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CAUGHT ON ARTIFICIAL LURES**

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¹ A contribution from Dingell-Johnson Project F-35-R, Michigan.

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Abstract.—The average hooking mortality per capture event for 630 trophy-sized wild brook trout (mean total length 33.9 cm) caught on five hardware lures was 4.3% during the first 48 hours after capture. Mortality was 8.3% for trout caught on Mepps spinners and Cleo spoons equipped with a treble pointed hook whereas fish caught on the same lures with a single-pointed hook died at a significantly lower rate of 2.4% per hooking event ($P < 0.05$). There was no mortality among 126 trout caught with Rapala lures rigged with two treble hooks. We believe that the differences in mortality of trout caught with different lures are due primarily to differences in the frequency and extent of damage to the gill arches and esophagus area. Certain lures were more likely to be engulfed deeply, particularly by larger trout, and thus were more likely to cause death. Lures which exhibit vigorous wobbling action when retrieved appear less likely to be deeply engulfed and consequently cause less mortality. Hooking mortality estimates for trout caught on Mepps or Cleo lures were positively and significantly correlated with size of fish. The probability of death within 48 hours of capture for heavily bleeding trout which were hooked in the gills and/or throat increased rapidly with increasing water temperature. Trout which did not bleed heavily following capture with Mepps and Cleo lures equipped with treble hooks which did not penetrate the gill or throat region were unlikely to die due to temperature effects until temperatures rose to approximately 14°C. The probability of death was not significantly associated with temperatures ranging from 5.6 to 17.8°C when trout were hooked with single-pointed hooks which penetrated anatomical sites other than the gills or throat and did not bleed heavily. Present regulations on Michigan's trophy trout lakes, which restrict lures to single pointed hooks and forbid harvest of fish less than 38.1 cm, appear quite adequate to minimize losses due to hooking mortality.

Large minimum size limits and no-kill regulations are two methods fisheries managers use to increase both the size and number of fish caught. Special regulations of artificial lures with single hooks, a creel limit of two fish per day, and a 38.1-cm minimum length size limit apply on 12 of Michigan's designated trout lakes. These regulations are designed to provide opportunities for trophy brook trout (*Salvelinus fontinalis*) fishing. Since brook trout in most inland lakes in Michigan do not grow to 38.1 cm until

approximately age 4 or 5, they are subject to many years of catch-and-release angling before they can be harvested. Although many studies of salmonid hooking mortality have been reported, we could find no references concerning mortality of large brook trout. The sample size (number of hooking events) in most studies we reviewed were generally far smaller than the 630 hooking events examined in this study. Moreover, many studies have employed hatchery trout as their test fish

whereas large wild brook trout in natural waters were used in this study.

This study focuses on estimating the hooking mortality rates of trophy-sized brook trout caught on different hardware lures and hook types. The relationships between hooking mortality and anatomical hooking site, bleeding severity, temperature and fish size are examined. Estimates of potential catch and hooking mortality of trophy-sized brook trout in a typical northern Michigan inland trout lake are made assuming catch-and-release or trophy-size limit regulations.

Study Area

Fishing was done at three sites in the Hunt Creek Fisheries Research area in Montmorency County, Michigan. Fuller Pond is a shallow flowage of 6.07 ha created by an earthen dike on the site of an old beaver dam. The outlet stream discharges approximately 0.085 m³/s through a fish trapping weir. Temperature and oxygen regimes are such that trout can frequent most areas of the pond throughout the year.

East Fish Lake, which is also located in the Hunt Creek Research area, is an oligotrophic kettle lake of 6.48 ha fed by one small tributary stream and numerous springs. The outlet of this lake discharges approximately 0.042 m³/s through a fish trapping weir. East Fish Lake becomes thermally stratified, with oxygen and temperature regimes satisfactory for trout from surface to bottom throughout the year.

Spring Pond, where most of the hooking events occurred, is approximately 0.16 ha.

Selected morphological and limnological characteristics of the above waters are summarized in Table 1. All three experimental waters are closed to public fishing.

Methods

Brook trout were captured using the following lure types with barbed hooks.

1. A Mepps size #1 spinner with French style blade and treble hook (6-mm gap, tip of hook to shank).
2. The same Mepps spinner with two points clipped from the treble hook (6-mm gap).
3. A 3.6-g, 4-cm Cleo spoon with a treble hook (6-mm gap).
4. A 3.6-g Cleo spoon with a #6 single Eagle Claw medium shank hook (11-mm gap).
5. A 5-cm floating Rapala lure with two treble hooks (5-mm gap).

Hooking events were recorded beginning April 6, 1987 and ending June 10, 1989. During April 1987, brook trout were captured by angling from East Fish Lake and Fuller Pond and transferred to Spring Pond. These original trout were then caught repeatedly over the course of the study along with native trout already residing in Spring Pond.

The original 78 trout were hooked, played until they could be easily netted, unhooked using fingers (or pliers when necessary), immediately transferred to a 19-L water bucket in the boat, and shifted within 5 minutes to a 1.8-m deep floating net near the center of the lake. The type of lure used, anatomical hooking site, surface water temperature, number of hook points penetrating the fish, and degree of bleeding observed were recorded for each hooking event. Three categories of bleeding intensity were defined. Fish were assigned to the first category when there was no bleeding or no flow of blood from the hook wound. Fish were assigned to a second category when there was a light to moderate flow of blood and to a third category when heavy bleeding occurred.

