Chapter 5

Monitoring fish stocks from survey data

W. Ligtvoet, O.C. Mkumbo, P.J. Mous & P.C. Goudswaard

In this chapter a detailed account is given of the suitability of various gear types for obtaining data, collected by researchers working independently of the fishery, on stock size, stock structure, growth, mortalitity, spatial and seasonal patterns, reproduction, condition and diet of the commercially important fish species of Lake Victoria, Nile perch (*Lates*), dagaa (*Rastrineobola argentea*) and Nile tilapia (*Oreochromis niloticus*).

5.1 Introduction

There are two important advantages in monitoring fish stocks by fishing surveys (fishery independent sampling), instead of using data obtained from landing sites:

1. The choice of sampling areas, sampling techniques and sampling time can be adjusted to the particular information which the fishery researcher needs on certain aspects of a fish stock;
2. The data collection can be standardized as much as possible.

Collecting data by fishing surveys is, however, much more expensive than collecting data from landing sites. All expenses relating to obtaining and operating the necessary gear types are paid by the research institute. As small scale fishing for research purposes under standardized conditions is rarely economically viable, the expenses cannot be covered by revenues. Under certain circumstances, the relatively small catch size as compared with commercial catch sizes may also be a disadvantage for the research.

In this chapter, the suitability of each type of gear for several research objectives is discussed. The research objectives, each followed by a short explanation, are summarized below.

Stock size, structure, growth and mortality

Information on stock size, stock structure, and growth and mortality of a fish stock is essential for fisheries management. These aspects of population dynamics tell something about the well-being of the fish stock. Stock size is represented by the biomass of fish per unit of area, while the structure of a fish stock is represented by either the length-frequency distribution or the age composition of the fishes. If data are processed using length-based methods (Pauly 1987; Sparre & Venema 1992), information on growth and mortality may be gathered from records of development of stock size and structure collected throughout the year on the basis of, for example, one survey per quarter.

Spatial and seasonal patterns

In monitoring the fish stocks, knowledge about the geographical distribution, preferred habitats and daily and seasonal migration patterns of the fish species studied is of vital importance. The available information on these subjects for the most important fish species of Lake Victoria is given in Appendix II.

Reproduction

Data on reproduction, like size at maturity, spawning periods and spawning areas, may be important information for detecting and avoiding the overfishing of fish stocks. It should therefore be collected by fisheries biologists.

Condition

The condition of a fish can be calculated with the aid of the length-weight relationship as: CF (condition factor) $= \frac{W}{a.L^b}$, where W = individual weight of the fish, L = length and a

and *b* are constants in a length-weight relationship based on many samples over time. As with the aspects of population dynamics, the condition factor also informs the fishery biologist of the health of the fish stock. The condition factor can fluctuate considerably as a result of changes in the availability of food and the activities of the fish such as spawning or migration.

Food

It is important to know the forage base of a fish stock. Large changes in the food source of a fish species may have an impact on the production of the fish stock. Conversely, the fish stock may influence the food source, which may result in a density-dependent growth of the fish. Fishery may interfere with predator-prey relationships. For example, a high fishing pressure on the *Rastrineobola* stock (prey) may well have a negative effect on the stock of *Lates* (predator), while a high fishing pressure on *Lates* may have a positive effect on *Rastrineobola*.

5.2 Research with gill nets

General considerations and sampling areas

Gill nets are cheap and easy to operate. They can be set from a canoe and they can be used almost everywhere, *e.g.* at any depth in the water column in shallow and deep waters, close to papyrus shores and over uneven, rocky bottoms. Disadvantages are their size selectivity and the fact that they only catch active fish. If theft of nets is common, it will be necessary to guard the nets in the chosen sampling area, either from the boat or from a short distance away on the shore.

If sampling is to be done with gill nets, one has to consider which species and in which size range specimens are needed. Then, nets with suitable mesh sizes can be selected, provided that information on the selectivity is available. If detailed information is not available, one can use the information provided in *Table 5.1* to compose the net fleet.

In obtaining samples of fish more or less evenly distributed over all size classes, one has to account for the fact that there are generally more small fishes than big fishes in the lake and that, consequently, one unit of effort (one standard size of net) with small mesh sizes will yield many more individuals than one unit with large meshes. The number of nets per mesh size in a gang therefore has to be balanced in such a way that large enough samples of all the required size classes can be obtained.

To prevent a systematic sampling error (bias) due to the sequence of the mesh sizes in one net gang, the gill nets within one gang should be randomly chained together, and the net gangs should rotate randomly over the complete net fleet. The possibility of sampling error needs special attention if representative samples over a wide size range have to be taken.

