Government of Saskatchewan

Aquaculture in Saskatchewan

Dugouts and Ponds

Their Future is in Our Hands

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I. Introduction

In Saskatchewan there are numerous highly productive dugouts and ponds that are not capable of supporting fish on a year-round basis. A combination of severe winter climate and shallow depth results in dissolved oxygen levels too low to support fish in these waters during the ice-covered period. Since the 1970's, these waters have become popular for aquaculture (fish farming).

The practice of dugout and pond aquaculture on the prairies is simple. A suitable body of water is selected and a number of young fish are stocked in the early spring. They are allowed to grow through the summer, eating the abundant natural food in the water. In the fall or early winter they are harvested. Any remaining fish perish in late winter and leave the water free for restocking the next year. This technique of stocking free-roaming fish in dugouts and ponds for harvest later is known as extensive aquaculture.

The appeal of this activity is that there is no feeding, no significant capital investment and no specialized skills required. This aquaculture, exploiting natural food and with no carryover of adult fish populations, is a process which fits easily into the seasonal cycle of work in agriculture.

Rainbow trout *(Oncorhynchus mykiss)* grow rapidly and reach a useful size in one summer and are therefore a suitable species for fish farming. Stocked as 10 to 12.5 cm fingerlings in early spring, they often grow to over 450 g by fall. See Appendix I for a table of metric/English and English/metric conversion factors. They are the main species currently used for extensive aquaculture in the province. Experiments have been conducted with several other species (brook trout, splake trout, arctic char, and some salmon species) but their growth and survival rates are not suitable for prairie pothole fish farming.

Whereas fish farming appears simple in theory, many problems have been encountered which have limited its success. This booklet is an overview to guide the potential fish farmer and provide an insight into the problems that they might encounter, with some suggested solutions.

Information herein is based on experiences of Saskatchewan participants and fisheries personnel in the provinces of Alberta, Manitoba, Saskatchewan, and the Department of Fisheries and Oceans, Canada.

II. Legal Aspects of Extensive Aquaculture in Saskatchewan

A yearly licence is required which permits the holder to obtain, transport, and raise fish in waters of the province. The licence is valid only for the period of time and the kind of fish specified thereon. Separate application must be made and separate licence obtained for each aquaculture operation. Transfer of fish to waters not listed on the licence is prohibited.

Types of Licences

1. **Private Aquaculture**
An aquaculture licence is not required for personal use if the aquaculture approved fish species, as set out in Table 4 of the *Saskatchewan Fisheries Regulations,* are raised or possessed in contained waters under the control of that person. Contained waters include; tanks, raceways, ponds or dugouts that do not flow directly or indirectly into another waterbody or watercourse. Fish produced by private aquaculture may not be sold, bartered or traded and are intended for personal use only.

2. **Commercial Aquaculture licence** - $15.00 fee
A commercial licence grants the holder rights for any of the following types of operations:

a) To stock and harvest fish for commercial market sale. The fish may be sold directly to local consumers, or,
To wholesalers, retailers and restaurants, providing they have been processed in licensed fish processing plants within the province. Fish sold outside the province are subject to federal regulation and approval. (see "Marketing" page 16 for further details)
b) To stock fish in a water body for sale to the public by means of angling, commonly known as a "U-catch-'em" or "fee-for-fishing" pond. People angling at such an establishment do not require a provincial angling licence, but must retain a receipt showing the source of the fish for their own protection.
c) To act as a broker, importing live fish from suppliers outside the province and reselling them in smaller lots to private or commercial fish farmers in Saskatchewan.

Water Qualifying for Extensive Aquaculture
1. Lakes, sloughs (potholes), reservoirs, borrow pits, gravel pits and farm dugouts surrounded by private land. To present escape of fish and disease, only waters having no permanent inlet or outlet may be used for extensive aquaculture. However, for waters having intermittent outflows, screening of the outlet may be acceptable. If the pond is bordered by land owned or leased by one or two persons, the applicant must obtain agreement from all owners or lessees to permit sole use of the pond for aquaculture purposes. Where the surrounding land is controlled by more than two persons, agreement from at least two-thirds of the owners or lessees must be obtained before an aquaculture licence will be issued.

2. Lakes, potholes, or permanently impounded reservoirs accessible by **Crown land.** Of these, only waters classified by the Ministry of Environment – Fish and Wildlife Branch, as incapable of supporting permanent fish populations, will be eligible for licensing. Aquaculture for personal use is not available on lakes accessible by Crown land.

Waters Not Qualifying for Extensive Aquaculture
Licences are not available for waters within provincial parks, recreation and historic sites, parkland reserves and protected areas.

How to Obtain an Aquaculture Licence
1. Application forms for an aquaculture licence are available at any Ministry of Environment office.

2. The applicant should examine the water body to determine if it meets aquaculture licence specifications.

3. Two copies of the application must be completed in full. Partially completed applications are not acceptable. The information is required to determine the eligibility of the aquaculture operation for a licence.

4. Separate applications are required for each operation for which a licence is desired.

5. Completed applications are to be sent to the local Conservation Officer, who will inspect the site and issue the licence, if approved.

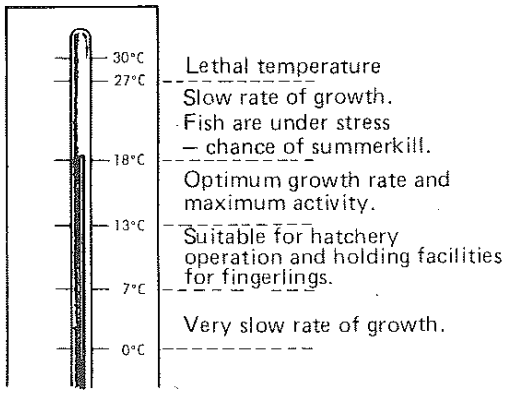
6. Licences will be issued as soon as possible following receipt of application, but applicants should allow adequate time for review and inspection. In the case of waters surrounded by Crown land, deadline for receipt of application is February 1.

7. If a licence was held previously, an application form is not required. The licence may be renewed at any Ministry of Environment Compliance Area office.

III. Criteria for Suitable Trout Culture Waters

Thousands of ponds are scattered throughout the province, but not all are useful for trout raising. In general, the pond must have certain physical characteristics before it is considered suitable.

1. **Temperature**



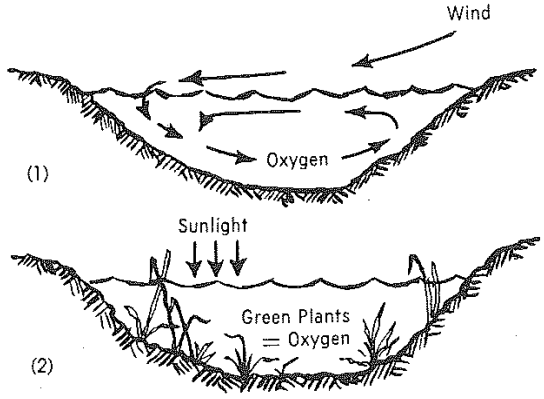
Optimum water temperatures for rainbow trout growth are from 13°C to 18°C. At temperatures above 21°C trout growth is reduced considerably. Trout can survive in water with temperatures up to 24°C for very short periods, and, with an abundant oxygen supply, up to 27°C. However, high water temperatures or rapid fluctuations often result in mortality. Temperatures above 24°C for extended periods of time place the trout under stress.

2. **Oxygen**
A high level of dissolved oxygen in the water is essential for trout survival and growth. Dissolved oxygen concentrations vary with the abundance of organic matter (plants and animals), water temperatures and circulation. Under natural conditions trout can survive dissolved oxygen levels as low as three parts per million (ppm) for a short period, but generally concentrations should exceed five ppm.

Ponds receive oxygen from: 1) the action of wind on the surface; and 2) green plants which give off oxygen when growing in sunlight (photosynthesis).

Respiration, on the other hand, is the process by which living organisms take in oxygen and produce carbon dioxide and water. In sunlight the rate of photosynthesis is much greater than the rate of respiration. However, photosynthesis ceases during darkness, while respiration continues both day and night.

Cool water can hold considerably more oxygen than warm water; as the water temperature rises, its ability to absorb or retain oxygen declines.



Carbon dioxide + water → Plant tissue + Oxygen
Sunlight

The water body should be fully exposed to wind to ensure dissolved oxygen levels are maintained. Without circulation, water at the bottom of the pond during the summer is cool, but lacks oxygen due to decaying organic matter in the mud; at the same time surface water becomes very warm. Wind circulates the well oxygenated water from the surface to the bottom, and the cooler low-oxygen water near the bottom, to the surface. This circulation disperses into the air poisonous gases (hydrogen-sulphide and ammonia) produced during the process of decay near the bottom and keeps the entire pond habitable for fish.

3. **Depth**

Pond depth is the main factor determining whether winterkill will occur, with shallow ponds being more prone to this occurrence. Winterkill occurs when ice and snow cover effectively seals off the water from contact with the atmosphere and blocks sunlight, thus eliminating the two main processes which add oxygen to the water (wind and photosynthesis). At the same time the processes of decay and respiration consume the oxygen in the water.

Winterkill ponds are especially suitable for commercial production of trout, as a uniform size of product is often desired. Deeper waters which allow overwintering are desirable when fish are stocked mainly for recreation.

