

Catch and Release Fishing Effectiveness and Mortality

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Abstract

Recent studies have measured the effects of various tackle and fishing techniques on fish mortality and offer insights for optimization of the protective aspects of catch and release fishing programs. The study data suggests that with the application of specific tackle types and selected fishing and handling techniques, the success of catch and release programs can be significantly improved. Recent data links the causes of catch and release angling mortality to all types of gear and techniques that increase the chances of 'deep-hooking' and elevated physiological stress. It is shown here that if a selection of fishery specific, mortality reducing techniques are applied, via angler education and fishing regulations, the conservation benefits of catch and release fishing can be optimized.

Introduction

Almost all of the United States' coastal and freshwater fisheries are routinely accessed by sport fishermen. Sport fishing is an enormous economic factor in the United States, bringing significant revenues to regions with attractive fisheries. Remote regions often generate the greatest interest among anglers and consequently receive the greatest proportional localized economic benefits. It is estimated that over 44 million Americans fish for sport. Anglers spend upwards of \$41 billion dollars yearly, directly on fishing¹. They generate over \$116 billion dollars in associated economic activity¹. The need to maintain these economically important fisheries and to protect the natural environments that make them possible has resulted in the evolution of highly effective conservation programs.

Typically, regional fisheries permit a controlled and selective harvest of targeted fish species. Seasonal regulations, size limits, bag limits and slot limits, together with catch and release techniques are used to reduce environmental impact and to maintain a healthy fishery with adequate brood stock for population maintenance. The U.S. federal government and all state governments maintain conservation agencies for the purpose of developing, studying, implementing and enforcing conservation programs. These government agencies are supported primarily by license fees paid by fishermen and contributions from interested non-governmental organizations².

Catch and release fishing is widely used as an aquatic conservation and environmental protection mechanism for preservation of fish fauna. The efficacy of catch and release fishing has been studied for nearly a half century. Because of the variability in techniques used in both the angling (catch) phase and the handling (release) phase of the typical fishing process, a range of conservation success has been achieved by these programs

In the first half of the 20th century, observation was the historical method used to justify the catch and release concept. Fish were caught, unhooked, and then observed to swim away. By the mid-twentieth century, however, the United States' population had significantly increased, and both citizenry and government became increasingly aware of the cost of environmental degradation of all types, caused not only by lack of protection but by simple growing population pressure. In the years since, as the need to protect the environment, and the economic value of sport fishing, became more apparent, the need to accurately determine catch and release fishing's actual effect on fish mortality has increased. As a result, a rigorous scientific approach is now used to study catch and release fishing and the effects of its different methodologies. These studies have been performed in a wide range of environments and on many fish species.

The long term use of catch and release fishing in observed fisheries has provided a significant amount of data documenting its efficacy as a tool for the minimization of environmental impact. Recent studies have provided additional insights into the effects of various tackle and techniques as a means to reduce fish mortality. By using the information obtained from these studies, programs can be designed to minimize environmental impact and fish mortality caused by human activity.

Methods Used in Catch and Release Mortality Rate Studies

Researchers rely on a variety of methods to determine the effectiveness of catch and release programs and techniques. Modern technology has enabled the creation of more accurate and reliable experimental designs. Depending on the physical attributes of the fishery, access to equipment, and manpower considerations, one or more of the following techniques are commonly used to measure catch and release mortality:

External tanks – Angled fish are marked (by tags or tail clips) to identify the catch circumstances, hook and hooking type, and ambient conditions. They are then transferred to an external holding tank and observed for a pre-defined time period. In some studies, a control group caught by other methods (electroshock or netting) may be used to eliminate baseline mortality caused by restraining fish in a tank^{3,4}.

In-water Pens – Similar to external tanks, this method uses cages constructed within the fish's source environment, perhaps reducing baseline mortality caused by restraint. Angled fish are examined, categorized and transferred into pens^{5,6}.

Telemetry – This method uses small, radio-emitting tags to track released fish. Angled fish are tagged and released into their environment. Researchers use radio tracking devices to follow and observe the released fish for an extended period. A control group to account for baseline mortality of the fish in their natural environment or statistical analysis to address the failure rate of the tracking devices may be used^{7,8,9}.

Observation in small or isolated fisheries – Where conditions are appropriate, an accurate determination of catch and release mortality can be made by studying fish released back into their natural environment and utilizing human observation to determine the aftereffects of catch and release fishing. Researchers may use small ponds or areas with natural barriers. This technique can be aided by observation-enabling devices. This technique is sometimes used opportunistically during seasonal or migratory life-cycle events^{10,8}.

Combined Techniques – To meet the often challenging conditions encountered in wilderness areas, combinations of these techniques may be used. For example, in a study by Thorstad, *et al*⁹, on the River Alta in northern Norway, radio telemetry and helicopter observation were used to count fish in individual spawning redds, concentrated in a small spawning area. This experimental construct opportunistically took advantage of both situational and technological aids.

