Fishery Data Series No. 93-1

Mortality of Arctic Char and large Arctic Grayling Captured and Released With Sport Fishing Gear

by

Timothy R. McKinley

January 1993

Alaska Department of Fish and Game

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[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-8, Job Nos. R-3-3(b) and R-3-2(f).

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ABSTRACT

In two separate hatchery experiments, the mortality rates of Arctic char *Salvelinus alpinus* and large Arctic grayling *Thymallus arcticus* caught with five commonly used sport fishing gears were estimated. Mortality rates of Arctic char in this experiment ranged from 0 mortality for fish caught with the two unbaited gears to 0.10 with baited treble-hook lures. There were no significant differences in mortality rates produced by each gear. Baited gears caused significantly more hooking of Arctic char in the gill area than did unbaited gears. Treble-hook gears caused significantly more bleeding in Arctic char than did single-hook gears. In the Arctic char experiment, the baited treble lure was the only gear that produced a mortality rate (0.10) significantly greater than the control. Reductions in mortality of caught and released Arctic char could be made with restrictions on the use of treble hooks and bait. In the experiment with large Arctic grayling, there were no significant differences in mortality rate of fish caught with barbed single-hook flies, barbless single-hook flies, treble-hook spinners, single-hook spinners, and baited single-hooks. None of the gears had a mortality rate significantly greater than the control nor significantly greater than 0.10. Mortality rates of Arctic grayling in this experiment were 0 for all gears except treble-hook spinners. Mortality rate of Arctic grayling caught with treble-hook spinners was 0.02. Hook placement in Arctic grayling differed significantly between gears, with spinning gears causing more hooking in the gill, gullet, or eye than the baited single-hooks and single-hook flies (barbed and barbless). Fishing with bait did not significantly increase mortality rate of large Arctic grayling.

KEY WORDS: catch-and-release mortality, baited single-hook, baited treble-hook, unbaited single-hook, baited treble-hook, barbed fly, barbless fly, hook placement, bleeding, Clear Hatchery, Arctic char, *Salvelinus alpinus*, Arctic grayling, *Thymallus arcticus*.

INTRODUCTION

When necessary, the Alaska Board of Fisheries and the Alaska Department of Fish and Game (ADF&G) impose restrictive sport fishing regulations to protect stocks from over-harvest. As a result, anglers may release a larger portion of their catch. Further, some anglers prefer to release sport caught fish regardless of the regulation structure. For some species, the number of fish caught and released can be substantial; in 1990, anglers in Alaska caught and released over 306,000 Arctic char *Salvelinus alpinus*/Dolly Varden *S. malma* (70% of the total number of fish caught) and over 355,000 Arctic grayling *Thymallus arcticus* (85% of the total number of fish caught; data from Mills 1991). Additionally, some fisheries experience high catch-and-release rates as related to population size; in 1988 sport fishermen on the Kenai River caught and released 73% of the estimated early run chinook salmon escapement (Bendock and Alexandersdottir 1992). ADF&G realizes that a portion of the released fish may die as a result of being caught and handled, but for most species and fisheries the rate of post-release mortality is unknown.

Recent studies in Alaska have estimated the mortality rates experienced by several species of fish caught with different types of sport fishing gear (Bendock and Alexandersdottir 1992; Burkholder 1992). However, there is no information on mortality rates of Arctic char or large (greater than 305 mm or 12 inches total length) Arctic grayling captured with sport fishing gear. Clark (1991) found that overall mortality was less than 5% for small (< 305 mm total length) Arctic grayling caught with three different types of terminal gear. Falk and Gillman (1975) reported 10% overall mortality for Arctic grayling captured with three gears, but the length distribution of captured fish was not reported, and sample sizes were not sufficient to test any of the variables that affect mortality (Clark 1991). The lack of information on catch-and-release mortality of Arctic char and large Arctic grayling, and the large number of these fish that are released annually in recreational fisheries, prompted this study.