The holding nets in East Fish Lake and Fuller Pond were checked for trout mortalities 24 hours after capture and again after 48 hours. After 48 hours, all trout were weighed and measured and the surviving fish were transferred to Spring Pond. Recaptured fish (identified by fin clips) and resident fish in

Spring Pond were hooked, played, and netted in the same manner described above. However, since angling was conducted from shore, captured fish were immediately transferred to a wire mesh live-box at the edge of the pond where they were checked for mortalities after 24 and 48 hours following capture. Fish which survived the holding period were returned to Spring Pond after they were weighed and measured.

Lure types used were varied randomly with the constraint that roughly equal numbers of fish be caught on each lure over time.

Pair-wise comparisons of means were used to determine significant differences in hooking mortality between lure and hook types. The variance for mortality estimates was computed using the formula:

$$s^2 = m(1-m)/n,$$

where s^2 is the sample variance, m is mortality expressed as a fraction, and n is the number of trout caught on an individual lure or combination of lures. The Student's t -distribution was used to calculate two-tailed 95% confidence limits for mortality estimates. Because Rapala lures had two treble hooks and a different action when retrieved, fish captured with this lure were excluded from the analysis of differences in mortality of trout caught on treble and single hooks. Mortality estimates and confidence limits were computed for all sizes of trout (21.6-49.8 cm) combined and for trout ≤ 38.1 cm and trout > 38.1 cm total length.

Logistic regression techniques were used to identify variables most useful for predicting trout death after hooking and to determine what factors are most important for predicting if fish will be hooked in the esophagus and gill arches. Least squares linear regression was also used to examine possible relationships between variables.

Results

Anatomical Hooking Site and Mortality

An average of 2.2 of the three treble hook points on the Mepps spinner and Cleo spoon penetrated trout captured with these lures, while an average of 3.2 points penetrated fish caught using the Rapala with two gangs of treble hooks. Hooks on all five lures penetrated the upper and lower jaws or roof of the mouth in the vast majority of hooking events. Only one of the 27 trout which died was hooked solely in the jaws or roof of the mouth. In contrast, 61% of the trout hooked in the gill arches or deep in the throat died. Of these trout, over 70% hooked with treble hooks died, while 50% died when hooked with the single hook lures in these locations. No Rapala-caught trout were hooked in either the throat or gill arches and none of the 126 fish caught on this lure died. Rapala-caught trout were hooked outside the mouth (foul hooked) by at least one point 43% of the time. In nearly all cases, these fish were first hooked in the mouth by either the front or rear treble. The second treble hook then became imbedded externally during the course of fighting, netting, or unhooking the fish.

Logistic regression analysis showed that the probability that a fish would be hooked in the gills or throat was positively correlated with trout size (Figure 1). The logistic regressions were highly significant for Mepps spinner and Cleo spoon treble-hooked lures either singly or in combination. Although regressions of hooking site versus trout size for lures equipped with single hooks also suggested that larger fish were more likely to be hooked in the throat or gills, the regressions were not significant ($P > 0.05$). Of the five lures tested, treble-hooked Mepps spinners were the most likely to penetrate this area and the Rapala lures were least likely to be imbedded in the throat or gills (Table 3).

Bleeding Severity and Mortality

The severity of bleeding associated with capture by each of the lure types is summarized in Table 4. Severe bleeding was closely associated with hook damage to the gill arches or throat. Over 80% of the severely bleeding brook trout caught on Mepps spinners or Cleo spoons with treble hooks died within 48 hours of capture. The mortality of severely bleeding fish caught on the same lures equipped with single hooks was 42%. More fish caught on Rapalas were classified in the second category of bleeding intensity (light to moderate bleeding) than fish caught on any other lure because, in many cases, the second treble hook penetrated external body areas. The increased difficulty in maneuvering and unhooking two treble hooks from a struggling fish also increased bleeding from hooks penetrating the inside of the mouth. In spite of this, Rapala-caught fish had the lowest incidence of severe bleeding. Logistic regression analysis indicated that bleeding intensity exhibited by fish caught on Mepps spinner or Cleo spoon lures was most strongly influenced by hook type (treble or single) and the size of fish (Figure 3) ($P < 0.0001$).

Mortality per Capture Event

The average mortality per capture by all lures combined for large brook trout (mean total length 33.9 cm, range 21.6-49.8 cm) was 4.3% during the first 48 hours after capture (Table 2). Of the five lure types, Mepps #1 spinners with treble hooks killed the largest percentage (10.9%) of brook trout, while none of the 126 brook trout caught on Rapalas with two gangs of treble hooks died. The other three lures induced intermediate levels of mortality ranging from 1.6 to 5.6% but were not significantly different from each other ($P > 0.05$). Mepps spinners with both single and treble hooks and Cleo treble-hooked spoons caused significantly greater mortality than Rapala lures ($P < 0.05$). Mortality caused by Cleo single-hooked spoons (1.6%) was significantly lower than mortality of trout caught on Mepps treble-hooked spinners.

