Towards the development of a pro-environmental strategy for improving catch-and-release behaviour in recreational fisheries – a case study on a competitive South African angling body.

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Abstract

Catch-and-release (C&R) is becoming increasingly popular in recreational fisheries with the potential to contribute towards conserving the oceans limited fish stocks. Several studies have highlighted high rates of mortality and many sub-lethal effects which ultimately have a negative impact on fish population viability. With poorly developed handling practices, the fish that are released suffer the consequences of physical and physiological stress and do not always survive, thus making the ethics of C&R fishing questionable.

Many studies have contributed to our understanding of the factors that influence the fate of fish released by anglers. Despite this, few interventions have been able to improve angler C&R behaviour. Pro-environmental behavioural strategies however hold some potential for improving angler C&R behaviour. To test their potential, we partnered with the South African Rock and Surf Super Pro League (RASSPL Africa), the biggest exclusively C&R competitive shore-based angling league in South Africa. The first two years (2013 and 2014) of the partnership were purely focused on building trust and relationships and making observations on angler behaviour. In 2015, we collected baseline data on angler behaviour and fish health during the RASSPL national fishing competition. This was followed by comparable data collection at the following two national competitions in 2016 and 2017 after the introduction of a combination of pro- environmental behaviour interventions, including rule changes, improving angler knowledge, behavioural modelling, rewards, penalties and feedback to improve C&R behaviour.

There were significant improvements in angler behaviour, including a decline in total air exposure from 101.93s ± 64.34 in 2015 to 77.37s ± 60.52 in 2017 ($F_{(2,618)} = 9.27$, $P < 0.01$), and the time taken for an angler to place their fish into a bucket declined from

105.86s ± 69.47 in 2015 to 23.05s ± 24.13 in 2017 ($F_{(2,556)}$ = 158.71, P < 0.01). There were also improvements in the health of the fish, with a decline in the blood lactate concentration and mean reflex action mortality predictor (RAMP's) scores for the dominant species, *Diplodus capensis* (lactate – 9.46 ± 3.80 mmol.l^{-1} in 2015 and 6.69 ± 2.99 mmol.l^{-1} in 2017, RAMP – 0.28 ± 0.22 in 2015 and 0.19 ± 0.17 in 2017), and *Haploblapharus fuscus* (lactate – 4.25 ± 1.89 mmol.l^{-1} in 2015 and 1.76 ± 0.78 mmol.l^{-1}in 2017, RAMP – 0.15 ± 0.18 in 2015 and 0 ± 0 in 2017).

In 2018, surveys were conducted to gain insight into angler demographics and external (social, economic, cultural and institutional) and internal factors (knowledge and awareness, motivations, attitudes and perceptions) associated with the RASSPL anglers. Surveys were also designed to assist in identifying what components were key drivers behind the angler's behavioural changes. The demographic characteristics of RASSPL anglers were not dissimilar from the general recreational angling public in South Africa, suggesting that this kind of intervention may have potential at a broader scale. In terms of the drivers of behavioural change, the surveys revealed that 68% of respondents strongly agreed that the structural rule changes contributed to their improved behaviour. This was followed by the educational presentations (66% of the respondents) and modelling / demonstrative videos (59% of the respondents). The conservation prizes were considered less effective, with only 27% of anglers strongly agreeing that this intervention improved their C&R behaviour.

Overall this study has demonstrated that it is possible to improve the C&R behaviour of anglers in a competitive setting, with the most effective component of the intervention being the use of rule changes (structural approach). These findings suggest that pro-environmental strategies hold potential for improving the C&R behaviour of anglers and the health of released fishes. It is suggested that interventions to improve C&R behaviour

should aim to develop long-term relationships, and implement a broad range of well communicated strategies based on reliable data and sound rationality.

Key words: marine shore-based fisheries; community engagement; pro- environmental behaviour; behavioural intervention

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Declaration

I, Samantha Lynn Mannheim, hereby declare that the work described in this thesis was carried out in the Department of Ichthyology and Fisheries Science, Rhodes University, under the supervision of Professor Warren Potts and Dr. Amber Childs. The components of this thesis comprise original work by the author and have not been submitted to any other university.

Signed:

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Publications arising from this thesis

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List of Tables and Figures

Contents

Chapter 1: General Introduction

Anglers racing the sunrise and enduring the tiresome journey necessary to find the perfect spot to catch the perfect fish. (Image credit: Samantha Mannheim)

The ever-growing state of the human population applies escalating pressure on the Earth's natural environment. With excessive resource use and continued environmental degradation, the planet's biodiversity and ecosystems are under major threat (Steffen et al., 2007; Schultz, 2011). The earth's current geological age has been titled the Anthropocene, meaning the period during which human activity has been the dominant influence on climate and the environment (Smith & Zeder, 2013). As a consequence the environmental problems we face are rooted in human behaviour (Gifford, 2014). In recent years there has been a significant increase in public concern and awareness with regard to the issue of the sustainability of the natural environment (Kennedy et al., 2009; Carfora et al., 2017; Danylchuk et al., 2018). This high level of awareness and concern however is not accompanied by a dramatic change in personal or societal actions and lifestyle choices (Schultz, 2011). The only way to reduce these anthropogenic pressures on the environment is by altering human behaviour directly and one of the strategies proposed is via the adoption of pro-environmental behaviours (Schultz, 2011).

Environmental psychology studies the relationship between people and their environment, and describes pro-environmental behaviour as when an individual consciously looks to reduce the negative impacts of their actions on the natural world (Kollmuss & Agyeman, 2002; Gifford, 2014). Pro-environmental behaviour has been the topic of much research over the past 40 years, with a number of different frameworks being designed to analyze pro-environmental behaviour (Burgess et al., 1998; Kollmuss & Agyeman, 2002).

The oldest and simplest model for analyzing pro-environmental behaviour is known as the Knowledge – Attitude – Behaviour (KAB) model. This model came about in the early 1970s and is based on a linear progression of environmental knowledge leading

to a change in environmental attitudes by creating awareness and concern, and thus leading to more pro- environmental behaviour (Kollmuss & Agyeman, 2002). This model identified the main problem being a 'deficit' in information provided to the public (Burgess et al., 1998). Unfortunately, this simplistic model did not see much success, and increased awareness is rarely followed by active participation in pro-environmental behaviour (Kennedy et al., 2009). This knowledge – attitude gap between environmental values and environmentally supportive behaviours is of growing concern globally and the discrepancy between stated and actual commitment has become the focus of much research (Kollmuss & Agyeman, 2002; Kennedy et al., 2009; Gifford, 2014). These studies have highlighted a significant number of important variables that could play a role in motivating behavioural choices.

Rajecki (1982) tried to explain this "knowledge – attitude – behaviour" (KAB) gap by identifying four critical factors, direct versus indirect experiences, normative influences, temporal discrepancy and attitude-behaviour measurements. With direct experiences (e.g. witnessing environmental degradation) having a stronger influence than indirect experiences (e.g. learning about environmental degradation), and normative influences including social norms, cultural traditions, and family customs. Temporal discrepancy and attitude-behaviour measurements have the potential to lead to flawed data and results. All of the above mentioned factors further emphasise the complexity in understanding human behaviour and by extension, pro-environmental behaviour (Kollmuss & Agyeman, 2002).

The Theory of Reasoned Action (Fishbein & Ajzen, 1975), later modified into the Theory of Planned Behaviour (Ajzen & Fishbein, 1980; Ajzen, 1991) has been one of the most influential attitude-behaviour models to date. This model classes humans as rational, meaning that people make systemic use of information provided to them and

are not controlled by unconscious motives or desires. Attitudes are seen as having an indirect effect on behavioural intentions, which in turn have the ability to change behaviour. This model highlights three specific determinants of behaviour; firstly the beliefs regarding the consequences of said behaviour; secondly the normative/social beliefs regarding the opinions of others about said behaviour; and thirdly the perceived behavioural control which specifies one's perceived ability to bring about change by performing said behaviour (Ajzen, 1991; Kollmuss & Agyeman, 2002; Carfora et al., 2017). This was an attractive model due to its simplicity and clarity, but limitations were evident in the underlying assumption that people act rationally.

In 1986 Hines, Hungerford and Tomera came up with the more sophisticated model of responsible environmental behaviour via a meta-analysis of many pro-environmental studies. They identified six variables associated with responsible pro-environmental behaviour, 1) knowledge of the issue at hand and its causes, 2) knowledge of relevant action strategies to lower the impact, 3) attitudes, 4) locus of control, 5) verbal commitment to take action, and 6) personal sense of responsibility. This model too was not as successful as intended, as relationships between knowledge and attitudes, attitudes and intentions, and intentions and actual responsible behaviour were found to be weak. It is suggested that even more factors need to be included, specifically situational factors such as economic constraints, opportunities and social pressures (Hines et al., 1986).

The next set of models looked at altruism, empathy and pro-social behaviour, which essentially focus on voluntary, intentional behaviours that result in beneficial outcomes for others (Eisenberg & Miller, 1987; Kollmuss & Agyeman, 2002). Often, altruism is evident among people who have satisfied all of their own personal needs and have more resources to care about larger issues (Borden & Francis, 1978). Maslow's

hierarchy (1971) states that the satisfaction of self- needs enables individuals to transcend themselves and emit altruistic behaviours. Allen and Ferrand (1999) conducted a study to test Geller's 'actively caring' hypothesis which states that in order to act pro-environmentally, individuals must focus beyond themselves and be concerned about communities at large (Geller, 1995). The hypothesis states that this altruistic state of actively caring occurs only once an individual's needs, self-esteem, belonging, personal control, self-efficacy and optimism have been satisfied (Geller, 1995; Allen & Ferrand, 1999). It is therefore accepted that altruism does not directly lead to pro-environmental behaviour but rather supports it (Kollmuss & Agyeman, 2002).

Blake (1999) discusses the 'value-attitude gap' and pointed out that all pro-environmental behaviour models are limited as they fail to take into account institutional, individual and social constraints. Blake identified three barriers of action: individuality, responsibility and practicality. Individual barriers are personal and generally have to do with one's attitude and temperament. These barriers are more influential among individuals who do not have a strong concern about the environment. The responsibility barrier is similar to the previously mentioned 'locus of control', which essentially means that people will not act pro-environmentally if they feel they cannot influence the situation and should not take responsibility for it. This is more common among communities that display a lack of trust in institutions and are suspicious of the prescribed necessary actions. The practicality barrier refers to the social and institutional constraints that can prevent pro-environmental behaviour, regardless of the intentions and attitudes of an individual. Examples would be lack of time, lack of money, or lack of information (Blake, 1999; Kollmuss & Agyeman, 2002).

Kollmuss and Agyeman (2002) concluded that all models relating to pro-environmental behaviour and bridging the attitude-action gap have some validity in specific

circumstances, but the underlying complexity of what shapes environmental behaviour, makes it impossible to visualize one single framework as it would be far too complicated to understand, let alone utilize. This is due to the many conflicting and competing factors that shape human decision making with regard to pro-environmental behaviour (Kennedy et al., 2009; Guckian et al., 2018). Kollmuss and Agyemann (2002) classify environmental knowledge, values and attitudes together with emotional involvement into a complex called pro-environmental consciousness, which is embedded in broader personal values and shaped by personality traits and other internal and external factors (Figure 1.1).

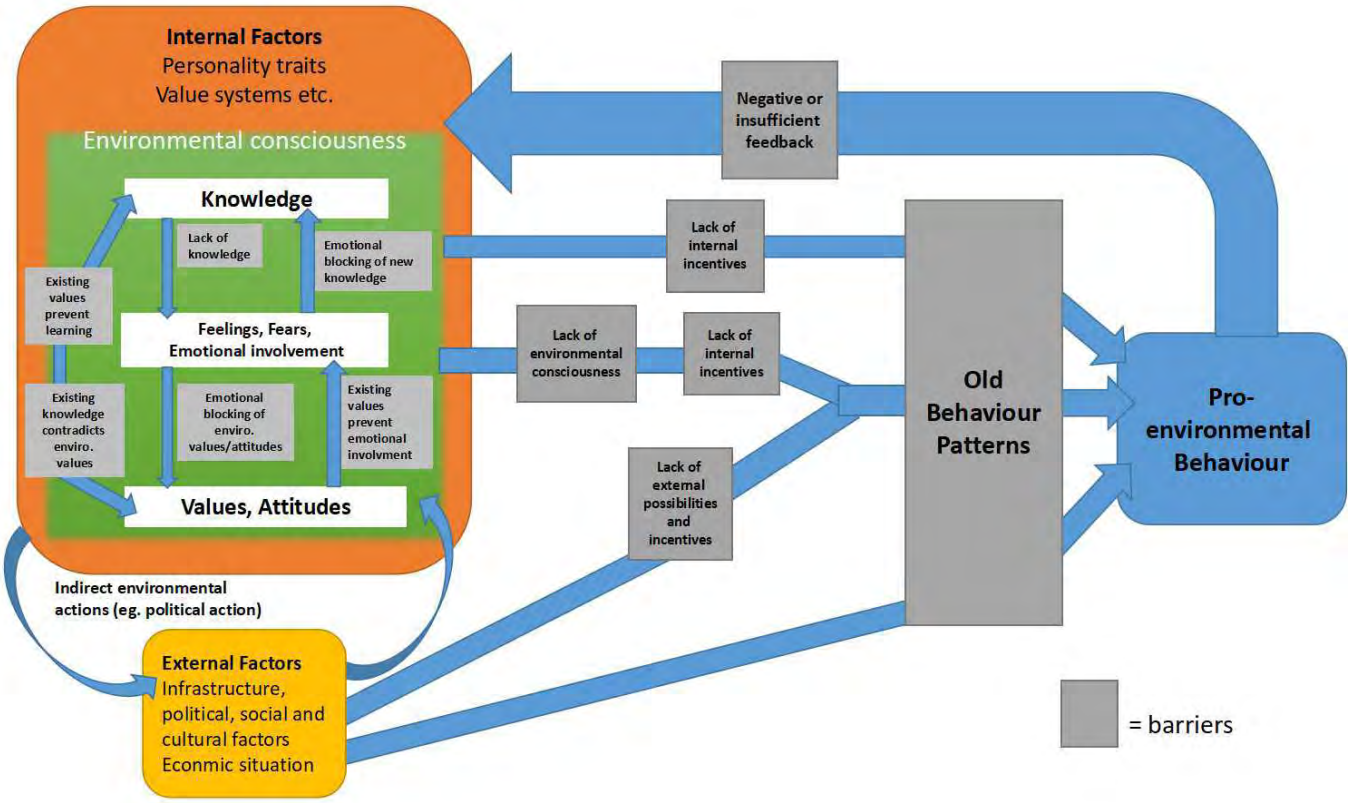

Figure 1.1 Kollmuss and Agyeman's model of pro-environmental behaviour (adapted from Kollmuss and Agyeman 2002).

A recent and practical framework for promoting behavioural change would be the Geller (2002) “DO IT” framework which identified four steps, ‘D’ for defining certain behaviours to work with, i.e. the targets of the environmental sustainability intervention. The ‘O’ for observing and collecting baseline information (how regularly the target behaviour occurs naturally). This section assists with fact finding and facilitates the discovery of behaviours that need to be changed. The ‘I’ for intervene, meaning the step where the interventions are designed and implemented, and ‘T’ for testing and redefining the interventions from the feedback for continuous improvement (Gellar, 2002). Steg and Vlek (2009) discuss environmental psychology’s merits and potential in terms of promoting environmental sustainability via behavioural change. They modified the above mentioned steps into the following, 1) carefully selecting the behaviour that needs to be changed, 2) examining which factors cause these behaviours, 3) applying well-tuned interventions to change the relevant behaviours and their antecedents, and 4) systematically evaluating the effects of the interventions on the behaviours themselves, their antecedents, the environmental quality and human quality of life.

Stern (2000) pointed out that the most effective behavioural change programs utilize a combination of interventions because behaviour is caused by multiple variables that sometimes interact with one another. Steg and Vlek (2009) emphasized two different types of intervention strategy, specifically informational and structural. Informational strategies look at changing aspects such as motivations, perceptions, knowledge and personal norms, without changing the external context. Structural strategies are more concerned with changing contextual factors or the circumstances that accompany the specific behaviour being changed (Steg & Vlek, 2009; Whitemarsh & O’Neill, 2010). Which of these strategies will be most effective in encouraging pro-environmental

behaviour is dependent on the specific barriers that arise, thus placing a large amount of importance on situational context (Stern, 2000; Bower et al., 2017). In more developed countries structural interventions focused on law and rule implementation are more likely to be effective than in lesser developed countries where monitoring, control and surveillance are generally lacking (Sutinen, 1993; Guckian et al., 2018). In developing countries it may be more effective to utilize social sanctioning due to the poor governance structures (Chapman et al., 2018; Guckian et al., 2018). Ultimately a good understanding of the context of people whose behaviour you want to change is critical to identify the most appropriate pro- environmental behavioural interventions (Black et al., 1985; Stern, 2000; Hunecke et al., 2001; Bower et al., 2017).

Proposed interventions for changing environmental behaviour include antecedent and consequence strategies. The sequence of Antecedent →Behaviour →Consequence is known as the three-term contingency model, and is the theoretical basis for many interventions aiming to improve environmental behaviour (Geller, 2002; Bolderdijk et al., 2012). Antecedent strategies take place before the behaviour of interest and include education through the provision of information via presentations and modelling videos (Bolderdijk et al., 2012). Consequence strategies operate on the premise that it is human nature to repeat behaviours that have led to positive outcomes and to reduce behaviours that have resulted in negative outcomes (Bolderdijk et al. 2012). These interventions are implemented after the targeted behaviour and generally aim to either reward or penalize certain behaviours.

Recreational fishing, specifically angling has become increasingly popular on a global scale (Arlinghaus et al., 2007; Brownscombe et al., 2017; Butler et al., 2017). Recreational fishing is defined as the capture or attempted capture of living aquatic resources mainly for leisure or personal consumption, with angling refering to fishing

with handlines, fishing rods and/or poles using baits and/or lures (ICES, 2013, Pawson et al., 2008). Anglers are a diverse group of individuals made up of a combination of men and women of all ages, stemming from a variety of different cultures and income brackets (Lewin et al., 2006; Arlinghaus & Cooke, 2009). Providing global estimates of recreational fishing participation has proven difficult due to the lack of representative data from many regions in the world as well as the various different sampling methods utilized (Arlinghaus & Cooke, 2009).There are well-developed recreational fisheries established in developed nations such as Australia (McPhee et al., 2002; Smallwood et al., 2011), the United States of America (Karpov et al., 1995; Coleman et al., 2004), France (Herfaut et al., 2013) and Canada (Post et al., 2002), as well as in developing countries like Brazil (Freire et al., 2016), Namibia (Kitchner et al., 2000), Argentina (Llompart et al., 2012) and South Africa (Brouwer et al., 1997). This high prevalence is because recreational angling takes place across a variety of habitats, ranging from freshwater inland systems to marine shore-based environments, as well as deep sea angling. In many coastal countries the marine shore-based fisheries are of cultural and social importance because of their recreational value (Arlinghaus et al., 2007). Cooke and Cowx (2004) extrapolated from Canadian values that approximately 11.5% of the global population are expected to take part in recreational fishing on a regular basis. Angling has grown in popularity across the world with a predicted 20% increase in fishing efforts over the past few decades (Coleman et al., 2004). It is estimated that only a minor 12% of the North American population have never participated in a recreational fishing activity (Pelletier et al., 2007). In South Africa specifically it was reported that only 10% of fishing activity in the marine shore-based environment fell under the subsistence fishery bracket, meaning that approximately 90% of all fishing along the South African coastline is recreational fishing (McGrath et al., 1997).

Overfishing is one of the most concerning anthropogenic impacts on the sustainability of wild fish populations as it has the potential to cause major structural and functional changes to ecosystems (Jackson et al., 2001; Daskalov et al., 2007). The majority of research on the global fish crisis focuses on the commercial fisheries as the main culprit behind stock depletion, where the recreational fishing sector should also be considered as it has a significant effect on many fish stocks (Arlinghaus et al., 2002; Colman et al., 2004; Cooke & Cowx, 2004). Commercial and recreational fishing have similar ecological and demographic effects on the specific populations that they exploit and therefore should both be considered as contributors to the overexploited state of the oceans (Coleman et al., 2004; Cooke & Cowx, 2004). In some parts of the world the prevalence of recreational fishing has surpassed commercial fishing, making it vital to consider this ever-growing body of anglers and their cumulative impact (Arlinghaus et al., 2002; Cowx, 2002; Cooke & Cowx, 2004; Lewin et al., 2006; Arlinghaus et al., 2007; Butler et al., 2017). A concerning factor about recreational fisheries is that they are not self-regulating, meaning that anglers do not reduce their fishing efforts as stocks decline (Post et al., 2002). Cooke and Cowx (2004) state that to facilitate the development of strategies to increase sustainability of angling, it is necessary to elevate recreational fishing to a global conservation concern.

One way of reducing the impact of recreational fisheries on wild fish populations is through the adoption of catch-and- release (C&R) angling as both a mandatory behaviour to comply with regulations (such as a minimum size or bag limit), as well as voluntarily for conservation purposes.

