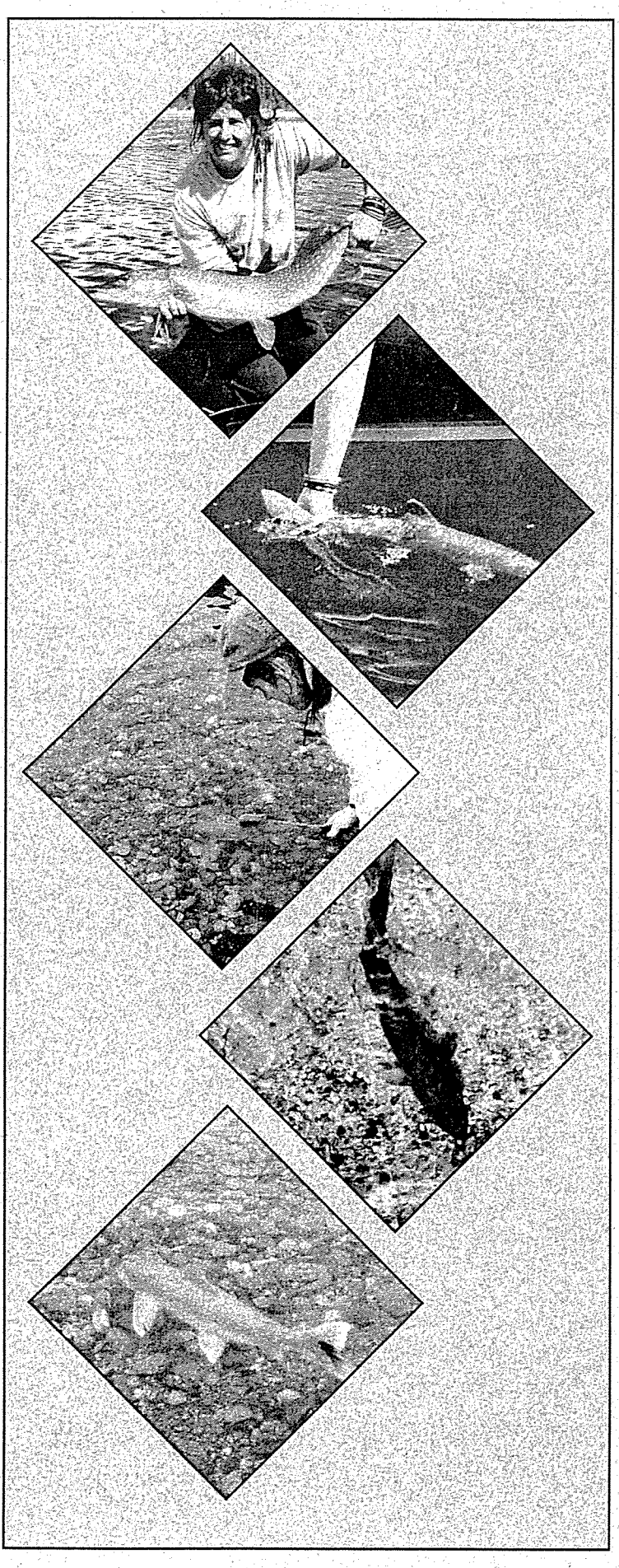

AN EVALUATION OF HOOKING MORTALITY RESULTING FROM LIVE-RELEASE FISHING PRACTICES

Prepared for the
Yukon Fish and Wildlife Enhancement Trust

by Laberge Environmental Services

October 1998

Report series #2

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ACKNOWLEDGEMENTS

We would like to thank Don Toews and the staff at the Fisheries Management Section of the Yukon Department of Renewable Resources for providing information on hooking mortality. Pat Milligan of the Department of Fisheries and Oceans kindly provided access to journals from his office library. The efforts of Dana Nordin in data collection and compilation are appreciated. Finally, we would like to thank the Yukon Fish and Wildlife Enhancement Trust for their guidance and support.

All photographs were provided by Yukon Renewable Resources.

Also available in this series:

The importance of fishing and fish harvesting to Yukon First Nations people, a summary, by Stephanie Muckenheim, August 1998 (Report series #1)

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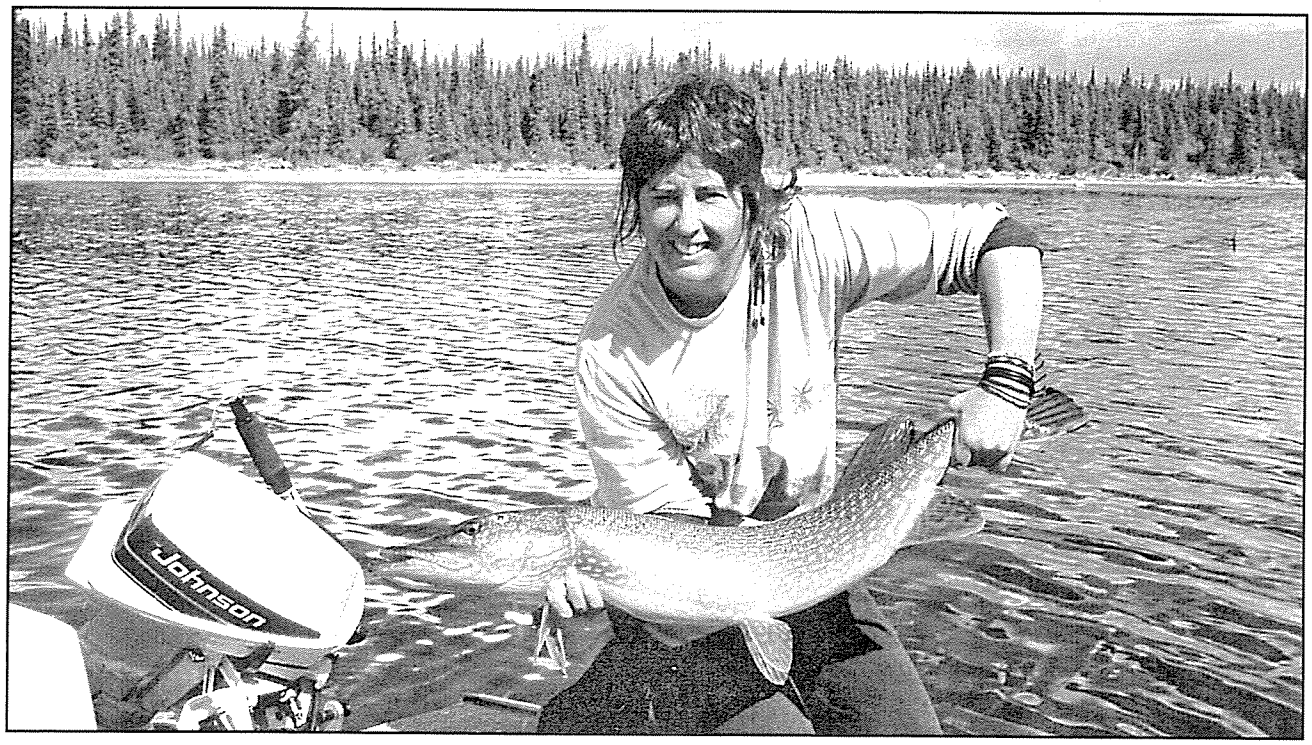
Introduction



