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Is Limited Entry Needed in Catch-and-Release Trout Fisheries?

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ABSTRACT

Anglers are not distributed randomly throughout fisheries in the western United States. Streams are generally utilized more heavily than lakes. Angler density varies substantially among streams and from reach to reach. In heavily-used catch-and-relese streams, anglers may impact the fish directly or they may affect their environment. Direct effects include hooking mortality, sub-lethal hooking stress, disturbance leading to shifts in fish behavior, and the trampling of embryos. Some trout species would be expected to be more vulnerable than others because of differences in catchability. Indirect effects include physical damage to instream and streambank habitat and destruction of aquatic invertebrates. To date, there is only minimal biological evidence that catch-and-release anglers are measurably impacting stream resources.

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Introduction

As the popularity of catch-and-release angling grows, the possible impact of heavy concentrations of anglers on trout populations and their environment becomes a concern. Are North American catch-and-release anglers putting sufficient pressure on stream systems to cause biological impacts? Is it necessary to restrict entry to popular catch-and-release fisheries in order to maintain these resources or allow them to continue to improve?

The concept of limiting entry to publicly-owned fisheries in the United States and Canada is not new. Government programs to limit the number of participants in specific fisheries have become commonplace over the last 15 years (Rettig 1984). However, the established programs deal with marine rather than freshwater resources, and commercial rather than sport fisheries. Entry limitations are used there as a tool to avoid overfishing fish stocks in both a biological and an economic sense. In the commercial marine context, biological overfishing refers both to the impairment of a population's potential to fully reproduce itself ("recruitment overfishing") and to the harvest of a stock at an age so early that they do not achieve their full growth potential ("growth overfishing": Gulland 1980). After overfishing has been identified in a particular fishery, entry limitation is implemented by agency managers. The process involves the use of either direct measures, such as license quotas, or indirect programs to create incentives or penalties that reduce the level of effort.

Entry limitation in freshwater sport fisheries, on the other hand, is essentially still in the conceptual stage and goals and procedures have not been developed. Here the definition of "overfishing" may be quite different than in the commercial setting. In terms of motivation, it is clear that the current interest in limiting entry in trout fisheries arises from the anglers, not the managers. There are important sociological considerations to the issue in addition to its biological aspects.

The intent of this paper is to examine the need for limited entry in popular catch-and-release stream fisheries by drawing on data from Idaho and around the West. I will first examine the distribution and abundance of anglers that is causing the present concern and then look at biological impacts that may result.

Angler Distribution

The distribution of effort by trout anglers is rarely random or uniform. First, streams are preferred over lakes. A recent survey in Idaho indicated that nearly twice as many of that state's trout anglers preferred stream fishing as opposed to lake and reservoir fishing, even though streams total only 20% of the water surface in the state (Moore 1986). The amount of effort expended on each unit of water surface area by trout anglers in western North American is typically greater on streams than on lakes. The number of hours of effort expended per surface acre of a lake or stream during one angling season provides an index of angler use. On two popular western lakes, Yellowstone Lake in Yellowstone National Park and Henry's Lake in Idaho, anglers spend an average of 25 hours and 3.5 per surface acre each year, respectively (Rohrer 1982, Jones 1987). On the other hand, effort on popular streams is generally at least 10 times higher (Table 1).

Secondly, anglers congregate on some streams in the western United States at much higher levels of effort than on others. For example, anglers on the Lewis River in Yellowstone National Park typically put in about 50 hours of effort per acre per year. A few miles away, portions of the Yellowstone River receive more than 500 hours (Table 1).

For any given stream, angler density also varies substantially from reach to reach, depending on, among other factors, ease of access and the area's reputation. An example of this is the Henry's Fork of the Snake River in Idaho, where effort on the easily accessed Last Chance portion is typically 300 hours per acre as compared with half that level on the adjacent Harriman Ranch (with its legendary green and brown drake hatches) and only 30 hours of effort in the Pinehaven area a few miles downstream.