With rapidly dwindling global fish populations, the prevalence of C&R is increasing in recreational fisheries (Arlinghaus et al., 2009; Brownscombe et al., 2015; Lennox et al., 2015) with studies estimating that at least 60% of all fish captured by recreational

anglers are released (Cooke & Cowx, 2004; Cooke & Schramm, 2007). Catch-and-release angling is an important strategy for managing recreational fisheries worldwide, and has a long history with increased attention in recent years (Arlinghaus, 2007; Arlinghaus et al., 2009; Brownscombe et al., 2015; Lennox et al., 2015; Chapman et al., 2018). It is an appealing approach towards recreational fishing as it aims to conserve exploited fish whilst maintaining angling use (Arlinghaus et al., 2007; Chapman et al., 2018; Weltersbach et al., 2018). Throughout history C&R has looked to conserve fish stocks with famous writer and fly-fisherman Lee Wulff (1939) writing that fish are too valuable to be caught only once, and later with Quinn (1989) reporting that C&R had the potential to "recycle" fish and thus improve fishing quality. The obvious conservation potential in putting fish back into their environment to reproduce or be caught another day by another angler, and the increasing number of publications surrounding the unique field of C&R science support the notion that its future is promising (Arlinghaus et al., 2007; Arlinghaus et al., 2009; Brownscombe et al., 2015; Lennox et al., 2015; Chapman et al., 2018; Danylchuk et al., 2018).

While many fisheries managers assume that the release of a captured fish means that the fish survives and is a viable member of the population, several studies have highlighted high rates of mortality (Bartholomew & Bohnsack, 2005; Cooke & Suski, 2005; Gingerich et al., 2007; Ferter et al., 2017; Weltersbach et al., 2018) and many sub-lethal effects (Cooke & Philipp, 2004; Alòs et al., 2016; Brownscombe et al., 2017; Martins et al., 2018) associated with C&R, which ultimately have a negative impact on population viability (Hessenauer et al., 2018). When C&R is practiced ineffectively it is almost guaranteed that the fish will experience injury, stress or a combination.

All aspects of C&R contribute to stress and injury and have the potential to disrupt fish physiology and biochemistry (Martins et al., 2018; Weltersbach et al., 2018). From the very start of a C&R event the fish face stressors with hooking being one of the primary causes of angling-related injury and mortality (Brownscombe et al., 2017). Hook injuries can be minor like small flesh wounds, or major if the respiratory system or any vital organs are hooked. Hooking injuries can be minimized by the utilization of circle hooks which generally only hook in the corner of the fish's mouth, causing minimal injury (Prince et al., 2002; Arkert et al., 2018). Next the fish experience the 'fight time' which is the period between hooking and landing where they go through highly exhaustive physical exercise trying to fight the angler (Raby et al., 2013). Landing of the fish poses further stressors as fish may be landed on rocky or sandy terrain, or with harmful landing equipment (nets, gaffs, cradles), which can damage the fish's mucus membrane and lead to infections or fungal growth on the skin (Arlinghaus et al., 2007). Tissue damage is inevitable (Cooke & Sneddon 2007). The handling of the fish by the angler during landing, hook removal, documentation and release also has a great influence on the health and survival of the fish as any direct contact with the fish's skin has the potential to cause detrimental harm (Brownscombe et al., 2017). Anglers with bad handling habits often drag or drop their fish in the sand or on the rocks, and hold the fish in the gills or by the tail. By sticking their fingers in the gills the angler is causing much damage to a highly sensitive, highly important area of the fish's body. Unhooking the fish can also play a role in causing stress as depending on where the fish was hooked it can take a significant amount of time to remove hooks and they are capable of causing much damage. Fish are generally unhooked out of the water which increases the air exposure they experience. Elevate air exposure can be considered acute hypoxia for the fish is one of the main stressors experienced by fish during C&R events (Cook et al., 2015). The final segment of the entire

C&R process is the release which is a crucial transitional period. Fish that are released are more likely to fall victim to predation as their ability to avoid and evade predators has been impaired as a response to the angling event (Schreck et al., 1997; Cooke & Phillips, 2004; Brownscombe et al., 2017). The fish must then focus its efforts on recovering and returning to homeostasis rather than investing energy into growth, reproduction and food acquisition. Most fish are able to recover from the physiological changes their bodies go through in somewhere between two to twenty-four hours. This time frame is wide as recovery is species- and variable- dependent (Martins et al., 2018). However, fish that are repeatedly caught and released may experience reduced growth rates due to the fact that energy was redirected for physiological recovery. Variables that lead to mortality often also lead to possible reproductive and growth defects and can have an effect at a population level (Arlinghaus et al., 2007; Danylchuk et al., 2018; Hessenauer et al., 2018; Weltersbach et al., 2018). After the C&R event, fish may experience alterations in behavioural norms with regard to food acquisition, predator avoidance, reproduction, movement and orientation (Arlinghaus et al., 2007). Mortality rates are high among these fish post release, and death often only occurs sometime after the C&R event (Hessenauer et al., 2018; Martins et al., 2018), leaving the angler unaware of the consequences for their actions. It is impossible to catch and handle a fish without eliciting a stress response or injury (Arlinghaus et al., 2007; Brownscombe et al., 2017).

It is well known that C&R (both voluntary and mandatory) aims to conserve fish stocks, however, its efficacy is dependent on the survival and population viability of the released fishes (Danylchuk et al., 2018; Martins et al., 2018; Twardek et al., 2018). The poorly-developed handling practices that are normally associated with high mortality make the ethics of C&R angling questionable (Arlinghaus et al., 2007; Cooke & Sneddon 2007; Cook et al., 2015). The current rise in support for animal rights has placed extra criticism

on C&R and many believe that C&R and other sport fishing should be banned as they look to intentionally cause the fish suffering (De Leeuw, 1996; Arlinghaus et al., 2007). In Germany, the Animal Protection Act has resulted in a social norm to kill all fish that are caught if they are not protected by size limits or protective seasons. C&R can be seen as 'playing' with the fish and is heavily frowned upon with punishments of public prosecution and imprisonment for up to three years (Arlinghaus et al., 2007). In places like this it is typically only acceptable to fish for food as that is the only reason one should be inflicting pain and suffering.

Due to the increased interest in reducing lethal and sublethal effects of C&R, recent research has focused on the development of knowledge for improving C&R practices to maximize the health and survival of released fishes (Brownscombe et al., 2017; Cooke et al., 2017; Gagne et al., 2017; Danylchuk et al., 2018; Guckian et al., 2018; Weltersbach et al., 2018). This research has found that effective C&R practices focus on altering angler behaviours such as reducing fish fighting times, limiting handling times and reducing air exposure times (Davis, 2010; Raby et al., 2012; Cooke et al., 2013; Cook et al., 2015; Danylchuk et al., 2017; Danylchuk et al., 2018; Twardek et al., 2018). Because it is impossible to not inflict some sort of stress on the fish, anglers should be focusing on decreasing the negative effects that they have control over (Arlinghaus et al., 2007). While this information has been suggested to the public in best practice guidelines for anglers (Cooke & Suski, 2005; Brownscombe et al., 2015; Brownscombe et al., 2017; Sims and Danylchuk, 2017; Guckian et al., 2018; Weltersbach et al., 2016; Weltersbach et al., 2018), under the assumption that improved knowledge would lead to changes in behaviour, there is limited evidence to suggest that this has happened (Cooke et al., 2017). This is not entirely surprising, as pro-environmental behaviouralists have long recognized that improved education does not necessarily lead to better attitudes and pro-environmental

behaviour (Kollmuss and Agyeman, 2002).

There is minimal C&R research on the integrative orientation incorporating the social with the biological sciences (Chapman et al., 2018; Danylchuk et al., 2018; Guckian et al., 2018; Weltersbach et al., 2018). From a biological perspective it is important to understand the lethal and sub-lethal effects of C&R, and from a social perspective it is vital to understand the drivers behind behavioural changes (Arlinghaus et al., 2007). Understanding the institutional and social dynamics associated with C&R behaviour is crucial for improving the implementation of C&R management policies. While Evans (2005) argues that C&R is strongly based on respect for the integrity of the environment and the populations within that environment, others consider C&R as pure animal torture for no good reason (Volpato, 2009). Catch-and-release in one form or another is a day-to-day practice in contemporary recreational fisheries. The implementation of effective C&R encourages biological, economic and social sustainability of recreational fishing.

The aim of this thesis is to implement Geller's strategy for pro-environmental behaviour and attempt to identify the most effective interventions for recreational anglers using a case study from a competitive angling body. To do this, this thesis is divided into five chapters (Figure 1.2). The first provides a general introduction on changing pro-environmental behaviour and C&R angling globally, the second chapter documents the context of the case study (i.e. The Rock and Surf Super Pro League (RASSPL) angling body and the relationship between science and angler), the third documents the interventions implemented and their outcomes. The fourth chapter attempts to gain an understanding of the drivers behind the behavioural changes seen in the previous chapter, and the final chapter provides a synthesis of the findings and recommends future research directions.

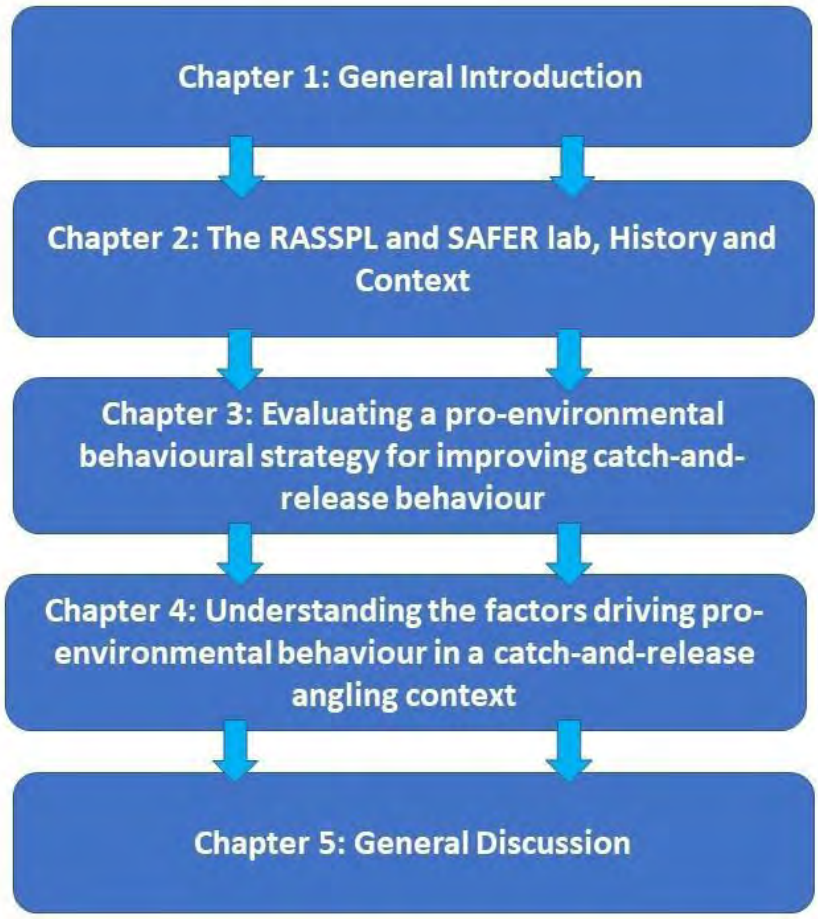

Figure 1.2 Flowchart displaying the direction of this thesis.

Chapter 2: The RASSPL and SAFER lab, History and Context

The Research Team at the RASSPL Nationals 2016 Prizegiving. (Image credit: RASSPL)

This thesis examines a collaborative community engagement project between the largest, competitive, C&R angling league in South Africa, the Rock and Surf Super Pro League (RASSPL) and the Southern African Fisheries Ecology Research Lab (SAFER Lab) that aims to improve angler C&R behaviour. This chapter attempts to provide context of the collaborative partnership and the development of the "engaged research" relationship between the two organizations. To do this, each organization is described and the history of the collaborative project is outlined.

2.1 Rock and Surf Super Pro League (*RASSPL*)

The Rock and Surf Super Pro League (RASSPL) was established in 2011 and comprises over 1000 active members in South Africa and Namibia. The RASSPL has also recently expanded to include a league in England and Angola.

The RASSPL began with the hopes of providing an alternative and more conservation-oriented option for marine shore-based competitive anglers, who partake in the South African Surf Angling Association (SASAA) leagues. While the SASAA league competitions reward those who have captured fish with the most weight and the anglers are not required to release their fish, the RASSPL leagues rewards anglers that capture the most species and require all fish to be released. The RASSPL in South African comprises eight franchises distributed along the coastline. Each franchise hosts eight competitions in their coastal area per year and there are 56 competitions in a year. The top twenty-four senior male anglers, top three female and top three junior anglers from each franchise are eligible to attend the national competition that is hosted over three days by a different franchise each year.

2.1.1 Competition format

During the competition, fish above the minimum size limit of 500g for teleosts and 1000g

for elasmobranchs are eligible for points. Once captured, anglers are required to immediately place the fish into a plastic C&R bucket (38×28×27 cm) filled with fresh seawater. Fish are then photographed (in the bucket), unhooked, measured and photographed on a measuring mat. The length of the fish is recorded on the angler's card and a witness is required to sign as confirmation of the catch. A third photograph, with the angler holding the fish with his back facing the sea is required for teleosts above 1000g and elasmobranchs over 2000g before the fish are returned to the sea. This is done as they may qualify for a prize.

At the end of the competition day, the cards are submitted. The points system is fairly complex. Bonus points are allocated for the first individual of each species. The number of bonus points for each species depends on its rarity (or difficulty of capture). An additional 200 bonus points are awarded to an angler who catches six species. A further 200 points are awarded to those who catch 10 species and 100 points are awarded for each additional species (11 and up). The weight of each fish is estimated using length-weight conversion equations. Four points are allocated per kilogram for teleosts and two points per kilogram for elasmobranchs. Critically, this scoring system rewards the capture of diversity, removes the main focus from catching large and often susceptible species (such as elasmobranchs) and spreads the targeted effort when compared with the SASSA competitions.

2.2 Southern African Fisheries Ecology Research Lab (SAFER Lab)

The SAFER lab is based at the Department of Ichthyology and Fisheries Science (DIFS), Rhodes University. The lab comprises two postdoctoral fellows and 18 postgraduate students and is led by Professor Warren Potts and Dr. Amber-Robyn Childs. The lab (www.safisheriesecologyresearchlab.com) has a strong socio-ecological focus and has

been involved in recreational fisheries research for over a decade. Many members of the lab are avid recreational anglers and this has provided an opportunity to create a truly collaborative partnership with the RASSPL.

Other important members include Mr. Matthew Parkinson, who is a PhD student at the DIFS. Matthew is responsible for the design and maintenance of the monitoring and scoring database. He has also been involved in the RASSPL Africa league for the last six years. Besides the monitoring database, Matthew is also responsible for the collation of the photographs and assists with the field data collection during the national competitive events.

Mr. David Drennan is the technical officer at the DIFS. He has been integrally involved in RASSPL Africa administration since its inception and is currently the RASSPL Africa records officer. He is involved in a technical capacity for all of the RASSPL-Africa field research.

Postgraduate students play a major role in this research project, with the entire DIFS honours class participating in the research during the RASSPL nationals each year (2015-2018). Other postgraduate students, including both MSc and PhD students have contributed significantly over the years with PhD student Mr. Alex Winkler acting as the research team leader in 2017 and delivering the necessary presentations to the RASSPL body.

The South African Institute for Aquatic Biodiversity (SAIAB) works intricately with the DIFS and Rhodes University, and therefore has also contributed in terms of field sampling and tracker implantation. Other partners include the South African Shark Conservancy (www.sharkconservancy.org), which is based in Hermanus, Western Cape, South Africa. This group has been involved in the field sampling. They have a particular interest in the

health and survival of sharks captured during the competition.

2.3 History of relationship

The SAFER lab began interactions with RASSPL in the beginning of 2012 when Professor Warren Potts defended the league in a published newspaper article after it received negative press report highlighting the possibility of a single fish may be killed for the winning prize during a RASSPL Nationals event. In the article, Professor Potts supported the goals of the league in the media, and provided relevant context comparing the RASSPL to other angling events where all fish captured were killed. In June 2012 the research group led by Professor Potts was invited by the league owner to join them at a few of their competitions. This resulted in five of the SAFER lab members joining their local RASSPL as competitors. The researchers saw this as an ideal opportunity to immerse themselves into the league culture and begin gaining the trust of the recreational anglers. The following year (2013) these research team members participated (as anglers) in the National tournament, with two of the members being selected as national representatives. After this event, the research team met with the league owner to discuss the development of the RASSPL and possible ways forward. By the end of 2013, the research team was asked to assist with the development of a database to simplify the complicated league scoring system. This was seen by the research group as an opportunity to begin collecting catch and effort data from the competitions. This new scoring system was successfully implemented at the 2014 National competition and lead to the research team being invited to join the RASSPL executive committee as a scientific advisory team. After discussions with the national executive committee, it was decided that the primary aim of the scientific advisory team would be to use the competition results to develop a national monitoring system for South African coastal fishes, and to improve the league's environmental footprint, by improving its C&R handling practices and the

health and survival of released fishes.

2.3.1 Baseline Assessment

While the scientific team was tempted to immediately implement largescale changes to the rules of the league, it was felt that rules should only be modified if there is supporting scientific evidence to justify the change. Thus, the decision was made to first collect baseline data on the behaviour of anglers and the response of fishes to the C&R event in RASSPL competitions. This information was also necessary to provide a baseline that allowed the group to evaluate the effects of any future interventions on angler behaviour and fish health and survival. The baseline data was collected during the RASSPL national competition that was held between the Gulu River mouth and the Biega River mouth near East London, South Africa from 30 April to 2 May 2015.

The baseline study formed part of a DIFS student's honours project (Edward Butler), which has subsequently been published in the journal Fisheries Research (see Butler et al., 2017). The aim of this study was to develop and utilise a rapid assessment technique to gather baseline information on the health and survival of fishes caught during the RASSPL nationals in 2015. The rapid assessment techniques used included the assessment of blood glucose and lactate concentrations, a "reflex action mortality predictor" (RAMP) assessment (Davis, 2010) and a medium-term mortality experiment using fishes caught on conventional shore-based angling gear.

2.3.1.1 Materials and methods of baseline (2015) assessment

Data collection was conducted over three days during the 2015 RASSPL Africa National tournament. Collection of data was performed by several pairs of researchers, with each member undertaking separate, pre-defined roles. Each group performed one of three main tasks: blood chemistry, RAMP and survival (day 3 only).

The RASSPL Africa rules require competing anglers to follow a three-step procedure for each fish that is landed (as seen in above section on RASSPL format). After the last step, the rules require that the fish be placed into the standardized bucket and returned to the sea. This process happened independently of the research team, with data collectors playing an observational role to this point. For the experiment anglers were asked to hand over the fish to the researchers at the water's edge, instead of releasing them as they normally would have (with the fish in a C&R bucket full of water).

Research teams started recording information as soon as they noticed an angler hooking a fish. Data collectors used stopwatches to record the time taken for the angler with a captured fish to complete different tasks. The "fight time" was recorded once the fish was landed. Researchers then estimated the approximate distance from the angler to their RASSPL bucket and timed how long it took for the angler to place the fish into the bucket. Other observational information like the species captured, time of day, hook placement (corner of the mouth, upper lip, lower lip, throat or foul-hooked somewhere on the head or body of the fish), ease of hook removal ("easy" < 20 s or "difficult" > 20 s for the angler to remove the hook) was recorded during the C&R event. The amount of bleeding caused by hook injury was categorized between 0 and 3; (0 = no bleeding, 1 = minimal bleeding, insufficient to stain the water in the bucket, 2 = bleeding sufficient to lightly stain the water and 3 = profuse bleeding, staining the water a deep red/brown colour). The length of each fish (teleosts: fork length (FL), smaller shark species: total length (TL), larger shark species: precaudal length (PCL)) was measured by the angler and recorded by the data collectors. The "air exposure" time (s) was recorded as the total amount of time a fish was outside of the water. This included all possible air exposure times, so from landing the fish until it was placed in the bucket, the time spent doing measurements on the canvas mat and the time taken to take the photograph with the

angler holding the fish. The research teams then performed the specific tasks assigned to their group of either, blood chemistry analysis, RAMP assessment or putting the fish into ponds for survival monitoring.

Blood chemistry analysis was conducted immediately after receiving the fish from the angler, by inverting the fish in a foam-padded trough and taking a small amount of blood (< 2 ml) from the caudal vasculature of the fish using a 22G needle and syringe. Point of contact devices that have been previously validated for use on fishes (Cooke et al., 2008) were used to measure blood lactate (mmol.l^{-1}, Lactate-Pro 2, Arkray Inc., Kyoto, Japan) and blood glucose (mmol.l^{-1} Accu-Chek Active, Roche Diagnostics, Basel, Switzerland).

