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Mortality of Anadromous Dolly Varden Captured and Released on Sport Fishing Gear

by

Alfred L. DeCicco

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ABSTRACT

The mortality of anadromous Dolly Varden *Salvelinus malma* captured on rod and reel using baited treble hooks, baited single hooks, single hook lures and treble hook lures was investigated on the Nome and Snake rivers near Nome, Alaska, and on the Wulik River near Kivalina, Alaska. Mortality rates by gear type were low ranging from 0 to 0.033, and none varied significantly from the control. No significant differences were found in the hooking mortality between single and treble hooks or baited and unbaited hooks. Hook and release may be a reasonable alternative in the management of high use Dolly Varden fisheries in Alaska.

KEY WORDS: Dolly Varden, *Salvelinus malma*, hooking mortality, northwest Alaska.

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) sometimes imposes restrictive sport fishing regulations to protect stocks from over-harvest. However, as fishing regulations become more restrictive, anglers may release a larger portion of their catch. Further, some anglers prefer to release sport caught fish regardless of the regulation structure. In 1990, anglers in Alaska caught almost 440,000 Arctic char *Salvelinus alpinus* and Dolly Varden *S. malma* and released over 306,000 (70% of the catch); during 1991, 461,000 were caught and almost 319,000 (69%) were released; and during 1992, 378,950 were caught and almost 302,000 (80%) were released (Mills 1991, 1992, 1993). Dolly Varden occur in coastal drainages throughout Alaska, while Arctic char occur in lakes in Southcentral and Southwestern Alaska and Alaska's North Slope. ADF&G does not differentiate between Arctic char and Dolly Varden for record keeping, however, given the relative distribution of these two species, it is probable that the majority of fish caught in the "Arctic char/Dolly Varden" category are Dolly Varden. ADF&G realizes that a portion of the released fish may die as a result of being hooked and handled but it has been assumed that the rate of mortality is low.

McKinley (1993) found that Arctic char caught from a hatchery raceway suffered a low overall mortality rate (0.033), and that all mortalities occurred with baited hooks. For a broad spectrum of species Wydoski (1977) reported overall mean mortality rates of 25% for fish caught with bait on barbed hooks and 6.1% for fish caught on artificial lures with barbed treble hooks. Retrieved, baited lures tended to cause mortality rates in salmonids similar to those of baited hooks that were still fished (Mongillo 1984). Fishing with barbless hooks has not been shown to reduce mortality significantly, but it may reduce handling time (Mongillo 1984). Vincent-Lang et al. (1993) found that the mortality rate of coho salmon *Oncorhynchus kisutch* caught and released in tidal areas was significantly higher than for fish captured and released in upstream freshwater areas. They concluded that anadromous salmon undergoing the osmoregulatory stress of returning to freshwater were more susceptible to the additional stress of being hooked than those already adapted to the freshwater environment. Pauley and Thomas (1993) found that mortality of anadromous coastal cutthroat trout *O. clarki* taken above and below tidal influence in Puget Sound, Washington was higher with worm baited hooks (39.5 - 58.1%) than for three different spinner treatments (10.5 - 23.8%). Another study dealing with cutthroat trout in the Yellowstone River found an overall hooking mortality rate of 0.3%, however it was estimated that each fish was caught 9.7 times resulting in a hook related mortality of 3% of the population (Schill et al. 1986).

Hook placement was the primary factor, and resultant bleeding the primary cause affecting mortality rates in captured fish (Mongillo 1984). Fish hooked in the gill arches or esophagus had much higher mortality rates than those hooked in the jaws or mouth (Mongillo 1984). McKinley (1993) found that 56% of Arctic char hooked in the gill arches died. Loftus et al.(1988) reported 71.4% mortality in lake trout *S. namaycush* hooked internally and 6.9% mortality when hooked externally. Pauley and Thomas (1993) found that the probability of death was greater for coastal cutthroat trout hooked in the

gill, tongue, esophagus or eye and was significantly higher than for those hooked in other locations.

