears have been developed worldwide (von Brandt, 1984), although relatively few of these have been adopted for management and research purposes. There has been, and continues to be, research conducted on the efficacy of the sampling methods that have been adopted, as well as on new approaches to sampling. Seven fishing gear types that are commonly used for surveys are reviewed separately below. Gear types include

1. Gill nets
2. Beach seines
3. Hoop, fyke and trap nets
4. Electrofishing
5. Underwater observation
6. Gee or minnow traps
7. Enclosure traps (pop, drop and throw).

TERMINOLOGY DESCRIBING SAMPLING GEAR AND METHODS

Active gear, Passive gear and Point or Quadrant sampling

Fishing gear is often referred to as being either ***active*** or ***passive***.

Active gear is moved in order to capture fish. An example of active gear is the beach seine, which is pulled through the water and encircles fish in its path. Typically, active gear is used to sample fish over a relatively large area during a short period of time.Eg: Pop Net, Drop Net, Electro Fishing, Grid/Drop Net, Throw Trap, Hoop Net, Fyke Net, Trap net.

Passive gear is stationary; fish swim into it. Gill nets are an example of passive gear. Passive gear is used to sample fish at a specific location over a longer period of time.Eg: Gill Net, Pond Net, Block Net, Flume Net, Minnow Trap,

A third approach, referred to as **point sampling** or **quadrant sampling**, samples fish within a small area at a single point in time.

Catchability, Efficiency, Selectivity and Catch-Per-Unit-Effort

There are several key terms that are used to describe the ability of fish sampling gears and methods to capture or observe fish and the susceptibility of fish to various gears and methods.

Catchability is defined as the proportion of the fish that are available to be captured that is caught by a defined unit of fishing effort (Ricker, 1975). The catchability of fish is equal to the *efficiency* of the fishing gear. To clarify, if a single pass through a section of stream with an electrofisher is defined as a unit of effort and half of the brook trout in the section of stream are removed by a pass, then both the catchability of brook trout and the efficiency of the electrofishing are 0.5 or 50%. Furthermore, assuming equal catchability among individuals, the probability that any individual will be captured by a defined unit of fishing effort is also equal to the catchability which, in the case of the above example, is 0.5.

The number of fish captured by a particular gear with a particular amount of effort is termed **catch-per-unit-effort** (CPUE). Efficiency varies among gears, among habitats, among species, and even among sizes of the same species. Gears for which efficiency is highly variable among species or sizes of fish are termed **selective**. Gears that capture a wide range of species and sizes equally are referred to as **non-selective**. In practice virtually all gears/methods vary to some degree in efficiency among species and sizes of fish.

The number of fish available for capture must be known in order to calculate catchability or gear efficiency. Some studies estimate catchability by releasing a known number of marked fish into the sampling area prior to sampling. If the assumptions are made that catchability is equal for marked and unmarked individuals and that all of the marked individuals are available for capture, then catchability is equal to the proportion of the marked fish that are captured. Other studies employ some means of collecting the remaining fish following the sampling (i.e. poisoning or draining the area). Still others estimate abundance using removal or mark-recapture methods, that use the rate at which the catches decline, or that the proportion of unmarked fish in the catches decline, to estimate the size of the population.

FACTORS TO CONSIDER WHEN DETERMINING WHAT FISH SAMPLING GEARS AND METHODS TO USE

Several factors must be taken into consideration when selecting a method to assess fish communities or populations. Key among these are:

- The question(s) that the investigators wish to answer,
- The habitats that are being investigated,
- The fish species that are being investigated, and
- The time of year when investigations will take place.

It is necessary to understand the capabilities and limitations of various gears and methods in order to determine those that will enable investigators to best answer the questions being posed. In practice, the types of gear available and the amount of time and staff available often play a major role in gear/method selection. In these instances, knowledge of the capabilities and limitations of various gears and methods will allow investigators to recognize the questions that can, or cannot, be answered with the resources available.

Presence/Absence and Species Richness

The simplest question that can be posed is “Are there any fish present?” It often is the first characteristic that investigators need to determine for small waterbodies or streams about which little or nothing is known. Initially, at least, abundance or densities are not of concern, although these may become of interest later. The presence of fish can often be confirmed simply by looking for them, especially in habitats where fish are abundant and visibility is good.

If the question is "Are fish present?" and fish are not readily visible, then methods that are effective at capturing a wide range of species in the type or types of habitats that are present should be utilized. It is important that all habitats be sampled and if the habitat characteristics vary widely it may be necessary to use more than one type of gear. Small fishes are usually more abundant than large fishes and within a species small individuals are usually more abundant that large individuals, so a gear that is effective for small fish are usually preferred. It is important to remember that, unlike presence, **absence can never be proven**. All that can be achieved is to demonstrate that there is a high probability that fish are not present.
Sometimes investigators wish to determine what species or how many species are present (species richness), but require no estimates of abundance. The gear selection criteria are similar to those for determining if any fish are present, bearing in mind, once again, that it is important to sample all of the habitats that are present.

Investigators may wish to determine whether or not a particular species, or even a particular size/age class of a particular species, is present. In those cases it is often desirable to use a highly selective gear that has a high efficiency for the particular target species/size.

Relative Abundance, Absolute Abundance and Density

Relative abundance is the ratio of abundance between two or more locations or species or size classes. If catchability is equal between the entities that are being compared, then relative abundance can be calculated from catch-per-unit-effort, without knowing what the catchability is. If catchability differs due to gear differences, habitat differences, or species differences, then this must be taken into account.

Absolute abundance is the number of fish present in a specific area.

Density is the number of fish present in a unit of area or volume. Knowledge of catchability is necessary to calculate absolute abundance and density. There are three general techniques that are commonly used to estimate catchability:

- Mark-recapture methods,
- Depletion methods, and
- Known catchability, or calibrated methods.

In **mark-recapture methods**, a known number of individuals are marked in some way and released into the population at large. (Population is defined here as the fish of a particular species occupying the area of interest, not in the genetic sense.) The population is then sampled and its size is estimated from the ratio of marked to unmarked individuals.

Depletion methods observe the rate at which catches decline with successive sampling. This provides an estimate of catchability that can be used to estimate the size of the population.

Calibrated methods, based on detailed knowledge of gear efficiency/catchability, use a pre-determined formula to estimate abundance from the catch that results from a unit of sampling effort.

There are assumptions with respect to catchability (among other things) for each of the methods of estimating absolute abundance or density. Mark-recapture methods assume equal catchability of marked and unmarked fish.

Most depletion methods assume equal catchability between successive samplings, although if sufficient sampling runs are completed some methods can estimate catchability for each run from the catch data.

Calibrated methods assume that catchability is the same as during the calibration studies. These assumptions are critical to the accuracy of the estimates. There is a large volume of literature dealing with methods of estimating abundance that should be consulted by anyone that needs to have a thorough understanding of these issues.

GEAR REVIEWS

1. Gill Nets

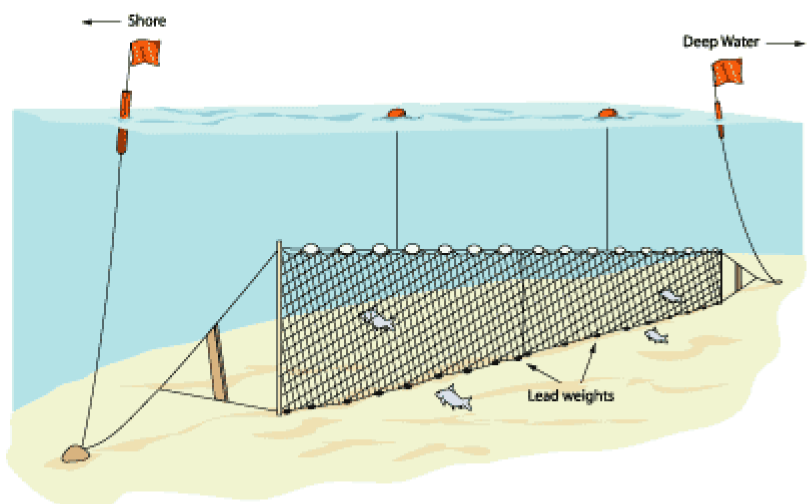

Fig – 4.2

- ***Description and method of use***
  Gill nets consist of mesh with square openings fastened to a positively buoyant line at the top, often referred to as the float line, and a negatively buoyant line at the bottom, often referred to as the lead line because lead has traditionally been used to weight this line. Gill nets are typically stretched between two fixed points (although drift nets are used in marine fisheries) (Fig.1). They are set by attaching one end to an immobile object such as an anchor or a tree along the shoreline and then moving away from that point while paying out the net. Once the other end it reached, it too is attached to an immobile object such as an anchor. The net is left in place and fish are captured when they swim into it. Gill nets are most often set with the lead line resting on the bottom, the float line floating above it, and the mesh stretched between the two. By adjusting the relative buoyancy of the float and lead lines, however, it is also possible to set gill nets that float at the surface and to suspend them at various depths. Gill nets can also be set vertically, a technique

