# Variable Mesh Gill Nets (in Lakes)

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## Background and Objectives

### Background

Along areas of the Pacific Northwest coast, gill nets were traditionally constructed of a coarse fiber twine made from willow bark (Coffing 1991) and other materials, such as seal skin (as reported in 1844 by Zagoskin [Michael 1967]) and moose or caribou sinew (Oswalt 1980; Stokes 1985). Linen twine was used for making gill nets beginning in the 1920s (Coffing 1991). Gill nets were used both for set net and drift net fishing. In the 1960s, nets made from synthetic fibers such as nylon came into wider use. Most nets were 50 m or less in length until the 1980s. Nets are generally 50–70 m long, with mesh size varying depending on the salmon species targeted (Charnley 1984).

Variable mesh gill nets have been used for fish population evaluation for about a century. The efficiency with which gill nets capture fish and the versatile use of these nets in lakes and streams have made them a common tool for fishery evaluation (Hamley 1975).

This supplemental technique addresses the use of gill nets targeting salmonids in the Pacific Northwest but can be used for other species as well. The chapter draws extensively from the following papers: Bernabo (1986); Baklwill and Combs (1994); Bonar et al. (2000); and Klemm et al. (1993). Additional insights into use of gill nets can be found in Hubert (1996).

### Rationale

Variable mesh gill nets are appropriate for sampling when fish mortality is not a limiting factor. Gill nets normally kill a high percentage of fish due to the trapping mechanism of the net around the gills. Careful net tending can reduce but not eliminate the mortality percentage. The use of variable size mesh panels in the gill net allows capture of fish of different sizes. As such, this method can be used to collect data on population abundance, stock characteristics, population distribution, and species richness. Gill nets are not species-selective, and as a result, it can be expected that as many or more nontarget species will be captured as target species. In addition, small aquatic mammals and birds will also occasionally become entangled in the mesh and drown.

### Objectives

- Determine relative abundance of lake or stream populations by measuring the catch-per-unit-effort (CPUE).
- Determine total abundance of lake populations by measuring the recapture rate of marked fish.
- Determine the length, sex, phenotypes, and genotypes of fish by collecting a representative catch of each sample.
- Determine the species composition and relative biomass of a lake or a stream.

## Sampling Design

Trend information based on results of gill-net sampling will only be as reliable at the reproducibility of the sampling technique for each monitored site. Location of nets, orientation along the bottom in relation to the shoreline, diel time of placement and collection, and season of placement must be standardized for each site. Because lake sampling programs will be site specific, standardization must be within a given lake and not between lakes. Each lake has a unique morphometry, and net placement must be carefully considered according to lake characteristics and target species.

The types of data acquired from gill nets include fish age, growth, relative weight, and proportional stock density calculations. Also, estimates derived from gill nets are typically given in CPUE or abundance within restricted habitat zones such as nearshore areas or coves (Dauble and Gray 1980; King et al. 1981; Johnson et al. 1988; Rider et al. 1994). CPUE methods assume that the calculated index is proportional to total population size, allowing trends through time to be detected. Unfortunately, violating this assumption is easy, but detecting the violation is not (Hillborn and Walters 1992). Given this situation, suggestions for estimating population abundance in deeper-water habitats must be tentative. Alternatively, one can use active capture gear or define a series of equally spaced transects over the entire water surface from which to sample randomly or systematically (Thompson et al. 1998).

Borgstrøm (1992) assessed the effect of population density on gill-net catchability of Brown trout *Salmo trutta* in four Norwegian high-mountain lakes. Catchability was found to be inversely related to the number of fish present; brown trout populations with low densities were more vulnerable to gill nets than high density populations; gill-net catches as an estimator of population density were biased.

While there are many ways to utilize gill nets, two examples of gill-net use in lakes are offered here.