Trout >38.1 cm experienced higher mortality than trout ≤ 38.1 cm following capture by treble-hooked Mepps spinners, and by treble- and single-hooked Cleo spoons (Table 2). Logistic regression analysis showed that there was a highly significant positive relationship between size of fish and probability of death following hooking for all Cleo spoon and Mepps spinner lures combined and also for Mepps spinner and Cleo spoon treble-hooked lures combined (Figure 2). Although larger trout caught on single-hooked lures also appeared more likely to die than smaller trout caught on these lures, the logistic regression model's significance level was low ($P = 0.34$). In addition, the magnitude of the increase in mortality with increasing trout size was much smaller than for treble-hooked lures (Figure 2). The increase in mortality with increasing trout size was greatest for Mepps spinner treble-caught trout, and the logistic regression was significant ($P < 0.05$). Larger trout may be more likely to die when caught on Cleo treble-hooked spoons ($P = 0.07$) and Cleo single-hooked spoons ($P = 0.06$). Mortality of trout hooked with Mepps single-hooked spinners did not appear to be related to trout size.

Treble Versus Single Hooks

Mortality for the 128 brook trout caught on Mepps spinners with treble hooks was not significantly higher ($P > 0.05$) than the rate for Mepps spinners with single hooks. Cleo spoons with treble hooks were not significantly more lethal than the same spoon with a single hook ($P > 0.05$). However, when sample size was increased by combining lure types, the 8.3% mortality for the 253 fish caught on either Mepps spinners or Cleo spoons with treble hooks was significantly higher than the 2.4% death rate for the 251 trout caught with these same lure types equipped with single hooks ($P < 0.05$).

Rapala-caught trout were not included in the analysis of single versus treble hooks due to the different design and action of the lure.

Effect of Temperature

Surface water temperatures over the course of the study ranged from 5.6°C to 17.8°C, with a mean of 11.8°C. The least squares regression of hooking mortality versus temperature for fish caught by all lure types combined indicated a significant positive correlation and slope ($P < 0.05$). The linear regressions of death rate versus temperature for fish caught with all Mepps spinners and Cleo spoons combined and Mepps spinner trebles alone likewise had significant positive correlations and slopes ($P < 0.05$). Among the multiple logistic regression models examined for predicting the probability of death, those which contained the independent variables of bleeding intensity, hook penetration site, and temperature were highly significant ($P < 0.0001$) for fish hooked on either single or treble-hooked Cleo spoons or Mepps spinners. Figure 4 illustrates that the predicted probability of death increased rapidly with increasing temperature when fish bled heavily and were hooked in the gill and/or throat region with either single or treble hooks. The predicted effect of increasing temperature on mortality of fish caught with Mepps spinner or Cleo spoon single-hooked lures which penetrated in areas other than the throat and gills and which did not bleed heavily was approximately zero within the range of temperatures tested (5.6-17.8°C) (Table 5). By contrast, the logistic model (Table 5) predicted that mortality for fish caught using treble-hooked Mepps spinners and Cleo spoons would approach 1.0% at 14°C and increase rapidly to 26.6% at 17.8°C, even when hooks did not penetrate the gill and/or throat region or cause heavy bleeding (Figure 4). Because no fish caught on Rapala lures died, there was no temperature/mortality relationship to test.

Timing of Mortality

Of the 27 brook trout that died within 48 hours of capture, 66.6% died during the first 24-hour period. We did not measure mortality after 48 hours. However, substantial numbers

of trout survived for long periods after being hooked. This was indicated by fully healed hook scars on the majority of fish caught after the study was well underway. Conversely, dead fish were occasionally observed on the bottom of Spring Pond and some of these trout may have died from long-term effects of hooking.

Discussion

The 4.3% hooking mortality for brook trout caught on five different artificial lures was very close to the average mortality rate of 6.1% reported by Wydoski (1977) in his review of many hooking mortality studies. It was also in close agreement with the 4.8% mortality for a large sample of wild trout caught on four hardware lures reported by Shetter and Allison (1958). However, our mortality estimate was substantially higher than the 0.3% hooking mortality reported for wild cutthroat trout in the Yellowstone River (Schill et al. 1986).

The effects of hooking or handling on delayed mortality (beyond 48 hours) was, in all likelihood, not significant. Hunsaker et al. (1970), who held wild cutthroat trout (mean total length 35.6 cm) for 2 weeks after capture, found that all mortalities occurred within 48 hours of capture. Both the size of fish and the water temperature range were very similar to this study. Although time to death after hooking varies between studies, there is a strong tendency for the vast majority of fish to die within 48 hours of hooking (Wydoski 1977).

A 3.5-fold greater hooking mortality was observed for trout caught on Mepps spinner and Cleo spoon treble-hooked lures versus the same lures with single pointed hooks. This is probably related to increased tissue damage and associated bleeding among trout hooked in the gill arch or esophagus areas. In general it was far more difficult to unhook a fish impaled on a treble hook in these anatomical locations than for those caught with a single hook. In addition, while unhooking one imbedded point of a treble another point would sometimes become imbedded. It also

took more time and greater physical pressure on trout to unhook treble versus single pointed hooks.

Mepps spinners with treble hooks were found in the esophagus or gill arches in 13.5% of the hooking events versus 7.9% for Mepps with single hooks. We anticipated that both treble and single pointed Mepps spinners would be equally likely to be engulfed deeply by large trout but during hook setting the single pointed hook was probably more likely to be jerked away from the gill arches or esophagus without becoming imbedded. Although no records were kept on strikes missed, it appeared that more fish evaded capture after striking at lures with a single pointed hook. Many investigators (Pelzman 1978; Warner and Johnson 1978; Hulbert and Engstrom-Heg 1980; Loftus et al. 1988; Payer et al. 1989) have found that hook penetration into the gills or esophagus is clearly associated with high hooking mortality.