Among stream segments with similar access, it appears that stream segments managed under special regulations generally receive more effort than those under general regulations. For example, on Silver Creek near Sun Valley, Idaho, the 460 hours of effort per acre on The Nature Conservancy Preserve managed for catch-and-release is more than twice that of a section of general regulations water a short distance downstream (Table 1). Effort nearly doubled on the Preserve in the last decade since initiation of catch-and-release regulations, while decreasing on the general regulations section (Riehle and Parker 1988).

Table 1. Angler effort expended in some stream fisheries in the western United States.

Fishery	Year	Regulations	Angling effort, hours/acre/year	Reference
Silver Creek ID				
Conservancy Preserve	1977	C&R	265	Thurow 1978
"	1986	C&R	460	Riehle and Park
Point of Rocks	1987	general	184	Riehle and Park
Henry's Fork ID				
Box Canyon	1984	slot	190	Rohrer 1984
Last Chance	1984	"	300	"
Railroad Ranch	1984	"	150	"
Harriman East	1984	"	43	"
Yellowstone National Park				
Lewis River	1985	restricted, varies by species	50	Jones 1986
Yellowstone River, Buffalo Ford Area	1986	C&R	509	Jones 1987
Madison River MT				
Snoball	1976	general	60	Vincent and Cla
Pine Butte	1979	C&R	100	" "
Bighorn River MT below Yellowtail afterbay	1982-83	slot	260	Fredenberg 1985
South Platte River MT				
Cheesman Canyon	1980 May-Oct	C&R	1,500	Anderson and Ne
Hot Creek CA	1973	2 fish	3,800	Dienstadt 1977

Anglers may also concentrate in a temporal sense as much as they do spatially. It is not unusual for effort to peak either on season openings or during reknowned insect hatches at levels that are 10 to 20 times higher than the season average.

Because of these patterns, anglers concentrate their effort on a small number of catch-and-release streams throughout the West. Are these resources capable of withstanding this attention? To address this, it is necessary to examine the nature and extent of the impacts. Anglers may impact the health or survival of the fish themselves (direct impact) or they may indirectly affect their environment.

Direct Impacts of Anglers Upon Fish

Hooking Mortality

Hooking mortality is the factor that has been most thoroughly evaluated. Recent reviews (Wydoski 1977, Mongillo 1984) cite evidence to indicate that hooking mortality from a single capture with flies or lures is about 5% for most salmonids, and this mortality ginerally occurs within 24 to 48 hours of capture. For cutthroat trout (Salmo clarki), there are indications that in some situations hooking mortality may be less than 1% per single capture (Dotson 1982, Schill et al. 1986). Brown trout (Salmo trutta) mortality may also be typically less than 5%, but data are limited (Mongillo 1984).

Estimates of hooking mortality are complicated by the fact that, in many fisheries, trout are caught and released a number of times. Because of differences in catchability and in recatchability, it is important to distinguish between species of trout when evaluating possible mortality from repeated capture. Cutthroat trout are particularly susceptible to angling (Behnke 1978). In Rattlesnake Creek, Montana, one tagged cutthroat trout was caught and released 13 times by anglers in 12 months (Wilson et al. 1987). In a section of the Yellowstone River in Yellowstone National Park, Schill et al. (1986) estimated that cutthroat trout were caught an average of 9.7 times during the course of a single season.

Brown trout demonstrate the opposite extreme from cutthroat trout. One indication of this is on Hot Creek, California, where each brown trout was only caught an average of three times each season despite angling effort of over 3,800 hours per acre (Dienstadt 1977). This comparison is even more remarkable when fish density is considered. About 140 adult cutthroat trout per acre were present in the Yellowstone River (Schill et al. 1986), as compared with about 500 brown trout per acre of Hot Creek (Dienstadt 1977).

Rainbow trout (Salmo gairdneri) appear to be intermediate in catchability. On the catch-and-release portion of Silver Creek in Idaho, rainbow trout (about 340 per acre) were each caught about 3 times in 1987 by anglers expending about 500 hours of effort per acre (Table 1 and Riehle and Parker 1988). This value is based on an estimate of the number of fish in the population and the number caught, and thus represents an average. Although direct data are not available, perhaps one of every five fish in this population (or any salmonid population) is never caught. In an experiment with naive hatchery rainbow trout, Lewynsky and Bjornn (this volume) found that about 20% of the individuals were never caught in 9 weeks of fishing with lures, flies, and bait. One fish was caught five times.