Stock size, structure, growth and mortality

As gill nets are a passive type of gear, it is very difficult to assess the area that is sampled. Gill nets are therefore not suitable for research aiming at estimates of absolute stock size (numbers or biomass/area), but they can provide indices or estimates of relative stock size (number or biomass/net). The structure of fish populations can be adequately investigated

Table 5.1 Estimated length (cm) at maximal selection for different mesh sizes and species. TL = total length, AL = anal length, FL = fork length, NA = not applicable (see text). Anal length is the length measured from the tip of the snout to the anus. It is assumed that fish with a maximum girth which measures 1.25 times the perimeter of the mesh is retained best. From this girth, the length at which the fish is retained best is calculated by using a length-girth relationship. a and b refer to the parameters of the length-girth relationship (Girth = a x Length + b).

		Lates	*Oreochromis niloticus*	*Rastrineobola argentea*	*Protopterus aethiopicus*	*Schilbe intermedius*	*Labeo victorianus*	*Bagrus docmak*
a		0.706	0.764	0.568	0.565	0.498	0.47	0.569
b		1.71	-0.26	0.7701	1.642	1.167	0.817	1.256
Length as		TL	TL	TL	AL	FL	FL	FL
Mesh size (stretched mesh)								
cm	inch							
1.27	0.5	NA	NA	4.2	NA	NA	NA	NA
1.91	0.75	NA	NA	7.0	NA	NA	NA	NA
2.54	1	NA	NA	NA	NA	10.4	11.8	NA
3.18	1.25	NA	NA	NA	NA	13.6	15.2	11.7
3.81	1.5	11.1	12.8	NA	NA	16.8	18.5	14.5
4.45	1.75	13.3	14.9	NA	16.8	20.0	21.9	17.3
5.08	2	15.6	17.0	NA	19.6	23.2	25.3	20.1
5.72	2.25	17.8	19.0	NA	22.4	26.3	28.7	22.9
6.35	2.5	20.1	21.1	NA	25.2	29.5	32.0	25.7
6.99	2.75	22.3	23.2	NA	28.0	32.7	35.4	28.5
7.62	3	24.6	25.3	NA	30.8	35.9	NA	31.3
8.89	3.5	29.1	29.4	NA	36.4	NA	NA	36.9
10.16	4	33.6	33.6	NA	42.0	NA	NA	42.4
11.43	4.5	38.1	37.7	NA	47.7	NA	NA	48.0
12.7	5	42.5	41.9	NA	53.3	NA	NA	53.6
13.97	5.5	47.0	46.1	NA	58.9	NA	NA	59.2
15.24	6	51.5	50.2	NA	64.5	NA	NA	64.8
16.51	6.5	56.0	NA	NA	70.1	NA	NA	70.3
17.78	7	60.5	NA	NA	75.8	NA	NA	75.9
19.05	7.5	65.0	NA	NA	81.4	NA	NA	NA
20.32	8	69.5	NA	NA	87.0	NA	NA	NA

with gill nets. Although gill nets are very selective, a broad length spectrum of fish can be captured by using a wide range of mesh sizes. But even in catches from one mesh size shifts in the mode of the length-frequency distribution can be observed. *Figure 5.1* gives an example of such a shift in the size of *Lates* caught in 100 mm gill nets.

If gill nets are to be used in investigating relative stock size and structure, a prerequisite is that the selectivity parameters for the fish species under study are known. With the selectivity parameters available, two approaches are possible:

1. Based on the shape of the selectivity curve, the mesh sizes can be chosen so that the selection is optimal and constant over a wide size range. The resulting selectivity curve is 'flat' over this size range, which means that an equal proportion of each size class in that range of the population is taken *(Figure 5.2)*.
2. The mesh sizes in the net fleet cover a certain length range of the fish, but the resulting selection is not constant over that range. In this case the actual number of a certain length class in the fish population can be inferred from the selectivity curve. For example, if the number of fish in the catch of the 25-26 cm class was 30, and if fish of this length class were caught with a relative probability of 0.5, the relative number of fish in the population would be:

$$30 \times \frac{1}{0.5} = 60$$

(The relative probability of 0.5 for the size class 25-26 cm was obtained from the selectivity curve.) A similar calculation could be performed for each size class.

With the second method, the estimate of the actual number of fish in the population is heavily dependent on captures over length classes that are less efficiently caught. This is disadvantageous since the sample size in these size ranges is generally low, resulting in a high relative error. A second problem relates to the larger fishes. Unknown deviations from the assumed model, the normal distribution, can lead to large errors in reconstructing the right hand side of the length-frequency distribution. For example, if the probability of capture of larger individuals is higher than expected with a normal distribution, reconstructions will result in a gross over-estimation of the number of large fishes in the population. However, with the second method fewer nets are needed to cover a certain size range than with the first method.

