

A SIMPLE 4-STEP METHOD TO MANAGE FOR QUALITY FISHING

Implementing Utah's Blue Ribbon Fishery Program



Publication Number 04-24

June 2004

Utah Department of Natural Resources, Division of Wildlife Resources
1594 West North Temple, Salt Lake City, Utah 84114

An equal opportunity employer
Kevin Conway
Director

A SIMPLE 4-STEP METHOD TO MANAGE FOR QUALITY FISHING

Implementing Utah's Blue Ribbon Fishery Program

Prepared by:

Dale K. Hepworth
and
Stan Beckstrom

Utah Division of Wildlife Resources
Southern Region Aquatic Program Biologists

Utah Blue Ribbon Advisory Council:

Randy Radant, Utah Division of Wildlife Resources
Jim Carter, Strawberry Anglers Association
George Sommer, Bass Anglers Sportsmen Society
Collin Allan, Utah Wildlife Board
Tom Ogden, Southeast Regional Advisory Committee
Wes Johnson, Trout Unlimited
Lori Batty, Big Foot Fly Shop
Byron Gunderson, Fish Tech
Paul Dremann, Trout Unlimited
Steve Schmidt, Western Rivers Flyfisher
Rick Rosenberg, Southern Utah Anglers
Jeff Taniguchi, Uinta Basin Bass Club
Bryce Bishop, Southern Utah Representative

Publication Number 04-24

June 2004

Utah Department of Natural Resources, Division of Wildlife Resources
1594 West North Temple, Salt Lake City, Utah 84114

An equal opportunity employer
Kevin Conway
Director

INTRODUCTION

The new concept of Blue Ribbon fisheries was introduced to Utah by Governor Michael O. Leavitt in 2001. The general idea was to improve fishing and increase opportunities for the angling public. Our perception of events leading up to the formal introduction of this new management initiative was that the angling public was asking for serious changes in how some Utah waters were being managed. Avid and influential anglers were asking for better and higher quality angling opportunities and looking for ways to help the Utah Division of Wildlife Resources meet these goals. Much of the effort to date has been in securing public access on private property and improving fish habitat, to a great extent, in streams and rivers.

Although significant progress has been made, misconceptions occur as to how biology applies when deciding if management changes should be made. The purpose of this article is to outline a simple method by which fishery resources can be biologically assessed and decisions made when implementing management changes.

This process includes 4 steps:

- (1) Inventory current status with a standard “yardstick.” This allows comparisons among fisheries to determine and rank overall potential.
- (2) Assess fish size and population density. The “magic” of fishery management is that fish size can often be controlled by adjusting relative abundance. This characteristic applies specifically to fish and is completely alien to management of mammals and birds.
- (3) Determine the limiting factors. The history and problems with the water in question should be objectively evaluated to understand why it is in its present state and what controls the situation.
- (4) Select appropriate management actions. If limiting factors can be addressed, actions can likely be taken to correct or improve these problems. Problems can be solved most efficiently if the right tool is used.

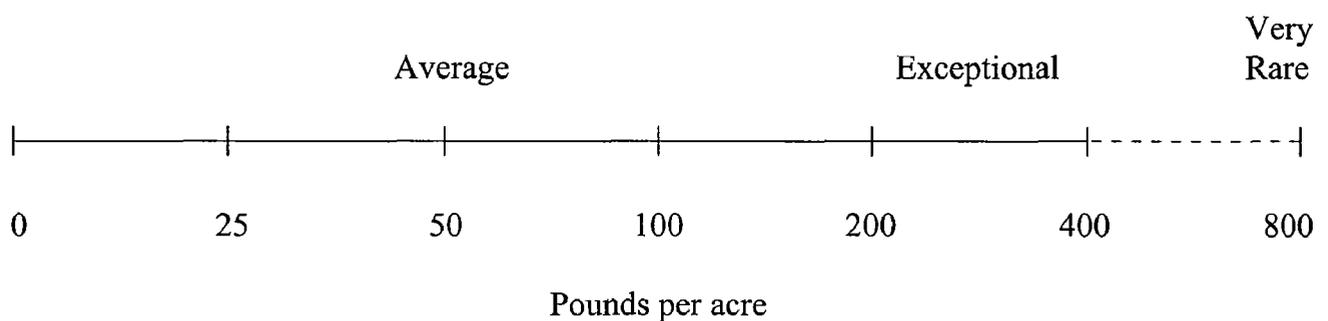
This all sounds simple enough, and it is, but there are pitfalls. Read on for more details and examples of how each of the 4 steps can work. Also, find out how common misconceptions can lead us down the wrong path.

