

DEPARTMENT OF THE ENVIRONMENT

FISHERIES AND MARINE SERVICE

Fisheries Operations Directorate Central Region

TECHNICAL REPORT SERIES NO.: CEN/T-74-1

COMPARISON OF MORTALITY BETWEEN
BARBED AND BARBLESS HOOKED
LAKE TROUT

by

M. R. FALK

D. V. GILLMAN

and

L. W. DAHLKE

Fishery Management Division
Resource Management Branch
Fisheries Operations Directorate
Central Region
Winnipeg

1974

ABSTRACT

An experiment was conducted at Taltheilei Narrows on Great Slave Lake, N.W.T. to assess hooking mortality among lure caught lake trout (*Salvelinus namaycush*) and to compare the effects of barbed and barbless treble hooks on the frequency of such mortalities. Mortality rates were 6.94 and 7.02 percent, respectively, from barbed and barbless hooks. This difference is not significant. More than 50 percent of fish captured were hooked in the upper and lower jaws. Less than 18 percent of fish captured were hooked in critical areas such as gill arches, gullet and eyes. The degree of hook damage and bleeding was generally light, with slightly less damage inflicted by barbless hooks. Severe bleeding from the gill arches was the primary cause of death for both barbed and barbless hooks. Hook placement was the principle factor causing death among lure caught lake trout and the use of barbless hooks will not necessarily reduce the overall mortality rate. Education of anglers to employ proper handling and hook removal techniques is proposed to keep hooking mortality to a minimum.

ACKNOWLEDGEMENTS

The authors appreciate the assistance given by L. Cardinal, N. Klassen, K. Callele, J. Lawler, G. Welbanks, R. Davies and other Resource Management staff who took part in the study. Special thanks are due to the management and staff of Great Slave Lake Lodge for their cooperation throughout the project. Mr. M. R. Robertson, Mr. J. N. Stein and Dr. M. Healey kindly reviewed the manuscript and provided criticism.

TABLE OF CONTENTS

	Page
Abstract	iii
Acknowledgements	iv
Table of Contents	v
List of Figures	vi
List of Tables	vii
Introduction	1
Literature	2
Materials and Methods	5
Study Area	5
Holding Cages	5
Angling Equipment	5
Experimental Procedure	8
Results	12
Handling Times	12
Hook Placement	15
Hook Damage and Bleeding	16
Mortalities	16
Discussion	20
Summary	23
Recommendations	24
Literature Cited	25
Appendix	27

LIST OF FIGURES

	Page
1. Great Slave Lake showing the location of Taltheilei Narrows	6
2. Schematic diagram of experimental holding cages	7
3. Photograph of holding cages and mooring dock	8
4. Photograph of a live transport tank in position	8
5. Diagrammatic view of a lake trout mouth illustrating hook placement area	10
6. Length frequency distribution for lure caught lake trout at Taltheilei Narrows	13
7. Scatter diagram illustrating the relationship between landing time and fork length	14

LIST OF TABLES

	Page
1. Summary of the number of trout caught on different treble-hook lures at Taltheilei Narrows	9
2. The number of trout caught on barbed and barbless hooks at Taltheilei Narrows and other locations	12
3. Single and multiple hook placement for treble hooked lake trout	15
4. Summary of hook damage and bleeding for lure caught lake trout	16
5. Mortalities of lure caught lake trout caught on barbed and barbless hooks	17
6. Summary of lure caught lake trout mortalities and associated data	18

INTRODUCTION

In the past, the problem of how many fish die after being hooked, landed, unhooked and released has been the object of much discussion and considerable experimentation. Although it is known that some fish are killed due to hooking (Shetter and Allison 1955; Klein 1965, 1965-a; Bouck and Ball 1966; and Horak and Klein 1967) pertinent questions remain. These are: a) what is the reduction in numbers; b) does the subsequent growth by survivors balance the loss in numbers and c) how may fish death be minimized? Hooking mortality is an important issue since regulations may be required to enforce size limits or to implement gear restrictions.

Substantial numbers of lake trout (*Salvelinus namaycush*) are being caught and released by anglers on Great Bear and Great Slave lakes (Falk et al. MS 1973). High mortality among released fish could greatly increase the total harvest of game fish already being taken by fishermen from these lakes. In addition there have been no detailed studies to show that barbless hooks cause lower mortality. In response to these questions, Fisheries and Marine Service undertook to determine the hooking mortality among lure caught lake trout and to compare the effects of barbed and barbless treble hooks on trout survival.

LITERATURE REVIEW

Hooking mortality research dates from the pioneer studies of Westerman (1932) but it was not until the mid 1940's that the need for a better understanding of hooking mortality and its causes was recognized. The emphasis of subsequent research (Shetter and Allison 1955; Lasater and Haw 1961; Klein 1956; Stringer 1967; Hunsaker et al. 1970) has been towards establishing fish losses attributed to different types of hooks and lures. Other studies by Bouck and Ball (1966), Horak and Klein (1967), Parker et al. (1959), have dealt with the effects of fatigue and exhaustion among hooked fish.

Shetter and Allison (1955) showed that hooking mortality from "worm" fishing is significantly higher than that resulting from the use of artificial flies. Hooking mortality following the use of worms as bait was: brook trout (*Salvelinus fontinalis*), 42.4 percent; rainbow trout (*Salmo gairdneri*), 35.4 percent, brown trout (*Salmo trutta*) 4, 20.3 percent. Flies killed 3.31, 11.3 and 0 percent of these trout species, respectively. When brook trout hooking mortality data were combined with creel census figures, worm hooking was responsible for a reduction of between 17 and 32 percent in the potential population. Flies were estimated to have reduced this population by between 0.7 and 1.4 percent.

Klein (1965) found an overall mortality of 11 percent for "throwback" rainbow trout caught on flies and lures. Greatest losses (22%) occurred during late summer as a result of environmental conditions such as temperature and changes in condition of the trout. He noted that in the case of extensive throwback, the managing agency is in an untenable position from the standpoint of inhuman treatment and wanton waste of fish by fishermen. This is especially true when a substantial portion of the fish caught must be returned to the water and when these fish are of a size normally caught by fishermen.

Klein (1965-a) in a series of experiments designed to compare the effect of single and treble hooks, found that a single hook was taken farther into the mouth and inflicted a more serious wound. Treble hook placement normally occurred near the edge of the mouth. Out of a total angled sample of 543 rainbow trout, 10.3 percent died as a result of single hooks and 4.8 percent as a result of treble hooks. Approximately 50 percent of the mortalities occurred in the first day after capture.

Horak and Klein (1967) observed less than 5 percent mortality among angled rainbow trout 35 days after capture. They found that stamina was reduced as a result of angling but not significantly.

Stressful methods of capture were shown by Bouck and Ball (1966) to induce significant changes in plasma-protein composition as well as in erythrocyte parameters and mortality. Capture by angling produced sufficient stress to induce a condition of progressive shock. Excessive lactate accumulation was believed to be the cause. A high, but delayed, mortality of 87 percent occurred among hooked fish over a 10 day period.