McLellan (2001) used electrofishing and gill nets to sample resident fish in eastern Washington reservoirs and streams. Of the taxa involved, four were salmonids (cutthroat trout *O. clarki*, rainbow trout *O. mykiss*, brown trout, and lake trout *Salmo namaycush*). A total of 10 horizontal experimental monofilament sinking gill nets (2.4 × 61.0 m; four 15.2-m panels with square mesh sizes 1.3, 2.5, 3.8, and 5.1 cm) were set at randomly selected shoreline sites per season. Two horizontal gill nets were set in reaches 1, 3, and 4, and four nets were set in reach 2. The nets were set perpendicular to the shore, with the smallest mesh size closest to shore. A total of eight monofilament vertical gill nets were set per season, four in the pelagic zones of both reaches 1 and 2, except during the spring, when flows were too high and the verticals were not set in the forebay. The nets (2.4 × 29.9 m), one of each mesh size (1.3, 2.5, 3.8, and 5.1 cm), were set in the upper 29.9 m of the water column at randomly selected pelagic locations. During the summer, two additional horizontal nets were set in the pelagic zone of the forebay, one at the surface and one at the bottom (61 m). Data collected from the pelagic horizontal gill nets were not used in the relative abundance or CPUE calculations; however, the data were included in age, growth, relative weight, and proportional stock density calculations. Gill nets in reaches 2, 3, and 4 were set at dusk and retrieved within 4 h. The gill nets set in reach 1 were set in the early morning (~02:00 hours) and retrieved within 4 h.

Since 1981, the Center for Limnology at the University of Wisconsin–Madison, with support from the U.S. National Science Foundation, has been administering the Northern Temperate Lakes Long-Term Ecological Research (LTER) program. The center is focusing its attention on eight deep-water lakes in Wisconsin for monitoring. Vertical gill nets are used to monitor yearly changes in the abundance of pelagic fish species (<http://lter.limnology.wisc.edu/fishproto.html>). Researchers sample the deep basins of these lakes with seven nets, each a different mesh size, hung vertically from foam rollers and chained together in a line. Each net is 4 m wide and 33 m long. From 1981 through 1990, the nets were multifilament mesh, in stretched mesh sizes of 19, 25, 32, 38, 51, 64, and 89 mm. In 1991 the multifilament nets were replaced with monofilament nets of the same sizes. One side of the net is marked in meters from top to bottom. Stretcher bars have been installed at 5 m intervals from the bottom to keep the net as rectangular as possible when deployed. The bottom end is weighted with a lead pipe to quicken the placement of the net and to maintain the position of the net on the bottom.

Gill nets are set at the deepest point of all long-term ecological research lakes except Crystal Bog, Trout Bog, and Fish Lake. The nets are set for two consecutive 24-h sets. The nets are set in a straight line, each connected to the next and anchored at each end of the line. Once the nets are in position, they are unrolled until the bottom end reaches the bottom and then tied off to prevent further unrolling. The nets are pulled by placing each net onto a pair of brackets attached to the side of the boat and by rolling the net back onto its float; the fish are picked out as the net is brought up and placed in tubs according to depth. The fish are processed when the net is completely rolled up and before it is redeployed.

## Field Methods

### Setup

#### Boats

The investigator should review the size and type of waterbody where the gill nets will be employed. Since gill nets are dangerous to work with and cannot normally be effectively set by personnel on foot, an effective boat, rubber raft, or canoe should be used. For work in remote lakes where transportation is restricted to foot travel, an inflatable rubber raft is the most effective method for setting gill nets. Where helicopters are available, a small skiff or canoe can be used. In lowland areas, a variety of boats are available depending on road access to the waterbody and the size and type of waterbody.

#### Nets

Recommended lake gill net specifications are as follows:

1. Length: 15–48 m (50–150 ft).
2. Depth: 2–2.5 m (6–8 ft).
3. Each net includes a proportional panel of 1.25, 1.90, 3.54, and 3.80 cm (i.e., 0.5, 0.75, 1.0, and 1.5 in) mesh. This mesh is capable of capturing fish as small as 7–8 cm total length.

4. The gill net is designed with a braided lead line of 7 g/m (0.3 lbs/fathom).
5. Floats are attached such that the lead line lies along the bottom and the floats suspend the net in the water column. Float line must be braided nylon with corks 15–20 cm (6–8 in) apart of a size to make the net either sink or float.
6. Nets are normally constructed of double-knotted monofilament and hung on a 2:1 basis (i.e., twice as much web as lead/cork line). Monofilament is nearly invisible under water and highly entangling, and it is nearly maintenance free. Its disadvantage is that it is more dangerous to handle, and if the net is lost, it continues to fish for years thereafter.
7. All nets must have nylon gables (side panels) of approximately 18 kg test.

