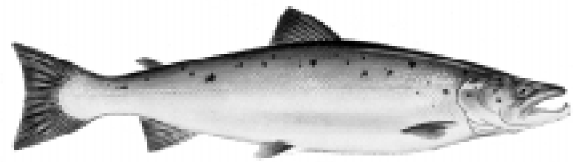

Effects of hook-and-release angling practises

Background

Hook-and-release angling as a management tool is not a recent concept. It was advocated for Atlantic salmon on the Penobscot River, Maine in the early 1800's. Hook-and-release only trout fisheries were in place for some rivers in Michigan by 1954. However the acceptance of hook-and-release as a conservation measure for Atlantic salmon is a recent phenomenon. In 1984, in the Maritimes and on the island of Newfoundland, it became mandatory that all large salmon (≥ 63 cm) caught by angling be released. Retention of large salmon continued to be permitted in Quebec and Labrador. In the 1990's hook-and-release only angling has routinely been permitted on rivers where salmon populations have been below established conservation levels. In Newfoundland, in 1997, hook-and-release was not permitted on some rivers when water temperatures exceeded 18° C. There are divergent opinions among user groups, on the effects of hook-and-release angling on salmon mortality and reproductive success.

An allowance for hook-and-release mortality is currently used in stock assessments in Newfoundland and the Maritimes, but not in Quebec. The Newfoundland assessments assume that 10% of the hooked-and-released salmon died; whereas in the Maritimes values less than and up to 10% are used.

The following terminology is used to identify various life stages of Atlantic salmon in this document. Grilse refers to salmon which spawn for the first time after one year at sea. Grilse are usually less than 63 cm in fork length. Multi-sea winter (MSW) salmon are salmon that spawn for the first time after two or more winters at sea. MSW salmon are usually greater than 63 cm in fork length. Kelt refers to grilse or MSW salmon that have spawned and have not yet returned to sea.

Historical research into the effects of hook-and-release angling on Atlantic salmon

During the past decade a number of studies were conducted to specifically address the effects of hook-and-release angling on Atlantic salmon. The primary focus of many of these studies was to analyse the physiological effects of exercise of the fish to exhaustion with secondary consideration given to estimating salmon mortality. Other factors considered were the effects of hook-and-release on bright fish, kelts, salmon caught in the autumn, and salmon caught under a variety of river conditions (e.g. temperature and water chemistry). Many of these studies have limitations on the interpretation of the mortality rates associated with salmon hooked-and-released. Limitations include, but are not limited to: small numbers of salmon used in experiments; some salmon being extensively handled or transported some distance; some being artificially hooked and played to exhaustion; and some being held in tanks to recover. One study on the Ponoi River, Russia, involved tagging and release of salmon caught by anglers with a range of expertise. These salmon were held in a holding pen to recover. and fitted with radio-tracking transmitters before being released. There was also a radio-tracking experiment, involving a small number of salmon, carried out on the Restigouche River, New Brunswick.

The results of experiments on the effects of hook-and-release angling or exhaustive exercise on Atlantic salmon are summarized in the attached table.

Variables affecting level of hook-and-release mortality

Temperature

Several studies have indicated that hook-and-release angling and associated handling at water temperatures 20 C or above, can result in elevated mortality (immediate or delayed) in Atlantic salmon. Some studies indicated that increased post hook-and-release mortality may result at lower temperatures if other stressful conditions are present. For instance, 32% of 59 grilse died when exercised to exhaustion (not angled) in soft water and at 15 C whereas 0% of 16 grilse died under identical experimental conditions but in hard water.

The precise temperature at which significant numbers of deaths begin is unclear since many experiments were designed to measure physiological changes. Some angling tests did not simulate natural angling techniques. For instance, fish may have been involuntarily hooked, extensively handled, transported, undergone surgery, and held in cages either before or after the being angled. Each of these actions by themselves can severely stress the fish, and probably lead to death at lower temperatures than would occur in more realistic angling situations.

In one study, 62 salmon which were angled using normal angling techniques in water less than 20° C, and held in a cage in a pool, had a 2% mortality. In a second study conducted on the Upsalquitch River (Restigouche system, New Brunswick) at 20° C, using volunteer anglers, and with the fish being released back into a barrier pool, all 15 fish survived. By contrast, in the same experiment, 20% (2) of the 10 fish angled and placed in a holding box for recovery, died.