The live-releasing of game fish has long been practised by Yukon anglers as a measure of conserving fragile northern fish stocks. The rationale behind live-release fishing is that anglers can voluntarily release legally caught fish (along with the mandatory release of sub-legal fish and slot limit fish in high quality waters), thereby increasing the number of fish that may be caught while controlling the size and number of fish harvested. The release of large spawners, in particular, is encouraged by the Yukon Department of Renewable Resources.

The success of this conservation effort depends entirely on the survival rate of the released fish. A number of factors influence the survival rate of released fish such as the fishing gear used, handling methods, playing time, and environmental factors such as the water and air temperature. With proper equipment and handling techniques, the extent of hooking mortality can be minimized, although a portion of the fish that are poorly handled and released inevitably succumb to injury or exhaustion.

There is currently little information on the impacts of live-release practices on Yukon fish populations. Limited data has been collected on the movements of tagged fish that have been angled and released on several Yukon lakes. There have, however, been a number of more intensive studies carried out on the hooking mortality of game fish by anglers in other North American jurisdictions, including studies on the main wild game fish species that occur in the Yukon, such as lake trout, northern pike, arctic grayling, chinook and coho salmon. The objective of this report is to summarize what information is available on the hooking mortality of these northern fish species and to highlight the factors that cause this mortality.

Previous studies

Research on hooking mortality has been carried out in North America for the past 60 years. Much of this work has focused on "southern" species such as largemouth bass, walleye, and stream populations of trout (brown trout, brook trout and cutthroat trout). The majority of these experiments have been designed to determine the extent that the mortality of released fish can be attributable to the injury inflicted by various types of terminal fishing gear, such as hooks, lures, artificial flies and natural bait. Others assess the effectiveness of fish handling and releasing techniques.

A more limited number of hooking mortality studies have been carried out on "northern" game fish species, such as lake trout, northern pike, arctic grayling, chinook and coho salmon. Few studies have been conducted north of 60° latitude. No field studies on hooking mortality have yet been done in the Yukon, although fish tagging projects on Tagish Lake, Mandanna Lake and Wellesley Lake have resulted in some information on the fate of lake trout that have been repeatedly caught and released by anglers.

The studies on northern fish species primarily assess the mortality caused by particular angling equipment or fish handling practices without addressing the potential impact of this mortality at the population level.

FISHERIES MONITORING OF LIVE RELEASE TAGGING INFORMATION

The Yukon Government Department of Renewable Resources, Fisheries Section has completed several tagging projects throughout the Territory in ongoing efforts to assess fish stocks. Floy or spaghetti tags are currently being used in several lakes including Tagish, Mandana, Wellesley, Aishihik, Canyon, Sekulmun and the lower Kathleen system. Sonar or radio tags have been used in the lower Kathleen system, Wellesley, Mandana and Deazdeash lakes. Fish that are tagged are primarily lake trout, but some rainbow trout, arctic grayling and whitefish have also been tagged. The sonar and radio tags have been used in lake trout and rainbow trout. All of the tags in Mandana, Wellesley and the Kathleen system have been applied to fish that were captured by angling methods using barbless hooks.

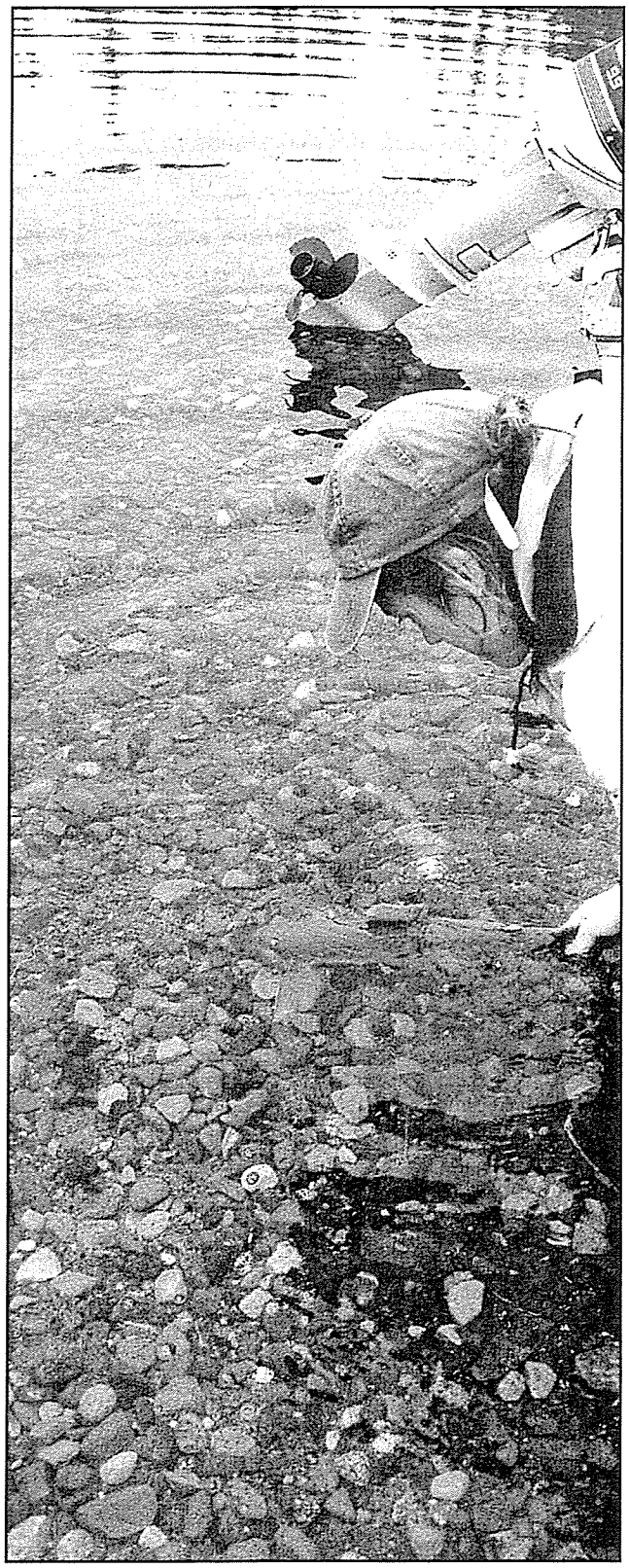
In each of these cases a percentage of the tagged fish have been recaptured in subsequent years by anglers and ourselves. In lakes where we have a reasonable sample size of tagged fish, the recaptures are relatively frequent. Some fish have been recaptured several times over a period of several years. The sonar and radio tagged fish were all periodically relocated and tracked around their respective lakes for subsequent periods of time which varied from project to project.