THE STANDARD YARDSTICK

We like to look at streams and rivers in terms of “*pounds of fish per acre.*” When evaluating trout streams, there is much information and many places with which to compare. Measuring in “*pounds per acre*” levels the playing field by allowing both small streams and large rivers to be compared, fairly equally. In contrast, measurements like “*fish per mile*” favor larger streams or

rivers because larger streams more often have more fish per unit of length. Another advantage of “pounds per acre” is that much data is available in metric units, reported as “kilograms per hectare” – but it doesn’t matter because metric and English units result in almost identical ratios and no conversions are necessary (1.0 pound per acre equals 1.1 kilogram per hectare).

Most importantly, there are some easily remembered standards that allow “yardstick”-type comparisons. The overall average for hundreds of western trout streams is 50 pounds per acre (Platts and McHenry 1988). After taking measurements in many southern Utah streams and calculating an average, we came up with essentially the same value. The better streams were over 100 pounds per acre and the best streams ranged up to 300 and 400 pounds per acre. Some very exceptional cases are reported in the literature of about 1,000 pounds per acre, but these may not be sustainable over time and they often result from unnatural circumstances (Behnke 1992).



Lake inventories are not quite as straight forward, but they basically work the same. We look at gill net catches with the nets being set over-night. The data is not as universally used as pounds per acre in streams, but it has worked well to establish some consistent standards in southern Utah. Catches of 20-45 trout per net-night are good, especially if condition and growth are high. Values above 40 trout per net-night can affect growth and limit maximum size. Stunted populations often have values of 80 trout per net-night or higher. Values below 20 usually indicate that fish numbers are lower than desired or a body of water might be so unproductive that it is unable to support greater numbers. Condition factors (a measure of relative plumpness) and visceral fat levels (a measure of body fat) compliment gill net data and help verify if fish numbers are high or low. For example, condition factors of less than 1.0, for rainbow trout, result when fish are in poor condition and indicate that continued growth is unlikely (Bennett 1971). Low conditions are usually associated with high gill net catches. Conversely, condition factors above 1.0 correlate with fat fish and suggest that growth will continue. These high conditions are often associated with relatively low gill net catches. Visceral fat levels provide much the same information as condition factors.

Other measures and parameters are useful, depending on the situation, but would only complicate this discussion. The major point is that productivity and sport fish potential can be determined fairly easily. Waters can be ranked and compared with standard values to better understand limitations and potentials. This is true regardless of the species of fish in question and whether the water is a lake, reservoir, stream, or river.

THE MAGIC OF POPULATION DENSITY AND FISH SIZE

If the overall average biomass found in trout streams is 50 pounds per acre, then half or more of all western trout streams are likely to contain less trout than this value. This does not mean that below average streams with 20 or 30 pounds of trout per acre are not worth fishing. At times, these streams can have large fish, even though the total number of fish might not be high. Conversely, streams with over 100 pounds of trout per acre might have populations consisting entirely of small fish. The best of both worlds, however, is to have a high biomass (over 100 pounds per acre) and have it made up of many large fish. To a great extent, with the right tools, this can be managed.

Birds and mammals are classified as having “*determinate*” growth. In contrast, fish have “*indeterminate*” growth (Lagler et al. 1962, Bennett 1971, Behnke 1992). The management implications of this difference is huge. Maximum size and growth of mammals and birds is predetermined and pretty much controlled by their genetics. With fish, maximum potential size is determined by genetics, but growth and actual size attained is more a function of the environment. Fish grow to match their environment. For example, consider brook trout, one of the smallest of the trout species. In a crowded, environment with relatively little food, maximum size might be 0.25 pounds. On southern Utah’s Boulder Mountain this can be altered to increase potential size to about 6.0 pounds. Fish numbers (density) have to be reduced to allow each individual fish to have a larger share of the total food supply, but overall fish biomass supported by the lake remains about the same. The reverse can occur just as quickly. Either way, the change represents a difference of 24 times in size (0.25 pounds to 6.0 pounds) in a very short amount of time.

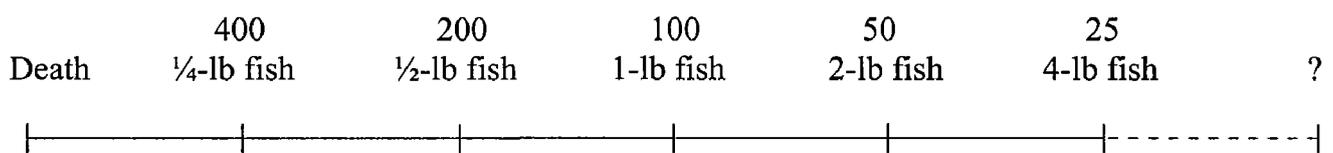


Imagine changing the size of an elk by 24 times. It doesn’t happen with elk, but it does happen with fish.