In this study, the probability that a trout would be hooked in the throat or gill region, the probability of heavy bleeding, and mortality were all positively related to size of fish (Table 5). The larger gapes of bigger fish apparently made it easier for them to engulf lures deeply into the mouth. Investigators working with smaller salmonids than tested in this study found single hooks more lethal than trebles and suggested that the small fish had more difficulty engulfing a treble hook (Klein 1965; Warner 1976). The large brook trout used in this study had large mouths relative to lure size and thus were not as physically constrained from deeply engulfing a treble-hooked lure.

Differences in hooking mortality for trout caught with different lures also appear related to where the hook tends to penetrate the mouth (Table 5). Rapala lures, which killed no fish, are relatively larger than other lures tested and have a vigorous wobbling action when retrieved. Apparently, this action effectively prevented any of the 126 brook trout caught on Rapala lures from taking the lure deep into the mouth. Conversely, Mepps spinners, which track in a relatively straight line when retrieved, were more frequently taken deeply enough into the mouth to

damage gill arches or the esophagus region. Percentages of fish hooked in the throat or gill arches with Cleo spoons were intermediate between Mepps spinners and Rapala lures. The likelihood of a hook penetrating deep into the esophagus or gill arches was again probably dictated in part by the action of the lure. Although Cleo spoons do not wobble as vigorously as Rapala lures, they do not travel in the relatively straight path characteristic of a spinner.

Hooking mortality also tends to be greater at higher water temperatures (Klein 1965; Hunsaker et al. 1970; Dotson 1982; Plumb et al. 1988). In this study higher temperatures were clearly associated with much higher mortality when trout bled heavily after being hooked in the gills and/or throat (Table 5). Trout which did not bleed heavily following capture with Mepps and Cleo lures equipped with treble hooks which did not penetrate the gill or throat region were unlikely to die due to temperature effects until temperatures rose to approximately 14°C. However, predicted mortality rose sharply to nearly 27% at 17.8°C, possible due to greater handling stress. By contrast, the logistic model predicted a probability of death of only 0.0006% at 17.8°C when trout did not bleed heavily following capture by the same lures equipped with single hooks which did not penetrate the gill or throat region (Table 5). When gill arches were broken, fish died 100% of the time regardless of temperature. Further, 93% of the 27 fish which died were hooked in either the gill arch or throat region. Yet there were an additional 16 trout hooked in these regions which did not die during the holding period. The reason for differential survival between these groups appears mainly due to a combination of temperature and degree of tissue damage as measured by bleeding severity. Greater bleeding from a given wound could be expected at higher temperatures due to higher metabolic rates and slower coagulation rates.

The effect of hooking on growth rates was not assessed since individual fish were not identified. Clapp and Clark (1989) found an inverse relationship between growth rate and the number of times an individual smallmouth

bass was caught and released. Fulmer and Ridenhour (1967) found a significant negative relationship between serious healed jaw injuries caused by a troll fishery, and condition factor of fall-run chinook salmon. However, they found no significant relationship for slightly injured fish. There was probably little lasting injury to the brook trout in this study, although stress or minor injury could have affected growth.

Management Implications

Trout stocked in lakes subject to general regulations are frequently caught and harvested within a year after stocking. Alexander and Shetter (1969) found that nearly all the seasonal harvest of brook trout occurred during the first 10 days of the season. In an earlier study, Alexander and Shetter (1961) found that anglers caught slightly more than half the available brook trout during the first 2 weeks of the season. This harvest occurred at the moderate fishing pressure level of 53 angler hours per ha per year.

Few brook trout survive long enough to grow to trophy size in inland trout lakes subject to standard Michigan regulations, which allow use of bait and harvest of fish 25.4 cm or longer. It has been well demonstrated that small inland lakes in Michigan not subject to angling mortality can produce from 40 to 80 brook trout approximately 33 cm long per ha and from 15 to 50 brook trout approximately 38 cm long per ha (Gowing 1986). Artificial lures, combined with regulations restricting

harvest to trophy-sized trout, could easily result in each trout being caught and released 10 times over its lifetime. Given an expected annual natural mortality rate of about 34% during the first 3 years after stocking (Gowing 1986), hooking mortality losses would be negligible if fish were caught an average of twice a year and died at the 4.3% rate per capture found in this study. The 3.5-fold greater mortality for trout caught on Mepps spinner and Cleo spoon treble-hooked lures (8.3% mortality) versus these same lures equipped with single hooks (2.4% mortality) could substantially reduce the number of times the largest trout could be recycled to anglers. Mortality could also be minimized by requiring the use of larger lures and hooks, which would reduce the probability that trout would be hooked in the throat or gill region. Similarly, lures such as Rapala lures that exhibit vigorous wobbling action when retrieved would reduce mortality, because they do not typically penetrate the gills and throat.

Present regulations on Michigan trophy trout lakes which restrict lures to single pointed hooks and forbid harvest of fish less than 38.1 cm appear adequate to achieve management goals.