This study is the first attempt to quantify the mortality rates due to catch and release of Dolly Varden. Since catches of Dolly Varden in Alaska are large, a high hook and release mortality would have significant management implications.

Field work for this study was conducted over two seasons, in the Nome area during 1993 and in the Kotzebue area during 1994. Four gear types were investigated: treble hook lure (1/2 or 3/8 oz. Hot Rod), single hook lure (1/8 oz. rubber skirted jig), single hook (no. 10) - baited, treble hook (no. 12) - baited. These terminal gears represent the present range of legal terminal gears used by anglers to catch Dolly Varden in the Arctic-Yukon-Kuskokwim region. Quantified mortality rates of Dolly Varden caught with these four terminal gears may substantiate the efficacy of catch-and-release regulations for controlling sport fisheries for Dolly Varden.

The Nome area was initially selected for this study because streams with Dolly Varden are easily accessible, and fish in this area are typically in the same size range as Dolly Varden that occur in most areas of Alaska. During 1993, three treatment groups were completed, and a fourth was begun. Dolly Varden did not return to Nome area streams in their usual numbers by early October, and the study was not completed. To ensure that fish were available, the remainder of the study was conducted on the Wulik River (Kotzebue area) in 1994. Nome area treatment groups included: a) single hook lure, 60 fish; b) single hook bait, 59 fish; treble hook lure, 14 fish; and c) single hook lure (early group fresh from the sea). Kotzebue area treatment groups included a) Treble hook lure, 46 fish; b) Treble hook baited with salmon eggs, 60 fish; and, c) a control of 60 fish caught with a seine.

The project objectives were:

1. to test the hypothesis that there is no significant mortality suffered by Dolly Varden caught once with the different gear types; and,

2. to test the hypothesis that there is no significant difference in the mortality rate of sport caught and released Dolly Varden which have recently entered fresh water (the early group), and the mortality rate of caught and released Dolly Varden which have been residing in freshwater for more than one week (all other Dolly Varden caught in regards to objective 1). The alternative hypothesis was that the hooking mortality rate is greater for caught and released Dolly Varden that have recently entered fresh water.

METHODS

Sampling Gear and Techniques

All fish were captured using a medium weight spinning rod and reel equipped with 8-lb or 10-lb monofilament line. Each person fishing used a variety of the selected gear types and fished in a normal manner to approximate methods used by anglers typically fishing for Dolly Varden in northwestern Alaska. Fish were "played" for a minimum of approximately 30 s before being brought to land. Other than the use of a hemostat or needlenosed pliers to remove the hook, special handling procedures were not followed. Each Dolly Varden captured was measured to the nearest millimeter in fork length (FL), tagged with an individually numbered Floy FD-67 internal anchor tag, and placed in a holding pen. The location of the hook and the amount of bleeding were noted for each fish. Hook placement was noted as in Figure 1, and the amount of bleeding was rated on a four point scale (adapted from Falk and Gillman 1975): 0) none, no evidence of external bleeding; 1) slight, a small amount of bleeding generally localized near the point of hook entry; 2) moderate, a greater amount of external bleeding generally localized around the point of hook entry; 3) severe, copious amounts of blood, staining the water in the holding bucket and generally surrounding and obscuring the point of hook entry. The time of day was also noted for all captures.