In applying either method, in order to determine the actual number of individuals in the population, one must account for the higher efficiency of gill nets with an increasing mesh size (*e.g.* Hamley & Regier 1973). Rudstam *et al.* (1984) proposed a correction for the increase in efficiency of gill nets with increase in mesh size founded on encounter probability.

Spatial and seasonal patterns

In research on distribution and migration patterns, gill netting has three specific advantages compared with trawling:

- gill nets are highly selective;
- gill nets can be used on any bottom type and be set very accurately at any particular place and depth;
- gill netting only disturbs the environment very slightly.

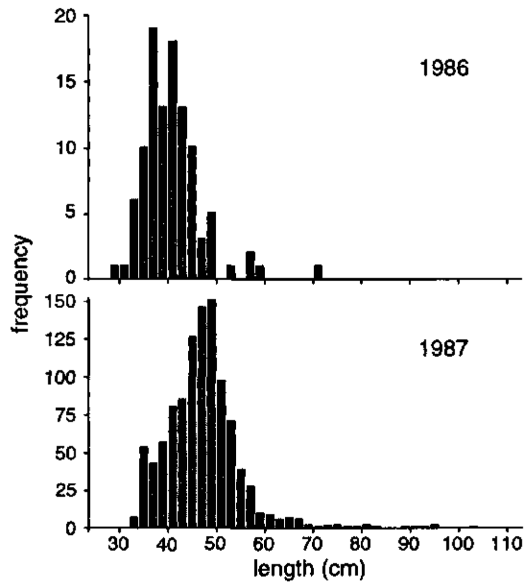

Figure 5.1 Length-frequency distributions of the *Lates* catch in 100 mm gill nets in 1986 and 1987. Note the shift in modal length.

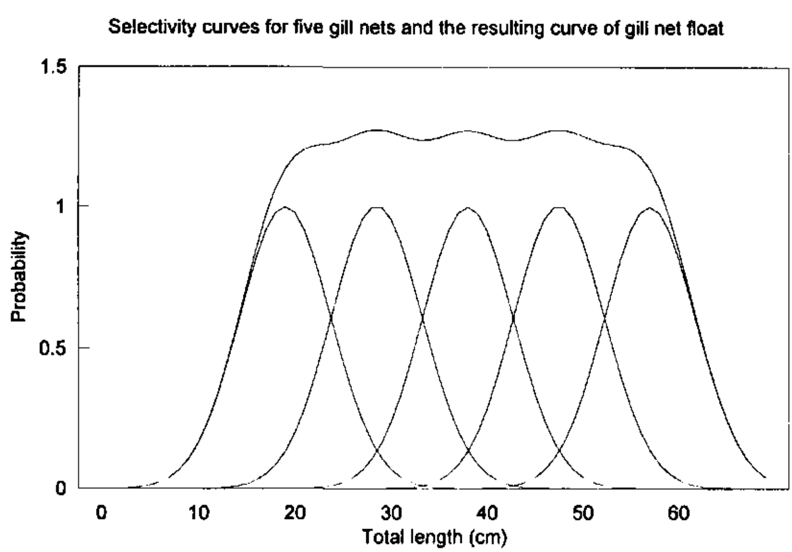

Figure 5.2 Example of the resulting selectivity curve of a net fleet to sample the *Lates* population over the length range 25-55 cm. Mesh sizes are chosen so that within the size range, specimens are caught with the same probability.

These characteristics make gill nets especially useful in:

1. Investigations in very shallow waters and/or waters with a rocky bottom.
2. Investigating both the horizontal and vertical distribution patterns of species. For such investigations on a comparatively large scale, identical net fleets should be set in the horizontal and vertical planes. If the population structure over a year is known approximately, from aselective sampling types of gear (trawl, beach seine), one may select a mesh combination which efficiently samples the most abundant size categories in the length-frequency distribution.
3. Investigating diurnal migration patterns either in the vertical or horizontal plane. The investigation of diurnal migration patterns (*e.g.* Goldschmidt *et al.* 1990) is a special case of point 2. In this case, the nets are lifted and cleaned at regular time intervals over a 24 hour period (*e.g.* every four hours). It should be noted that in view of the amount of work involved, these kinds of studies are generally carried out with a restricted number of nets and mesh sizes. Two net structures are at our disposal to cover the vertical water column. The first is a construction with parallel net gangs at different depths (see *Figure 4.12*), the second is a set of vertical nets which covers the complete water column (see *Figure 4.5*). With parallel horizontal net gangs the information should be taken per gang. With vertical nets, the data have to be recorded per indicated (marked) depth layer.