This study investigated the effects of five general gears used to catch Arctic char and Arctic grayling. The gears chosen are representative of the range of legal, commonly used gears for these species.

The specific objectives of this study were:

1) to test the hypothesis that there is no significant mortality (H_0 : $m_{gear} \leq m_{control}$) suffered by Arctic char caught once with one of the five different gears;

2) to test the hypothesis that there is no significant mortality (H_0 : $m_{gear} \leq m_{control}$) suffered by large (≥ 305 mm total length) Arctic grayling caught once with one of the five different gears;

3) if the null hypothesis in objective 1 or 2 is rejected for at least two gears (for the same species), then test the hypothesis that gears that produce significant mortality rates produce equal mortality rates.

These objectives were addressed in two similar but separate experiments. Experiment 1 tested for differences in mortality rate between five gears used to catch Arctic char; experiment 2 tested for differences in mortality rate between five gears used to catch Arctic grayling. Both experiments were conducted in an outdoor raceway at Clear Hatchery (operated by the Fisheries Rehabilitation and Enhancement Division of the Alaska Department of Fish and Game) on Clear Air Force Base near the town of Anderson.

METHODS

Experiment 1 occurred during 20 through 24 April 1992. A total of 360 Arctic char were sampled from a population of approximately 3,500 in a 10.2 m × 2.4 m × 1.5 m deep section of the raceway. Of these fish, 60 were dip netted and served as a control and 300 were subjected to capture with hook and line gear. Water temperature in the raceway was held relatively constant at 13°C. Experiment 2 occurred during 16 through 19 June 1992. Approximately 330 Arctic grayling were available for this study, and fish were held in a 2.0 m × 2.4 m × 1.5 m section of the same raceway. Water temperature was held relatively constant at 12°C. Food was withheld from the fish for the duration of both experiments so that each species could be angled more readily. Capture and handling methods were similar for both experiments, although different gears were used to capture each species. The gears used to capture Arctic char were:

1) a size 12 treble-hook attached to a 1/8 oz Pixie™ spoon;

2) a size 12 treble-hook attached to a 1/8 oz Pixie™ spoon that was baited with either a single salmon egg or a single kernel of corn;

3) a size 12 single-hook attached to a Mepps™ Comet™ spinner;

4) a size 12 single-egg hook that was baited with either a single salmon egg or a single kernel of corn; and,

5) a size 12 treble-hook that was baited with either a single salmon egg or a single kernel of corn.

The gears used to catch Arctic grayling were:

1) a size 12 single-hook fly (barbed) tied as a Salcha Pink or a Royal Coachman;

2) a size 12 single-hook fly (barbless) tied as a Salcha Pink or a Royal Coachman;

3) a size 12 treble-hook attached to a Roostertail™ spinner;

4) a size 12 treble-hook with two hooks cut off and attached to a Roostertail™ spinner; and,

5) a size 12 single-egg hook that was baited with either a single salmon egg or a single kernel of corn.

The five gears were rotated systematically (gear one was used to catch the first fish, gear two to catch the second ...) until one fish had been caught with each gear. Every sixth fish was removed with a dip net to serve as a control. Sixty fish were captured with each gear for a total of 360 fish used for experiment 1. Due to an unexpected shortage of Arctic grayling in experiment 2, only 47 fish were captured per gear and only 44 control fish were captured.

After being hooked, each fish was played for approximately 30 s before being landed and the hook removed by hand. If the fish was hooked in the gullet, the line was cut. All fish captured were measured to the nearest 1 mm fork length (FL), and tagged with individually numbered Floy anchor tags. The location of the hook in the fish was recorded using criteria adapted from Falk and Gillman (1975; see also Figure 1). Bleeding was categorized using a four point scale adapted from Falk and Gillman (1975):

0) none: no evidence of any external bleeding;

1) slight: small amount of external bleeding, generally localized near the point of entry of the hook;

2) moderate: greater amount of external bleeding, but generally localized near the point of entry of the hook; and,

3) severe: copious amount of blood, generally staining the water, and surrounding and obscuring the point of entry of the hook.