All of our tag recaptures, returns and monitoring of sonar and radio tags indicate an excellent level of survival after the tagging event. The sonar tags are especially indicative of this as the fish were angled, handled for a moderate period of time as the tags are inserted surgically into the body cavity and then the fish is released. In all cases, with one exception, fish survived well and were recurrently relocated. The one exception was a fish which died after surgery before being released. In a number of cases fish which were hooked deeply and which were bleeding when released after applying a Floy tag were recaptured in a subsequent year.

Exact details on numbers of fish and locations of projects are in our files and available upon request.

• *information provided by Renewable Resources, December 1, 1998*

Review of hooking mortality studies: northern species



The following reports on the mortality of live-released game fish were selected because they include studies on northern fish species. The results of these studies, therefore, may have significant implications for the management of the Yukon freshwater sports fishery. The majority of these studies were carried out on lake trout, while others have focused on northern pike, arctic grayling, chinook and coho salmon.

Annotated summaries

Lake trout

- *An Evaluation of Lake Trout Hooking Mortality in the Upper Great Lakes.* Loftus, Taylor and Keller, 1988.

This study took place at lakes Michigan, Huron and Superior during 1984 and 1985. A sample size of 67 fish was used, ranging in size from 461 to 801 mm. Fish were caught in open water at depths between 7.5 and 49 m by recreational anglers and commercial charter boat operators. Most fish were caught by deep trolling with artificial lures attached to downriggers. The three main lure types used were small plug-like lures with small treble hooks, spoons with large treble hooks and spoons with large single hooks. Playing time ranged from 53 seconds to 5 minutes, with deck times of 1 minute and 10 seconds to 4 minutes 30 seconds. Fish were tethered to floats with 60 metres of monofilament line and their condition was monitored for 48 hours.

Survival rates were 85% overall, with 80% for treble hooks and 93% for single hooks. Playing time and deck time, as well as temperature differential and angling depth, were found to have no effect on survival. There was a 71.4% mortality for internally hooked fish (gullet, gill arches, roof and floor of mouth), and a 6.9% mortality for mouth hooked fish (upper or lower jaw). Small fish were found to have the highest mortality rate. It was found that most bloated floating fish eventually swim down and survive. The headfirst plunge method of release was recommended, and burping and puncturing were not necessary. The conclusions found in this study support the use of season limits, size restrictions and creel limits as effective methods for reducing sport fishing mortality.

◆ *Hooking Mortality of Lake Trout Angled Through Ice by Jigging and Set Lining.* Persons and Hirsch, 1994.

This ice fishing study took place at Gunflint Lake, Minnesota in January 1991. A sample size of 96 fish was used. Fish were caught by angling through the ice by means of set lining and jigging at 8 to 15 metre depths. Dead fish bait was used with single or treble hooks. Air temperature ranged from -5 to -30°C. Fish were put in water-filled coolers, transported from 0.2 to 2.4 kilometres and put in an underwater crib at 12 metres depth for 7 to 10 days.

Overall survival rate was 76%, with 68% for fish caught by set lining and 91% for fish caught by jigging. Mortality for gill or gut hooked fish was 36%, mouth hooked fish mortality was 29% and lip hooked fish mortality was 0%. Of set lined fish, 70% were gut or gill hooked, and 11% were lip hooked. Of fish caught by jigging, 9% were gut or gill hooked, and 64% were lip hooked. Hooking location was found to be the primary mortality factor. Clipping line on deeply hooked fish was found to aid in survival. It was recommended that set line use be restricted if high release rates are desired.

◆ *Comparability of Mortality Between Barbed and Barbless Hooked Lake Trout.* Falk, Gillman and Dahlke, 1974.

A comparison of the effects of barbed and barbless hooks took place at Taltheilei Narrows on Great Slave Lake, NWT in 1974. A sample size of 129 fish, ranging from 320 to 960 cm in length (0.3 to 15 kg) was used. Researchers angled with barbed and barbless treble hooks with 1 to 3 trebles. Fish were caught in open water, with water temperatures of 5 to 9°C. Tanks were used for hook removal and transport. Transport time was up to 6 hours, with an average of 48 minutes. Fish were transported to, and held in cages at, a central location for up to 10 days, while being observed at durations of 24, 48, 72 and 96 hours.