Fishermen often underestimate how fast trout can grow and overestimate the time it takes to grow a trophy trout. Large trout are most often a function of fast growth rather than old fish. Several good trout streams in southern Utah lack spawning habitat and are therefore stocked with fingerling brown trout. Brown trout of known ages commonly reach sizes of 18-20 inches in 3-4 years. We have measured brook trout from Boulder Mountain lakes that reached 5 pounds after surviving only two winters (3 summers of growth). Brook trout stocked as 3-inch fingerlings and at a rate of 50 per acre, grow to a size of about 13 inches and 1.0 pounds in a year. If the stocking rate is increased to 100 per acre, growth decreases to about 0.5 pounds in a year. If growth is rapid, then harvest of trout by fishermen is not a great threat to quality fishing. In either Boulder Mountain lakes or brown trout streams, moderate annual harvest of 16-18 inch trout is replaced annually by younger fish quickly growing to this same size. Even if 80-90% of the 16 to 18-inch trout are harvested, they are replaced each year and there are still some fish left to potentially grow even larger.

Consider another example. The worlds largest cutthroat trout historically came from Pyramid Lake, Nevada. Roughly 80 years ago, some eggs or fry from Pyramid Lake were moved to a small stream on Pilot Mountain near Wendover, Nevada-Utah. This new population persisted for about 50 years before being discovered again in 1978. Although there were no individual fish in the stream that exceeded 10 inches, once they were put into small ponds with increased forage and feed they grew dramatically to over 36 inches and 14 pounds (personal communication and pictures, Bryce Nielson, Utah Division of Wildlife Resources). This group of fish now provides the brood stock producing millions of fish for population restocking in their native waters. Although these fish had persisted in the small stream for many generations and their genetics and growth potential may have been somewhat altered, they still remained amazingly adaptive and responsive when they were again removed from the restrictive small stream habitat. This most recent change occurred with fish taken from the stream, not even requiring the next generation to complete the transformation to 14-pound trout.

Options between numbers and size



100 ponds per acre
Standing Crop

Indeterminate growth can be applied to fishery management if numbers of fish in a population can be controlled. The arithmetic is simple. Given a situation of 100 pounds per acre, it can be managed as 100 1-pound fish, 200 half-pound fish, or 400 quarter-pound fish. Going the other way, size can be manipulated to 50 2-pound fish, 25 4-pound fish, etc. Theoretically, size could be changed to one 100-pound fish. Even at this extreme, it could come close to reality if king

salmon or lake trout were the species of fish in question. Obviously, fish of this unusual size are seldom the case. In Utah streams and rivers, however, maximum size can usually be at least 16-18 inches. Potential maximum size is even greater in lakes and ponds. When food is sufficient to allow continued growth, the upper limit on size is usually set by some other environmental limiting factor, such as water temperature, winter habitat, sport fish harvest, or size of holding pools. Before these limits are reached, the balance between numbers and size is as proportional as given in the preceding examples. When we have been able to control overall fish numbers (for example by stocking), maximum size and growth are also manageable.

LIMITING FACTORS

Limiting factors have already been mentioned several times. It is an important biological concept that particularly concerns managers. It is a condition that prevents the biological potential of fish from attaining a higher level. Improving a biological attribute will not help the situation if that attribute is not the real problem. It is not unusual for a situation to be incorrectly evaluated, leading to false assumptions, and for the real limiting factor to be over-looked.

Utilizing the information gained by “*yardstick*” inventories and correct assessments of population densities helps us along the road to Blue Ribbon management, quality sport fishing, and an understanding of limiting factors. If the “*yardstick*” shows low “*pounds per acre*” and there is potential to improve conditions such as water quality, temperature, annual stream flow variations, bank erosion, and fish cover, then there is a high probability that habitat work could be conducted to increase trout biomass. A predetermined standard could be set for achieving Blue Ribbon status. For example, current trout biomass might be 40 pounds per acre and the goal might be to improve this to at least 100 pounds per acre.

On the other hand, an inventory might show a stream to already be above 200 pounds of trout per acre, but the fish might all be small and in poor condition. In this case, habitat improvements conducted to improve fish size and condition would likely be a waste of time and money. The “*yardstick*” for biomass might already be at its maximum. Actions, however, could be taken to adjust high fish numbers and high density. Reducing overall density would correlate to increases in average fish size. Blue Ribbon standards might be set to adjust population size structure to a point where 25 % of the fish exceed 14 inches in length, compared to a starting point of nearly 100% being less than 12 inches.

FISHERY MANAGEMENT TOOLS

In total, there are only four fishery management tools: (1) fishing rules and regulations; (2) public relations and education; (3) fish stocking and fish removal, and (4) habitat improvement and manipulation. There are many ways to measure and evaluate fisheries, but all efforts to affect change in fish populations fall into one of these categories.