Stringer (1967), found percent survival of rainbow trout captured on fly, treble hook and single hook (with worm) to be 92.1, 17.2 and 55.4-70.6 percent, respectively. Stringer concluded that capture and release of rainbow trout is not a serious problem in his study area since most anglers used artificial lures, especially flies. The high mortality for bait caught trout was determined, in part, by the area of hook penetration. Trout caught in the gill arch or esophagus generally died within a few hours after capture.

Deeply hooked rainbow trout were used by Mason and Hunt (1967) to determine if hook removal was beneficial to fish survival. Baited single hooks were used in this experiment. They found that trout usually die if deeply embedded hooks are removed. In contrast, if the hooks are not removed approximately two-thirds of the trout would survive and continue to grow.

Hunsaker et al. (1970) found no significant differences in mortality among rainbow trout caught with barbed and barbless flies (4.0 and 3.3%), treble-hook lures (2.7 and 6.0%) or trolled worms. A significant difference, however, was apparent for trout which swallowed the single-hook and worm. 73 percent mortality occurred among trout which swallowed the bait and 8.2 percent among those that did not. There also was a trend towards higher mortalities with increased water temperature.

Marnell and Hunsaker (1970) showed that 10 minutes of tiring does not cause complete physiological exhaustion in adult cutthroat trout (*Salmo clarki*). A mean mortality of 5 percent was observed among trout in combined water temperature and fatigue experiments. This was consistent with the expected range of hooking losses for this species caught on treble-hook lures (Hunsaker et al. 1970) and confirmed Stringer's (1967) contention that lure- caused mortalities in Salmonids will usually be less than 10 percent. Experiments showed no reason for concern that sexually

mature trout will not survive long enough to spawn if incidentally hooked and released with reasonable care.

Concern that excessive hooking mortality was occurring among Pacific salmon led Lasater and Haw (1961) to determine the hooking mortality from the use of treble and single hooks. They found no significant difference in the recovery of silver salmon (*Oncorhynchus kisutch*) caught with a treble hook compared with those with a single hook.

Black (1958) noted death in fishes under certain circumstances following severe muscular activity. The conditions he described included struggling in a live box, swimming through swift water and struggling on a trolling line. The precise cause of death is not known but it is likely that a severe acid-base disturbance following a large accumulation of lactic acid may be the principle cause. Black explained that hyperactivity as a lethal factor in fishes is of very great significance in fisheries management. The consequence of severe muscular activity is important in every aspect of handling fishes, for example capture, live transport, tagging and construction of fishways. Black (1957) found that following severe muscular activity for 15 minutes, blood levels of hemoglobin and glucose for lake trout were not altered significantly but the level of lactic acid increased sevenfold. After 24 hours the lactic acid level dropped to the initial unexercised level.

Chinook (*O. tshawytscha*) and coho salmon, caught by trolling, were observed to undergo hyperactivity by Parker et al. (1959). This condition often led to a distressed condition which was delayed, the severity of which could not be predicted for any individual at the time of capture. Death resulting from capture by trolling was observed to be significant. For coho, mortality was between 34 and 52 percent and for chinook salmon between 40 and 88 percent. They found that mortality rate and blood lactate levels were closely correlated with post-exercise time. For those fish which died, blood lactate rose until death. Survival occurred either when lactate did not reach critical levels (above 125 mg%) or reached a critical level and then subsided.

In summary, despite numerous studies on hooking mortality and its possible causes, a general statement cannot be made. Many factors, including the species of fish, type of lure, fishing method and environmental variables have to be considered.

MATERIALS AND METHODS

STUDY AREA

The main study was carried out at Taltheilei Narrows, located between Hearne Channel and McLeod Bay in the East Arm of Great Slave Lake, N.W.T. (Fig. 1). A description of this area has been previously given by Falk *et al.* (MS 1973). The area is unique in that a considerable current keeps the narrowest portion ice-free throughout the winter. As a result, large areas of open water often exist adjacent to the Narrows in early June while the remainder of the lake has heavy ice cover. Taltheilei Narrows is also well known for its abundance of lake trout and is the site of a sport fishing lodge. The ice-free conditions and availability of fish permitted the study to be done during the month of June. During July and August the experiment was continued on a reduced scale at three other sports fishing lodges on Great Bear and Great Slave lakes.

HOLDING CAGES

Angled fish were held at the site in 11 two-compartment holding cages measuring 3.05 x 1.22 x 1.87 m (Fig. 2). The cages were constructed of 5.08 cm aluminum angle framing, overlaid with 1.91 cm plastic netting. The frames were bolted together and the plastic netting attached with heavy wire. Styrofoam floats (1.22m x 0.31 m x 5.08 cm) were attached to each end of the frames, holding the cages approximately 15 cm out of the water. Holding cages were lashed to a dock anchored in a sheltered bay in 2 to 5 m of water (Fig. 3). Removable plywood covers prevented the escape of fish and provided shade during experiments. Fish were inserted and removed from the cages through a small opening in the plywood cover. Fish were transported from the capture site to the holding cage in plywood live tanks measuring 1.22 x 1.53 x 0.31 m (Fig. 4).

ANGLING EQUIPMENT

Trout were angled from boats using 1.24 to 1.83 m trolling or spinning rods and monofilament line from 1.82 to 9.08 kg test strength. A variety of treble hooked lures was employed depending mainly on the time of day, availability of fish and size of fish required. The types of lure used were, for the most part, representative of those used by guests at the nearby lodge. A breakdown of the number of trout caught on different lures is given in Table 1.

