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## 11.4 The Atlantic salmon C&R story

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Members of the salmon family, mainly salmon, trout and char, have been important recreational species for centuries. Since the middle of the twentieth century there has been increasing, although not uniform, acceptance of catch-and-release (C&R) fishing for them, most notably for brown (*Salmo trutta*) and rainbow (*Oncorhynchus mykiss*) trout, the latter discussed elsewhere in this volume. For Atlantic salmon (*Salmo salar*), which have a long history of being killed when caught, this acceptance has tended to come later.

The extent and people's acceptance of C&R angling for Atlantic salmon vary among countries within the species' distribution range. C&R angling for Atlantic salmon has the longest history in North America, being advocated as early as the 1880s (Wydoski 1977). A hundred years later, in 1981, the first C&R only fisheries were introduced in some Canadian rivers (Tufts *et al.* 2000). In eastern Canada, anglers have been required by law to release all Atlantic salmon  $\geq 63$  cm since 1984, and are actively encouraged to voluntarily release smaller salmon so as to maintain recreational angling in declining populations. However, within Canada, C&R as a management tool has not been widely accepted in Newfoundland (see Dempson *et al.* 2002).

Interestingly, although the US state of Maine has prohibited all angling for salmon since 2000 for reasons well described by the NRC (2004), it allowed a limited C&R fall season in the Penobscot River for 2006. A recent press release from the Atlantic Salmon Federation (ASF 2006) explains that 'ASF supports a limited, carefully controlled, C&R fishery for the Penobscot that uses single, barbless hooks. Such a fishery will rekindle the conservation spirit, and support local salmon clubs and other affiliates of ASF's Maine Council in their work towards clean, free-flowing rivers and healthy fish populations.'

Until the 1990s, few anglers in the United Kingdom released salmon other than kelts or fish close to spawning. Since then C&R has become widely practised and promoted. In recent years, over half the recorded rod catch has been released (Environment Agency 2004; Fisheries Research Services 2004). While most fish are released voluntarily, it has been compulsory since 1999 to release salmon caught before 16 June in England and Wales because of depleted runs of spring salmon. In Norway, there is a traditional culture of fishing and hunting and killing fish for consumption. C&R angling until very recently was not accepted as a management tool to protect declining populations, but in December 2006 a parliamentary report on salmon management indicated a change towards regarding C&R as an important and acceptable tool for salmon management (Norway Ministry of Environment 2006). Even before that, regulatory policy was

to close fishing when stocks were below conservation levels, and anglers are required by law to release multi-sea-winter salmon in some of the rivers (for instance when runs of anadromous brown trout are healthy), and the extent of voluntary C&R seems to be increasing in some areas. For example, in the River Alta, which is visited by many foreign anglers, approximately 35% of the captured multi-sea-winter salmon and 15% of the grilse are now being released (Ugedal *et al.* 2005). In Northwest Russia, recreational fisheries in the Murmansk Province began developing in 1989, with foreign anglers releasing most of their catch. In the Russian River Varzuga, which has one of the largest Atlantic salmon populations in the world, less than 3% of the spawning stock is annually captured by anglers (Ziuganov *et al.* 1998).

The International Council for the Exploration of the Sea receives C&R reports from six countries (Denmark, Canada, Iceland, Russia, UK and USA) (ICES 2006). The proportion of the total catch being released has increased the last decade, and varied between 17% in Iceland and 87% in Russia in 2005. Altogether, 128,000 Atlantic salmon were released in these six countries in 2005, according to these reports.

### ***Effects of C&R***

Despite the cultural and economic importance of Atlantic salmon angling, effects of C&R have received modest focus in reviews (Muoneke and Childress 1994; Bartholomew and Bohnsack 2005). However, currently at least 25 publications cover effects of C&R angling in Atlantic salmon from studies in North America, United Kingdom, Norway, Finland and Russia (based on Ziuganov *et al.* 1998; Tufts *et al.* 2000; Dempson *et al.* 2002; Thorstad *et al.* 2003; Thorstad *et al.* 2007). Most of these studies were published after 1994, and most of them were conducted in North America (17 of 25 publications). A summary of the reported results is presented here.

### ***Mortality***

The C&R mortality in studies of Atlantic salmon has been highly variable, ranging from 0 to 80% (summarized in Dempson *et al.* 2002; Thorstad *et al.* 2003). Generally, mortality rates are low (2–8%) when water temperatures are below 18°C (Webb 1998; Whoriskey *et al.* 2000; Dempson *et al.* 2002; Thorstad *et al.* 2003, 2007). From 17°C to 18°C, mortalities start to increase, and are predicted to increase to above 20% from 20°C (Dempson *et al.* 2002; Thorstad *et al.* 2003). Wilkie *et al.* (1996) reported hooking mortalities of 40% at 22°C and 0% at 6°C. However, additional well-designed mortality studies at the higher water temperatures are needed.