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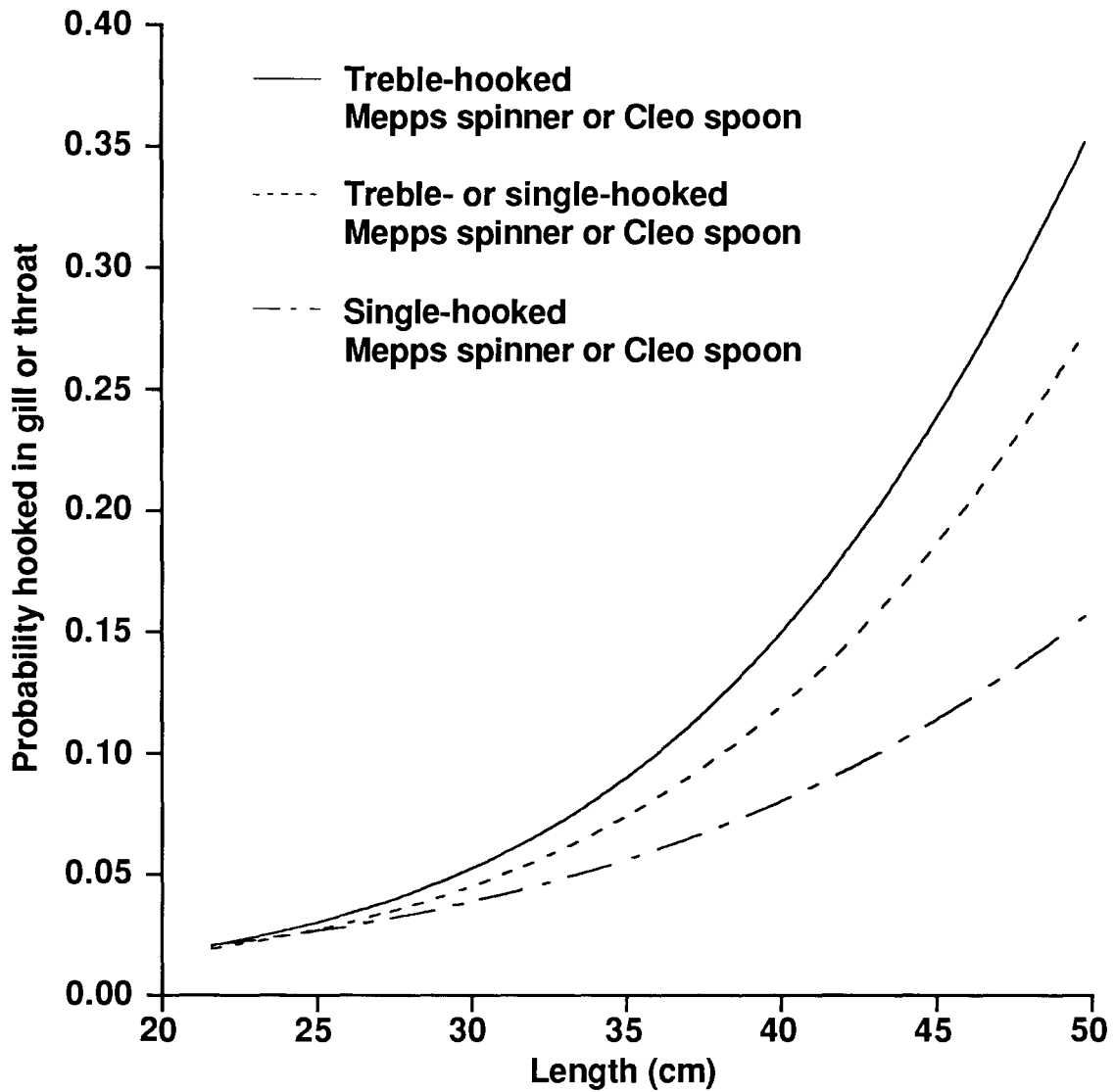


Figure 1.—Probability of a trout being hooked in the gill or throat region as a function of fish total length, given that the trout is captured with a Mepps spinner or Cleo spoon. No fish were hooked in the gill or throat region with a Rapala lure.