Key Mortality Factors

Two factors predominate when considering the causes of angled fish mortality: the hooking location, and the degree of physiological stress suffered by the fish.

Hooking location – This factor demonstrates the largest source of variation in mortality observed in the studies and experiments reviewed. It is consistently shown that deep-hooking (hooking in the gills or gullet) causes relatively high mortality, up to 35% when accompanied by bleeding, whereas normal hooking (lips or jaw area) consistently causes minimal mortality, which is consistently less than 5% and often less than 1%. The Maryland Department of Natural Resources, in its Recreational Catch and Release Mortality research program concludes that the location of the hook wound is the single most important factor influencing catch and release mortality⁴. If the hook wound affects a vital organ, mortality, is high. The location of the wound site has been demonstrated to be a function of hook size, type, the use of natural bait versus artificial lures and additional situational factors. Studies show that when fish are hooked in the lips or jaw area (shallow hooked), mortality is negligible, typically less than 1%^{4,5}. Conversely, mortality is at its highest when fish are hooked in the esophagus or gills (deep hooked)^{5,11}. Necropsies performed on gut hooked fish in a study by⁵ Grover, et al, found that the majority had sustained major internal damage to the heart, stomach or liver. Grover demonstrates that hooking location effectively correlates to mortality rate.

Physiological Stress – Exercise performed by fish during a catch event, or caused by angler handling methods and air exposure all create measurable physiological responses. Physiological stress in fish has been measured by experimenters using cortisol, lactate and respiratory gas concentrations.

Although the catch and release mortality studies reviewed do not show statistical results directly correlating the degree of physiological stress to mortality, an experiment by Ferguson and Tufts examined the effects of artificially induced stress on rainbow trout. They concluded that various forms of physiological stress contribute to fish mortality¹². It is reasonable to infer that such stress also contributes to mortality in angled fish and therefore, that minimization of stress assists in reduction of catch and release mortality.

Results

Mortality studies without consideration of optimized techniques

Table 1 summarizes the range of results obtained in studies examining the mortality rates of catch and release fishing without considered the use of optimized tackle or techniques. Statistics were gathered from a wide range of study types, fish species and environments. It can be noted that many of the studies used a varied catching and handling techniques.

Table 1
Summary of Results of Catch and Release Mortality Studies
 (Without Consideration of Optimized Techniques)

Study #	Species	Study Type	Environment	Mortality	Notes
5	Tautog	pens	Ocean	1.70%	Mostly baited hooks
7	Billfish	telemetry	Ocean	1.00%	All techniques
1	Walleye	tanks	Lake	1.00%	Artificial lures
8	Tarpon	telemetry	Inshore	4.00%	Various
4	Shad	tanks	river	1.00%	Lures only
4	White Perch	tanks	river	0.20%	Baited lures
4	Yellow perch	tanks	river	2.90%	Bait
10	LM Bass	test ponds	ponds	5.80%	Baited hooks
8	Bonefish	Isolation	inshore	4.00%	All techniques
8	Snook	Isolation	Inshore	2.00%	All techniques
8	Seatrout	Isolation	Inshore	5.00%	All techniques
6	Striped bass	pens	Inshore	4.30%	Baited hooks
9	Salmon	telemetry	river	3.00%	Fly
Average Mortality =				2.76%	

The study results presented here represent a mixture of recent international, national U.S, and regional state studies. While the environmental factors in these studies vary and demonstrate differing results, the mortality data nonetheless fall into a relatively narrow, low range.

Mortality studies considering potential optimization techniques

Sport fishing anglers use a wide range of tackle and techniques to catch and release fish. An analysis of corresponding data indicates that catch and release efficacy and mortality are strongly affected by the techniques used in its application. The studies discussed here were those that examined variables that are applicable to a wide variety of species and fishing situations. Studies examining other variables, such as water temperature differential, water depth differential and ambient air temperature, although extremely important in certain specialized applications, are narrower in their applicability. In the specialized applications where these parameters are important, their optimization can further contribute to catch and release mortality reduction.

The experimental constructs used in the studies examined vary in their approach to tackle and technique comparisons; therefore, the data is compiled in separate tables to accommodate the format in which results are expressed. The following tables display key variables that have significant statistical or observed impact as measured by mortality, hooking depth or physiological stress;

Table 2 compares the catch and release efficacy of hook types, hooking depth, bait types and release techniques by measuring the effects of their use on the mortality rates of released fish. Data are expressed either in numerical percentage or by the author's observational description. The mortality reduction factor is expressed either as the numerical ratio between the results of the variables compared or simply expressed as a positive or negative effect on fish survival in the observed descriptions.

