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An assessment of the health and survival of fishes caught-and-released in high-energy surf zones during a South African competitive angling event

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ABSTRACT

Recreational marine shore-based (MSB) fisheries are growing rapidly in many developing countries where they compete with subsistence and small-scale fisheries for resources. Many MSB fisheries are managed using regulations (e.g. size- and bag-limits) that require mandatory catch-and-release (C & R). More recently, voluntary C & R angling has become increasingly popular within the MSB recreational sector and has even expanded into competitive angling. Unfortunately, there is limited information pertaining to its effects on fish health and survival in the nearshore marine environment and particularly in high-energy surf zones. The aim of this study was to examine the impacts of C & R on a range of nearshore coastal fish species during a C & R MSB angling competition. The health and survival of fishes was assessed during the national Rock and Surf Super Pro League C & R tournament near East London, South Africa. The tournament rules require fish to be handled and unhooked in a bucket filled with seawater. The fight time, total air exposure, hook injury, difficulty of hook removal, extent of bleeding, angler distance from bucket, fish time into bucket and total time was recorded for each C & R event. Fishes were then subject to either blood sampling, a reflex impairment assessment or a short-term (18–24 h) survival experiment in three 3 425 l ponds. In total, 247 fish, belonging to 23 different species, were sampled (49 "blood chemistry", 113 "reflex impairment", 35 "survival", 50 "independent" samples). A linear mixed effects model (LMM) identified fight time ($P < 0.01$) as a significant predictor of blood glucose concentration and air exposure as a significant predictor of blood lactate concentration ($P < 0.01$) in teleosts. In elasmobranchs, air exposure was a significant predictor of blood glucose concentration ($P < 0.05$) while air exposure ($P = 0.03$) and fight time ($P = 0.04$) were the best predictors of blood lactate concentration. A total of 83.9% of the teleosts suffered some form of reflex impairment (4 indicators) compared with 31.4% for elasmobranchs (3 indicators). A cumulative link mixed model (CLMM) identified fight time ($P < 0.01$) and hook removal ($P = 0.02$) as the best predictors of reflex impairment in teleosts, while fight time ($P < 0.01$) was the best predictor of reflex impairment in elasmobranchs. The total mortality during the survival experiment was 14.3%, however, mortality was only observed in one family, the Ariidae (38.5%). The reflex impairment scores of all surviving fishes showed a complete recovery from the impacts of the C & R event. Although the findings suggest that immediate mortality within this fishery was low, with the exception of the Ariidae, the superior fish handling practices applied during this event still resulted in considerable physiological stress and reflex impairment. This is most likely ascribed to the extensive energy expenditure endured by fishes during capture in a high-energy environment.

1. Introduction

Marine shore-based (MSB) fisheries are popular in many coastal countries and are culturally and socially important due to their recreational value (Arlinghaus et al., 2007). In developed nations, such as Australia (Smallwood et al., 2011), the United States of America (Karpov et al., 1995) and France (Herfaut et al., 2013), recreational MSB fisheries are well-developed and compete with commercial fishing industries, mostly through the exploitation of smaller individuals (often the juveniles) of many target species (McPhee et al., 2002). Recreational MSB fisheries are growing rapidly in emerging economy countries and are already well established in Brazil (Freire et al., 2016), Argentina (Llompart et al., 2012), Namibia (Kirchner et al., 2000) and South Africa (Brouwer et al., 1997), where they compete directly with local subsistence and artisanal fisheries. In South Africa for example, subsistence fishing communities, who are highly dependent on the

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coastal resources (Sunde and Isaacs, 2008), make up only a small proportion (10%) of the MSB fishery (McGrath et al., 1997). Therefore, the activities of the recreational sector, which makes up the remaining 90% of the participants (McGrath et al., 1997), have a major impact on these communities. With significant participation rates, it is critical that global recreational MSB fisheries are sustainably managed to prevent declines in the viability of recreational, commercial and subsistence fisheries.

Recreational MSB fisheries are traditionally managed using species-specific size limits, bag (creel) limits, closed seasons and closed areas. The former three regulations generally require fishes that fall outside of the regulatory framework to be released immediately after capture. Besides the legal obligation for C & R, there is an increase in voluntary C & R amongst recreational anglers (Cooke et al., 2013a). As a result C & R has become increasingly prevalent as a conservation measure in recreational fisheries globally (Arlinghaus et al., 2007). The cumulative extent of mandatory and voluntary C & R is significant. Although not specific to MSB fisheries, Raby et al. (2014) estimated that 60% of all fishes captured in global recreational fisheries are released.

Unfortunately, many fisheries managers assume that the effects of C & R on released fishes are negligible (Cooke and Cowx, 2004) and, therefore, that all fish released by recreational anglers are healthy and survive. However, several studies (Cooke and Philipp, 2004; Cooke and Suski, 2005; Gingerich et al., 2007) have shown that C & R practices significantly increase fish mortality. Furthermore, C & R impacts appear to be specific to both the species angled and the environment in which they are captured (Cooke et al., 2013a) and this is evident in many single species studies that have been performed in a range of habitats (Arlinghaus et al., 2007; Bower et al., 2016; Brownscombe et al., 2014, 2013; Cooke et al., 2001; Danylchuk et al., 2014, 2007; Lennox et al., 2015; Meka and McCormick, 2005; Raby et al., 2014; Thorstad et al., 2003). Despite extensive recent research, there are limited studies that have examined C & R impacts in high-energy nearshore coastal habitats and this hinders the development of best practice guidelines and the ability of fisheries managers to better estimate mortality and manage MSB fisheries. In addition, there are few multispecies studies that have simultaneously compared the response of different species to the impacts of C & R in a single habitat or fishery and this limits our understanding of interspecific responses to C & R impacts.