After an accurate assessment of limiting factors is made, the choice of what tool should be selected to implement a management change is relatively easy. Whether it is “practical or cost effective” might be another story. Again, the question can be asked: “is Blue Ribbon status a reasonable goal– can improvements in the fishery be reasonably made?” A few examples from current Blue Ribbon waters and a list of potential Blue Ribbon waters illustrate choices and the use of different management tools:

- East Fork Sevier River, Kingston Canyon – Problems have included limited public access and some degraded stream habitat. Surveys conducted in 2003 found brown and rainbow trout combined biomass to average 80 pounds per acre. Trout ranged in size up to about 20 inches. Public access was secured in 2003 by purchasing a key piece of property (public relations – tool # 2). Habitat improvements are planned that include restoring a channelized portion of stream to its former natural channel, and re-vegetating eroded stream banks (tool # 4). At present, stocking of brown trout (tool # 3) and fishing regulations (tool # 1) are recommended to remain unchanged. It is suggested that Blue Ribbon status be granted if trout biomass can be increased to over 100 pounds per acre.
- Donkey Reservoir, Boulder Mountain – Natural reproduction of brook trout has resulted in a large population of small fish. Other area lakes with the same general productivity but lower density of trout produce much larger fish (standard yardstick comparisons). Stocking of all trout has been discontinued at Donkey Reservoir (tool # 3). A 1999 survey resulted in brook trout being captured at the rate of 99 trout per net-night. Maximum fish size was 14 inches and 0.9 pounds; the mean K-factor was 1.0. Fishing regulations allow a bonus of 4 brook trout and a total limit of up to 8 fish (tool #1); fishing is allowed year-round. Proposed actions include working with the local irrigation company to procure additional irrigation water (tool # 4) by re-building an old reservoir (Middle Donkey Reservoir – which will be another new sport fishery). The added irrigation water will give the irrigation company the latitude to alter reservoir release patterns, taking irrigation water first from Donkey Reservoir. Such reservoir withdrawals should reduce brook trout reproduction by lowering Donkey Reservoir below springs when spawning takes place in late fall. Blue Ribbon status should be considered after these actions are implemented and if associated increases in fish size occur.
- Fish Creek Reservoir, Boulder Mountain – This reservoir has the same general problem as Donkey Reservoir. Natural reproduction of brook trout has resulted in a stunted population. A 1999 survey found brook trout to average only 10 inches and 0.38 pounds. Mean condition was 0.88 and maximum fish length was less than 12 inches. Two rotenone treatments were conducted in the past (1970 and 1984) to reduce brook trout densities and improve growth. Following both treatments, growth of brook trout greatly improved and some fish were produced that exceeded 5 pounds. Benefits from both treatments, however, were short-lived. As a result, Fish Creek Reservoir has been scheduled for a third treatment with rotenone, currently planned to completely and permanently remove brook trout from this body of water (tool # 3). Following treatment, the reservoir will be restocked with Colorado River cutthroat trout, tiger trout, and splake

(tool # 3). These fish will not have the capability to over-populate like brook trout. Stocking densities will be managed to allow fish growth up to at least 20 inches. Blue Ribbon status will be considered after these actions are implemented.

- Minersville Reservoir, Beaver County – Chronic problems occurred at this reservoir over many years. A special research project was conducted in conjunction with Utah State University to understand and determine limiting factors. Utah chubs were known to be a problem and the reservoir had frequently been treated with rotenone to temporarily reduce chub numbers. Good fishing resulted after rotenone treatments but typically lasted only 2-3 years. It was understandable that chubs competed with trout and reduced trout growth, but it was not understood why trout survival became so low that the fishery collapsed only a few years after a rotenone treatment. It was found that the reservoir was a major stop-over on the annual migration route of fish-eating waterfowl. Cormorants, in particular, were observed to consume, over a period of a year, more catchable-size trout than fishermen. When trout growth was fast, some fish grew past sizes that were vulnerable to birds, but fishermen were quick to harvest fish of these sizes. As chub numbers increased, trout growth decreased and fish remained vulnerable to birds over a longer period of time. Spring-stocked trout were particularly vulnerable to spring bird migrations. When harvest of trout by birds and fishermen was combined, it was evident that exploitation of trout exceeded what could be stocked and the fishery failed. A new management plan was put into effect in 1991 that included restricted angling methods and harvest regulations (tool #1) to avoid over-harvest, and changing time of stocking, size of fish stocked, and species stocked (tool # 3) to avoid bird migrations and predation, and at the same time increase predation on Utah chubs. Besides rainbow trout, Bear Lake cutthroat trout and smallmouth bass were added to the reservoir. As a result, catch-and-release fishing was used to reduce over-harvest and a trophy fishery was produced throughout most of the 1990s. Overall, the plan was successful in maintaining a sport fishery even without additional rotenone treatments. The catch in annual gill net surveys was generally increased from under 10 trout per net-night to over 20. Although drought conditions and reconstruction of the dam caused the reservoir to be drained in recent years, plans are to re-establish this fishery and Blue Ribbon status when adequate water levels are restored.
- Fremont River, upstream from Mill Meadow Reservoir – Brown trout were introduced into this stream in the mid-1990s to create a wild trout fishery. Standing crops of trout have been measured at over 300 pounds per acre. Fish range in size up to about 3 pounds. Fishing pressure is generally low. Water releases from Johnson Reservoir result in reduced water clarity throughout the summer and last until the end of the irrigation season. This is discouraging to fly fishermen. Trends indicate continued increases in trout numbers and decreases in average size. Blue Ribbon status has been recommended for this stream along with general public encouragement to harvest more fish (tool # 2) in order to maintain quality fish size.