that is sometimes used to assess the depth distributions of fish. If boating conditions are favourable, gill nets can easily be set and lifted by two people from a small boat (Fig. 2) Fish are caught in gill nets when they become wedged in the openings in the mesh or become entangled in it. Consequently, the size of the openings, commonly referred to as mesh size, is a critical parameter affecting efficiency. Mesh size is usually measured and described as ***stretched mesh***, which is equal to the sum of the lengths of two sides (the distance between two opposing corners of a square when it is stretched into a straight line). Mesh size can also be described by the length of one side of the square. This is referred to as ***bar mesh***. Thus, for a given square, the stretched mesh size is twice the bar mesh size. Most individual gill nets contain only one mesh size. Often several nets are joined together into what is referred to as a ***gang***. Gangs can contain nets of different mesh sizes and often resource agencies use specific combinations of mesh sizes for index or inventory work. There are also gill nets designed specifically for scientific purposes that contain a range of mesh sizes in a single net. Gill nets are also described in terms of their length, the distance or the number of mesh openings between the float and lead lines, and the material that the mesh is made of. Most gill nets today are made of monofilament nylon, but older nets were made of cotton and multi-filament nylon. An example of a net description would be *a 100 metre long by 40 mesh deep, 10 cm stretched mesh monofilament gill net*.

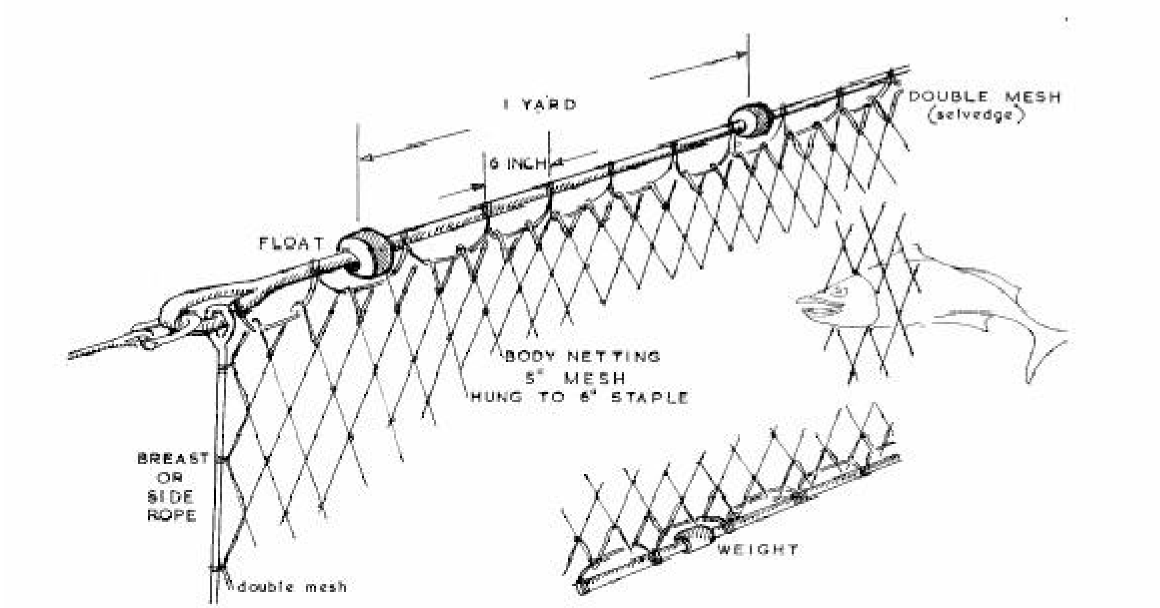

Fig -4.3

- ***Habitat considerations***

  Gill nets can be set wherever there is sufficient unobstructed depth for the lead and float lines to fully separate. Emergent and floating vegetation, and brush, trees and other obstructions near the surface can preclude their use. Gill nets tangle on any rough object, so retrieving them can be difficult and result in damage to the nets in habitats where there is a lot of wood or other debris, as is often the case in reservoirs where forests have been flooded or in areas where logs have been stored.

Gill nets cannot be set perpendicular to strong currents, but may be set parallel to them. Even in relatively gentle currents, however, debris can accumulate in gill nets, decreasing their fishing efficiency and increasing their water resistance. In rivers, the accumulation of fallen leaves is often a problem in autumn. Gill nets can be set over any substrate, although efficiency is probably reduced, especially for benthic species, when the substrate is very uneven (i.e., boulders). Visibility plays a role in catch efficiency, so light and turbidity can affect catch (Berst, 1961; Hansson and Rudstam, 1995), as can net colour (Jester, 1973, 1977). Efficiency can decrease with time set if the nets become fouled with algae or debris (Hamley, 1975).

Fig - 4.4

- ***Selectivity/Efficiency***

  Gill nets are highly selective and there is a large body of literature addressing the relationships between mesh size and fish size. There are two aspects to the selectivity of gill nets. First, like all passive gear, their efficiency is directly related to the probability that a fish will encounter them. Gill nets are not effective for catching sedentary fishes. Catchability increases as movement of the target species increases. In addition to behavioural differences (sedentary versus roaming), distance traveled can be influenced by swimming ability, which, for a given species, is often related to size. Consequently, some researchers have used fish size to estimate the relative probability that fish of various sizes will encounter the nets (Rudstam et al. 1984; Spangler and Collins, 1992).

Seasonal differences in fish movement can be very important in determining the likelihood of encounter. Changes in movement in response to weather, or any other stimulus, can influence encounter probability. There is a high encounter probability for gear sets along spawning migration routes during spawning season.

The second aspect of catchability in gillnets is the probability that a fish that does encounter the net will be retained. Gill nets capture fish by three principal methods, **wedging, gilling and tangling** (Baranov, 1914). **Wedged fish** attempt to swim through an opening in the mesh and are eventually prevented from swimming further by the mesh that encircles their body. **Gilled fish** are not necessarily tightly held by the mesh around them, but are prevented from backing out of the opening because the strands lodge under their opercula. **Tangled fish** are held by mesh that is tangled on various parts of their bodies such as fin spines, pre-opercles, maxillaries, and teeth.

Gill nets can be highly selective with respect to fish size, particularly if wedging is the principal means of retention. McCombie and Berst (1969) examined the relationship between mesh size and fish girth. The fact that few fish are captured whose maximum girth is less than the mesh perimeter is not surprising, as we would expect that they could swim through the mesh. The fact that the maximum girth is often larger than the mesh perimeter reflects a number of factors: the fish is not always caught at its point of maximum girth, the mesh can compress the body of the fish as it struggles, and nylon thread is somewhat elastic.

The relationship between fish girth and retention means that changes in girth due to gravidity or other factors can influence the length of fish that are captured by a given mesh size. Several authors have investigated the difference in size and selectivity between fish that are wedged and fish that are tangled. Not surprisingly, fish caught by tangling tend to have a wider range of relative girths than those caught by wedging (McCombie and Berst, 1969; Hamley, 1975; Hovgård, 1996; Hansen et al. 1997).

The third aspect affecting gill net selectivity, retention, is influenced by the material that the mesh is made of. In the 1930s, cotton thread, which was softer and more elastic, replaced linen thread in the construction of net twine (Pycha, 1962). In the late 1940s and early 1950s, net manufacturers switched from cotton twine to multifilament nylon twine (Pycha, 1962; Hamley, 1975). Monofilament nylon is the predominant mesh material used today. Understanding the effect of changing mesh construction on catchability has been important for interpreting long-term catch/effort data series that are based on more than one mesh type. Consequently this topic has received considerable attention. Pycha (1962) found that multifilament nylon nets were 2.25 – 2.8 times as efficient as cotton nets in capturing lake trout. Henderson and Nepszy (1992) reported that catches were larger in monofilament gill nets than in multifilament gill nets for 16 of the 23 species caught, with a maximum efficiency increase of approximately 3 fold.