Survival rates for fish caught with barbed hooks was 93.06%, and with barbless hooks, 92.98%. Hook removal and handling time was greater for fish caught with barbed hooks. Hook damage and bleeding was negligible, but was less for barbless hooks. All mortalities occurred during the first 4 hours, except for one which occurred after three days. Damage resulting from hook placement was found to be the main cause of death. Normal angling did not cause complete physiological exhaustion and fish quickly recovered. It was recommended that efforts be made to educate anglers about proper hook removal and handling techniques. The use of small mesh dip nets was encouraged for landing lure caught game fish.

◆ *An Assessment of Mortality for Lake Trout Angled from Deep Water.* Manitoba Department of Natural Resources, 1986.

The mortality of lake trout angled from deep water took place at Clearwater Lake, Manitoba, in July and August 1986. A sample size of 288 fish was used. Fish were caught by researchers and recreational anglers with single hooked jigs and treble jigs, barbed and barbless. Fishing was done in open water, with water temperatures of 10 to 18°C. Three different methods were used to assess survival. Forty-nine fish were held in cages from 18 to 48 hours at the depths at which they were caught. Six fish were implanted with sonar transmitters and the remaining fish were tagged and immediately released. Fish implanted with transmitters were tracked for one year.

Survival rate was 96% for cage held fish, and mortalities were likely caused by angler injury. The survival rate was 67% for transmitter-implanted fish, with mortalities likely due to stress from the implantation procedure. Of 89 angler tag returns, 70 had been hooked in the jaw area, 10 had been hooked in gills, 4 had been hooked in the eye and 5 had been hooked in the body. Barbless hooks reduced handling and releasing time, causing less injury. Ongoing tag returns lead researchers to conclude that catch and release is a valuable management tool for maintaining or enhancing the angling quality of lake trout.

◆ *Hooking Mortality of Lake Trout Angled Through the Ice.* Dextrase and Ball, 1991.

This ice fishing study took place at Little Raleigh Lake, northwestern Ontario, in February 1990. A sample of 50 fish was studied, ranging from 24 to 41 cm in length. The air temperature ranged from -8 to -14°C. Fish were caught by a volunteer angler using live bait fish and barbed single hooks in 2 to 7 metres of water. Fish were put into water-filled coolers and transported to a holding net within 5 minutes. The holding net was suspended under ice in 8 metres of water for 48 hours.

Survival rate was 90% overall. Of all fish caught, 54% were hooked in critical areas (deep mouth, gill and stomach) and 46% were hooked superficially (lips and mouth anterior to the first gill arch). Cutting lures rather than removing hooks from the deeply hooked fish was found to reduce mortalities. Hooking in gills was found to be the main mortality factor. All of the fish that died were hooked in critical areas and showed signs of bleeding. All fish which were hooked superficially survived.

◆ *Hooking Mortality Among Lure Caught Lake Trout.* Nadeau, 1982.

This study took place at Lake Maganasipi, Quebec, in May of 1981. Surface water temperature was 8.5°C. A sample size of 61 fish was used, ranging in size from 34.0 to 49.5 cm. Fish were caught by trolling with light casting gear using spinners with one barbed treble hook. After being caught, fish were placed in a nylon enclosure in water for 15-60 minutes and then transferred to a holding tank, where they were held for a minimum of 24 hours.

Overall survival rate was 88.5%. Of all fish caught, 84% were jaw hooked with no mortality, and 13% were hooked in gill arches. Hook placement was found to be the principal factor affecting survival rate.

◆ *Catch and Release of Lake Trout: An Experimental Management Program to Study Harvest Control Regulations in Algonquin Provincial Park.* Quinn and Hicks, 1988.

A catch and release mortality study was carried out at Smoke Lake, within Algonquin Provincial Park, on May 30 and 31, 1988. Surface water temperature was measured on May 30 at 17.8°C, with thermocline forming around 4 metres. A sample of 33 fish was taken, with a mean fork length of 34.2 cm. Fish were caught by 42 experienced anglers from the Ministry of Natural Resources and from the Whitney Fish and Game Club. They used a variety of gear with artificial lures, and a boat equipped with a holding tank and sampling facilities. Fish were placed in the holding tank to be tagged and examined. Fork lengths were measured and scales were taken for ageing. Three types of tags were used to assess survival. Ultrasonic pinger tags were attached to 5 fish, spaghetti tags were attached to 20 fish, and a streamer tag was attached to 1 fish. The tagged fish were then released, with the exception of 6 which were attached to a tether for 24 hour evaluation. Three fish were released untagged.

Six fish died during the study. Four died during handling and two of the tethered fish were found dead upon retrieval. This represents a survival rate of 82%. All dead fish were small, with a 29.5 cm average length. Small trout were found to be more vulnerable. Large trout seemed to withstand handling and releasing, and recovered quickly. The prime mortality factor was severe hooking and snagging. Five pinger tagged fish were monitored. One of the tags began malfunctioning at the outset, but the other four fish were tracked and were observed to be doing well. In mid-June, one of the tags ceased movement. It is not known whether the fish died or the tag fell off. Information regarding the other tagged fish is being accumulated as the fish are caught.

Northern pike

◆ *Mortality Data for Angled Arctic Grayling and Northern Pike from Great Slave Lake Area, Northwest Territories.* Falk and Gillman, 1975.

A study was undertaken to determine the mortality rates for angled northern pike (and arctic grayling — see below) in the vicinity of Brabant Island, Beaver Lake, Stark River and the Stephanie Minesite in the Great Slave Lake region from June to late August 1973 and 1974. Pike were angled from boats or shore using spinning and fly rods. A variety of lures, flies and hooks (barbed and barbless) were used. A total of 94 northern pike were caught (75 with barbed hooks and 19 with barbless hooks). All fish were transferred to holding cages anchored near the capture site and observed periodically for 96 hours. Conditions at the capture site were duplicated in the holding cages as closely as possible.

A mortality rate of 5.3% was reported for northern pike caught on barbed hooks and 10.5% for those caught with barbless hooks (average mortality rate of 6.4%). Hook damage and bleeding was light. The degree of hook damage was higher for those fish caught with barbless hooks than those caught with barbed hooks. Hook damage and bleeding depended more on hook placement than any other factor. Hooking in the gill arches and the gullet were the primary cause of damage.

◆ *Mortality of Northern Pike Captured and Released with Sport Fishing Gear.* Burkholder, 1992.

