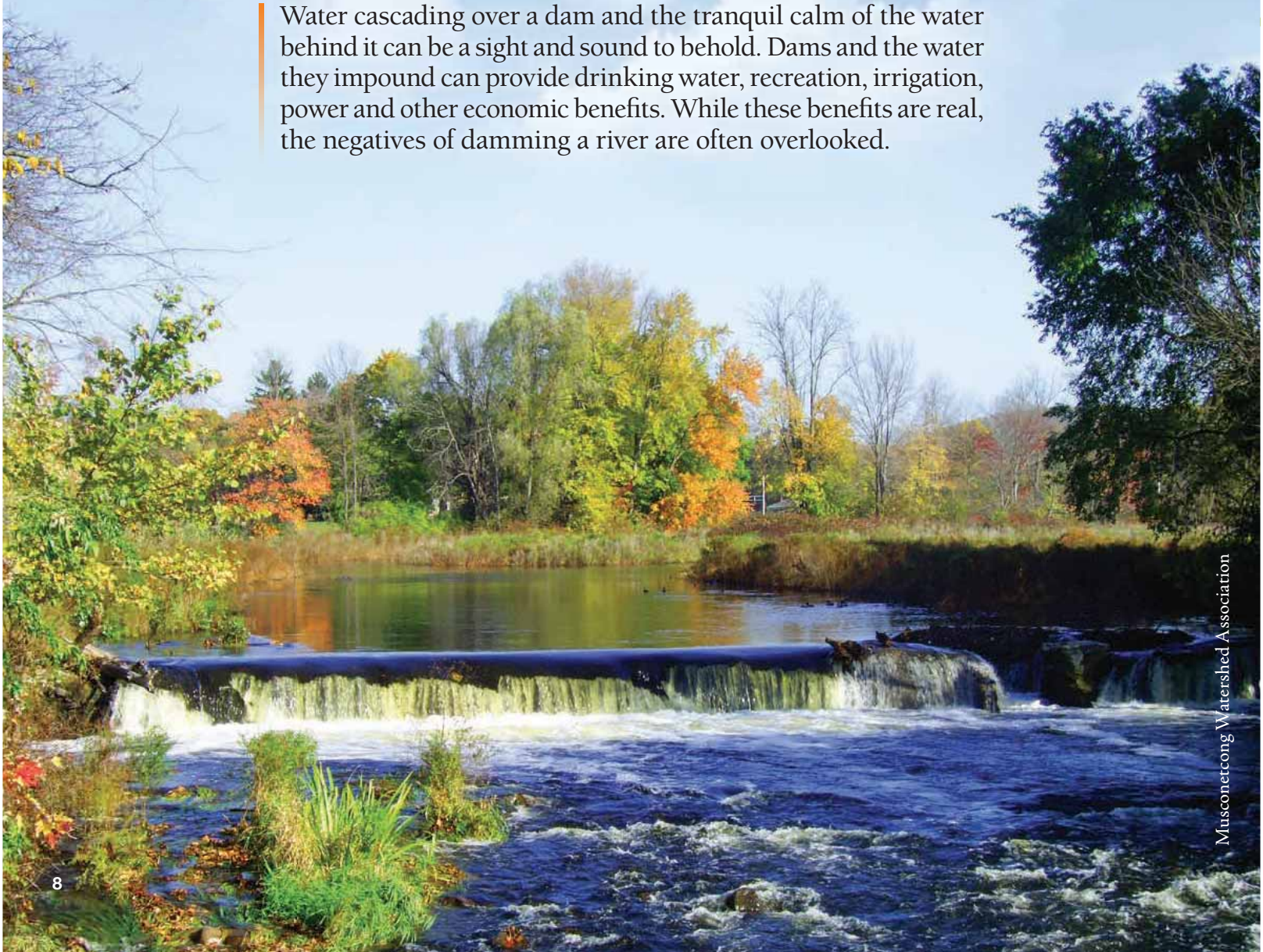
Restoring Free-flowing Rivers

Bringing Down the Dams

By Pat Hamilton, Principal Fisheries Biologist
with Dr. Laura Craig, American Rivers

Water cascading over a dam and the tranquil calm of the water behind it can be a sight and sound to behold. Dams and the water they impound can provide drinking water, recreation, irrigation, power and other economic benefits. While these benefits are real, the negatives of damming a river are often overlooked.



