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To what extent does catch and release contribute to mortality in Atlantic salmon?

J. B. Dempson, D. G. Reddin, and M. F. O'Connell

Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland, A1C 5X1

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Abstract

Information on the history of catch and release is briefly reviewed, highlighting the fact that it is not a new concept in recreational fisheries management. In Newfoundland, given the widespread concern for the health of the salmon resource, and the realization that there is now a defined limit to the introduction of new management measures to conserve salmon, fisheries managers are seeking additional advice on the operational use of catch and release. This is particularly important given that the contribution of the recreational fishery to the total harvest of Atlantic salmon has increased steadily since 1992, and accounted for 70% of the total catch, in numbers of fish, in 1996. Most recent catch and release studies have focused on the physiological effects of exhaustive exercise on salmonids. Nevertheless, results from various studies are summarized, and second order polynomial regressions are fitted to data on catch and release survival at various water temperatures to infer the possible extent of mortality. Should these predictive equations have any merit, then managers can now decide the level of mortality they are willing to live with to allow catch and release fishing at certain temperatures. Proper handling of salmon in catch and release fishing is imperative; otherwise, temperature of the water becomes irrelevant and higher mortalities will occur regardless.

Résumé

Il est traité de l'historique de la capture et de la remise à l'eau en soulignant le fait qu'il ne s'agit pas d'un nouveau concept en gestion des pêches récréatives. À Terre-Neuve, dans le contexte de l'inquiétude généralisée à l'égard de la ressource en saumon et des limites de l'adoption de nouvelles mesures de gestion visant la conservation du saumon, les gestionnaires des pêches demandent des avis supplémentaires sur les modalités d'application de l'approche par capture et remise à l'eau. Cela est particulièrement important étant donné que la part relative de la pêche récréative à la récolte totale du saumon de l'Atlantique a augmenté de façon constante depuis 1992 et qu'elle représentait 70 % de cette récolte, en nombre de poissons, en 1996. Les études les plus récentes sur la capture et remise à l'eau les plus récentes ont porté sur les effets physiologiques d'un exercice épuisant sur les salmonidés. Les résultats de diverses études sont résumés et des régressions de polynômes de second degré sont ajustées aux données sur la survie après la remise à l'eau à diverses températures de l'eau afin d'en déduire l'ampleur de la mortalité. Si ces équations de prévision s'avèrent valables, les gestionnaires pourront décider du niveau de mortalité acceptable et permettre la pêche par capture et remise à l'eau à certaines températures. Une manutention adéquate des saumons s'avère essentielle au cours de ce type de pêche, sinon, la température de l'eau n'est plus un facteur pertinent et une forte mortalité sera observée de toute façon.

Introduction

The 1984 Atlantic salmon management plan formally introduced the concept of catch and release fishing in Newfoundland when it became mandatory to release all salmon greater than 63 cm in length. Various modifications to catch and release provisions have been made over the years (e.g. see O'Connell et al. 1992), with current regulations (1997) permitting the catch and release of four salmon per day. Newfoundland has recently initiated regulations to require the mandatory use of barbless hooks for the 1998 fishing season. These measures are all part of the continuing evolution and acceptance of catch and release as a management practise. Managers see catch and release as a way of permitting angling when stocks are low, with little or no mortality associated with the practise.

Catch and release, however, is not a new concept. It was proposed in the early 1800's in some areas (see Wydoski 1977), advocated for Atlantic salmon on the Penobscot River, Maine, as early as 1873 (see Barnhart 1989), and apparently first introduced as a management tool in the United States in 1954 (Barnhart 1989). Indeed, as Wydoski (1977) reports, serious concern about the mortality associated with catch and release became an issue during the 1950's and 60's. Earlier studies on landlocked Atlantic salmon focused on such aspects as the type of gear used (e.g. baited gear, lures, flies) or on the use of single versus treble hooks (Warner and Johnson 1978; Warner 1979). Issues such as barbed versus barbless hooks, the importance of temperature, handling and type of injury inflicted, initial versus delayed mortality, and physiological responses to hooking stress are also summarized in Wydoski (1977). Indeed, the current controversy on whether catch and release contributes to mortality in salmon is also not a new concept.