ANALYZING SOME FREQUENT MISCONCEPTIONS

- Fact or myth? -- *Increased stocking can compensate for increased fishing pressure.* There is a common attitude that the more fish stocked the better the fishing. In the social/political world, fish stocking is generally considered good and is a simple answer to maintaining public recreation as human populations increase. In fact, the only way increased fish stocking can provide for more pounds per acre from recreational fishing waters is by producing the additional pounds in a fish hatchery. This evolves into what is commonly known as put-and-take management. Catchable-size fish are stocked one day, ready to be harvested the next day. This is a totally artificial situation, with the lake or stream being nothing more than a receptacle for hatchery fish. Although these generalities usually apply, the specifics of each situation need to be considered. To the serious angler put-and-take fishing is very different from catching wild fish, or even catching a fish stocked as a fingerling, that has grown to catchable-size in the wild. With wild fish management and “put-grow-and-take” management, stocking can only be increased to a certain point. When “indeterminate growth” is understood, it is realized that increased stocking simply reduces growth rates and maximum fish size. Stocking rates in put-grow-and-take waters can only be increased to the point that fish will still grow to acceptable sizes. Some of the worst management mistakes ever made resulted from over-stocking. Consequently, managers were forced to spend valuable time and resources reducing fish numbers, because anglers would not accept fish of inferior size.
- Fact or myth? -- *Catch-and-release fishing regulations allow fish to live longer and thus, grow larger.* Acceptance of catch-and-release practices among many anglers has generally been good and much needed. It addresses the problem discussed above about meeting angling needs and having plenty of fish, even as human populations and angler numbers continue to increase. In simple terms, fish can be caught, utilized, and enjoyed more than once. On the other hand, the assumption that released fish are predestined to become large with old age is false. By now, this should be obvious based on what has been discussed about population density and indeterminate growth. The size-limiting factor is often not age (or time) but the environment. Fish grow to match environmental conditions. Catch-and-release can lead to over-crowded conditions and small fish. In many cases, some harvest is beneficial and needed to maintain quality-size fish.
- Fact or myth? -- *When fishing regulations allow large fish to be harvested, only the small fish survive. Over time, the genetics of the population become altered and the potential to produce large fish is lost.* At first, this sounds very logical. But again, this theory is based on common associations most people have with “determinate growth.” We tend to think that fish growth is governed by the same rules as other animals. In contrast, fish have evolved and are genetically programmed to be very plastic and adaptive, a characteristic that serves as a long-term survival strategy. The Pyramid Lake cutthroat trout example, previously noted, where large fish were changed to small fish, then again changed to large fish, just by altering the habitat where they lived illustrates the great range of adaptability that fish can undergo. Many generations of selective breeding of

only small Pyramid Lake cutthroat trout had little influence on the final outcome. There is no substantial evidence that selective sport fish harvest genetically alters growth and maximum fish size (Behnke 1992).

SUMMARY

Sport fisheries can be managed for quality fishing by a simple 4-step process. First, “standard yardstick” measurements of biomass are made to evaluate where a fishery ranks compared to other fisheries of the same sort. Secondly, the population biomass is evaluated in terms of individual fish size. Third, factors that limit total biomass and individual fish size are determined. Questions are asked: Can biomass be increased or can fish densities be altered to adjust individual fish size? The fourth step is implementation of appropriate management tools to change the fishery to a more desirable state. After a suitable amount of time, the fishery is evaluated to see if management actions were effective and if goals were attained, which is actually part of starting the whole process over again.

SOME GRAPHIC MODELS OF POPULATION GROWTH

This section provides some supplemental information for the more serious angler or student of fishery science. Although this information is supplemental to the above discussion, it graphically illustrates important concepts and visually shows how fish populations can be manipulated to improve quality fishing.