Musconetcong Watershed Association

Lasting Legacy

Rivers and streams once flowed freely in New Jersey, or nearly so, except for blockages caused by beaver dams and fallen trees. The dams initially built by European settlers to power saw mills, forges and grist mills were small and scattered. As manufacturing processes evolved and our population grew, so too did the need to "tame" rivers. As people prospered and new modes of transportation improved their mobility, savvy real estate investors built dams on smaller streams and swamps to create attractive recreational lakes coveted by vacationers and home buyers.

Removal of the Gruendyke Mill Dam on the Musconetcong River in Hackettstown (2008).

There are nearly 1,700 regulated dams in New Jersey (i.e., greater than 5 feet in height or, in the Pinelands, higher than 8 feet) and an untold number of smaller, unregulated dams (<5 feet in height). Regulated dams fall under state jurisdiction, meaning there are laws relating to their construction, repair and inspection. Most of the dams in New Jersey are less than 25 feet high and greater than 50 years old. Many have been impeding the natural flow of our rivers and streams for more than a century. Surprisingly, only a small fraction of New Jersey's dams provide hydropower (<2 percent) or flood control (<6 percent) according to the U.S. Army Corps of Engineers' National Inventory of Dams—yet these functions are the ones that most people associate with dams.

Dams Impact River Ecosystems

Think of a river as a living, dynamic entity. Trickles of water emerging from seeps, springs and swamps unite, giving birth to flowing water in headwater areas of streams and rivers. Though shaped by the forces of this flowing water, our rivers do so much more than simply convey water, as complex biological and physical processes are continuously at work. Dams negatively affect the health of river by:

- Disrupting the natural flow regime and slow the movement of water.
- Impacting water quality such as temperature and dissolved oxygen.
- Altering the transport of sediment, causing abnormal sediment accumulation upstream. Existing plant and animal species may be replaced by those more tolerant of this altered habitat.
- Obstructing fish migration and movement
- Decreasing connectivity, causing fragmentation of the river corridor, isolating aquatic habitats and biotic communities along with floodplains.
- Reducing habitat complexity.

Although dams can be retrofitted with fish ladders to help mitigate fish passage issues, the ladders must be properly designed and maintained, like the one for alewives at Union Lake dam on the Maurice River. Fish ladders are costly to construct and do not alleviate other negative effects from dam.

Benefits of Dam Removal

Dams are a visible reminder that human activities within a watershed can have long-term consequences for a river ecosystem. When dams come down the benefits include:

- **Restore free-flowing conditions**—Allows for recovery of natural riverine processes responsible for creation and maintenance of habitat.
- **Improve water quality**—Seasonal and weather-induced flows, temperatures and oxygen levels return to their natural variations and normally associated flora and fauna.
- **Enhance connectivity for movement of resident and migratory fish**—Pathways for migratory fish species such as American shad, alewife, blueback herring, striped bass, and American eel may be restored.
- **Reconnected floodplains, habitats and aquatic habitats**—When dams come down, upstream and downstream areas within and adjacent to rivers are reconnected.
- **Improve sediment release and transport**—Water flow and turbulence revert to normal, distributing sediment naturally.
- **Enhanced public safety**—Even a properly maintained dam can be a safety hazard, especially for recreational users like anglers and boaters. Removal eradicates the risk of injury, loss of life and property destruction from dam failure.
- **Eliminated maintenance/repair costs**—Over time, dam removal is less expensive.

"Rarely when working in natural systems do we get the opportunity to see such immediate, measurable and permanent results for our efforts."

Beth Styler-Barry,
September 8, 2016, then Executive Director
Musconetcong Watershed Association
Musconetcong.org

Dam Removals Gaining Traction

Our long-standing relationship with dams is beginning to show some cracks. Dam removal was not widely recognized as a means to address unsafe, unwanted or obsolete dams until the mid-to-late 1980s. The first recorded dam removal in New Jersey occurred in 1985 on Hollow Brook near Pottersville.