At least two symposia have been held on catch and release (Barnhart and Roelofs 1977, 1987), followed by supplementary reviews (Barnhart 1989). A comparison of hooking mortality among various species has also been published (Muoneke and Childress 1994). The latter paper reviews comparative information on factors such as: 1) environmental conditions (temperature, salinity etc.); 2) biological characteristics (size, age, gender; 3) immediate versus delayed mortality; 4) gear (single versus treble hooks, barbed versus barbless hooks, hook size, etc.), and 5) physiological and anatomical effects of hooking mortality (stress, injury, handling).

Current status of Newfoundland Atlantic salmon stocks and the link with catch and release

Following substantive increases in Atlantic salmon returns to northeast and northwest coast rivers coincident with the moratorium on the Newfoundland commercial fishery, salmon returns to most Newfoundland rivers fell dramatically in 1997. For some stocks, total population sizes were now among the lowest observed since 1984, when data prior to 1992 have been adjusted for marine exploitation. Given the widespread concern for the health of the resource, and the realization that there is now a defined limit to the introduction of new management measures to conserve salmon, fisheries managers are again seeking advice on the operational use of catch and release in salmon management. This is particularly important given that the contribution of the recreational fishery to the total harvest of Atlantic salmon has increased steadily since 1992, and accounted for more than 70% of the total catch, in numbers of fish, in 1996 (Fig. 1). Also, at four salmon per day, as allowed in 1997, the potential impact of catch and release angling on the salmon population from upwards of 25,000 anglers could be significant at even relatively low mortality rates.

Dilemma regarding catch and release

The Department of Fisheries and Oceans (DFO) is in an awkward position in relation to the catch and release issue. The confusion stems from the very different views that anglers, and others, have about catch and release. Which anglers should be listened to? Those who accept and promote catch and release as a viable management tool (e.g. 'Catch and release saves salmon', St. John's Evening Telegram, Jan. 17, 1998), or the others who express a passionate disgust for the practise and state that catch and release was "*shoved down our throats*", or that "*The no-kill theory ... is just a smoke screen ...*" ('Losing control of our salmon rivers', St. John's Evening Telegram, Jan. 10, 1998). The latter view is not uncommon. A survey of the 1996 Newfoundland Region Atlantic salmon Licence Stub return cards clearly indicates that many anglers believe or have seen "*many salmon floating down the river belly-up. ... This practise should be stopped. It's destroying our stocks*", or "*What a waste and poor management*", "*Hook and release is killing more fish than are caught*". As well, "*... systematic and scientific surveys of salmon anglers on both the Gander and Salmonier rivers ... show that a majority of anglers on both rivers are opposed to catch and release angling*" ('Catch and release misunderstood', St. John's Evening Telegram, Jan. 24, 1998).

Attempts to educate and promote catch and release have certainly been made (e.g. Bielak 1987, 1988). But, as illustrated above, in Newfoundland it is still not universally accepted. Newfoundland is not alone in regard to the position some have about catch and release. For example, catch and release is practised in some trout waters in southern and central Finland. But, there is practically no catch and release for Atlantic salmon. Both the Finnish Animal Protection Organization and the Finnish Nature Protection Organization are strongly against catch and release (Jaakko Erkinaro, River Tenojoki Fisheries Research Station, Finnish Game and Fisheries Research Institute, Utsjoki, Finland, personal communication). A recent essay in an American Fisheries Society publication highlights the controversy and subsequent measures taken in Germany where catch and release is now apparently prohibited (Spitler 1998).

Recent studies on catch and release

During the past decade there have been a number of additional studies carried out on catch and release of Atlantic salmon. The primary focus of many of these studies, however, was usually the analysis of physiological effects of exhaustive exercise on Atlantic salmon or rainbow trout. Justification for the studies was related to the need to assess the biological effects of catch and release, although the physiological research took precedence over components related solely to fish survival. A wealth of information on the physiological effects has now been obtained (e.g. Tufts et al. 1991; Ferguson and Tufts 1992; Booth et al. 1995; Brobbel et al. 1996; Wilkie et al. 1996; Anderson et al. 1997; Wilkie et al. 1997) and general concepts related to the utility of catch and release fishing as a management tool clarified. However, many of the practical aspects related to successful catch and release were already well known. We note that recent studies are also being carried out on the Ponoi River, Russia, where the emphasis appears to be more related to the behaviour and survival of the salmon (Whoriskey and Lee 1997).