For some operations the net may be allowed to float on the surface of the lake. In this case, the floats would be replaced with larger, more buoyant floats capable of suspending the net and the lead line with fish (Balkwill and Combs 1994). Gill nets should be clearly labeled with the researcher's name and contact phone number. In urban areas, the net may cause concern with the public, and special arrangements may need to be made with a local landowner or others to arrange for access and to prevent vandalism to the equipment.

### Other equipment

The sampler should plan to bring measuring boards, scale envelopes, buckets, global positioning system (GPS) unit, weighing scales, clipboards, waterproof forms, and other equipment if genetic information is also being collected. Proper collecting permits may need to be obtained depending upon species collected, jurisdictions, and other factors.

## Events Sequence

#### Setting the net

1. Set the net along the bottom in shallow waters not exceeding 5–7 m in depth to capture a representative sample of the total fish stock when sampled at night.
2. Nets should be placed perpendicular to the shoreline in shallow water or at a 45° angle in deep water, with the small end of the mesh nearest the shoreline.
3. The deep end of the net should have a line with a float attached to it to aid in retrieving the net if it becomes snagged. The location selected should be free of sunken logs, jagged rocks, pipes, and other objects that can snag the net and keep it from being retrieved.
4. Nets should be set at dusk (one hour before sunset) and retrieved at dawn (1 h after sunrise).
5. The net is coiled in the bow of the boat with the lead line on one side and the float line on the other side. The small mesh end is tied to the shore or to a log or an anchor near the shore, and the boat is moved out towards deep water. The net is allowed to pay out over the bow. The person paying out the net should be vigilant to keep the net from snagging on the

vessel. When the net has been fully deployed, the net should be stretched as tightly as possible before being released. (Note: It is very important that the person deploying the net ensure that all buttons, zippers, and other apparel that could be entangled in the net are secured.)

6. Nets can be set with or without bait. Baiting is effective for many purposes and can be accomplished by dispensing the contents of a can of tuna fish along the length of the net.
7. Net sets may need to be modified when testing for presence of bass and other nonsalmonid species. Trout and salmon tend to swim forward when encountering the net and then quickly become entangled. Bass will tend to back up when encountering the net and swim perpendicular to an obstacle to avoid it. When sampling waters where bass and other non-salmonid species are present, at least a few of the sites should be set with one net perpendicular to the shore and another perpendicular to the first net to increase the probability of capturing the bass avoiding one of the nets.
8. The following morning, the net is retrieved by the sampler paddling out to the float and bringing up the deep end of the net first. This minimizes snagging and allows the sampler to work the net towards shore. If the net is pulled from shore, the net has a higher chance of snagging on the bottom obstructions as it slides along the bottom.
9. Repeat steps 1–7 for each sample site.

**Setting nets on ice-covered lakes**

1. Gill nets can be fished through the ice when necessary. This can be accomplished by first determining the net location during the summer when bottom contours and obstacles can be assessed.
2. During the winter, the sampler must locate the net site and then mark out the length of the net on the ice perpendicular to shore as before.
3. Use an ice saw or chain saw to cut two parallel lines in the ice the distance of the net set. Remove blocks of ice and clear the hole of debris.
4. Lower the net into the hole as described in steps 3–5 under Setting the net.
5. The next morning, the hole may have refrozen and will need to be cleared of ice either with a saw or an axe.
6. In subfreezing conditions, the net should be pulled quickly from the hole and spread out on the ice as straight as possible. This will allow the net to be picked after it freezes.

**Number of nets**

Following is a rough guideline for the number of nets to use:

| Lake size (ha) | Number of nets |
|---|---|
| < 4 | 1 |
| 4–10 | 2 |
| 10–20 | 3 |
| 20–40 | 4 |
| Each additional 40 ha | Add 1 net |

If the initial sampling effort yields few or no fish, the sampling stations should be moved and the sampling effort repeated. A careful description of the sampling location is important in order to find and duplicate the same location the following sampling period.

