This paper reviews concepts of participatory entry limitation in fisheries. I contend that entry control should lead to higher, not lower, annual return to society, hence maximizes fishery value in competitive resource allocation. I suggest that managers could limit entry in sport fisheries by sale of weekly permits, or of even day fishing controlled by ending license number, drawings, or check stations. I argue that entry control will prove necessary in cash and release fisheries.

We hereby acknowledge that catch-and-release fishing limits entry in sport fishing. I review here the concept of entry limitation and the connection to non-conservative regulations. I discuss the role of entry limitation in natural resource allocation, and more direct means of entry limitation that would permit harvests.

Entry limitation originated in commercial fishery management. Crutchfield's (1962) landmark paper on "Economic aspects of the Pacific halibut fishery" first treated the concept of excess capital investment and fishing capacity. Crutchfield pointed out that the problem of policy in pelagic management turned on the necessity of conserving the halibut resource. He noted that in pre-regulation days, halibut were treated as a completely free good, open to all comers without restriction. Overfishing resulted. The quota system for halibut, which allowed a fixed harvest each year, prevented overfishing, but posed social and administrative inefficiency, discouraged investment in fishing vessels that could travel to and from the fishing grounds rapidly to obtain a greater share of the quota. Engine sizes increased accordingly, for example. The regulations led to disruption, with no apparent gain in economic costs.

What has the halibut fishery to do with sport fishery management, especially with wild sport? The answer requires review of

Some basic truths of fish population response to harvest, as well as some simple ideas from economics.

An unharvested fish population will contain a relatively large number of large, older animals and will have somewhat low survival in the early life history stages. It will also have a low population growth rate, in the sense of tissue elaboration or production, because the larger animals have a higher requirement for maintenance energy, and do not contribute energy to tissue or efficiently as do young, rapidly growing animals.

As fishing mortality increases, the population for a time becomes less efficient because the large, slowly-growing population components die sooner, "release" younger fish to produce efficiently. Reproductive success and survival of young fish increase as competition relaxes. As a result, total weight yield in the fishery reaches a peak at moderate rates of fishing mortality (Figure 1).

Total weight (biomass) yield to the fishery does not occur without other effects. For example, the mean weight of fish in the population decreases with increased fishing mortality because the large, slowly-growing fish disappear (Figure 1). This result, anathema to many sport fishermen, must occur in conservative fisheries.

Finally, aggregate weight of the population declines with increased fishing mortality (Figure 1). In spite of this, the
Population actually produces the most tissue at intermediate fishing, not at zero harvest. Fishing mortality increases with fishing effort, so total weight yield from the population has a dome-shaped relationship to fishing effort (Figure 2).
just equal costs. Very efficient fishermen, sometimes called "light-keepers" continue to realize a positive net return, but many other fishermen lose money.

Commercial fishermen (to say nothing about sport anglers) always think the next voyage will yield the bonanza catch that will turn their fortunes around. This optimistic opinion, as well as a poor market for Venice and gear and "once a fisherman, always a fisherman" inertia resistant to occupational change, keeps effort at point A. Furthermore, many fishermen tend not to think in terms of opportunity cost, the return they could realize in alternative investments, they tend also to forget to include owner/angler labor's costs of effort. A false picture of real return on investment thus emerges when these fishermen total up incomes and costs at the end of the year.

If a prudential monopolist owned the fisheries resource, he would manage effort at the point at which the distance between the cost and return line maximized (Figure 3, point E). Point E denotes the maximum net economic yield from the fishery. All fishery management operates under these constraints: ecological, technological, and socio-economic. Fishery conservation should provide economic benefits to man (Brutchfield 1962). Sound conservation would control effort so as to maximize net economic return. I suggest later that we should inquire when the calculated costs of effort in this harvest, as Jim McFadden first suggested in 1949.