Two separate experiments were carried out in this study. In the first experiment, the mortality of northern pike caught and released with commonly used terminal tackles was estimated for multiple captures. This multiple capture experiment was conducted at Colorado State University between April 4 and July 21, 1991. 63 fish captured with gill nets from nearby College Lake were released into experimental ponds on the university campus. Terminal tackle types used in this experiment included double treble hooks, large treble hooks and single hooks. No bait was used. Captured fish were measured and tagged, and the tackle type, playing time, hook placement and level of bleeding was noted. The experiment lasted 102 days. Approximately 260 hours of fishing effort were expended to make 90 captures.

No mortality of northern pike resulted from catch and release angling in this experiment. Of the 63 original fish, 18 were never caught, 16 were caught once, 19 were caught twice, 8 were caught three times, 1 was caught four times and 1 was caught eight times.

One northern pike that had never been caught died during the experiment. Of the 90 captures, 64 occurred with double treble hooks, 18 with large treble hooks and 8 with single hooks. The size of the fish captured ranged from 400 to 900 mm (fork length).

In the second experiment of this study, the rates of mortality among different terminal tackle types was estimated. Four types of artificial lures were investigated: single hooks, single large treble hooks, single small treble hooks and double treble hooks. 240 northern pike (60 fish per tackle type) were caught at George Lake, Alaska, during June 1991. Each fish was measured and tagged, and the tackle type, hook placement, playing time and the level of bleeding was noted. The captured fish were then held in an enclosed area of George Lake from 5 to 16 days. A group of seined northern pike were held as a control for the experiment. The mortality rate was defined as the number of fish that died within five days of capture (by each tackle type) divided by the total number captured with each type of tackle.

No fish caught with double treble hooks or single hooks died during the experiment, whereas two fish caught with large treble hooks and three fish caught with small treble hooks died within five days of capture. One control fish also died within five days of capture. The mortality rate for northern pike held for 5 days after capture was therefore: 0.00% for fish caught with double treble hook lures, 3.33% for fish caught with large treble hook lures, 4.84% for fish caught with small treble hook lures and 0.00% for fish caught with single hook lures. The mortality rate for the control fish was 1.37%.

◆ *Hooking Mortality of Northern Pike Angled Through Ice.* Du Bois et al., 1994.

The hooking mortality of northern pike was studied at Long Lake, Lipsett Lake and Mendota Lake, Wisconsin from December to February 1992. Air temperature ranged from -6 to 4°C. A sample size of 185 fish was used, ranging in size from 325 mm to 759 mm. Fish were caught by volunteer anglers, using size 4 treble hooks baited with live white suckers, and size 10 Swedish pike

hooks baited with dead rainbow smelt. The total hooking and handling time ranged from 10 seconds to 315 seconds. The fish were placed in water-filled coolers and transferred to a holding net within 10 minutes of capture. The fish were held in the underwater holding net in 4.5 metres of water for 48 hours.

Survival rates were 94.1% overall, 99% for treble hooks and 67% for pike hooks. Of the 24 fish caught on pike hooks, 11 were deep hooked. Of the 161 fish caught on treble hooks, 26 were deep hooked. Of the 9 fish that died, 7 were deep hooked. Of 25 gill hooked fish, only 1 died. All 9 fish that died were bleeding, but 46 of 55 (84%) bleeding fish survived.

Arctic grayling

◆ *Mortality Data for Angled Arctic Grayling and Northern Pike from Great Slave Lake Area, Northwest Territories.* Falk and Gillman, 1975.

This study on the hooking mortality of arctic grayling was carried out in conjunction with the study on northern pike mortality in the Great Slave Lake region in 1973 and 1974 (see above). A total of 158 grayling were caught with a variety of flies, lures and hooks (119 with barbed and 39 with barbless) and transferred to holding cages as in the field study on northern pike.

The mortality rate for arctic grayling caught on barbed hooks was 11.8%, compared with 5.1% for those caught on barbless hooks. The degree of hook damage and bleeding was light. Hook damage was greater for those grayling caught with barbed hooks than those caught with barbless hooks. Hook damage and bleeding was most dependent on hook placement. Hook damage and bleeding was more severe on arctic grayling caught with spinning lures than those caught with flies.

Chinook and coho salmon

◆ *Hooking Mortality of Chinook Salmon Released in the Kenai River, Alaska.* Bendock and Alexandersdottir, 1993.

A study of the hooking mortality of chinook salmon took place on the Kenai River, Alaska, including early runs (May-June) in 1990 and 1991 and late runs (July-August) in 1989 and 1990. The sample consisted of 446 fish, with mean mid-eye lengths of 819 mm for males and 948 mm for females. Fish were caught by recreational anglers using artificial lures and lures with bait. Angling times ranged from 20 seconds to 1 hour, with an average time of 6.5 minutes. Tagging times ranged from 2 to 10 minutes, with an average time of 4.3 minutes. Fish were fitted with radio transmitters and tracked for 5 days.

The average survival rate for all experiments was 92.4%. Survival rates ranged from 89.4% during the 1989 late run to 95.9% during the 1991 early run. Of 24 fish hooked in vital areas, 11 (46%) died. Of 70 bleeding fish, 15 (21%) died. Survival estimates include effects of handling and tagging. Fish length, hooking location and bleeding affected survival. Small males had the lowest survival rates. Bleeding fish had less chance of survival, as did fish that were hooked in a vital location, such as gills, eye or tongue.

◆ *Mortality of Chinook and Coho Salmon in Their First Year of Ocean Life Following Catch and Release by Anglers.* Gjernes, Kronlund and Mulligan, 1993.

This juvenile salmon hooking mortality study took place in the Georgia Strait, British Columbia, from September 6 to October 14, 1985. The sample consisted of 413 juvenile chinook and coho salmon (ocean age 0), with a mean length for dead chinooks of 21.4 cm and for dead coho of 25.8 cm. Water temperature ranged from 10 to 14°C. during the study. Fish were caught by 4 volunteer anglers, trolling off a 10-metre boat using weights, flashers and artificial lures. Size 1/0 single hooks and size 4 treble hooks were used, both barbed and barbless. Fish were lifted on board by leader, without a landing net. Landing time was usually less than 1 minute, while hook removal took from 15 to 30 seconds. Fish were held for 6 to 8 hours in a holding tank. The numbers of dead and live fish were then recorded and the survivors were returned to the sea. The injury locations and fork lengths of dead fish were recorded.