- ***Quantification of Effort***

Gill net effort is usually calculated by multiplying the length of net by the length of time it was set. Catches are then standardized to units such as number of fish captured per metre-hour, or per 100 metre-days. There are some complicating factors with respect to length of time set. Catches can be expected to decline due to localized depletion of fish unless fish are very abundant or mobile, or both. Also, the efficiency of gill nets can decrease as fish accumulate in the net, a phenomenon known as gear saturation. The rate of saturation depends on the rate at which fish are caught, which in turn is typically related to fish abundance, so that catchability can be inversely related to density (Hansen et al. 1998; Borgstrøm, 1992; Henderson and Nepsy, 1992). Obviously, damage to (holes in) nets decreases their efficiency.

The part of the day during which nets are set can also influence catches. Minns and Hurley (1988) observed both increasing and decreasing catch-per-unit-effort with increasing set time in gill nets set in the late afternoon and lifted 1.5 to 12 hours later. Species richness increased with length of time set. They hypothesized that time-of-day influences on activity contributed to differences in catch rates and species richness, as the sets variously included daylight, dusk, overnight and dawn periods. Often gill nets are set in the late afternoon and lifted in the morning. This is referred to as an overnight set, and because an overnight set fishes during dawn and dusk and overnight, as well as during a portion of daylight hours, it should sample fishes that are active during any of these periods. Dawn and dusk are probably important periods as many species demonstrate crepuscular activity. Minns and Hurley (1988) also examined the influence of the length of net on catch-per- unit-effort.

Clearly, it is important to standardize gear and methods as much as possible if gill net catches are to be used as an index of abundance. Even with standardization, gill net catches are notoriously variable and large numbers of sets are likely to be required if the goal is to demonstrate statistically significant differences between locations or years.

- ***Fish Injury/survival***

Gill nets are not usually thought of as a gear to be used when investigators wish to keep fish alive, except when fine mesh gill net sets are set for short periods on spawning shoals to catch lake trout (*Salvelinus namaycush*) by their teeth. However, mortality appears to vary widely depending on the species and ambient conditions (C. Portt, personal observation). Fish that become wedged or tangled in a manner that obstructs the opercula or the mouth so that they are prevented from ventilating usually die. However, fish that are able to ventilate after they are caught often survive capture. The likelihood that fish will survive capture also appears to increase as water temperature decreases, which may be related to dissolved oxygen concentrations. Physical injury during retention and removal can also occur, including injury to the gills and the integument. We are aware of no post-capture survival studies.

2. Beach Seines

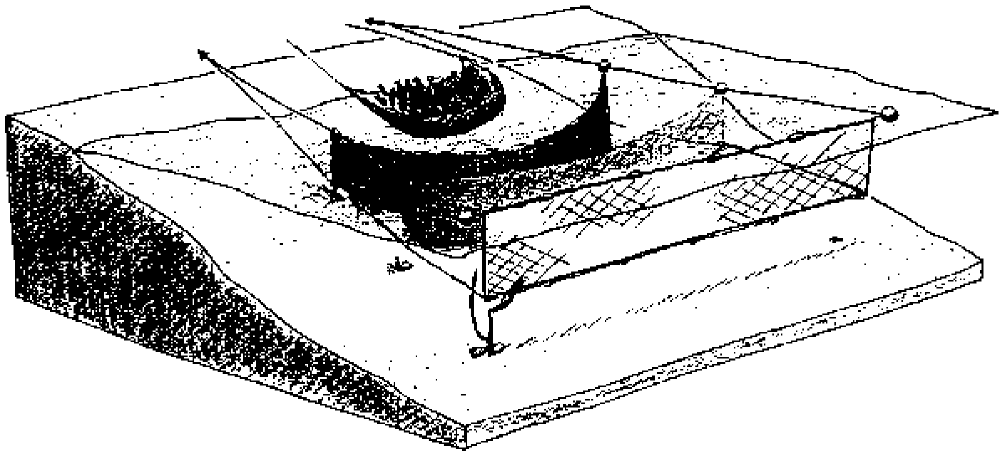

Fig – 4.5

- ***Description and method of use***

Beach seines consist of a length of fine mesh strung between a positively buoyant line (the float line) and a negatively buoyant line (the lead line) that is pulled through the water to encircle fish. Often a *bag* of the same mesh that extends behind the plane of the net is built into the midpoint, so that fish move into the bag as the net is pulled forward. Seines with a bag are referred to as *bag seines*. Seines can be built using a variety of mesh types and sizes, but the typical beach seines used in research are made of a woven (also called knotless) nylon mesh with 6 mm (1/4 inch) openings. The weight or strength of meshes varies and can have a significant effect on durability. A description of a seine normally includes its length, depth, the dimensions of the bag (if present), and the mesh size and material. Sometimes the amount of floatation and weight on the lead and float lines is also provided.

Beach seines can be used by wading or deployed from a boat. A single deployment and retrieval of a beach seine is usually referred to as a *haul*. In the simplest technique two people, one on each end of the seine, walk in parallel through the water with the seine forming a U-shape behind them. Seines are also often deployed by keeping one end fixed and deploying the net in a semi-circle, either by wading or from a boat. To prevent fish from escaping, it is critical that the lead line remain on the bottom. Sometimes a pole is attached to each end of the seine and used as a handle. The lead line is attached to the bottom of the pole, which is kept on or at the substrate. An alternate method is to tie a loop in each end of the lead line and place it over the operators' feet that are closest to the net, and to hold the float line in the hand closest to the net. The bottom line is pulled forward by the operators leg (Fig. 4.3).

The beach seine haul is culminated by bringing the two ends of the seine together and pulling the net forward so that the encircled fish end up either in the bag or, if no bag is present, in the mesh that is between the lead and float lines. This is achieved by bringing the two ends of the lead line together and retrieving the lead line, slightly in advance of the float line, forcing fish back into the bag or back of the net. This is normally done at the shore (hence beach seine). It is possible to retrieve a seine into a boat, but the efficiency is lower (Bayley and Herndeen, 2000).

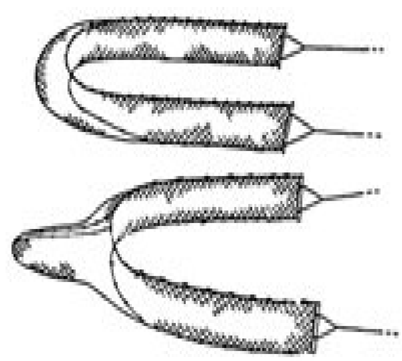

Fig.4.6

- ***Habitat considerations***

Beach seines are normally only used in water depths that are less than one half or two thirds the depth of the seine, so that the lead line remains on the bottom and the float line remains at the surface as the net is pulled forward. Deployment and retrieval is easiest over smooth bottoms with no debris or obstructions. Seine nets can become snagged on rocks, logs, etc., and often can only be freed by pulling the net backward, off the object. Where debris is present it is useful to have a third person follow the net who can free it when it becomes snagged. Often the lead line is raised off the bottom when the net is snagged, and this, in combination with the unsnagging process, can allow fish to escape. Pierce et al. (1990) found that capture efficiency decreased with the number of snags that were encountered. Rough bottoms will also increase the likelihood that fish can escape beneath the lead line. Parsley et al. (1989) found that, generally, efficiency was higher over smooth substrates than rough substrates, although the difference was often not statistically significant.

Dense macrophytes prevent the lead line from reaching the bottom. Macrophytes or other debris caught in a seine can cause the seine to roll up upon itself, so that the lead line is raised from the bottom and the outside of the net becomes the leading edge, which reduces capture efficiency (Pierce et al. 1990). In some circumstances, debris can prevent water from flowing through the mesh, creating a current away from the front of the net and making it difficult or impossible to pull the net forward. Accumulations of macrophytes or other objects can become so heavy that weight alone makes it impossible to pull the net forward. However, Pierce et al. (1990) found that when corrected for rolling, catchability increased with increasing macrophyte density. They attributed this to fish being less agitated and less likely to flee during capture where macrophytes were present. High turbidity may have a similar effect.