Winterkill is dependent on the amount of oxygen stored in the water. Deeper ponds store larger quantities of oxygen and are, therefore, less likely to winterkill. In the small fertile prairie ponds, winterkill can generally be expected up to depths of 7.5 m. However, this depends on the transparency of the ice at the time of its formation and the amount of snow cover which accumulates. Winterkill also depends to a large extent on the fertility of the pond and therefore the amount of organic material settling to the bottom of the pond during the winter. For this reason, some newly excavated highway borrow pits and farm dugouts, as shallow as 4 to 5 m, do not experience winterkill.

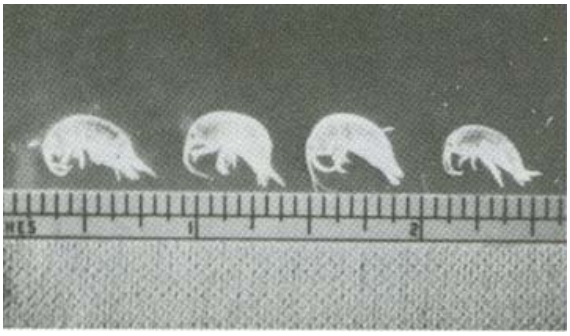
Winterkill ponds are quite suitable for trout culture because while fish cannot over winter, many small invertebrate animals do survive in these conditions. The animals which survive (among which the freshwater shrimp **Gammarus lacustris** is noteworthy) become the top link in the food chain when fish are absent. Being relatively free from predation, they develop dense populations which later become the primary food for re-introduced trout.

The simplest test for winterkill is to drill a hole through the ice in late winter (preferably March, or just before break-up when oxygen is at its lowest level) and smell the water. The odor of rotten eggs (hydrogen sulphide) indicates the water is poisonous to fish. The lack of a rotten egg smell, however, does not necessarily mean fish will over-winter.

Extremely shallow ponds are not suitable for trout culture due to the possibility of summerkill (see Page 9).

4. **Food**

Most water bodies in southern Saskatchewan are abundantly supplied with a variety of organisms including small crustaceans, insects and insect larvae, which serve as food for trout. The most important food organism is the freshwater shrimp, **Gammarus lacustris**. It is responsible for the development of an attractive orange-pink colour in the flesh of trout, besides stimulating a rapid rate of growth. Another abundant food item in prairie ponds is the phantom midge larva (**Chaoborus**). Ponds containing large populations of native minnows and sticklebacks may produce trout with flesh that is light in colour. During the summer months, trout can often be observed in the evening jumping out of the water to feed on insects.



Most Saskatchewan waters are teaming with freshwater shrimp. These crustaceans are about 1 cm long.

There is no need to feed trout after they have been stocked. At the stocking rates mentioned on Page 7 trout can grow rapidly on the natural food produced in the pond. Although supplemental feeding may increase the growth of trout slightly, the majority of fish farmers find that feeding is expensive in view of the results obtained.

Dugouts and borrow pits should be at least three years old to allow rooted aquatic plants and shore vegetation time to become established. The plants are necessary for the growth of aquatic insects and crustaceans which provide food for trout. A new dugout may be used if it is connected to a slough or small pond. The slough will provide natural food organisms for the trout and the dugout will provide a cool refuge in hot weather.

If trout are raised in a new dugout, they may be fed manufactured trout feed, available from the fingerling suppliers, or from large feed supply outlets. These suppliers will provide information on how much and how often to feed. If a handful of pellets is scattered in one particular area of the pond every day or two, trout often form the habit of coming to the surface whenever the pellets are tossed in. If trout are fed, care must be taken to avoid introducing more food in the pond at any one time than the fish will eat immediately. Unused food will accumulate on the bottom and decompose. This decomposition may build up to such a point that it depletes the local oxygen supply.

5. **Aquatic Vegetation**

Algae and plant life are an important source of food and oxygen. However, ponds with extremely heavy growth of algae or pond weeds should be avoided, for summerkills are common in those with heavy algae blooms and the trout are difficult to harvest in ponds with massive growths of submergent vegetation.

6. **Alkalinity**

Most waters in Saskatchewan are suitable for raising trout but alkaline water (pH more than 9.0) is not recommended for fish culture purposes. A white chalky ring deposited along the shoreline is often characteristic of alkaline water. A general indication of suitable water is the presence of cattails and bulrushes along the shore.

7. **Drainage**
A fish pond should be self-contained (no permanent inlet or outlet). This limits exposure of native fish to possible imported diseases, prevents predaceous fish such as pike from entering the pond, and prevents stocked trout from leaving.

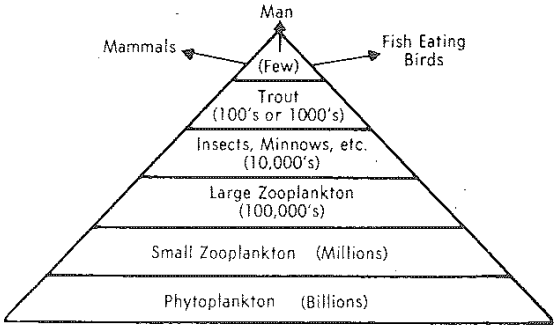
Ponds which receive drainage through barnyards, feedlots, etc., should be avoided. Wastes from livestock, which are high in nitrogen and phosphorus, may cause excessive algae blooms in the water and hence result in possible summerkill of fish. Dugouts should be fenced to deny livestock access to the water.

8. **Clear Water**
Trout require clear water for good health and growth. Quite often newly constructed dugouts and those fed by drainage water from cultivated land are turbid. Turbidity is usually caused by fine clay particles in suspension.

Muddy water holds down the production of fish food because sunlight cannot penetrate the water to produce microscopic plants which form the basis of all fish food. Also, trout are sight-feeding fish and must be able to see their food in order to eat. Therefore, waters that are turbid should not be used for trout farming until the condition has been rectified.

IV. Food Interrelationships in a Trout Pond

The Food Pyramid
The food supply in water depends upon basic dissolved nutrients (organic matter and minerals), sunlight, and air. If microscopic plants (phytoplankton) grow well, these in turn supply food for microscopic animals (zooplankton). Together, the microscopic plants and animals are called plankton. These tiny organisms multiply and become forage for larger animals such as small crustaceans (e.g. freshwater shrimp), insects and insect larvae.



Pyramid showing relationships of food organisms in a typical trout pond.

During the first month or so after stocking in the spring, rainbow trout fingerlings utilize plankton as their source of food. For the remainder of the summer and fall, they consume primarily freshwater shrimp and insects.

The plankton organisms that are not eaten eventually die and fall to the bottom of the pond. Dead plankton, along with other dead and dying plants and animals return organic matter to the water and the food cycle is started over again.

The ratio of deep to shallow water in a pond has an important bearing on the amount of fish produced. Shallow water areas produce more food than deep water areas because there is greater sunlight penetration to the bottom, resulting in an abundance of plant growth. However, shallow water bodies are more likely to summerkill.