If a fish was hooked deep in the esophagus, the line was cut. For all other hook placements, the hook was removed. All captured fish were placed in 1.2m X 1.2m X 1.2m, or 0.9m X 1.4m X 0.9m holding pens with a maximum of 60 fish per pen. Dead fish were removed from the pens when they were observed (time and tag number noted). Pens were checked for mortalities as additional fish were added, each morning, and several times each day that fish were held after pens were filled. Each pen was monitored for 48 h after the last fish was released into it; all fish were then released. Only fish that died within 48 hours of capture were considered mortalities from fishing. The mortality rate for each gear type was calculated as follows:

$$\hat{m}_i = \frac{X_i}{n_i} \qquad (1)$$

where:

$\hat{m}_i$ = the mortality rate of fish caught with gear i

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

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

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

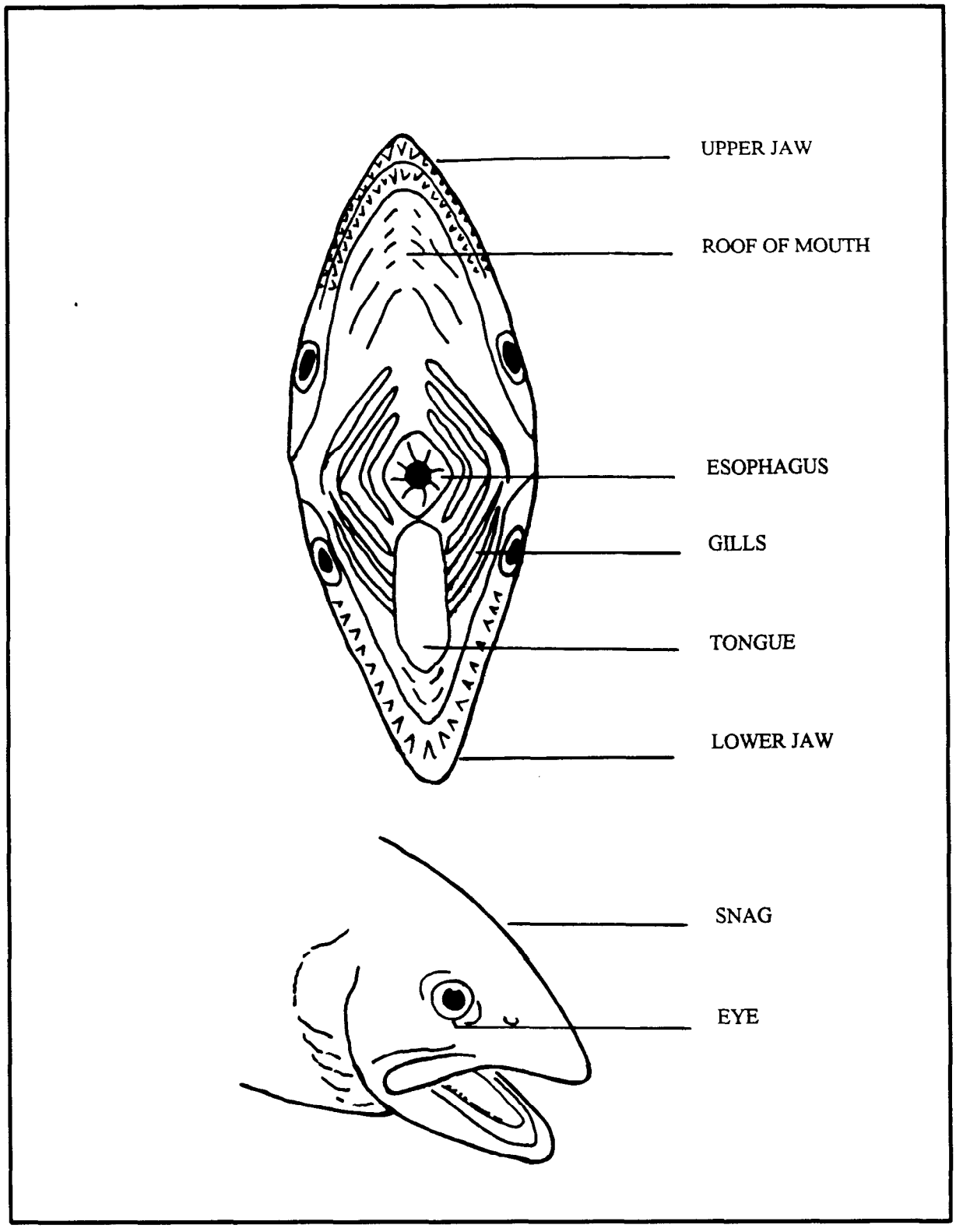

Figure 1. Description of hook placement.