Only a handful of additional removals occurred between 1985 and the mid-1990s, when the National Park Service removed several dams as part of their agency's plan to "maintain or drain" impoundments. These removals were largely driven by dam safety issues. Since then, dam removal has also become an increasingly popular approach for restoring rivers. According to records compiled by the non-profit organization American Rivers, with the assistance of the New Jersey DEP Bureau of Dam Safety, 34 dams were removed in New Jersey between 1985 and 2015. New Jersey currently ranks 10th among states for the total number of dams removed.

It was not until 2006 that New Jersey saw its first dam removal with the explicit goal of river restoration – the removal of Pursel's Mill Dam on Lopatcong Creek in Phillipsburg. This 8.3-foot high dam was built in 1927 to replace a lock on the defunct Morris Canal and provide water for a working mill owned by Henry Pursel. Over time

Musconetcong River in Hackettstown after Gruendyke Dam removal.

Removal of the Robert Street Dam on the Raritan River (2008) helped clear the way for migrating American shad, striped bass, American eel and river herring.

the dam outlived its original purpose.

Because it had begun to deteriorate and became a liability, the Pursels agreed to remove most of the structure. This dam was the only blockage on Lopatcong Creek; its removal opened 10 miles of new habitat for American eel and other migratory fish species. The open waterway also improved habitat and connectivity for the resident wild trout population. This notable project ushered in the use of dam removals as a tool to restore rivers in New Jersey, bringing together a suite of partners that continue to drive removal projects today.

Partnerships – Getting the Job Done

Not all dams are good candidates for removal, but those that are share several features in common: 1.) the dam no longer serves a purpose, 2.) the owner is facing prohibitively expensive maintenance or repair costs and/or is concerned about public safety and liability associated with the dam, and 3.) the ecological benefits of removal outweigh any advantages to keeping the dam. In situations like these, an owner may choose to work with organizations and agencies interested in bringing down the dam and restoring the river.

In New Jersey, successful dam removal projects are often the result of partnerships between nonprofit organizations, federal and state agencies plus others working together toward the common goal of river restoration. For example, over the past eight years the Musconetcong River Restoration Partnership, led by the Musconetcong Watershed Association, has championed the successful removal of five obsolete dams on this 42-mile-long tributary to the Delaware River including the Seber, Gruendyke Mill, Riegelsville, Finesville and Hughesville dams. The Partnership "… is a superb example of collaborative conservation" remarked Sally Jewell, Secretary of the U.S. Dept. of Interior when she toured New Jersey to observe the breaching of the Hughesville Dam.

The strength of this partnership, and others like it, relies upon participating nonprofit organizations like the Musconetcong Watershed Association, American Rivers, Trout Unlimited, as well as federal and state agencies such as NOAA, US Fish and Wildlife Service, the U.S.D.A.'s Natural Resources Conservation Service, the Army Corps of Engineers and multiple New Jersey DEP programs.

Challenges of Dam Removal

Just as damming a river can be a life-altering event, so too can be its removal. The main considerations for every dam removal project, as compiled by American Rivers and other dam removal experts, include:

- Dam owner concurrence—A willing and cooperative landowner is key.
- Project funding—Dam removal can be expensive; often outside funding must be obtained.
- Sediment and contaminant release—A huge logistical challenge is managing the sudden release of years of sediment and silt built up behind a dam. In free-flowing rivers, this material would have been transported and deposited naturally over time and space.
- Hydrologic effects—Changes such as water elevation, velocity, flooding and more.
- Impacts on plant and animal abundance, diversity—Protection of native/threatened/

endangered species; prevention of exotic plant and animal species from invading upstream areas and impacting native communities.

- Social impacts—Residents may regard the dam beneficial, an iconic part of their local community. Removal can be delayed or derailed by skeptical residents not swayed by the ecological merits of the project, by those resenting outside interference or simply to resist change.
- Cultural preservation—Where historical features are present, often these must be retained to preserve the spirit of a way of life long-since passed.
- Infrastructure impacts—Existing bridges, utilities, etc. can be affected.
- Monitoring—Assess the outcome of a dam removal to determine if goals were achieved.