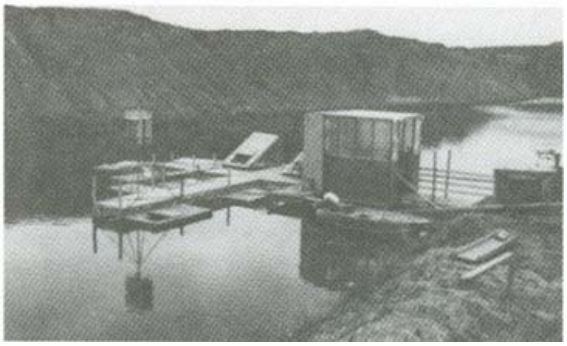
V. Obtaining and Stocking Fingerlings

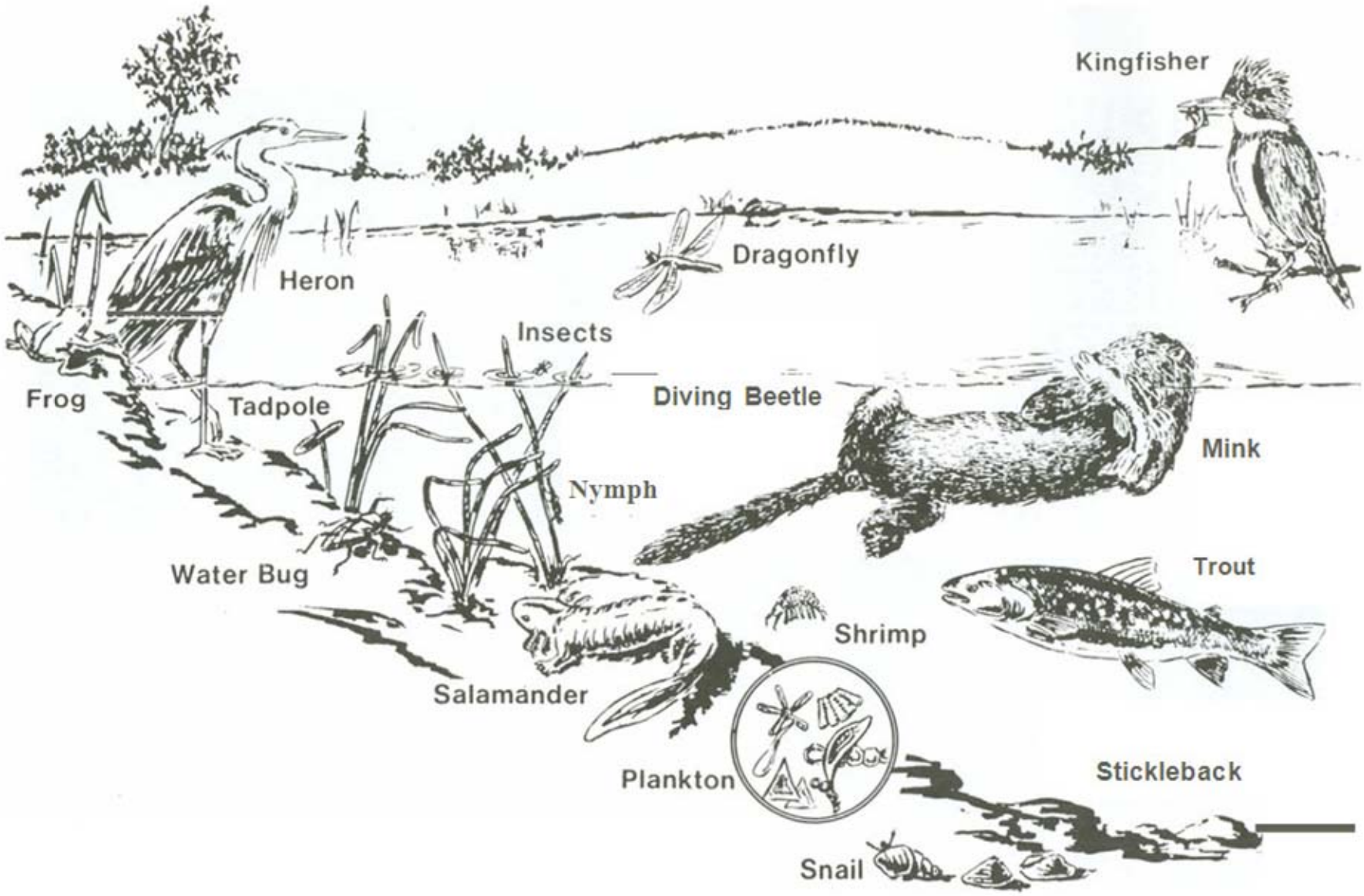
Obtaining Fingerlings
All fingerlings for aquaculture purposes must be obtained from commercial suppliers. Since there are few commercial trout broodstocks in Western Canada, most of the trout imported into Saskatchewan originate as eggs or fingerlings from hatcheries in the north-west United States.

Anyone wishing to import live fish into the province from any other province or country must first obtain a live fish import permit from the Ministry of Environment – Fish and Wildlife Branch. In addition, fish imported into the province from another country also require an import permit from the Canadian Food Inspection Agency. These regulations apply to live cultured fish, eggs of fish and dead products of cultured fish destined to move into Canada or across provincial boundaries within Canada. Further information on the regulations governing the importation of live fish may be obtained from the Ministry of Environment - Fish and Wildlife, Regina.

In most cases, aquaculturists obtain rainbow trout fingerlings from fingerling brokers and commercial hatcheries within the province. Where a fish farmer obtains fingerlings from a source outside Saskatchewan, it is his responsibility to ensure the necessary clearance arrangements have been made.

A current list of fingerling suppliers may be obtained from the Ministry of Environment – Fish and Wildlife Branch.


An example of fingerling holding facilities in Saskatchewan.



The diversity of life-forms in a typical trout pond.

Size of Fingerlings to Stock

Fingerlings 7.5 to 10 cm in length should be stocked for trout to grow to table size in the five or six-month growing season. Smaller fingerlings are less expensive but are less likely to reach a suitable size before harvest. Fingerlings larger than 10 cm are substantially more expensive.

Trout farmers stocking large numbers of fingerlings probably will find 6 to 7.5 cm fingerlings to be the most economical size to purchase, while trout farmers stocking dugouts and borrow pits suggest 12.5 cm fish are most satisfactory.

Fingerlings are generally sold by weight. The following table summarizes the approximate weight of trout of various sizes:

Size Relationships of Rainbow Trout Fingerlings

Length of Fingerlings (cm)	Number Per Kilogram	Weight of 1,000 Fish (kg)
6.0	410	2.4
7.5	210	4.7
1.0	90	11.2
12.5	45	21.9
15.0	26	37.9
20.0	11	89.8

Although these figures approximate the length-weight relationship for rainbow trout, it can vary according to the culture technique and growing environment of the fish. Fish produced in Saskatchewan hatcheries may be somewhat lighter or heavier for their length than this table indicates.

Cost of Trout Fingerlings

Fish farmers stocking a small number of fish can usually reduce the cost of fingerlings by ordering co-operatively with neighbouring trout farmers, as there are generally quantity discount prices for large orders.

For those trout farmers ordering large quantities of fish, it is advisable to compare prices from different suppliers. Delivery costs are included in the price from some suppliers, but are extra from others, and therefore should also be checked before placing an order for fish.

Stocking Rates

The number of fish stocked may influence the size and amount of fish produced. Stocking too many fingerlings may result in poor growth and poor survival, whereas too few fish may not utilize the water to the best advantage.

It is best to employ low stocking rates in the first year of operation, because it is difficult to predict the suitability of a pond for fish farming. Expansion can then be undertaken the following year if conditions appear to warrant such. Stocking rates of 600 to 750 fingerlings per hectare produce good results and should not deplete natural food supplies. In some cases stocking rates in excess of 750 per hectare have been very successful. The optimum stocking rate varies among water bodies and is directly related to the pond's natural fertility. Dugouts, because of low fertility and available food, should be stocked at no more than 500 to 750 fish per hectare. The following table is a guide to use for stocking dugouts, using the maximum recommended stocking rate of 750 fish per surface hectare. The sizes given are for standard P.F.R.A. dugouts with a minimum of three metres of water.

Size	Approximate Surface Area	Maximum Recommended Number of Fish
18 m x 36 m	0.065 ha	50
20 m x 50 m	0.01 ha	75
23 m x 60 m	0.14 ha	100
23 m x 75 m	0.17 ha	125
30 m x 60 m	0.20 ha	150

When to Plant the Fingerlings

Fish stocked shortly after break-up will make maximum use of the short growing season. Within a week after break-up there should be sufficient oxygen replenished to support fish.

Determining number of fingerlings by weight.

Stocking Procedure

In the case of large orders, the fingerlings are generally brought to the stocking site in distribution tanks. For smaller orders, the supplier will put the fingerlings in plastic bags or cubitainers filled with oxygen-saturated water. The fingerlings should be taken to the stocking site as quickly as possible and should be kept cool en route: the containers should be kept out of direct sunlight.

To avoid shocks from changes in water temperature and water chemistry the fingerlings should be "tempered" before being placed in their new environment. The containers should be placed in the pond for at least one-half hour to equalize the two temperatures. At the same time, pond water should be gradually poured into the containers. The greater the difference in temperature between the pond water and the water in the containers, the longer the time required for tempering. The oxygen-filled containers should not be opened until it is time to "temper" the fingerlings.

When the fingerlings are tempered, they can be poured from their containers into the lake. Care should be taken to see that the fingerlings swim away from shore, as they can become entangled in the shoreline vegetation. Fingerlings in shallow water are easy prey for birds such as gulls, grebes, terns, and blue herons, so it is advisable to keep these birds away until the trout have adjusted to the water and are away from shore. (However, it is illegal to shoot these birds as they are protected under the Migratory Birds Convention Act).

Fingerlings being tempered to equalize water temperature.

To alleviate some of the hazards of stocking, offshore plants should be made whenever possible. Stocking the fingerlings at scattered locations in open water lessens the chances of fingerling mortality due to predation and entanglement in shoreline vegetation.

Cages have been demonstrated to be an effective tool for stocking fingerlings in fish ponds. Studies undertaken by the Freshwater Institute, Winnipeg, and by the ministry indicate that trout survival can be increased by stocking the fingerlings in holding cages for about two weeks in the spring. Mortalities in the cages are generally negligible and the fingerlings are in excellent condition after two weeks confinement. The cages provide an attaching media for invertebrates and they provide an abundant food supply for the confined trout.

Fingerlings transferred from cubitainer to lake.

When stocked in a pond, trout fingerlings are exposed to a great number of hazards which can result in high post-stocking mortality. Some of these hazards are:

1. The weakened fish can get tangled in old weed growth and are unable to free themselves.

2. They are accustomed to being fed on the surface at the hatchery and tend to congregate there expecting food. This leaves them exposed to predation by birds.