In the absence of the private entrepreneurial option to limit entry, government must control fishing in a way that maximizes conservation, defined as assurance that the stock can perpetuate itself. In salmon fisheries, this means management to assure adequate escapement when the fishery managers are certain that fishing is in abundance, and certain that no material or fishery: in short, management to assure effectiveness in the fishery. Gear and time restrictions that assume insufficiency become extremely onerous. Most of us would agree that entrepreneurs in a capitalistic system ought to have every opportunity to become efficient. However, does not limit entry to a commercial fishery or a common-property resource? Government, authorized by legislatures, may simply stop issuing new licenses, increase the cost of annual relicensing, or license from willing sellers, and buy boats and gear with license proceeds or general tax revenues. Once the fleet reaches the desired size, licenses change hands much as private land does. Some Canadian salmon fisheries, the lower Columbia River Gillnet fishery for salmon, and certain Alaskan fisheries offer examples of this approach. In some cases the escutcheon are owned. Limiting entry.

Has entry limitation worked in real time? After entry limitation, the value of a British Columbia Gillnet license increased by at least 15-fold. When last I heard, one could buy a license for perhaps $260,000 (without boat and gear). The British Columbia sockeye fishery now is worth more in net annual return to investment. What connection can we find between entry limitation and stock-recruitment relationships? The latter define the relationship between process numbers as affecting the partial escapement. These functions developed historically that salmon management most, especially in stocks and species with predominently fixed generation time. Coho salmon, pink salmon, sockeye salmon, and chinook salmon offer examples of mostly three, two, and four-year generation times. A generalized partial recruitment function (Figure 4) relates parent spawners on the x axis to progeny adults in the resulting return run on the y axis. The straight line above where returning run just equals parent spawner numbers. Any point above the replacement line, a given escapement produces a harvestable surplus.

An escapement of about 1.9 spawners produces a maximum returning run (maximum M) of about 2.9 (Figure 4). Harvestable surplus equals about 1.4 (difference between replacement line and curve). A lower escapement of about 0.8 spawners produces only about 2.6 return run, but will sustain a harvest of 1.3. This occurs because of reduced competition at the lower escapement; competition for spawning sites and perhaps for juvenile rearing. Still, an escapement of 0.8 "fully seeds" the available environment. We term
Figure 4. Progyny adults in relation to parent spawners. A spawner population of about 1.5 leads to maximum returning progeny, while a population of about 2.0 leads to maximum sustained yield (distance from replacement line to curve).

Management for an escapement of 0.8 at management for maximum sustained yield (MSY). We call management at 2.3 spawners as maximum sustained numbers (MSP). A resident management would manage his fishery for MSY, where he can take about 65% of the returning run, or average, if he manages at MSY. He would harvest the surplus with limited entry to make maximum efficiency. The connection between entry limitation and MSY in publicly owned fisheries is that both management schemes would maintain effort, hence fishing mortality, at intermediate levels that maintain the stock at highest productivity (selective growth).

Management for MSY becomes very difficult when two or more stocks with different stock-recruitment functions mix in the fishery. The less-productive stock in Figure 5 has a harvest rate at MSY of less than 40%. Fishing at MSY at the required 70% harvest rate for the productive stock would overshoot the less productive one, and may drive it to extinction, or at least to greatly underscoped levels. This has happened, and continues, on the Columbia River, where gillnet fisheries for mixed fall chinook salmon and large Idaho steelhead leads to underscoped wild alewife. The problem would greatly decline in severity, but would not disappear, without some massive management.

Biological conservation must often require severe, strict, and gear restrictions to reach MSY or MSP. But what about MSP or MSN? These might define as maximum sustained yield of aesthetics or maximum sustained days of aesthetic experiences.

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Most of us would probably argue, for example, that the value per fish as meat declines with each steelhead caught. That is, we do not value the fourth steelhead caught as highly as the first. We must, for it usually ends up a year later with locker burn. I also argue that the first steelhead caught has high aesthetic value, but that additional fish add less per fish to the aesthetic experience (Figure 6). I hurriedly note that the total value of the aesthetic experience increases for each added fish caught. The marginal value decreases. I have, a few times, reached the point of zero marginal benefit, where the next fish was not worth the effort required to catch it. Some would call that nirvana; nonetheless it fits with economic theory.