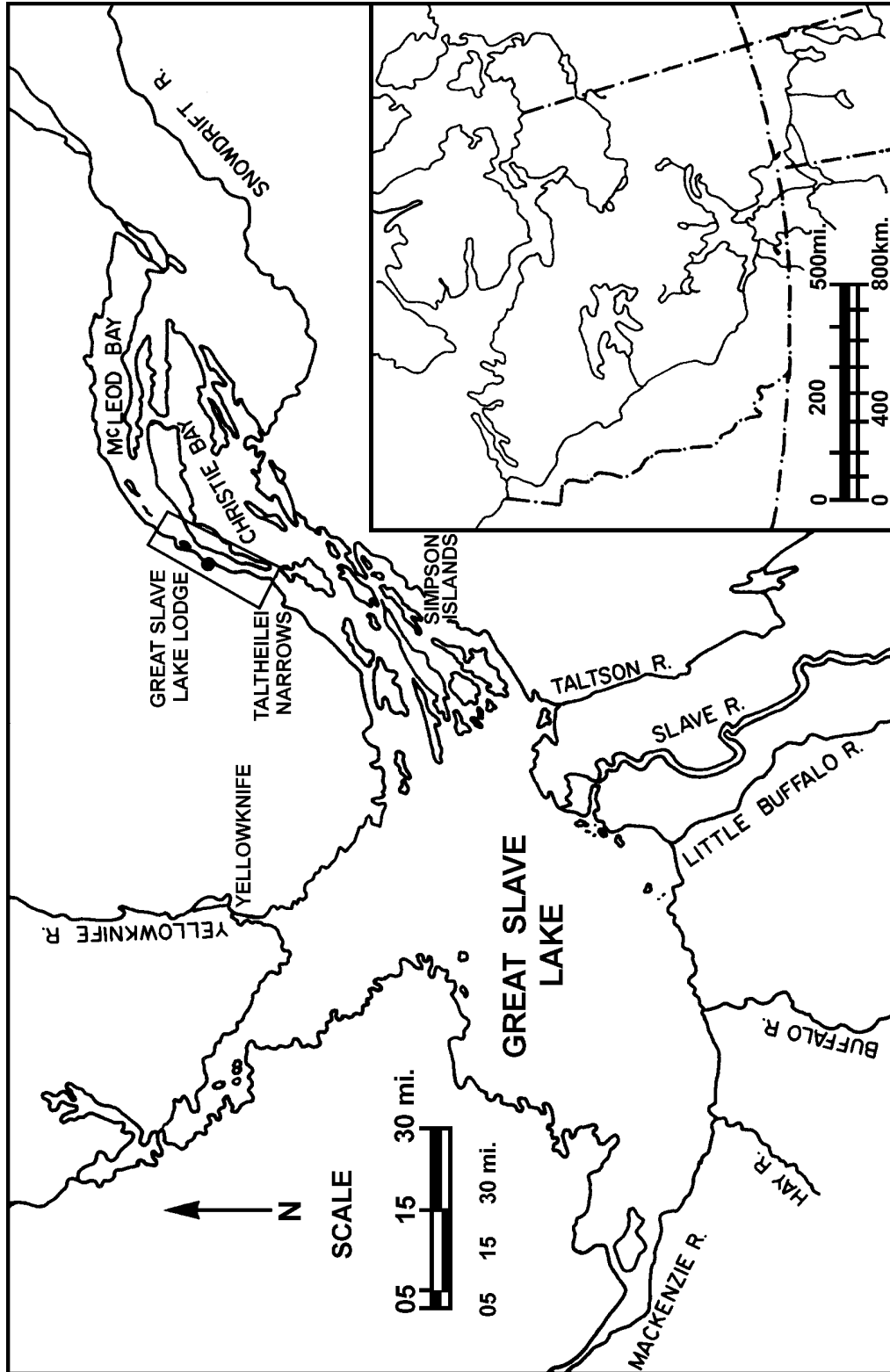


Figure 1. Great Slave Lake showing the locations of Taltheilei Narrows

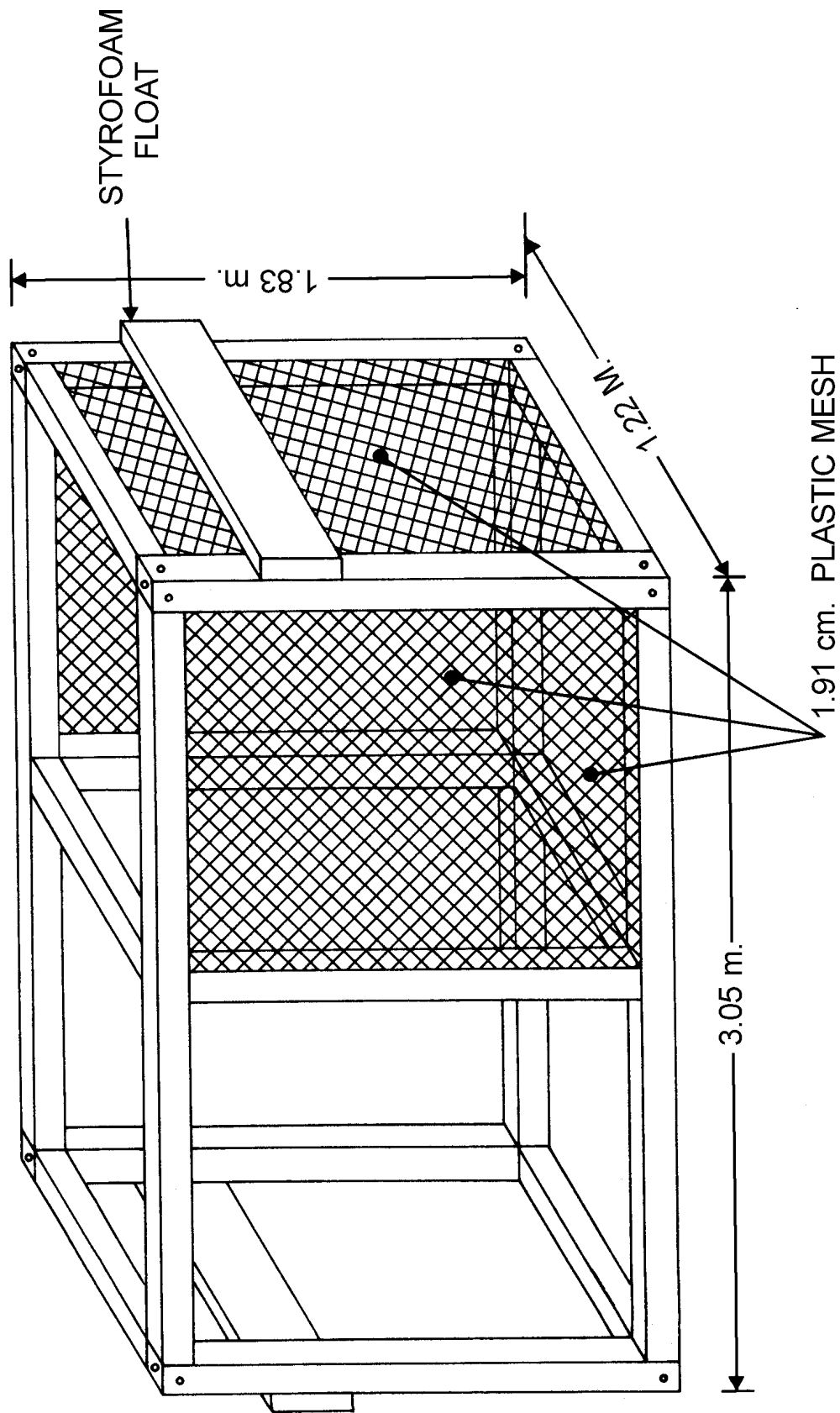


Figure 2. Schematic diagram of experimental holding cages.