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

A one-tailed binomial test was performed to determine if the mortality rate for any one gear type is significantly greater than the control. Confidence intervals were used to compare mortality among gear types. Confidence intervals are calculated as (Zar 1984):

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

and,

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

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;

F_{γ_1,γ_2} = probability from the F distribution with γ_1,γ_2 degrees of freedom

where:

$\gamma_1 = 2(n_i - X_i + 1)$;
$\gamma_2 = 2X_i$;

$F_{\gamma_1',\gamma_2'}$ = probability from the F distribution with γ_1,γ_2 degrees of freedom where:

$\gamma_1' = 2(X_i+1)$;
$\gamma_2' = 2(n_i - X_i)$;

To retain an overall level of significance of 10%, the alpha level for each test between gears was set at 0.02.

A similar one-tailed binomial test was performed to determine if the mortality rate for the single gear type used on fish recently entering fresh water (the early group) is significantly greater than the mortality rate for that same gear type used on fish which have been resident in fresh water for more than one week. Confidence intervals were constructed in the same manner as described above for this second objective (no alpha level adjustment needed).

Data on hook placement and level of bleeding were collapsed into generalized categories and compared using contingency tables. If the hypothesis of

independence of hook placement and level of bleeding failed to be rejected (P> 0.10), then the hook placement categories were pooled.

The length distributions of control fish and fish caught with each gear type were compared using the Anderson-Darling k-sample test (Scholz and Stephens 1987).

A control group of 60 fish was seined and distributed in the holding pens. Control fish were captured in 1994 the day after the last two gear type samples were taken.

RESULTS

Of 359 Dolly Varden captured and held in this experiment, only six (1.7%) died during the monitoring period. Three died within 30 min, two within 6 h, and one within 12 h of capture. The mortality rates did not vary significantly among the treatment groups and the control. The mortality rate of all Dolly Varden caught with single hook gear types was 0.017 (SE < 0.001), virtually identical to that of all fish caught on treble hook gear types, 0.017 (SE < 0.001). Mortality from baited gears (0.025, SE < 0.001) was only slightly higher than, but not significantly different from that for all unbaited gears (0.011, SE < 0.001)(Table 1).

The Early Group:

The first Dolly Varden observed in the Nome area during 1993 were found in the Snake River during late August. Of the 60 fish captured using single hook lures, two (mortality = 0.033, SE = 0.023) died during the holding period, both within 30 min of capture. Both mortalities were hooked in the eye, bleeding was noted as "moderate" in one case and "slight" in the other (Appendix A). Although mortality in this group was higher than that of the later single-hook lure group (no mortalities) it was not significantly different (Table 1).

Mortality By Gear Type

No deaths occurred during the monitoring period in the 60 fish sample caught from the Nome River using unbaited single hook lures. Likewise, there were no deaths recorded in the 60 fish sample caught on unbaited treble hook lures. Fish in this sample were taken from the Snake, Nome and Wulik rivers.

Only one fish died of 59 caught from the Nome River using single hooks baited with salmon eggs (mortality = 0.017, SE < 0.001). This fish was hooked in the tongue and was bleeding heavily. Of 60 Dolly Varden caught from the Wulik River with treble hooks baited with salmon eggs, only two died (mortality = 0.033, SE = 0.023). One of the dead fish was hooked in the eye and was bleeding "heavily" while the other was hooked in the lower jaw and was experiencing "moderate" bleeding.

Table 1. Estimates of mortality rate, standard error, and 90% confidence intervals for Dolly Varden caught by gear types.