Time of capture was recorded to the nearest 1 min. To avoid multiple captures of the same individual, captured fish were held in a partitioned area in the same raceway. Treatment fish were held in this raceway for a minimum of 48 hours after the completion of the experiment. Approximate time of death was recorded for mortalities; only fish that died within 48 hours of capture were considered to be mortalities from the gear. Mortality rate for each gear was calculated using:

$$\hat{m}_i = \frac{X_i}{n_i} \tag{1}$$

where:

m_i = the mortality rate of fish that were caught with gear i;

n_i = the number of fish that were caught with gear i; and,

X_i = the number of fish that were caught with gear i and died.

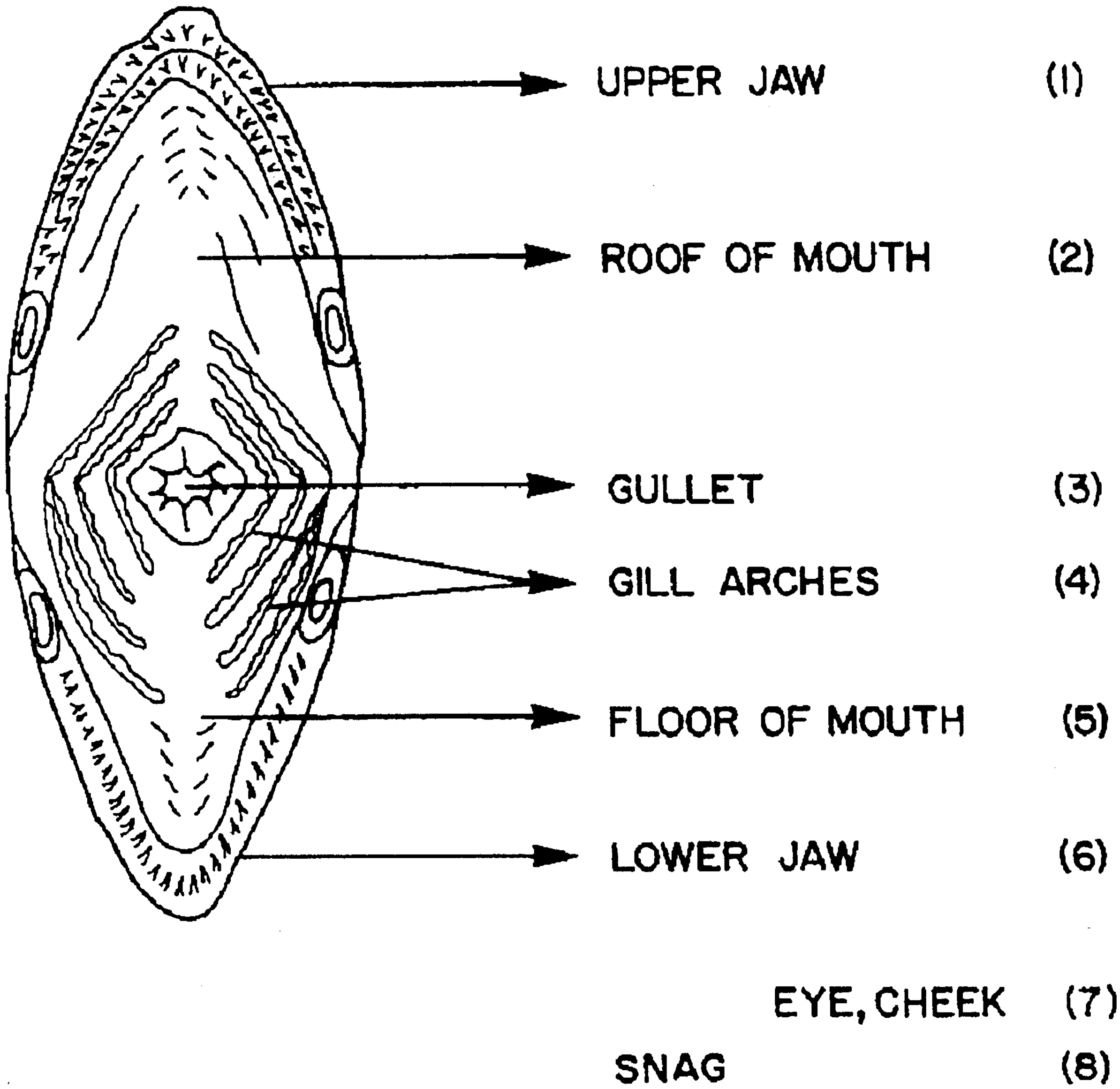

Figure 1. Description of hook placements used in the two experiments at Clear Hatchery in 1992.

The standard error of this rate was estimated by (Zar 1984):

$$SE[\hat{m}_i] = \left[\frac{\hat{m}_i (1 - \hat{m}_i)}{(n_i - 1)} \right]^{1/2} \tag{2}$$

To determine if the mortality rate for any one gear was significantly greater than the control (objectives 1 and 2), a one-tailed binomial test (Zar 1984) was performed using the upper confidence limit of the control as a critical value. A sample size of 60 fish per gear in experiment 1 allowed differences between gears of 10% or greater to be detected; a one-tailed binomial test was used to test the null hypothesis that mortality rate for each gear was less than or equal to 10%. The probability of a Type I error (α) was adjusted to 0.02, so that an overall α=0.10 could be maintained for the five comparisons. Confidence intervals were then used for a comparison between gears (objective 3) and the most and least injurious gears were identified. Binomial confidence intervals were calculated as (Zar 1984):

$$LCI_i = \frac{X_i}{X_i + (n_i - X_i + 1)\ F_{\gamma 1,\gamma 2}} \tag{3}$$

and,

$$UCI_i = \frac{(X_i + 1)\ F_{\gamma 1',\gamma 2'}}{n_i - X_i + (X_i + 1)\ F_{\gamma 1',\gamma 2'}} \tag{4}$$

where:

LCI_i = lower 90% confidence interval for the mortality rate of gear i;

UCI_i = upper 90% confidence interval for the mortality rate of gear i;

n_i = the number of fish that were caught with gear i;

X_i = the number of fish that were caught with gear i and died;