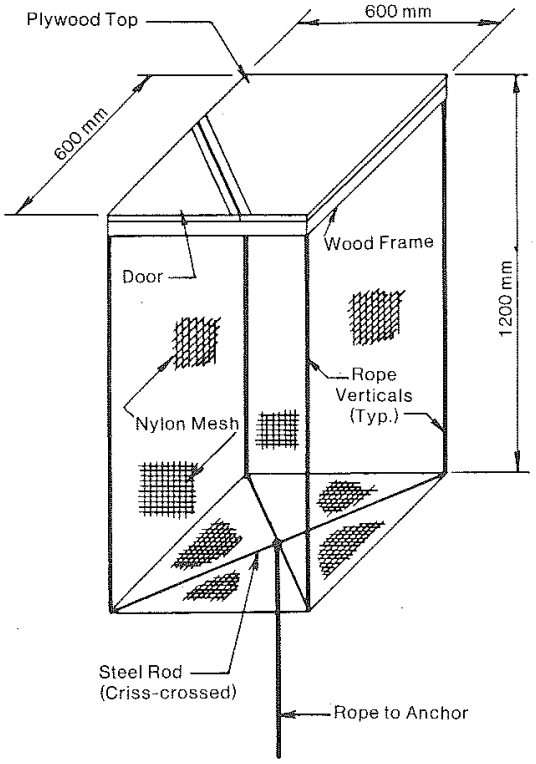
3. If trout are stocked soon after the lake is ice-free, they may sink into a layer of toxic hydrogen sulphide (also lack of oxygen) near the bottom and perish. Experiments show that when trout are under stress from transportation shock, they cannot distinguish between good water and toxic water.

4. Dytiscid beetles (large, black, hard-shelled water beetles) can catch and kill weak fingerlings.

A cage can aid in preventing the above problems. Cages should be constructed of a wood frame with plastic or nylon mesh as these materials are non-toxic, non-corrosive and light weight. The cage should also have a plywood top for flotation to prevent it from sinking to the bottom of the pond. With a plywood top, the cage becomes a natural haven for insects and other trout food by preventing the sun's blistering rays from entering. The cage must be anchored to the bottom by a weight and rope of appropriate length.

Good success has been achieved stocking 2,000 7.5 cm rainbow trout in a 60 x 60 x 120 cm cage. Larger fingerlings, of course, must be stocked at lesser densities. Cage size can be altered to handle the number of fish being stocked.

Mesh for construction of these cages may be available from the fingerling suppliers in the province. Nylon mesh is available from Leckie's Freshwater Fishing Supplies, 547 King Edward Street. Winnipeg, Manitoba, R3J 1L9.



Collapsible holding cage for fingerlings.

VI. Problems in Dugout and Pond Aquaculture

1. **Summerkill**

The main problem experienced by rainbow trout farmers in Saskatchewan during the summer months is a partial or complete summerkill of their ponds, caused by high water temperatures and low oxygen levels.

a) **High Water Temperature:** Rainbow trout prefer temperatures of 18°C and undergo considerable stress when the water temperature rises above 24°C. After a few days of hot, still weather, it is not uncommon for fish summerkill to occur in shallow water bodies. Water temperatures in small water bodies tend to fluctuate closely with the ambient air temperature, and therefore dugouts experience this problem sooner than larger ponds.

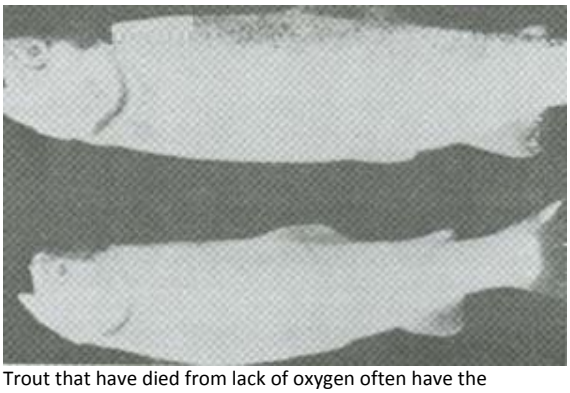
Under these circumstances, a slow progression of trout mortality generally occurs. Some fish may be noted on the bottom or floating at the surface, while others may appear to be very inactive or sluggish, or they may be swimming in slow circles or with a spiraling motion.

Because high temperature kills are often gradual and because carcasses either sink to the bottom or drift ashore and are disposed of in a short time by birds, water beetles, freshwater shrimp. etc., it is possible for a large or even complete kill to occur without the fish farmer's knowledge. Failure to observe dead fish does not necessarily mean a summerkill has not taken place.

b) **Oxygen Depletion:** For respiration, fish depend entirely on dissolved oxygen in the water. If the dissolved oxygen content of the water becomes too low, the fish suffocate.

The most common cause of summerkill in southern Saskatchewan is the dense growth and sudden collapse of blooms of filamentous blue-green algae (**Aphanizomenon** sp.). This algae resembles small grass clippings suspended throughout the water. These "clippings" continue to grow until they reach bloom proportions, after which time they exhaust the nutrient supply in the water, then they die. This usually occurs during July and August. The rapid collapse of the algae bloom results in masses of dead algae settling to the bottom of the pond where it is broken down (oxidized) by bacteria. During this process the oxygen supply may be exhausted in the water, resulting in a summerkill.

In addition to oxygen used by the process of decay, the living plants and animals in the pond use large amounts of oxygen. Plants growing in the pond produce oxygen during the daylight hours, but at night photosynthesis ceases, and plant and animal life continue to respire (use oxygen). The only means of replenishment of oxygen during the night is by diffusion through the surface. If there is no wind to aerate the surface layer, then the rate of loss of oxygen may exceed the uptake resulting in the oxygen content reaching its lowest point just before dawn. Thus fish kills of this nature most commonly occur just prior to sunrise. This type of summerkill occurs often in dugouts, after a period of hot calm weather. All or most of the fish are affected at the same time and can be seen struggling or gasping at the surface.



Trout that have died from lack of oxygen often have the mouth open and the gills flared out.

2. **Algae Control to Prevent Oxygen Depletion**

Algae often becomes a problem in fertile agriculture areas where the water is high in productivity. Fertilizer or barnyard manure, carried by runoff from land adjoining the pond, may be the source of nutrients for the algae. The problems associated with this algae growth are discussed in the foregoing section.

Although algicides may provide a short-term remedy for algae problems in ponds and dugouts, prevention is the most satisfactory solution. Keeping water free of algae depends on avoiding conditions that contribute to the introduction and rapid growth of these minute water plants. Since algae lacks true roots, the cells must obtain their nutrients from the water. Thus, the landowner can control algae by limiting the introduction of nutrients into the pond. The best method is to simply prevent nutrient-rich water (e.g. from manure or fertilizers) from entering the pond. Also the shores can be stabilized with retaining walls to prevent runoff from carrying leaves, grass and nutrient-rich topsoil into the pond. Rocks and gravel along the shoreline will act as a natural filter and will prevent soil erosion from wave action. Another method of preventing algae growth in a dugout is to use an irrigation pump to suck water from one end of the pond (near the surface) and release it as a fountain at the opposite end. This aeration procedure oxygenates, circulates, and cools the water of the pond. Aeration once or twice a week (at night) during hot, sunny periods will prevent stagnation and hence reduce algae blooms.

If chemical treatment is necessary, copper sulphate (bluestone) or Diquat (Reglone A) is recommended. Both these algicides have been used by trout farmers in the province with relatively good success and with little or no apparent harm to the fish in most instances.

For best results, treatment should take place early in the season when the algae is growing vigorously and before it has reached "bloom" proportions. Young plants absorb the chemicals readily and are easily killed. Early treatment reduces the possibility of oxygen depletion caused by decay of large masses of vegetation. Applying herbicides to large masses of algae bloom merely speeds up the summerkill process, as the rapidly decaying material will rob fish of all available dissolved oxygen.

It is best to treat not more than half the total pond area at one time. The remainder should be treated a week or two later. Often, the hazard of fish suffocation is greater than the chemical danger.

Control of algae may be feasible in small bodies of water, but it is not practical to attempt control in a large water body. Chemical control is a continuous program and may be effective for only part of the season.

In water bodies on Crown land or where there is an outlet to a stream or other water body, a permit is required from the Ministry of Environment, before algicides are applied to the water. A permit is not required by an individual when the water to be treated is enclosed entirely within and does not discharge surface waters beyond the boundaries of their land.

Copper Sulphate (CuS04) – is the standard treatment for algae in farm ponds. It is probably the best and cheapest all round chemical for the control of algae. However, caution must be used when applying this chemical to ponds containing trout. Copper sulphate in sufficiently high concentrations is toxic to trout and food organisms.

The following table gives recommended treatment rates for various depths of ponds:

Mean Depth (m)	Kilograms $CuSO_4$ per hectare
1.2	2.3
2.0	4.1
3.0	5.9
4.0	7.7

Note: If mean depth is unknown, one-half the maximum depth is usually equal to the mean depth.

The copper sulphate may be dissolved in water and applied to the pond surface as a spray, or it may be placed in a fine mesh bag (e.g. flour sack) and dragged through the water until it has dissolved. It is most effective when the water temperature is 16℃ or higher.

Diquat (Reglone A), though much more expensive than copper sulphate, is safer for use in ponds containing fish. It is not necessary to calculate water volumes when applying this herbicide as it will work effectively up to 2.5 m in depth when applied at a rate of 10 to 20 litres per hectare.

Diquat should be applied on cloudy days or in late afternoon. It can be applied by spraying the diluted chemical uniformly over the water surface. It is a contact weed killer and should, therefore, be applied only after the algae is visible and in an early active stage of growth, which is normally June through early July. Aquatic insects and other invertebrates are tolerant of this chemical and do not appear to be affected by it.