So, what is known? Basically, what many have professed to have known for a long time. That is, when handled properly under suitable conditions (e.g. cooler water temperatures) most salmon survive (at least for the short term) (see review by Bielak 1996). But, can results from the above referenced studies be extrapolated to natural situations? Some do not think so, while others do.

Criticisms of many of the catch and release studies to date can be summarized as follows:

- salmon were often handled or transported to distant locations prior to when experimental procedures were carried out;
- catch and release angling was often done under artificial situations (e.g. in spawning channels, or 'chasing' fish in circular tanks to simulate angling events);
- some salmon were subjected to various procedures (e.g. anaesthetized, subjected to surgery, etc.) prior to catch and release experiments;
- representative anglers in actual angling situations were rarely used;
- salmon were often either 'chased' or angled to exhaustion; while this technique may adequately serve to model physiological disturbances (Wilkie et al. 1997), generally salmon anglers do not apparently angle a fish to exhaustion (B. Slade, DFO St. John's, Newfoundland, personal communication);
- water temperatures may have represented conditions at time of angling, but rarely was there reference to temperatures over the duration of the experiment in cases where fish were not in artificial environments;
- flow conditions during catch and release experiments have generally been ignored;

- experiments were frequently of limited duration and impacts associated with delayed mortality were thus ignored; and,
- sample sizes in most catch and release survival experiments have been relatively low, and frequently there has been little reference to parallel controlled experiments.

Despite concerns as above, there is often agreement that at warmer water temperatures improperly handled salmon die. But, improperly handled salmon will likely die at cooler temperatures as well.

In discussing one particular experiment carried out in Newfoundland at a water temperature of 20° C, Rich (1997) stated that the most striking result was that four out of five fish did not survive the 72-hour experiment. Alternatively, one could argue that the 'surprise' was not that four fish died, but rather one fish actually *survived* given the procedures the fish was subjected to during the course of the entire experiment.

A summary of results pertaining to the more recent catch and release studies is presented in Table 1. As indicated, sample sizes are often small and the duration of the experiments shown was no more than 72 hours.

Modelling results of current studies: predictability of results?

Results from the studies carried out on Atlantic salmon summarized in Table 1 are illustrated in Figure 2. Up to temperatures of approximately 18° C, survival during the course of the experiments was commonly 100% (Fig. 2). Above 18° C, survival declined, but the results from different studies were conflicting. In the Newfoundland study at 20° C (Anderson et al. 1997), only 20% of the salmon survived. In contrast, one study in New Brunswick carried out when "*water temperatures approached 22° C when postangling survival was monitored*" (Wilkie et al. 1996) reported a survival of 60%. Salmon were monitored for only 12 hours in the latter study, in contrast with 72 hours in the Newfoundland experiment. The difference in results, therefore, could either be related to the duration of the experiment, or, to the different procedures and added stress salmon in the Newfoundland experiment were subjected to. In a separate study using hatchery-reared salmon from Nova Scotia, survival over 72 hours was 70% at an experimental temperature of 23° C (Wilkie et al. 1997). Thus these results could suggest that the Newfoundland study at 20° C is somewhat of an 'outlier'.

We pooled the data on Atlantic salmon survival from the different experiments summarized in Table 1 and fit a second order polynomial regression (Fig. 2). This was done both with the Newfoundland 20° C point included (bottom panel), or excluded. With the point excluded (equation 1 below), 75% of the variation in survival is accounted for by temperature. With the point included (equation 2 below), only 43% of the variation in survival could be explained by temperature. This relationship, however, is no longer statistically significant.

(1) $y = -0.238x^2 + 4.861x + 80.255$; $r^2 = 0.753$ $P = 0.0075$

(2) $y = -0.256x^2 + 4.601x + 83.323$; $r^2 = 0.432$ $P = 0.1038$

In the absence of longer term studies, could either of the above relationships have any utility in answering the question posed in the title of this paper, namely, *to what extent does catch and release contribute to mortality in salmon?* If the relationships do have some utility then the answer to the question is dependent entirely upon the temperature. Managers could then decide the level of mortality they are willing to live with to allow catch and release fishing at certain temperatures. Below 18° C, predicted results from equations 1 and 2 are similar. Above this temperature, predicted survival drops more quickly, as expected, using equation 2 that includes the Newfoundland study at 20° C:

Temperature	Predicted survival %	
° C	Equation 1	Equation 2
17	94.2	87.4
18	90.8	83.0
19	86.8	78.1
20	82.4	72.7
21	77.5	66.8
22	72.2	60.4
23	66.4	53.5

Science in Newfoundland has advised that catch and release fishing should be permitted "*only if the projected spawning escapement in either the pre-season or in-season forecast will provide greater than 50% of the established conservation egg deposition and under appropriate environmental conditions*" (Porter 1997). In addition, Science has also recommended the following protocol (Porter 1997):

> *"A river should be closed to angling when the water temperature is equal to or greater than 22° C on two consecutive days, measured in mid-afternoon when the water temperatures are normally at the daily maximum."*

The above pertains largely to retention fisheries, but the 1997 Anglers Guide (Department of Fisheries and Oceans 1997) advocates that anglers should refrain from the practise of catch and release when water temperatures reach 18 ° C. A review of mean water temperatures throughout the day during the period June 15 to August 15, 1995, at Conne River, Biscay Bay River, Middle Brook, Salmon Brook, and Northeast River Placentia, indicated that during the early evening (2000 hours; 8:00 pm) water temperatures were generally warmer from 69 - 83% of the time than temperatures recorded at mid-afternoon (1600 hours). Thus water temperatures are often continuing to warm up beyond the suggested time when river closure criteria are taken. On a number of occasions, there would have been several days, or blocks of days that would have rendered the rivers closed based on the 22° C criteria if the reference temperatures were recorded at 2000 hours rather than at mid-afternoon. Similarly, temperature criteria related to catch and release angling would likely differ depending upon the time of day when water temperatures are recorded.

Summary

At the outset we indicated that catch and release was not a new concept. It is practised widely in many areas and on many different fish species (see Muoneke and Childress 1994). For example, in British Columbia, the 'wild' steelhead salmon fishery is restricted to catch and release fishing (Hooton 1987). Most of the 'wild' steelhead broodstock for the British Columbia hatchery program is derived from fish that are angled, usually with baited hooks, and fish are often transported and held for several months prior to being striped for their reproductive products (T. Gjernes, DFO Pacific Region, pers. comm). The steelhead are frequently out of water from more than 60 seconds during process of obtaining broodstock specimens. In contrast to results demonstrated by Ferguson and Tufts (1992), most fish survive.

Given the concerns commonly expressed about previous catch and release studies that we summarized above, there is still room for additional research, and equations like those shown above may not be entirely relevant and thus should be applied with caution. In Newfoundland, Conne River and Campbellton River would be likely choices to investigate short term (Conne River) as well as overwinter post-spawning survival (Campbellton River) of caught and released fish. Much of the background information associated with having proper control groups is already available.

In conclusion, based on the available information, catch and release fishing appears to contribute minimal mortality to Atlantic salmon when fish are handled in a proper manner at temperatures below 18° C. A conservative, or more conservation minded approach could tend to error on the side of caution and choose cooler temperatures from those currently recommended as reference points for allowing catch and release fishing. The emphasis, however, is on ***proper handling***. If salmon are not handled properly, then temperature becomes irrelevant and higher mortalities will occur regardless. Managers must also be cognisant of the apparent opposition by many, perhaps, in continuing to allow catch and release fishing.

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Table 1. Summary of various papers dealing primarily with physiological effects associated with exhaustive stress in salmonid fishes, as a surrogate for assessing 'catch and release'. Capture refers to method fish were initially caught; month = the month the experiment was conducted. Under Method, Hooked - U = fish manually hooked in upper jaw; Hooked - L = fish manually hooked in lower jaw; Chased = fish manually chased in a tank to exhaustion.