Four reflex action mortality predictors (RAMPs) were executed per fish once they had been handed over by the angler. Fish were immediately placed into a rectangular holding bucket full of seawater so that RAMP assessment could begin. Assessing “Head complex” involved checking whether the fish’s opercula beats were regular (regular = 0, irregular or none = 1). “Tail grab” assessment involved gently grabbing the fish’s tail and recording its response (reactive swimming action = 0, no response = 1). Assessing “Equilibrium” consisted of gently inverting the fish and noting whether or not it was able to correct itself within three seconds (positive response = 0, slow/no response =1). Measuring the final predictor “Body flex” involved lifting the fish above the water and holding it on its side. Fish that reacted by flexing their torso within three seconds were given a score of 0, and fish that did not were given a score of 1. The overall RAMP score was then calculated by averaging the four predictor scores per fish so as to give a score of somewhere between 0 and 1, with 1 indicating a high level of reflex impairment. As with other studies RAMP values were treated as objective measurements (e.g. Bower et al., 2016).

Three survival ponds were set up using a flow through system and water from a nearby

tidal pool. The water was fed into each of the ponds at a flow rate of 3 450 l/h (> 1 replacement per hour) by a BVP5000 submersible water pump (Leader Pumps, Italy), which was powered by a 6kVA petrol generator. Each pond had a thermometer in it so that temperature could be measured every three hours. Fish were transported in holding tanks containing seawater to the survival ponds by two vehicles on the third competition day. All fish were tagged with a t-bar anchor tag (Hallprint TBA) before being placed into the ponds, so as to make identification at the end of the experiment easier. Elasmobranchs were placed in one pond, and teleosts were split between the other two. Information on the time of introduction into the pond and the tag number were recorded for all fish, and mortality was assessed and recorded every three hours when temperature was recorded. A RAMP analysis was performed on each fish the following morning. Fish were then retrieved from the ponds using a landing net and released back into the sea.

2.3.1.2 Results of baseline (2015) assessment (as presented in Butler et al., 2017)

A total of 247 fish were sampled, belonging to 23 different species and seven different families. The average fight time was 67.7 s ± 59.6 and anglers landed their fish on average 34.7 m ± 34.6 away from their RASSPL bucket. The average time to get the fish into the bucket was 38.2 s ± 36.8, and the average air exposure time was 101.9 s ± 64.3. Air exposure was found to be higher for elasmobranchs (mean: 114 s ± 73.1) than teleosts (mean: 94.3 s ± 37.1). Bleeding was observed in 61 (26.9 %) of the fish, with majority (67.2%) showing limited bleeding and only 5 (8.1 %) were bleeding profusely. The average blood glucose concentration was 2.18 $mmol.l^{-1}$ (± 0.80) for teleosts and 3.75 $mmol.l^{-1}$ (± 1.93) for elasmobranchs, while the average blood lactate concentration for teleosts and elasmobranchs was 6.96 $mmol.l^{-1}$(± 3.66) and 4.79 $mmol.l^{-1}$(± 1.85), respectively. The RAMP score for teleost and elasmobranch fishes was 0.30 ± 0.23 and

0.12 ± 0.20 respectively. “Body flex” appeared to be the most sensitive of the RAMP indicators. Statistical analysis via a linear mixed effects model (LMM) identified fight time ($P < 0.01$) as a significant predictor of blood glucose and air exposure as a significant predictor of blood lactate ($P < 0.01$) in teleosts. Air exposure was found to be a significant predictor of blood glucose ($P < 0.05$) while air exposure ($P = 0.03$) and fight time ($P = 0.04$) were the best predictors of blood lactate in elasmobranchs. A total of 83.9% of the teleosts suffered some form of reflex impairment compared with 31.4 % of the elasmobranchs. 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. During the survival experiment mortality only occurred in the *Ariidae* family with a mortality rate of 38.5%, and the RAMP scores of the surviving fishes indicated complete recovery from the impacts of the C&R event.

2.3.1.3 Findings of baseline (2015) assessment

After the baseline data was collected the scientific advisory team examined the data and although we found that the C&R practices resulted in low immediate mortality for most species, there was evidence of short-term physiological and motor impairment. Since the inshore coastal region is predator rich, this impairment is likely to result in reduced survival of these fishes and it was decided that an intervention to improve angler C&R behaviour and fish health was required. Based on these findings and our experience in the fishery, several angler behaviours and rules that contributed to long air exposure times and were thought to negatively impact the health of captured fishes were identified. These included: 1) the time it took anglers to transfer fish from the shoreline to their C&R bucket; 2) the extended time that anglers took to measure and photograph the fish on the mat and for the “trophy” photo; 3) the transport of fish back to the sea for release without the use of

the C&R bucket and 4) the rule that required the length of the fish to be written on the card for the photograph on the mat. The implementation of this rule increased the air exposure as the fish either had to remain out of the water while the angler wrote down its length, or the fish had to be taken from the C&R bucket and measured for a second time.

The scientific advisory team decided that a broad-scale intervention to improve the above-mentioned concerns would be necessary to improve the environmental impact of the RASSPL and this intervention is described in Chapter 3.

Chapter 3: Evaluating a pro-environmental behavioural strategy for improving catch-and-release behaviour

Early morning sunrises enjoyed by anglers and researchers alike, at the 2017 RASSPL Nationals. (Photo credit: Angus Van Wyk)

3.1 Introduction

Voluntary catch-and-release (C&R) angling is increasingly being adopted by recreational anglers worldwide as a conservation mechanism with hopes of reducing the impact of anglers on the decreasing global fish populations (Arlinghaus, 2007; Arlinghaus et al., 2009; Brownscombe et al., 2015; Lennox et al., 2015; Chapman et al., 2018; Weltersbach et al., 2018). Studies estimate that more than half of all fish captured by recreational anglers are released (see Chapter 1), emphasizing the importance of C&R angling worldwide. The appeal of C&R fishing is that the released fish survive and rejoin the population as viable individuals. This however is not the case with many studies emphasizing that released fishes are not guaranteed survival due to the many adverse effects caused by negligent C&R practices (Cooke & Philipp, 2004; Bartholomew & Bohnsack, 2005; Cooke & Suski, 2005; Gingerich et al., 2007; Alòs et al., 2016; Brownscombe et al., 2017; Ferter et al., 2017; Hessenauer et al., 2018; Martins et al., 2018; Weltersbach et al., 2018).

While the survival of a fish after a C&R event is influenced by a number of factors (including environmental conditions, fish species characteristics and the presence of predators), several factors can be influenced by improving angler behaviours with regard to fish handling practices (Arlinghaus et al., 2007; Raby et al., 2013; Cook et al., 2015; Brownscombe et al., 2017; Arkert et al. 2018; Guckian et al., 2018). Altering angler behaviour is vital as these are generally the only factors that can be directly controlled. Researchers have identifying effective C&R practices as reducing fish fighting times, limiting handling and reducing air exposure (Davis, 2010; Raby et al., 2012; Cooke et al., 2013; Cook et al., 2015; Danylchuk et al., 2017; Danylchuk et al., 2018 Twardek et al., 2018).

This information has been disseminated in the form of best practice guidelines (Cooke and Suski, 2005; Brownscombe et al., 2015; Brownscombe et al., 2017; Sims and Danylchuk, 2017; Guckian et al., 2018; Weltersbach et al., 2018), however there are limited examples demonstrating improvements in angler C&R behaviour in response to interventions (Delle Palme et al., 2016; Cooke et al., 2017). The lack of evidence supporting improvement in angler C&R behaviour in response to intervention (besides Delle Palme et al., 2016) may be due to the traditional interventions having focused on the outdated KAB models, which are not considered to be particularly effective for improving environmental behaviour (Burgess et al., 1998; Courtney-Hall & Rogers, 2002; Kollmuss & Agyeman, 2002; Kennedy et al., 2009).

The constant increase in the human population and the negative effects on the environment that accompany it have resulted in the development of a multitude of pro-environmental strategies that aim to reduce these anthropogenic pressures by altering human behaviour (see Chapter 1). The Gellar (2002) “DO IT” strategy (adapted by Steg & Vlek, 2009) provides an appropriate framework to implement a pro-environmental behavioural intervention on the C&R behaviour of recreational anglers. This four-step strategy included: (1) the careful selection of the behaviours to be changed, (2) the examination of what factors cause these behaviours and their antecedents, (3) the application of interventions to change relevant behaviours and (4) the systematic evaluation of the effects of these interventions on the behaviour. Gardner and Stern (2002) proposed that a combination of interventions is most likely to be effective in changing environmental behaviour, and Steg and Vlek (2009) suggested the range of interventions should both address the poor behaviours and their antecedents to be effective and that the implementation should occur before and after the behaviour.

At present in a C&R science context, few studies have implemented interventions that

have measurable outcomes, with majority of research being focused on providing education via best practice guidelines (Cooke & Suski, 2005; Brownscombe et al., 2015; Brownscombe et al., 2017; Sims & Danylchuk, 2017; Guckian et al., 2018; Weltersbach et al., 2018). Delle Palme et al. (2016) provides the only formal assessment of effective C&R outreach activities that not only focus on angler knowledge but also include measurable consequences of the intended behavioural change on the released fish. They focused on implementing three different educational interventions and then compared the biological evidence so as to measure the efficacy of the interventions. The results from this study were promising as they identified that fishing workshops can transfer information on C&R practices that lead to improved fish conditions, however this study only assessed short term knowledge retention and application. There is also no evidence of any interventions having included consequence components, which could be extremely valuable as it is human nature to repeat behaviours that result in positive outcomes and reduce behaviours that have led to negative consequences (Bolderdjik et al., 2012).

The RASSPL provided an excellent case study to test the efficacy of the Geller (2002) strategy. Butler et al. (2017) collected baseline information on the C&R behaviour of this group of anglers (see Chapter 2). They found that the mean air exposure time of the fish was high (94.3 ± 57.1s for teleosts and 114.0 ± 73.1s for elasmobranchs) and that several components of the C&R event, including the time taken for anglers to get their fish into the C&R bucket and the time taken for measurement and photographs were high and could be considered for the implementation of appropriate interventions.

The aim of this chapter was to evaluate the efficacy of the Gellar (2002) four-step framework in a C&R context by utilizing the RASSPL to alter angler behaviour in a pro-environmental manner. To do this, the research team developed and implemented several interventions to improve the poor C&R behaviours and then measured the impacts of the

interventions in subsequent national competitions over the next two years (2016 and 2017).

3.2 Materials and methods

3.2.1 Interventions

A combination of antecedent and consequence strategies was used to address the high air exposure time of fishes released during the RASSPL. The antecedent interventions included informational strategies, such as presentations and behavioural modelling, and structural strategies, such as rule-changes. Behavioural modelling refers to the physical demonstration of the correct manner to fulfil the specific behaviour in question. Gifford (2014) describes modelling as "when a key player enacts the desired behaviour so as to influence proximate others to follow suit". The consequence strategies included rewards, penalties, and feedback.

Two presentations were designed to improve angler knowledge. The first, entitled "*The science of C&R angling*" provided information on why recreational angling has the potential to be destructive, highlighted why C&R was an important practice for improving the state of fish stocks and provided a summary of some of the most relevant research on the topic. This presentation was disseminated eight times from a local franchise to national level between May 2015 and April 2016. The second presentation, entitled "*RASSPL and science: working together for a sustainable fishery*", reinforced scientific knowledge on C&R, but also placed it into a RASSPL context by using the information collected during the baseline experiment in 2015 (Butler et al., 2017). It also emphasized the potential role of RASSPL anglers in educating their peers on best practices for C&R. This presentation was disseminated on four occasions at local, regional and international fora between May 2016 and April 2017.

The behavioural modelling comprised two videos that demonstrated best-practice for C&R

with the RASSPL rule framework. A video of a national RASSPL representative illustrating the best practices from capture to release was distributed via the RASSPL website (www.rasspl.com) and Facebook page (https://www.facebook.com/Rock-And-Surf-Super-Pro-League-162436383790950/), and presented to anglers during local and national competitions in 2015. A second video that incorporated the new rule changes was distributed in a similar fashion and on each franchise's WhatsApp groups in 2016.

Several rule changes were recommended by the research team and incorporated into the RASSPL competitions. These rules were first mentioned in the annual scientific report which was distributed to the national committee in June and accepted for promulgation in July 2015. These included a rule that restricted anglers from sharing a C&R bucket and a rule that restricted the allowable maximum distance (50 m) between an angler and their water-filled C&R bucket. In addition, several non-enforceable guidelines were suggested. These included encouragement for anglers to assist one another with the C&R process to ensure fish were released as soon as possible, a suggestion that anglers must be prepared, with the mat, camera, score card and longnose pliers before the C&R event, that their fellow anglers were aware of how to operate the digital camera that they were using and that they should release fish, where possible, into large rock-pools with access to the sea (on a higher tide), so that they could recover, before exposure to predators.

Consequence strategies included prizes for best handling practices during the national tournament (assessed as the individuals with the lowest mean air exposure times when more than three C&R events were observed by the research team). A floating "conservation" trophy was introduced to the local franchise team with the lowest mean air exposure time and least "poor handling practices" for their C&R events during the national competition. This was awarded during the prize-giving held on the last day of the competition. In terms of penalties, fish were disqualified if an angler hooked them further

than 50 m from their C&R bucket, or if the C&R bucket was empty when the fish was landed.

Another consequence strategy was feedback, which comprised annual science reports which were distributed to the national committee and then to all RASSPL anglers. In addition, data collected during the national competitions were summarized and presented to anglers during the prize-giving of the national competitions. This included basic information such as the number of species and individuals captured, and aspects of angler behaviour (e.g. average fight time, distance of the angler from the bucket and the mean air exposure times for elasmobranchs and teleost species). During the 2016 and 2017 national competitions, this information was compared with the previous years to illustrate the progress that was made.

3.2.2 Evaluation of the intervention

To measure the efficacy of the strategy, angler C&R behaviour and the health and survival of fishes were monitored during three RASSPL national competitions held near East London (EL) in the Eastern Cape (2015), Struisbaai (ST) in the Western Cape (2016) and Mossel Bay (MO) in the Western Cape (2017) (Figure 3.1). All three sites are situated in the warm-temperate bioregion along the South coast of South Africa. The habitats in each site were similar with an approximately 40 km long fishing zone and were comprised of areas with sandy, rocky and mixed shorelines. Sea temperature was recorded several times daily during each competition.

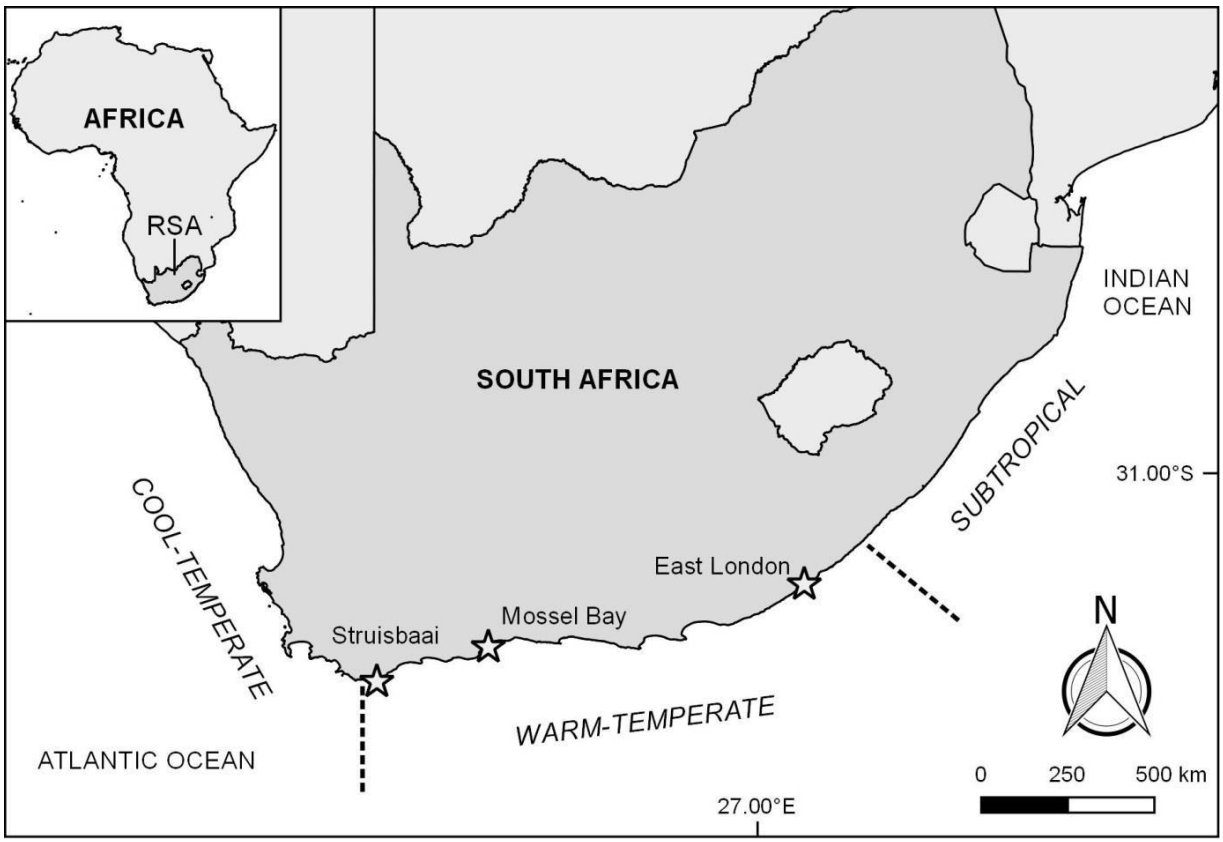

Figure 3.1 The different biogeographic zones of the South African coastline highlighting the three different venues of the Rock and Surf Super Pro League (RASSPL) National competitions between 2015 and 2017 (East London, Mossel Bay and Struisbaai).

Data collection was performed using methods described by Butler et al. (2017) (see Chapter 2). Research teams, consisting of between two and three individuals, started recording information from the moment they noticed an angler hooking a fish. A stopwatch was used to record fight time, time taken to place the fish in the C&R bucket, total air exposure and total time of the C&R event. The distance from where the angler hooked the fish to their C&R bucket was estimated.

From a biological perspective, the time of day, species, hook placement (corner of the mouth, upper lip, lower lip, throat or foul-hooked somewhere on the head or body of the fish) and ease of hook removal ("easy" < 20 s or "difficult" > 20 s for the angler to remove

the hook) were noted. The level of bleeding caused by hooking or other injuries was categorized between 0 and 3. The length of each fish was measured by the angler and noted by the researchers. To assess the stress levels incurred by the fish during the C&R event, teams either conducted reflex action mortality predictor (RAMP) assessments (Davis, 2010), or extracted blood to measure the secondary stress responses in the same manner as described by Butler et al. (2017), (see Chapter 2). The RAMP values were treated as objective measurements, as has been done in previous studies (Bower et al., 2016).

3.2.3.Statistical Analysis

Angler behaviour and fish health data were analyzed separately. Angler behaviour data included “distance from bucket”, “time into bucket” and “total air exposure” for all fish observed during the three competitions. As there is considerable interspecies variability in the response of fishes to C&R (Cooke & Suski, 2005; Jerome et al., 2017), fish health was only compared for species where reasonable numbers were captured during each competition. Thus, mean blood lactate level, blood glucose level and RAMP were only compared between the three competitions for the teleost *Diplodus sargus capensis* (Sparidae), and elasmobranchs, *Haploblepharus* spp. (Scyliorhinidae) and *Rhinobatos annulatus* (Rhinobatidae), (Figure 3.2). Data that met normality and homogeneity of variance assumptions were compared using ANOVAs, followed by Tukey HSD post-hoc tests. Non-normal data were analysed using the non-parametric Kruskal-Wallis rank sum test and the Dunn (1964) post-hoc test. All statistical analyses were conducted in R version 3.4.1 (R Development Core Team).

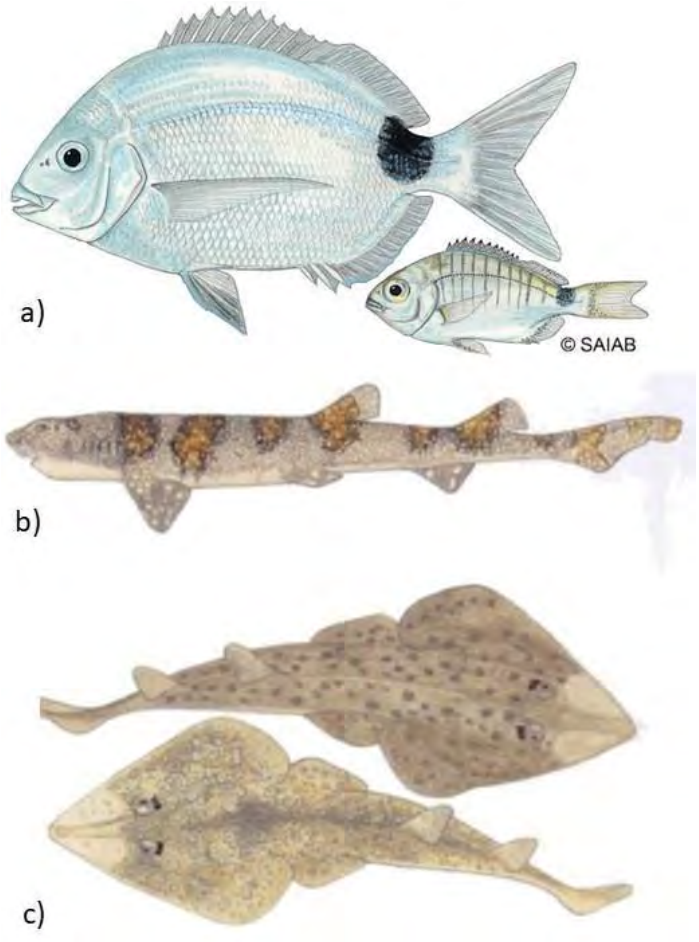

Figure 3.2 Illustrations of the three species most commonly caught at the Rock and Surf Super Pro League (RASSPL) National competitions between 2015 and 2017, and therefore examined in the fish health section, namely a) *Diplodus capensis,* b) *Haploblepharus* spp and c) *Rhinobatos annulatus (illustrations courtesy of South African Institute for Aquatic Biodiversity).*

3.3 Results

3.3.1 General

A total of 160, 119 and 115 anglers competed in the 2015, 2016 and 2017 competitions, respectively, with a total of 269 individuals across all three competitions. Of these 269, 12% participated in all three competitions, 22% participated in two and 66% participated in only one of the competitions. Only 12% of these participants were female anglers (31 out of 269), with numbers ranging from 18 in 2015 to 12 in 2017.