3. **Predation**

Birds such as gulls, loons, mergansers, kingfishers, herons, bitterns and terns and such animals as mink and raccoons have been known to prey on rainbow trout stocked in farm ponds. Trout are especially vulnerable to predation when first stocked in the spring. Stocking trout into holding cages can prevent predation at this time.

Considerable damage may be caused by some of the larger bird species, but a Federal Statute, **The Migratory Birds Convention Act**, prohibits the killing of all migratory birds, therefore other methods must be used to control and discourage these predators.

Predator control methods fall into two general categories – devices intended to frighten away the predator, and devices meant to exclude it from the pond area. When controlling bird predators, it is important that action is taken early in the spring, before the birds have established feeding habits or nearby nesting sites. Prompt action will often encourage birds to seek nesting areas elsewhere.

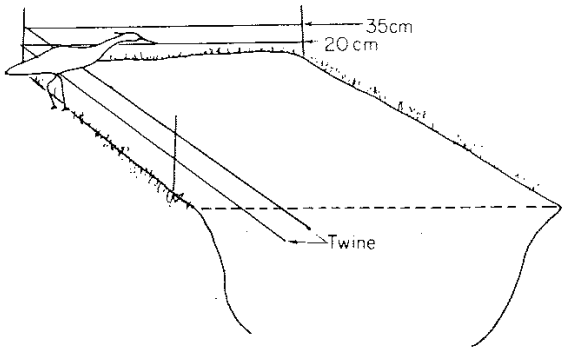
Birds can often be frightened away from trout ponds

by the use of scare cannons which emit a loud boom at predetermined intervals. With this device a fairly long interval between blasts, or the use of a timer for irregular intervals between blasts, is most effective. Short regular intervals may result in the birds becoming accustomed to the noise. The cannon should be used in an elevated position and moved frequently for greatest effect. Bird control or "cracker" shells (similar to blank shotgun shells) are sometimes successful in discouraging birds as well.

Other scare techniques which may be effective include scarecrows, streamers and reflectors. When using scarecrows, best results are obtained by using brightly coloured scarecrows mounted on floating, movable platforms. Plastic streamers and bags attached to stakes are often effective when placed at various locations around the pond. Reflectors suspended from a rope stretched across the pond deter birds when turned by the breeze. Suitable reflectors include aluminum pie plates and tin can lids.

Since birds do not scare easily, it may be necessary to physically exclude them from the trout pond to achieve effective control. Several methods of exclusion control can be used against great blue herons, the most common predator of stocked trout. Since they feed by wading in shallow water, steep drop-offs at the pond's edge prevent feeding. Also, if pond banks are steep, with a difference of at least 35 cm between the top of the bank and the water surface, herons will be unable to feed from shore.

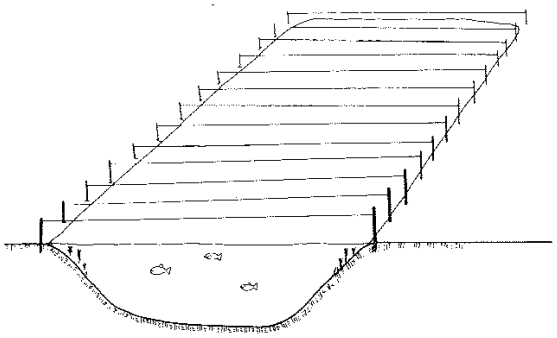
If pond banks are not steep perimeter fencing can be a very effective control. Strands of twine attached to posts at the water's edge and stretched around the pond at heights of 20 and 35 cm prevent herons and other wading birds such as bitterns from entering the water to feed. This method is most effective for ponds with relatively small areas of shallow water near the edges.



Perimeter Fencing

If large shallow areas exist, overhead wires will prevent the herons from landing in the shallows. Twine or heavy monofilament line should be stretched above the water to stakes or posts on each side, at intervals of about 30 cm. It will still be necessary to protect the edges by means of perimeter fencing.

Effective control of gulls, terns, pelicans, cormorants, loons, mergansers and grebes can be achieved by a system of overhead lines, as described for great blue herons. Lines need to be spaced about 30 cm apart for terns, while a larger spacing is sufficient for the other species. Best protection is achieved by placing the lines 20 to 30 cm above water level.



Overhead Lines

The only sure method of preventing depredation by kingfishers is complete enclosure of the pond, as most other methods have little effect. Once kingfishers establish themselves near a pond, they are very difficult to drive away. The most critical period for their control is during the spring migration, when kingfishers are seeking nesting sites. A combination of various frightening devices at this time may encourage kingfishers to nest elsewhere. Once established, kingfishers quickly become used to the noises of scare cannons and other scare devices. Posts and trees should be removed from the pond area, as these provide observation perches and may attract the birds.

Mink are the most troublesome animal predator at trout ponds; however, the raccoon occasionally causes problems in southern areas of the province. Scare tactics such as the use of scare cannons or cracker shells should be tried but, if unsuccessful, the only alternative is to trap or shoot problem animals. Animals causing damage on farms may be destroyed, but all incidents should be reported to the local conservation officer. In the case of mink, if the farmer wishes to retain the pelt, it is necessary to first obtain a trapper's licence and follow all trapping regulations. A licence is not required to trap or shoot raccoons.

Large trout which have overwintered do not appear to prey on trout fingerlings stocked the following spring. The large trout apparently become accustomed to a specific diet (e.g. freshwater shrimp) and the newly-introduced fingerlings do not appeal to them as a food source.

4. **Fish Diseases**

Trout, like other living organisms, are subject to many forms of disease. The source of origin of live fish must be certified free of disease by an approved pathologist before entry is permitted into the province. Even with this control, there is always the possibility of diseased fish entering the province, or of fish becoming diseased once in Saskatchewan.

The presence of fish showing signs of disease should be reported immediately to the Ministry of Environment – Fish and Wildlife Branch.

5. **Muddy Flavour**

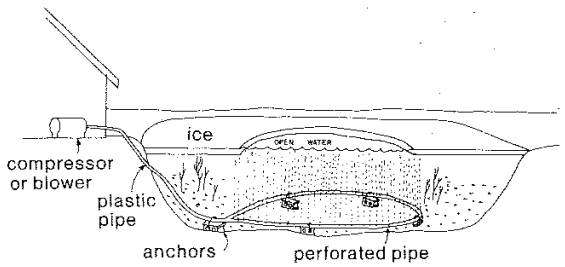
In some prairie ponds trout develop a rather unpleasant "muddy" taste and odour. Muddy flavor ponds are detectable only by trial plantings of rainbow trout. The presence or absence of muddy flavor in ponds is consistent from year to year and light plantings of trout the first year are sufficient for a test. The condition is particularly noticeable during the summer, but tends to diminish in the fall as the water temperature cools. The longer the fish remain in cold water in the fall, the less likely is the problem to persist.

6. **Aeration to Prevent Winterkill**

Oxygen depletion commonly occurs during the winter season in sloughs and dugouts. After ice forms in the autumn, snow and ice prevent diffusion of oxygen from the air, and light penetration is reduced, thereby reducing oxygen produced by photosynthetic activity. Decomposition of organic matter in the pond utilizes all of the available oxygen causing the fish to suffocate. A winterkill is said to have occurred.

Winter oxygen levels in ponds can be improved by means of aeration. This technique involves the addition of oxygen or air by artificial means, and has been used successfully by many Saskatchewan aquaculturists to provide sufficient oxygen for year-round survival of trout in winterkill ponds.

The most common method of aeration is the diffused air system used with success by many Saskatchewan fish farmers. A compressor or blower forces air through a perforated or porous plastic pipe near the pond bottom, and oxygen is transferred from the rising bubbles to the water. Best oxygen transfer is achieved with a small bubble size. This is a fairly efficient aeration system, but problems may be encountered with clogging of the holes in the pipe if the system is not used for long periods. This problem can usually be avoided by suspending the pipes about 30 cm above the pond bottom. Compressors used should be of the oiliness type, or oil coating the bubbles will lessen the diffusion of oxygen to the air. A check valve should be installed to prevent water from backing up and freezing the line in winter.

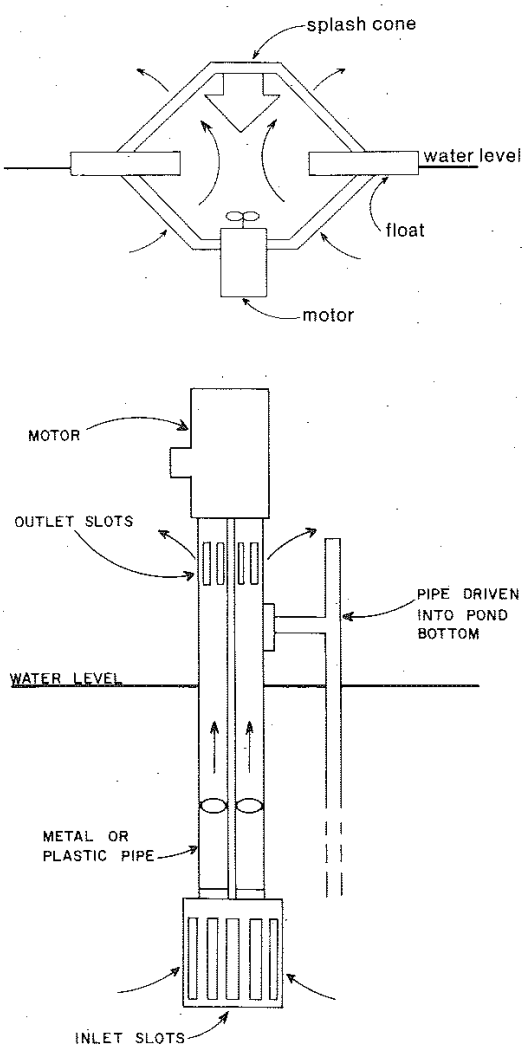


Air diffusion system for pond aeration.