Reproduction

To establish the length at first, and at 50% and 100% of maturity, nets with a large range of mesh sizes are needed in order to catch both immature and adult fish. For research on the reproductive cycle, only adult individuals have to be caught; this means that only nets with larger mesh sizes can be used. Problems arise if the girth of the fish is related to the stage of ripeness. If so, the probability of capture with gill nets is not the same for the ripe and unripe fish of equal length. This can result in a bias of the estimation of the real length at 50% maturity, and the duration of a reproductive period may be shorter or longer than suggested by the fish sampled. To overcome this problem, nets with a range of mesh sizes must be set, even if the objective is just to catch adult fish. The fleet should be structured in such a manner, that the probability of capture is the same for each adult fish in the population. This may be difficult to put into practice, especially if the stock of nets is not comprehensive.

A proper monthly sample for research on reproduction of *Lates* should consist of some 150 *Lates* divided homogeneously over the length range 30-130 cm total length (see Section 3.4). We found that with a net fleet of about 40 nets of 25 m length each, and with mesh sizes ranging from 100-210 mm, it was possible to catch on average 1.5 individuals per 25 m net per night, at a station in the Mwanza Gulf at 15 m depth during March-July 1988. The TL of the fish caught ranged from 15-90 cm, the majority being 35-50 cm. It can be concluded that this fleet of gill nets was not very suitable for doing research on the reproduction cycle of *Lates*. Using more gill nets with larger mesh sizes will increase the mean length of the catch, but it is hardly possible to catch enough large specimens (100 cm TL) with gill nets. Thus, it is not efficient to use gill nets for the sole purpose of reproduction research.

To establish the length at first maturity in *Rastrineobola*, monofilament gill nets with very small mesh sizes (*ca.* 7 mm and smaller) would have to be used. These nets are very expensive and delicate. Adult *Rastrineobola* can be sampled using monofilament gill nets with a mesh size of about 13 mm. Because of the vertical migration of adult *Rastrineobola* at night, it is best to use bottom set gill nets during day time and surface set gill nets during night time.

Fishing during day time will have the advantage that parasitized *Rastrineobola* are not caught, since they are surface-dwelling (Wanink 1992). There are some indications of inshore breeding by *Rastrineobola* (Wanink 1988). Setting gill nets inshore at fishing grounds with a depth of 1-3 m, and farther offshore at fishing grounds with a depth of 10 m may reveal further information. Three small nets of some 1.5 m height and 5 m length with mesh sizes of 10, 13 and 16 mm (monofilament) will probably yield an adequate sample of *Rastrineobola*. The size range 5.5-8 cm TL is caught efficiently in these meshes. Sampling for 3 days each month during one year should yield enough specimens to obtain information on the reproduction cycle. The results (% ripe males and females) should be evaluated per size class of 5 mm.

Condition

Maximum girth may be related to condition for some species. A certain mesh selects from the smaller fishes those in relatively good condition (large girth for its length) and from the larger fishes those in poor condition (small girth for its length). Therefore it is advised to use a range of mesh sizes when the conditon of the fish is monitored.

Food

Experience has taught that routine gill net sampling, where the nets are left in place overnight, is an ineffective method for investigating the forage base. The majority of the fish caught are found to have empty or only slightly filled stomachs. The food is probably digested during the period that the fish are kept in captivity, or it may be expelled during the fishes' struggles to free themselves. Only during 24 hour sessions, when the nets are regularly hauled at short intervals, may gill net catches provide suitable data on the forage base and feeding pattern.

5.3 Research with trawlers

General considerations and sampling areas

Trawling is relatively expensive by comparison with the other types of gear discussed in this chapter. However, with trawlers one can sample large areas of a lake in a short time and the gear is less selective than gill nets. Trawlers cannot operate in very shallow areas, nor in areas where the bottoms are covered with obstacles such as rocks. It is important to have good maps of the area one wants to survey. The maps of the British Admirality in London (no. 3252 and no. 3665 for the northern and southern parts of the lake respectively; scale 1:294 000) are the best maps currently available for Lake Victoria. These maps give some depth records and show objects above water. A detailed map of the lake bottom does not exist. Outside the regular shipping routes there is a danger of collisions with uncharted rocks. The main characteristics of the areas surveyed by R.V. Kiboko are presented in *Table 5.2*.

Although the bottom of Lake Victoria is generally suitable for bottom trawling, there are areas where trawling is impossible due to rock formations and stones. Lake Victoria can be very rough, especially during the dry season. The main wind pattern is from east to west and therefore the western part of the lake is the roughest. As well as an annual cycle there is also a daily cycle, with winds blowing from the land towards the lake in the morning and changing to the opposite direction in the afternoon.

Table 5.2 Areas surveyed by R.V. Kiboko during the period 1984-1990. (See also *Figures 1.1* and *1.2*).