A typical population growth curve is shown in Figure 1 (Odum 1959). The horizontal axis represents time, in units of years (basically seasons of growth and reproduction). The vertical axis represents biomass, which we have discussed in units of pounds per acre. Over time, a population will increase in biomass following an S-shaped curve. A few individual fish representing a new population, having just been placed in a void environment will initially reproduce slowly, simply because of low numbers. This is shown at the bottom of the S-curve. With time, the population will begin to expand more rapidly and grow at an exponential rate (the middle of the S-curve). Eventually, growth will begin to slow as environmental constraints are encountered, and finally the S-curve will flatten out at the top as the environmental carrying capacity is reached. *Carrying capacity can be viewed as the size of a “bucket,” – the environmental ability to hold a finite amount of fish.* Capacity is reached when the bucket is full of fish. The environment cannot support additional biomass.

Fish populations are near or at the bottom of a growth curve when a reservoir is drained or after a lake is treated with rotenone. In such cases, a population has to be re-established, basically starting at zero. Flash floods and fires can result in similar situations, or push a population part way down the curve from the top of the carrying capacity level. Over-harvest by fishermen can do the same thing.

One of the main management implications of the graph is apparent when the amount of biomass produced is considered over a period of a single season of growth. The shaded areas show this for three segments of the S-curve. At both the bottom and top of the curve relatively little population growth occurs during a single season compared to the middle of the curve where a relatively large amount of growth can occur during the same amount of time. A fish population might be near the bottom of the curve because of over-harvest. A fish population at the top of

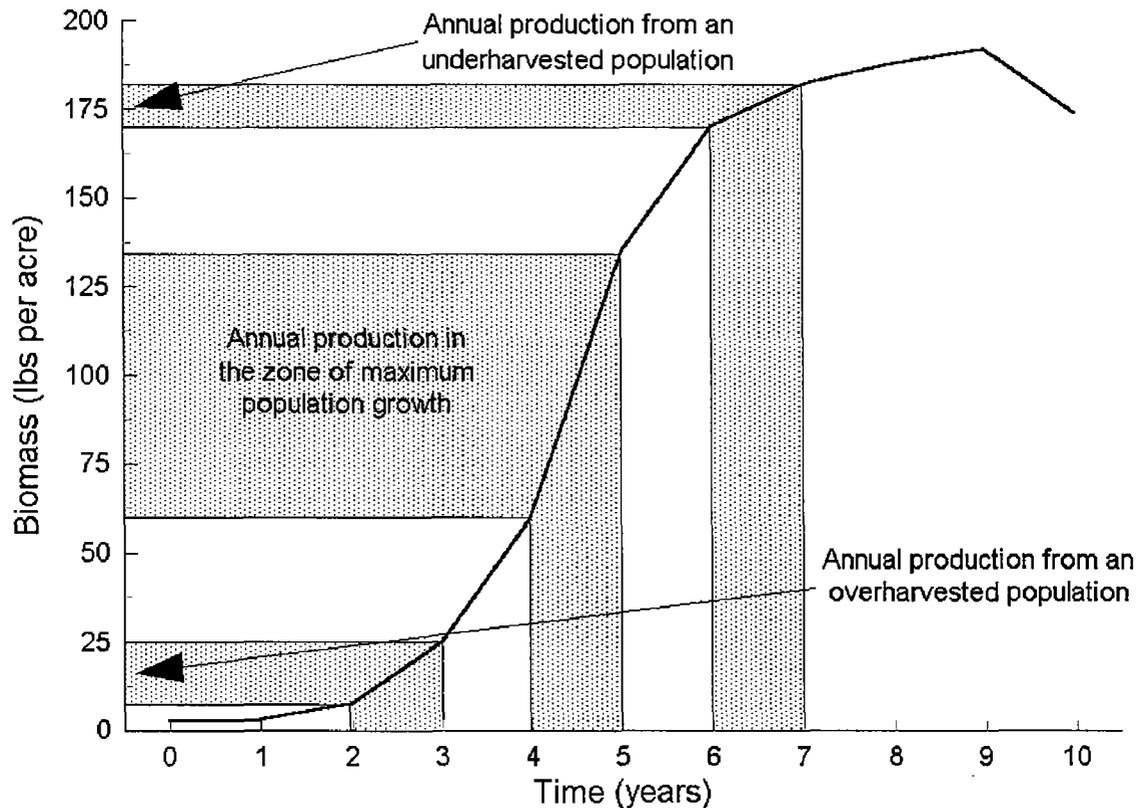


Figure 1. Typical population growth curve over time showing various harvest options.

the curve might be under-harvested. Populations at the top often convert to abundant numbers of fish of small average size. Keep in mind there are differences between fish numbers and total biomass as they apply to the graph. When considering quality of fishing, a strong argument can be made that the best location on the S-curve is the middle, where the curve is steepest and growth is most rapid. When in this area, the fish population has the most potential for increase both in terms of total biomass and individual fish size. The middle portion of the S-curve also falls into traditional fishery management concepts of maintaining a “*harvest-able surplus*” and “*maximum sustained yields*” (Bennett 1971).