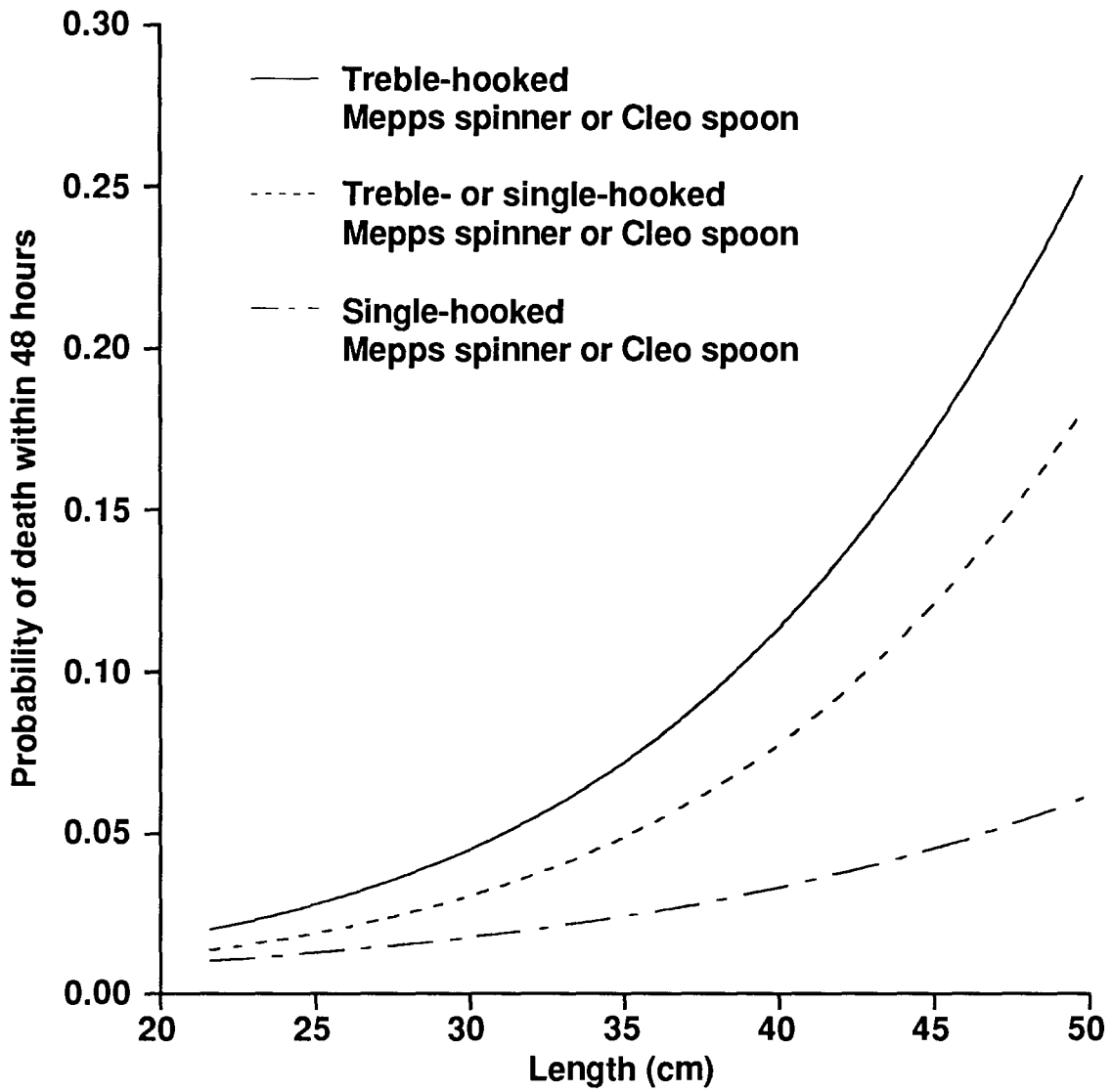


Figure 2.—Probability of trout death within 48 hours of capture as a function of fish total length, given that the trout is captured with a Mepps spinner or Cleo spoon. No fish hooked with a Rapala lure died within 48 hours of capture.