I can combine the discussion so far by depicting a yield function for recreational fishing where meat and aesthetic values exist (Figure 7). I take the liberty here of assuming that a day of fishing has a dollar value, as many economists have shown indirectly (Mathews and Vendier 1961, Brown et al. 1964). Suppose we eliminate meat yield, at whatever cost in the spectrum of participants, and nutrition, and let each angler who remain or come to fish in a catch-and-release fishery differ in characteristics from those who participate in a harvest-oriented fishery. I am suggesting that first steelhead catch per fisher contribute to human nutrition to some degree; a value lost in catch-and-release fisheries. Ignoring these factors, I suggest that catch

VALUE PER FISH

Figure 6. Value per fish for aesthetics and meat as related to number of steelhead caught.
anglers may capture steelhead more than once, the rate may rise, especially where fish take the lure, even a harmless one, deeply. I think this describes Idaho's catch and release program for wild fish on the Salmon River.

The point of MSY for esthetics lies at effort level B in Figure 7. A present monopoly, who charged for access to his fishery resource would limit entry at B so that his net return maximizes. Can society do the same? If so, why?

On some public shooting grounds, a limited number of blinds are available to mark hunters who must apply in advance and receive a blind for a given day, or who must line up at the entrance to the shooting ground well before dawn on a first-come, first-served basis. Why must one use only the established blinds? The answer is that decoy shooting for ducks offers a classic case of decreased net benefits with increased effort. Too many hunters too close to each other completely spoil hunting for everyone as ducks never have a chance to work to the decoys.

Golf offers a fine example of limited entry. In fact, I golf more that I fish, in part because of golf's entry limitation. Yet times every 8 minutes or no guarantee spacing on the course. Certain rules permit fast golfers to move through slow ones. The amazing feature of the system is that conflicts between good and poor golfers are so few. From a profit and reward experience to all entrants (although some would argue that golf is a game of loss and suffering to willing masochists!).

On the popular Middle Fork Salmon River, one can only begin a float (of 5 days or so) if in possession of a permit that was applied-for in January and issued on a random basis based on part of a numerical quota (or one can float with commercial outfitters who guarantee a permit for half of all permits; a problem outside the thrust of my paper) and over 8,000 floaters use the river each summer. A catch and release regulation for the stream, together with the float quota, guarantees a quality experience. If too many floaters used the stream, solitude would disappear, campgrounds on the few available areas in the deep canyon would not offer sufficient space, and the cutthroat trout fishing would suffer.

How can some of these resource partitioning programs apply to fisheries, even to catch and release? All angling licenses end with a digit. Regulations might allow anglers with odd-ending licenses to fish only on 26 of the available 52 weeks, even digits would fish on the alternate weeks. One might obtain a special permit to fish two weeks (actually three) in a row. A block of these permits could be made available to anglers in a drawing. Alternatively, regulations on popular catch and release streams would require a fishing permit obtained from a drawing each winter, with unused permits available on a second drawing. We already manage many big game harvests in this manner. In some cases governments collect significant revenue from limited-entry drawings. Last desirably, entry checkpoints might allow a quota of anglers into given stream reaches, with no more entrants until someone departs.

This all sounds rather bureaucratic. Why should we go to such lengths? I think that our objective should be to maximize net returns, at least for many salmonid fisheries. This maximization increases the annual "rent" from the resource, whether society actually collects that rent or gives it away to anglers. I would maximize rent from unused permits available for salmonid fisheries. Once the obligation of follow and many adults is assured, society should then maximize net benefits from fishing harvest and opportunity. My reasoning is that net benefit maximization provides a high-quality experience for participants and assures the most competitive role possible in resource allocation. Not all allocation decisions (Kayaking V. fishing, kayaking V. fish habitat, grazing V. riparian zones) will or should be made on economic criteria. However, fisheries will get the most consideration possible from resource owners or managers by having the greatest economic "clout" possible. Sport fishers will have least clout if managers dissipate "rent" by excessive entry.

In a paper called "Economic criteria for division of catch"...
between sport and commercial fisheries, with special reference to Columbia River chinook season. 1 Mathews and Wendler (1964) examined net rent from sport and commercial fisheries. They concluded that the proportion of catchability in the sport fishery on the Columbia River is five times as high as in the spring chinook run as on the fall run. Since net value of sport fishing depends on the average level of angling success, the spring fish are potentially more valuable for sport fishing. The authors showed that only if the commercial fleet were reduced to increase net economic value could a continued commercial fishery be justified. On the basis of the economic criteria examined, the authors stated that resource managers should consider managing the spring chinook stocks with more favor toward the sport fishery unless the commercial fleet were reduced in size (made more economically efficient). They suggested no change in the fall season fishery, although entry limitation would substantially increase economic rent in that fishery.