Survival rates were 70% for chinook and 85% for coho. Large relative hook size in relation to fish size was found to increase hooking mortality. Fish caught on treble hooks were subject to considerably more handling and injury during hook removal than fish caught on single hooks, and removal of barbed hooks was more difficult than removal of barbless hooks. Single hooks carried a higher frequency of injury in a lethal location than treble hooks. Landing fish was more successful using single hooks.

◆ *Hooking Mortality of Chinook Salmon Released by Commercial Trollers.* Wertheimer, 1988.

The objectives of this study were to determine the immediate and short-term mortality rates of chinook salmon hooked and released from commercial trolling gear typical of the gear used in coho salmon fishing, and to examine the association of mortality with wound location. For 2 five-day periods, researchers chartered power trollers to fish in Hawk Inlet in southeastern Alaska. Operators of the trollers fished with their normal complement of coho salmon gear and operated in their normal manner. In total, 108 legal and 398 sublegal (less than 71 cm long) chinook salmon were caught.

Size was a factor in the mortality rate: 23.6% of the sublegal fish died and 13.0% of the legal fish died. In both size categories, fish hooked in the gills had the highest total mortality. The recalculated estimate of total hooking mortality for sublegal fish based on wound location was 25.7%. The recalculated estimate of total hooking mortality for legal and sublegal fish based on wound severity was 23.5%.

Discussion of study results

The results of the hooking mortality studies on lake trout, northern pike, arctic grayling, chinook and coho salmon are outlined below.

Lake trout

Mortality studies on lake trout indicate that hook placement (the part of the fish where the fish is hooked) is the major factor affecting the chances for survival after release. The Upper Great Lakes Study (Loftus et al. 1988) found that there was a

mortality rate of 71.4% for internally hooked fish (gullet, gill arches, roof and floor of mouth) compared to a 6.9% mortality for mouth hooked fish (upper or lower jaw). Similarly, Persons and Hirsch (1994) in their winter study at Gunflint Lake found a mortality of 36% for gill or gut hooked fish, compared to 29% for mouth hooked and 0% for lip hooked fish. Severe external snagging injuries, such as to the gills, eyes, etc. have been found to contribute to higher mortality in several of the studies.

The one study comparing the effects between barbed and barbless hooks on lake trout (Falk et al. 1974) was inconclusive. This extensive experiment on Great Slave Lake found no significant difference in the mortality rates (6.94% for barbed hooks and 7.02% for barbless hooks). It was reported, however, that bleeding and injury from hook placement and removal were less on lake trout caught with barbless hooks. Other studies report that the use of barbless reduces handling and releasing time.

The use of treble hooks has been linked to higher mortality in lake trout. The rate of mortality in lake trout caught during the Upper Great Lakes study (Loftus et al. 1988) was found to be 20% using treble hooks and 7% when single hooks were used. It was believed that higher mortality from treble hooks was attributable to the longer handling time and more extensive injury inflicted when removing these hooks. Mongillo (1984) concludes, however, that single hooks cause slightly higher mortality than treble hooks. The reason for this, he suggests, is that single hooks are more easily ingested, resulting in more internal injury than when treble hooks are used.

Fishing with live bait is also believed to contribute to higher hooking mortality in lake trout. Trout often swallow live bait, along with the hook, immediately upon striking. Dextrase and Ball (1991), however, reported a mortality rate of only 10% during their winter study using live bait on single hooks at Little Raleigh Lake in northwestern Ontario. They attribute this lower mortality to the practice of cutting lines rather than removing hooks from deeply hooked fish.

Larger lake trout have been found to have a higher chance of survival. Loftus et al. (1988) concluded during their Upper Great Lakes study that the smallest size category of fish experienced the greatest mortality.

Northern pike

The hooking mortality rates of northern pike have been found to be relatively low. Although pike are voracious feeders and will sometimes engorge the lure completely, the Great Slave Lake study (Falk and Gillman 1975) found average mortality rates of only 6.4%. An Alaska study by Burkholder (1992) on the hooking mortality of northern pike found that mortality ranged from 0% for fish caught on single hook lures to 5% for fish caught on large treble hook lures.

Hook placement has been found to be the primary factor affecting hook damage and mortality in northern pike. Hooking in the gill arches and gullet are the primary causes of mortality.

The use of barbless hooks in the Great Slave Lake study (Falk and Gillman 1975) proved to be of no benefit in reducing mortality in northern pike. The mortality was found to be 10.5% when