The Future of Dam Removals

Many dams still remain, a lasting testament to the past when humans dared to tame the forces of water and won. Dam removal can enhance aquatic habitats, help restore plant and wildlife species diversity and abundance, provide recreational and economic opportunities, ensure human safety and reclaim the natural function of a river.

Successful Dam Removals (2006 – 2016)

Raritan River

Calco Diffusion Weir Dam - removed 2011
(3.2 ft. high by 245 ft. wide)

Roberts Street Dam - removed 2012
(6.5 ft. high by 255 ft. wide)

Nevius Street Dam - removed 2013
(3.5 ft. high by 195 ft. wide)

Musconetcong River

Hughesville Dam - removed 2016
(18 ft. high by 150 ft. wide)

Riegelsville Dam – dam remnants removed 2011

Finesville Dam - removed 2011 (9 ft. high by 109 ft. wide)

Seber Dam - removed 2009 (4 ft. high by 100 ft. wide)

Gruedyke Mill Dam – removed 2008
(7 ft. high by 150 ft. wide)

Hakihokake Creek (Milford Brook)

Milford Dam – removed 2012 (8 ft. high by 80 ft. long)

Lopatcong Creek

Pursel's Mill Dam - removed 2006
(8.3 ft. high by 85 ft. wide)

The Truth About Hooks & Lures

By Scott Collenburg, Fisheries Biologist

The prevalence of catch-and-release fishing among today's anglers—coupled with increased restoration efforts for struggling species such as trout—has renewed some age-old debates about hooks and lures.

In the realm of fishing, facts on which hook types are the most ethical (barbed versus barbless, treble versus single) and which hooks will have minimal impact— from the fishes perspective—have been debated since the 1930's when Fred Westerman, while Chief of Fisheries for the Michigan Department of Conservation, conducted one of the earliest studies. Over 80 years and numerous studies later, the dispute about hooking mortality continues.

Conservative approaches to managing fisheries resources have been implemented over time in an effort to protect vulnerable species such as trout. Knowledge of what practices are most effective is essential. In New Jersey Division of Fish and Wildlife's 2012 trout angler survey, 64 percent of trout angler respondents indicated they released most, or all, trout caught—an 11 percent increase from 2003 when the same question was asked. In a 2016 online survey of anglers who fish for wild trout, 74 percent either moderately, or strongly, supported catch-and-release-only regulations on wild trout streams.

When the conservative catch-and-release approach spread among anglers, so did an increased interest in restricting the use of specific gear types. As a result, requests for regulations implementing barbless hook restrictions, banning of treble hooks or banning bait have increased steadily in recent years. The ultimate success of catch-and-release angling (either by regulation or by angler choice) undoubtedly rests with ensuring high survival rates of the released fish.

Scientist, Neil deGrasse Tyson once stated, "The good thing about science is that it's true whether or not you believe in it." But what if the science isn't so clear? Like an angler in a stream, let's wade through the myriad of—often contradictory— scientific literature about hooking mortality.

Do barbless hooks cause more mortality than barbed hooks? Are treble hooks more dangerous to fish than single hooks? Are timing restrictions beneficial such as no wading or fishing during spawning?

Hooks: Barbed vs. Barbless

Fish mortality from barbed versus barbless hooks seems intuitive. No barb makes removing a hook easier. There's less stress and, naturally, less mortality, right? Surprisingly, no. A majority of scientific studies on trout, a species intolerant of any level of mishandling, have shown that mortality from either barbed or barbless hooks is not significantly different (Mongillo 1984; Schill and Scarpella 1997; Dubois and Dubielzig 2004; Dubois and Pleski 2007.)* This suggests there is scant biological basis for restricting barbed hooks.

Since unhooking a fish is easier when no barbs are used, why don't more studies reveal a higher mortality with the longer handling time using barbed hooks? Dubois and Dubielzig (2004) explain that "…barbless single hooks were quicker to remove than other hooks, but the difference was insufficient to reduce mortality."

In fact, handling time is taken into account in each of these studies. Post-release mortality is often monitored by retaining fish for a 48-hour period after being caught. Still, in many cases, no mortality difference is documented between barbed or barbless hooks. Some studies suggest that a barbless hook causes higher mortality through what is called the "stiletto effect," where single hooks tend to penetrate deeper (Behnke et al 2007).