I suggest that as fuel costs rise, making ocean trolling even less economical, more salmon return in net pens reach the market at low prices, and less are sold for sport. As sport fisheries becomes much more appropriate. Furthermore, even if terminal commercial fisheries continue to harvest important quantities of salmon, additional economic returns from salmon would increase substantially. Fishing biologists would reach the mouths of parent streams. Ocean larvaceans (sport and commercial) take salmon that are proving new tissues faster than natural larvaceans would. Furthermore, hooking mortality is very high, wasting more biomass. About 117,000 coho salmon were wasted in hooking mortality during a chinook-only fishery off Oregon last year, or about 17% of the legal harvest of coho salmon. In a bi-species season. An additional hooking mortality is associated with the latter fishery. I estimate that every hundred coho in a legal harvest off Oregon represents 30 more fish killed and lost. Coho salmon could be taken in tandem with sport fisheries with great increases in net rent.

Will the angling public support limited entry? To answer this question, I examined a 1988 angler opinion survey of Idaho fishermen (Idaho Fish and Game Dept., March-April 1988). The survey was a 10% random sample of the state's 30,000 licensed anglers. Of the respondents, 56% of respondents would be willing to restrict harvest and size of harvest to maintain fishable wild populations; 54% would manage salmon and lakes to provide larger than average trout at increased catch rates, even where methods, numbers and size would need restriction; and 4% would continue to fish a favorite trout stream if the water were managed for trophy trout with catch and release. When asked whether they considered it important to avoid angler crowding, 86% of the respondents said it was important (22-44), very important (24-28). From these data, I conclude that anglers went to maintain wild trout and would accept catch restrictions, including catch-and-release regulations, to do so. The respondents do not want crowding, so limited entry appears acceptable in some form.

Limited entry certainly would control crowding. It would also lead to increases in fish size, if coupled with much measures as catch and release, and perhaps a moratorium for those who would not support large fish management. On the other hand, the latter would likely limit taking entry. On the May 14, 1987 Idaho Stateanaknowout report in an article titled "Sportmen may see end of Big Wood rule," The Idaho Fish and Game commissioners had voted 3 to 1 to restrict 17 miles of the Big Wood River above Deer Creek to catch and release fishing with an exception for fishery called a "Fish-in" on opening day, with one ranger-leader stating: "I've already told the fish and Game where I'll be opening day, and I told them to bring their handoffs." Presumably, this individual would have several other anglers among the half of questionnaire respondents who would not support catch and release as a measure to increase fish size or protect wild trout. On the other hand, I think that respondents who support such protective measures in general, sometimes or often would not support them if applied to their favorite stream.
The time may yet not have arrived for wide support of limited entry, whether accomplished by catch-and-release or otherwise. But it will. One need only visit trout streams in popular areas, or the growth of tourism in the mountains of the Western United States, to see the developing pattern. I have watched the West change for more than 35 years as a professional biologist and fisherman. I know that 35 years ago very few fly anglers fished for steelhead on the Clearwater River in Idaho. One could fish all day without seeing another rod. Today one often cannot find a known holding spot for steelhead that does not contain a fly fisherman. Where the lower Clearwater was little used, it now is super-saturated with steelheaders. I think it is time to initiate entry limitation on certain popular waters to increased net benefits.

Apart from direct benefits to anglers, high net rents from resident fisheries, whether oriented to harvest or catch-and-release, provide ammunition to allow Forest Service and BLM administrators to more easily justify livestock reductions or public subdivision zones. They give the manager justifications to improve stream habitat, better land planning, or other measures. The benefits of reading and timber harvest close to metropolitan areas and other resources are traditionally considered commodities. Should the fishery manager fear economic comparisons? I do not think so. From the ranks of concerned anglers come informed and participating publics.

Literature cited