	Depth	Bottom	Fishery	Remarks
Kagera	15-22 m	mud	limited by weather conditions	An exposed area with few islands. The weather can be rough, particularly in the afternoon. In some areas, trawling is impossible because of rocks on the bottom.
Emin Pasha Gulf	3-22 m	mainly mud	limited, due to lack of market	An area of shallow bays rich in papyrus swamps sheltered from the main lake by islands. Trawling is possible almost everywhere.
Maisome/Kome	3-40 m	mud, sand, rocks	at subsistence level	An area of islands and bays. Trawling is difficult, due to submerged rocks.
Mwanza Gulf	3-25 m	mud	intensive gill net fishery	A long relatively sheltered area. Trawling is possible almost everywhere.
Speke Gulf	3-35 m	mud, sand, rocks	intensive gill net and trawl fishery	Trawling in the western part is impossible due to rocks on the bottom.
North Ukerewe/ Majitta	3-35 m	mud, sand, rocks	mainly light fishing for *Rastrineobola*	Trawling is difficult, due to rocks on the bottom.
Open lake	40-60 m	mud	formerly some gill netting for *Bagrus*	Trawling is often difficult, due to strong winds and high waves.

If trawling is done in an area where commercial gill net fishing takes place, gill nets may become entangled in the trawl net. If this is the case, the results of that haul are biased; this means that the haul has to be repeated. When a trawl survey is planned in areas where no regular trawling takes place, the fishing program should be announced to the regional fisheries officers and the fishermen, so that the latter can retrieve their gill nets in time or set the nets in another place.

Stock size, structure, growth and mortality

Research on stock size and structure mainly involves weighing and measuring the catch (*Figure 5.3;* Sections 3.1 and 3.2). Unlike with gill nets, it is possible to get a minimum estimate of the absolute stock size with a trawler. This is done *via* the swept area method. This area is calculated as the distance which has been trawled, multiplied by the width of the trawl net. Normally the latter is considered to be 0.7 to 0.5 times the head rope length, but for Lake Victoria, with a soft bottom on which is much decaying plant material, a factor 0.33 was estimated. An easy and cheap method of estimating the speed of the ship is by measuring the time (seconds) the ship takes to pass an object (*e.g.* an orange thrown into the water). The speed per hour can be calculated from the length of the ship and the time that was taken to pass the object.

R.V. Kiboko fished with a head rope of 18 m and made a speed of 3 nautical miles per hour (1 nautical mile = 1852 m). The swept area for a trawl shot of half an hour can be calculated as follows:

$$(18 \times 0.33) \times (1852 \times 3) \times 0.5 \;=\; 16{,}668 \text{ m}^2$$

If, during this trawl shot, 200 kg of *Lates* was caught, the standing stock for that area can be calculated as follows:

$$\frac{200}{16{,}668} = 0.01199 \text{ kg/m}^2 = 120 \text{ kg/ha}$$

The amount of fish generally varies with depth, and therefore the total sampling area can be stratified according to depth. A sufficient number of trawl shots must be made in each stratum (or depth zone). From a bathymetrical map, the surface area of every zone can be calculated and the stock size per depth zone can be estimated.

Trawling is a good technique for collecting data about the stock size and structure as it is a less selective way of sampling than gill netting. In Lake Victoria good results were obtained for *Rastrineobola* with a small surface trawl (Wanink 1988, 1991; Wanink *et al.* 1993) and for *Lates* with a bottom trawl (Goudswaard 1988; Goudswaard & Ligtvoet 1988; Ligtvoet & Mkumbo 1990), although the larger *Lates* specimens (*ca.* 70 cm TL) are under represented in the catches because they swim too fast to be caught. *Oreochromis niloticus* cannot be sampled properly with a trawler as a major part of the stock lives in waters that are too shallow for this gear, *i.e.* less than 3 m deep. With a small, outboard engine powered trawler, which can operate in such shallow areas, only juvenile *Oreochromis* are caught.

Recording changes in stock size and structure throughout the year reveals information on growth and mortality. If one has a general idea about the distribution of the fish, the number of samples needed to follow the development of a fish stock can be restricted, *e.g.* monitoring of the juvenile (0+ group) of *Lates* has to be done in the months when they are present (October-January) and in areas where they are most abundant (water less than 15 m deep).

Spatial and seasonal patterns

In research on distribution and migration patterns, trawling has the disadvantage, when compared with gill netting, that shallow water cannot be sampled, and both bottom and pelagic or surface trawls are needed to obtain vertical migration data. The advantage of trawling is that large areas can be covered, and that resting fish are also caught. When sampling with gill nets, the latter would erroneously be considered absent.

The catch of *Clarias gariepinus* in the Speke Gulf provides an example of a clear seasonal pattern *(Figure 5.4)*. Low catches between January and July may be due to the fact that during the rainy season these fishes migrate to spawn in rivers and temporary streams (Greenwood 1966).