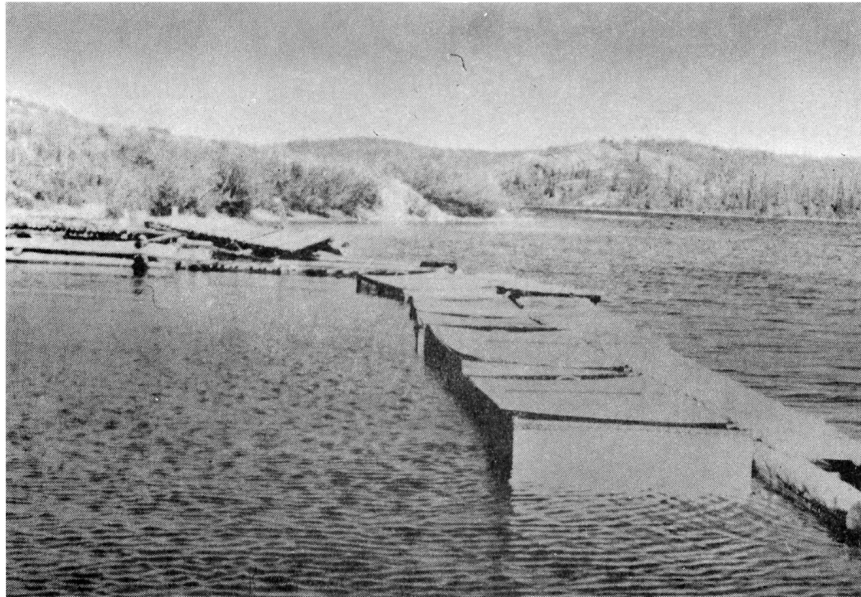


Figure 3. Photograph of holding cages and mooring dock.

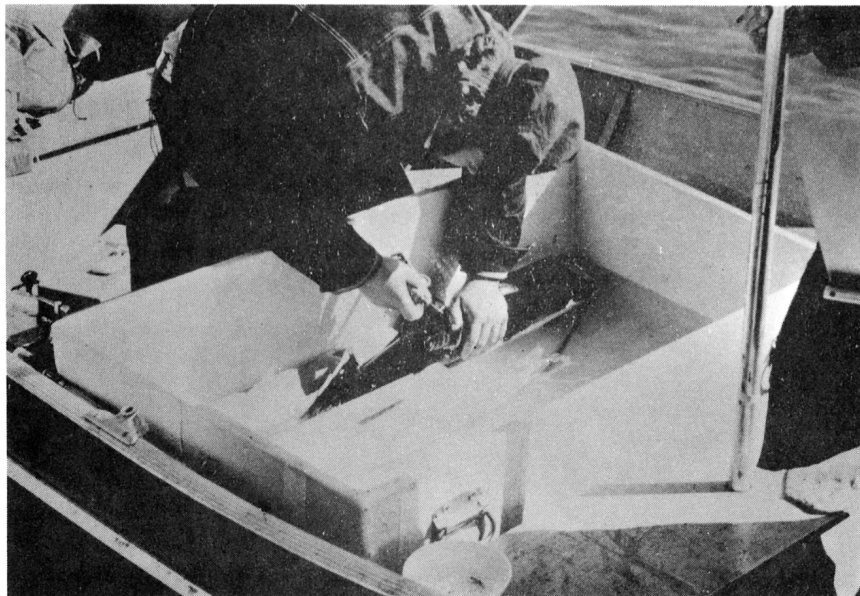


Figure 4. Photograph of a live transport tank in position.

Table 1. Summary of the number of trout caught on different treble-hook lures at Taltheilei Narrows.

Lure	No. of Treble Hooks	No. of Trout Caught
Flatfish	2	36
Rapalla	3	28
Cisco Kid	1	12
Five of Diamonds	1	9
Daredevil	1	4
Mepps Spinner	1	3
Lazy Ike	2	1
Silver Doctor	1	1

On different days some of the anglers were instructed to use barb- less hooks. Barbs were removed by pinching them back with needle nose pliers.

EXPERIMENTAL PROCEDURE

All personnel were given the same instructions at the start of the study. Basically, these were to fish for lake trout using the equipment described above and the methods typically used by lodge guests. A form was designed (Appendix) to record each capture and the subsequent observation period. Each section of the form: capture, transport, observation, tag and release was completed as it occurred.

When a fish was hooked, the transport tank was filled and a stopwatch started to record the capture time. Lake trout were either landed by grasping the leader or by using a dip-net (4.31 cm stretched measure). Immediately after landing the number of barbs embedded, hook placement, hook damage and bleeding were noted. Hook placement areas are illustrated in Figure 5. The fish was then placed in the live tank, covered and transported to the holding cages. Live fish were placed in the holding cage with a dip net. The cage number and the time of introduction were recorded. Fish were observed continuously for 15 minutes

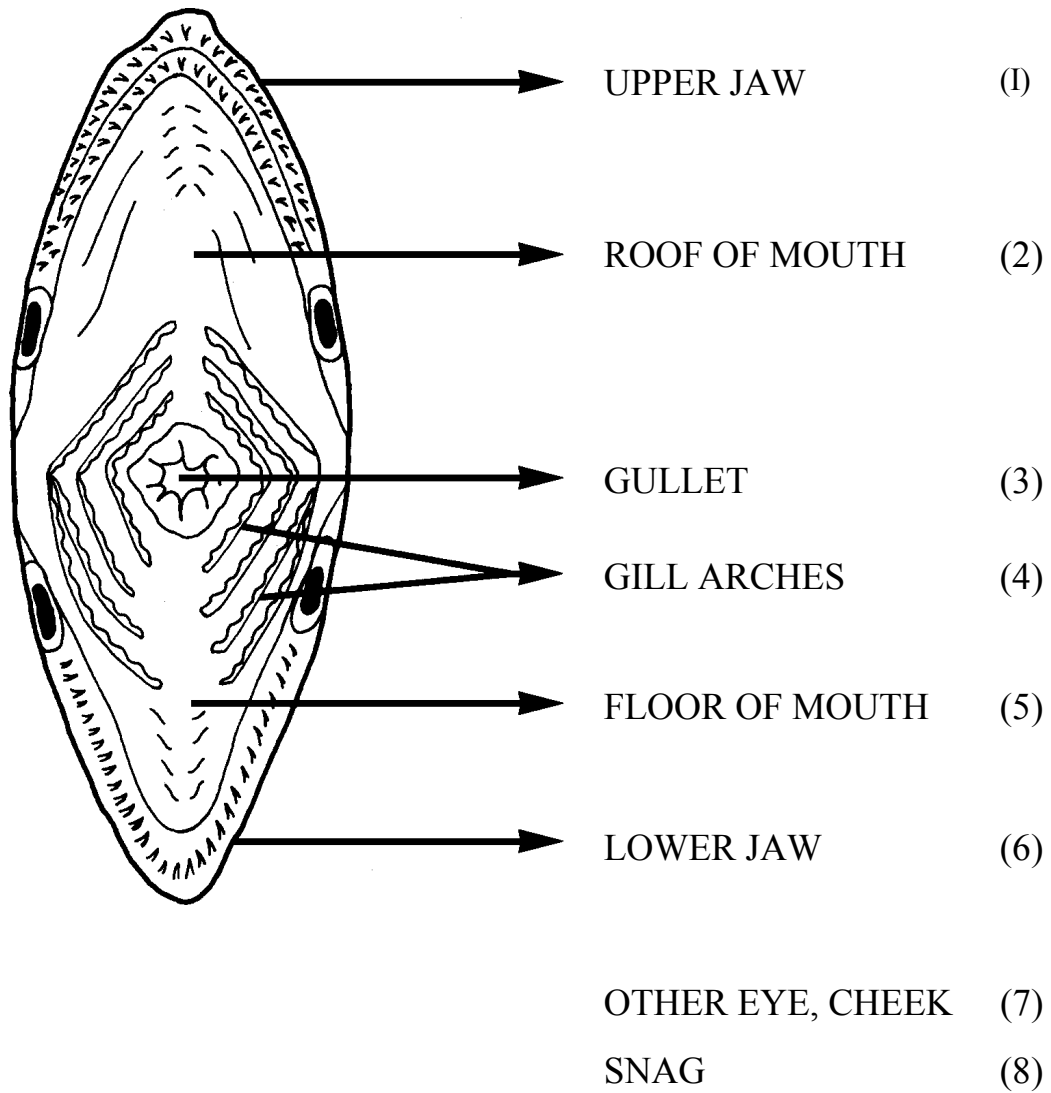


Figure 5. Diagrammatic view of a lake trout mouth illustrating hook placement areas.