$F_{\gamma 1,\gamma 2}$ = probability from the F distribution with γ_1, γ_2 degrees of freedom where:
$\gamma_1 = 2(n_i - X_i + 1)$; and,
$\gamma_2 = 2X_i$;

$F_{\gamma 1',\gamma 2'}$ = probability from the F distribution with γ_1, γ_2 degrees of freedom where:
$\gamma_{1'} = 2(X_i + 1)$; and,
$\gamma_{2'} = 2(n_i - X_i)$;

To test for size selectivity by gear the length frequency distributions of control fish and fish caught with each gear were compared using the Anderson-Darling k-sample test (Scholz and Stephens 1987). Data on hook placement, bleeding, and gear type were collapsed into generalized categories for further analysis using contingency tables. Contingency tables were used to test the independence of hook placement and level of bleeding on the gear used. If the hypotheses of independence of hook placement or level of bleeding failed to be rejected ($P > 0.10$), then hook placement and level of bleeding data were pooled among gears and a test of independence of the level of bleeding on hook placement was performed.

RESULTS

Experiment 1 (Arctic char)

Overall mortality rate for the 300 Arctic char captured with all five gears was 0.033 (10 fish died; Table 1). All mortalities occurred within 12 h of capture; 80% of mortalities (eight of 10 fish) occurred within 10 min of capture (Table 1). There were no mortalities of control fish or fish caught with unbaited gears (Table 2). All mortalities were of fish caught with one of the three baited gears (baited treble lures, baited treble-hooks, and baited single-hooks; Table 2). Mortality rates of Arctic char caught with baited gears ranged from 0.033 (SE = 0.023) for treble and single-hooks to 0.100 (SE = 0.039) for the treble lures (Table 2). Only one gear (baited treble lures) produced a mortality rate that was significantly greater than that of the control group (single-tailed binomial test, $P < 0.10$). However, there were no significant differences between mortality rates of Arctic char captured with the five gears tested (Table 2), and none produced mortality rates in Arctic char significantly greater than 0.10 (single-tailed binomial test, $P > 0.10$). The mortality rate of all fish caught with baited gears pooled was 0.055 (SE = 0.017), while the mortality rate of all fish caught with unbaited gears pooled was zero.