To investigate horizontal distribution according to depth, a sufficient number of trawl shots in each depth zone should be made. Diurnal patterns of fish movements can be monitored by a 24 hour trawl survey. During such a survey in the Mwanza Gulf one trawl shot of 30 minutes was made every hour. Catches of *Lates* were higher during the day than at night, while the reverse was true for *Oreochromis niloticus*. However, the interpretation of such patterns is not always unequivocal. Lower catches may result from a horizontal or vertical migration of the fish or from their having a better chance to escape the trawl net.

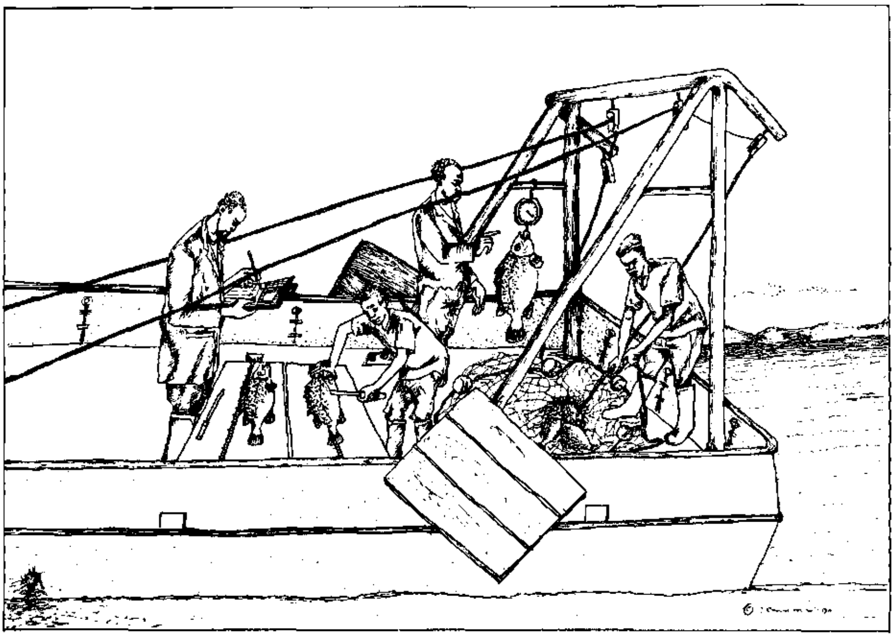

Figure 5.3 Research team on board R.V. Kiboko, making observations on the *Lates* catch.

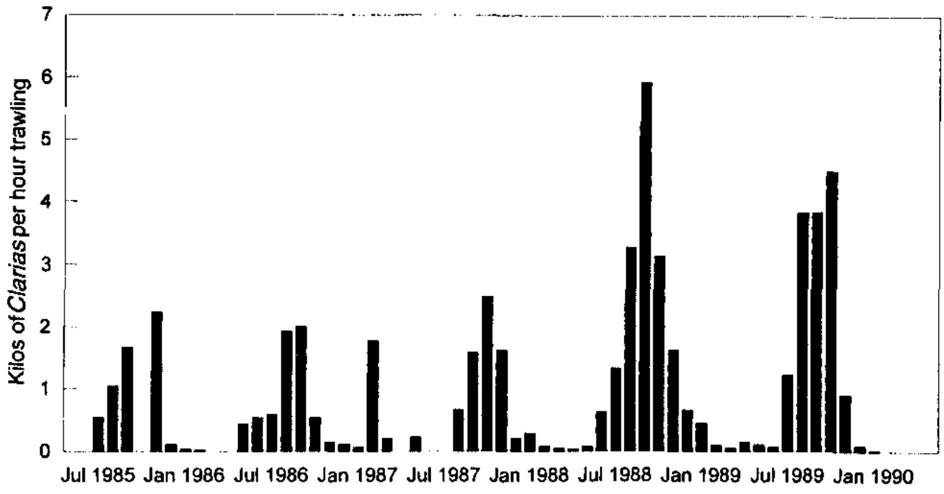

Figure 5.4 Seasonality in *Clarias gariepinus* catches in the Speke Gulf during the years 1986-89.

Reproduction

Provided that the codend mesh is small enough, trawl nets, unlike gill nets, are not selective for fish with different girths due to the stage of ripeness.

When the trawl nets have a 20 mm codend, *Lates* ranging from about 3 to 150 cm TL length are caught. This range is partly suitable for establishing the length at first, 50% and 100% maturity of *Lates*. Individuals of more than 70 cm total length are under represented in the catches; this usually means that not enough ripe females can be caught.