Fine mesh seine nets cannot be used in strong currents because the resistance that they create makes it impossible to pull them. Even if the net can be pulled forward, the force of the current can raise the lead line from the bottom, much like accumulated debris can in still water. Larger mesh seines built for use in strong current are often equipped with very heavy lead lines or weighted with chain along the bottom to prevent this from occurring. Seasonal differences in efficiency were reported by Allen et al. (1992). They suggested that these may be due to seasonal differences in fish size, temperature influences on swimming ability, or seasonal differences in turbidity.

- ***Selectivity/Efficiency***

Like all mesh-based equipment, the minimum size of fish retained is determined by the size of the openings in the mesh. Some fish that could pass through the openings are often retained in small mesh seines, apparently because they are not aligned perpendicular to the openings. Tangling is not prevalent, but can occur.

Avoidance is a major factor affecting selectivity of seines and it is influenced by swimming ability and behaviour. The efficiency of seining can be broken down into encircling efficiency and retention efficiency. For individuals that attempt to avoid being encircled by fleeing, catchability generally decreases as swimming speed increases (Bayley and Herendeen, 2000). This results in catchability decreasing with fish size.

Several researchers have documented that benthic fishes are less likely to be captured than mid-water species (Pierce et al. 1990; Lyons, 1986; Parsley, 1989), presumably because they escape beneath the lead line. Bailey and Herendeen (2000) found that the catchability was highest for surface and mid-water schooling species, intermediate for territorial and cover-seeking species and lowest for demersal and eel-like species. Pierce et al. (1990) found that catchability increased with size for benthic species but not for midwater species. They attributed this to smaller benthic individuals being more likely to pass beneath the net than larger individuals.

Pierce et al. (2001) reported that seining at night resulted in significantly higher species richness estimates than seining during the day, but total density did not differ significantly between day and night samples. It has been the experience of the senior author that in relatively clear water with adjacent deep habitats, species composition can differ markedly between night and day seine catches. Allen et al. (1992) found that maximum species richness in estuarine habitats was reached after between 6 and 12 seine hauls depending on year and season. Dewey et al. (1989) noted that species richness in seine catches was much higher than in pop net catches. This can be attributed in part to the larger area sampled by seining, and possibly also to the finer mesh of the seine.

- ***Quantification of Effort***

Effort is usually expressed in terms of catch per haul if all hauls are similar, catch per distance hauled (e.g. catch per m) or catch per unit area seined (e,g, catch per m2). Usually in any given study the same seine or identical seines are used for all hauls so that gear characteristics, such as the presence of a bag or the length of the seine, do not contribute to variability. There is rarely an attempt to correct for snags, debris or other factors that can affect the efficiency of individual seine hauls. Such corrections would be difficult since the affect of such events on the probability of fish escaping would vary widely. In practice, investigators will often abort hauls when catchability is compromised, or will complete them but exclude them from analyses that assume constant catchability among hauls.

- ***Fish Injury/survival***

Seined fish are subject to the stress of capture but are usually not injured. Exceptions are small individuals that are wedged in the mesh and fragile species, including those that lose scales easily (e.g. some *Notropis* spp). Additional stress and mortality can occur while the catch is being processed. Processing time increases markedly when fish must be sorted from algae, macrophytes or organic debris. Leaving the bag of the seine in the water or placing the catch in a water-filled container during processing reduces stress.

3. Hoop Nets, Fyke Nets and Trap Nets

- ***Description and method of use***

These three gears trap fish inside mesh enclosures. The fish enter through constrictions, referred to as tunnels or funnels or throats.

In **hoop nets**, the mesh is supported by rigid frames or hoops. These frames were historically made of wood but today are usually made of aluminum tubing. The hoops may be round, D-shaped or square. The tunnels are cones of mesh that are attached to a pair of hoops, so that when the net is set and the hoops are separated the narrow end of the tunnel points to the rear. Usually there are two tunnels per net. The hoops can be held apart by spreader bars that are attached to the hoops, or by stretching the net between fixed points. (Fig.4)

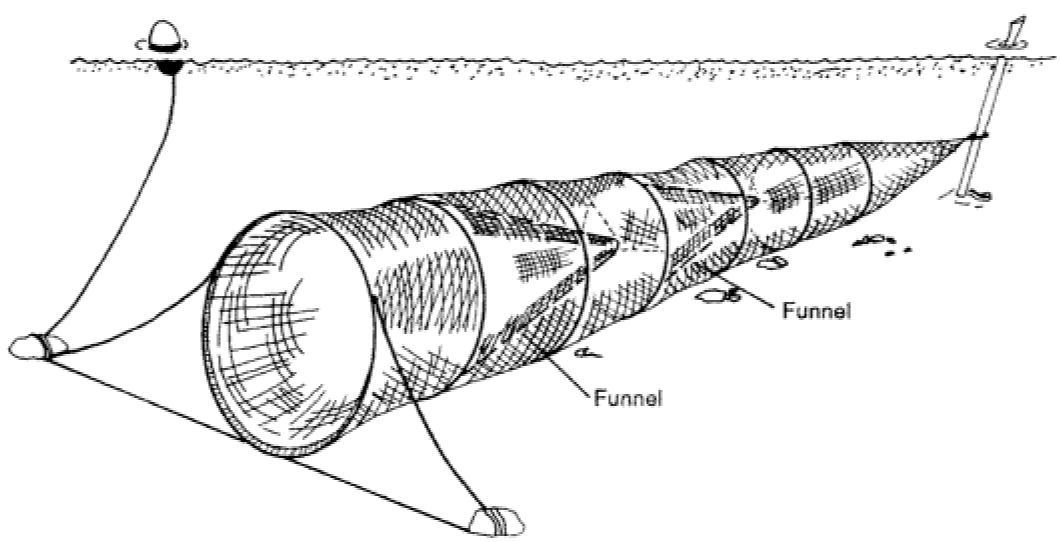

Fig – 4.7

A **fyke net** is simply a hoop net to which wings and a lead (or leader) are attached. (Fig.5) Wings are short lengths of mesh with float and lead lines that are attached to the lateral margins of the first hoop and extended at ∀45º to the longitudinal plane of the trap. A lead is a length of mesh that is attached to float and lead lines and is fastened to the midpoint of the first hoop and extended forward parallel to the longitudinal plane of the trap.