In total, the C&R event was observed for 659 fish belonging to 40 different species (20 families). These included 242 in 2015 (45 "blood chemistry", 113 "RAMP", 84 independent samples including survival), 208 in 2016 (48 "blood chemistry", 92 "RAMP", 68 independent samples including survival) and 209 in 2017 (80 "blood chemistry", 68 "RAMP", 61 independent samples) (Appendix A, B, C). A significant difference was observed between the mean sea water temperatures at the different sites (EL = 17.94 ± 0.69, ST = 16.23 ± 0.49, MO 16.40 ± 0.57, Kruskal-Wallis ANOVA: $H_{2, 70}$ = 41.45, $p < 0.01$). Post hoc analysis identified that all three years were significantly different from one another.

3.3.2 Angler Behaviour

There was a significant difference in average total air exposure among all three years (Kruskal- Wallis ANOVA: $H(_{2, 618})$ = 29.48, $P < 0.01$), with a significant decline from 2015 (101.93 s ± 64.34) to 2016 (87.57 s ± 49.37) and 2017 (77.37 s ± 60.52) ($P < 0.01$) (Figure 3.3a). The mean distance between the angler and their C&R bucket was greatest in 2015 (34.65 m ± 34.57), followed by 2017 (29.4 m ± 31.01) and 2016 (17.11 m ± 17.25) (Figure 3.3b) and was significantly different among years (Kruskal-Wallis ANOVA: $H(_{2, 582})$ = 56.92), $P < 0.01$). Dunn post hoc analysis identified that all three years were significantly different from one another. The mean time taken from the landing of a fish to its placement in the C&R bucket declined from 47.80 s ± 64.30 in 2015 to 32.32 s ± 27.52 in 2016 and 23.05 s ± 24.13 in 2017. There was a significant difference among each year (Kruskal-Wallis ANOVA: $H(_{2, 559})$ = 289.01, $P < 0.01$) (Figure 3.3c). Dunn post hoc analysis identified that all three years were significantly different from one another ($P < 0.05$).

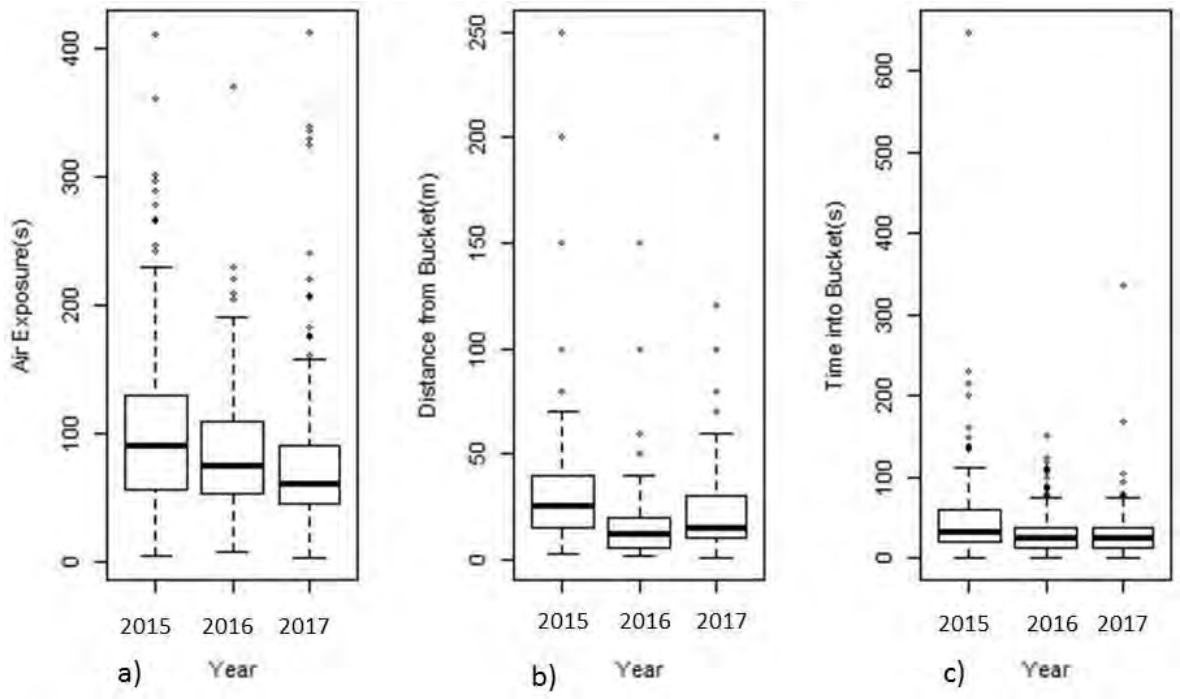

Figure 3.3 Comparison of the mean air exposure (a), distance from bucket (b) and time into bucket (c) for all species caught during the Rock and Surf Super Pro League (RASSPL) annual national competitions between 2015 and 2017.

3.3.3 Fish health

There were significant differences in the mean blood glucose level for all fish among the three years (Kruskal-Wallis ANOVA: $H_{(2,\ 162)} = 10.42$, $P < 0.01$), changing from 2.94 mmol.l^{-1}± 1.65 in 2015 to 2.08 mmol.l^{-1}± 0.69 in 2016, but then increased to 3.03 mmol.l^{-1}± 1.71 in 2017 (Appendices A, B, C). Significant differences were observed between 2015 and 2016 ($P = 0.01$), as well as between 2016 and 2017 ($P < 0.01$). The mean blood lactate level decreased significantly over the years, from 6.10 mmol.l^{-l} ± 3.23 in 2015 to 5.19 mmol.l^{-l} ± 2.42 in 2016, and 4.72 mmol.l^{-l}± 3.69 in 2017 (Kruskal-Wallis ANOVA: $H_{(2,\ 153)} = 7.53$, $P = 0.02$), with significant differences observed between 2015 and 2017 ($P = 0.03$). While there were no significant differences observed between

the mean ordinal RAMP scores among years (Kruskal-Wallis ANOVA: $H_{(2, 271)} = 3.19$, $P = 0.20$), mean RAMP scores were highest in 2015 (0.25 ± 0.23), followed by 2016 (0.20 ± 0.22), and 2017 (0.23 ± 0.25).

3.3.3.1 Diplodus capensis

There was no significant difference in the mean length of *Diplodus capensis* among years (2015 = 268.85 mm ± 36.45, 2016 = 262.04 mm ± 25.73, 2017 = 259.41 mm ± 31.52) (ANOVA: $F_{(2, 84)} = 0.682$, $P = 0.51$). There was a significant change (Kruskal-Wallis ANOVA: $H_{(2, 85)} = 9.63$, $P < 0.01$) in mean air exposure for this species, with 2017 (52.06 s ± 33.31) significantly lower than 2015 (88.22 s ± 50.45) ($P < 0.01$) (Figure 3.4a). There was a significant difference (ANOVA: $F_{(2,21)} = 4.66$, $P = 0.02$) in mean blood glucose levels of *Diplodus capensis* among years, with the difference being between the years 2016 (2.06 $mmol.l^{-1}$ ± 0.86) and 2017 (2.94 $mmol.l^{-1}$ ± 0.37) ($P = 0.02$) (Figure 3.4b). Although the blood lactate levels declined from 9.46 $mmol.l^{-1}$ ± 3.80 in 2015 to 7.17 $mmol.l^{-1}$ ± 3.39 in 2016 and 6.69 $mmol.l^{-1}$ ± 2.99 in 2017 (Figure 3.4c) they were not significantly different (ANOVA: $F_{(2, 19)} = 1.53$, $P = 0.24$). Mean RAMP values remained fairly stable (2015 = 0.28 ± 0.22, 2016 = 0.23 ± 0.16, 2017 = 0.19 ± 0.17) and were not significantly different (Kruskal-Wallis ANOVA: $H_{(2, 43)} = 1.51$, $P = 0.47$) among the years (Figure 3.4d).

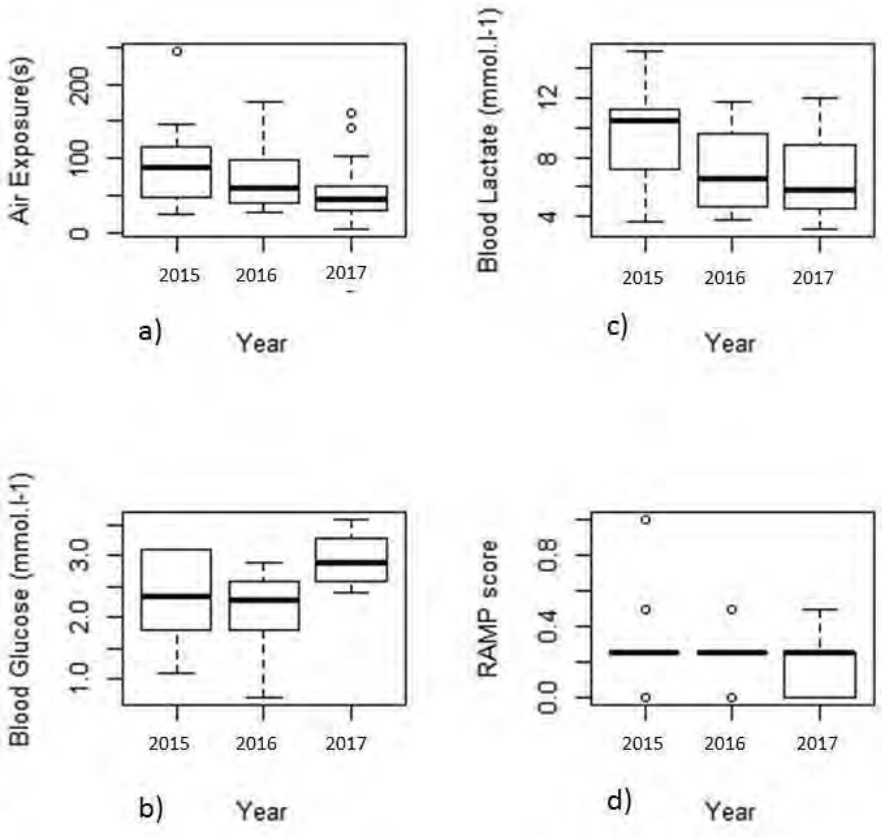

Figure 3.4 Comparison of the mean air exposure (a), blood glucose level (b), blood lactate level (c) and Reflex Action Mortality Predictors (RAMP) (d), for *Diplodus capensis* during the Rock and Surf Super Pro League (RASSPL) annual national competitions between 2015 and 2017.

3.3.3.2 Haploblepharus spp

There was no significant difference in the mean length of individuals belonging to the *Haploblepharus* species complex (*Haploblepharus edwardsii* and *Haploblepharus fuscus*) among years (2015 = 523.16 mm ± 91.21, 2016 = 437.68 mm ± 186.56, 2017 = 581.43 mm ± 45.98) (Kruskal-Wallis ANOVA: $H_{(2,\ 59)} = 5.51$, $P = 0.06$). There was a significant difference between the mean air exposure times for *Haploblepharus* spp over the three-year period (Kruskal-Wallis ANOVA: $H_{(2,\ 68)} = 10$, $P < 0.01$) with lower values in 2016 (58.22 ± 33.07) than in 2015 (99.56 ± 54.99), ($P < 0.01$) (Figure 3.5a). Blood glucose concentrations (Figure 3.5b) remained fairly stable (2015 = 3.4 $mmol.l^{-1}$ ± 1.13, 2016 = 2.68 $mmol.l^{-1}$ ± 0.73, 2017 = 3.16 $mmol.l^{-1}$ ± 0.33), and were not significantly different

among years (ANOVA: $F_{(2,\ 24)} = 1.32$, $P = 0.29$). There was a significant difference (Kruskal-Wallis ANOVA: $H_{(2,\ 23)} = 11.47$, $P < 0.01$) among mean blood lactate concentrations (Figure 3.5c) for *Haploblepharus* spp, with 2017 (1.76 mmol.l^{-1} ± 0.78) being significantly lower than 2015 (4.25 mmol.l^{-1} ± 1.89) and 2016 (4.34 mmol.l^{-1} ± 2.18) ($P < 0.01$). The RAMP values for this species complex remained fairly constant over the years, from 0.15 ± 0.18 in 2015 to 0.14 ± 0.20 in 2016, and < 0.01 ± < 0.01 in 2017, with no significant differences among years (Kruskal-Wallis ANOVA: $H_{(2,\ 30)} = 1.44$, $P = 0.49$) (Figure 3.5d).

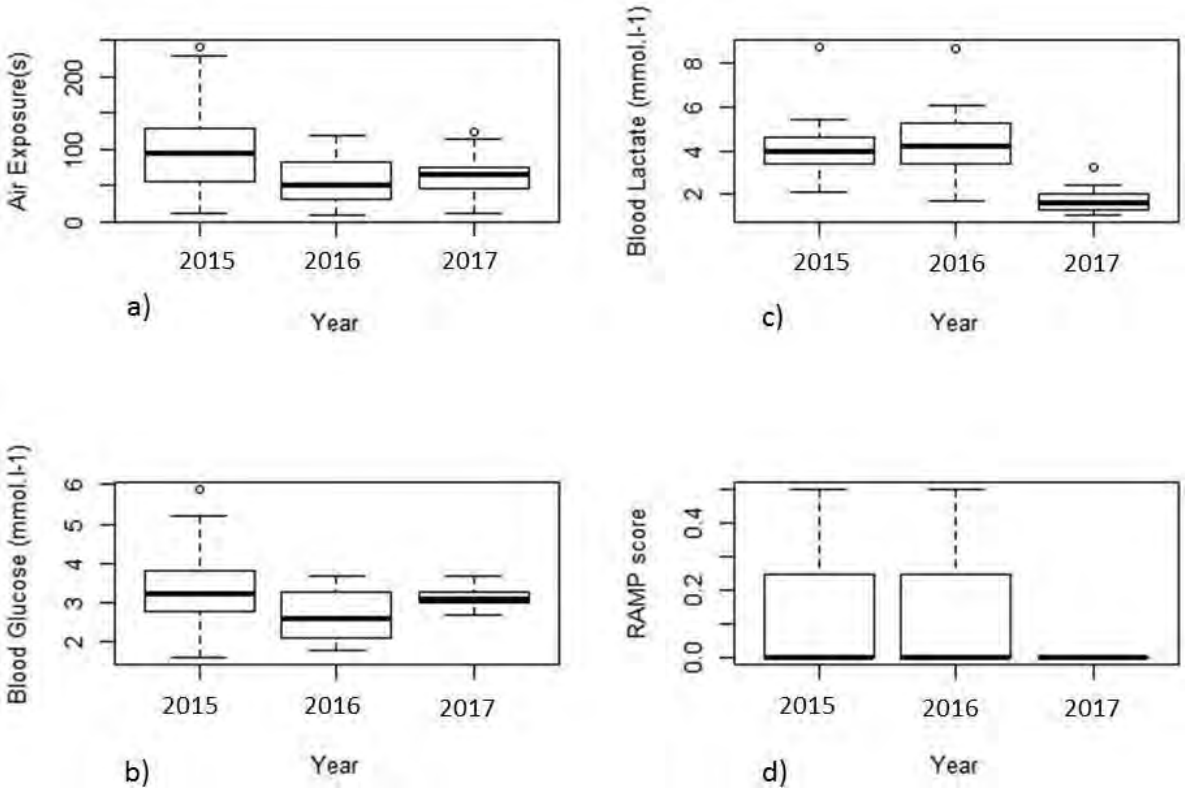

Figure 3.5 Comparison of the mean air exposure (a), blood glucose level (b), blood lactate level (c) and Reflex Action Mortality Predictors (RAMP) (d), for the *Haploblepharus* species complex during the Rock and Surf Super Pro League (RASSPL) annual national competitions between 2015 and 2017.

3.3.3.3 Rhinobatos annulatus

Rhinobatos annulatus were significantly smaller in 2015 (600.77mm± 134.56), than in 2016 (781.59 mm ± 100.86) and 2017 (758.72 mm ± 222.35) (ANOVA: $F_{(2, 75)} = 4.56$, P = 0.01; Tukey HSD). There was a significant difference in the mean air exposure between years (Kruskal- Wallis ANOVA: $H_{(2, 80)} = 7.23$, P = 0.03) (Figure 3.6a), with the difference being between 2016 (112.24 s ± 51.1) and 2017 (78.22 s ± 37.74) (P = 0.01). Blood chemistry parameters were only collected in sufficient numbers for blood glucose level comparisons between 2015 (2.4 $mmol.l^{-1}$ ± 0.57) and 2017 (1.91 $mmol.l^{-1}$ ± 0.55), and blood lactate level comparisons between 2016 (3.6 $mmol.l^{-1}$) and 2017 (2.55 $mmol.l^{-1}$ ± 1.83). There were no significant differences present between lactate concentrations (Figure 3.6c) (ANOVA: $F_{(1, 12)} = 0.21$, P = 0.66) or between glucose concentrations (Figure 3.6b) (Kruskal-Wallis ANOVA: $H_{(1, 15)} = 1.65$, P = 0.20). RAMP values (Figure 3.6d) were significantly different (Kruskal-Wallis ANOVA: $H_{(2, 35)} = 8.13$, P = 0.02) between 2015 (0.33 ± 0.24) and 2016 (0.09 ± 0.15) (P < 0.01).

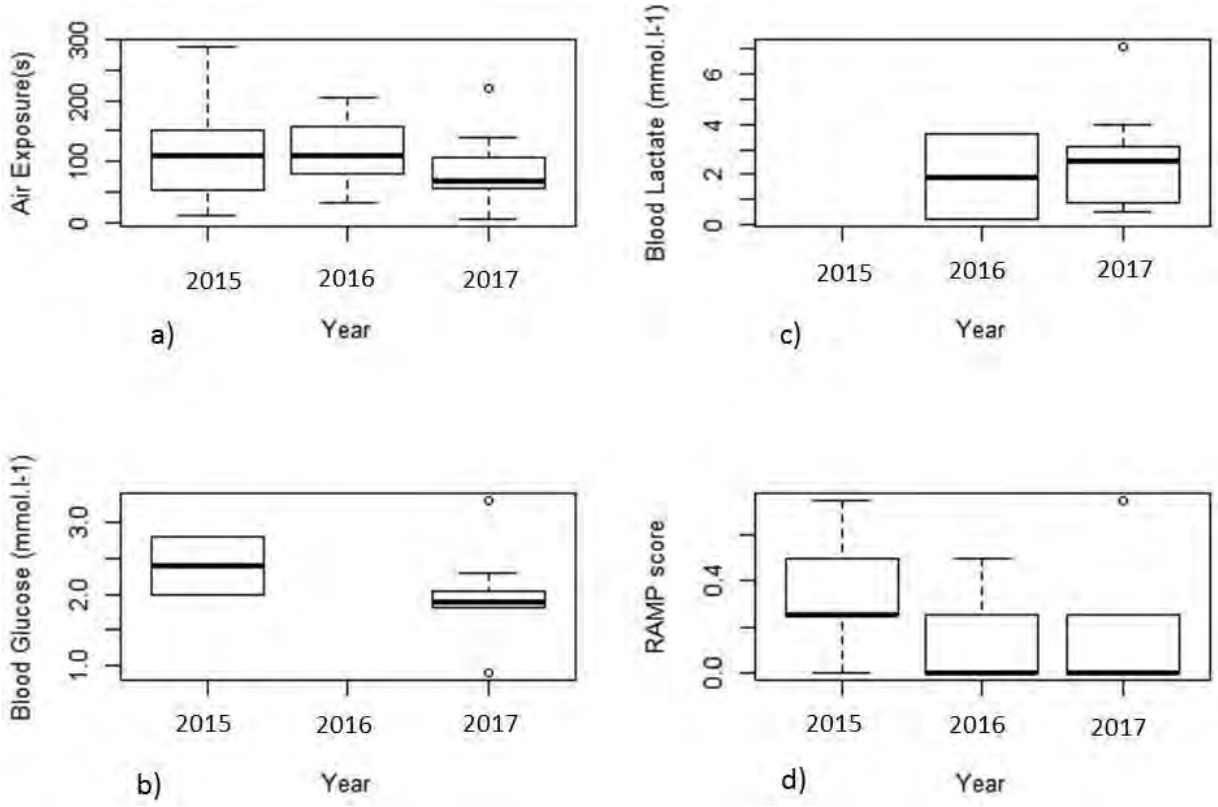

Figure 3.6 Comparison of the mean air exposure (a), blood glucose level (b), blood lactate level (c) and Reflex Action Mortality Predictors (RAMP) (d), for *Rhinobatos annulatus* during the Rock and Surf Super Pro League (RASSPL) annual national competitions between 2015 and 2017.