Experiments using normal angling techniques have not been conducted at water temperatures greater than 20° C.

Water flow

No information is available on the relation between water flows and hook-and-release mortality. However, summer low flows are often associated with high temperatures.

Season

In the studies reviewed, all grilse kelts in the spring, and all MSW and grilse salmon in the autumn, which were hooked-and-released survived.

In another study, there was a 25% mortality of 12 grilse which were hooked-and-released shortly after entering fresh water, at water temperature of 16° C. Thus it would appear that fish that have recently entered fresh water (physiologically adapting to fresh water from salt water) and are hooked-and-released, have an elevated rate of mortality.

Time of day

The effect of time of day on hook-and-release mortality has not been specifically investigated, but it is likely that its effect will mainly result from daily water temperature cycles rather than actual time of day.

Size of fish

The magnitude of the physiological disturbances in MSW salmon, which were experimentally hooked-and-released in October, was less than in grilse which were hooked-and-released under similar conditions. This occured even though the MSW salmon took longer to reach exhaustion. Grilse may, therefore, exhaust their short-term energy supplies faster than MSW salmon during angling. At cool temperatures on the Ponoi River, MSW salmon and grilse both showed high survival.

Sex of fish

No studies examined differential hook-and-release mortality for male versus female salmon.

Fishing and handling practices

Proper release procedures are important and handling should be minimized to increase a fish's likelihood of survival. Based on experiments with rainbow trout, holding a fish in air (for example, to show friends, take pictures or even to remove the hook) increases the probability of the fish dying. One experiment, where grilse were exercised to exhaustion and exposed one minute to air, did not confirm this concern, but only 14 grilse were used in the test and the study was done at a relatively cool temperature (15° C).

Salmon hooked-and-released on the Ponoi River showed high rates of survival with landing times ranging from one to 10 minutes, when caught with flies with one or two barbless hooks. Flies with two hooks were noted to produce greater jaw erosion which is not desirable.

Water chemistry

Grilse exercised to exhaustion at relatively low temperatures (15° C) in soft water (less than 50mg/L $CaCo_3$) suffered 32% mortality, whereas those exercised to exhaustion at the same temperature in hard water (greater than 90 mg/L $CaCo_3$) had 0% mortality. In these experiments, mortality rates were the same in soft neutral water as they were in soft acidic water, indicating water hardness, not acidity, was the important factor.

Delayed and cumulative effects

Studies have not addressed the delayed effects of hook-and-release angling on long-term survival and ability of salmon to return and spawn repeatedly. Nor have studies been done to see if being hooked-and-released can lead to increased susceptibility to contracting diseases or to predation.

Radio-tracking of fish on the Ponoi River (26 fish tagged over two years) showed that a large number of the salmon survived for at least several months after being caught in early June. Spawning by some hooked-and-released fish on this river has been confirmed.

Hooked-and-released salmon taken late in the angling season and moved to and spawned at a hatchery, produced viable gametes. A radio-tracking study using a small number of salmon on the Upsalquitch River suggested hooked-and-released salmon had different upstream movement patterns from radio-tagged fish that had not been angled.

Little information is available on the cumulative effects of salmon being stressed by two or more factors. Angling in soft water resulted in mortalities at 15° C rather than greater than 20° C. The one mortality (of 62) in the Ponoi River study was a fish which had been obviously injured prior to being hooked-and-released.

Conclusions

Under the right conditions, hook-and-release angling can be an effective *conservation and management tool for Atlantic salmon. In particular, angling mortalities are generally low at temperatures less than 20° C. However, fish may die at much lower temperatures when they are stressed by other parameters (e.g., soft water, osmoregulatory stress as newly arrived fish adapt to fresh water) or improper handling. Also, stressors may act cumulatively. To minimize mortalities, anglers should minimize handling of the fish.*

Impact of hook-and-release mortality on Atlantic salmon spawning stock

The overall impact of hook-and-release angling on potential egg deposition in a river is related to the number of fish angled, the biological characteristics of angled fish, and the hook-and-release mortality rate. An example of a model to assess the effect of a hook-and-release only angling fishery used data from the Saint John River stocks above mactaquac Dam, New Brunswick. The estimated impact on salmon stocks of the Saint John River, with an assumed hook-and-release mortality rate of 5%, was a loss of less than 1% of the potential total egg deposition. The estimated impact declined from 0.95% to 0.89% to 0.70% during periods when returns decreased from 21,000 to 12,900 to 7,750 fish (1974-1980, 1988-1993, 1994-1996). The estimated impact of the fishery did not increase when salmon returns were low, but a small stock could possibly be reduced below a viable population size.