SUMMARY TABLE ON THE ANNOTATED BIBLIOGRAPHIES

Study	Dates and locations	Sample size	Fishing methods and gear	Survival rates	Comments
LAKE TROUT					
An Evaluation of Lake Trout Hooking Mortality in the Upper Great Lakes, by Loftus, Taylor and Keller, 1988	1984 and 1985, open water lakes Michigan, Huron and Superior	67	Deep trolling using 3 main lure types, from 7.5 m to 49 m deep	Overall: 85% Treble hooks: 80% Single hooks: 93% Internally hooked: 27%	Smaller fish had higher mortality rates, rates not affected by playing time, deck time, temperature or depth
Hooking Mortality of Lake Trout Angled Through Ice by Jigging and Set Lining, by Persons and Hirsch, 1994	January 1991, Gunflint Lake on Minnesota-Ontario border	96	Set lining and jigging at 8-15m deep, dead fish bait with single or treble hooks	Overall: 76% Set lining: 68% Jigging: 91%	Hooking location primary mortality factor
Comparability of Mortality Between Barbed and Barbless Hooked Lake Trout, by Falk, Gillman and Dahlke, 1974	June 1974, open water Great Slave Lake and Great Bear, NWT	129	Trolling or spinning rods with treble hooked lures	Barbed: 93.06% Barbless: 92.98%	Main cause of death was hook placement
An Assessment of Mortality for Lake Trout Angled from Deep Water, by Manitoba Department of Natural Resources, 1986	July and August 1986, Clearwater Lake, Manitoba	288	Angling from depths of 25 to 38m using single and treble jigs	Cage held fish: 96% Transmitter implanted fish: 67%	Transmitter deaths likely associated with stress of implant
Hooking Mortality of Lake Trout Angled through the Ice, by Dextrase and Ball, 1991	February 1990, Little Raleigh Lake, northeastern Ontario	50	Angling through ice in shallow water, 2-7m, using live minnows on barbed single hooks	Overall: 90% Hooked in mouth or superficially: 100% Hooked deep in mouth, gills: 81%	Cutting lures rather than removing hooks reduced mortality. All fish that died were hooked in critical areas
Hooking Mortality Among Lure Caught Lake Trout, by Nadeau, 1982	May 1981, Lake Magansipi, Quebec	61	Trawling with light gear using single barbed treble hook	Overall: 88.5% Hooked in jaw: 100% Hooked in gill: 12.5%	Hook placement was principal factor; all dead fish hooked in gill arches
Catch and Release of Lake Trout: An Experimental Management Program to Study Harvest Control Regulation in Algonquin Provincial Park, by Quinn and Hicks, 1988	May 1988, Smoke Lake, Ontario	33	Angling with a variety of gear using artificial lures	Overall: 82%	Small trout were more vulnerable than large trout; prime mortality factor was severe hooking and snagging
NORTHERN PIKE					
Mortality Data for Angled Arctic Grayling and Northern Pike from Great Slave Lake Area, Northwest Territories, by Falk and Gillman, 1975	June to August, 1973 and 1974, Great Slave Lake region, NWT	94	Angling using spinning or fly rods with lures, spinners, flies and hooks (barbed and barbless)	Barbed hooks: 94.7% (sample size - 75) Barbless: 89.5% (sample size - 19)	Hook damage and bleeding due to hook placement (gill arches and gullet) was main factor in mortality

Study	Dates and locations	Sample size	Fishing methods and gear	Survival rates	Comments
NORTHERN PIKE (continued)					
Mortality of Northern Pike Captured and Released with Sport Fishing Gear, by Burkholder, 1992	April and July 1991, College Lake, Colorado	63	Caught with gill nets then put in ponds, angled using baitless double and large treble hook and single hooks	100%	No mortality with any of the equipment
	June 1991, George Lake, Alaska	240	Angled using single hook, single large treble hook, single small treble hook, and double treble hook. All were artificial lures.	Double treble hook: 100% Large treble hook: 96.7% Single hooks: 100% Small treble hook: 95.16%	Statistically there was little significant difference between tackle type
Hooking Mortality of Northern Pike Angled Through Ice, by Du Bois et al, 1994	December 1992 to February 1993, Long Lake, Lipsett Lake and Mendota Lake, Wisconsin	185	Angling through ice using #4 treble with live white suckers and pike hooks with dead rainbow smelt	Overall: 94.1% Treble hooks: 99% (sample size - 161) Pike hooks: 67% (sample size - 24)	45% of pike hooked fish were deeply hooked; 16.1% of treble hooked fish were deeply hooked. For live release, pike hooks should not be used
ARCTIC GRAYLING					
Mortality Data for Angled Arctic Grayling and Northern Pike from Great Slave Lake Area, Northwest Territories, by Falk and Gillman, 1975	June to August, 1973 and 1974, Great Slave Lake region, NWT	158	Angling using spinning or fly rods with lures, spinners, flies and hooks (barbed and barbless)	Barbed hooks: 88.2% (sample size - 119) Barbless: 94.9% (sample size - 39)	Damage and bleeding was due to hook placement and was more severe with spinning lures than with flies
SALMON					
Hooking Mortality of Chinook Salmon Released in the Kenai River Alaska, by Bendock et Alexandersdottir, 1993	July to August 1989 and 1990, May to June 1990 and 1991	446	Angling using artificial lures and lures with bait	Overall: 92.4% Lowest was 1989 late run of 89.4%, highest was 1991 early run of 95.9%	Small males had lowest survival rate; hooking location most significant factor affecting mortality
Mortality of Chinook and Coho Salmon in their Fist Year of Ocean Life Following Catch and Release by Anglers, by Gjernes, Kronlund and Mulligan, 1993	September to October 1985, Strait of Georgia, B.C.	413	Trolling using weights, lures, single and treble hooks, barbed and barbless	Chinook: 70% Coho: 85%	Chinook have higher mortality than same age coho; large hook size relative to fish size increased mortality; suggest using treble hooks rather than single hooks to reduce number of small fish hooked in lethal locations
Hooking Mortality of Chinook Salmon Released by Commercial Trollers, by Wertheimer, 1988	August 1988, Hawk Inlet, southeastern Alaska	506	Trolling using commercial gear for Coho	Overall: 76.5% Legal size (>71cm): 87% (sample size - 108) Sublegal: 76.4% (sample size - 398)	Size a factor affecting mortality; all fish hooked in gills had highest mortality; wound severity related to mortality

barbless hooks were used compared with only 5.3% for pike caught with barbed hooks.

During their study on three Wisconsin lakes, DuBois et al. (1994) concluded that pike hooks contributed to significantly higher mortality than treble hooks. They found that the use of treble hooks resulted in a mortality of less than 1%, compared to 33% when pike hooks were used. Pike hooks tend to hook fish deep in the mouth or in the gills, esophagus or stomach, causing crippling or fatal injuries.

Arctic grayling

The only study available on the release of angled arctic grayling (Falk and Gillman 1975) reported an average mortality rate of 10.1%. Barbless hooks were shown to reduce mortality rate from 11.8% to 5.1%. Spinning lures cause more hook damage and bleeding to arctic grayling than the use of flies.

Hook placement has been found to be the major factor influencing mortality rates of arctic grayling, as with most other game fish species.

Chinook and coho salmon

Wound location and the extent of bleeding appear to be the factors principally associated with mortality in released chinook salmon. The average mortality rate for chinook salmon caught by recreational anglers on the Kenai River in Alaska with artificial lures (Bendock and Alexandersdottir 1993) was determined to be 7.6%. 46% of the fish hooked in vital areas died (mostly within 72 hours of release).

