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Challenges of estimating post-release mortality of istiophorid billfishes caught in the recreational fishery: A review

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ABSTRACT

Istiophorid billfishes are targeted in recreational fisheries throughout the tropical and subtropical waters of the world's oceans. Over the past thirty years, changes in management regulations and increased angler conservation awareness have resulted in an increasing proportion of the billfish catch being released alive, and in many areas the fishery is principally catch-and-release. However, the fate of released fish, and thus the fishing mortality associated with the recreational fishery, is not well understood. Some insights into post-release mortality of billfishes caught in the recreational fishery have been gained from analyses of conventional tag data, hooking location information, and acoustic tracking data. Over the past 10 years pop-up satellite archival tags (PSATs) have been used to specifically estimate post-release mortality for a limited number billfish species. Extrapolation of the results of these limited studies throughout the various recreational billfish fisheries is not prudent due to potential influences of different species, areas, seasons, fishing styles, and hook types. The current high cost of PSATs presents a significant obstacle to evaluating the effect of these variables on rates of post-release survival. Nonetheless, the results of the few studies to date have had an important impact on fisheries management and the behavior of recreational anglers.

1. Introduction

Istiophorid billfishes are apex predators common to tropical and subtropical marine pelagic ecosystems. Six species of istiophorid billfishes occur in the Atlantic Ocean, and of these, the blue marlin (*Makaira nigricans*), the white marlin (*Kajikia albida*), and the sailfish (*Istiophorus platypterus*), comprise the vast majority of billfish landings. Atlantic billfishes are targeted in some subsistence and artisanal fisheries, but the magnitude of these catches are not well known (ICCAT, 2013). The majority of reported Atlantic billfish fishing landings result from bycatch in the pelagic longline fishery that targets tunas and swordfish (ICCAT, 2013). In addition, billfish are targeted by recreational anglers, and while there is also uncertainty regarding the magnitude of landings in this fishery due to non-reporting, reported recreational landings are less than 2% of the total of all gear types (ICCAT, 2013).

As of the most recent assessments, the Atlantic-wide stocks of blue marlin and white marlin are considered overfished, while the eastern Atlantic sailfish stock is estimated to be likely overfished, and the western Atlantic sailfish stock to be possibly overfished (ICCAT, 2013). The member nations of the International Commission for the Conservation of Atlantic Tunas (ICCAT) have adopted various management measures for blue marlin and white marlin. In 2000, the Commission adopted a measure requiring mandatory live release of blue marlin and white marlin caught in the pelagic longline and purse seine fisheries, and also limited the United States recreational landings to a total of 250 blue marlin and white marlin combined (ICCAT Recommendation 2000-13). Subsequently, in 2011 ICCAT adopted measures that include country-specific catch limit reductions for blue marlin and white marlin (ICCAT Recommendation 2011-07), and in 2012 adopted a measure that reduced overall country quotas for the two species and established minimum sizes for blue marlin and white marlin caught in recreational and sport fisheries (ICCAT Recommendation 2012-04). No binding management measures for sailfish have been adopted by ICCAT.

In the United States, retention of Atlantic istiophorid billfishes by commercial fishermen has been prohibited since 1988. Recreational fisheries have been managed with minimum sizes that were increased in 1998 to ensure compliance by the United States with an ICCAT management measure requiring parties to reduce landings of blue marlin and white marlin by 25% (NMFS, 2006). The larger minimum sizes, in addition to increased angler awareness

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of the conservation benefits of live release, have resulted in a fishery that is primarily catch-and-release. Goodyear and Prince (2003) estimated that more than 99% of white marlin caught off the U.S. Atlantic and Gulf coasts were released alive. The release ethic is so strong, that even in those tournaments that offer large monetary prizes for the largest white marlin, release rates typically exceed 90% (Graves, unpublished data).

While the U.S. reports very low landings of blue marlin, white marlin, and sailfish, the recreational fishery clearly interacts with a large number of these animals on an annual basis. For example, Goodyear and Prince (2003) estimated the annual catches of white marlin off the U.S. Atlantic and Gulf coast at that time to be 4,000–8,000 individuals. More recently, during the 2013 Virginia Beach Billfish Tournament off Virginia Beach, Virginia, anglers on 69 boats fishing for 2 days released 463 white marlin (J. Graves, pers. obs). In 2012, 46 boats fishing in the three day Silver Sailfish Derby off Palm Beach, Florida released 1174 sailfish (http://www.westpalmbeachfishingclub.org/sailfish-derby-magazine/2014/). It is highly unlikely that all released billfish survive the trauma and stress of the capture event, and considering the numbers of billfish released annually from the recreational fishery, the overall impact of the fishery on the stock could be quite high if there is significant post-release mortality. In this paper we review those studies that have contributed to our understanding of the magnitude of post-release mortality in recreational billfish fisheries, highlighting the relationship between terminal tackle and post-release mortality in some fisheries, the industry, and management.