The cumulative mortality expected from repeated capture during a season must be multiplied by the number of years those fish are in the fishery, usually 2 to 4 years. An implication of this is that playing and handling stress, although not generally considered an important source of hooking mortality, may indeed be so if stress from repeated capture during a period of time is cumulative.

Sub-lethal Stress

Another direct impact is sub-lethal stress from hooking, where fish do not die but show physiological or behavioral changes after being caught and released (Wydoski 1977). In the laboratory, it has been shown that there is a distinct metabolic cost associated with stress in fish. Acute physical stress in juvenile steelhead (Salmo gairdneri) reduced, by about one-quarter, the energy available for other activities such as sustaining swimming and resisting disease (Barton and Schreck 1987). The relevance of such observations to actual stream conditions has not yet been evaluated.

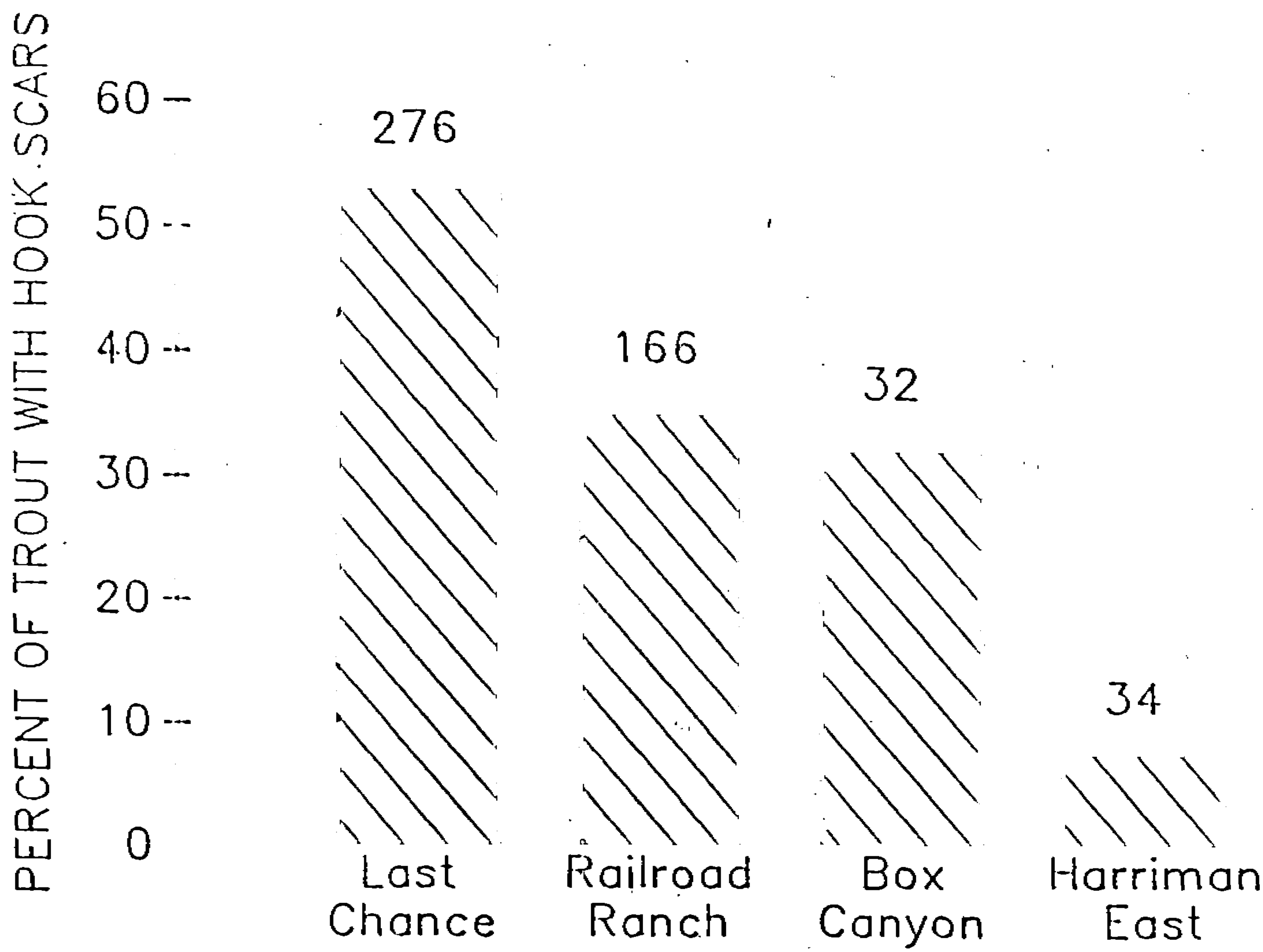
Hooking stress has recently been shown by Lewynsky and Bjornn (this volume) to affect the ability of caught-and-released cutthroat trout to maintain their position in a dominance hierarchy. The highest ranking fish in a hierarchy had the highest probability of capture by angling, and these dominant fish lost (at least temporarily) their social status and feeding stations after they were returned to the water. These preliminary results suggest that social disruption may be a subtle consequence of catch-and-release fishing.