Mortality has found to be highest in small males (<750 mm mid-eye length) compared with large males and all females (Bendock and Alexandersdottir 1993).

The selection of lures has shown to be a significant factor affecting mortality in both chinook and coho salmon. Gjernes et al. 1993 in his Georgia Strait study found that the use of treble hooks resulted in more handling and injury than the use of single hooks, although single hooks were more frequently placed in more lethal locations. They also found barbed hooks to be more difficult to remove than barbless hooks, though this did not contribute to a higher mortality rate.

Chinook salmon have been found to have a higher rate of hooking mortality than coho salmon (Gjernes et al. 1993).

Conclusions

The hooking mortality studies summarized in this report were all conducted outside of the Yukon. The data from these reports, however, should be applicable to Yukon waters, particularly the studies carried out for lake trout, arctic grayling and northern pike on Great Slave Lake.

The rate of hooking mortality in northern game fish

A wide range of hooking mortalities for northern game fish species have been reported in the studies that were reviewed. These, of course, reflect the variety of fishing gear and handling techniques that were employed. If the more destructive angling equipment is eliminated, however, it appears that hooking mortality can be minimized for all species.

If the deep-hooking of fish (internally and in the gill arches) can be avoided, and proper handling techniques are followed, the hooking mortality for all species can be reduced to nearly 0%. Some mortality resulting from deep-hooking appears to be inevitable, however, even with the use of unbaited, barbless hooks. Whether any level of mortality from the live-releasing of angled fish is acceptable depends on a number of factors, including the size, health and viability of the target fish stock as well as the current and anticipated angling pressure.

How to reduce hooking mortality

The following factors should be considered when trying to reduce mortality in angled game fish:

1. Hook placement is the most significant factor associated with injury and death of angled fish (all species). Gullet and gill hooked fish have low chances of survival.

   Live-baited hooks cause the most serious injury to fish. Single hooks are probably less harmful than treble hooks (although there is some disagreement about this). Artificial flies cause the least damage.

2. Handling time should be kept to a minimum. Barbless hooks are quicker to remove than barbed hooks. When handling deep-hooked fish, cutting the line is preferable to removing the hook.

3. Removing fish from the water during handling adds significantly to their exhaustion. Fish should be kept in the water during handling. Dip nets are useful in handling fish.

4. Playing time should be minimized when fish are to be live-released. This will reduce the exhaustion level of the fish and increase their chances of survival.

5. Fish caught from deep cold water should not be released in warm shallow water.

6. Exhausted fish should be held upright in the water until they begin to swim normally.

7. Small lake trout have been shown to be more vulnerable to hooking and handling than mature lake trout. Catching and releasing large numbers of these fish should be avoided. Small male chinook salmon are also particularly vulnerable to hooking and releasing.

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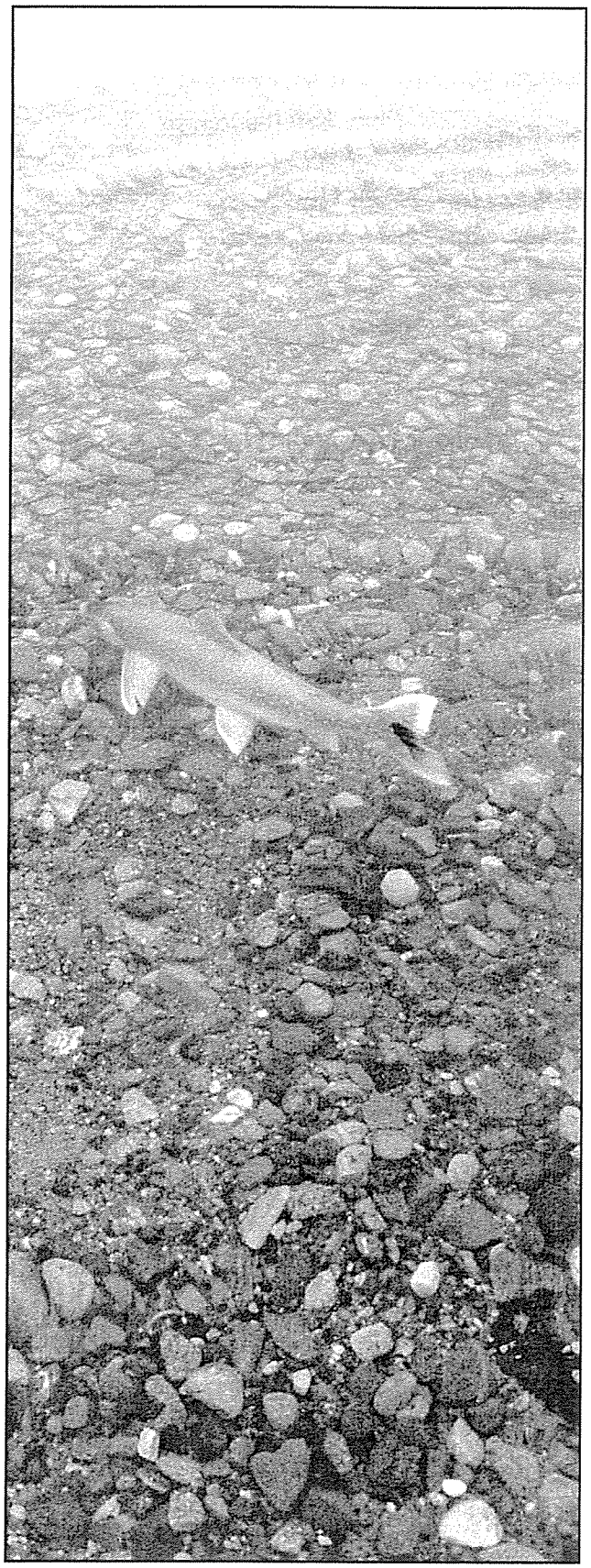

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Yukon Fish and Wildlife Management Board
Box 5954
Whitehorse, Yukon Y1A 5L7
phone (867) 667-3754, fax (867) 393-6947
e-mail: yfwmb@hypertech.yk.ca