Table 2
Effects of Varying Tackle and Fishing Techniques on Mortality

Study #	Study Species	Study Variable	Raw data type	Non-Optimal Type	% Mort.	Optimized Type	% Mort.	Mortality Reduction Factor
6	S. Bass	Hook type	Mortality	"J" Hook	9.10	Circle hook	0.80	11.3
10	LM. Bass	Hook type	Mortality	"J" Hook	6.60	Circle hook	5.10	1.3
8	Various	Hook type	Mortality	"J" Hook	High	Circle hook	Low	Positive
4	Y. Perch	Hook depth	Mortality	Deep	35.70	Shallow	1.00	35.7
5	Tuna	Hook depth	Mortality	Deep	High	Shallow	Low	Positive
13	LM. Bass	Bait type	Mortality	Natural bait	High	Artificial lures	Low	Positive
11	Various	Bait type	Mortality	Natural bait	31.40	Artificial lures	4.35	7.2
3	Walleye	Bait type	Mortality	Natural bait	High	Artificial lures	Low	Positive
5	Halibut	Release	Mortality	Careless	2.50	Careful	1.00	2.5

The results shown in Table 2 demonstrate that the use of specific tackle types and fishing techniques can significantly reduce the mortality of catch and release fishing. The mortality rate when using optimal tackle or technique is, in all cases consistently lower than the non-optimized alternatives.

Table 3 compares the effects of hook and bait type on whether a fish is hooked in either a “deep” or “shallow” manner. The data from these studies are based on previously established results that demonstrate that deep hooking is more likely to cause mortality than shallow hooking. In the studies, fish were examined for the location of hook wounds and released. Mortality was not measured directly. Data are expressed either in the numerical percentage of fish deep or shallow hooked or by the authors observational description.

Table 3
Effects of Varying Tackle and Techniques on Hooking Depth

Study #	Species	Study Variable	Raw data type	Non-Optimal Type	% Deep Hooked	Optimized Type	% Deep Hooked	Depth Reduction Factor
5	Tuna	Hook type	Hook depth	"J" hook	32.00	Circle hook	4.00	8.0
5	Billfish	Hook type	Hook depth	"J" hook	46.00	Circle hook	1.00	46.0
5	Flounder	Hook type	Hook depth	"J" hook	15.60	Circle hook	4.70	3.3
8	Various	Bait type	Hook depth	Natural	High	Artificial	Low	Positive

In all cases, studies showed that the use of a “circle hook” rather than a “J” hook, or the use of “artificial” rather than “natural” bait resulted in a significant reduction in deep hooking. It can therefore be inferred that requiring the use of “circle hooks” with natural baits, or using “artificial” baits in a catch and release program would result in increased fish survival¹⁶.

Table 4 summarizes the effects of handling time, use of resuscitation, air exposure and playing time (the time spent landing the fish) on fish physiological stress. The data from these studies are based on previously established results that demonstrate that various forms of increased physiological stress contribute to fish mortality. Data are expressed by the author’s determination of higher or lower physiological stress.

Table 4
Effect of Varying Tackle and Techniques on Physiological Stress

Study #	Species	Study Variable	Data type	Non-Optimal Type	Stress Amount	Optimized Type	Stress Amount	Stress Reduction Factor
5	S. Bass	Time handled	Stress	More time	Higher	Less time	Lower	Positive
5	Pelagics	Resuscitation	Stress	None	Higher	Provided	Lower	Positive
9	Salmon	Air exposure	Stress	Long	Higher	Short	Lower	Positive
12	Trout	Playing time	Stress	Long	Higher	Short	Lower	Positive

The results of these studies indicate that less time handled, exposed to air and played before landing results in reduced physiological stress to fish. Additionally, time used for resuscitation prior to release resulted in lower fish stress.

Discussion of Optimization Techniques

The use of specific tackle and technique parameters can directly reduce mortality, as previously demonstrated. The following presents a more detailed discussion of their actions on critical physiological aspects of catch and release fishing.

1. Bait Type – Sport fish are generally caught using either natural or artificial baits. Several studies compare mortality rates between these two catch methods^{13,11,3,8}. In each case, without considering hook type, it was reported that artificial baits (lures or flies) significantly reduced both the incidence of deep hooking and the rate of fish mortality. The low mortality associated with artificial lures is probably the result of their active motion, increasing the likelihood that fish are hooked immediately on contact in the lips or jaws and avoiding deep hooking injuries⁶. This information suggests that, where applicable, (not all species can be caught with artificial baits), using artificial baits rather than natural baits can significantly reduce mortality.