2. Estimating post-release survival in recreational billfish fisheries

Estimating post-release mortality for the recreational billfish fishery is a difficult undertaking. In addition to the different species, areas and seasons in which the fisheries occur, there are different methods of fishing that may affect post-release mortality rates. These include high speed trolling with artificial lures or lure/natural bait combinations, slow trolling of natural baits, lure/natural bait combinations, or live baits, and still fishing with live baits. In addition, hook type can have an important effect on post-release survival of billfish (Prince et al., 2002; Horodysky and Graves, 2005; Serafy et al., 2009; Graves et al., 2012).

Estimating mortality of billfishes released from the recreational fishery is also complicated by the physical size of the animals and the location of their habitat. Several studies of post-release mortality have been conducted for smaller species of freshwater and shore fishes that can be quickly transported to tanks and pens following capture for observation of short term post-release mortality (Payer et al., 1989; Millard et al., 2003; Vecchio and Wenner, 2007; Donaldson et al., 2011; Butcher et al., 2011). However, it is not currently possible to transport or maintain adult billfishes in captivity for observation following recreational capture (Holland, 2003). Consequently, techniques either borrowed from research on other fishes or developed specifically for research with large pelagic vertebrates have been required to investigate post-release survival. Among these are inferences derived from conventional tagging (Ortiz et al., 2003; Hoolihan, 2006), analyses of hooking location (Prince et al., 2002, 2007), sonic tracking (Jolly and Irby, 1979), and pop-up satellite archival tags (PSATs; Graves et al., 2002; Domeier et al., 2003; Horodysky and Graves, 2005).

For more than 50 years, recreational anglers have been deploying conventional tags on released billfish, with large concentrations of effort in the western North Atlantic Ocean. Ortiz et al. (2003) reported a total of more than 45,000 blue marlin, 42,000 white marlin, and 112,000 sailfish tagged and released in the Atlantic Ocean. Rates of tag recovery and reporting for each of the three species were below 2%, an observation that could be consistent with high levels of post-release mortality. However, other confounding factors including unknown rates of tag shedding as well as domestic and international issues surrounding reporting of recovered tags could contribute to the low tag recovery/reporting rates (Bayley and Prince, 1994; Jones and Prince, 1998). As a result, conventional tags are generally not used to estimate the post-release survival of billfishes.

Analyses of hook location have been used to make inferences regarding post-release survival of pelagic fishes caught in the recreational fishery. The increasing use of circle hooks in the fishery has been the focus of many studies, and results have demonstrated a much higher incidence of internal hooking and physical damage with J hooks (reviewed in Cooke and Suski, 2004; Serafy et al., 2009; Graves et al., 2012). Skomal et al. (2002) reported a much higher incidence of deep hooking events in juvenile bluefin tuna caught on J hooks relative to circle hooks in a drift bait fishery. Based on dissections to reveal physical hook damage, the authors estimated that post-release mortality for fish had they been released would have been 28% for those caught on J hooks and 4% for those caught on circle hooks. Although not specifically providing estimates of post-release survival, several studies have investigated hooking location of J hooks and circle hooks in billfish caught in recreational fisheries, with the underlying assumption that post-release mortality will be higher for those fish that are deeply hooked or have hooks in non-desirable locations. Prince et al. (2002) evaluated the performance of J hooks and circle hooks in the slow troll natural bait fishery for sailfish off the Pacific coast of Guatemala. Analysis of 360 fish indicated that 46% of those caught on J hooks were deeply hooked in the throat or stomach, while only 2% of those caught on circle hooks had deep internal hooking locations.

A common practice in the slow troll and drifting recreational billfish fisheries using natural or live baits is for anglers to "drop-back" (free-spool the line for several seconds) when the marlin attacks bait. This action, which may mimic a stunned baitfish (Mather et al., 1975), allows time for the billfish to process the bait and increases the probability of internal hooking locations. Prince et al. (2007) reported on an analysis of 766 sailfish caught in the Florida live bait fishery and noted a higher incidence of undesirable release condition (based on observations of physical hook damage and trauma associated with internal hooking locations) with increased drop-back time for all hook types. There was also a significantly higher incidence of undesirable hooking locations for fish caught on J hooks relative to those caught on circle hooks with the traditional rounded shape. Similarly, Graves and Horodysky (2010) noted significantly higher rates of internal hooking locations for 123 blue marlin, 272 white marlin, and 132 sailfish caught on natural baits rigged with J hooks relative to circle hooks in the slow troll fisheries occurring in the western North Atlantic.

While analyses of hooking location can be used to make inferences regarding post-release survival of billfish caught in the recreational fishery, acoustic tracking technology provides a means to directly observe the fate of a released fish, at least for short durations after release. Several species of billfish have been acoustically tracked following release from recreational capture, including blue marlin (Holland et al., 1990; Block et al., 1992), white marlin (Skomal and Chase, 2002), sailfish (Jolly and Irby, 1979), and black marlin (Pepperell and Davis, 1999). In these studies, fish were followed for periods from a few hours to a few days, as track durations were limited by the stamina of the crew and sea conditions. In general, survival rates of released billfish were very high over the time course of the tracks, although some mortality was noted (Table 1). During the late 1990s, the development of pop-up satellite archival tag technology provided a means to study the fate, movement and habitat use of released pelagic fishes without directly following or