Table 3.1 Comparison of fish health parameters (means ± SD) and statistical significance (P values) for the three most dominant species (*Diplodus capensis, Haploblepharus* species complex and *Rhinobatos annulatus)* caught in the Rock and Surf Super Pro League (RASSPL) annual national competitions between 2015 and 2017.

Species		2015	2016	2017	P-value
		mean ± SD	mean ± SD	mean ± SD	
Diplodus capensis	Length (mm)	268.85 ± 36.4	262.04 ± 25.73	259.41 ± 31.52	0.51
	Air Exposure (s)	88.22 ± 50.45	73.7 ± 45.82	52.06 ± 33.31	< 0.01
	Blood Glucose (mmol.l-1)	2.3 ± 0.8	2.06 ± 0.86	2.94 ± 0.37	0.02
	Blood Lactate (mmol.l-1)	9.46 ± 3.8	7.17 ± 3.39	6.69 ± 2.99	0.24
	RAMP	0.28 ± 0.22	0.23 ± 0.16	0.19 ± 0.17	0.47
Haploblepharus spp	Length (mm)	523.16 ± 91.21	437.68 ± 186.56	581.43 ± 45.98	0.06
	Air Exposure (s)	99.56 ± 54.99	58.22 ± 33.07	65.8 ± 35.05	< 0.01
	Blood Glucose (mmol.l-1)	3.4 ± 1.13	2.68 ± 0.73	3.16 ± 0.33	0.29
	Blood Lactate (mmol.l-1)	4.25 ± 1.89	4.34 ± 2.18	1.76 ± 0.78	< 0.01
	RAMP	0.15 ± 0.18	0.14 ± 0.20	< 0.01 ± < 0.01	0.49
Rhinobatos annulatus	Length (mm)	600.77 ± 134.56	781.59 ± 100.86	758.72 ± 222.35	0.01
	Air Exposure (s)	115.25 ± 77.87	112.24 ± 51.1	78.22 ± 37.74	0.03
	Blood Glucose (mmol.l-1)	2.4 ± 0.57	-	1.91 ± 0.55	0.2
	Blood Lactate (mmol.l-1)	-	3.6	2.55 ± 1.83	0.66
	RAMP	0.33 ± 0.24	0.09 ± 0.15	0.16 ± 0.27	0.02

3.4 Discussion

The results of this study have demonstrated that long-term strategic interventions can promote improvements in angler C&R behaviour. When compared with the baseline year (2015), there were significant improvements with regards to the air exposure of fish and angler handling practices in general and that these could be linked to strategies in the intervention. There was concurrent evidence of improvements in fish health, with some of the indicators (e.g. blood lactate levels for *Haploblepharus* spp, RAMP scores for *Rhinobatos annulatus*) showing significant improvements between the baseline and later years. These findings suggest that interventions may lead to considerable improvements in the survival of released fishes in the predator rich, coastal environment.

Until now the one dimensional (mostly educational) approach that has been taken by scientists and managers to improve C&R behaviour has been met with limited success (Cooke et al., 2017). However, this study demonstrated that the Gellar (2002) pro-environmental behaviour framework provided an appropriate method for implementing behavioural changes in a C&R context. While this method may be appropriate, it should be noted that the research team had extensive knowledge of the RASSPL league and the angler ethics and culture before its implementation and were able to accurately identify the behaviours that impacted fish health and select appropriate interventions for improving those behaviours. This will not always be the case, and it is suggested that scientists or managers either partner with, or embark on an extensive consultation process with anglers that are experienced in a given fishery to ensure a thorough understanding of the contextual factors surrounding their C&R behaviour.

Besides the implementation of the Geller (2002) framework, it is likely that the use of a diverse range of antecedent (informational, structural) and consequence (rewards, feedback) strategies were necessary to encourage behavioural change. Steg and Vlek (2009) proposed that strategies should be identified based on the behavioural determinant. In the case of this study, the RASSPL rules, which required specific photographs (including length information of the fish on the angler's score card), were both a behavioural determinant and a contextual barrier to behavioural change. This could only be remedied using a structural change, which was brought about through an amendment to the rule system. In another example, the seemingly lax attitude of anglers when moving the captured fish to the C&R bucket during the baseline study (2015) was attributed to a lack of knowledge of the impacts of air exposure on fishes. We attempted to remedy this using an educational intervention. Thus, scientists or managers that aim to change C&R behaviour should ensure that the strategy that is chosen is based on the determinant of

the behaviour selected for change.

Stern (2000) proposed the use of a combination of interventions to improve environmental behaviour. Indeed, the value of the diverse interventions implemented in this study was evident from their apparent synergistic interactions. This was demonstrated when one examines the changes in the distance from the angler to his/her C&R bucket (Figure 3.2b) and the time taken for the angler to place the fish into the C&R bucket over the years (Figure 3.2c). It was clear that the structural rule change played a major role in reducing the distance between the angler and the time that it took to place the fish into the C&R bucket in 2016. However, by 2017, the continued decrease in the time taken to get the fish into the C&R bucket could no longer be attributed to the rule change (as the mean distance from the bucket was actually further than 2016). Education has proven to promote pro-environmental behaviour (Lehman & Gellar, 2004; Steg & Vlek, 2009; Hessami & Yousefi, 2013) and it is most likely that the increased awareness of the importance of limiting the air exposure of fishes could explain the reduced time to place the fish into the C&R bucket in 2017. Ultimately, interventions that include multiple strategies, each targeted to remove specific barriers will most likely be more effective when attempting to improve angler C&R behaviour.

Despite observations of improved angler C&R behaviour using the Geller (2002) strategy, the importance of gaining the trust of the RASSPL anglers before this intervention cannot be overemphasized. In general, the relationship between scientists and fishers in South Africa and many parts of the world is rather distrustful (Dedual et al., 2013). Recreational anglers, in particular, blame scientists for increased restrictions in the regulatory frameworks, suggest that scientists are out of touch with reality and feel that they are arrogant (Bower et al., 2017; Danylchuk et al., 2017). It is likely that the initial measured approach was a key to this successful intervention as it allowed the researchers an

opportunity to build trust, offer a service (the development of the database) and understand the culture and values of the RASSPL anglers. As competitors in the league, the research team was also able to understand contextual factors which shape how anglers think and behave during competitions. Ultimately, this helped the research team devise appropriate rules and recommendations for change that in the RASSPL context and were thus readily accepted by anglers.

Although these results do suggest that anglers improved their C&R behaviour as a result of these interventions, it is possible that this was an artefact of altered behaviour in the presence of the research teams. In this case, the differences between the baseline and other competitions could potentially be attributed to improvements in angler knowledge, which then translated to “improved” angler behaviour in the presence of a research team. Although it is possible that the findings were not a true reflection of angler behaviour, they do however suggest that the educational component of the interventions was operating as these improvements would only be possible with better angler knowledge.

Although the results demonstrated that it is possible to improve angler C&R behaviour, it is imperative that these changes should positively impact the health of released fishes to justify the considerable time and effort required for such an intervention. Comparisons on fish health were possible for *R. annulatus, Haploblepharus* spp and *D. capensis* (Figure 3.2). The significant decline in the mean RAMP score of *R. annulatus* between 2015 and 2016 (Figure 3.5d) suggested that there were lower levels of stress and motor impairment (Davis, 2010; Raby et al., 2012) and thus most likely reduced detection by predators and improved the escape response of this species (Jerome et al., 2017). There was also a clear, albeit, insignificant decline in the blood lactate level for *D. capensis* over the years (Figure 3.3c) and a significant decline in the blood lactate level for the *Haploblepharus* complex in 2017 (Figure 3.4c). These findings are unsurprising as several studies have

found a relationship between blood lactate levels and air exposure in fishes (Arends et al., 1999; Butler et al., 2017). There is limited information on the consequences of high blood lactate levels on predation (Raby et al., 2014). Dallas et al. (2010) failed to identify a response of the predatory lemon shark to a pulse of lactate, suggesting that this stressor may not attract predators. However, increased blood lactate levels provides evidence of a build-up of lactic acid in fish muscles (Arlinghaus et al., 2007) and may therefore provide an indication that predator avoidance will be impaired. Arlinghaus et al. (2009) suggested that physical recovery should occur within one hour. However, since the coastal zone is rich in large predators, it is likely that released individuals may encounter a predator within that time. Therefore, reductions in blood lactate levels will most likely translate to reduced incidences of post-release predation and improved survival after a C&R event.

The findings of this study have shown that it is possible to change the behaviour of competitive recreational fishers. However, the potential greater benefits of this intervention should also be explored. Competitive anglers generally have a high social status among recreational anglers. The general angler populous often look upon these well respected anglers to set trends, including the development of new fishing techniques, testing of the latest fishing tackle, and general behaviour. Therefore, it is hoped that interventions that improve the C&R behaviour of competitive anglers may provide an avenue to modify the behaviour of all anglers through social movements of self-reform.

Finally, while this chapter has shown that it is possible to change angler behaviour through the implementation of multiple interventions, these extensive interventions are time-consuming and cost prohibitive. Therefore, to develop our knowledge on the types of interventions that may be more successful for recreational anglers, it is critical to gain insight into the key motivators of the behavioural change in this case study. This is the focus of Chapter 4 of this thesis.

Chapter 4: Understanding the factors driving pro-environmental behaviour in a catch-and-release angling context

RASSPL anglers scattered across the rocks during the 2018 RASSPL Nationals Tournament. (Image credit: Samantha Mannheim)

4.1 Introduction

In Chapter 3 there was evidence for improved C&R behaviour by RASSPL anglers. This suggested that the overall pro-environmental behavioural approach, which comprised several interventions including awareness and knowledge transfer using presentations and behavioural modelling; structural strategies, such as rule-changes and the penalties associated with the rules; individual prizes and a team trophy for best fish handling practices; and feedback, which included annual science reports and presentations after national competitions, could be successful in improving angler behaviour. However, with multiple highly intensive and time- consuming interventions, the likelihood of implementing similar extensive programs on other recreational fisheries, with limited funding and manpower is low. This limits the reproducibility of these kinds of pro-environmental approach interventions. Therefore, the identification of key interventions that drive improved environmental behaviour is critical to streamline this process and improve our understanding of what kind of pro-environmental interventions are appropriate for recreational anglers. However, understanding the drivers behind pro-environmental behaviour has proven to be a highly complex field because of the many different factors that influence behaviour and decision-making (as seen in Chapter 1).

Kollmuss and Agyeman (2002) categorized the factors that influence behaviour into demographics, external factors and internal factors. External factors refer to social, economic, cultural and institutional aspects, and internal factors refer to motivations, knowledge and awareness, values, attitudes, emotions, locus of control, responsibilities and priorities. Understanding how each of these factors may influence environmental behaviour is important as these may explain why specific interventions have been more successful than others.

The demographic context of a community is important as previous studies have found that age (Stern et al. 1995; Tindall et al., 2003), gender (Dietz et al., 1998; Zelezny et al., 2000; Vaske et al., 2001), level of education and income (Cordell et al., 2002; Xiao & Hong, 2007), and ethnicity (Johnson et al., 2004; Floyd, 2007) can influence pro-environmental attitudes and behaviour. For example, Chen et al. (2013) found that highly educated, young, single, female respondents displayed more pro-environmental behaviours than their counterparts. This corresponds with most research on demographics which indicates that the best response to pro-environmental behavioural interventions is normally associated with younger, female individuals with higher levels of education (Dunlap et al., 2000; Kollmuss & Agyeman, 2002; Peterson et al., 2008). In contrast, older individuals often give in to the influence of habits (Shove, 2010), with Carfora et al. (2017) concluding that past behaviours are the strongest predictor of future behaviours. Fliegenschnee and Schelakovsky (1998) suggested that practice is vital when trying to establish a new behaviour (as seen in Kollmuss & Agyeman, 2002). Thus, old behavioural patterns can pose as the largest barriers when trying to change behaviour (Stern 2000; Kollmuss & Agyeman, 2002) and thus examining the perceptions of anglers in different age classes may be important to predict future behaviours.

Of the external factors, economics plays a vital role in determining the efficacy of pro-environmental behaviours as they have a strong influence on people's decisions (Kollmuss & Agyeman, 2002). An individual will always weigh up the economic costs and benefits of adopting a new behaviour before committing to it. Earlier studies suggest that there is a positive relationship between income and pro-environmental attitudes and behaviour because wealthier people have more freedom to focus on environmental issues as their material needs are satisfied (Van Liere & Dunlap, 1980; Scott & Willits, 1994). However, in recent years, studies have identified higher pro-environmental attitudes

among citizens of developing countries, highlighting that citizens of poorer countries are more willing to make economic sacrifices for the benefit of the environment as they are more exposed to environmental harm and therefore more willing to make the necessary sacrifices for environmental security (Whittaker et al., 2005; Vikan et al., 2007; Dunlap & York, 2008; Chen et al., 2013). These contrasting findings emphasize the intertwined nature of the many factors (economic, social, infrastructural, institutional) that influence behaviour, as well as support the notion that situational aspects are critical when trying to identify drivers behind behaviour, and therefore it is essential to understand the context of the community for which the intervention is intended (Black et al., 1985; Hunecke et al., 2001).

The majority of pro-environmental behaviours require the development of appropriate institutional structures (Kollmuss & Agyeman, 2002). Schofer and Hironaka (2005) investigated the circumstances under which institutions can be successful in achieving pro-environmental goals, and found institutional success in decreasing environmental degradation. Their findings outlined three criteria for this success; interventions need to be highly structured; they need to penetrate multiple levels of the social system and they are persistent over time (Schofer & Hironaka, 2005). In the context of C&R, these structural factors may include policies that are often developed and implemented as rules and regulations by governing agencies. An example of this is a rule on the exclusive use of a specific hook type. Sauls and Ayala (2012) found altering fisheries regulations to exclusive use of circle hooks as effective in reducing potentially lethal hooking injuries in Florida reef fishes. However, they could also be voluntary rules, developed and implemented by anglers through peer pressure (Chapman et al., 2018; Danylchuk et al., 2018; Guckian et al., 2018). Chapman et al. (2018) and Guckian et al. (2018) both highlighted the underappreciated role played by anglers in promoting best practices through interpersonal

social sanctioning, and Nguyen et al. (2012) identified angler-to-angler interactions as the main channel of communication on responsible practices. When looking at competitive angling bodies there are usually a range of rules and regulations specific to their angling context. The RASSPL league is no different with a variety of steps for each fish that is landed (as seen in Chapter 2). Once a fish (above minimum size limit) is captured, anglers immediately place them into a full C&R bucket to be unhooked, photographed and measured. Anglers record relevant information on score cards and have a witness sign as confirmation of the catch. After the last step, the rules require that the fish be placed into the standardized bucket and returned to the sea.

While traditional, government management regulations are generally effective in the developed world (Arias & Sutton, 2013), they often have limited effectiveness in developing countries where monitoring and surveillance is limited and knowledge of regulations is poor (Kramer et al., 2017). It is also common for these government bodies to create rules and regulations without including public involvement and feedback forums (Kennedy et al., 2009). Unfortunately, these regulations may not always result in the intended outcomes. Indeed, Kramer et al. (2017) found poor support for government regulations that where developed without stakeholder consultation.

In contrast, the development of rules and regulations by anglers themselves, in particular, competitive anglers, may lead to higher levels of compliance (Cooke et al., 2013). Therefore, understanding the structural context of the target community and how they perceive those structures is critical for interpreting research that aims to identify pro-environmental drivers.

Social norms have an important role in shaping the environmental behaviour in general (Thomas & Sharp, 2013; Keizer & Schultz, 2018) and more specifically recreational angler behaviour (Bova et al., 2017; Chapman et al., 2018; Danylchuk et al., 2018; Guckian et al.,

2018). Social norms are the rules or standards understood by a group that guide and constrain behaviour without the force of laws (Keizer & Schultz, 2018). Thomas and Sharp (2013) highlight the power of 'social pressure' on influencing recycling behaviour and the resultant normalization of recycling thereafter in the United Kindgom. A fisheries-specific example would be recreational anglers playing a role in promoting compliance via interpersonal sanctioning and self-policing (Chapman et al., 2018; Guckian et al., 2018). Mackay et al. (2018) encouraged the use of behavioural nudges to fill the gap in fisheries management and improve compliance. Nudges were defined as subtle changes and indirect suggestions to make certain decisions. Danylchuk et al. (2018) suggested that bottom up social norms activities may be the way in which meaningful and long-term improvements in behaviour can be achieved.

Knowledge and awareness are important internal factors that may influence behaviour (Kollmuss & Agyeman, 2002; Kennedy et al., 2009; Cooke et al., 2013). Kennedy et al. (2009) reported that a lack of knowledge or information on pro-environmental behaviour was a significant issue among individuals, and that well-timed and strategically positioned information that addressed a broad range of audiences could be a powerful mechanism for enabling pro- environmental behaviour. Although knowledge and awareness drives on their own have seldom altered environmental behaviour (Burgess et al., 1998; Stern, 2000; Kollmuss & Agyeman, 2002; Schultz, 2011; Gifford, 2014; Cooke et al., 2017), gauging the levels of knowledge and awareness of anglers is most likely a critical contextual factor when interpreting research on pro-environmental drivers.

Motivation is another important internal factor that not only encourages behaviours, but is seen as the driver behind certain behaviours, or the reason for action (Kollmuss & Agyeman, 2002; Schultz, 2011). It can be conscious or unconscious and can take the form

of self -interest, social responsibility and self-transcendent values (Schultz, 2011). Researchers distinguish between primary motives, which focus on the bigger picture like living an environmentally friendly lifestyle, and selective motives, which focus on one specific action (Kollmuss & Agyeman, 2002). Often primary motives are abandoned due to the presence of more immediate selective motives that evolve around one's personal needs. Thus, in a competitive angling setting, immediate selective motives, such as landing a winning fish, may trump the primary motives of care for fish stocks as the angler for example, drags a fish over rocks while landing it. Thus, evaluating the secondary motives of anglers is critical to provide context when identifying drivers of improved behaviour. Incentives and consequences are another form of motivation, with incentives driving individuals to act in a certain way because of what they get out of this desired behaviour, and consequences motivating individuals to act in a certain manner so as to avoid the negative aspects associated with non-compliance (Milner-Gullard, 2012). Schultz (2011) emphasized the need for education and awareness campaigns to be accompanied by some sort of motivational element, stating that when information is coupled with motivation, change can be induced. Indeed, Milner-Gullard (2012) concluded that it is important to understand the drivers motivating a particular behaviour in order to intervene effectively so as to combat biodiversity loss.

Environmental beliefs and perceptions are propositions accepted to be empirically true and therefore used to prioritize conditions and behaviours (Kennedy et al., 2009). People's perceptions and beliefs with regards to the environment and environmental risks are of great importance when it comes to understanding behaviour as they are highly influential in guiding behavioural choices (Smith & Jehlička, 2012; Danylchuk et al., 2017). Perceptions of environmental risks can be defined as the degree to which people see various environmental issues as threatening to their way of life. These perceptions of

threats are important as they play a relatively strong role in shaping environmental behaviours (Smith & Jehlička, 2012). Beliefs and perceptions are often situation-specific and can be subject to change depending on information we learn and context or how one perceives their surroundings (Kennedy et al. 2009). It is a common belief that the adoption of pro-environmental behaviour is demanding in terms of time, cognitive effort, economic and psychological resources (Coelho et al., 2017). These perceived costs are influential as they can deter the adoption of these more environmentally friendly behaviours (Kennedy et al., 2009). Locus of control is an individual's perception of their capability to make a difference and is vital in motivating the adoption of pro- environmental behaviour, as if an individual does not believe their actions have an effect on the situation they are less likely to act in a pro-environmental way (Kennedy et al., 2009; Coelho et al., 2017). The improvement of an individual's locus of control can lead to a sense of responsibility for the state of the environment that they live in and thus improve their behaviour. Therefore, it is essential to gain insight on perceptions and beliefs of the target audiences to promote the adoption of pro-environmental behaviours, so that it becomes possible to attempt to alter these perceptions by addressing their concerns (Kennedy et al., 2009).