2. Hook Type – For certain types of fish, natural bait is a requirement for capture. The data reviewed show that the type of hook used can dramatically reduce the likelihood of deep hooking and lethal injury with natural bait. Use of the traditional “J” hook, shaped like the letter “J”, demonstrates a significantly higher risk of lethal injury than the recently adopted “circle” type hook. A white paper recently issued by



the Atlantic States Marine Fisheries Commission¹⁴, provides detailed analysis and comparisons of hooks and recommends the use of circle hooks to minimize fish injury. Circle hooks, because of their recurved point, are unlikely to penetrate a fish until they lodge in the corner of the jaw, thus greatly increasing the likelihood of safe, shallow hooking and rarely result in deep hooking^{6,10,8,5,13,11,3}.



3. Degree of exhaustion of fish – Although studies show that all measurable physiological effects of sublethal stress as a result of being caught are fully reversed within approximately 24 hours¹², it is reasonable to infer that fish played to exhaustion may suffer more serious stress than fish that are relatively rapidly landed⁹. Therefore, rapid landing is safer and less likely to result in complications affecting survival after release. Strong tackle and heavy lines allow fish to be landed rapidly, avoiding exhaustion and minimizing extreme exercise and the possibility of negative stress effects. It can, therefore, be inferred that the use of heavy tackle is desirable in lowering mortality. Conversely, extremely light tackle and lower strength lines may increase the risk of exhaustion, and should be avoided.

4. Time spent out of water – Studies show that the longer the length of time that fish are removed from the water, the greater the measurable effects in the fish’s short-term biochemical profile. Increases are seen in the physiological indicators of stress (increased blood cortisol and lactate concentration) and the direct gas exchange measurements (carbon dioxide retention and lowered oxygen tension). Smaller fish have been shown to have significantly lower anaerobic resiliency than larger fish¹². These results demonstrate that minimizing time spent out of water, minimizes the risk of mortality, especially in smaller fish.

5. Landing technique – Fishermen have traditionally used various types of nets to “land” or secure a fish at the boat and to finalize the “catch”. Nets can cause a variety of injuries and tend to greatly increase the time required to release a caught fish. Depending on the type of material, nets can inflict varying degrees of damage to a fish’s sensitive fins, gills, slime coat and scales. Exposed hooks tend to snag in nets often exacerbating the time needed to remove hooks and release fish. The use of an alternative landing method, such as a Boga-grip tool can eliminate these hazards. The Boga-grip utilizes a pair of blunt jaws that can encompass the bony jaw edge or the fleshy area in the corner of a fish’s mouth without puncturing or applying pressure to the area. The tool’s rotatable component eliminates torque and an internal shock absorber dampens motion to help prevent injury to restrained fish¹⁵.

6. Handling – Simple observation as well as experimental results indicate that minimized handling will reduce the probability of additional post-catch stress, the likelihood of physical injury to fish due to struggling and loss of body slime. The use of purpose-designed unhooking devices and handling tools that are designed to hold fish without physical damage and enable quick release, such as the Boga-grip dramatically reduces the amount of handling necessary prior to release¹⁵.

7. Method of release – Haphazard release of fish after capture has been shown to be an additional source of stress. Fish should be released in safe (reduced predator access), low stress (minimal current), recovery areas. Prior to release, fish displaying any signs of exhaustion or stress can be effectively resuscitated by holding the fish (using a Boga-grip to prevent injury) with its head pointing into the current. If no current is present, fish may be moved in a figure-8 pattern. Fish can be observed rapidly recovering from the effects of exercise and stress. Upon demonstrating stable equilibrium and strong swimming ability, fish are released. Safe, low stress recovery areas (minimal current and protection against predation) further afford released fish adequate time to recover their strength without requiring further exercise against adverse water conditions while simultaneously isolating fish from potential predators.

Boga-grip Tool



Conclusions

Eight potential optimization techniques were assessed. Each of them demonstrated a positive effect on reducing mortality in catch and release fishing. If one or more of these techniques are applied, either by education or legislation, to a catch and release program, it can be inferred that significant reductions in fish mortality can be realized. Although it cannot be assumed that applying more than one technique will necessarily yield proportionately greater reductions, it can readily be extrapolated that some further improvement can occur with each incremental optimization of tackle or technique.

It may therefore be concluded, that a catch and release program, designed to utilize those parameters applicable to a particular fish, fishery or region, can provide a significant reduction in mortality. Real-world, empirical testing is indicated to test and determine actual performance improvements attainable by such programs. More knowledge is needed in this area to help further the efficacy of catch and release programs and their use as fishery management tools. Such information is also needed to educate conscientious anglers in the best ways to catch, handle and release fish.

A review of the current literature and an assessment of available statistics indicate that relatively low levels of fish mortality are associated with catch and release fishing. . Scientific evidence further indicates that the use of selected optimized tackle and techniques can then further reduce catch and release mortality rates. A variety of tackle and technique options are applicable to individual regions and gamefish species, allowing the design of mortality reducing programs appropriate to specific fisheries.

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