Further information on equipment required and installation techniques for this type of aeration system can be obtained from local suppliers.

Spray type aerators work by propelling water upwards against a cone or through slots in a tube. The water forms a fine spray which absorbs oxygen, and some mixing of the pond occurs. These units can be mounted on floats and are easily moved when not in use. Both 115 volt and 230 volt models are available.

Spray type aerators cannot raise dissolved oxygen levels quickly in large ponds, but are useful when regular aeration is required to maintain suitable oxygen concentrations in smaller ponds. These units are the most efficient in terms of oxygen transferred for energy consumed and area ideal for use on dugouts less than 0.2 ha in size. This type of aerator has been successfully used during both winter and summer in Saskatchewan.



Spray-type surface aerators (cross-section).

When electrical power must be supplied to an aerator, a ground fault interrupt (GFI) breaker should be used. These breakers will trip if there is an electrical leak from the line and are essential for a safe aeration system.

Always disconnect the power supply to an aerator before doing any work on the water.

Wind powered pond mills have paddles which stir the water surface to mix in air and circulate water through the pond. A constant wind is required for their operation, thus they are not a totally reliable means of aeration. When used in winter, problems may be encountered with ice during calm weather.

Continuous aeration is usually not necessary to overwinter fish. Aeration for six to eight hours twice per week is usually sufficient in dugouts unless they are very large. Weekly monitoring of oxygen levels during the winter will help determine the frequency and length of aeration needed to maintain acceptable conditions. Electronic testing equipment is available, but chemical methods are less expensive and generally adequate for most use.

VII. Trout Harvesting

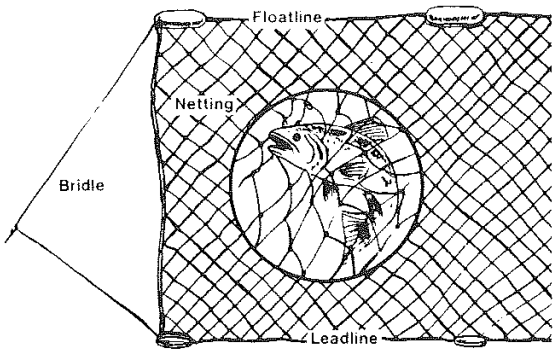
Harvesting the crop of fish is among the most troublesome problem experienced by trout farmers. The most common method of harvesting, and to date the most efficient method, involves the use of 5 cm to 9 cm mesh gill nets.

Seine nets are effective in small dugouts with a uniform bottom, but are rather expensive. The net is simply pulled through the water gathering the trout alive. Fish caught in seine nets are often of better quality than gill-netted fish, since they do not remain in the water for several hours and deteriorate as happens when gill nets are used. Net suppliers will make up seines to any depth and width.

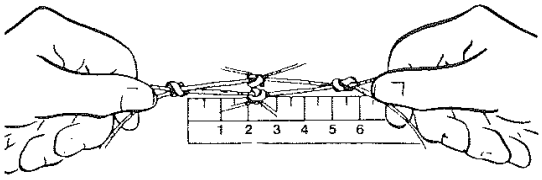
Many trout farmers try angling, but this provides more of a recreational opportunity than a means of harvest. Catching rainbow trout on lures in potholes and dugouts proves a difficult task; however, fly fishing provides satisfying results and is becoming an increasingly popular sport.

Selecting the Right Gill Net

It is important to have the correct size of gill net for the size of fish available. The thread of the gill net catches fish behind the gill covers as the fish try to swim through the mesh. Mesh size should allow only the head of the fish through. At this point, the fine threads catch behind the gills and the fish can go neither forward or backward.



Mesh size of gill net is measured by pulling on opposite knots until the mesh square lies in a straight line.



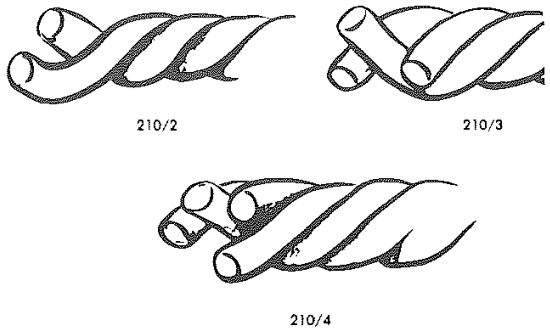
Determining Mesh Size

Most trout grown in Saskatchewan waters catch best in 6.0 cm and 7.5 cm mesh nets after one summer's growth, 5.0 cm mesh catches the smaller fish and 9.0 cm catches the larger ones.

The following tables show an approximate correlation between the length and weight of rainbow trout, and the recommended mesh size to use in harvesting:

Length (cm)	Approx. Weight (grams)	Recommended Mesh Size
20.0	130	5 cm mesh
21.0	155	
22.0	180	
23.0	205	
24.0	235	6.0 to 7.5 cm mesh
25.0	265	
26.0	300	
27.0	340	
28.0	370	
29.0	410	
30.0	450	9.0 cm mesh
31.0	500	
32.0	550	

Gill nets are manufactured with varying sized thread (e.g. 210/2, 210/3, 210/4, etc.)



The finer the thread used to make a gill net, the more trout it will catch. Fine thread is more difficult for fish to see, and it clings to and entangles the fish better than heavier twine nets. Nets with 210/2 twine are efficient for trout farming.

For most winterkill ponds, nets of 45 m or less are the easiest to handle. Shorter nets should be used for dugouts and other small ponds, 90 m nets are more efficient on large lakes.

Net depth should be between 1.5 and 3.0 m depending on depth of the pond.

If there are several local trout farmers whose anticipated harvest is small, it would be advisable to buy nets co-operatively. When ordering nets, mesh size, thread size length and depth required must be specified. Nets should be ordered from a supplier well in advance (July or early August) to ensure delivery by harvest time.

When to Harvest

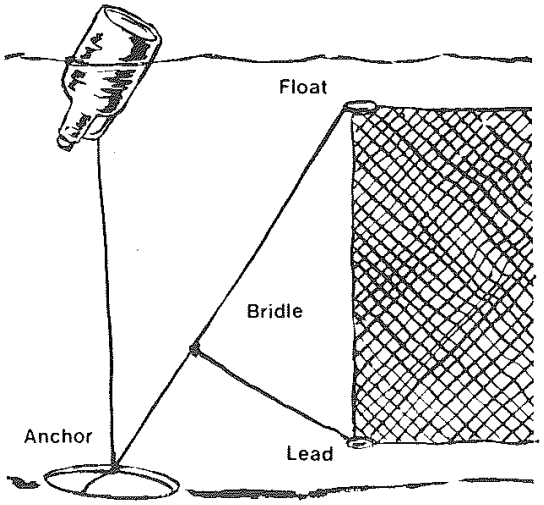
Harvest should be delayed until shortly before or just after freeze-up. Besides adding to the growing season, exposure of fish to cooler water temperatures improves flesh quality and reduces muddy taste problems. Harvesting after freeze-up greatly reduces spoilage problems. Whether harvest takes place in open water or through the ice often depends on the amount of time at the trout farmer's disposal. Trout farming is a sideline activity for most farmers, and other agricultural harvesting operations take precedence in the fall.

Fall Fishing

The best time for open water fishing is during October. Delay beyond the end of October may prohibit the harvest of trout in open water, and cause nets to freeze in. The most productive nets are those set in the late afternoon and lifted early the following morning. Trout tend to avoid nets during daylight hours, especially in clear water.

Nets set perpendicular from shore toward the lake centre are generally most productive. It is best for two people to work together, one to handle the motor or oars and one to set the net. The top bridle can be tied to a tree or stake on the shore, and the net played out of the tub as the boat moves toward the centre of the pond.

The net bridle lines are tied to the anchor line (see illustration) and any extra slack pulled out of the net before anchoring.

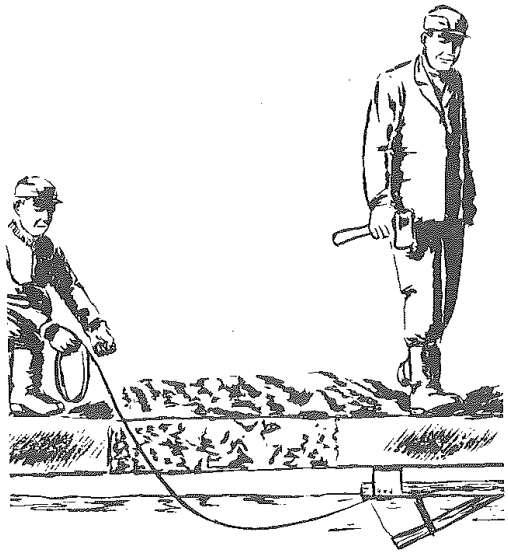


Nets should be "lifted" or "run" from the bow or side of the boat, moving into the wind. If the net is to be moved, it should be pulled into the boat and the trout removed in the process. If the net is to be left in the same location, then it can simply be pulled across the bow or along the side without lifting the anchor. The trout can be taken from the mesh and the net returned to the water.