In reviewing some examples of Blue Ribbon fisheries and potential Blue Ribbon waters, consider where they fall on the S-curve and the management tools proposed to move these

populations towards the center of the curve. Minersville Reservoir and Kolob Reservoir were near the bottom of the S-curve because of over-harvest. Restrictive fishing regulations were imposed to correct problems and create Blue Ribbon fisheries. Donkey Reservoir, Fish Creek Reservoir, and the Fremont River were at or near the top of the curve, with recommendations made to reduce fish numbers.

Figures 2 and 3 show how populations can naturally fluctuate in regard to carrying capacity and what management implications result from these fluctuations. When a fish population reaches levels near carrying capacity, it does not necessarily stay at that static level. Populations continually adjust to environmental changes. Harsh winter conditions, floods, fires, droughts, or prolonged periods of exceptionally good water conditions all influence and change the carrying capacity. Some environments are more stable than others. Figure 2 shows a relatively stable environment such as a spring creek or tail water below a dam with good year-round base flows. Population fluctuations still occur but do not deviate much from the maximum potential capacity. As noted before, this can be a potential problem if high biomass with little room for

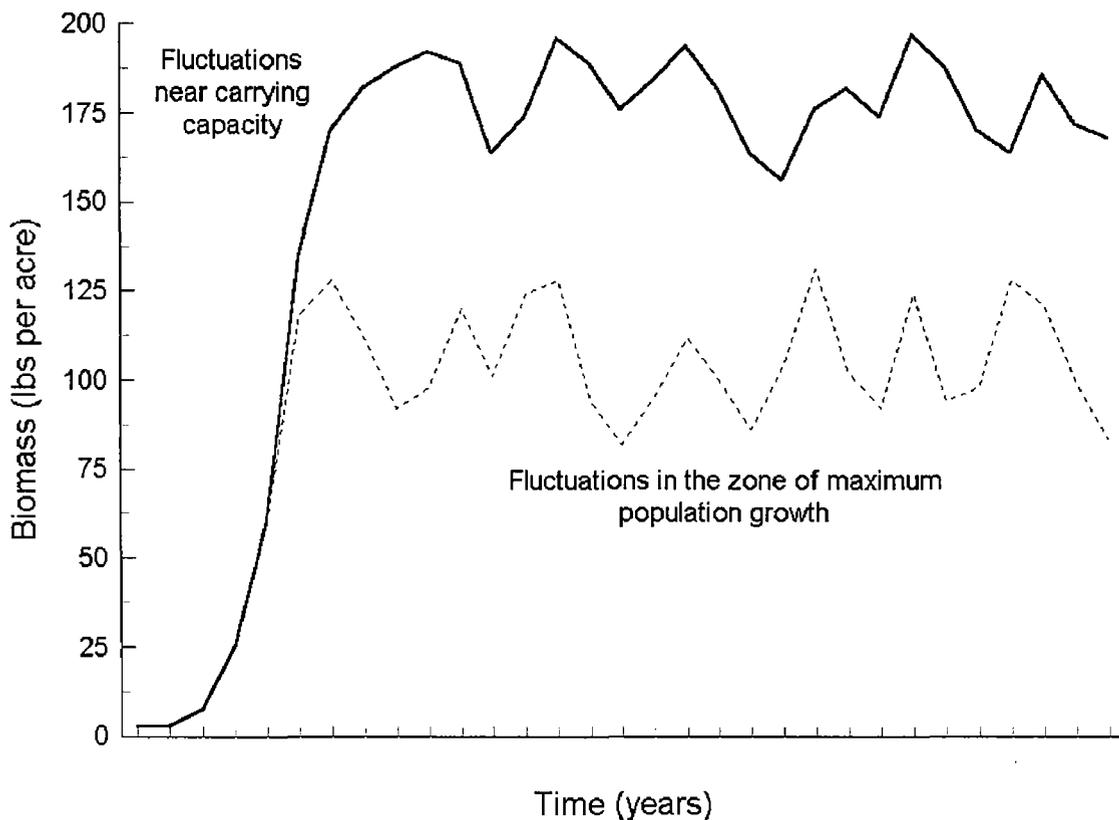


Figure 2. Population fluctuations over time in a relatively stable environment.

growth leads to abundant fish of small average size. In such situations, it might be better to

manage the population at a lower overall total biomass (reduced density), shown by the dotted lines, where production would be higher (the steepest area of the S-curve). In this case, the population and individual fish would continually be trying to grow to a higher level to reach potential carrying capacity.