then at one hour intervals until six hours elapsed. Following this, each fish was observed at durations of 24, 48, 72 and 96 hours after capture. A number of fish were retained in the cages for up to 10 days to determine if delayed mortality was a factor. Upon completion of the test run, fish were weighed, measured, tagged, checked for cage damage and released. An internal and external autopsy was performed on each dead fish in an effort to determine the cause of death.

RESULTS

Throughout the summer 129 lake trout were angled and held for observations (Table 2). Of these, 114 were caught at Taltheilei Narrows and the remainder at other locations on Great Bear and Great Slave lakes. The number of trout caught on barbed hooks was 72 and that for barbless hooks was 57. Trout ranged in length

Table 2. The number of trout caught on barbed and barbless hooks at Taltheilei Narrows and other locations.

Location	Barbed	Barbless	Total
Taltheilei Narrows	61	53	114
Other	11	4	15
Total	72	57	129

from 320 to 960 mm (mean = 644.4 mm) (Fig. 6) and ranged in weight from 300 g to over 15 kg (mean = 4.1 kg).

HANDLING TIMES

Capture times ranged from 1 to 25 minutes with an average of 4 minutes, 24 seconds. In general, larger trout required a longer landing time. However, lake trout from northern colder waters, despite being relatively large, are not known for being fighters. A scattergram of capture time vs. length (Fig. 7) demonstrates this relationship. Time in the transport tanks was up to 370 minutes, with an average of 41 minutes, 30 seconds. The total average handling time from capture to pen introduction was 48 minutes, 48 seconds. Trout appeared in good condition after transport despite the long time intervals encountered. Low temperatures and constant agitation are believed to have been beneficial in maintaining adequate dissolved oxygen concentrations. In addition it was noted that the hook removal and handling time was greater for barbed hooks. This was due to the fact that the barbed hooks were more difficult to remove from the fish and be-

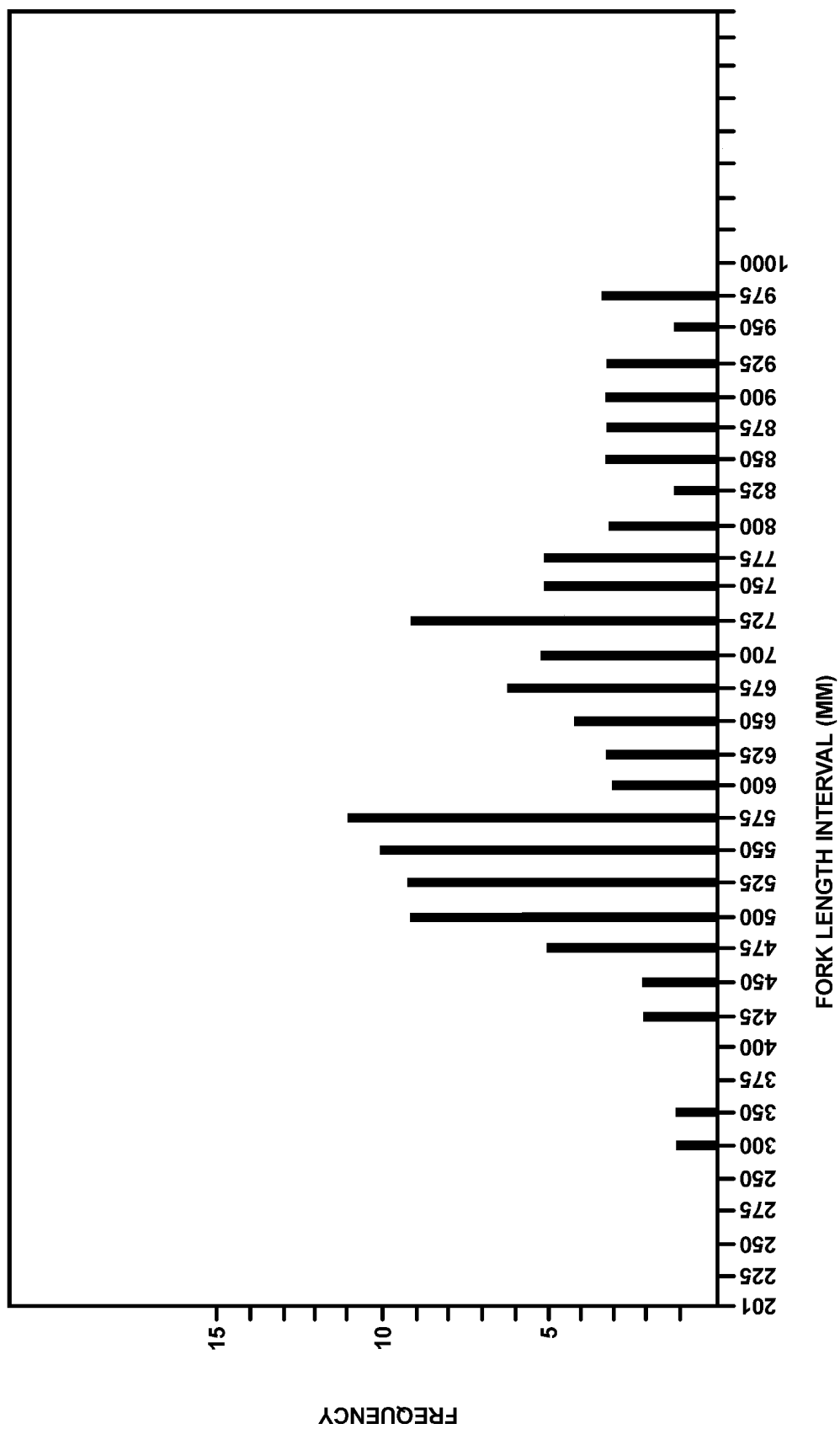


Figure 6. Length frequency distribution for lure caught lake trout.