Species	Type	Average Size or Life stage	Capture	Transported	Experimental group						Reference
					Month	Method	N	Temperature	Duration	Survival	
Atlantic salmon	Wild	1.5 kg	Fishway	Yes	July	Chased	6	18	24 hr	100%	1
Atlantic salmon	Wild	MSW	Trap/seine	Yes	Oct	Hooked - U	20	6	?	100%	2
Atlantic salmon	Wild	< 63 cm	Angled	Yes	May	Hooked - L	24	4	12 hr	100%	3
	Wild	< 63 cm	Trap	Yes	July	Hooked - L	25	16	12 hr	88%	3
Atlantic salmon	Wild	55 cm	Trap	No	Aug	Hooked - U	10	~ 22	12 hr	60%	4
Atlantic salmon	Wild	58.8 cm	Trap	Yes	Aug	Hooked - U	5	20	72 hr	20%	5
	Wild	54.4 cm	Trap	Yes	Aug	Hooked - U	5	16.5	72 hr	100%	5
	Hatchery	61.3 cm			Sept	Hooked - U	6	8	72 hr	100%	5
Atlantic salmon	Hatchery	60.7 cm			Aug	Chased	10	12	72 hr	100%	6
	Hatchery	60.7 cm			Aug	Chased	10	18	72 hr	100%	6
	Hatchery	60.7 cm			Aug	Chased	10	23	72 hr	70%	6
Rainbow trout	Hatchery	300-500 g			-	Chased	8	8 - 10	12 hr	88%	7
							? air - 30 s	8 - 10	12 hr	62%	
							7 air - 60 s	8 - 10	12 hr	28%	

References:

1	Tufts et al. 1991	5	Anderson et al. 1997
2	Booth et al. 1995	6	Wilkie et al. 1997
3	Brobbel et al. 1996	7	Ferguson and Tufts 1992
4	Wilkie et al. 1996		

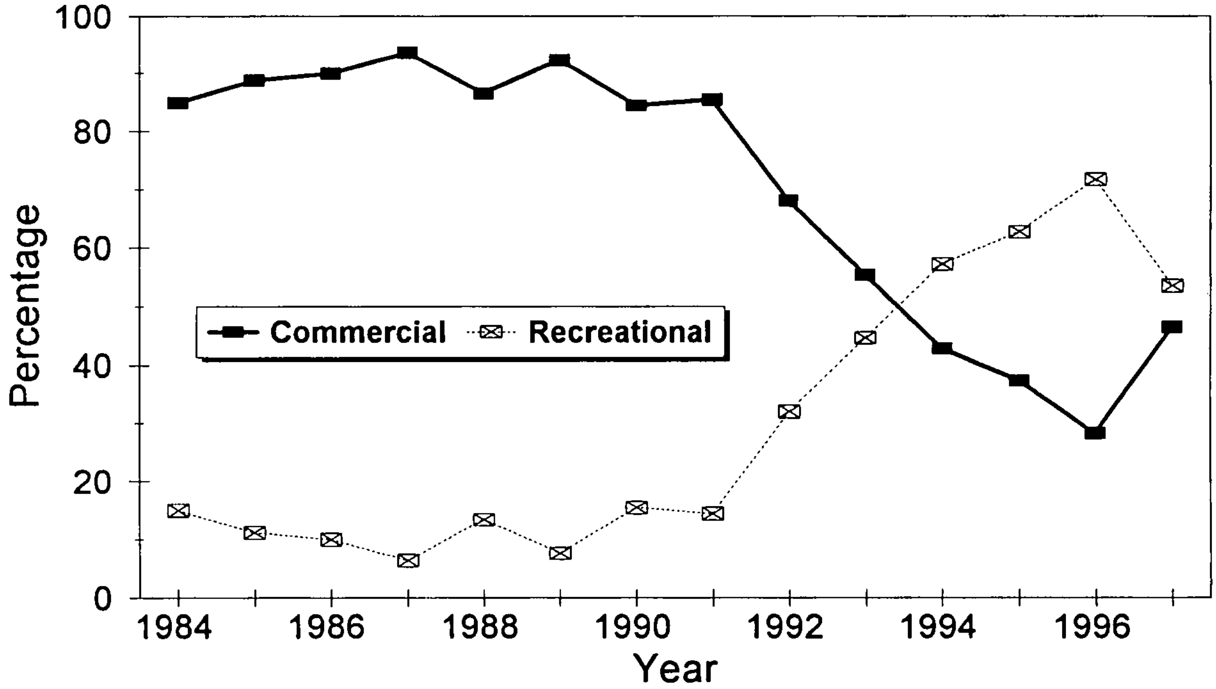

Fig. 1. Change in the relative percentage of Atlantic salmon harvested in commercial versus recreational fisheries, in terms of numbers of fish, in Newfoundland and Labrador, 1984 - 1997.