Gear Type	n	x	m	SE	LCI	UCI
Single Hook Lure (Early Group)	60	2	0.033	0.023	0.003	0.120
Single Hook Lure	60	0	0		0	0.064
Treble Hook Lure	60	0	0		0	0.064
Single Hook Bait	59	1	0.017	<0.001	<0.001	0.092
Treble Hook Bait	60	2	0.033	0.023	0.003	0.120
All Baited Hooks	119	3	0.025	<0.001	0.009	0.056
All Unbaited Hooks	180	2	0.011	<0.001	0.003	0.030
All Single Hooks	179	3	0.017	<0.001	0.006	0.037
All Treble Hooks	120	2	0.017	<0.001	0.004	0.044
Control Group (beach seine)	62	1	0.016	<0.001	<0.001	0.088

Bleeding, Hooking Location and Size of Fish

The numbers of fish experiencing varying degrees of bleeding were compared by the location of hook placement using contingency tables. The distribution of bleeding severity from fish hooked in the jaw was found not different from those snagged (hooked somewhere other than in the eye or mouth area) (χ^2 = 3.69, DF = 2, $P < 0.001$). These groups were then pooled and compared with fish hooked in the eye, tongue, gill or roof of mouth. The distribution of bleeding severity between these groups was found to be different (χ^2 = 64.17, DF = 3, $P < 0.001$). More fish hooked in the eye, tongue, gill or roof of mouth experienced moderate or severe bleeding than those snagged or hooked in the jaw (Figure 2).

The length distributions of samples by gear type (Figure 3) were compared using the Anderson Darling K-sample test and found to be different (Takn = 42.68, $P < 0.001$). Since significant differences in mortality by gear type were not found, none could be directly attributed to differences in fish length.

DISCUSSION

Overall mortality related to hooking and handling Dolly Varden in this experiment was found to be very low. Significant differences were not found in mortality among different gear types and the control group. Hook and release fishing may therefore be regarded as a reasonable management option for Dolly Varden populations in northern Alaska. It is probable that southern-form Dolly Varden react similarly to hook and release fishing; if so, this management option may be applicable statewide.

One of 62 seine caught control fish died. This fish was a spent male which became entangled in the netting of the holding pen by its type. When the water level dropped during the night, the fish was left suspended out of the water. Even though no fish from any of the treatment groups experienced this fate, the fish was considered a holding mortality. If this fish were not considered a mortality, the results of this experiment would have been left essentially unchanged. Mortalities from treatment groups would have still not been significantly different from the control group.

Although no size-based differences in hooking mortality were shown in this experiment, the length distribution fish varied significantly among treatment groups. Dolly Varden captured from the Wulik River (46 fish in the treble hook lure treatment group, the treble hook bait group and the control group) were larger than fish caught in the Nome area (other groups). Observed mortality may have been different had smaller fish been captured in the treble hook groups, or had larger fish been captured in the single hook groups.

Mortality rates have been found to be similar between hook types in most studies (Dotson 1982, Falk and Gillman 1975, Mongillo 1984). Klein (1965) found higher mortalities in rainbow trout *O. mykiss* caught with single hooks

