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Importance of Assessing Population-Level Impact of Catch-and-Release Mortality

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Importance of Assessing Population-Level Impact of Catch-and-Release Mortality

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Many studies have measured the mortality of fish that are recreationally caught and released (i.e., catch-and-release [CR] mortality); however, little work has explored methods to understand the cumulative impact of CR mortality on fish stocks. Despite considerable examination of biological, ethical, and practical aspects of CR fisheries (Arlinghaus et al. 2007, 2012; Cooke and Schramm 2007), little research has evaluated the cumulative effects of the different sources of mortality on recreational fisheries. The purpose of this essay is to provide a brief discussion of the different components of mortality for fisheries with high rates of CR and the possible cumulative impacts of CR mortality on the quality of these fisheries. We demonstrate the need for studies that evaluate the impacts of CR mortality on fish stocks and estimate the fishing mortality rates associated with CR (F_{cr}).

Future research needs to move past estimating CR mortality to developing more intensive field studies to measure F_{cr} for a wide range of fisheries.

COMPONENTS OF FISH MORTALITY

The instantaneous total mortality (Z) of a fished population is described by the equation

$$Z=F+M$$

where F is the instantaneous fishing mortality and M is the instantaneous natural mortality. Fishing mortality is the rate at which fish are removed from a population due to fishing. Natural mortality is the rate at which individuals are lost from a population due to natural causes (i.e., predation, senescence, or disease). Components of fishing mortality include harvest and deaths of fish that are caught and released (e.g., CR mortality from either immediate or delayed release of caught fish). To account for these components, the above equation can be expanded to

$$Z=F_h+ F_{cr}+M$$

where F_h is the instantaneous fishing mortality rate from harvest and F_{cr} is the instantaneous fishing mortality rate via CR mortality. Fishing mortality from harvest is one of the most commonly estimated parameters in fisheries investigations via tagging studies, stock assessment models, and other approaches. It is important to make the distinction between F_{cr} and CR mortality: F_{cr} is the instantaneous fishing mortality rate resulting from CR mortality, whereas CR mortality is the proportion of individuals that die after being caught and released. Bartholomew and Bohnsack (2005) and Muoneke and Childress (1994) reviewed hundreds of published estimates of CR mortality, but we found no synthesis or literature reviews of F_{cr} values. Relatively few studies have measured F_{cr} for fish stocks.

For some stocks, F_{cr} can be a significant source of mortality resulting from harvest regulations or behavior of anglers (e.g., voluntary release; Driscoll et al. 2007). Harvest regulations can cause F_{cr} to be a substantial mortality source, particularly if the CR mortality rate is high and a large portion of the age structure is protected from harvest (Coggins et al. 2007). Even if CR mortality is not high, impacts can be substantial. For example, Florida's common snook (*Centropomus undecimalis*) fisheries have been managed with increasingly stringent harvest regulations to prevent overfishing, which has increased release rates from 31% in 1981 to over 90% in the late 1990s (Muller and Taylor 2006). Common snook have relatively low CR mortality (approximately 3%), but due to increasing fishing effort, about 35% of the total fishery-related deaths are attributed to F_{cr} (Muller and Taylor 2006). Many recreational fisheries (e.g., trout [Family: Salmonidae] or black bass [*Micropterus* spp.]) have high release rates of fish that are legal to harvest; thus, traditional measures of F_h may not indicate the full impact of fishing on fish abundance, size, or age structure.

Although estimates of F_{cr} are not common, this mortality source has not been completely ignored. Most marine and anadromous stock assessments incorporate indirect estimates of F_{cr} by estimating the number of fish released in a fishery and multiplying this by an average CR mortality rate obtained from experimental studies. The resulting estimate of dead releases is then added to the catch to determine total fishing mortality in stock assessment models (i.e., F_h + F_{cr}). Similarly, Driscoll et al. (2007) used a tag-return study and a range of CR mortality rates from literature to understand the impact tournament fishing was having on a largemouth (*Micropterus salmoides*) fishery in Sam Rayburn Reservoir, Texas. The combined mortality associated with CR fishing (i.e., mortality of tournament released and fish immediately caught and released) accounted for 19–50% of the total fishing mortality.

FUTURE RESEARCH AND MANAGEMENT NEEDS

Future research needs to move past estimating CR mortality to developing more intensive field studies to measure F_{cr} for a wide range of fisheries. In our experience, many fisheries professionals report CR mortality as if high values are harmful and low values are not a concern. However, the ultimate impact of CR mortality on fish populations is known only through estimates of F_{cr}, because low CR mortality can have large population impacts (see common snook example above). Only by estimating F_{cr} will we understand the impacts of CR mortality on fish stocks.

There are two basic options for estimating F_{cr}. First, applying literature-derived CR mortality rates in stock assessments or tag-return studies as per Driscoll et al. (2007) would provide estimates of F_{cr}. This may be the only feasible option for evaluating F_{cr} for recreational fisheries that occur in the open ocean or on some of the larger inland lake and riverine systems. However, for many freshwater and estuarine fisheries a second method is possible. We suggest using a combination of telemetry and tag-return methods that have been shown to provide unbiased estimates of fishing and natural mortality rates (Pollock et al. 2004). In this framework, a fishery-dependent high-reward tag-return study is primarily used to estimate F_h, whereas telemetry or fishery-independent tags are used to estimate M (Pollock et al. 2004; Bacheler et al. 2009). Pollock et al. (2004) illustrated that combining the two tagging methods incorporated the advantages of both approaches and provided more precise estimates of F_h and M than either method would individually. This design could be expanded to include additional mortality components if the fates of all caught telemetered fish are known. For example, tagging all telemetered fish with an additional external high-reward tag would allow researchers to document when fish are caught. If the fish is harvested it would contribute to F_h in the typical way. If the fish is released, then its survival could be monitored to estimate F_{cr}. This method also assumes a reporting rate of 100%, which is realistic due to the use of high reward tags. Nonreporting may still occur but it would be considered negligible. Although this method is not infallible (e.g., tag loss, incorrect fate determination, and tag failure), it is an improvement upon the resolution and uncertainty of conducting tag-return and telemetry studies independently (Pollock and Pine 2007).

Thus, we contend that future fisheries research should be directed less at estimating CR mortality where estimates exist under a range of environmental conditions for well-studied species (see examples in Cooke and Suski 2005). Instead, efforts should shift toward measuring F_{cr}, which could be compared to F_h to understand whether F_{cr} could be a significant component of total fishing mortality. Using this information, biologists could explore the population-level effects of both voluntary and regulatory release of fish. Managers could then incorporate this information into comprehensive management plans and future data collection needs to further reduce uncertainty in understanding stock status.

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