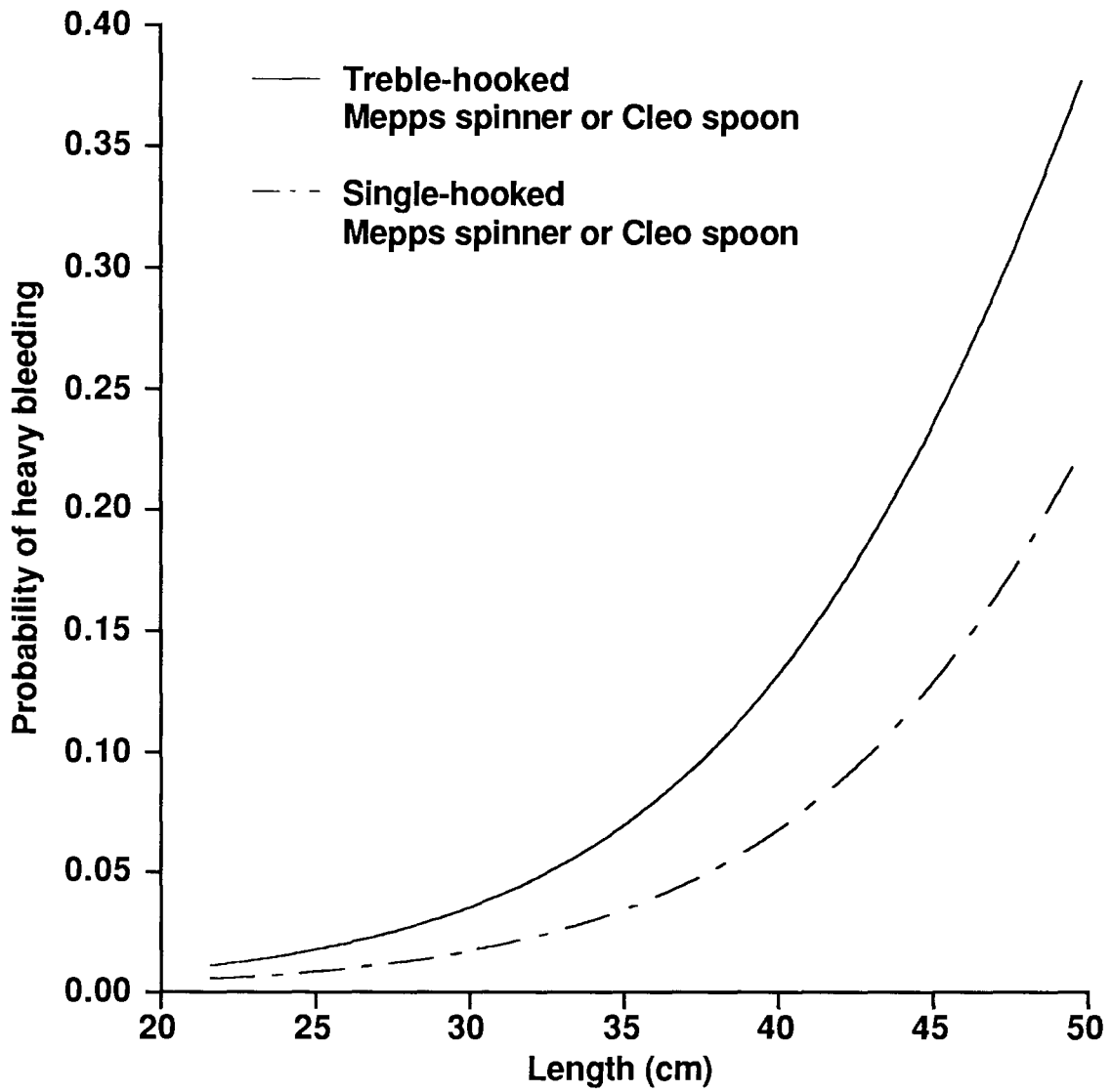


Figure 3.—Probability of heavy bleeding by trout caught on single- and treble-hooked lures as a function of fish total length, given that the trout is captured with a Mepps spinner or Cleo spoon. Only 1.6% of fish hooked with a Rapala lure exhibited heavy bleeding.

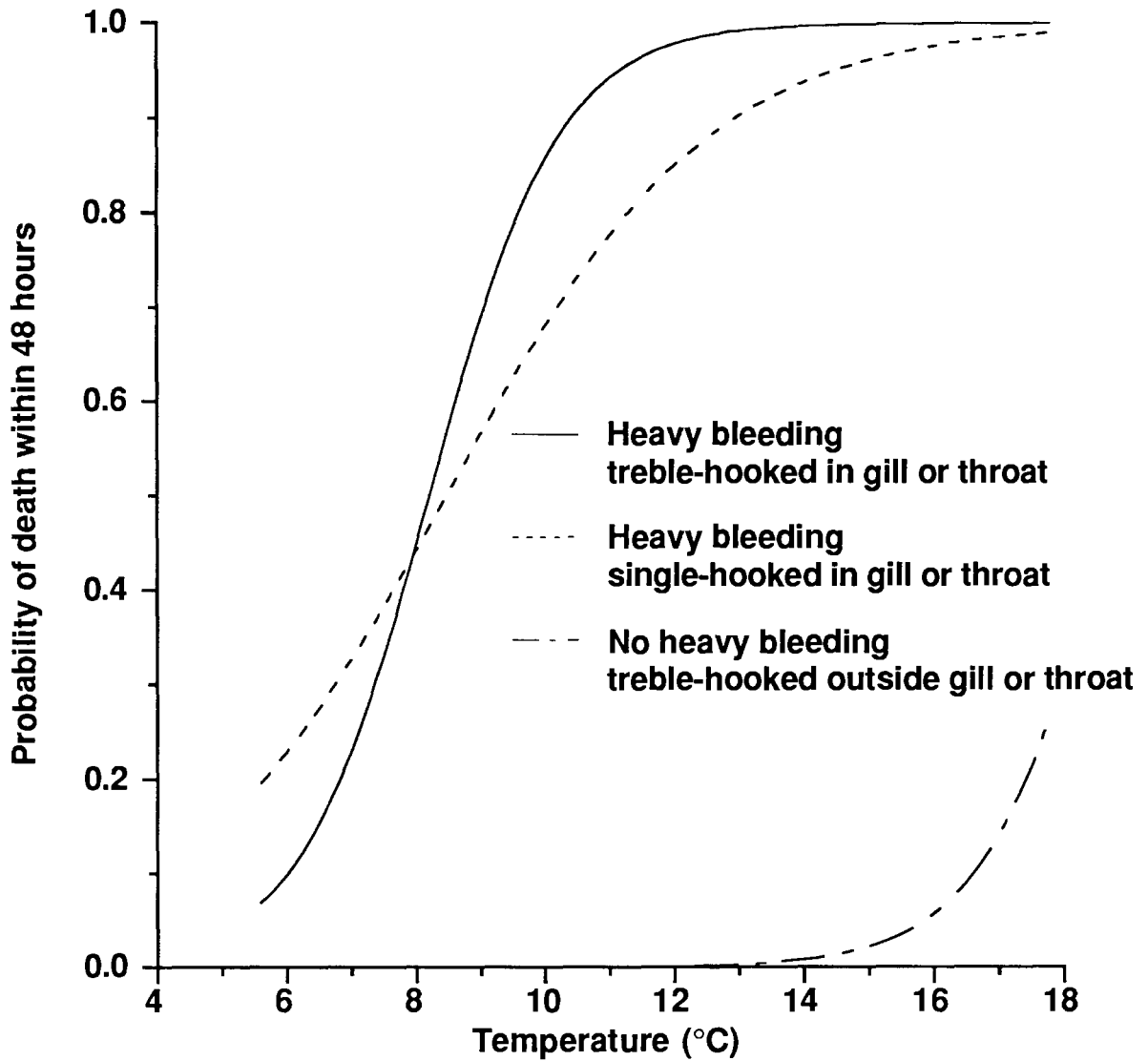


Figure 4.—Probability of trout death within 48 hours of capture as a function of temperature, hook penetration site, and bleeding intensity, given that the trout is captured with a Mepps spinner or Cleo spoon. No fish hooked with a Rapala lure died within 48 hours of capture.