The sub-lethal impacts mentioned above may also be expected to occur if trout are simply hooked without being captured. Our casual observations on catch-and-release fisheries in Idaho suggest that three fish may be hooked for every fish that is eventually landed.

The fraction of fish displaying hookscarring can be high in popular catch-and-release fisheries. Twenty-eight percent of the rainbow trout longer than 10 inches that were present on the Silver Creek Preserve during the summer of 1986 had hookscars. On the Henry's Fork, over 50% of the rainbow trout longer than 10 inches that were electroshocked in the Last Chance section during the summer of 1986 were hookscarred (Fig. 1). The frequency of hookscarring was lower at other river sections that received less angler effort, but scarring at the Railroad Ranch and Box Canyon exceeded 30% (Fig. 1). Cutthroat trout in the catch-and-release portion of the Yellowstone River, Yellowstone National Park, had a hookscarring frequency of 13% but the sample was taken in the spring of 1980 before the opening of the fishing season (Jones 1981).

One way to evaluate the impacts of sub-lethal stress and physical damage from hooking is to evaluate the body condition factor (weight divided by the cube of the length) of fish with and without hook scars. Idaho State University graduate students Craig Contor and Ted Angradi studied rainbow trout in Henry's Fork

Figure 1. Percent of rainbow trout longer than 10 inches collected on the Henry's Fork of the Snake River, Idaho, by electrofishing in 1986 that had hook scars. Sample size is indicated at the top of each bar.


PERCENT OF TROUT WITH HOOK SCARS
60
50
40
30
20
10
0
276
166
32
34
Last Chance
Railroad Ranch
Box Canyon
Harriman East

and found that hookscarred rainbow trout are in significantly poorer condition than non-scarred fish at two locations on the river (Table 2). Data from Silver Creek collected by graduate students Mike Riehle and Blaine Parker indicate that hookscarred rainbow trout had condition factors that were lower than non-scarred fish, but differences were not statistically significant.

The behavior of trout may be altered if they are repeatedly disturbed by anglers, regardless of whether the fish are hooked or not. Disturbance may lead to a shift in the habitat used by those fish or a shift in their feeding behavior, such as abandoning surface feeding in the presence of anglers. Research on Silver Creek has been initiated to examine these questions. Anglers on The Nature Conservancy Preserve were asked to refrain from fishing a 100-yard long section of stream for a 10 day period during the peak of the angling season in 1987. Idaho State University graduate student Blaine Parker monitored the amount of surface feeding done by those trout before, during, and after that time period. Surface feeding rates did not decrease during the periods of angler disturbance. The feeding rates of adult trout ranged from 26 to 39 insects per minute, depending on insect species, with most feeding periods lasting from 45 minutes to 2 hours. Surface drift rates of the mayfly Tricorythodes minutus sometimes exceeded 800 mayflies per minute through a net 5 inches wide. A 2-lb trout in Silver Creek could conceiveably ingest enough prey in 2 hours of feeding to meet its daily energy requirements (Riehle and Parker 1988). Based on the data that have been collected to date, there is reason to believe that the impacts of angling disturbance on surface feeding by trout in