A few variables other than temperature have been found to affect mortality, even though studies have included variables such as fish size, duration of angling event, handling time, air exposure, bleeding at hook wound and different stages of the return migration (Dempson *et al.* 2002; Thorstad *et al.* 2003, 2007). However, a higher mortality was recorded for bright salmon that had recently entered freshwater from the ocean, compared with kelts returning to the ocean after a prolonged period of starvation (Brobbel *et al.* 1996). Further, high mortalities (73%) were recorded for landlocked Atlantic salmon allowed to swallow worm baits, and worm and fly-hooked salmon generally suffered higher mortality than those caught with hardware lures (Warner 1976, 1979).

### ***Sub-lethal effects***

For C&R to be successful as a management tool, fish should not only survive C&R, but severe sub-lethal effects should also be avoided to maintain reproductive fitness and production as well as for ethical reasons. Several studies have examined the effects of different variables on the physiological disturbance in Atlantic salmon after C&R (summarized by Tufts *et al.* 2000). Increased water temperature, air exposure and softness of water, and moderately acidic water, increase the degree of physiological disturbance (Tufts *et al.* 2000). Further, bright salmon seem to experience larger physiological disturbance than kelts (Tufts *et al.* 2000). Similarly, grilse seem to suffer more physiological disturbance than multi-sea-winter salmon, even though the duration of angling is shorter than for multi-sea-winter salmon (Booth *et al.* 1995; Tufts *et al.* 2000; Thorstad *et al.* 2003). Hooking in the throat, bleeding at the hook wound, air exposure and increased handling time have also been shown to decrease condition at release, based on appearance of the fish and time gills had to be ventilated before the fish swam off (Thorstad *et al.* 2003).

### ***Migration patterns***

Catch-and-release angling is also shown to alter the upriver migration pattern of Atlantic salmon, with unusual delays, downstream movements and erratic movement patterns observed (Webb 1998; Mäkinen *et al.* 2000; Thorstad *et al.* 2003, 2007), and may even reduce the migration distance (Tufts *et al.* 2000). The importance of delays in the upstream migration and erratic movement patterns as a result of C&R is not known, as long as the salmon arrive on the spawning grounds before the spawning season. The distribution of salmon populations within rivers might be affected by alterations in migration behaviour, which is potentially negative for the total production of salmon.

### ***Population effects***

Documentation of the correspondence between physiological and behavioural effects and the effects on reproductive fitness and production is lacking in most studies. The few studies so far do not indicate any negative effects by C&R angling on gamete viability, survival of eggs, survival to hatching or first feeding for the fry (Davidson *et al.* 1994; Booth *et al.* 1995). Positive population effects of C&R angling are indicated in the River Alta, where the number of spawning redds more than doubled after introduction of compulsory C&R in a section of the river that had reduced population and recruitment after being affected by a hydropower dam (Thorstad *et al.* 2003). Also in the River Ponoï in Russia, densities of Atlantic salmon juveniles increased after the introduction of C&R angling (Whoriskey *et al.* 2000).

### ***Recapture of released fish***

Are the same individuals being captured many times in the C&R fishery? Individual Atlantic salmon seems rarely to be recaptured more than once within the same season (Webb 1998; Whoriskey *et al.* 2000; Thorstad *et al.* 2003). Webb (1998) noted that exploitation rates in the Aberdeenshire Dee (approximately 5%) were similar to recapture rates of previously captured Atlantic salmon (8%), implying no avoidance of recapture. In contrast, recapture rates of Atlantic salmon in the River Alta were only 4%, compared with exploitation rates of 50–70%, implying either avoidance of recapture or fish being more prone to being captured during the early upstream migration phase compared with later in the season (Thorstad *et al.* 2003).

### ***Conclusion***

Atlantic salmon is one of the better-studied species regarding the effects of C&R angling. Enough information exists to conclude that C&R angling might be a successful management strategy to protect declining populations. Still, additional information would be useful on mortality rates at the higher temperatures, and generally on how it affects reproduction and production. Further, more information on how different environmental factors and angling and handling practices affect survival and reproduction will positively add to the formulating of guidelines for C&R angling to minimize negative effects. There is also a great potential in educating anglers in optimal handling of the fish (Thorstad *et al.* 2003), and information programmes directed towards anglers, anglers' organizations and stakeholders are needed.

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