Winter Fishing

Winter fishing should take place during November and December. There should be at least 10 cm of good ice before walking on the ice. Some ponds may winterkill as early as December, limiting winter harvest in such cases to three to four weeks.

Whereas fall harvesting necessitates equipment such as a boat and motor (or oars), winter fishing requires the use of an ingenious device known as an **ice jigger**. The jigger is lowered into the water through a hole cut in the ice and, being buoyant, floats to the underside of the ice.



It is then pointed in the desired direction and propelled along under the ice by means of jerking pulls of an attached line. Using an ice jigger requires two persons, one to propel the jigger along and the other to follow its movement under the ice (see following illustration).

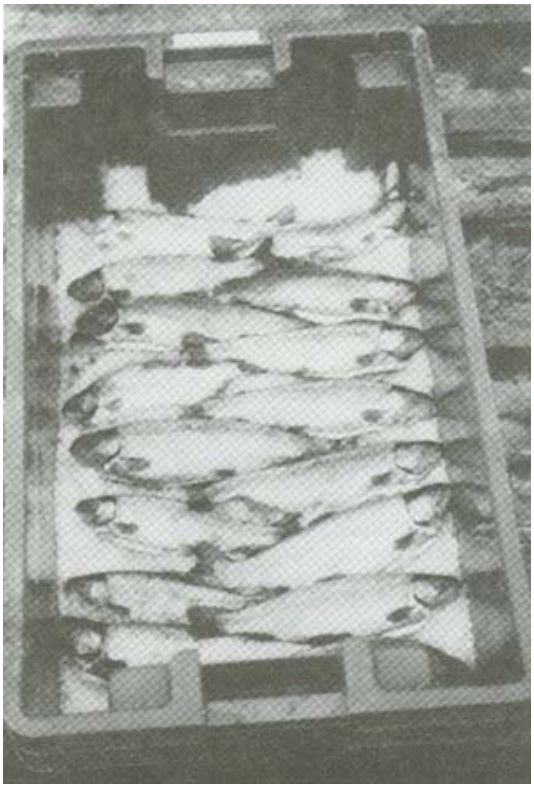
After the jigger is sent out to the desired distance, another hole is cut in the ice to remove the jigger, and the attached line is then used to haul a length of net between the two holes. The net is suitably weighted at each end to sink to the required depth. The net should be set deep enough so it does not float to the underside of the ice, otherwise the float line will "freeze in".

Ice jiggers are available from most gill net suppliers. For those trout farmers wishing to construct their own jigger, plans are included in Appendix II.

Recovery Rate to be Expected

A fish farming operation will produce variable results depending on the type of water selected, climatic factors, and management employed. Just as the productivity of farm land differs, so the productive nature of ponds differ.

The rate of stocking the size and condition of the trout at the time of stocking, and the method of stocking are all important factors affecting fish survival and, thus the number of trout harvested. The most prevalent problem affecting survival is summerkill, occurring with varying degrees of severity in different ponds, so fish kills may be partial or total.



Tub of dressed and iced rainbow trout.

Fish mortality is generally fairly high so do not expect all fish stocked to survive to harvest time. Recovery rates from zero to those in excess of 80 percent have

been reported: most Saskatchewan trout farm ponds have recovery rates of 20 to 40 percent.

Disappointing harvest results can often be attributed to a) an inadequate number or wrong size of nets, and b) insufficient time spent on harvesting.

Growth Rate to be Expected
The growth of rainbow trout in prairie winterkill ponds is highly variable, depending on a number of factors, including initial size of stock, stocking rates, length of growing season, variability between strains, and lake morphometry and fertility.

The final size of trout at harvest time is proportional to the initial size of fingerlings planted. Eight to 10 cm rainbow trout fingerlings planted in the spring commonly attain a weight of 450 g by fall, while 10 to 12 cm fingerlings may reach 550 g during the same period.

Experiences by Saskatchewan trout farmers indicate that growth in dugouts is considerably slower than in larger water bodies, due primarily to higher stocking rates in the former.

VIII. Handling, Dressing and Marketing of Rainbow Trout

Handling

Fish are much more perishable than other meats. Careful handling is therefore necessary at every stage of fish harvest and processing to ensure that spoilage will not occur.

When removing trout from the net, try to back them out rather than force them through the mesh. Forcing the fish through the mesh may cause the ribs to separate from the flesh and result in bruising.

Nets should be lifted daily (early morning) and preferably twice daily to avoid loss of drowned fish. Trout that have drowned quickly lose their characteristic bright colour, faded patches appear, the flesh becomes soft, and the gills change from dark red to pale pink. Such fish should be discarded.

Trout should be placed in crushed ice immediately upon removal from nets. Ice quickly reduces the fish temperature and slows the spoilage action by reducing bacteria growth. Immediate icing is the most important step in maintenance of high quality. After a fish is landed, decomposition begins almost at once. If fish are left lying in a boat, they will spoil after only a few hours. When fishing through the ice, of course there is no problem in keeping fish in good condition all day.

Handle trout carefully so they do not get bruised. Bruised fish spoil quickly. Keep harvesting equipment clean (ie. boats, tubs, etc.).

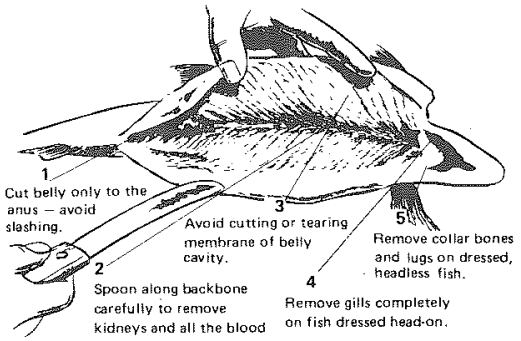
Dressing
Trout should be packed in ice during transport from lake to dressing location and dressed as soon as possible. A delay in dressing will cause rib separation, flesh discoloration and softening of whole trout even when they are well iced.

When dressing fish for private use or for sale directly to consumers, the dressing site must be maintained in sanitary condition. All equipment must be kept clean, and washed each time after use. Insecticides must not be sprayed near dressing facilities as this will contaminate the trout.

Trout should be re-iced or refrigerated immediately after dressing.

Fish offal should be placed in containers while dressing and disposed of some distance from the dressing site.

Proper dressing is important (see illustration)



Commercial producers planning to sell fish to wholesalers, retailers, and restaurants within Saskatchewan, or to markets outside the province, must process their fish in accordance with *Saskatchewan Fisheries Regulations*. Copies of these regulations and fish processing plant requirements are available from the Ministry of Environment.

Marketing
Only fish harvested under authority of a commercial aquaculture licence may be sold. Fish raised for private aquaculture purposes are intended for personal use only and may not be sold, bartered or traded.

Fish raised under authority of a commercial licence may be sold -

1. direct to **local consumers**, which means to Saskatchewan residents for their own consumption.

2. to **wholesalers, retailers and restaurants** within Saskatchewan, providing the fish have been processed in licenced fish processing facilities. Marketing of fish products by commercial aquaculturalists outside this province is subject to federal regulation.

3. to anglers on a "fee-for -fishing" basis. In this type of operation, the licensee may sell fish caught from the pond for a set fee.

The commercial aquaculture licence itself gives the fish farmer authority to sell his produce through any of the above mentioned channels. In all cases the commercial aquaculturist should keep a complete record of his entire operation throughout the year. A record of all fish harvested and sold will be required by the Ministry of Environment at the end of each season.