In summary, to interpret responsible environmentally-orientated behaviour, one needs to have an in-depth understanding of the socio-demographics and the context of the target audience (Black et al., 1985; Hunecke et al., 2001). It is also necessary to gain an understanding of the structural context of the community, the knowledge, attitudes and perceptions and attempt to alter these perceptions in a positive manner (Kollmuss & Agyeman, 2002). Knowledge of the situation and of potential action strategies should be provided in a well-planned manner so as for optimal information absorption (Kennedy et al., 2009).

This chapter aims to gain insight into the factors that were the most influential in altering

angler's perceptions of C&R behaviour and to use the context of the RASSPL angling community to begin building our understanding of the contextual factors that may influence the efficacy of pro-environmental behavioural interventions with recreational anglers. To do this, a survey that examined the demographics, attitudes, knowledge, motivations, angler perceptions and awareness of RASSPL anglers and their perceptions of the efficacy of our various interventions was designed and disseminated.

4.2 Materials and methods

Permission to contact RASSPL anglers was granted by the RASSPL chairman (see letter in Appendix D) and ethical approval was attained from the Rhodes University Science Faculty (ethical clearance code SCI2018/036, Appendix E). Data collection was conducted via once-off online and in-situ surveys between July and September 2018 and was aimed at anglers that had participated in the RASSPL national events (Appendix F). Angler participation was incentivized by offering a lucky draw prize to all participants. Participants were provided with a brief breakdown of the purpose of the survey, as well as the option to not partake in the survey if they did not wish to.

The survey aimed to gather information on angler demographics, knowledge and awareness, as well as on angler attitudes and perceptions. The survey made use of yes/no questions, Likert scale questions (1-5) and open-ended questions (Appendix F).

Surveys contained questions on demographic information (including age, gender, education, employment status, income and ethnicity), RASSPL fishing history, internal factors (knowledge and awareness, motivations, attitudes and perceptions), and external factors (social norms, economic, cultural or institutional) (see Appendix F for detailed questions). The survey was designed to be as inoffensive and un-incriminating as possible

so as to promote angler honesty.

4.3 Results

A total of 69 anglers completed the surveys which provided data on RASSPL angler demographics and information on their angling histories, external factors and internal factors.

Table 4.1 The RASSPL angler survey findings displaying summarized information on angler demographics, perceptions, attitudes and knowledge, with mean values or percentages of respondents who strongly agreed.

Demographics		**Q3. RASSPL Franchise Survey Participation**		**Q19.** Presence of Research Team Positive	52%
Q63. Age		Border Blacktips	14%	**Q6.** Importance of C&R Angling	82%
Mean	41years	Kowie Crackers	14%	**Q7. Likelihood of survival of released fish**	
Range	18 - 63years	EP Raggies	2%	Mean	87%
Q64. Gender		Namibia	6%	Range	30-100%
Male	90%	SC Great Whites	13%	**Q8.** Improvement since joining RASSPL	67%
Female	10%	WC Blue rays	9%	**Q58. Fishing partner**	**99%**
Q65. Ethnicity		WP Bronzies	38%	**Q59.** Partner air exposure	54%
White	84%	UK	4%	**Q60.** Partner distance from bucket	49%
Coloured	13%	**Q11. Number of RASSPL National competitions**		**Q61.** Partner full bucket	58%
Black	2%	Mean	3	**Q62.** Partner influence you	37%
Asian	2%	Range	0 – 8	**Percentage of anglers who strongly agreed with the following potential motivations for fishing in the RASSPL competitions**	
Q66. Highest Level Education		**Q9. Number of RASSPL franchise competitions per year**		**Q14.** 100% C&R	74%
Pre-matric	12%	Mean	8	**Q15.** Competition	69%
Matric	30%	Range	1 - 16	**Q16.** Prizes	22%
Diploma	42%	**Q10. Days spent fishing per year (excluding RASSPL)**		**Q17.** Challenge of specific format	75%
Tertiary	14%				

Q67. Employment Status	
Employed	93%
Unemployed	3%
Retired	3%
Student	1%

Q68. Annual Income (before tax)	
no income	7%
self-employed	1%
R1 - R9,600	1%
R9,601 - R38,400	15%
R38,401 - R76,100	9%
R76,101 - R153,600	9%
R153,601 - R307,200	18%
R307,201 - R614,400	22%
R614,401 - R1,228,800	13%
R1,228,801 or more	3%

Mean	59days
Range	4-250 days
Q12. Compete in other competitions	57%
Q4. Attended educational presentations	67%
Q5. Attended video demonstration	84%

Percentage of respondents who strongly agreed that each intervention was effective	
Q45. Conservation prizes	27%
Q46. Rule changes	68%
Q47. Informative presentations and educational posters	66%
Q48. Videos demonstrating best handling practices	59%

Q21. Perceived status of RASSPL target species	
Decreasing	19%
Staying the same	48%
Increasing	14%

Perceived threats to the RASSPL target species	
Q22. Trawl Fishery	66%
Q23. General rock and surf anglers	21%
Q24. Competitive rock and surf anglers	7%
Q25. Commercial linefishers	54%
Q26. Recreational ski boaters	24%
Q27. Spearfishers	12%
Q28. Pollution	60%
Q29. Climate change	39%

Percentage of respondents who strongly agreed that the following factors contributed to the fate of a fish after C&R	
Q31. Where it is hooked	75%
Q32. Fight time	46%
Q33. Air exposure	91%
Q34. Handling	81%
Q35. Weather	10%
Q36. Release	68%
Q37. Water temperature	15%

Percentage of respondents who strongly agreed with the legitimacy of the different rules	
Q38. Under minimum size limit	61%
Q39. Empty C&R bucket	40%
Q40. More than 50 m away from the C&R bucket	34%
Q41. Another fish is in their C&R bucket	31%
Q42. Not placed into the C&R bucket	63%

Percentage of respondents who strongly agreed with the following rule changes:	
Q49. Smooth gully rule	28%
Q50. C&R bucket rule	85%
Q51. 50m from the bucket rule	66%
Q52. Full bucket before casting rule	79%
Q53. Prohibition of 2nd rod handling rule	54%

Q56. Percent of respondents who utilize RASSPL handling outside of the competition	63%
Q57. Percent of respondents who attempt to spread good RASSPL handling techniques	60%

4.3.1 Demographics

The respondents ranged in age from 18 to 63, with an average of 41 years (Table 4.1). The majority of survey respondents were male (90%) and white (84%). The most common level of education was a diploma (42%), followed by matric (30%) and then bachelor's degrees (14%). Almost all anglers that took part in the surveys were employed (93%), with a small portion of pensioners (3%) and students (1%). Annual income (before tax) varied, with most indicating that they earned between R307 201 and R614 400 (22%), followed by R153 601 and R307 200 (18%), R9 601 and R38 400 (15%) and R614 401 and R1 228 800 (13%), (Table 4.1).

4.3.2 Respondents' history with RASSPL

On average, survey respondents indicated that they had participated in three (range: 0 – 8) RASSPL national competitions and eight RASSPL franchise competitions annually, although some competed in as many as 16 competitions (Table 4.1). The average number of days spent fishing (excluding RASSPL) each year was 59days (range 4 - 250). Approximately 57% of anglers also participated in other rock and surf angling competitions (Table 4.1).

4.3.3 Fishing Partner

Almost all (99%) anglers regularly fished with the same angling partner (Table 4.1). The majority (54%) of anglers rated their fishing partner's practices in terms of fish air exposure as very good, 29% as good, 14% as neutral and 3% as poor. Similarly, the majority of anglers (49%) rated their partner's adherence of the "distance from bucket" rule as very good, 26% as good, 15% as neutral, 4% as poor and 6% as very poor. The majority of anglers (58%) also felt that their partner's adherence to the rule which required anglers to fill their buckets before casting was very good, while 25% felt that it was good, 12% felt that it was neutral, 1% poor and 4% very poor. Just over one third (37%) of the

respondents felt that their partners had a very strong influence on their C&R practices, 28% felt that their partner had no influence on their C&R practice, while 24% felt that their partner had a strong influence (Table 4.1).

4.3.4 Importance of C&R

Most respondents (82%) felt that C&R fishing was extremely important for the sustainability of recreational fishing (Table 4.1). However, there was variation (30 – 100%, mean 87%) in the perception on the percentage of fish that survived a C&R event (Table 4.1). Anglers also indicated that they believe that the fish they release now, after RASSPL angler education, are 85% more likely to survive than when they first started fishing.

4.3.5 Motivation to participate in RASSPL

The majority of respondents strongly agreed that they participated in the RASSPL because of its “100% C&R” rule (74%), for the competitive nature of the league (69%) and for the specific format (75%) of the league (Figure 4.1a, Table 4.1). In contrast, only 22% strongly agreed that the prizes offered motivation for them to fish in RASSPL competitions, while 41% of the respondents were neutral (Figure 4.1a, Table 4.1).

4.3.6 Perceptions of targeted species fish stocks

The majority (48%) of respondents felt that the populations of the targeted species in the RASSPL competitions had remained the same, with only 19% indicating that the populations were decreasing (Figure 4.1b, Table 4.1).

4.3.7 Perceptions of threats to targeted species fish stocks

Overall, the commercial fisheries were considered to be a greater threat to the RASSPL target species than recreational fisheries (Figure 4.1c, Table 4.1). The majority of respondents strongly agreed that the trawl fishery (66%) and commercial line fishery (54%) were a threat to the RASSPL target species. In contrast only 21%, 24%, 12% and 7% of

the respondents strongly agreed that the general rock and surf angling public, recreational skiboat fishery, the spearfishery and competitive rock and surf anglers were a threat to the RASSPL target species, respectively (Figure 4.1c, Table 4.1). Respondents also strongly agreed that other factors such as pollution (60%) and climate change (39%) were also a threat to the RASSPL target species(Figure 4.1c, Table 4.1).

4.3.8 Knowledge of factors affecting the fate of the fish

The majority of respondents displayed good knowledge on the factors affecting the fate of the fish, 91% felt air exposure was a very important and 81% felt how the fish was handled is an important factor (Figure 4.1d, Table 4.1). Other important factors were where the fish is hooked (75%), and how the fish is released (68%). Respondents placed less importance on the other factors with only 46%, 14% and 10% of respondents indicating that fight time, water temperature and weather are important factors (Figure 4.1d, Table 4.1).

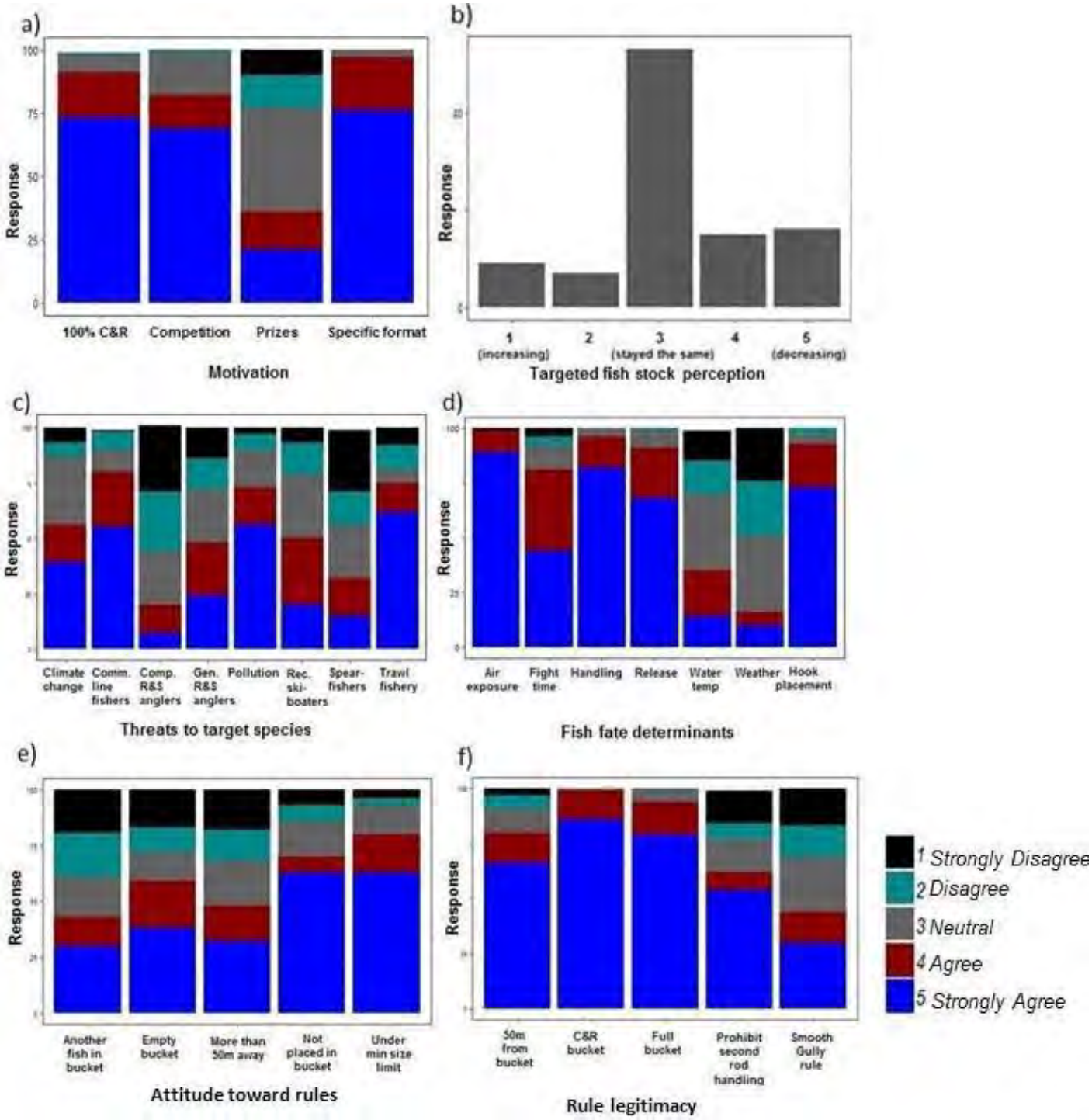

Figure 4.1 Stacked bar-plots displaying the survey responses of anglers to questions regarding a) motivations to participate in the RASSPL, b) perceptions of targeted fish stocks, c) perceptions of threats to targeted fish stocks, d) knowledge on factors affecting the fate of fish, e) attitudes toward specific RASSPL rules and f) perceptions of rule legitimacy. Responses are in Likert form ranging from 5 (strongly agree) to 1 (strongly disagree), unless otherwise stipulated.

4.3.9 Attitudes towards the legitimacy of rules

Anglers had mixed attitudes towards the RASSPL rules and the likelihood of disqualification if infractions occurred. Most respondents believed that it was very likely that an angler would be disqualified if an undersized fish was recorded on their score card (61%), or if the fish was not placed in the C&R bucket (63%), (Figure 4.1e, Table 4.1). In contrast only a few respondents believed it was likely that anglers would be disqualified if their C&R bucket was empty when a fish was landed (40%), if they had landed the fish more than 50m from their C&R bucket (34%), or if a fish was captured while another fish was already in the C&R bucket (31%), (Figure 4.1e, Table 4.1).

4.3.10 Attitudes towards rule changes

Respondents generally agreed with the rule changes that were recommended by the scientific research team (Figure 4.1f, Table 4.1). The majority strongly agreed with the rule that required the use of a C&R bucket (85%), that the C&R bucket should be filled before casting (79%) and that the angler should not angle further than 50m away from their C&R bucket (66%). Although, 54% of anglers strongly agreed with the rule that prohibits an angler from handling their second rod if they already had a fish in the C&R bucket, 15% strongly disagreed with this. Respondents also displayed mixed feelings about the smooth gully rule (this rule groups spotted gully sharks (*Triakis megalopterus*) and smooth hound sharks (*Mustelus mustelus*) under a certain size as one species, to reduce the problems with misidentification), with 28% of anglers having strongly agreed with this rule and 25% strongly disagreed (Figure 4.1f, Table 4.1). Respondents also did not agree with the 100% no take rule, and rather believed it should be acceptable to take a fish if after all efforts to release it, it had died anyway (61%).

4.3.11 Intervention Efficacy

Of the surveyed anglers, 67% recalled being exposed to the educational presentations,

and 84% recalled seeing the educational videos that demonstrated best-practice guidelines. Of the various interventions, the majority of respondents strongly agreed that the rule changes (68%), educational presentations (66%) and video modelling (59%) interventions improved angler C&R behaviour (Figure 4.2, Table 4.1). Interestingly only 27% strongly agreed and 24% strongly disagreed that the conservation prizes interventions improved angler C&R behaviour.

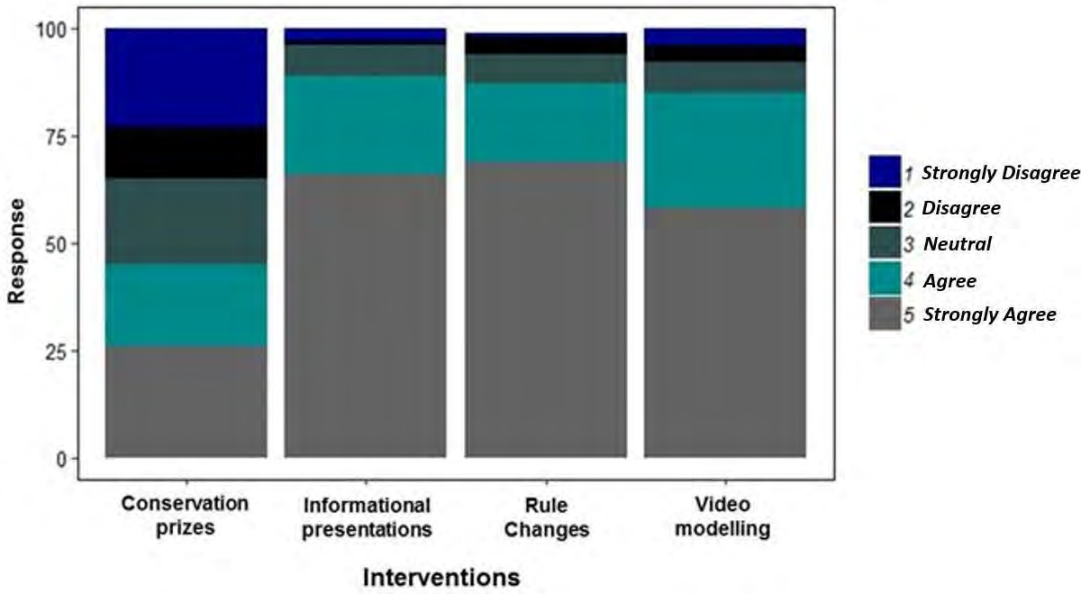

Figure 4.2 Angler's perceptions on the efficacy of the pro-environmental behavioural interventions implemented to improve C&R practices of anglers belonging to the RASSPL, ranging from strongly agree to strongly disagree.

4.3.12 Perceived Self-improvement

When anglers were asked how much they believed their handling practices had improved since joining RASSPL, the majority (69%) responded with extreme improvement, with only 3% of respondents indicating that they believed their handling practices were the same before joining RASSPL as they are currently.

4.3.13 Research Team

The majority of respondents (52%) indicated that the presence of the research team had affected their RASSPL experience extremely positively, and only 22% indicated that the research team had no effect on their RASSPL experience (Table 4.1).

4.3.14 Spreading good handling

Majority of anglers (63%) stated that they frequently utilised RASSPL fish handling techniques outside of RASSPL competitions, with 60% of respondents indicating that they frequently educated or tried to educate other anglers on good RASSPL handling techniques outside of the competition (Table 4.1).

4.4 Discussion

There was strong agreement by the majority of respondents (85%) that the intervention had resulted in self-improvement and that their released fishes were more likely to survive than before. In addition, the majority of respondents (62%) reported that they regularly utilized RASSPL handling techniques outside of the RASSPL league as well as attempted to educate other recreational anglers on these good handling practices (61%). As competitive anglers generally have a higher social standing among other recreational anglers, it is likely that these practices may too be emulated by the general angling public. Indeed, Danylchuk et al. (2017) encouraged the use of ‘C&R ambassadors’ to promote the

cause and provide effective knowledge and awareness, because anglers are likely to follow behavioural attributes of high- profile participants. Thus, the results of this study appear to not only confirm the findings of Chapter 3, which indicated improvements in angler C&R behaviour, but also suggest that these behavioural improvements may extend beyond the confines of the RASSPL competitions.

The perceptions of the RASSPL anglers suggested that the structural changes to the rules was the most important intervention that influenced the improved C&R behaviour (Figure 4.2). This was followed by video modelling and presentations (Figure 4.2). Interestingly, incentives, in the form of conservation prizes and awards, were perceived to be the least important component influencing angler C&R behaviour (Figure 4.2).

Structural changes have proven useful in altering pro-environmental behaviour in general (Schofer & Hironaka, 2005), and in a fisheries context (Sauls & Ayala, 2012; Arias & Sutton, 2013). The findings of this study agree with this notion and suggest that appropriate structural changes may be the most effective method of improving angler behaviour in a competitive context. Steg and Vlek (2009) suggested that pro-environmental behaviour is influenced by weighing costs and benefits. In an angling competition, where the angler's primary goal is winning, even the slightest chance of the disqualification of one fish is too much of a negative consequence and anglers are likely to quickly alter their behaviour. Bolderdijk et al. (2012) emphasized the use of consequences and suggested that it is human nature to repeat behaviours with favourable outcomes and reduce behaviours that result in negative outcomes. Thus, rule changes (provided they are considered to be legitimate) provide an opportunity to rapidly induce long-term change in the behaviour of competitive anglers.