A comparison of length distributions using the Andersen-Darling k-sample test failed to detect a significant difference between fish caught with the five gears ($T_{kn} = -0.808$, $P > 0.25$), so any differences in mortality, hook location, or bleeding could not be attributed to differences in size of fish. Fork length of treatment Arctic char ranged from 247 mm to 410 mm with a mean of 348 mm (SD = 27 mm). The length distribution of control fish, however was found to be significantly different from that of treatment fish ($T_{kn} = 2.302$, $P < 0.10$). Fork length of control (dip netted) Arctic char ranged from 258 mm to 377 mm with a mean of 335 mm (SD = 27 mm).

Arctic char captured with all five gears tended to be hooked in the upper jaw or roof of mouth (64% of captures; Table 3). Only 5% of the fish were hooked in the gill, but over 56% of these fish died (9 of 16 fish). There was no significant difference in the level of bleeding, hook placement, or severity of bleeding between fish caught with the various gears (Tables 3 and 4). There appeared to be a significant difference in the frequency of hooking in the gill area for fish caught with different gears ($P = 0.07$; Tables 3 and 4); baited hooks caused significantly more hooking in the gill area ($P = 0.02$;

Table 1. Fishing gear used, hook location, and level of bleeding observed for Arctic char that died during Experiment 1.

Date	Gear	Hook Location	Bleeding	Interval of Time Between Capture and Death
20 - April	Treble lure, baited	floor of mouth (5)	severe (3)	$\leq$ 12 h[a]
21 - April	Treble lure, baited	gill (4)	severe	$\approx$ 1 h
	Treble lure, baited	gill	severe	$\approx$ 10 min
	Treble lure, baited	gill	severe	$\approx$ 10 min
	Treble hook, baited	gill	severe	$\approx$ 10 min
	Treble hook, baited	gill	severe	$\approx$ 10 min
22 - April	Single hook, baited	gill	severe	$\approx$ 2 min
23 - April	Treble lure, baited	gill	severe	$\approx$ 5 min
24 - April	Treble lure, baited	gill	severe	$\approx$ 1 min
	Single hook, baited	gill	severe	$\approx$ 1 min

Totals:	Treble lure, baited	6
	Treble hook, baited	2
	Single hook, baited	2

[a] Fish was found dead the next morning.

Table 2. Estimates of mortality rate, standard error, 90% confidence intervals, and probability of the mortality rate being less than or equal to 0.10 for Arctic char caught and released with five gears, with gears pooled by baited and unbaited types, and a control (dip net), 20 through 24 April 1992.

Gear	n[a]	X[b]	m[c]	SE	LCI[d]	UCI[e]	P[f]
Baited:							
Treble lure	60	6	0.100	0.039	0.036	0.211	0.556
Treble hook	60	2	0.033	0.023	0.003	0.120	0.986
Single hook	60	2	0.033	0.023	0.003	0.120	0.986
All baited	180	10	0.055	0.017	0.026	0.102	0.989
Unbaited:							
Treble lure	60	0	0	---	0	0.063	---
Single lure	60	0	0	---	0	0.063	---
All unbaited	120	0	0	---	0	0.032	---
Control	60	0	0	---	0	0.063	---

[a] n is the number of fish caught and released.
[b] X is the number of fish that died within 48 h.
[c] m is the mortality rate.
[d] LCI is the lower 90% confidence interval of m.
[e] UCI is the upper 90% confidence interval of m.
[f] P is the probability of a greater observed m based on the one-tailed binomial test.