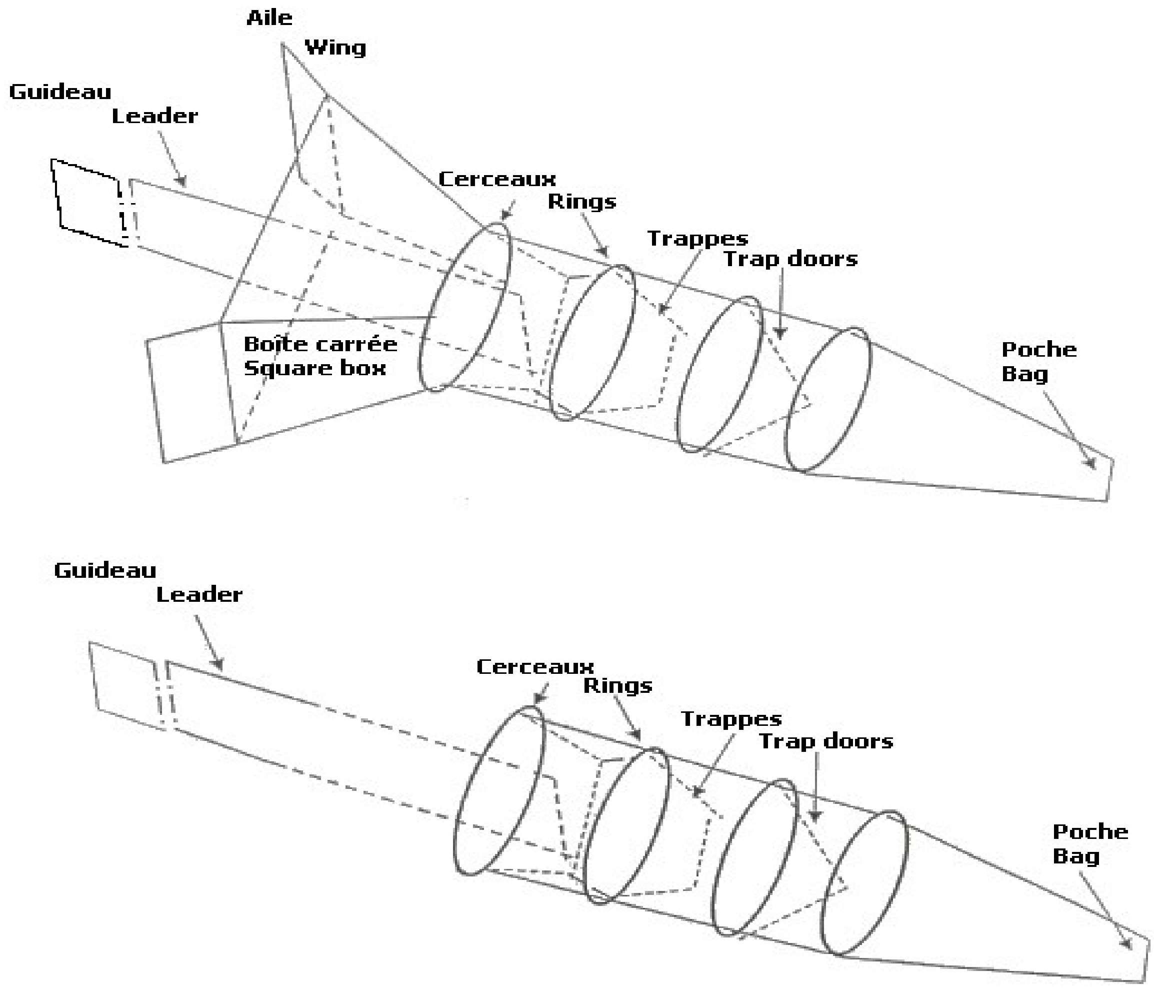

Fig – 4.8

A **trap net** is similar to a fyke net, in that it has wings and a lead attached and a tunnel or tunnels through which fish enter, but it is does not have rigid frames. It relies instead on floats, weights and attachment to anchors or other fixed points to maintain the shape of the enclosure (Fig. 6). Trap nets have a seam in the top of the heart, the mesh box that contains the trapped fish, that is laced or zipped closed while the net is fishing but can be opened to provide access so that fish can be removed, usually with a dip net. Variations on the basic design of these nets have been developed for specific applications, including a floating version (Miranda et al. 1996) and versions suspended from cables in fast currents (Tsumura and Hume, 1986).

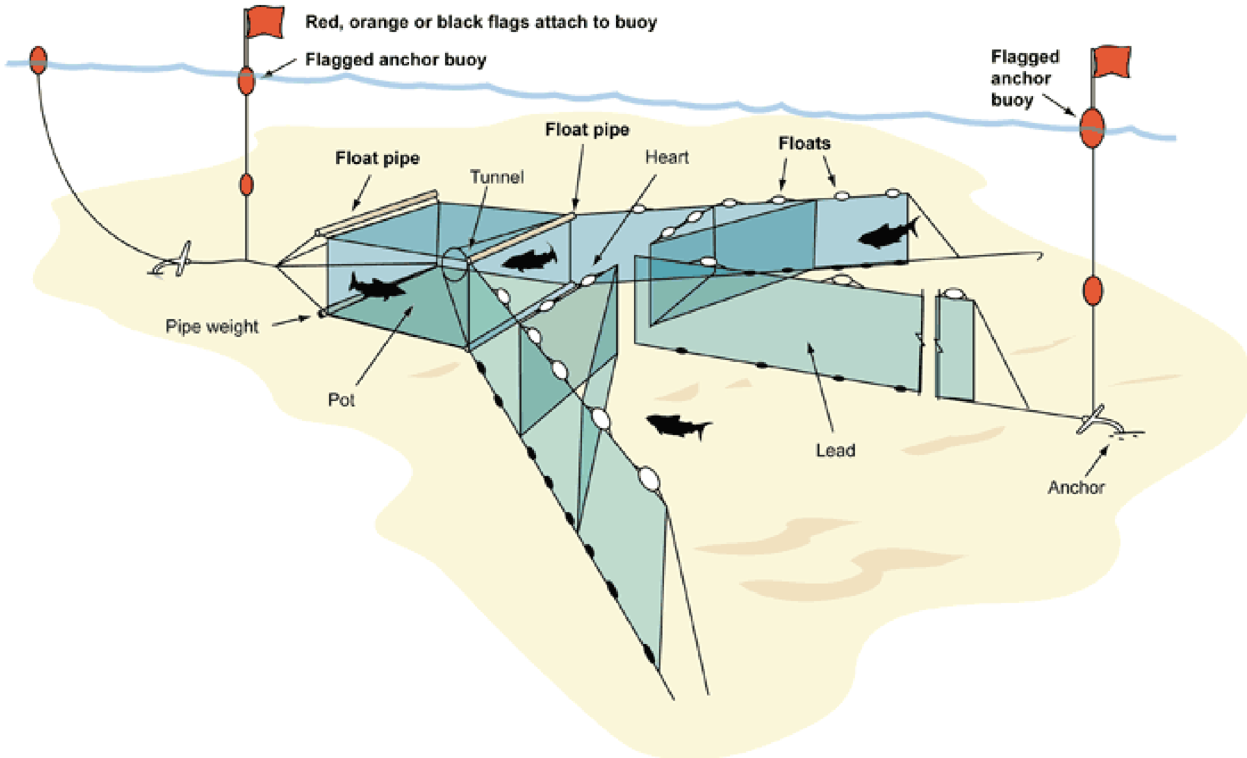

Fig – 4.9

Most hoop nets, trap nets and fyke nets used for research purposes can be set and lifted by two people. Both setting and lifting can be difficult in rough water, and lifting trap nets can be dangerous. Often, the lead is fixed to an object on shore and extended perpendicular to shore, with the trap portion at the offshore end. The nets can also be attached to anchors or to stakes driven into the bottom. If it is to be reset at the same location, a trap net is usually emptied by slackening the rope that is attached to the rear of the net, positioning a boat crosswise beneath this rope so that the rope straddles the boat, and then raising part of the heart out of the water so that the fish are confined to a smaller area. The seam is opened and the fish are removed. Once the fish have been removed the seam is closed and tension is re-applied to the rear rope.

Fyke nets and hoop nets are accessed at the posterior end, where the mesh that extends beyond the last hoop, sometimes referred to as the cod end, is usually closed by a drawstring and secured by a rope that is wrapped around the mesh forward of the drawstring and tied. To lift the net, the rope attached to the rear of the net is slackened. The hoops are then lifted sequentially from the front, forcing fish in the front of the net through the tunnels and into the rear. If the fyke net and its catch are light, the hoops can be raised sequentially by working over the side of the boat. If the net or the catch is too heavy it may be necessary to pass the hoops over the boat or to empty some of the fish before moving fish that are in the forward part of the net to the rear. The fish can be dip-netted through the opening in the rear of the net, or dumped out of this opening if the trap can be lifted out of the water. Hoop nets that use spreader bars are usually lifted completely out of the water and into the boat to remove fish.

Hoop nets are described by the size, shape and number of hoops, the size and material of the mesh that covers the hoops and makes up the tunnels, and the number of tunnels and the size of the openings in them. For **fyke nets**, the length, height and mesh size and material of the wings and lead should also be reported. **Trap nets** are described by mesh size and material, the dimensions of the heart, the number of tunnels, the size of the throats(s) and the wing and lead dimensions and materials. Many agencies have adopted standards for the construction of these nets, so that the term 4-foot trap net, for example, would imply all of the dimensions and characteristics of the gear. **Hoop nets** are often baited in order to entice fish to enter. **Fyke and trap nets** are normally not baited, relying instead on the lead and wings to guide fish into them. These nets can trap a variety of creatures other than fish, including turtles, waterfowl (especially diving ducks) and aquatic mammals such as muskrats, beavers and otters (C. Portt, personal observation). Turtles rarely cause damage to the nets, but waterfowl and mammals often chew holes (sometimes several) in the mesh that allow them and fish to escape and that take time to repair. The probability of catching waterfowl is greatly reduced if the front hoop is completely submerged, so that only birds that dive and enter the net are caught, instead of birds that are swimming on, or flying just above, the surface. The amount of damage caused by mammals is also greatly reduced if the net is completely submerged.