Knowledge dissemination is often the only strategy used to alter C&R and other environmental behaviours and has generally been met with limited success (Burgess et al.,

1998; Stern, 2000; Kollmuss & Agyeman, 2002; Schultz, 2011; Gifford, 2014; Cooke et al., 2017). However, Dell Palme et al. (2016) showed that the right form of hands-on educational intervention, coupled with behavioural modelling can improve angler C&R behaviour in the short-term. Indeed, in this study, most respondents indicated that the informational presentations and video modelling components were efficient intervention strategies that contributed to their improved C&R behaviour (Figure 4.2).

For long-term changes in environmental behaviour however, it is likely that educational drives should be combined with other interventions, such as structural changes, in order to increase the efficacy of knowledge dissemination (Gardner & Stern, 2002; Larson et al., 2015). This appeared to be the case in this study. For example, the 2017 distance from bucket and time into bucket results from Chapter 3 demonstrated the value of combining components, where anglers continued to decrease the time taken for them to get their fish into the C&R bucket even though the corresponding distance from the bucket had not decreased (Figure 3.2). This suggests that anglers began understanding the importance of limiting air exposure, and is evidence of the synergistic interactions between different strategies. Indeed, Stern (1999 and 2000) suggested that behavioural interventions will be more effective when strategies are combined.

Incentives, which included individual and franchise conservation prizes for the lowest air exposure times, were considered to be the least efficient at improving C&R behaviour (Figure 4.2). It was also evident when looking at what motivated anglers to participate in RASSPL that the prizes were least effective (Figure 4.1a). This was surprising as several authors have recommended incentives as a central component for pro-environmental behavioural interventions (Gellar, 2002; Thøgersen, 2005; Steg & Vlek, 2009). Indeed, Bolderijk et al. (2012) emphasize the importance of positive consequences in motivating the adoption of pro- environmental behaviour and state that rewards are generally more

effective and preferred over penalties as they instill positive attitudes around the desired behaviour.

There may be several reasons for the poor perceptions of the influence of incentives in this study. Firstly, the likelihood of winning a conservation prize was dependent on a member of the research team being present and recording the angler's catch information. Since the research team was not always present to observe every C&R event, this may have undermined the perceived legitimacy of these prizes. The second possible reason for the perceptions of the reduced efficacy of the conservation prizes may be that the incentives that were used may have provided the wrong kind of positive consequences. For example, it is likely that these competitive anglers may have responded better if the incentive been related to the likelihood of winning the competition. In other words, if anglers received additional points for low air exposure times, they may have been more motivated to reduce fish air exposure. It is also possible that the reduced efficacy of incentives could have been attributed to the "low" value due to the fact that the prizes on offer were not valuable enough to motivate better behaviour from anglers, or simply that the anglers were unaware of the conservation prizes on offer for reduced air exposure as it was not implicitly specified before the competition started. Indeed, Bolderdjik et al. (2012) highlighted the importance of the antecedent component of the incentive, stating that the beneficial impact of the incentive is highly dependent on how it is announced and delivered.

Ultimately, for competitive angling it is likely that incentives that improve an angler's chances of winning are critical. The antecedent, which in this case could be raising awareness of the incentive, should also be an integral part of this component.

When combinations of components are used for pro-environmental behavioural interventions, it is critical that these are aligned. For example, in this study, the modelling

videos specifically demonstrated how to undertake the C&R procedure with the new rules (structural changes), while the educational component specifically focused on elements of the C&R event (primarily air exposure) that was subject to the greatest structural manipulation (rule changes) and the incentives specifically rewarded those who subjected their catch to the least air exposure. Conflicting messages, such as for example, emphasizing the importance of hooking injury above air exposure in determining the fate of a released fish, in the educational presentations and then changing rules to limit air exposure and not hooking injury will most likely reduce the success of the intervention. Kennedy et al. (2009) also emphasized the need for a well-thought- out educational component in environmental behaviour interventions and based on this research, it appears that alignment should be a central component of this process.

This study has demonstrated that pro-environmental behavioural interventions can be effective for changing the behaviour of RASSPL anglers. However, it is less clear whether this type of intervention may be effective for changing the behaviour of recreational f ishers in general. Steg and Vlek (2009) and Stern (2000) emphasized the importance of understanding the context of the community on which the intervention is implemented. Thus, the efficacy of the different components and the intervention as a whole is most likely specific to this context. Nevertheless, a socio-demographic characterization of the RASSPL community is necessary to understand for which other recreational angling communities this kind of pro-environmental behavioural intervention may be appropriate. As recreational angling communities are known to be extremely diverse in demographics, motivation, culture, religion, education and other internal and external factors (Wilde et al., 1998; Kearney, 2001; Sutton, 2006; Johnston et al., 2010; Greiner et al., 2013; Bova et al., 2017), it may be useful to identify communities with similar socio-demographic characteristics so that this type of intervention could be tested.

When looking at the fishing experience of RASSPL anglers it was evident that the respondents were a diverse group in terms of angling experience and participation, ranging from beginners to highly experienced anglers (Table 4.1). When examining the demographic results for this study it was evident that the RASSPL is dominated by mainly white males with an average age of 41 years old. Level of education and income varied among respondents indicating minor diversity however the low representation of females and other ethnic groups results in a homogenous RASSPL angler population. More recent surveys of South African recreational anglers displayed similar results with regard to demographics. Bova et al. (2017) surveyed recreational anglers along the Eastern Cape coastline so as to assess the suitability of a social norms approach for improving compliance behaviour and found the average angler was a 42-year-old, white, Christian, employed male with a secondary education. Another South African study by Kramer et al. (2017) that looked to analyze demographic and psychographic angler attributes along the KwaZulu-Natal coastline, displayed similar results in that the participants were majority White or Indian males between the ages of 31 and 45 years old. However, overall, it appears that this fairly homogenous demographic structure of predominantly middle-aged white males is typical for a South African shore-based recreational fishery. This pattern of male domination in recreational fisheries is not only evident in South Africa but worldwide (Wilde et al., 1998; Arlinghaus et al., 2008; Bull, 2009). Given the similar demographic profile between the RASSPL and general angling population, it is possible that this type of intervention may be more broadly appropriate.

The knowledge and attitudes of anglers is an important contextual factor that may determine the efficacy of a pro-environmental behavioural intervention. The respondents in this study felt that the commercial trawl and line fisheries were the largest threats to fish stocks targeted by RASSPL anglers (Figure 4.1c). Although this response was surprising

as commercial fisheries target offshore zones and different target species to RASSPL anglers, it is fairly common for recreational anglers to blame the commercial sector (Arlinghaus et al., 2002; Coleman et al., 2004; Cooke & Cowx, 2004; Arlinghaus et al., 2007). Trawlers in particular, often receive majority of the blame because of the large catches associated with these industrialized commercial fishing vessels. In Kwa-Zulu Natal (South Africa), the recreational shore-based angling public also identified similar reasons for stock declines (Kramer et al., 2017). Regardless of location, recreational anglers are known for shifting the blame for the decline in fish stocks to other fisheries as they refuse to take responsibility themselves, and cannot understand the cumulative impact thousands of recreational anglers can have over many years of angling (Arlinghaus et al., 2002; Arlinghaus et al., 2007; Cooke et al., 2014).

Overall, it appears that the socio-demographic characteristics of RASSPL anglers were similar to South Africa's recreational angling population. This may suggest that structural changes were clearly effective in a competitive angling context, and may have potential for improving the C&R behaviour of the general recreational angling population. Certainly, in countries, where recreational fisheries are well managed, stakeholder consultation is imbedded in the regulation development process and compliance with the regulations is high, it is likely that regulatory changes (e.g. to the exclusive use of circle hooks or the mandatory use of a C&R bucket) that favour improved C&R methods or behaviours may be successful. However, in countries where recreational fisheries are less well-managed and compliance is low (e.g. South Africa, Bova et al., 2017) the efficacy of structural changes may be lower.

There may be a number of other factors that may have contributed to the success of this pro- environmental behavioural intervention. The first may be the favourable attitudes of the RASSPL community towards the researchers (see Table 4.1). This indicates that the

anglers have experienced the value in having scientists involved when it comes to sustainable C&R fishing. This result is very positive as in much of the literature the relationship between anglers and science is rather acrimonious, particularly among recreational anglers who blame scientists for increased restrictions regarding regulatory frameworks (Arlinghaus, 2007; Arlinghaus et al., 2007; Bower et al., 2017). Anglers are often skeptical of collaborating with scientists as they feel they are arrogant and out of touch with reality (Bower et al., 2017; Danylchuk et al., 2017) and thus researchers should aim to look at the development of long-term projects that build trust to ensure positive results.

The RASSPL anglers also displayed a positive attitude towards majority of the rule changes that were recommended by the scientific team (Figure 4.1). This was expected as these regulations were not only developed in consultation with the anglers, but anglers were also involved in the collection of the data that informed these regulations. One rule, which prohibits an angler from touching their second rod when they have a fish in the bucket, was not as well supported. This could be attributed to the lack of consensus (amongst the scientific team and anglers alike) whether it is better to allow a fish to remain in the bucket for some time or to allow another fish additional opportunity to swallow the bait and face an increased likelihood of a severe hooking injury.

The majority of respondents (53%) believed that the status of the populations of the target species had remained the same over the years (Figure 4.1b). This was an interesting outcome as worldwide there is concern of decreasing fish stocks in all fisheries (Jackson et al., 2001; Arlinghaus et al., 2007; Daskalov et al., 2007). Brouwer et al. (1997) interviewed South African inshore anglers and reported a definite decrease in catches. Kramer et al. (2017) also found that majority of surveyed anglers believed their catches had declined over the years. However, since RASSPL anglers target a far broader range

of species, and often those that are not targeted by other competitive or non-competitive recreational anglers, this result is perhaps less surprising.

Angler perceptions on the importance of C&R angling were overwhelmingly positive (Table 4.1). Interestingly these perceptions were almost contradictory to their perceptions about the recreational sector, which they suggested has little impact on fish resources when compared to other sectors, such as the commercial trawl or commercial linefishery (Figure 4.1c). This is similar world over, where recreational anglers fail to recognize the impact of recreational fishing (Arlinghaus et al., 2007; Kramer et al., 2017). There is evidence of 'halo effect' as the RASSPL angler's responses show that most of the options that would fall under recreational angling have been rated low, with the option of competitive rock and surf anglers receiving the lowest percentages of all options (7%). Kramer et al. (2017) suggested that this shift in blame is a worldwide occurrence among recreational anglers because they refuse to take responsibility for their own impact on the constantly decreasing fish stocks. Other studies have also found the recreational angling community is unaware or unable to understand the cumulative impact of many thousands of recreational anglers over many years of fishing (Arlinghaus et al., 2002; Cooke et al., 2014). In order to combat this misunderstanding among anglers, future studies should aim to provide increased awareness of their effects on the oceanic ecosystem. The larger commercial fisheries sector regularly receives the blame for the world fisheries crisis (Arlinghaus et al., 2007), but the recreational fisheries have started to be recognized as the number of recreational anglers increases (Cooke & Cowx, 2004; Coleman et al., 2004).

Anglers displayed good knowledge on the factors affecting the fate of the fish (Figure 4.1d), indicating that the RASSPL anglers were well educated on what aspects of the process have an effect on the survival of the fish. This shows how the long-term relationship with the SAFER lab has been effective in terms of education and awareness

on fish handling. Stern (2000) emphasized the importance of combining incentives and relevant information, stating that behavioural interventions are more effective when multiple components are utilized in conjunction with one another. Therefore, knowledge dissemination is vital but it must be done via the provision of understandable information, as the environmentally responsible decision is not always intuitive and people may not be aware of exactly how to act in an environmentally responsible manner (Kennedy et al., 2009).

When looking at the legitimacy of and attitudes towards the rules, the majority of respondents strongly agreed that disqualification would occur if the fish was undersized or if a C&R bucket was not used but the responses to the other rules, although still mostly in agreement, were more varied (Figure 4.1f). This indicates that anglers do not feel that all of the rules have the same consequences as some are more easily monitored than others. Monitoring whether buckets are full at the time the fish is caught, and if buckets are more than 50m away is quite difficult without a sizable monitoring group. As a result, these rules are seen as a sort of guideline and disqualification is therefore not very likely. This further supports the notion that structural rule changes can only be truly effective if efficient monitoring is possible (Arias & Sutton, 2013).

As with all studies conducted via surveys, there are a variety of potential biases associated with this research, leaving much room for improvement in the future. Typically, there are response biases associated with survey data of this nature where respondents may give the response that they believe to be most acceptable in the situation even if they do not truly feel that way. This is known as a social desirability bias and can mean that responses are not entirely truthful (Baumgartner & Steenkamp, 2001; Bova et al., 2017; Kramer et al., 2017). Future work should attempt to at least account or mitigate for this bias, possibly using innovative interview techniques, such as the use of a ballot box (Bova

et al., 2017).

In conclusion, this chapter further supports the suggestion that angler behaviour can be improved via a pro-environmental intervention. It is evident that anglers were able to recognize that they had improved over time and overall the structural changes seemed to be the most effective and have potential in other recreational fisheries, particularly those with good governance and compliance. For a pro-environmental behaviour intervention to be successful there should be alignment between the different components and incentives and consequences should be well considered and be appropriate for the specific context of the situation.

Chapter 5: General Discussion

Recreational C&R anglers competing in the 2018 RASSPL Nationals. (Image credit: Samantha Mannheim)

Throughout this thesis we have seen that angler behaviour can have various impacts on the environment and in the case of a C&R event, the angler has control over a number of factors that can improve the environmental consequences (Arlinghaus et al., 2007; Danylchuk et al., 2018). Attempting to alter angler behaviour is important as it is generally the one factor that can be directly controlled. Anglers have control over whether they will release or retain a fish, their compliance with regulations and environmental laws (Bova et al., 2017; Kramer et al., 2017), their C&R behaviour (Davis, 2010; Arlinghaus et al., 2009; Brownscombe et al., 2015; Lennox et al., 2015; Danylchuk et al., 2017; Danylchuk et al., 2018; Twardek et al., 2018) and their environmental behaviour in its more general sense (pollution/litter/habitat destruction) (Maitland & Turner, 1987; O'Toole et al., 2009; Czarkowski et al., 2016). The environmental behaviour around these components are driven by angler context (Black et al., 1985; Hunecke et al., 2001) and include external (social/economic/cultural and institutional) and internal factors (knowledge and awareness, motivations, attitudes and perceptions) (Kollmuss & Agyeman, 2002).

In this case study it was clear that the C&R behaviour of anglers can be improved using a systematic, long-term and diverse intervention. While this thesis focused on shifting C&R behaviour, the strategies are similarly suited to other angler environmental behaviours, such as compliance with regulations and the destruction of habitat, pollution and littering. The general approach is summarized into a conceptual framework illustrating the process of shifting angler environmental behaviour (Figure 5.1).

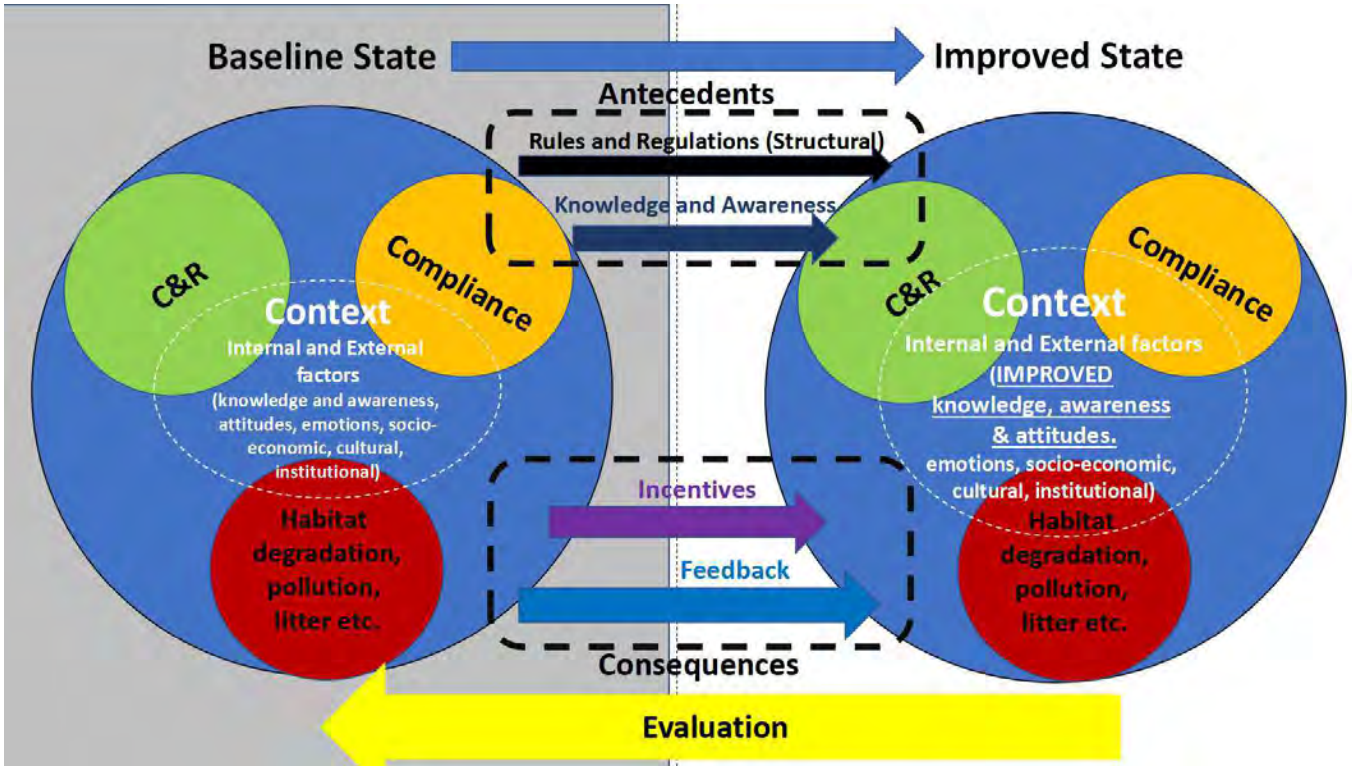

Figure 5.1 Conceptual framework of how to alter and evaluate angler environmental behaviour so as to inform adaptive intervention/modification.

An intervention should start with the recognition of a problem and then you need to take steps to understand the problem (Geller, 2002; Steg & Vlek, 2009). In this study understanding the problem was approached in a unique way, in that we tried to take the long road in the hope that we could build trust (which is a key component of attempting a behavioural intervention) within the community. Not all people interested in changing angler behaviour will have that amount of time to invest in an intervention.

The first step, if you do not have the time to assimilate yourself into the league is to do a baseline behavioural (see Chapter 2, Butler et al., 2017) and social (Kramer et al., 2017) assessment. A behavioural baseline assessment should collect data on the behaviour of anglers as well as on the results of these behaviours (in the case of C&R fishing that would be the health and response of the fishes after the C&R event). Baseline

assessments are important as they can provide information on what needs to be modified, and they facilitated the evaluation of the effects of any future interventions on angler behaviour and fish health and survival.

Unfortunately, there was no baseline social assessment as surveys were only completed after the intervention was implemented, and ideally, these surveys should have been completed before and after intervention implementation for comparison. In this study, the social survey was only conducted after the third national event. While this study would have most likely benefitted from an earlier social survey, the “deep” two-year engagement with the RASSPL during the initial two years most likely provided sufficient context for a successful intervention.

On completion of a baseline assessment, the Geller (2002) framework (adapted by Steg & Vlek, 2009) suggests that one should use the baseline assessment to identify the behaviours that you want to change and use the social survey data to help identify which factors cause these behaviours. Once this is done, the next step is to design appropriate and multiple components for an intervention (Stern, 2000; Gardner & Stern, 2002). This should ideally be informed by the data that was collected to change the relevant behaviours and their antecedents (Steg & Vlek, 2009) (Figure 5.1). While this can be done by the research team, if they are comfortable with the context of the situation, the incorporation of appropriate members from the stakeholder group may be necessary to ensure that the interventions are appropriate.

With regard to this study, an example of an effect component in our intervention would be the rule change that included the use of a RASSPL bucket for keeping the fish between photographs and measurement. This rule was only implemented after the baseline air exposure information was collected. These baseline results were not only reported on (in presentations and annual reports), they were combined with information on the impact of

high air exposure times on fish survival. This then helped motivate the rule change and generally the anglers felt that the change was legitimate (Figure 4.1f). It is also important that the actions and the messages in the different components of the intervention align to improve the intervention's efficacy. In this case, the messages of the impact of air exposure time were clearly heard by the anglers, as they reported this to be the greatest cause of mortality in fishes that were subjected to C&R (Table 4.1).