This analysis demonstrates that for the Saint John River, the effect of hook-and-release angling on egg deposition would be low, but these results cannot be directly transferred to other rivers due to differences in the various factors which would have to be used in the model. Angler exploitation rates (under mandatory hook-and-release) for large salmon, the major contributor of eggs to the Saint John River, did not exceed 26 % in the years of the study. The model assumed that angling effort would not increase or decrease with mandatory hook-and-release. It is possible that catch rates would be higher than those in a retention fishery since they are less easily limited by regulations. River conditions, especially temperature, would also affect the rate of hook-and-release mortality.

Evaluating the impact of hook-and-release on salmon spawning stock requires consideration of the extent to which salmon are caught at higher water temperatures. This question was examined using the angling catch statistics in 1992-1995 at four Crown Reserves on the Upsalquitch River. Minimum daily water temperatures taken at 8 AM commonly reached greater than or equal to 20° C on some days in three of the four years. In two years, the heaviest angling pressure occurred at the warmest temperatures. There were up to 100 angler-days of effort on days with minimum temperature greater than or equal to 20° C. In 1995, 55% of the catch was angled on days with minimum temperature greater than or equal to 20° C. It was concluded that fishing effort and catch does occur at water temperatures above 20° C and that in some years, this catch could be significant. Caution should be taken in applying these results to other areas, since in Crown Reserves, angler access is controlled by a lottery draw and successful applicants paid for these specific waters several months in advance of the fishing activity. Thus, their fishing effort may be higher during warm water conditions than that of anglers on public waters.

Research recommendations

Further studies are required to examine the lethal and sublethal effects of temperatures, water chemistry, and other factors on survival of hooked-and-released salmon. These studies should include water temperatures greater than 22° C and the effects of cumulative stressors. These experiments should be conducted under normal angling conditions using practises of the general angler and should be done over the full geographic range of salmon.

Daily and seasonal temperature profiles for rivers may be required to assess the potential impact of hook-and-release angling and to regulate the fisheries.

Evaluation of catch rates at different temperatures is required to properly assess the potential impact of hook-and-release angling on a particular river..

Evaluation of the effects of hook-and-release on migration and spawning behavior is required to assess delayed effects of this practise.

Management recommendations

Although hook-and-release angling is a conservation measure relative to retention angling, caution must still be exercised when considering implementation. Mortality and resulting impact on resource conservation is potentially increased under certain river conditions and if anglers do not take care in releasing hooked fish.

For additional information, see:

Anderson, W. G., R. Booth, T. A. Beddow, and R. S. McKinley. 1997. Remote monitoring of heart rate as a measure of recovery in angled Atlantic salmon, *Salmo salar*. Unpublished CASEC Report. (Version also submitted to Hydrobiologia)

Booth, R. K., J. D. Kieffer, K. Davidson, A. T. Bielak, and B. L. Tufts. 1995. Effects of late-season catch and release angling on anaerobic metabolism, acid-base status, survival, and gamete viability in wild Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 52: 283-290.

Brobbel, M. A., M. P. Wilkie, K. Davidson, J. D. Kieffer, A. T. Bielak, and B. L. Tufts. 1996. Physiological effects of catch and release angling in Atlantic salmon (*Salmo salar*) at different stages of freshwater migration. Can. J. Fish. Aquat. Sci. 53: 2036-2043.

Ferguson, R. A., and B. L. Tufts. 1992. Physiological effects of brief air exposure in exhaustively exercised rainbow trout (*Oncorhynchus mykiss*): implications for “catch and release” fisheries. Can. J. Fish. Aquat. Sci. 49: 1157-1162.

Tufts, B. L., Y. Tang, K. Tufts, and R. G. Boutilier. 1991. Exhaustive exercise in “wild” Atlantic salmon (*Salmo salar*): acid-base regulation and blood gas transport. Can. J. Fish. Aquat. Sci. 48: 868-874.