Generally it is not possible to use the more sensitive scales for weighing the viscera on the ship (see Section 3.2). To deal with this problem, the following method was used during the HEST/TAFIRI research:

1. A fish is weighed and measured and the measurements are noted on the field form.
2. After weighing and measuring, the fish is gutted.
3. All viscera (liver, fat and gonads) are stored in plastic netting.
4. The net is tied to a rope in the sequence of the numbers of the fishes and stored in a bucket with some water to prevent drying of the viscera.

Further analysis can then be done at the laboratory. From the sequence of the viscera filled nets on the rope and the numbers of fish that were weighed and measured, the weight and length measurements on the form can be related to the viscera in the nets.

A surface trawl with a codend mesh size of 5 mm used during the night is suitable for reproduction studies on *Rastrineobola*.

Trawling is not satisfactory for studying the reproduction of tilapiines. A large trawler cannot fish in shallow areas, where most tilapiines live, and a small trawler cannot catch the larger *Oreochromis niloticus* since they usually swim too fast. Some information on the reproduction of tilapiines can however, be obtained by sampling juvenile tilapiines. A seasonal cycle in their abundance may reflect the reproductive cycle of the adults. Sampling juveniles can be done by trawling with a small trawler, say 25 hp, in shallow areas, preferably with a 5 mm mesh size codend (bottom trawl).

Condition

Trawl nets are suitable for obtaining representative data on the condition of fishes because of their aselectivity.

Food

Trawling provides an excellent opportunity to determine the forage base of demersal fish populations. Trawl catches contain freshly captured specimens over a wide range of length classes and the stomach contents usually give a good indication of the main food items for a fish stock if analysis if done shortly after catching, or if the stomachs are properly preserved. If fishes are caught at depths of more than 20 m, stomach contents are often lost due to expansion of the swim bladder on surfacing, which squeezes out the stomach.

5.4 Research with beach seines

General considerations and sampling areas

Beach seines are more expensive than gill nets. They are easy to operate and can be set from a canoe. However, in contrast with gill netting, beach seining is restricted to littoral areas where the bottom is free from obstacles and where there is a beach onto which the net can be hauled. More manpower is needed to operate beach seines than gill nets. Even for a small beach seine of 100 m length, 8 men are required, and the large beach seines (800-1000 m) currently used in the *Lates* fishery require at least 30 people. Like trawl nets, beach seines make comparatively unselective catches.

Stock size, structure, growth and mortality

Beach seines are suitable for investigating the stock structure of a species because they are non-selective over a wide length range. However, a disadvantage is that in operating from the shore, the area covered is spatially restricted. The known distribution of a particular fish species in the lake (inshore or offshore distribution) therefore determines to what extent beach seines can be used to investigate its stock structure. With regard to the three main fish species in Lake Victoria, the following should be noted:

1. *Lates* has a lake-wide distribution, occurring in waters up to 60 m deep. Experience has shown that when using medium sized beach seines with net lengths of 200-300 m, *Lates* are captured up to a length of 80 cm TL, while larger specimens are mostly absent. With the large beach seines used in the *Lates* fishery a distance of almost 1 km can be reached from the shore, and *Lates* from 30-150 cm TL are captured, although the majority are not larger than 60 cm TL. Beach seines of this size are not likely to be operated by researchers.
2. *Oreochromis niloticus* has an inshore distribution and lives mainly in shallow waters up to 10 m deep. With medium sized beach seines, all sizes of *Oreochromis* can be captured, but it is likely that the largest specimens will be under represented because they live farther from the shore in deeper water. In general, however, a sample which is representative of the largest part of the population can be obtained.
3. *Rastrineobola* is a schooling species and there are indications that individuals of different sizes occur in different areas. Wanink (1988) found that the size of *Rastrineobola* in the Mwanza Gulf increased with increasing water depth. Concentrations of small juveniles only were observed in shallow bays. These findings indicate that there is little likelihood of obtaining a representative sample of the whole population with mosquito seines.

With beach seine surveys the relative stock sizes can be indexed by the catch weight per haul. Absolute estimates of stock size (number or kg/ha) can also be made since the area that is fished with one haul of a beach seine can be determined quite accurately (except in the case of light fishery). Information on growth and mortality can be derived from the data on stock structure throughout the year, using length-frequency analysis and catch curve analysis.

Spatial patterns

In research on distribution and migration patterns, beach seines are only useful for stocks which are restricted to the shallow inshore waters over bottoms without boulders. Moreover, unlike gill nets and combinations of bottom and pelagic or surface trawls, beach seines cannot be used for studies of vertical migration.

Beach seines may be useful in investigating the spatial distribution of small (1-10 cm TL) *Lates* juveniles in the inshore waters. Very little is known about the distribution and habitat use of this size group, but incidental information indicates that this size group is mainly found in littoral and sub-littoral waters (E.F.B. Katunzi *et al.* in MS). For the smallest *Lates* of 1-4 cm TL a mosquito seine should be used.