In addition, researchers have theorized that even if a difference in hooking mortality is documented, the effect on the overall population is negligible because natural mortality rates for wild trout are so much higher, commonly ranging from 30 percent to 65 percent of the population annually. Although research indicates little protection is afforded to trout populations through the use of barbless hooks from the mortality aspect, two studies do document a decreased rate of injury with their use. (DuBois and Dubielzig 2004; DuBois and Pleski 2007).

Contrary to research results there is strong social support among New Jersey wild trout anglers for implementing barbless hook restrictions. In Fish and Wildlife's 2016 online wild trout survey, anglers were asked if they support or oppose a barbless hook-only restriction. Results: 68 percent either strongly or moderately supported such a restriction. This would not come without cost. Bloom (2013) documented a 13 percent decreased angler efficiency in landing trout using barbless hooks. (Mean capture efficiency of 76 percent for anglers using barbed flies vs. 63 percent using barbless flies.)

Only marginal benefits of reduced injury to individual fish were realized using barbless hooks. Overall, requiring the use of barbless hooks is not beneficial to trout populations and can reduce angler catch rates. In the end, with the lack of strong scientific support, the best option may be to let anglers continue to decide for themselves.

Hooks: Single vs. Treble

The safety of single versus treble hooks is about as straightforward as it gets. The logic is simple: more

hooks, more injury, therefore increased mortality, right? Again, not true. On treble hooks, research is just as conclusive as the barbed vs. barbless question. However, deviations exist when we delve into variables related to size of fish and temperature.

The data is based on two major scientific papers which reviewed multiple studies; Taylor and White (1992, review of 18 hooking studies); and a review by Mongillo (1984). Both concluded that the number of hooks did not show a statistically significant relationship to hooking mortality. Mongillo (1984) concluded that little justification exists for gear restrictions for artificials and data even indicates that the practice of using single hooks on lures may actually cause higher mortality than treble hooks.

A study by Titus and Vanicek (1988) also found no significant difference with mortality (using either gear type) at less than 1.5 percent when water temperatures were low. Surprisingly, when temperatures were higher, single barbless hooks actually caused the highest mortality (59 percent).

A more recent study by DuBois and Dubielzig (2004) also demonstrated that hook types did not differ statistically in causing mortality. A higher mortality rate from treble hooks was documented with larger trout. Larger fish have a larger gape enabling them to fully engulf a treble hook (Nuhfer and Alexander 1992). However, many investigators fail to discover this relationship because test fish, like many of our wild trout, are typically small, less than 12 inches.

Interestingly, the inverse relationship is sometimes found with smaller salmonids, where single hooks are found to be more lethal than treble hooks (Klein 1965; Warner 1976). This was a result of treble hooks being more difficult to engulf for smaller salmonids.

Research shows little justification to restrict treble hooks based on fish mortality although one study reviewed by Dubois and Dubeilzig (2004) documented a significantly greater rate of jaw injury in brown trout using treble hooks with spinners than with other hook types. No differences were evident with rainbow trout nor when assessing serious injuries to eyes or gullet. It should be noted that the study design could not determine if jaw injuries occurred from previous capture events, an inherent problem with this type of research.

While treble hooks pose no greater impact to trout populations than single hooks and can even be beneficial with larger fish, there is evidence of increased jaw injury. Although the injury may not result in mortality because of the prevalence of catch-and-release, is it in the best interest of the resource for measures to be taken to reduce injury? Anglers may think so as 77 percent of New Jersey wild trout anglers responded that they strongly or moderately opposed the use of treble hooks in wild trout streams.

Bait, Lures and Flies

The use of bait causes significantly higher mortality than the use of artificial lures or flies and can

be expected to range from 20-50 percent of fish caught on bait (Mongillo, 1984). Many studies have reached the same conclusion. For comparison, Mongillo concluded that all artificials induce a mortality of less than 10 percent, results consistent with other literature (Taylor and White 1992).