Wilkie, A. P., M. A. Brobbel, K. Davidson, L. Forsyth, and B. L. Tufts. 1997. Influences of temperature upon the postexercise physiology of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 54: 503-511.

Wilkie, M. P., K. Davidson, M. A. Brobbel, J. D. Kieffer, R. K. Booth, A. T. Bielak, and B. L. Tufts. 1996. Physiology and survival of wild Atlantic salmon following angling in warm summer waters. Trans. Am. Fish. Soc. 125: 572-580.

Whoriskey, F., and P. Lee. 1997. Wild river science. Atlantic salmon Journal Autumn 1997: 26-31.

Table 1. Survival of Atlantic salmon after exhaustive exercise or angling under various conditions.

Study/Conditions	N-number	% Survival	Comments
Late Fall @ 6 C	20 MSW salmon	100%	Wild salmon experimentally angled to exhaustion in their natural environment. Recovery (24h) in holding boxes in the river.
Mid-Summer @ 22 C	10 grilse	60%	Wild grilse experimentally angled to exhaustion in their natural environment. Recovery (24h) in holding boxes in the river.
Temperature @ 12 C	10 grilse	100%	Hatchery-reared grilse exercised to exhaustion and
18 C	10 grilse	100%	recovered in a holding tank for 3 days.
23 C	10 grilse	70%	
Mid-to-late summer - fish below subjected to surgery prior to experiments.			
8 C	6 grilse	100%	Hatchery-reared fish exercised to exhaustion.
16.5 C	5 grilse	100%	Wild fish exercised to exhaustion
20 C	5 grilse	20%	Wild fish exercised to exhaustion.
Different migratory stages			
Kelts @ 4 C	12 grilse	100%	Wild grilse experimentally angled to exhaustion. Recovery
Bright fish @ 16 C	12 grilse	75%	(4-12h) in holding boxes.
Water Chemistry @ 15 C			
hard neutral pH water[1]	16 grilse	100%	Hatchery-reared grilse. Some grilse (roughly half) in each
soft neutral pH water[2]	25 grilse	68%	group underwent surgery 24h prior to experiments. All groups
soft acidic water[3]	34 grilse	68%	exercised to exhaustion and recovery (24h) in holding tank.
Air exposure @ 15 C	14 grilse	100%	Wild grilse. Exercised to exhaustion and then air exposed for 1 min.. Recovered in holding tanks for 24 hours.
Normal Angling			
Upsalquitch R. @ 20 C	25 grilse	92%	All groups are wild fish, angled normally by the general public with recovery (24 hr.) in fenced pool in river
LaHave R.[4]	9 grilse	89%	Recovery (24h) in holding tank/boxes/cage
Ponoi R.	62 various sea-age	98%	Ponoi River wild fish are 8 large salmon kelts, 6 grilse kelts, 17 spring grilse, 15 autumn run MSW salmon, 15 autumn run grilse, and 1 uncategorized kelt.

N-number refers to the number of Atlantic salmon used in each survival experiment. [1] $CaCO_3$ = 90-100 mg L^{-1}, pH = 6.7-7.2.
[2] $CaCO_3$ = 30-50 mg L^{-1}, pH = 7.1-7.5. [3] $CaCO_3$= 30-50 mg L^{-1}, pH = 5.3-5.9. [4] Angling at various temperatures.

For more information:

Contact: Bruce Atkinson, Director
Science Branch
Newfoundland Region
Dept. of Fisheries and Oceans
P.O. Box 5667
St. John's, NFLD
A1C 5X1

John S. Loch, Director
Science Branch
Maritimes Region
Dept. of Fisheries and Oceans
P.O. Box 1006
Dartmouth, NS
B2Y 4A2

R. Chatelain, Directeur
Ministère de l'Environnement et de la Faune
150 boul. René-Lévesque Est
Québec, Qc
G1R 4Y1

Canadian Stock Assessment Secretariat
Dept. of Fisheries and Oceans
200 Kent St., Stn 12032
Ottawa, Ont.
K1A 0E6

This report is available from the:
Canadian Stock Assessment Secretariat
Dept. of Fisheries and Oceans
200 Kent St., Stn. 12032
Ottawa, Ont.
K1A 0E6
Phone number: 613-993-0029
Facsimile number: 613-954-0807
e-mail address: *csas@dfo-mpo.gc.ca*

ISSN 1480-4913

La version française est disponible à l'adresse ci-dessus.