Reproduction

Beach seines are not particularly useful in studying reproduction of *Lates*. Both medium sized and large seines mainly fetch individuals between 30 and 60 cm TL. In this size range, only a few of the males (50% maturity at *ca.* 60 cm total length, *Figure 3.9*) and even fewer females (50% maturity at *ca.* 75 cm total length) appeared to be mature and active during our surveys.

Beach seines are more suitable for studying the reproduction of tilapiines. Being aselective and capturing more or less the complete size range of the *Oreochromis niloticus* population, beach seines can be applied in investigations on the reproduction of this species. However, one should take into account that there are indications that sexually active fishes and mouth brooding females may inhabit areas different from those inhabited by the rest of the population (Trewavas 1983). This may be a problem since it is not possible to cover all littoral habitats when using beach seines, especially if the shore is not readily accessible.

The available information about the breeding behaviour of *Rastrineobola* does not give a clear indication as to where breeding occurs, although there are suggestions for both inshore (Wanink 1988) and offshore spawning (Graham 1929). It is currently impossible to tell if an important part of the sexually active population is found in waters that can be sampled by mosquito seine.

Condition

The aselectivity of the beach seine makes this gear appropriate for collecting representative data on the length and weight of individual fishes for all three species *Lates*, *Oreochromis* and *Rastrineobola*.

Food

As with trawling, beach seining also yields freshly caught fishes over a wide size range and provides the best opportunity for obtaining reliable information on the forage base. It should be realized, however, that the feeding habits of individuals caught inshore with a seine may differ from those of fishes feeding in deep offshore waters.

5.5 Research with light fishing, using lift nets, encircling nets and scoop nets

General considerations and sampling areas

As indicated in Section 4.10, beach seining for *Rastrineobola* in combination with light is not recommended for research purposes. The utility of a lift net for fisheries research is limited, except of course for doing research on lift net fishing, *i.e.* into the selectivity and efficiency of the gear itself. For all other purposes a small trawler with bottom and surface trawls can be used with similar or even lower operational costs. At night, artisanal type lift nets can be used at depths of more than 10 m, using an artificial light source to attract fish. The selectivity, and the area fished by a trawler, are easier to assess because the catches are not influenced by the light factor. Moreover, a small trawler can be operated during day time and it can be used in shallower water than lift nets.

The assumptions concerning the selectivity of lift nets being influenced by light hold true for scoop netting and fishing with an encircling net as these are also done at night using an artificial light source. The input requirements for scoop netting and fishing with the encircling net are fewer, (see Section 4.10). Therefore, the scoop net and encircling net are more suitable as sampling gear than the lift net. Further, scoop netting can be done both in deep and shallow waters.

Stock size, structure, growth and mortality

Studies on stock size, structure, growth and mortality with encircling nets and scoop nets would be possible in principle if more were known about the selectivity of these types of gear. A quantitative approach to determining stock size and structure would only be possible if it were known in what area *Rastrineobola* is attracted by the light source and what percentage of *Rastrineobola* in the area is attracted.

Spatial patterns

Scoop netting and fishing with encircling nets may be of use for research into distribution patterns of *Rastrineobola*. Neither gear type is suitable for studies on the vertical distribution in the water column.

Reproduction

At least part of the sampling effort should be directed towards shallow water, as there are indications that the spawning of *Rastrineobola* occurs in shallow waters. Therefore, for research into reproductive matters, a scoop net is a particularly suitable type of sampling gear.

Condition

In principle, condition can be investigated by research with encircling and scoop nets, although it might be difficult to sample the complete size range of *Rastrineobola* this way.

Food

A scoop net or encircling net in combination with light fishing during the night is unsuitable for studying the forage base of *Rastrineobola* for the following reasons:

1. *Rastrineobola* mainly forages during the day time, and therefore a high percentage of the *Rastrineobola* which is caught at night time will have empty or partly empty stomachs (Hoogenboezem 1985; Wanink 1988).
2. The average stomach fullness in fish caught the same night by artisanal fishermen using light attraction is significantly higher than in fish caught with a surface trawl without light attraction (P. Mous pers. obs.). It might be that *Rastrineobola* attracted by light feeds to some extent on zooplankton and *Chaoborus*, which are also attracted by the light source. This implies that doing research on the forage base by studying fish which were caught by light attraction is of no use.

5.6 Research with long lines

Long lining can only be used for *Lates*, *Protopterus* and the two larger catfishes, *Bagrus* and *Clarias*. In principle, long lines are not very efficient as a type of gear for research. Generally, in Lake Victoria, using between 500-1200 hooks (Ligtvoet & Mkumbo 1991), the artisanal fishermen catch only small numbers of fish. In the *Lates* fishery, the average landings are 15 individuals per night, with a range of 0-25 specimens.