Table 2. Comparison of condition factors for rainbow trout with and without hookscars from Silver Creek (Riehle and Parker 1988) and Henry's Fork (Angradi and Contor 1988), Idaho. Fish were collected throughout the summer of 1986 by electrofishing. Sample sizes indicated in parentheses.

Site	Length category, inches	Mean condition factor				Sign at
		hookscarred		non-hookscarred		
Henry's Fork						
Railroad Ranch	>12	1.04	(28)	1.16	(64)	y
Box Canyon	>12	1.19	(33)	1.30	(110)	y
Silver Creek Preserve						
	8-12	1.08	(17)	1.15	(30)	
	>12	0.96	(26)	0.99	(67)	

Silver Creek are minimal as the fish habituate to the presence of anglers.

Embryo Damage

Another category of direct impacts is possible mortality of trout embryos and pre-emergent fry which are trampled by anglers while in the gravel. In the laboratory study, Roberts (1988) simulated the effects of anglers walking over redds of brown, rainbow, and cutthroat trout. Trampling a single time just prior to hatching led to mortality of 42.6% for cutthroat trout, 43.4% for rainbow trout, and 15.7% for brown trout. If eggs were trampled twice-daily throughout the course of their development, mortality ranged from 82.8 to 96.0%, depending on fish species. In Nelson Spring Creek, Montana, eggs and pre-emergent fry of both rainbow and cutthroat trout were developing in the gravel during summer months (through July for rainbows and August for cutthroat) while anglers were using the stream (Roberts 1988). These data indicate that in streams that are fished (or trampled by large ungulates) while eggs are developing in the gravel, care should be taken to avoid these impacts.

Indirect Impacts

Indirect impacts possible from intensive angler use of a stream system include the trampling of instream aquatic vegetation and stream banks and the destruction or displacement of aquatic invertebrates. Little work has been done to evaluate these.

Idaho State University graduate student Scott Grunder conducted a preliminary study on Silver Creek in 1983 to assess trampling of aquatic vegetation and invertebrates. He systematically walked through enclosed test areas of Silver Creek once each week for six weeks and then measured the amount of live versus dead plant material and aquatic insects in the areas where trampling occurred. The predominant aquatic vegetation on Silver Creek and on many other western spring creeks is Chara, an alga which grows in beds that may be several feet deep. Grunder found that only after five weekly tramplings was he able to detect a decline in the amount of live Chara that was present in his study sites. Also, it was not until six successive tramplings that the aquatic insects associated with that habitat declined in abundance. Silver Creek anglers typically wade in trails throughout the dense Chara growth and the deep bottom sediments, leaving much of the channel unaffected. A preliminary evaluation suggested only 2% of the stream surface was noticeably trampled by anglers. Because of this and because of the high level of production of invertebrates, angling at the level at which it now exists on Silver Creek would not be expected to have a measurable on impact the food or physical habitat of those trout.

In streams where the substrate is gravel with fewer aquatic plants, aquatic invertebrates may be more suceptible to damage by fishermen. If trout production is limited by food availability, angler impact could be significant, but not studies have yet thoroughly examined the question. The relationship between disturbance and invertebrate drift has been established. Larkin and McKone (1985) working in artificial spawning channels in British Columbia, and VanHouten (1986) in a Michigan trout stream, found that substrate disturbance increased invertebrate drift. Larkin and McKone scuffled across the streams six times at two minute intervals in several day-time trials, and collected displaced invertebrates in nets located immediately downstream. After the last disturbance, the gravel was removed and organisms that remained were counted. Approximately 50% of the organisms that left the substrate did so after the first disturbance, and each successive disturbance also removed about half of the remaining disturbable organisms. This relationship held for the mayfly taxa tested, all of which are valuable components of trout diet, but not for midge larvae which were not easily disturbed. Unfortunately, the fraction of the invertebrates that was killed by the trampling was not evaluated either by Larkin and McKone or VanHouten.