Table 3. Summary of level of bleeding and hook placement for Arctic char captured with five gears at Clear Hatchery, 20 - 24 April 1992.

	Gear									
	Treble Lure Baited		Treble Lure Unbaited		Single Lure Unbaited		Single Hook Baited		Treble Hook Baited	
Bleeding[a]	51	6[b]	55	11[b]	49	5[b]	54	6[b]	53	10[b]
No bleeding	9		5		11		6		7	
Gill/eye[c]	10	6[d]	10	1[d]	3	1[d]	7	2[d]	10	6[d]
Jaw/mouth/snag[e]	50		50		57		53		50	

[a] Bleeding category is the sum of fish that exhibited slight, moderate, or severe levels of bleeding as described in Falk and Gillman (1975).
[b] The number of fish that exhibited level 3 (severe) bleeding of Falk and Gillman (1975).
[c] Hook placements 4 or 8 of Falk and Gillman (1975).
[d] The number of fish that were hooked in the gills.
[e] Hook placements 1, 2, 5, 6, or 8 of Falk and Gillman (1975).

Table 4. Summary of hypothesis tests used to evaluate the independence of bleeding and hook placement on gear, bait, and hook type for Arctic char and Arctic grayling captured with hook and line gear.

Species	Hypothesis Tested[a]	χ^2	df	P	Adjusted α[b]
Arctic char	Some bleeding × gear	3.50	4	0.48	0.02
	Hook placement × gear	5.48	4	0.24	0.02
	Severe bleeding × gear	4.51	4	0.34	0.02
	Gill hook × gear	8.85	4	0.07	0.02
	Gill hook × bait	5.33	1	0.02	0.02
	Gill hook × hook type	3.18	1	0.07	0.02
	Severe bleeding × bait	0.46	1	0.50	0.02
	Severe bleeding × hook type	4.35	1	0.04	0.02
	Hook placement × severe bleeding	24.76	1	0.00	0.02
Arctic grayling	Bleeding × gear	8.05	4	0.09	0.03
	Hook placement × gear	12.70	4	0.01	0.03

[a] Terms used in hypothesis tests are:
Some bleeding - none versus any detected bleeding (slight through severe);
Gear - all five gears tested independently;
Hook placement - gill, gullet, or eye versus jaw, mouth, or snag;
Severe bleeding - none, slight, or moderate versus severe;
Gill hook - gill versus all other hook locations;
Bait - baited gears versus unbaited gears; and,
Hook type - treble hook gears versus single hook gears.

[b] The α level was adjusted from 0.05 to provide a more conservative test when multiple comparisons were made using related data.

Tables 4 and 5). Treble-hook gears were found to hook fish in the gill more often than single hook gears ($P = 0.07$; Tables 4 and 5).

Arctic char in this study tended to bleed heavily after being hooked; 56% of the treatment fish exhibited moderate to severe bleeding (level 2 or 3). All mortalities (10 of 10 fish) exhibited severe bleeding; 23% of fish that exhibited severe bleeding died (10 of 44 fish). The occurrence of severe bleeding was not affected by the gear used or the use of baited gears ($P > 0.25$ for both comparisons; Tables 4 and 5). Treble hooks, however, were more likely to produce severe bleeding than single hooks ($P = 0.04$; Tables 4 and 5). There was a significant interaction between hook placement and the severity of bleeding ($P < 0.01$; Table 4). Gill and eye hooked fish sustained a higher percentage (40%) of severe bleeding than fish hooked in the jaw or mouth (12%).

Experiment 2

Due to an unexpected shortage of fish, only 47 Arctic grayling were captured with each gear, and only 44 fish were dip-netted for a control. Only one Arctic grayling died within 48 h of capture, for an overall mortality rate of less than 0.01. This fish was hooked in the gill with a treble-hook spinner, and exhibited severe bleeding. Three Arctic grayling died after the 48 h post-capture period, and thus were not considered mortalities from this experiment; one of these mortalities was a control fish.