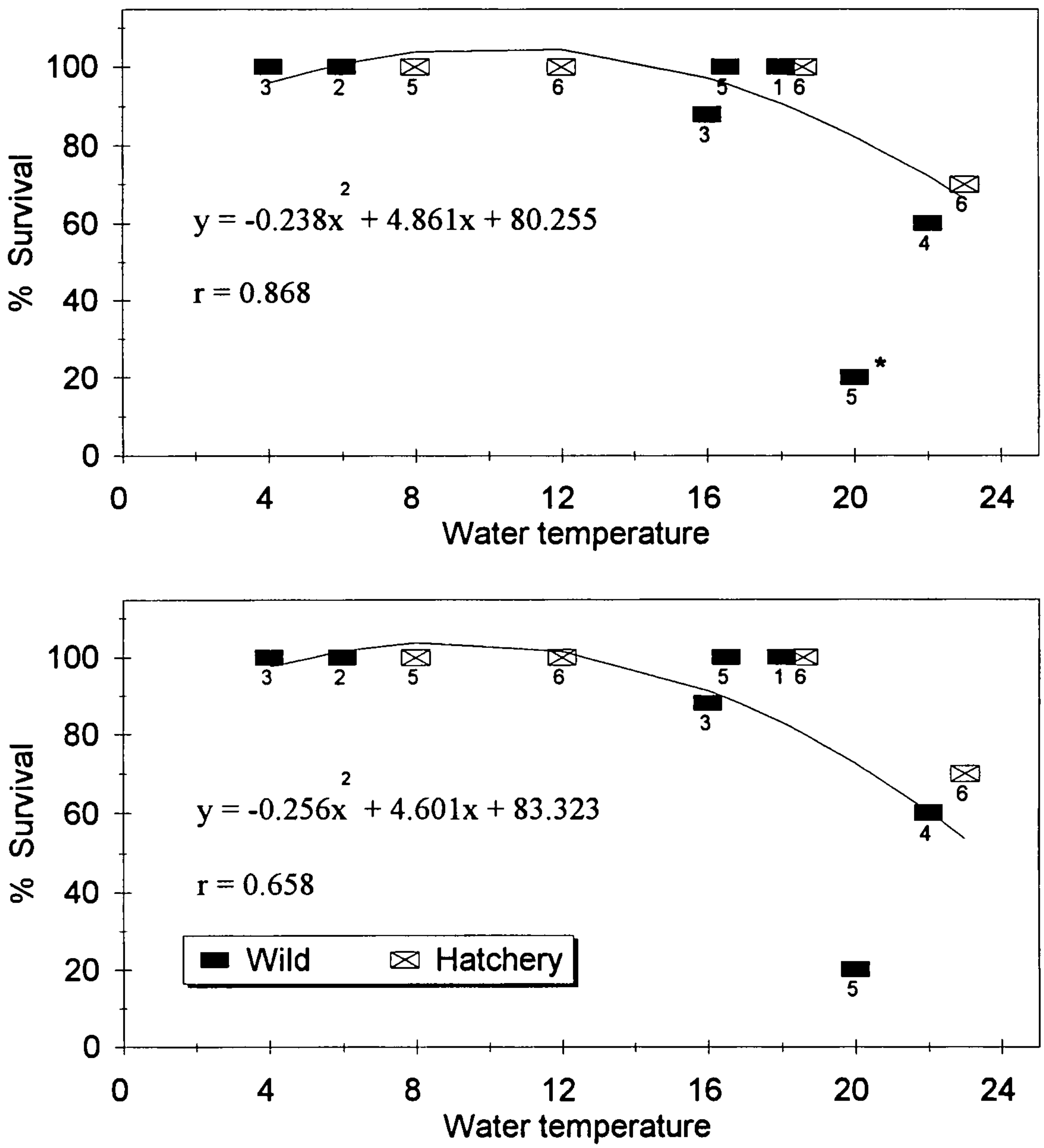

Fig. 2. Relationships between water temperature and survival from various catch and release experiments with Atlantic salmon. In the upper panel, the point marked with an asterisk (*) has been omitted from the relationship. Numbers refer to the studies listed in Table 1. Studies using wild versus hatchery salmon are identified.