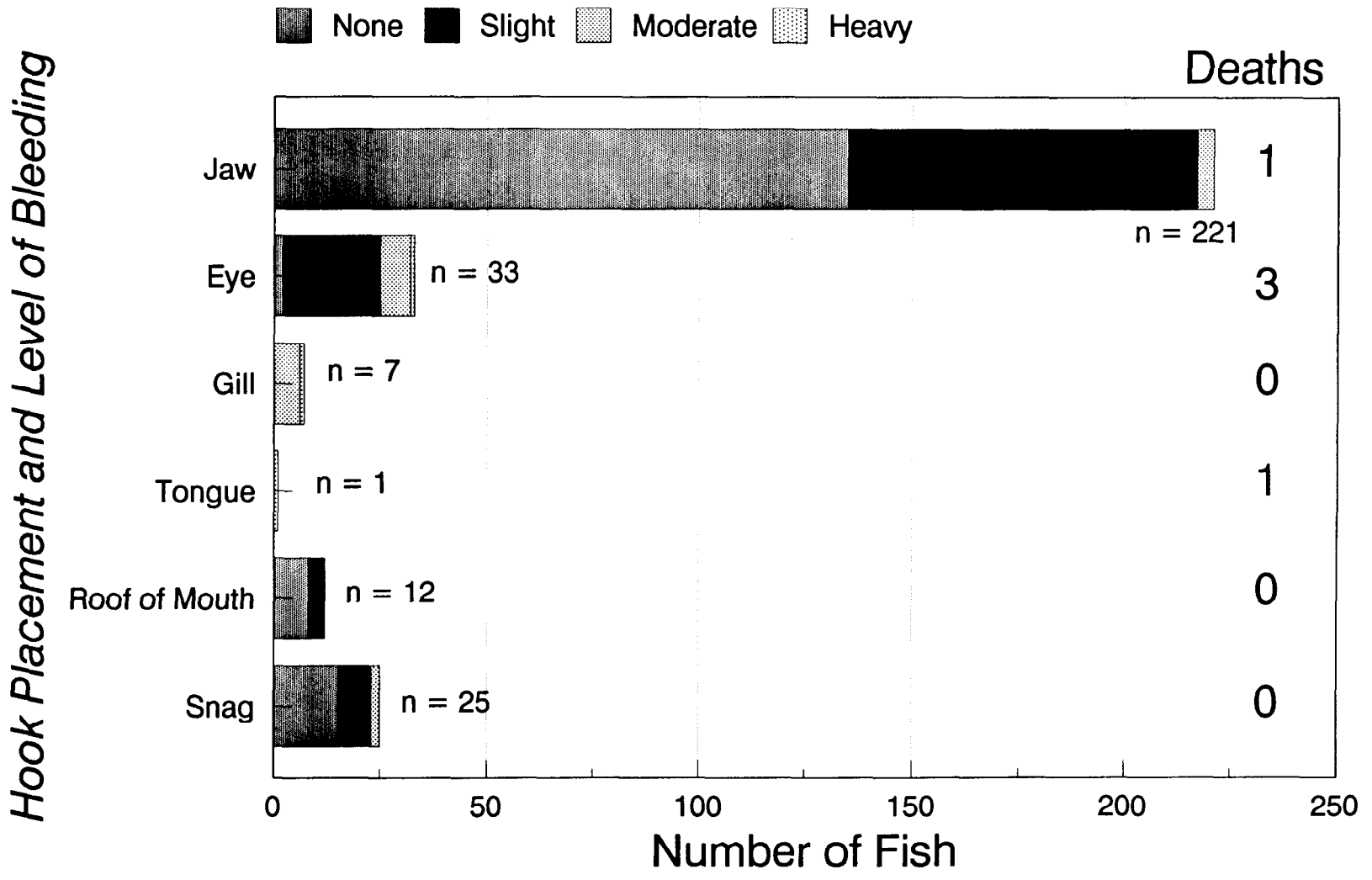

Figure 2. Mortality and level of bleeding by hooking location of Dolly Varden caught on sport fishing tackle, gear types pooled.