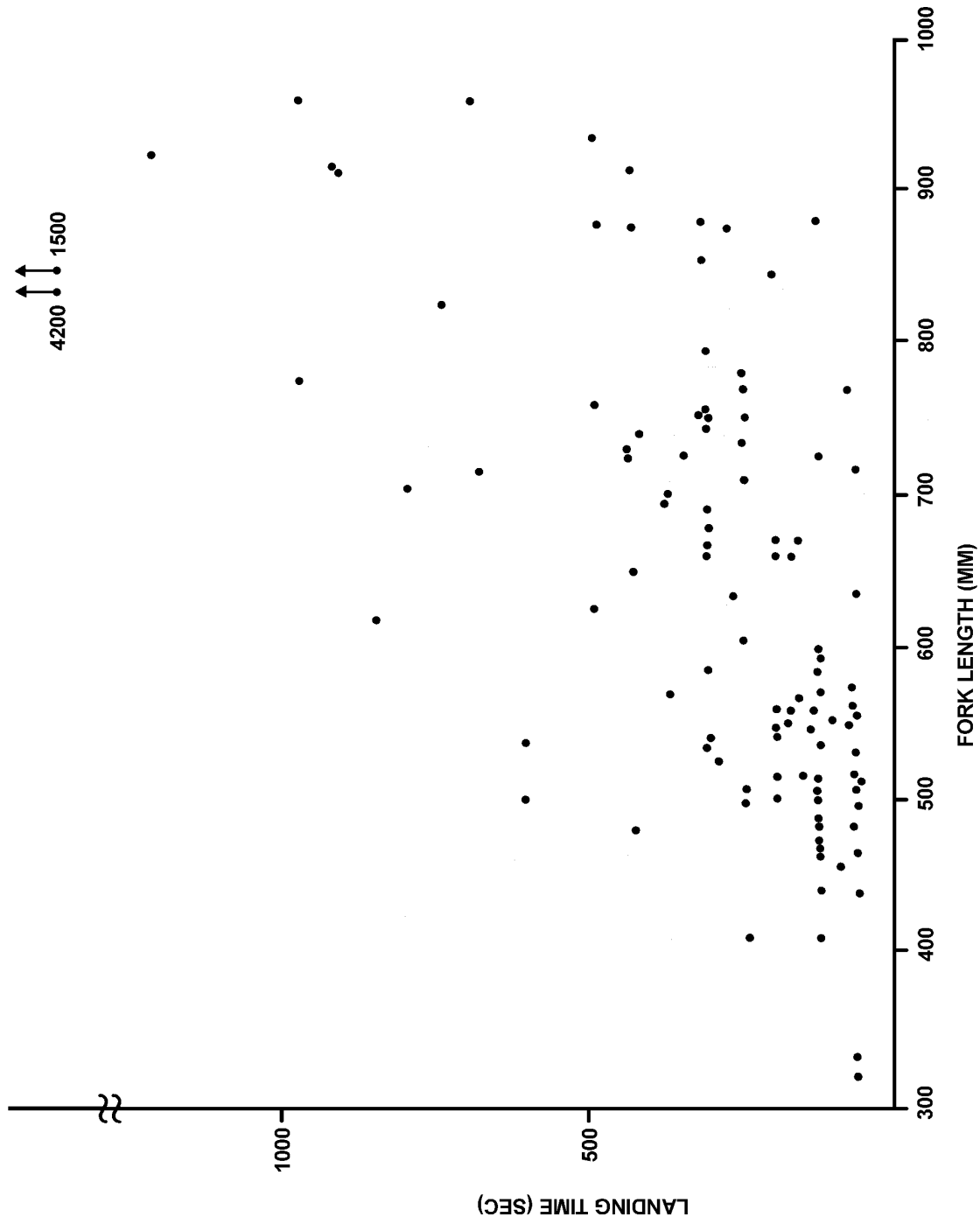


Figure 7. Scatter diagram illustrating the relationship between landing time and fork length.

came entangled with the dip net.

HOOK PLACEMENT

With the variety of fishing gear used in the study the maximum number of treble hooks was three or nine individual hooks. However, 58 percent of the captured fish had only one or two individual hooks embedded. Less than one percent had six embedded. Percentages for three, four and five individual hooks were 15.1, 2.4 and 1.6, respectively, with 20.3 percent unknown.

Hook placement for both single and multiple hooks embedded is summarized in Table 3. In this table, single refers to one individual hook while multiple refers to two or more individual hooks. The upper and lower jaws (Fig. 5) accounted for more than 50 percent of the mouth areas hooked. Of particular concern to the present study were critical areas such as the gill arches, gullet, eye and body snag. These areas accounted for 6 and 25 percent of the hookings for single and multiple hook placement, respectively. It appears from this summary that the potential damage increases with the number of hooks embedded. Further, as more hooks became embedded, handling time reaches a point where there is a greater risk of damage. No differences in hook placement and the number of hooks embedded between barbed and barbless hooks were noted.

Table 3. Single and multiple hook placement for treble hooked lake trout.

Area Hooked	<u>Single Hook Placement</u>		<u>Multiple Hook Placement</u>	
	No. of Times	%	No. of Times	%
Upper Jaw	15	30	21	21
Roof of Mouth	0	-	3	3
Gullet	0	-	4	4
Gill Arches	2	4	6	6
Floor of Mouth	1	2	8	8
Lower Jaw	18	36	30	30
Eye, Cheek	1	2	8	8
Snag	0	0	7	7
Unknown	13	26	13	13

HOOK DAMAGE AND BLEEDING

Both hook damage and bleeding were, for the most part, negligible (Table 4). Severe hook damage and bleeding depended on hook placement more than any other factor. Both the degree of hook damage and bleeding were found to be less for barbless hooks (Table 4). Removal of barbed hooks caused more damage than barbless hooks, and as a result) bleeding was greater. It appears, however, that if a fish is hooked in the gill arches, gullet, eye or is snagged, bleeding and hook damage are great, whether the hooks are barbed or barbless. Subsequent handling and hook removal only adds to the damage.

MORTALITIES

The overall mortalities of lure caught lake trout were 6.94 percent for barbed hooks and 7.02 percent for barbless hooks (Table 5). Statistically there was no significant difference between mortalities attributed to barbed or barbless hooks (Chi = 0.00013; 1 df).

Table 5. Summary of mortalities from lure caught lake trout.

Hook type	No. of Trout		Mortality
	Caught	Dead	
Barbed	72	5	6.94
Barbless	57	4	7.02
Total	129	9	6.98

Mortalities of lure caught lake trout and the associated data are summarized in Table 6. Hook placement for barbless hook mortalities was primarily in the lower jaw, while that for barbed hook mortalities was the gullet and gill arches. Both the number of hooks embedded and the total handling times were not excessive and fell well within the ranges given previously. However, in most cases severe bleeding, particularly from the gill arches was primarily responsible for fish death. Other injuries which may have occurred through hook removal and subsequent handling may also have contributed to these mortalities. With the exception of one fish, death occurred within the first

Table 4. Summary of hook damage and bleeding for lure caught lake trout.

Damage	Hook Damage				Bleeding			
	<u>Barbed</u>		<u>Barbless</u>		<u>Barbed</u>		<u>Barbless</u>	
	No.	%	No.	%	No.	%	No.	%
Nil	0	-	2	3.2	8	12.3	9	14.3
Light	36	55.4	40	63.5	34	52.3	37	58.7
Moderate	17	26.2	15	23.8	11	16.9	8	12.7
Severe	5	7.7	1	1.6	4	6.2	4	6.3
Unknown	7	10.7	5	7.9	8	12.3	5	8.0

Table 6. Summary of lure caught lake trout mortalities and associated data.