IX. Technical Assistance

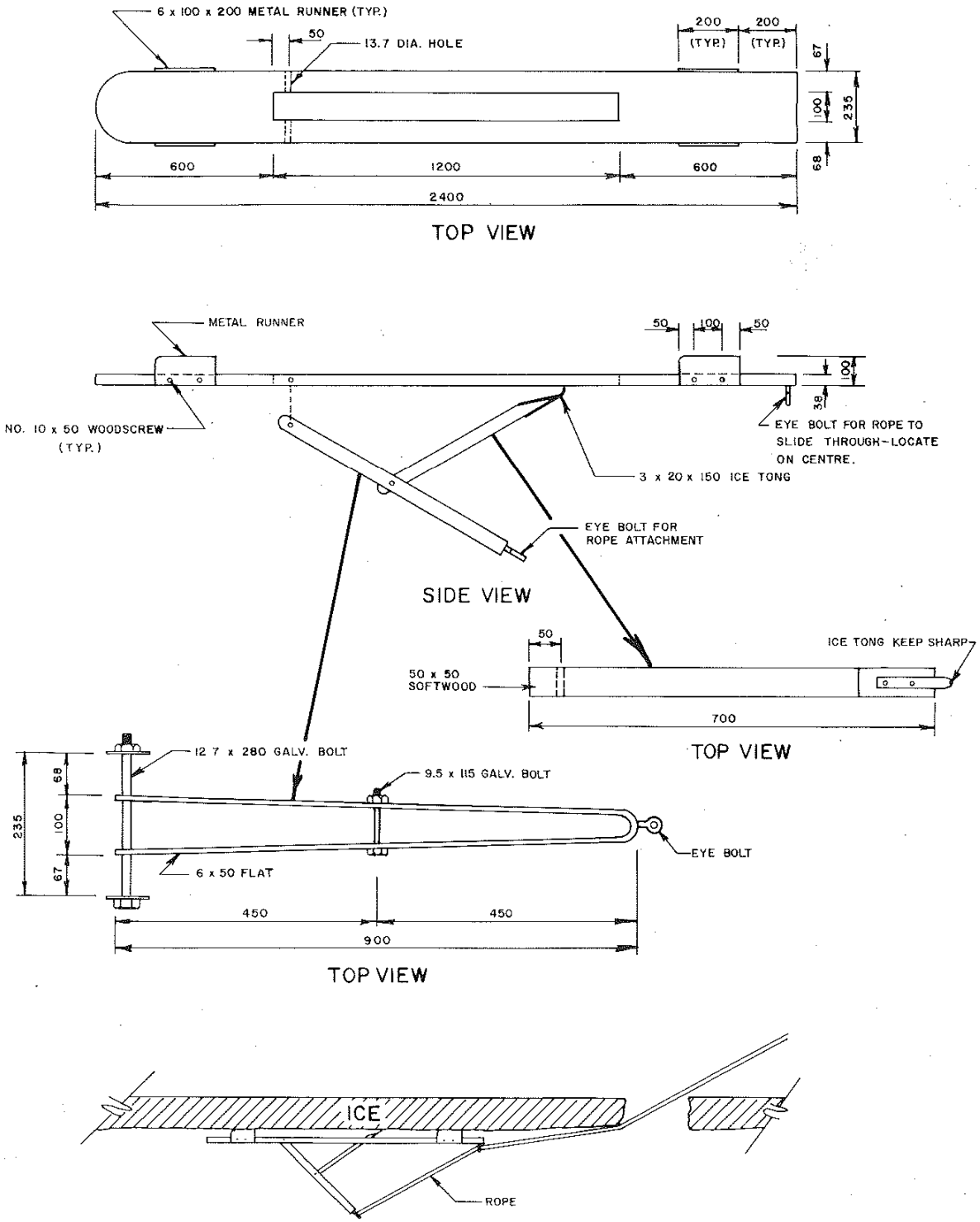
Technical advice and further information on subjects relating to fish farming may be obtained by contacting the Ministry of Environment – Fish and Wildlife Branch.

Information regarding applications, licences, and special local problems may be obtained from the Ministry of Environment Compliance Area offices.

Appendix I

Conversion Factors

To Convert	Multiply By	To Obtain
°C	(°C x 1.8) + 32	°F
°F	(°F – 32) x 0.5556	°C
acres	0.4047	hectares
centimetres	0.03281	feet
centimetres	0.3937	inches
centimetres	0.01094	yards
feet	30.48	centimetres
feet	0.3048	metres
gallons	4.5456	litres
grams	0.03527	ounces
grams	0.0022	pounds
hectares	2.4710	acres
inches	2.540	centimetres
inches	0.0254	metres
inches	25.40	millimetres
kilograms	35.274	ounces
kilograms	2.2046	pounds
litres	0.220	gallons
metres	3.281	feet
metres	39.37	inches
metres	1.094	yards
millimetres	0.03937	inches
ounces	28.349	grams
pounds	453.59	grams
pounds	0.4536	kilograms
yards	91.44	centimetres
yards	0.9144	metres



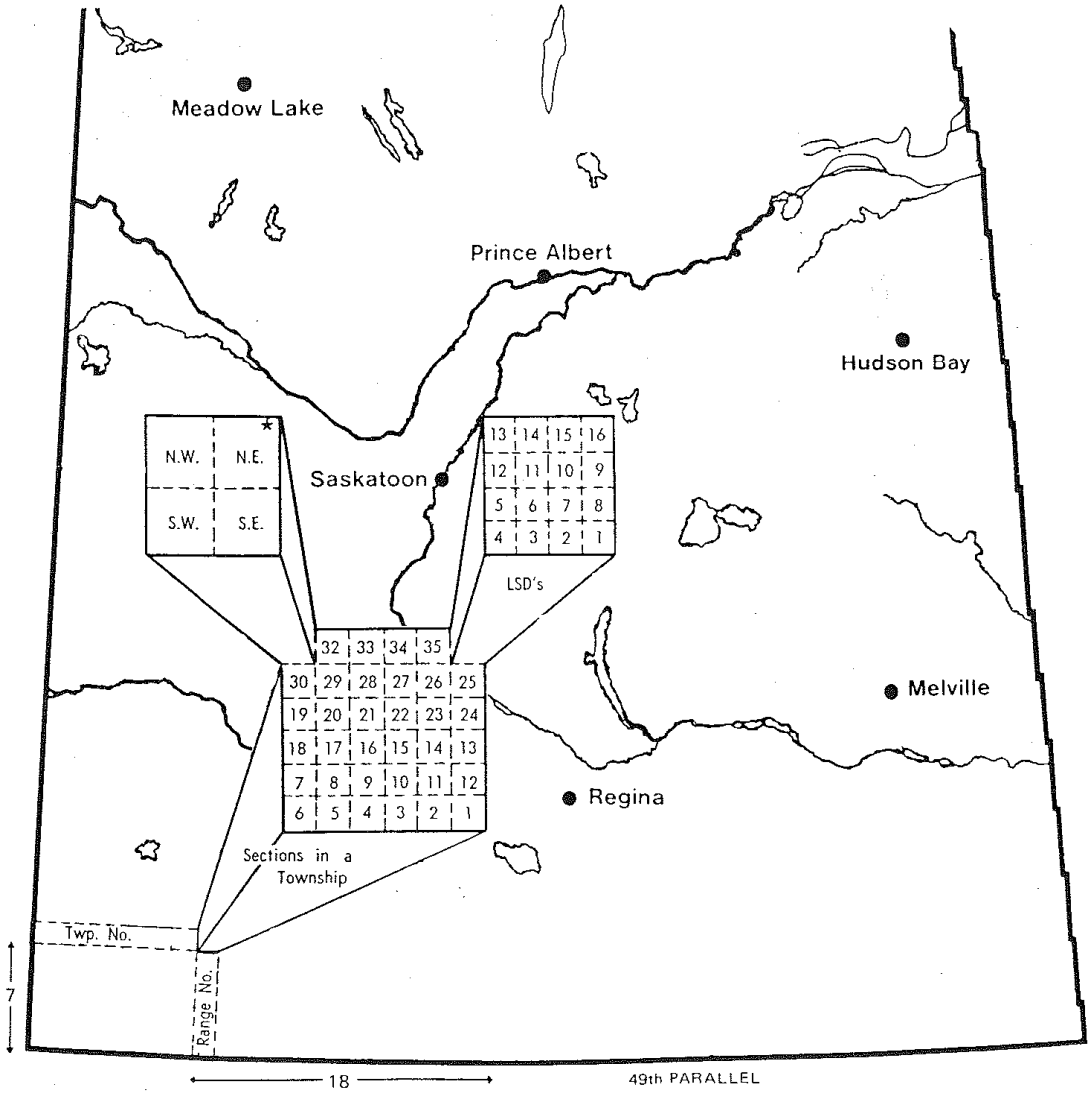
SIDE VIEW

ICE JIGGER IN OPERATION

All measurements are in mm.

Appendix II

Ice Jigger



Appendix III

Determining Pond Location

Agriculturally settled land in Saskatchewan is divided into blocks called townships, six miles square. The location of the blocks is indicated by numbered **townships** and **ranges**.

The ranges are six-mile wide strips of land running north and south, each numbered as west of a principal meridian. The townships are six-mile wide strips of land running east and west, numbered from the 49th parallel.

Each township is divided into 36 sections, each one mile square. The sections are numbered, beginning at the SE corner and ending at the NE corner, as shown in the example.

Each section has an area of 640 acres. Sections are further divided into quarter-sections, each containing 160 acres.

Sections may also be divided into blocks of 40 acres each, commonly called Legal Subdivisions (LSDs)

Locations are given in the following order: Section – Township – Range – Meridian.

The example shown would be: NE 31-7-18W3.

Appendix IV

Do's and Don'ts of Water Safety

1. Always wear a life jacket.

2. If you can't swim don't go out in a boat alone.

3. Never leave a running boat motor unattended.

4. Keep the floor of the boat clear. Put nets and fish in tubs, not loose on the floor of the boat. Keep knives sheathed when not in use. Stow ropes and anchor stones under the seats or out of the way.

5. Be particularly careful that, with extra equipment and fish, you do not overload the boat.

6. Keep the boat in good repair. Always carry oar or paddles in a motor boat.

7. Respect your boat and know its limitations.

8. Don't go out on a lake during rough weather or during a lightning storm.

9. Don't wear chest waders in a boat.

10. Be careful when operating a canoe. These craft are particularly dangerous if not handled by an experienced person.

11. Chances of survival are reduced considerably when falling into the cold water in the late fall or early spring because of low water temperature.

12. If winter fishing, make certain there is at least 10 cm of solid ice before walking on the ice: light vehicles require 18 to 20 cm of solid ice.