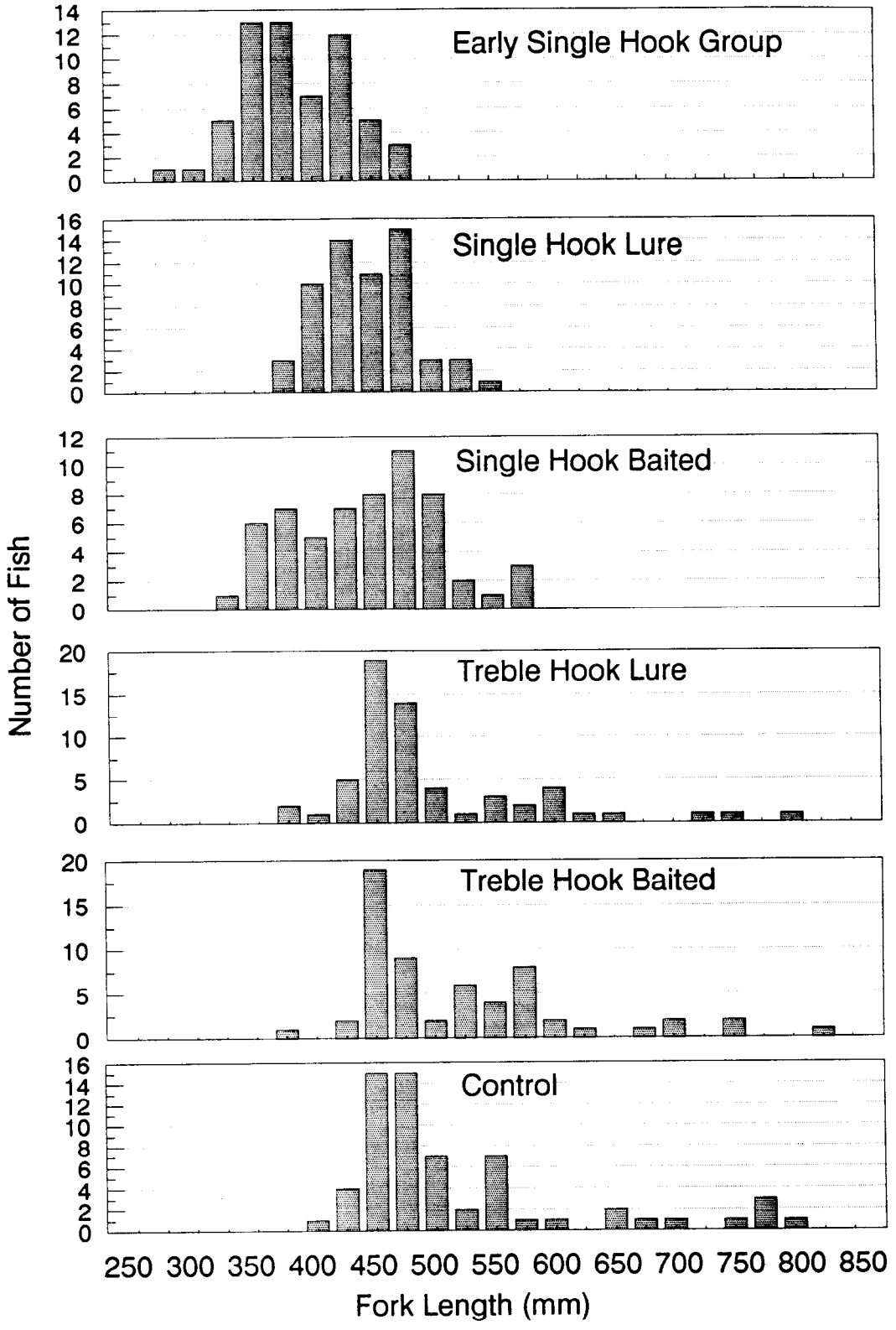

Figure 3. Fork length distributions of treatment groups of Dolly Varden captured with different sport fishing tackle and control (Beach seine).