- ***Habitat considerations***

Trap nets can be set in water that is deeper than the height of the net, but they are usually not set in water that is shallower than the height of the net because they rely on floatation to maintain their shape. **Hoop nets and fyke nets** can be set in water that is deeper or shallower than the height of the hoops, as long as the tunnels are submerged. These nets are difficult to set where the bottom is uneven, such as among boulders, and where there is dense vegetation or an abundance of other obstructions such as logs or stumps. In shallow water it is often easier to set these nets by wading than from a boat. Kreuger et al. (1998) reported that, in deeper water, round fyke nets were easier to set than D-shaped fyke nets because they tended to roll into the proper position. It is difficult to set these nets perpendicular to strong currents. Setting perpendicular to even a moderate current is ill-advised if there is a lot of debris moving downstream that can become caught in the mesh and add to the resistance of the set, as the increased force can dislodge and/or damage the gear. **Fyke nets and trap nets** can, however, be set parallel to quite strong currents. The attachment of fyke and trap nets depends upon depth, substrate and current velocities. In deep water or over coarse substrate anchors must nearly always be used. In shallow water over soft substrates the net can often be fixed to posts driven into the substrate. In nearshore areas of lakes or rivers, one or more points of attachment can often be trees or other objects on shore.

- ***Selectivity/Efficiency***

There are three aspects to the selectivity/efficiency of these nets. First, like all passive gear, their efficiency is directly related to the probability that a fish will encounter them. The second aspect is the probability that fish that encounter them will enter them, and the third is that fish that enter them will be retained. The probability of a fish encountering these nets increases with distance traveled, so that the behavioral and seasonal factors relevant to all passive gear come into play. Hamley and Regier (1973) reported that the catchability of walleye in trap nets increased with fish size. Laarman and Ryckman (1982) found that trap net catchability increased with size, although not necessarily in a linear fashion. It is likely that the increase in catchability with size that has been commonly reported is because large fish move farther than small fish in a given period of time, and thus are more likely to encounter the net. Ricker (1975), however, suggested that the greater catchability for larger fish might be due to their tendency to seek cover, which the net could provide.

Most studies of catchability in these gears are based on mark-recapture data, and it is possible that larger fish are less affected by handling and marking. Predation upon small fish by larger fish can also occur in trap and fyke nets, which effectively biases catches.

- ***Quantification of Effort***

Effort is usually expressed in terms of catch per net per length of time set. Net dimensions are normally standardized if comparisons between catches are to be made. Gear saturation can occur when catches are high, such as during spawning migrations, because the net becomes so full that more fish have difficulty entering (C. Portt, personal observation).

The variability in trap net catches is often very high. The result is that large numbers of catches are often required to detect even large changes in abundance (Kreuger et al. 1998; Lester et al. 1996; Hamley and Howley, 1985).

- ***Fish Injury/survival***

Fish captured in hoop, trap and fyke nets are usually not injured, although this is influenced by factors such as water temperature and dissolved oxygen concentrations. It is not unusual for small numbers of fish to be wedged or tangled in the mesh of the net, like they are in gill nets, but the heavy twine used in the mesh of these nets is not very efficient in this regard. There are reports of entire catches being killed by sudden temperature changes when upwelling conditions change in large lakes, or when a seiche exposes captive fish to anoxic hypolimnetic water. Larger fish can, and do, eat small fish inside these nets, thus affecting the apparent catch of small fish and the stomach contents of the larger fish.

3. Electrofishing

- ***Description and method of use***

Electrofishing is the term generally applied to a process that establishes an electric field in the water in order to capture fish. When exposed to the field, most fish become oriented toward the anode and as the density of the electric field increases they swim toward it. In close proximity to the anode, they are immobilized. The actual sequence of responses to the electric field is more complex and varies depending upon the type of current applied (AC, DC, pulsed DC), the initial orientation of the fish with respect to the field and field density.

There are three types of electrofishers:

- Backpack models,
- Towed barge models,
- Boat mounted models, sometimes called a **stunboat**.

Fig – 4.10

All models rely on two electrodes which deliver current into the water to stun fish. The current runs from the anode to the cathode, relating a high-voltage potential. When a fish encounters a large enough potential gradient, it becomes affected by the electricity. Usually pulsed DC current is applied, which causes galvanotaxis in the fish. Galvanotaxis is uncontrolled muscular convulsion that results in the fish swimming toward the anode. At least two people are required for an effective electrofishing crew: one to operate the anode, and the other to catch the stunned fish with a dip net.

Backpack electrofisher generators are either battery or gas powered. They employ a transformer to pulse the current before it is delivered into the water. The anode is located at the end of a long, 2 meter pole and is usually in the form of a ring. The cathode is a long, 3 meter braided steel cable that trails behind the operator. The electrofisher is operated by a deadman's switch on the anode pole. There are a number of safety features built into newer backpack models, such as audible speakers that sound when the unit is operating, tilt-switches that incapacitates the electrofisher if the backpack is tilted more than 45 degrees, and quick-release straps to enable the user to quickly remove the electrofisher in the event of some emergency.

Towed barge electrofishers operate similarly to backpack electrofishers, with the exception that the generator is located on a floating barge instead of on a backpack. Often the barge can be left stationary on the shore and longer cathodes and anodes allow the crew to sample large areas. Barge electrofishers often employ gas-powered generators since a user does not have to carry the extra weight on his or her back.

When boat electrofishing, the boat itself is the cathode, and the anode(s) are generally mounted off the bow. The stunned fish swim toward the anode, where they are caught alive using a dip net.

A relatively new fishing technique is **electrofishing** (electric fishing). Electrofishing is used primarily in freshwater by zoologists as a sampling technique. Typical uses include collecting fish for stream classification surveys such as Index of Biotic Integrity surveys, to capture brood stock for hatcheries, or to collect representative samples from fish populations for the estimation of population size and structure. Most commonly, pulses of direct current (DC) are used to induce capture-prone behavior in fish. For example, with the apparatus correctly tuned as to pulse speed, voltage gradient and current, fish will exhibit galvanotaxis; they turn into the electric field and swim toward the apparatus.

The effectiveness of electrofishing is influenced by a variety of biological, technical, logistical, and environmental factors. The catch is often selectively biased as to fish size and species composition. When using pulsed DC for fishing, the pulse rate and the intensity of the electric field strongly influence the size and nature of the catch. The conductivity of the water, which is determined by the concentration in the water of charge carriers (ions), influences the shape and extent of the electric field in the water and thus affects the field's ability to induce capture-prone behavior in the fish.

Electrofishing systems can be powered by one or more batteries or by a generator and come in various sizes, from those that are mounted to a backpack to those mounted in large boats. Systems are typically equipped with various safety devices including one or more dead man’s switches and a tilt switch designed to disable the device if the unit is tipped beyond a certain limit by, for example, the operator becoming incapacitated or falling into the water. Rubber gloves and rubber boots must be worn to isolate the operator and to prevent electrocution.

- ***Quantification of Effort***

The make and model of the electrofishing unit, the electrical output settings, and the size of the dip net mesh should be provided in any description of electrofishing. Electrofishing effort can be expressed in terms of the length of stream or shoreline fished, the area fished, the length of time spent fishing, or the amount of time that a current is actually being applied to the water (electroseconds). In some situations, and with some gears, current is continuously applied, so that time spent fishing and electroseconds are the same.

The amount of time required to electrofish a reach of stream or shoreline increases as fish abundance increases because of the time required to net fish. Often the operator will leave the anode of backpack or shore units stationary with the power on, or cycling on and off, in order to ‘hold’ fish until they can be netted, so that electro-seconds also increase with fish abundance. Similarly, it is common to reduce boat speed if fish are abundant.

Consequently, time is not a satisfactory measure of effort for calculating CPUE using these methods. Usually, a single pass through the subject area is considered to be one unit of effort. The consistency of effort can be increased if certain conventions are adopted, including being sure to electrofish all of the available habitat, attempting to capture all fish that are observed (but not going back and re-shocking areas in order to do so), and standardizing power output to the extent possible.

- ***Fish Injury/survival***

The effects of electrofishing on fish health have been the subject of a considerable amount of research. Survival rates, injury rates, growth rates, physiological effects and gamete viability have all been examined. Much of this research has examined the relationship between electrical characteristics (type of current and wave form) and mortality and injury rates, and most has been conducted on salmonids. Mortality rates are generally low for DC electrofishing.

The most commonly reported serious injuries to fish from electrofishing are spinal dislocations and, in extreme cases, vertebral fractures that are apparently caused by strong muscular contractions. Internal hemorrhaging has also been reported and skin discolourations, referred to as branding, also occurs. A large proportion of spinal injuries evident on X-rays are not evident from external examination (Kocovsky et al. 1997). In several studies, fish have been X-rayed to determine the rate of injury. Both the rate and severity of injury increased with fish size.