Figure 3 shows an example of a relatively unstable environment, where population fluctuations are more frequent and fish more easily influenced by environmental changes. The East Fork Sevier River in southern Utah is an example of such a situation. Flash floods, in particular, cause frequent fish losses, followed by periods of recovery. At first, this could be viewed as detrimental and a negative aspect of the overall fishery. Note, however, that even with relatively extreme population fluctuations, most of these occur within the rapid growth portion of the S-curve. We have advised anglers to expect unstable conditions and not be too upset with occasional declines. The other side of this roller coaster ride is exceptional fishing and production of large fish. Periodic “highs” are not continually sustainable, but are the product of circumstances over a period of years that also include and result from periodic “lows.” With a basic understanding of aquatic ecology, both types of environments, as contrasted in Figures 2 and 3, should be enjoyed for what they are and for the variety of fisheries they produce.

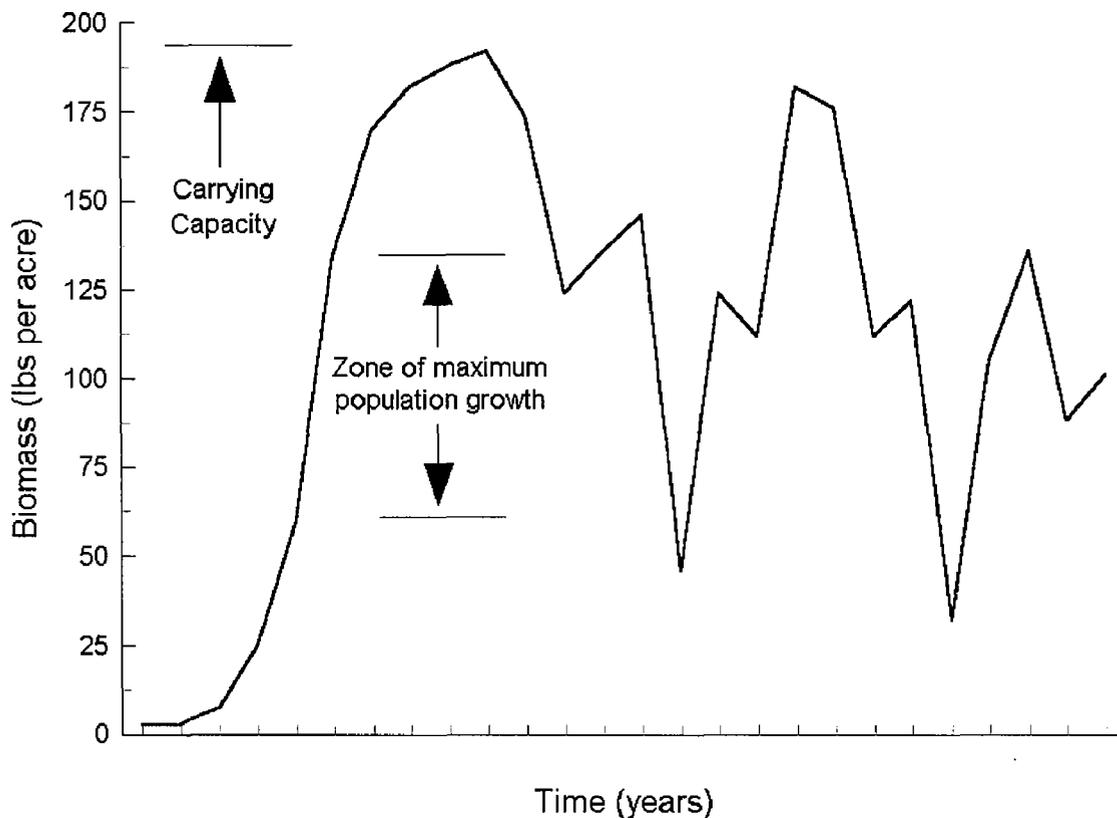


Figure 3. Population fluctuations over time in a relatively unstable environment.

REFERENCES

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monograph 6.

Bennett, G.W. 1971. Management of lakes and ponds. Second Edition. Van Nostrand Reinhold Company, New York.

Lagler, K.F., J.E. Bardach, and R.R. Miller. 1962. Ichthyology. The University of Michigan, Ann Arbor.

Odum, E.P. 1959. Fundamentals of Ecology. Second Edition. W.B. Saunders Company, Philadelphia.

Platts, W.S. and M.L. McHenry. 1988. Density and biomass of trout and char in western streams. U.S. Forest Service General Technical Report INT-241.