A situation has recently arisen in some fisheries where anglers have learned that by scuffling the substrate they increase the drift of invertebrates and attract feeding fish. This activity could lead to impacts on aquatic invertebrates if their densities cannot be maintained by recolonization from upstream drift.

Discussion

The ultimate test of whether catch-and-release anglers are impacting fish populations and their environment would be to compare populations of fish in pristine unfished streams with those in identical streams that are open to catch-and-release fishing, or to complete a before/after comparison. Such a comparison has not yet been made. Until this can be done, we will not know how "perfect" catch and release is.

There is evidence of some biological impact from intensive catch-and-release angling, and hooking mortality appears to be the most important factor at present. What level of impact constitutes "overfishing" and therefore should trigger entry limitation or a related regulatory change as occurs in commercial marine fisheries? First of all, "recruitment overfishing" is not a possibility under these circumstances. A special case of "growth overfishing" is involved. For some, overfishing exists if a single trout dies from catch-and-release angling instead of dying from natural causes. Others might equate overfishing with a trout population that is significantly different from what existed under pristine unfished conditions. This point is difficult for biologists to establish because, as Behnke (1979) points out, low levels of angling mortality are largely compensatory and the fewer fish that are killed by anglers, the more die from natural mortality.

It is clear that "catch-and-release overfishing" will become evident at different levels of effort for different trout species. Cutthroat trout, on one hand, have very high catchability but a low mortality rate per capture. In the high-quality habitat of the Yellowstone River in Yellowstone Park, 15 years of catch-and-release angling at 200 to 500 hours of effort per acre shows no signs of negatively impacting the cutthroat trout there. In fact, the average age of spawners sampled each spring in the LeHardy Rapids area has been increasing from 3.7 years when catch-and-release was implemented to 6.1 years in 1986, and the catch rate remains over 0.9 trout/hour (Jones 1987).

On the opposite extreme are brown trout, which have such a low catchability that they are apparently not susceptible to high cumulative mortality. Rainbow trout appear to be intermediate in catchability, but because of the energy they expend after hooking they might be expected to display a higher level of sub-lethal stress (perhaps as evidenced by a decline in condition factor) occurring from hooking than other species. Thus, it seems that if direct impacts were to have a measurable effect on population levels of any species of western trout, it would be for the rainbow trout. Further evaluation of this hypothesis is needed.

Much, and perhaps most, of the interest in limiting entry comes from the anglers who are concerned that the quality of their experience is being reduced by the high density of fishermen present. The limited entry that has been instituted, or is being considered, by state or provincial agencies in British Columbia and Montana and by The Nature Conservancy on Silver Creek, Idaho, is being motivated by sociologic considerations. Entry would be limited in order to maintain a quality experience. In some cases, it appears that the level of angling effort that impairs angler satisfaction in a sociologic sense is lower than that level of effort that causes biological damage to the system.

What are the options if a heavy-use problem is diagnosed in a catch-and-release fishery? If a biologic problem is documented, it may be possible to modify angler behavior to reduce avoidable impacts. Examples include a ban on wading or an education campaign (now on-going) to minimize playing and handling stress on fish landed. Solutions to a sociologic problem include developing additional fisheries and/or limiting entry to disperse effort, and "forcing" anglers to habituate to crowded conditions or cease fishing. Fishery managers will be placed in an uncomfortable position by calls for limited entry. Traditionally, managers have been trained that their main responsibility is to maximize angler satisfaction. If fishermen pack into a fishery, their individual presence indicates they are satisfied, and the more that are there, the greater the overall satisfaction. So, although they may realize that limited entry could provide another level of quality angling, it is unlikely that fishery managers will be in the forefront of any movement to limit entry to public streams.

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