Short-term physiological effects induced by pulsed DC current in the absence of injury include lactacidosis and disturbance of the inter-renal stress response (Mitton and MacDonald, 1994). Field studies examining the effect of electrofishing on growth and condition of salmonids have reported mixed results.

5. Underwater Observation

- ***Description and method of use***

Underwater observations can be made by snorkeling, by using SCUBA, or with underwater video cameras. The observer must be able to identify the fish observed without having them in hand. Diver/snorkeler observations can be recorded on underwater writing tablets and video can be recorded. Fish can be counted across the entire width of streams, using single or multiple observers depending on stream width and visibility. Observations can also be made along transects of known length and width (Pratt, 2004; Buckland et al. 1993). Schill and Griffith (1984) describe the use of PVC pipe to maintain multiple observers in the same relative position along a transect. An alternate to transects is to count fish within a specified radius from a given point (Graham, 1992), which is effectively point sampling.

Fish length can be estimated visually, or by aligning the snout and tail with adjacent objects and measuring that distance (Cunjak and Power, 1986). Objects are magnified by

20%-30% underwater, and some investigators have applied a correction factor to visual estimates of length to compensate for this (e.g., Mullner et al. 1998). There are often significant differences between length-frequency distributions based on visual observations and those based on measurement of electrofished individuals (Roni and Fayram, 2000; Mullner et al. 1998).

Because the fish are actually observed in their habitat, rather than removed from it, direct observation can be used to determine specific habitat relationships that are difficult or impossible to determine using any other means (Cunjak and Power, 1986). The effort required to count fish in a section is much lower, in terms of person-hours, than is required to conduct removal-method population estimates by electrofishing (Hankin and Reeves, 1988; Cunjak et al. 1988).

- ***Habitat considerations***

Snorkeling or SCUBA can be used in a wide variety of situations, but is not possible in extremely small or shallow streams, or in extremely high velocity habitats. Accurate counts are difficult or impossible in very shallow habitats (Cunjak et al. 1988; Hillman et al. 1992). Video cameras are most effective where there are no obstructions to camera manipulation.

Visibility and cover are both considerations in direct observations. One would expect that dense cover, such as weed beds and cobble or boulders would reduce the proportion of fish present that are observed.

Comparisons of day and night counts have yielded inconsistent results. Thurow and Schill (1996) reported no significant differences between them, while Roni and Fayram (2000) reported night counts to be much higher. Undoubtedly the differences between night and day counts will vary among habitats, among species and, in some cases, between seasons.

- ***Selectivity/Efficiency***

Because observational methods do not allow any way of marking or removing fish, efficiency has usually been estimated by comparing counts to electrofishing depletion estimates. Some authors have reported highly significant regressions between counts and electrofishing estimates for salmonid species (Hillman et al. 1992; Mullner et al. 1998; Roni and Fayram, 2000; Hankin and Reeves, 1988), while other authors have reported counts to vary widely in efficiency (e.g., Cunjak et al. 1988). In this approach, and other methods that correlate on estimation method with another, it is important to remember that there is error associated with both estimates and that the regression predicts the mean of the dependent variable (Bakke, 2000).

Any factor that affects visibility can affect observation efficiency. Thus, count efficiencies are often lower for smaller fish (Cunjak et al. 1988; Thurow and Schill, 1996). Efficiency is expected to be lower for sedentary and cryptic species. Differences in preferred habitats, which differ in ease of observation (e.g. cover versus no cover, shallow versus deep, riffles versus pools), can cause efficiency to vary among species (Cunjak et al. 1988; Hankin and Reeves, 1988; Hillman et al. 1992; Roni and Fayram, 2000).

Some studies have shown count efficiency to be lower when fish densities are high (Cunjak et al. 1988; Roni and Fayram, 2000). This is likely to be more of a concern if multiple species are being examined, and may be particularly problematic for schooling species (Hillman et al. 1992).

- ***Quantification of Effort***

Effort is usually expressed in terms of fish observed per length or area of stream or shoreline or per transect of known length and width. The latter can then be expressed ascounts per unit area if desired.

- ***Fish Injury/survival***

One of the advantages of direct observation is that it is benign.

4. Gee or Minnow Traps

- ***Description and method of use***

Gee traps or minnow traps are widely used by anglers to collect small fish for bait, and are readily available at sporting goods stores. They are typically circular, slightly tapered toward the ends, and made of metal or, more recently, plastic with inward facing funnels at each end. The traps split into two halves so that fish can be removed or bait added, and they can be nested for storage. Although the term ‘standard’ minnow trap is sometimes used, these traps are commercially available in a variety of materials, dimensions, mesh sizes, and colours.

Consequently these aspects of the traps, including the dimensions of the funnel openings, should be described. Three custom-designed minnow traps, constructed of lengths of 7.5 cm diameter pipe with a funnel at one or both ends were described by Culp and Glozier (1989). Minnow traps are usually deployed on the bottom without anchors, and attached with rope to a fixed object or a buoy so that they can be retrieved. Culp and Glozier (1989) found that baiting traps with commercial trout pellets in cloth bags significantly increased catch. Minnow traps are small and light and are easily deployed and retrieved by one person. (Fig.7)

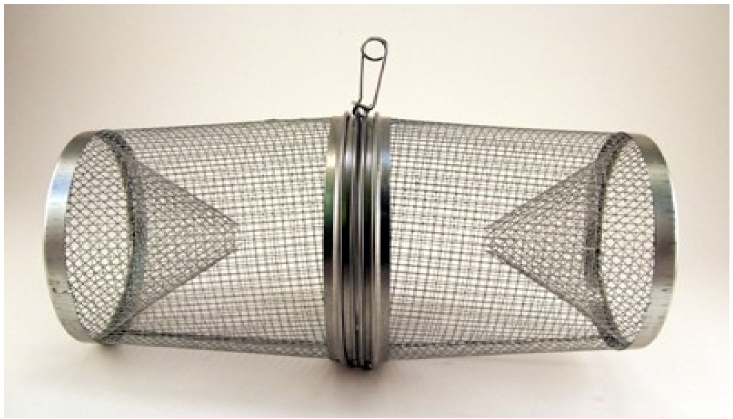

Fig – 4.11

- ***Habitat considerations***

Minnow traps are typically used in low velocity stream or littoral habitats. Water depth must be sufficient to submerge the trap entrances. The traps described by Culp and Glozier (1989) were anchored in riffle habitats, but anchoring commercially available minnow traps in fast currents can be problematic, as the trap shape can be distorted when a significant amount of force is applied, creating openings along the joint between the two halves of the trap. Because they are small, minnow traps can be deployed amongst aquatic vegetation or woody debris.Although no published reports were found, the seasonal differences in catches reported for most gears would be expected to also apply to minnow traps.

- ***Selectivity/Efficiency***

The maximum size of fish that minnow traps can catch is determined by the size of the funnel openings, which are usually quite small, and the minimum size retained is determined by the size of the mesh.

Minnow trap catches of the pairs of species were uncorrelated, as were those of plastic traps. This contrasts with trap net and gill net catches which were correlated. The correlation of catches in some gears and not in others may indicate that different factors determined catch for different species. For example, differences in size distributions among species and in size-efficiency among gears, or behavioural differences in response to bait, could contribute to a lack of correlation. The relative efficiency of gears in determining species richness depends upon the habitats to be sampled.

Jackson and Harvey (1997) found that in a lake where the diversity of small species was high, baited minnow traps captured more species than trap nets or gill nets, but fewer than plastic traps. They noted the advantages of a small gear that can be set in dense cover for capturing species that inhabit these areas.

- ***Quantification of Effort***

Effort is usually expressed in terms of catch per trap per length of time set, with 'overnight' catches often used, as they are for other passive gears. As with all funnel gear, fish do escape from these traps. Culp and Glozier (1989) found that mean escape time was shortest from double funnel opaque traps (approximately 35 minutes), longer from single funnel opaque traps (approximately 110 minutes), and longest from single funnel transparent traps (approximately 300 minutes).

- ***Fish Injury/survival***

Trapped fish are subject to the stress of capture and handling but are usually injury free.

7. Enclosure (pop, drop and throw) Traps

- ***Description and method of use***

Enclosure traps surround fish from a relatively small area at a single point in time. Kushlan (1974) described hand-held samplers made of garbage cans or wash tubs with the bottom removed that are plunged through the water and into the substrate, thus trapping fish.