Recent research suggests baitfishing mortality is lower than the earlier studies of the 60s, 70s and 80s indicate. Schill (1996) documented only 16 percent baitfishing mortality of wild rainbow trout. Lower still, DuBois and Kuklinski (2004) found that when using an active baitfishing technique, mortality was no higher than 7 percent. The hook type and technique employed by the individual angler may be responsible.

A study by High and Meyer (2014) found that using baited circle hooks caused only 7 percent mortality in trout, compared with dry flies at 4 percent and treble hook spinners at 29 percent. It is important to note that the treble hook mortality rate seen in this study was much higher than those seen in single- versus multiple-hook studies. They suggest the use of circle hooks instead of J-hooks when baitfishing to reduce deep-hooking and mortality.

A practice that may be common among catch-and-release anglers using bait is the use of barbless hooks, again, to reduce effects of deep hooking. Schill and Scarpella (1997) noted there may be merit to using barbless hooks when fishing with bait but this is based on only two trials in the study by Fred Westerman in 1932.

There is significant variation between study conclusions on mortality from baitfishing, but in most cases lures and flies are the safest for trout. When using bait, anglers should employ methods that help reduce mortality including the use of circle hooks plus active fishing rather than a passive technique.

Timing Restrictions

In some states, closures during trout spawning season are utilized to protect redds and to avoid further strain on trout already stressed due to spawning activities. Few such studies have been conducted due to the ethical dilemma of deliberately destroying trout redds for research purposes. However, as shown by Robert and White (1992), damage done by anglers wading through redds is a valid concern in areas that receive significant fishing pressure. Evidently, twice-daily wading (very heavy wading in a controlled, man-made channel) throughout the egg development period destroyed up to 96 percent of eggs and pre-emergent fry. Even a single wading just prior to hatching destroyed 43 percent of eggs. In areas where spawning habitat is limited and intensive angler wading occurs, restrictions on wading would appear well-justified.

Another study by Kelly (1993) found that wading-related mortality—in a natural environment, documented by anglers—of Yellowstone cutthroat trout ranged from less than 10 to 26 percent for eggs and pre-emergent fry. Kelly (1993) indicates that in a stable population where less than 1 percent of trout survive from egg to spawning adult anyway, wading-related mortality would not affect the population.

In fisheries that receive a significant amount of fishing pressure, restrictions during spawning may be beneficial. For healthy populations where only moderate fishing pressure occurs, negative effect of wading or fishing during spawning times appears to be negligible. Perhaps of greater concern is mid- to late-summer fishing pressure because the already-increased stress of higher temperatures and low flows are documented to cause high mortality (Titus and Vanicek 1988). As a result, some states have seasonal closures to protect specific fisheries during these times.

Conclusion

While specific gear types—aside from the use of bait—may have little effect on survival of released fish, an angler's technique can be significant. Regulations aside, the following angler practices have been shown to reduce fish mortality:

- Keep handy at all times a small pair of pliers or forceps for quick and efficient hook removal.
- Reduce play time. Land fish as quickly as possible to minimize stressing the fish. Extended play time can exhaust the fish causing sub-lethal stress, reducing growth, impairing reproductive success and increasing susceptibility to disease or pathogens (Casselman, 2005).
- Keep the fish in the water as much as possible; minimize handling.
- Avoid fishing during very hot temperatures. Multiple studies have shown increased mortality under such conditions regardless of gear used.
- For an engulfed hook that's deeply imbedded, cut the line and leave the hook. Numerous studies demonstrate that fish have the ability to shed the hook. For example, Mason and Hunt (1967) examined the effect of hook removal on the survival of rainbow trout up to four months after release. Fish released without hook removal had a 66 percent survival rate while only 11.5 percent of fish whose hooks were removed survived. Of those that survived with hooks left in place, more than half had shed the hooks.

When choosing bait:

- Actively fishing the bait—instead of passive fishing—decreases the chance the fish will engulf the hook.
- Use circle hooks. Although variation is seen among species, Cooke and Suski (2004) found that using circle hooks reduced mortality by about 50 percent.

***Literature citations are available with this article's online version at http://www.njfishandwildlife.com/pdf/fwfisheries/hooksandlures.pdf.**

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