Several characteristics of the habitat in which MSB fishing takes place can influence the post-capture health and survival of released fishes. For example, the strong currents and powerful waves often associated with this zone may result in a more exhaustive capture event. The high-energy shore-breaks can also result in damage as the fish is landed, particularly along a rocky shoreline, where sharp barnacles, mussels and rock-edges may injure the fish. The dry sand, typically associated with the beach environment, can disturb the glycol-protein mucous layer on the fish and may influence its hydrodynamics, osmoregulation and disease resistance (Rottmann et al., 1992). The surf zone environment, and marine environment in general, hosts a variety of predators including birds, mammals, cephalopods and other fishes. Many of the teleost and smaller elasmobranch species that are captured by MSB fishermen form part of the diet of these predators and fishes that are impaired by C & R practices are, therefore, more susceptible to predation (Raby et al., 2014). Since these factors operate cumulatively, they may have a profound impact on the survival of fishes captured in the marine nearshore environment.

A broad range of methods have been used to assess the health and survival of fishes after a C & R event (Arlinghaus et al., 2007; Cooke and Schramm, 2007). The more general indicators include physiological and behavioural responses of fishes, while post-release mortality has also been monitored over time (Arlinghaus et al., 2007; Bartholomew and Bohnsack, 2005). Stress and predicted mortality have been linked to physiological responses, and are reflected in the blood glucose and blood lactate concentrations of fishes (Arends et al., 1999). Elevated levels of glucose and lactate in the blood of teleosts have been associated with anaerobiosis, confinement, exhaustion and increased handling (Arends et al., 1999; Bower et al., 2016; Brownscombe et al., 2014; Ferguson and Tufts, 1992). High blood glucose and blood lactate concentrations have also been used as indicators for stress in elasmobranchs and have been positively correlated with stressors such as confinement and tiring (Cliff and Thurman, 1984; Gallagher et al., 2012).

Reflex impairment has become an important indicator during the assessment of fish health and survival in C & R experiments. Here typical reflex actions, termed “reflex action mortality predictors” (RAMP), which are defined as involuntary or stereotyped movements, are examined after the C & R event to predict the survival outcome of fishes (Davis, 2010). These methods are simple, cheap and their efficacy in predicting delayed mortality, stress and behavioural impairment in fishes has been validated in a number of studies (Davis, 2010, 2005; Raby et al., 2012).

Post-release mortality has been effectively monitored by retaining fish in temporary holding facilities, such as keep nets and cages within natural water bodies, and under experimental conditions after capture (Cooke and Schramm, 2007). Although expensive and often logistically challenging, they offer a method to quantify short-term mortality. Biotelemetry has been used to monitor the post-release physiological response and behavioural impairment of fishes (Capizzano et al., 2016; Donaldson et al., 2008; Ferter et al., 2015). However, this method is often prohibitively expensive and is not suited to the powerful, noisy South African coastal environment.

One of the bottlenecks to the collection of rigorous C & R data is the ability of the scientists or angling teams to capture sufficient numbers of fish in short periods. This is particularly true in overexploited MSB fisheries. Live-release competitive angling not only provides an opportunity for meaningful research, but also “inserts the angler into C & R angling science” (Cooke et al., 2017). In South Africa, a growing interest in C & R has culminated in the establishment of an exclusively C & R marine shore-based competitive league, the Rock and Surf Super Pro League (RASSPL). Their annual national competition attracts the best anglers from several coastal franchises and allowed us to rapidly obtain C & R information from a large number of fish during a three-day experiment.

The aim of this study was to develop and utilise a rapid assessment technique to obtain baseline estimates of the health and survival of fishes caught in a competitive South African recreational MSB fishery. In doing so, we describe and present the results of an experiment to examine the impact of C & R in the RASSPL national competition, which included independent assessments of blood glucose and lactate concentrations, a RAMP assessment and a short-term (up to 24-h) survival experiment using fishes caught on conventional shore-based angling gear.

2. Materials and methods

Data collection was conducted over three days during the RASSPL Africa national tournament between the Gulu River mouth (33°07′08.17″S, 27°43′52.20″E) and the Biega River mouth (33°23′00.69″S, 27°19′33.51″E) near East London, South Africa from 30 April to 2 May 2015. Temperature (air and sea) was measured several times daily. Data collection was performed by seven pairs of researchers, with each of the members undertaking separate, pre-defined roles, following several training sessions. Each pair performed one of three main tasks: blood chemistry, RAMP or survival (day 3 only).

Two pairs were responsible for blood chemistry measurements and five pairs were responsible for RAMP analyses on day 1 and day 2. On day 3, one pair was responsible for blood chemistry measurements, four pairs for RAMP analyses and two pairs for the survival experiment. The RASSPL Africa rules required anglers to follow a three-step procedure for each fish that was landed. The first step was to place the fish (after capture) into a standardised white, opaque rectangular RASSPL bucket