The Andersen-Darling k-sample test failed to detect differences in the length distributions of control fish and fish caught with each treatment gear ($T_{kn} = -0.297$, $P > 0.50$), so any differences in mortality, hook location, or bleeding could not be attributed to differences in size of fish captured by each gear. Fork length of treatment Arctic grayling ranged from 237 mm to 357 mm with a mean of 293 mm (SD = 21 mm).

Arctic grayling captured with all five gears tended to be hooked in the upper jaw or roof of mouth (82% of captures; Table 6). Only 1% of the Arctic grayling captured were hooked in the gill, but 33% of these fish died (1 of 3 fish). No fish were hooked in the gullet. Arctic grayling caught with spinning gears were more likely to be hooked in the gill or eye than fish caught with other gears ($P = 0.01$; Tables 4 and 6).

Overall, Arctic grayling captured in this study bled very little; 60% of the fish did not bleed at all, and only 2% exhibited severe bleeding (Table 6). Level of bleeding was affected by the gear used ($P = 0.09$; Tables 4 and 6), with spinning gears causing more bleeding than the other gears.

DISCUSSION

This study demonstrated how the effects of catch-and-release fishing can differ between species. Arctic char had higher mortality rates, were more likely to bleed and bled more severely than Arctic grayling. Also, fishing with bait increased the mortality rate of Arctic char, but not Arctic grayling. Clearly, when catch-and-release rates are high for a

Table 5. Capture data according to pooled gears, hook placements, and bleeding levels for Arctic char captured with five gears at Clear Hatchery, 20 - 24 April 1992.

		Number of Fish Caught			
		Use of Bait		Hook Type	
Criteria	Category	Baited[a]	Unbaited[b]	Treble hook[c]	Single hook[d]
Hook placement:					
	Gill	14	2	13	3
	Other[e]	166	118	167	117
Bleeding:					
	Severe	27	16	32	11
	Other[f]	153	114	148	109

[a] Baited category is the sum of fish that were caught with a baited treble lure, baited single hook, or baited treble hook.

[b] Unbaited category is the sum of fish caught with an unbaited treble lure or unbaited single lure.

[c] Treble hook category is the sum of fish captured with a baited treble lure, unbaited treble lure, or baited treble hook.

[d] Single hook category is the sum of fish captured with an unbaited single lure or a baited single hook.

[e] Fish hooked in the upper jaw, roof of mouth, floor of mouth, lower jaw, eye, cheek, or snagged.

[f] Fish that exhibited moderate, slight, or no bleeding as described in Falk and Gillman (1975).

Table 6. Summary of level of bleeding and hook placement for Arctic grayling captured with five gears at Clear Hatchery, 16 - 19 June 1992.

	Gear				
	Barbed Fly	Barbless Fly	Treble Spinner	Single Spinner	Baited Single Hook
Bleeding[a]	19	14	24	23	14
No bleeding	28	33	23	24	33
Gill/eye[b]	0	2	6	5	0
Jaw/mouth/snag[c]	47	45	41	42	47

[a] Bleeding category is the sum of fish that exhibited slight, moderate, or severe levels of bleeding as described in Falk and Gillman (1975).
[b] Hook placements 4 or 8 of Falk and Gillman (1975).
[c] Hook placements 1, 2, 5, 6, or 8 of Falk and Gillman (1975).

species/fishery, mortality rates should be ascertained directly from the species and fishery of concern instead of relying on information from other species.

The finding that fishing with bait increases the post-release mortality rate is a common conclusion from many studies (Mongillo 1984). Mortality rates are generally the same between hook types, although some studies report higher mortality rates from single hooks, rather than treble hooks (Mongillo 1984). It has been theorized that treble hooks cannot be taken into the mouth as deeply before hooking occurs (Wydoski 1977). Arctic char are known to strike lures that are large in comparison to their body size; perhaps they have the ability to engulf large prey, allowing them to swallow treble hooks deeper. Once taken deeply, a treble hook is probably more likely to lodge in the gills than a single hook simply due to the greater number of hooks.