Table 1.—Depth, total alkalinity, and pH of the three experimental waters.

Site	Depth (m)		Total alkalinity (mg/L)	pH
	Maximum	Average		
Fuller Pond	2.4	0.6	149	8.1
East Fish Lake	12.2	8.6	175	8.2
Spring Pond	1.8	0.6	170	8.1

Table 2.—Number and percent mortality (with 95% confidence limits) of brook trout caught using five different artificial lures and held for 48 hours. Sample sizes in parentheses.

Lure	Number	Percent mortality		
		All trout	Trout ≤ 38.1 cm	Trout > 38.1 cm
Mepps #1 spinner with treble hook	128	10.9 \pm 5.46	8.8 \pm 5.90 (91)	16.2 \pm 12.29 (37)
Mepps #1 spinner with single hook	127	3.2 \pm 3.09	4.1 \pm 3.97 (98)	0.0 \pm 0.00 (29)
Cleo spoon with treble hook	125	5.6 \pm 4.04	3.5 \pm 3.98 (85)	10.0 \pm 9.60 (40)
Cleo spoon with single hook	124	1.6 \pm 2.20	0.0 \pm 0.00 (88)	5.6 \pm 7.75 (36)
Rapala lure with two treble hooks	126	0.0 \pm 0.00	0.0 \pm 0.00 (117)	0.0 \pm 0.00 (9)
Mepps and Cleo trebles combined	253	8.3 \pm 3.43	6.3 \pm 3.60 (176)	13.0 \pm 7.63 (77)
Mepps and Cleo singles combined	251	2.4 \pm 1.89	2.2 \pm 2.10 (186)	3.1 \pm 4.28 (65)
All five lures combined	630	4.3 \pm 1.58	3.1 \pm 1.56 (479)	8.0 \pm 4.35 (151)

Table 3.—Percentage of captures where at least one hook point penetrated the anatomical location indicated.

Anatomical location	Artificial lure type ¹				
	MT	CT	MS	CS	RAP
Upper jaw	45	52	30	18	67
Lower jaw	56	56	38	49	80
Roof of mouth	35	25	14	10	25
Eye or orbit	0	4	0	2	0
Gill arches	10	5	1	2	0
Deep in throat	6	3	7	1	0
Cheek	13	13	5	13	5
Tongue	8	8	5	3	10
Foul hooked ²	2	2	0	2	43
Total percentage ³	175	168	100	100	230

¹MT - Mepps spinner with treble hook.

MS - Mepps spinner with single hook.

CT - Cleo spoon with treble hook.

CS - Cleo spoon with single hook.

RAP - Floating Rapala lure with two treble hooks.

²Hooked outside the mouth by at least one hook point.

³Summed percentages exceed 100 for lures with multiple hook points.

Table 4. Percentage of captured trout in three bleeding severity classes.

Lure	No blood flow	Light to moderate blood flow	Heavy blood flow
Mepps #1 spinner with treble hook	54.8	33.3	11.9
Mepps #1 spinner with single hook	78.5	16.7	4.8
Cleo spoon with treble hook	54.0	40.5	5.5
Cleo spoon with single hook	69.0	26.2	4.8
Rapala lure with two treble hooks	41.3	57.1	1.6
Mepps and Cleo trebles combined	54.4	36.9	8.7
Mepps and Cleo singles combined	73.8	21.4	4.8

Table 5.—Logistic regression coefficients relating trout length or water temperature to the estimated probability of events associated with hooking mortality. The probability, P , of the event occurring is estimated using the logistic equation $P = 1/[1 + \exp(-Z)]$, where $Z = a + b \cdot x$, and x is the independent variable, either trout length (cm) or water temperature (°C). These estimated probabilities assume that the trout is captured with a Mepps spinner or Cleo spoon; no fish hooked with a Rapala lure was hooked in the gill or throat region or died within 48 hours of capture.

Event	Conditions	Coefficient		Independent variable ¹
		<i>a</i>	<i>b</i>	
Hooked in the gill or throat region.	Treble-hooked lures combined.	-6.3435	0.1151	Length***
	Single-hooked lures combined.	-5.5112	0.0768	Length
	All spinner and spoon lures combined.	-6.1889	0.1047	Length***
Heavy bleeding	Treble-hooked lures combined.	-7.5568	0.1417	Length****
	Single-hooked lures combined.	-8.2952	0.1417	Length****
Death within 48 hours of capture.	Treble-hooked lures combined.	-6.0399	0.0996	Length**
	Single-hooked lures combined.	-5.9715	0.0650	Length
	All spinner and spoon lures combined.	-6.4075	0.0983	Length**
	Treble-hooked in gill/throat and heavy bleeding.	-8.2042	0.999	Temperature****
	Single-hooked in gill/throat and heavy bleeding.	-4.164	0.4913	Temperature****
	Treble-hooked outside gill/throat and no heavy bleeding.	-18.7956	0.999	Temperature****
	Single-hooked outside gill/throat and no heavy bleeding.	-20.6345	0.4913	Temperature****

¹Asterisks denote $P < 0.01^{**}$, $P < 0.001^{***}$, or $P < 0.0001^{****}$ for the model's χ^2 significance level.

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