Location	Hook Type	Areas Hooked	No. Hooks	Handling Time (Mm.)	Length (mm)	Hook Damage	Bleeding	Time to Death
Taltheilei	Barbless	5	2	2	513	light	severe	2 hrs
Taltheilei	Barbless	6	1	2	-	-	severe	30 mm
Taltheilei	Barbless	4,6	2	45		light	light	150 mm
Taltheilei	Barbless	6	1	35	-	light	severe	72 hrs
Taltheilei	Barbed	3,4	3	3	510	severe	severe	3 mm
Taltheilei	Barbed	6	1	18	970	light	severe	4 hrs
Taltheilei	Barbed	3,4	2	10	595	severe	severe	6 mm
Taltheilei	Barbed	3,4	2	20	462	severe	severe	16 mm
Great Bear Lake	Barbed	5	2	105	728	moderate	moderate	100 mm

four hours. It is expected that a fish would die very quickly from the loss of blood while it may take a longer time for internal injuries to cause death. Despite holding fish up to 10 days, no further mortalities were recorded. It should be noted from Table 6 that for barbless hooks, damage was generally light while for barbed hooks it was generally severe. Excessive bleeding, which is believed to be the main cause of death, occurred in most cases for barbed and barbless hooked trout. Cage damage, consisting of lost scales and torn fins was light, occurred on 13 of the test fish.

DISCUSSION

Although high mortality rates among angled trout have been previously reported (Bouck and Ball 1966) results of the present study substantiate Stringer's (1967) assertion that lure-caused mortalities in Salmonids will usually be less than 10 percent. Losses of 2.65 and 6 percent were reported from the use of barbed and barbless treble-hook lures by Hunsaker *et al.* (1970). Klein (1965) reported mortalities of 1.8 and 4.8 percent in two groups of rainbow trout caught on barbed treble-hooked lures. Shetter and Allison (1958) observed losses of 7.0, 5.9 and 2.3 percent for brook, brown and rainbow trout caught with spoon-type treble-hook lures. The present mortalities of 6.94 and 7.02 percent for barbed and barbless treble-hook lures concurs with Klein's (1965) contention that restrictions on the use of treble-hook lures contribute little, if any, to reduction in overall mortality of trout which are caught and released.

Death of lake trout in the present study was primarily due to bleeding and damage caused by hook placement. Since no difference in mortality from the use of barbed or barbless treble-hooks was apparent, a definite statement cannot be made advocating the use of barbless hooks. However, it was noted that the damage inflicted on a fish before and during hook removal was greater with barbed hooks. This was especially true for critical areas such as the gullet, gill arches and the eyes. Long term physical damage may result in death or impaired growth in such an injured fish. Handling time was also reduced for barbless hooked fish since the hooks were removed from the fish easily and did not become entangled with the dip net to the extent that barbed hooks did.

Hunsaker *et al.* (1970) noted a general but not significant difference in trout mortality at higher water temperatures. His observations compared with Klein (1965), although he mentioned angler technique and variation in condition of individual trout as possible contributing factors. Fish losses in relation to hooking and handling appeared to increase at higher water temperatures. Marnell and Hunsaker (1968) found that the post-release survival of cutthroat trout caught with treble-hook lures was not affected by water temperature in their experiments. In contrast, Benson and Buckley (1963) reported that cutthroat trout mortality increased from 0.7 to 20.2 percent as water temperatures reached a mid-summer peak. Water temperature is not believed to have been a major factor governing mortality in the present study. Tempera-

tures during June ranged from 5 to 7 C and reached a high of 9 C in August. These temperatures are generally lower than those reported in previous studies and probably act to lower the overall mortality rate by limiting blood volume loss and depressing fish activity. Lake trout are not known for their fighting quality and appeared more lethargic during June than in August. Throughout the study lake trout did not display a large degree of voraciousness in taking a lure. The majority of hooks were embedded in the upper and lower jaws while only in a few instances were lures taken deeply enough to contact the gill arches and gullet. This generalization was common to all sizes of trout and for all types and sizes of lures. Infection of hook induced wounds is not expected to be a compounding factor in delayed mortalities due to the low water temperatures. Both handling and cage inflicted injuries were light and not of a serious nature. There were no noticeable instances of infected fish after a ten-day holding period.

Several workers (Parker and Black 1959; Parker *et al.* 1959; Bouck and Ball 1966) have claimed that severe exhaustion accompanying capture by hook and line causes delayed mortality in fishes. The exact cause of mortality is not clear, but there is evidence of a relationship between death and fatigue products in the blood, mainly lactic acid. Our data indicate that normal angling methods do not cause complete physiological exhaustion in adult lake trout and the degree of exhaustion imposed is quickly recoverable. Most fish continued to resist when netted and only a few showed temporary respiratory distress after release into the holding pens. Low water temperatures and the lethargic nature of lake trout are believed to be responsible for absence of stress induced mortalities.

Hunsaker *et al.* (1970) found that a 10-day observation period was adequate to determine mortality resulting directly from hooking injuries. Other studies of similar design have involved shorter periods (Shetter and Allison 1955, 1958; Klein 1965; Stringer 1967). Mortality was complete within 48 hours after hooking and groups of trout were held for 20 days without further losses. In view of these findings and the fact that no additional mortalities occurred among trout held up to 10 days in the present study, a four-day observation period is felt to be adequate to assess hooking mortality. Further, the fact that the majority of deaths occurred within the first four hours after capture, suggests that physical damage is the major factor contributing to death.

Hook type and placement has been cited as being responsible for high mortalities among angled fish. Hunsaker *et al.* (1970) found significantly high mortalities when trout swallowed a single baited hook. The premise that hook-swallowing causes increased mortalities is reflected in the findings of Shetter and Allison

(1955) and Klein (1965) among other investigations. Stringer (1967) observed mortalities of 75, 74 and 95 percent from hookings in the tongue, gill arches and esophagus, respectively for rainbow trout.

Handling-induced injuries were minimized in the present study by the use of live tanks for hook removal and subsequent transport to holding pens. For the most part the absence of such a tank requires that the fish be placed in the hold of the boat, the hooks removed, the fish disentangled from the dip net and released. Often, this process is lengthy if the hooks and dip net are entangled or if several photographs are taken. A fish handled in this way may suffer serious after effects from the lack of oxygen and loss of mucous and/or scales. It was noted that the simple act of netting a fish near a boat causes stress and additional injury since lake trout struggle a great deal during the process. This causes both internal and external injuries. The large mesh commonly used in these dip nets often becomes lodged under the gill cover and causes additional bleeding. Personnel taking part in the study were careful during handling and were supplied with equipment to ensure minimal distress or damage. The overall mortality rate of 6.98 percent may be less than that actually occurring among angled lake trout. It is therefore important to be cautious when the mortality rate determined in the present study is extrapolated to the lake trout population. Poor release methods employed by anglers could substantially add to this figure. One possible method to prevent a higher mortality rate may be to educate anglers and guides on proper handling and release methods, not only for lake trout, but for other game fishes. There still remains the facts that a difference in mortality rate between barbed and barbless treble-hook lures was not demonstrated and damage resulting from hook placement is the main cause of death.