Drop traps are typically constructed of mesh stretched around a rigid frame, with an open bottom. They are suspended from structures placed on or driven into the bottom. The trap is released remotely, usually by a rope attached to a simple release mechanism, and falls into the water. The fish within it are removed using a dipnet. One variation has a base that rests on the bottom and which is lifted with the trap, so that fish can be easily removed. These traps can be used repeatedly at the same location or moved from place to place. (Fig.8)

Fig – 4.12

Throw traps are similar to drop traps. Kushlan (1981) described 1 metre square or 1.5 metre square by 0.5 metre high box-like frames of metal pipe, with netting on all four sides. The traps are thrown by one or two persons and the enclosed fishes are collected by dip netting. Kushlan (1981) reported two people could collect 15 samples with a 1 m2 throw net in about 4 hours. It took more time to collect samples with the larger trap and because there was little or no gain from using a larger trap with respect to sampling efficiency, Kushlan (1981) recommended using 1 m2 traps.

Peterson and Rabeni (2001) describe a similar quadrat sampler for use in riffles that can be operated by one person. Two 1 m by 1m rigid frames are attached 0.5 m apart to corner pieces that extend 0.25 m below the bottom frame, forming 'legs'. Mesh is fastened to the frames, forming three straight sides and a bag that extends beyond the frame on the side that is placed downstream. The sampler is placed in a riffle and secured to the stream bed. Then the substrate within the sampler is disturbed by kicking, dislodging fish which move or are swept into the collection bag. Peterson and Rabeni (2001) stated that 12 samples could be collected by one person in about 15 minutes.(Fig.9)

Fig – 4.13

Larson et al. (1986) described a buoyant **pop net** consisting of a 4.3 m diameter mesh cylinder that is open at the top. The perimeter mesh is collapsible and attached to a floating collar. The net is set on the bottom by divers. The collar is released by remotely triggered solenoids and floats to the surface, enclosing the area above it. Then the entire device is lifted by cranes mounted on two boats. The net can be removed from the floating collar to facilitate fish removal. This gear cannot be used effectively in high winds (Larson et al. 1986). Dewey et al. (1989) described two smaller pop nets, 1.8 m wide by 3.1 m long by 1.8 m high. One of these was enclosed on the bottom and was used for sampling unvegetated habitats. The other had a retractable bottom panel, allowing it to be set in vegetated habitats, and the bottom to be closed after the net was released. These nets are quite time consuming and labour intensive to use.(Fig.10)

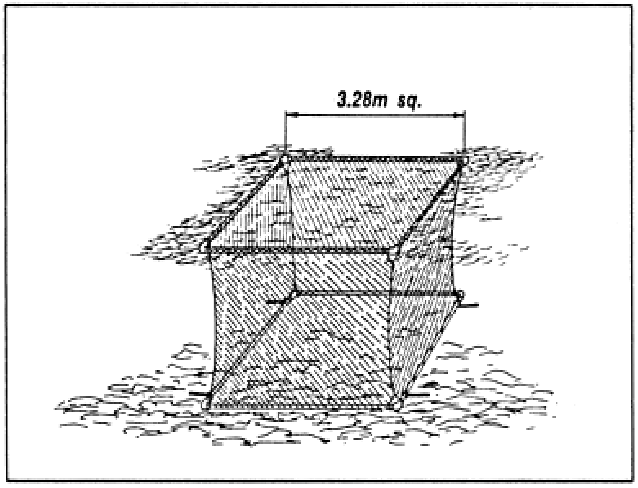

Fig – 4.14

- ***Habitat considerations***

The drop, throw and pop traps are designed for use in habitats with little or no current and are often employed in vegetated habitats where seining or electrofishing is difficult. Although they used it to sample riffles, Peterson and Rabeni (2001) reported that the capture efficiency of their quadrat sampler decreased with current velocity for certain families of fishes. They experienced difficulty deploying their traps in fast currents and recommended that they not be used in riffles deeper than 0.25 m or where currents are faster than 1 m/s.

The depth of drop nets is limited by the weight that can be lifted and suspended and the height of the supporting structure, plus the fact that, for most designs, fish must be dipped from the trap. The area of bottomless drop nets is also limited by the need to be able to dipnet fish from them reasonably efficiently. Kushlan (1974) estimated the maximum habitat depth at which drop nets were effective ranged from 1 m to 1.6 m.

Weight and depth both limit the size of throw traps, and 1.5 m sides and 0.5 m depth is probably about the maximum size that can be used.

Pop nets can be used in deeper water. Larson et al. (1986) used their model in water 2 – 4 m deep. Kushlan (1974) reported using a drop net effectively to sample in stands of emergent vegetation, but dense submergent vegetation would be expected to impede the net's descent and could prevent the trap from sealing at the substrate. A poor seal would also occur where the bottom is uneven, especially if the substrate is hard.

None of these gears can be used where woody debris or other obstructions are present unless the debris can be enclosed by the trap (i.e., does not impair the trap's descent). Vegetation is disturbed when fish are dipnetted from inside drop traps, so the habitat may be altered by repeated sampling at the same location (Kushlan, 1974). Pop nets cannot be used where debris will snag the net.

- ***Selectivity/Efficiency***

  Kushlan (1974) observed that some fast-swimming species were able to avoid falling traps. Comparisons of a 1.0 m square drop trap and 1.0 m square and 1.5 m square throw traps revealed that the 1 metre square throw trap caught more fish and more species than the same sized drop trap, and that the coefficient of variation for the drop trap was much higher (CV = 91% and 38% for the drop and throw traps respectively). Consequently, he concluded that the 1 square metre throw trap was the preferred gear.

  Jordan et al. (1997) evaluated the clearing efficiency for throw traps by determining the recovery rate of marked fish that were placed inside the trap, and their overall efficiency by comparing throw net catches inside blocking nets to density estimates from subsequent poisoning, which were also corrected for recovery efficiency by releasing marked fish inside the nets. In most cases there were no significant differences in size between the throw trap samples and the larger population. Throw trap accuracy did not appear to be affected by the abundance of aquatic vegetation.

  Larson et al. (1986) considered the efficiency of their pop net to be nearly 100%; divers did not observe fish avoidance of the rising pop net collar and mesh. Dewey et al. (1989) reported that there was no significant difference in total fish abundance between pop net catches and seine catches in either vegetated or non-vegetated habitats. However, the variability among catches for both gears was high, especially in non-vegetated habitats where it equaled or exceeded the mean in several cases, and even large differences would have been undetectable.

  Dewey (1992) reported that pop nets and drop nets were equally effective in sampling juvenile fishes in turbid, vegetated environments, and both were more effective than pre-positioned electrofishing arrays under those conditions. Pre-positioned electrofishing arrays caught more fish than either of the nets in clear water, where dip netters could see the fish better.

  Pop traps with fixed bottoms and drop traps that are dropped onto a platform alter or cover the substrate, which could attract some species and reduce the abundance of others. The supporting posts drop traps or the shade of the suspended trap could also attract or repel some species of fish.

- ***Quantification of Effort***

  Effort for these gears can be expressed as catch per deployment or per unit area.

- ***Fish Injury/survival***

  Fish injury and mortality from pop and drop nets should be negligible, but can result from dip netting or net retrieval and subsequent handling.

Recommendations for Bioassessment:

1. **Fish Sampling Methods by Wetland Type**

- **Floodplain Forests** - Electrofishing boat
  - difficult to use seines and active trap gears, easy to loose passive gears in floods
- **Great Lakes Coastal Wetlands** - Fyke nets possibly in combination with electrofishing
  - active traps may also work but large effort may not be worth it, seines often not feasible
- **Vegetated Intertidal Marsh/Mangrove Swamps** - Flume weir/flume nets or fyke-nets
  - flume weir/block nets can lead to high mortality
  - fyke-nets set in tidal creeks need vertebrate exclusion device (alligators - Ryan King)
  - salinity often too high for electrofishing
- **Freshwater Marshes** - Mini fyke-nets, minnow traps or both (fykes need alligator exclusion device)
  - throw traps if habitat destruction not important and density is important, electrofishing and seining often not feasible
  -

2. **Shallow Water Fish Sampling Methods**

- Fyke nets
- Trap nets
- Hoop nets
- Pound nets
- Minnow traps
- Slat trap
- Pop nets
- Drop nets
- Throw nets
- Lift net
- Flume weir
- Electrofishing gear
- Beach seine
- Purse seine
- Light trap
- Tow sled
- Hydraulic pumps

Source:
http://nptel.ac.in/courses/120108002/4