The low overall mortality rate suffered by Arctic char suggests that catch-and-release regulations are a viable option for limiting the harvest of this species. However, the fact that some Arctic char die after release should be considered in determining total fishing related mortality rather than simply considering reported harvest. In fisheries where post-release mortality needs to be minimized, restrictions on baited treble lures, baited gears, or treble-hook gears should be considered. Anglers should also be instructed to keep Arctic char that have been hooked in the gill and are bleeding severely, due to their low probability of survival.

The overall mortality of Arctic grayling in this study fell within the range reported by Clark (1991) for small Arctic grayling but was substantially lower than that of Falk and Gillman (1974). Few Arctic grayling were hooked in the gill and none in the gullet, areas that are more likely to result in mortality. In the clear water of a hatchery raceway, the fish were very visible and it was possible to predict a strike and set the hook very quickly. When fishing in a more natural setting the hook may be taken deeper before it is set, resulting in more gill or gullet hooked fish. This could explain the disparity of these results with Falk and Gillman's (1974) study of fish in the wild. However, Clark (1991) found that the mortality rate of Arctic grayling caught and released in the Chatanika River was similar to the mortality rate observed in his study at Clear Hatchery.

The use of baited single-hooks did not result in high post-release mortality rates of Arctic grayling. This suggests that the current restriction on this gear in several streams is unwarranted.

Spinning gears hooked Arctic grayling more often in the gill/gullet/eye than other gears, but most of these captures were in the "non-lethal" eye. Because of the confining space of the raceway in the Arctic grayling study, it was necessary to jig the spinner gears vertically, resulting in the large number of hookings in the eye.

Similar to the results of Clark (1991), Arctic grayling in this experiment bled very little and infrequently. However, as in the Arctic char experiment, severe bleeding from the gills accounted for the only mortality.

The ultimate goal of this study was to estimate hook and release mortality rates for Arctic char and Arctic grayling, and to determine what gear restrictions, if any, would be effective in minimizing post-release mortality. Both experiments were conducted in a hatchery, and so the results may not be directly applicable to situations in the wild. In fisheries where the water temperature is higher, higher mortality rates can be expected (Dotson 1982). Also, the method of handling has been shown to affect post-release mortality (Wydoski 1977). Fish in this study were "played" for an intermediate amount of time (30 s), and handled as carefully as possible while removing the hook. In reality, mortality rates may be higher (regardless of gear type or hook location) due to longer "play" times and poorer handling methods of the average angler. Although some of the variables that affect mortality are not easily regulated, their effects may be minimized through the education of anglers.

ACKNOWLEDGEMENTS

Thanks goes to David Parks, Tim Burke, and Don Bee of FRED Division at Clear Hatchery for the use of the facility and help in fish transport and logistics. Thanks also goes to Bob Clark for his invaluable assistance during all stages of this project. A special thanks goes to Terry Bendock for a very thorough review of the manuscript which greatly improved the final draft. John H. Clark and Peggy Merritt are commended for their supervisory, coordination, and editorial roles that provided the structure necessary for implementing this project. Pat Hansen did an excellent job of developing an operational plan for this project and providing helpful biometric input. Sara Case is thanked for providing word processing support and printing of this report. This project and report were made possible by partial funding provided by the U.S. Fish and Wildlife Service through the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under project F-10-8, Job Numbers R-3-3(b) and R-3-2(f).

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APPENDIX A
Data File Listing

Appendix A1. Data files[a] used to estimate mortality of Arctic char and Arctic grayling caught and released with sport fishing gear, 1992.

Data File	Description
U9870LB1.DTA	Capture data for Arctic char used in the catch-and-release experiment at Clear Hatchery in 1992.
U9870LB2.DTA	Capture data for Arctic grayling used in the catch-and-release experiment at Clear Hatchery in 1992.

[a] Data files have been archived at, and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.