### Sample Processing

The following steps should be used when processing fish caught in the gill net:

1. Fish should be carefully removed from the gill net. For most of the fish species, it will require untangling the gill opercles from the net mesh. Some species, such as catfish *Siluriformes* tend to spin once they are entangled and will require a lot of work to release.
2. Measure to the nearest millimeter, identify to species, weigh to the nearest gram, and take scale samples from the left side (just posterior to and below the dorsal fin and above the lateral line). If genetic samples are needed, take samples per the protocol being employed for DNA or electrophoresis. Depending on the purpose and need, stomach samples may be taken, most commonly via gastric lavage, and internal organ, examined for parasites, gender, and maturity.

Field data recording should be standardized and should include the following:

1. lake
2. sampling date
3. gear type
4. net location (shore orientation, depth, placement time, collection interval)
5. hours fished
6. species
7. weight (gm)
8. total length (cm)
9. scale number
10. parasites observed
11. deformities observed
12. wounds observed
13. universal transverse mercator or latitude/longitude coordinates
14. names of survey personnel

Other physical measurements such as temperature, pH, and visibility may also be taken. These factors often affect fish activity and net visibility and efficiency and should be tracked.

## Personnel Requirements and Training

### Responsibilities

The net should be set with two people, whenever possible, with one person deploying the net and one person propelling the vessel. This reduces the chance that the net will become entangled, and it helps ensure that it will be deployed properly. If only one person is available, the way the person initially prepares the net is crucial to successful deployment. In turn, during net retrieval, two persons are ideal: one person controls the vessel against water and wind conditions while the other person slowly brings the net on board and either picks the net as it is brought on or brings in the entire net and later picks the fish out of the net on shore under more stable conditions.

The samplers can determine who will record and who will weigh, measure, and conduct other examinations of the fish when they are being processed.

### Qualifications

The person using a gill net should have been properly trained by an experienced field biologist and should have a degree in biology or one year of experience in sampling fish in the geographic area where the sampling is to occur. The use of volunteers should be carefully evaluated due to the danger involved and potential adverse reactions with the public.

### Training

Training should either be provided through videos and demonstrations under cover prior to the season or through on-the-job training by accompanying an experienced field biologist.

## Operational Requirements

### Field Schedule

The field schedule for setting gill nets is normally during the spring when fish have become active and before there is a lot of recreational lake activity; however, as noted above, the sampling can occur at any time, including winter, depending upon the objectives of the study and the needs of the monitoring.

### Equipment List

Use this list to help in developing a budget estimate.

| Item | Comments |
|---|---|
| 4 m aluminum rowboat with oars | |
| 15 hp outboard motor | |
| 25-L gas tank and other motor repair items | |
| One-person raft with kayak paddle | Used for remote applications |
| Net tubs or buckets | |
| Meter board | |
| Anchor and anchor lines | |
| Dissecting kit | |
| 10% formalin or 70% ethanol | |
| Screw-top vials | |
| Scale envelopes | |
| Collecting permits | |
| Secchi disk | Measures transparency of water |

| Item | Comments |
|---|---|
| GPS unit | Location of nets |
| Life jackets | |
| Sharp knives | To cut loose an entangled person or net; for fish samples |
| First-aid kit | |
| Ice saw or chain saw | For under-ice sampling |
| Axe | For under-ice sampling |
| Net labels | |
| 50-m variable mesh gill nets | Number as needed |
| Clipboard | |
| Sample forms | |
| Thermometer | |
| Wire clippers | Used for catfish spine removal |
| Cell phone, two-way radio, or satellite phone | Communications |

## Personnel Budget

The following guidelines can be used to estimate time budget for personnel:

| Activity/item | Cost |
|---|---|
| Staff time* | 3 h |
| Travel time | Variable |
| Preparation time | 4 h |
| Training | 1 h |
| Lab workup | 2 h |
| Data analysis, report writing | 8 h |

* two biologists to set the net and to retrieve and process the catch

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