SUMMARY

1. A study was carried out at Taltheilei Narrows on Great Slave Lake, N.W.T., to assess hooking mortality among lure caught lake trout and to compare the effects of barbed and barbless treble hooks.
2. A total of 72 barbed and 57 barbless hooked lake trout were caught and held for a four day observation period.
3. Mortality rates were 6.94 and 7.02 percent, from barbed and barbless hooks, respectively, for an overall mortality of 6.98 percent.
4. The upper and lower jaws accounted for more than 50 percent of the mouth areas hooked. Critical areas such as the gill arches, gullet and eyes accounted for a small fraction of the areas hooked.
5. There was no difference in either the number of hooks embedded and the area hooked for barbed and barbless hooks.
6. Both the degree of hook damage and bleeding were, for the most part, negligible with approximately 60 percent light or nil.
7. Severe hook damage and bleeding depended on hook placement more than any other factor, and were slightly less from the use of barbless hooks.
8. It was noted that the bleeding and damage from hook placement is the principle factor causing death among lure caught lake trout and that the use of barbless hooks will not necessarily reduce the overall mortality rate

RECOMMENDATIONS

1. Regulations to prohibit the use of barbed hooks on Great Bear and Great Slave lakes are not warranted.
2. The study should be continued in the future to investigate the effect of barbed and barbless hooks on other game fishes and to determine hooking mortality at higher temperatures encountered in smaller lakes.
3. A program should be initiated to educate guides, resident anglers and non-resident anglers in the Northwest Territories on proper hook removal and handling techniques.
4. The use of smaller mesh dip nets should be encouraged to land lure caught game fish in the Northwest Territories.

LITERATURE CITED

- Benson, N. G. and R. V. Buckley. 1963. Equilibrium yield and management of cutthroat trout in Yellowstone Lake. U.S. Fish and Wildlife Serv., Res. Rep. No. 62, 44 p.
- Black, E. C. 1957. Alterations in the blood level of lactic acid in certain salmonid fishes following muscular activity.
II. Lake trout (*Salvelinus namaycush*). J. Fish. Res. Bd. Can. 14: 645-549.
- _____. 1958. Hyperactivity as a lethal factor in fish.
J. Fish Res. Bd. Can. 15: 573-584.
- Bouck, G. and R. Ball. 1966. Influence of capture methods on blood characteristics and mortality in the rainbow trout. Trans. Amer. Fish. Soc. 95: 170-176.
- Falk, M. R., D. V. Gillman and L. W. Dahlke. MS 1973. The 1972 sport fishery on Great Bear and Great Slave Lakes, N.W.T. Can. Dept. of the Environment, Fish. and Mar. Serv., Res. Manag. Br., Central Region. Tech. Rep. No. Cen/T-73-8. 100 pp.
- Horak, D. L. and W. D. Klein. 1967. Influence of capture methods on fishing success, stamina and mortality of rainbow trout (*Salmo gairdneri* in Colorado. Trans. Amer. Fish. Soc. 96: 220-222.
- Hunsaker, D., L. F. M. Marnell and P. Sharpe. 1970. Hooking mortality of Yellowstone cutthroat trout. Prog. Fish-Cult. 27: 171-172.
- Klein, W. D. 1965. Mortality of trout caught on artificial lures and released by fishermen. Trans. Amer. Fish. Soc. 94:326-328.
- _____. 1965-a. Mortality of rainbow trout caught on single and treble hooks and released. Prog. Fish-Cult. 27:171-172.
- Lasater, J. E. and F. Haw. 1961. Comparative hooking mortality between treble and single hooks on silver salmon. Pac. Mar. Fish. Comm. Bull. No. 5: 73-76.

- Marnell, L. F. and D. Hunsaker. 1970. Mortality of lure-caught cutthroat trout (*Salmo gairdneri*) in relation to water temperature, fatigue and reproductive maturity of released fish. Trans. Amer. Fish. Soc. 99: 684-688.
- Mason, J. W. and R. L. Hunt. 1967. Mortality rates of deeply hooked rainbow trout. Prog. Fish-Cult. 39: 87-91.
- Parker, R. R., E. C. Black and P. A. Larkin. 1959. Fatigue and mortality in troll-caught Pacific salmon (*Oncorhynchus*). J. Fish. Res. Bd. Can. 14: 429-447.
- Shetter, D. S. and L. N. Allison. 1955. Comparison of mortality between fly-hooked and worm-hooked trout in Michigan streams. Mich. Dept. Cons., Misc. Publ. No.9. 44 p.
- _____. 1958. Mortality of trout caused by hooking with artificial lures in Michigan waters. 1957. Mich. Dept. Cons., Misc. Publ. No. 12. 15 p.
- Stringer, G. E. 1967. Comparative hooking mortality using three types of terminal gear in rainbow trout from Pennask Lake, British Columbia. Prog. Fish-Cult. 39: 17-21.
- Westerman, F. A. 1932. Experiments show insignificant loss of hooked immature trout when they are returned to the water. Mich. Dept. Cons., Monthly Bull. 2 (12): 1-6.

APPENDIX
SPORTS FISHING

CAPTURE RECORD _____
MORTALITY

DATE _____ LOCATION _____ RECORDER _____

ANGLER _____ GEAR _____

HOOK _____ TYPE _____ SIZE _____

SPECIES _____ FORK LENGTH _____ WEIGHT _____

TIME CAUGHT _____ HRS TIME LANDED _____ HRS MAP REF _____

DURATION _____ DIP NET ☐ LEADER ☐ BOTH ☐

HOOK PLACEMENT

NUMBER OF BARBS IMBEDDED _____

1 Upper Jaw ☐	5 Floor of Mouth ☐
2 Roof of Mouth ☐	6 Lower Jaw ☐
3 Gullet ☐	7 Other, Cheek, Eye ☐
4 Gill Arches ☐	8 Snag ☐

HOOK DAMAGE

BLEEDING

Light ☐	Light ☐
Moderate ☐	Moderate ☐
Severe ☐	Severe ☐

TIME HANDLING COMPLETED _____ HRS DURATION _____

TRANSPORT TIME _____ PEN INTRODUCTION _____ PEN NO. _____

TOTAL DURATION _____

OBSERVATION

TIME OBSERVED HOUR

INTRODUCTION 15 MIN	1	2	3	4	5	6	24	48	72	96
OTHER HRS										
OK										
DEAD										

OBSERVATIONS TIME _____ DATE _____

TIME OF DEATH _____ AUTOPSY REPORT NUMBER _____

RELEASED ☐ EXTERIOR CAGE DAMAGE YES ☐ NO ☐

TAGGED ☐ LENGTH _____ mm WEIGHT _____

TAG COLOR _____ NUMBER _____