than those caught with treble hooks. He stated that this was because single hooks were often taken more deeply into the mouth and was more likely to inflict a more serious wound. More fish in my study were hooked in the eye, a potentially lethal location, in the single hook samples than in treble hook samples (Appendix A). This was probably due to the choice of the single hook rubber skirted jig as the single hook lure. This lure rides with the hook oriented upward, and was more likely to hook fish in the upper jaw than other lures. Both single hook mortalities were in fish hooked in the eye. These mortalities were both from the early single hook sample. This sample contained the smallest fish (Figure 2) which may have been a contributing factor to the two mortalities. These fish were 312 and 350 mm FL respectively, and were the smallest of the five hooking mortalities. Other mortalities ranged from 425 to 511 mm FL. A potential contributing factor to the slightly higher mortality in this group may have been higher water temperatures, approximately 10° C vs < 5° C for the other groups. Dotson (1982) found evidence for increased angler induced mortality in cutthroat trout at water temperatures above 15° C, but Marnell and Hunsaker (1970) found no evidence for this. Physiological stress due to the osmoregulatory changes necessary for anadromous fish to enter fresh water was suggested by Vincent-Lang et al. (1993) to contribute to hook and release mortality for coho salmon caught in an estuary. This effect could influence the mortality rate of angler-caught Dolly Varden, however, since the mortality rate in this group was not significantly higher than that of the later single hook group, or other treatment groups, these considerations have little management value for this species in northern areas.

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APPENDIX A

Appendix A. Hook location and level of bleeding by gear type.

Single Hook Lure (Early Group)							
Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	32	0	0	0	0	0	32
Slight	10	16*	0	0	2	3	25
Moderate	1	1*	2	0	0	0	3
Heavy	0	0	0	0	0	0	0
Total	36	17**	2	0	2	3	60

Single Hook Lure							
Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	35	1	0	0	6	3	45
Slight	10	2	0	0	1	0	13
Moderate	1	1	0	0	0	0	2
Heavy	0	0	0	0	0	0	0
Total	46	4	0	0	7	3	60

Single Hook Bait							
Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	34	0	0	0	2	3	39
Slight	13	2	0	0	0	1	16
Moderate	0	0	3	0	0	0	3
Heavy	0	0	0	1*	0	0	1
Total	47	2	3	1*	2	4	59

Treble Hook Lure							
Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	14	0	0	0	0	6	20
Slight	26	3	0	0	1	3	33
Moderate	1	4	0	0	0	2	7
Heavy	0	0	0	0	0	0	0
Total	41	7	0	0	1	11	60

Treble Hook Bait							
Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	20	1	0	0	0	3	24
Slight	29	0	0	0	0	1	30
Moderate	2*	1	1	0	0	0	4
Heavy	0	1*	1	0	0	0	2
Total	51*	3*	2	0	0	4	60

All Single Hook							
Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	101	1	0	0	8	6	116
Slight	27	20	0	0	3	4	54
Moderate	1	2*	5	0	0	0	8
Heavy	0	0	0	1*	0	0	1
Total	129	23*	5	1*	11	10	179

-continued-.

Appendix A. (Page 2 of 2).

All Treble Hook

Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	34	1	0	0	0	9	44
Slight	55	3	0	0	1	4	63
Moderate	3*	5	1	0	0	2	11
Heavy	0	1*	1	0	0	0	2
Total	92*	10*	2	0	1	15	120

All Baited Hooks

Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	54	1	0	0	2	6	63
Slight	42	2	0	0	0	2	46
Moderate	2*	1	4	0	0	0	7
Heavy	0	1*	1	1*	0	0	3
Total	98	5*	5	1*	2	8	119

All Unbaited Hooks

Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	81	2	0	0	6	9	97
Slight	40	21*	0	0	4	6	71
Moderate	2	6*	2	0	0	2	12
Heavy	0	0	0	0	0	0	0
Total	123	28**	2	0	10	17	180

All Fish Captured and Held

Bleeding	Jaw	Eye	Gill	Tongue	Roof of Mouth	Snag	Total
None	135	2	0	0	8	15	160
Slight	82	23	0	0	4	8	117
Moderate	4	7	6	0	0	2	19
Heavy	0	1	1	1	0	0	3
Total	221	33	7	1	12	25	299
Deaths	1	3	0	1	0	0	5

* indicates a fish that died.