The final step of the Geller (2002) framework is to 4) systematically evaluate the effects of the intervention on the behaviours themselves, their antecedents, the environmental quality and human quality of life (Figure 5.1). A decision on the appropriate time to assess the efficacy of the intervention is necessary. You may expect a relatively quick response in some interventions, for example, in the case of a structure change, such as an amendment to the rules. In these cases, an evaluation of the efficacy can be done relatively soon. However, in situations where the primary intervention focusses on things like social norms, these changes may be slower and longer periods between evaluations may be necessary (e.g. Kramer et al., 2017). Contextual factors may be important here. For example, the best opportunities for the assessment of behavioural change in the RASSPL context were during the annual national competitions. However, depending on the type of intervention, less frequent evaluations may be more appropriate. Besides monitoring the behaviour of the anglers, it is also necessary that these evaluations cover the contextual information, surveys that look at knowledge, awareness attitudes, motivations and social norms should be a component of the evaluation process angler opinion of effective components is critical), as these may change due to other influences over time.

Once the information from the evaluation has been collected, you should compare the baseline and new (behavioural and social) data, in the hope of evaluating the efficacy of

the different components and your intervention as a whole. The evaluation is a critical component of the process as it helps one set the new baseline (Figure 5.1). Then you use a feedback loop to set a “new baseline”, modify your approach and components based on what you have found and repeat the process. Through this process you will hopefully eventually get to that ‘improved state’ of angler behaviour (Figure 5.1).

Understanding what the ‘improved state’ is can prove challenging, and does not necessarily need to be fixed. For example, initially during the RASSPL interventions, we felt that getting average air exposure below 60 sec was an appropriate ‘desired state’. This was primarily because the baseline data that was collected showed that there were, on average, negative physical and physiological impacts when fish were exposed to air for more than 60 seconds. However, this goal was not only surpassed (for example, the mean air exposure time in the 2019 national event was 40 sec), but there has been a realisation that it can be further reduced. Therefore, ideally one should plan to set realistic, achievable goals and then modify them as appropriate (ideally including stakeholders into the process). In the case of RASSPL anglers who are by nature competitive, a recent strategy has been to use realistic targets to unlock their competitive nature and provide anglers with additional motivation to improve their C&R behaviour. The anglers have responded positively and are fully engaged and taking up the challenge, thus promoting the use of psychology to facilitate improved behaviour. To this end, one incentive, in particular, the conservation trophy, which is awarded to the team with the lowest average air exposure and lowest number of poor C&R behaviours, has become an important component of the national competition.

Ultimately, this example, which uses the competitive nature of these anglers to improve their C&R behaviour, speaks to the importance of understanding one’s target angler group. Understanding the motivations and characteristics of your group opens up the potential for

using environmental psychology techniques, which have been underappreciated and poorly researched in the context of recreational fisheries.

This study unfortunately only incorporated the behaviour of one recreational angling community. While it is possible that this intervention may not be representative of these kinds of interventions in other communities, it is hoped that the process described is sufficiently adaptable to be broadly applicable to other communities. To further develop this type of pro-environmental approach, it is critical that this type of intervention be tested on different angling communities and behaviours (for example non-compliance). Presently a similar approach has been implemented on the C&R behaviour of a less conservation-conscious deep sea angling club and on angler compliance in the South African marine shore-based recreational fishery.

Another potential caveat of this study was the potential impact of the presence of scientists during the data collection. In this case, a pilot study using covert observation that angler C&R behaviour has suggested that angler behaviour with and without scientists present may be different. While the longer air exposure times in the covert observations, when compared with the scientist observations are a concern and may speak to the moral and ethical characteristics of the RASSPL anglers, this needs to be explored further.

Finally, I would like to further emphasize the value in building trust between researchers and the angling community. This study supports the Cooke et al. (2017) hypothesis that calls for inserting the angler into the C&R science for optimal behavioural changes, as the time that was dedicated to developing a positive relationship between the two parties appeared to be a valuable component of this process and may very well be a critical determinant in the success of any pro-environmental intervention.

References

Ajzen, I. 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Processes 50:* 179–211.

Ajzen, I., & Fishbein, M. 1980. Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prenticeó Hall.

Allen, J.B. & Ferrand, J.L. 1999. Environmental locus of control, sympathy, and proenvironmental behavior: A test of Geller's actively caring hypothesis. *Environment and Biology 31(3):* 338-353.

Alós, J., McGrath, S.P, Pérez-Mayol, S., Morales-Nin, B. & Butcher, P.A. 2017. The chemical signature of retained hooks in mulloway (*Argyrosomus japonicus*) revealed by otolith microchemistry. *Fisheries Research 186:* 658–664.

Arias, A. & Sutton, S.G. 2013. Understanding recreational fishers' compliance with no-take zones in the Great Barrier Reef Marine Park. *Ecology and Society 18(4):*18.

Arends, R.J., Mancera, J.M., Muñoz, J.L., Wendelaar Bongal, S.E. & Flik, G 1999. The stress response of the gilthead sea bream (*Sparus aurata L.)* to air exposure and confinement. *Journal of Endocrinology 163:* 149–157.

Arkert, N.K., Childs, A-R, Parkinson, M.C., Winkler, A.C., Butler, E., Mannheim, S.L. & Potts, W.M. 2018. Evaluating the effects of catch-and-release angling on Cape stumpnose *Rhabdosargus holubi* in a South African estuary. *African Journal of Marine Science 40(3):* 235- 244.

Arlinghaus, R. 2007. Voluntary catch-and-release can generate conflict within the recreational angling community: a qualitative case study of specialised carp, *Cyprinus*

carpio, angling in Germany. *Fisheries Management and Ecology 14:* 161–171.

Arlinghaus, R. & Cooke, S.J. 2009. Recreational Fisheries: Socioeconomic Importance, Conservation Issues and Management Challenges. Recreational Hunting, Conservation and Rural Livelihoods. *Science and Practice*: 39–58.

Arlinghaus R., Mehner T. & Cowx, I.G. 2002. Reconciling traditional inland fisheries management and sustainability in industrialized countries, with emphasis on Europe. *Fish and Fisheries 3: 261*–316.

Arlinghaus, R., Cooke, S.J., Lyman, J.O.N., Policansky, D., Schwab, A., Sutton, S.G. & Thorstad, E.V.A.B. 2007. Understanding the Complexity of Catch-and-Release in Recreational Fishing: An Integrative Synthesis of Global Knowledge from Historical,
Ethical, Social, and Biological Perspectives. *Reviews in Fisheries Science 15:*75–167.

Arlinghaus, R., Bork, M. & Fladung, E. 2008. Understanding the heterogeneity of recreational anglers across an urban–rural gradient in a metropolitan area (Berlin, Germany), with implications for fisheries management. *Fisheries Research 92 (1):* 53-62.

Arlinghaus, R., Klefoth, T., Cooke, S.J., Gingerich, A. & Suski, C. 2009. Physiological and behavioural consequences of catch-and-release angling on northern pike (*Esox lucius L.*). *Fisheries Research 97:* 223–233.

Bartholomew, A. & Bohnsack, J.A. 2005. A review of catch-and-release angling mortality with implications for no-take reserves. *Reviews in Fish Biology and Fisheries 15:* 129–154.

Baumgartner, H. & Steenkamp, J-B. 2001. Response Styles in Marketing Research:

A cross- national investigation. *Journal of Marketing Research 38(2):* 143- 156.

Blake, J. 1999. Overcoming 'value-action gap' in environmental policy: Tensions between national policy and local experience. *Local Environment 4(3):* 257-278.

Black, J.S., Stern, P.C. & Elworth, J.T. 1985. Personal and contextual influences on household energy adaptations. *Journal of Applied Psychology 70:* 3–21.

Bolderdijk, J.W., Lehman, P.K. & Gellar, E.S. 2012. Encouraging proenvironmental behaviour with rewards and penalties. In L Steg, AE van den Berg & J de Groot (Eds.), Environmental Psychology: An Introduction (pp.234-242). New York: Wiley.

Borden, R.J. & Francis, J.L. 1978. Who cares about ecology? Personality and sex differences in environmental concern. *Journal of Personality 4(1):* 190-203.

Bova, C.S., Halse, S.J., Aswani, S. & Potts, W.M. 2017. Assessing a social norms approach for improving recreational fisheries compliance. *Fisheries Management and Ecology 24:* 117- 125.

Bower, S.D., Danylchuk, A.J., Brownscombe, J.W., Thiema, J.D. & Cooke, S.J. 2016. Evaluating effects of catch-and-release angling on peacock bass (Cichla ocellaris) in a Puerto Rican reservoir: a rapid assessment approach. *Fisheries Research 175:* 95–102.

Bower, S.D., Danylchuk, A.J., Raghavan, R., Danylchuk, S., Pinder, A.C., Alter, A.M. & Cooke, S.J. 2017. Involving recreational fisheries stakeholders in development of research and conservation priorities for mahseer (*Tor* spp.) of India through collaborative workshops. *Fisheries Research 186:* 665–671.

Brouwer, S.L., Mann, B.Q., Lamberth, S.J., Sauer, W.H.H. & Erasmus, C. 1997. A survey of the South African shore-angling fishery. *South African Journal of Marine*

*Science 18:*165–177.

Brownscombe, J.W., Griffin, L.P., Gagne, T., Haak, C.R., Cooke, S.J. & Danylchuk, A.J. 2015. Physiological stress and reflex impairment of recreationally angled bonefish in Puerto Rico. *Environmental Biology 98:* 2287-2295.

Brownscombe, J.W., Danylchuk, A.J., Chapman, J.M., Gutowsky, L.F.G. & Cooke, S.J. 2017. Best practices for catch-and-release recreational fisheries − angling tools and tactics. *Fisheries Research 186:* 693-705.

Bull, J. 2009. Fisheries property rights and recreational/commercial conflict: implications of policy developments in Australia and New Zealand. *Gender Place and Culture, A Journal of Feminist Geopgraphy 4:* 445-465.

Burgess, J., Harrison, C.M. & Filius, P. 1998. Environmental communication and the cultural politics of environmental citizenship. *Environment and Planning 30:* 1445 -1460.

Butler, E.C., Childs, A-R., Parkinson, M.C. & Potts, W.M. 2017. An assessment of the health and survival of fishes caught-and-released in high-energy surf zones during a South African competitive angling event. *Fisheries Research 195:* 152–168.

Carfora, V., Caso, D., Sparks, P. & Conner, M. 2017. Moderating effects of pro-environmental self-identity on pro-environmental intentions and behaviour: A multi-behaviour study. Journal of *Environmental Psychology 53:* 92-99.

Chapman, D.A., Gagne, T.O., Ovitz, K.L., Griffin, L.P., Danylchuk, A.J. & Markowitz, E.M. 2018. Modeling intentions to sanction along anglers in a catch-and-release recreational fishery for golden dorado (*Salminus brasiliensis*) in Salta, Argentina. *Human Dimensions of Wildlife 23(4):* 391-398.

Chen, X., Peterson, M.N., Hull, V., Lu, C., Hong, D. & Liu, J. 2013. How perceived

exposure to environmental harm influences environmental behavior in urban China. *AMBIO 42:* 52-60.

Coelho, F., Pereira, M.C., Cruz, L., Simões, P. & Barata, E. 2017. Affect and the adoption of pro-environmental behaviour: A structural model. *Journal of Environmental Psychology 54:* 127- 138.

Coleman, F., Figueira, W.F., Ueland, J. & Crowder, L.B. 2004. The impact of United States recreational fisheries on marine fish populations. *Science 305(5692):* 1958-1960.

Cook, K.V., Lennox, R.J., Hinch, S.G. & Cooke, S.J. 2015. Fish out of water: how much air is too much? *Fisheries 40(9):* 452-461.

Cooke, S.J. & Cowx, I.G., 2004. The role of recreational fishing in global fish crises. *Bioscience 54:* 857–859.

Cooke, S.J. & Philipp, D.P. 2004. Behaviour and mortality of caught-and-released bonefish (*Albula* spp.) in Bahamian waters with implications for a sustainable recreational fishery. *Biological Conservation 118:* 599–607.

Cooke, S.J. & Schramm, H.L. 2007. Catch-and-release science and its application to conservation and management of recreational fisheries. *Fisheries Management 14:* 73–79.

Cooke, S.J. & Sneddon, L.U. 2007. Animal welfare perspectives on recreational angling. *Applied Animal Behaviour Science 104 (3-4):* 176-198.

Cooke, S.J. & Suski, C.D. 2005. Do we need species-specific guidelines for catch-and-release recreational angling to effectively conserve diverse fishery resources? *Biodiversity and Conservation 14:* 1195–1209.

Cooke, S.J., Suski, C.D., Danylchuk, S.E., Danylchuk, A.J., Donaldson, M.R., Pullen, C., Bulté, G., O'Toole, A., Murchie, K.J., Koppelman, J.B., Shultz, A.D., Brooks, E. & Goldberg, T.L. 2008. Effects of different capture techniques on the physiological condition of bonefish Albula vulpes evaluated using field diagnostic tools. *Journal of Fishery Biology 73:* 1351–1375.

Cooke, S.J., Raby, G.D., Donaldson, M.R., Hinch, S.G., O'Connor, C.M., Arlinghaus, R., Danylchuk, A.J., Hanson, K.C., Clark, T.D., Patterson, D.A. & Suski, C.D. 2013. Review: The physiological consequences of catch-and- release angling: perspectives on experimental design, interpretation, extrapolation and relevance to stakeholders. *Fisheries Management and Ecology 20:* 268–287.

Cooke, S.J., Palensky, L.Y. & Danylchuk, A.J., 2017. Inserting the angler into catch-and release angling science and practice. *Fisheries Research 186:* 599–600.

Cordell, H.K., Green, G.T. & Betz, C.T. 2002. Recreation and the environment as cultural dimensions in contemporary American society. *Leisure Science 24(1):* 13-41.

Cowx, I.G. 2002. Recreational fishing: *Handbook of fish biology and fisheries 2:* 367–390.

Courtney-Hall, P. & Rogers, L. 2002. Gaps in Mind: Problems in environmental knowledge- behaviour modelling research. *Environmental Education Research 8(3):* 283-297.

Czarkowski, T.K., Kapusta, A., Kupren, K., Bogacka-Kapusta, E. & Kozłowski, K. 2016. Composition and seasonal changes of litter along the shorelines of selected water bodies in warmia and mazury region (north-eastern poland). *Polish Journal of Natural Sciences 31(1):* 123–135.

Dallas, L.J., Shultz, A.D., Moody, A.J., Sloman, K.A. & Danylchuk, A.J. 2010. Chemical excretions of angled bonefish Albula vulpes and their potential use as predation cues by juvenile lemon sharks *Negaprion brevirostris*. *Journal of Fish Biology 77:* 947–962.

Danylchuk A.J., Tiedemann, J. & Cooke, S.J. 2017. Perceptions of recreational fisheries conservation within the fishing industry: Knowledge gaps and learning opportunities identified at east coast trade shows in the United States. *Fisheries Research 186:* 681–687.

Danylchuk, A.J., Danylchuk, S.C., Kosiarski, A., Cooke, S.J. & Huskey, B. 2018. Keepemwet Fishing- An emerging social brand for disseminating best practices for catch-and- release in recreational fisheries. *Fisheries Research 205:* 52-56.

Daskalov, G.M., Grishin, A.N., Rodionov, S. & Mihneva, V. 2007. Trophic cascades triggered by overfishing reveal possible mechanisms of ecosystem regime shifts. *Proceedings of the National Academy of Science of the United States of America 104(25):* 10518-10523.

Davis, M.W., 2010. Fish stress and mortality can be predicted using reflex impairment. *Fish and Fisheries 11:* 1–11.

De Leeuw, A. D. 1996. Contemplating the interests of fish: The angler's challenge. *Environmental Ethics 18:* 373–390.

Dedual, M., Sague Pla, O., Arlinghaus, R., Clarke, A., Ferter, K., Geertz Hansen, P., Gerdeaux, D., Hames, F., Kennelly, S.J., Kleiven, A.R., Meraner, A. & Ueberschär, B. 2013. Communication between scientists, fishery managers and recreational fishers: lessons learned from a comparative analysis of international case studies. *Fisheries*

Management and Ecology 20(2-3): 234-243.

Dell Palme, C.A., Nguyen, V.M., Gutowsky, L.F.G. & Cooke, S.J. 2016. Do fishing education programs effectively transfer 'catch-and-release' best practices to youth anglers yielding measurable improvements in fish condition and survival? *Knowledge and Management of Aquatic Ecosystems 417(42):* 1-8.

Dietz, T., Stern, P.C. & Guagnano, G.A. 1998. Social, Structural and Social Psychological Bases of Environmental concern*. Environment and Behavior 30(4):* 450-471.

Dunlap, R.E., York, R. 2008. The globalization of environmental concern and the limits of the postmaterialist values explanation: Evidence from four multinational surveys. *Sociological Quarterly 49(3):* 529-563.

Dunlap, R.E., Van Liere, K.D., Mertig, A.G. & Jones, R.E. 2000. Measuring endorsement of the new environmental paradigm: A revised NEP scale. *Journal of Social Issues 56:* 425–442.

Dunn, J.A., 1964. Factor structure of the test anxiety scale for children. *Journal of Consulting Psychology 28(1):* 92.

Edwards, R.W., Cryer, M., Maitland, P.S. & Turner, A.K. 1987. Angling and wildlife conservation - are they incompatible? In Maitland, P.S., Turner, A.K. (eds.), Angling and wildlife in fresh waters. Grange-over-Sands, NERC/ITE, 76-81. (ITE Symposium, 19).

Eisenberg, N. & Miller, P. 1987. The relation of empathy to prosocial and related behaviors, *Psychological Bulletin 101:* 91–119.

Evans, J.C. 2005. With Respect for Nature – Living as part of the Natural World. State

University of New York Press, Albany, NY.

Ferter, K., Rikardsen, A.H., Evensen, T.H., Svenning, M.A. & Tracey, S.R. 2017. Survival of Atlantic halibut (*Hippoglossus hippoglossus*) following catch-and-release angling. *Fisheries Research 186: 6*34–641.

Fishbein, M. & Ajzen, I. 1975. Belief, attitude, intention and behaviour: An introduction to theory and research. Reading, MA: Addison-Wesley.

Floyd, M.F. 2010. Research on race and ethnicity in leisure: Anticipating the fourth wave. *Leisure 31(1):* 245-254.

Freire, K.M.F., Tubino, R.A., Monteiro-Neo, C., Andrade-Tubino, M.F., Belruss, C.G., Tomás, A.R.G., Tutui, S.L.S., Castro, P.M.G., Maruyama, L.S., Catella, A.C., Crepaldi, D.V., Danie, C.R.A., Machado, M.L., Mendonça, J.T., Moro, P.S., Motta, F.S., Ramires, M., Silva, M.H.C. & Vieira, J.P. 2016. Brazilian recreational fisheries: current status, challenges and future direction. *Fisheries Management and Ecology 23:* 276-290.

Gagne, T.O., Ovitz, K.L., Griffin, L.P., Brownscombe, J.W., Cooke, S.J., Danylchuk, A.J. 2017. Evaluating the consequences of catch-and-release recreational angling on golden dorado (*Salminus brasiliensis*) in Salta, Argentina. *Fisheries Research 186:* 625–633.

Gardner, G.T. & Stern, P.C. 2002. Environmental problems and human behaviour (2nd ed.). Boston, MA: Pearson Custom Publishing.

Geller, E.S. 1995. Actively caring for the environment: An integration of behaviorism and humanism. *Environment and Behavior 27(4):* 184-195.

Geller, E.S. 2002. The challenge of increasing proenvironmental behaviour. In RB Bechtel, & A Churchman (Eds.), Handbook of environmental psychology (pp.525–540).

New York: Wiley.

Gifford, R. 2014. Environmental Psychology Matters. *The Annual Review of Psychology 65:* 541-79.

Gingerich, A.J., Cooke, S.J., Hanson, K.C., Donaldson, M.R., Hasler, C.T., Suski, C.D. & Arlinghaus, R., 2007. Evaluation of the interactive effects of air exposure duration and water temperature on the condition and survival of angled and released fish. *Fisheries Research 86: 169–178.*

Greiner, R., Franklin, D.C. & Gregg, D. 2013. Towards an improved understanding of angler tourism in northern Australia. Fisheries Management and Ecology 20: 161–173.

Guckian, M. L., Danylchuk, A. J., Cooke, S. J. & Markowitz, E. M. 2018. Peer pressure on the riverbank: Assessing catch-and-release anglers' willingness to sanction others' (bad) behavior. *Journal of Environmental Management 219:* 252–259.

Herfaut, J., Levrel, H., Thèbaud, O. & Vèron, G. 2013. The nationwide assessment of marine recreational fishing: A French example. *Ocean and Coastal Management 78:* 121-131.

Hessami, H.Z. & Yousefi, P. 2013. Investigation of major factors influencing green purchasing behaviour: Interactive approach. *European Journal of Natural and Social Science 2 (4):* 584– 596.

Hessenauer, J-M., Vokoun, J., Davis, J., Jacobs, R. & O'Donnell, E. 2018. Size structure suppression and obsolete length regulations in recreational fisheries dominated by catch-and- release. *Fisheries Research 200:* 33-42.

Hines, J.M., Hungerford, H.R. & Tomera, A.N. 1986. Analysis and synthesis of research on responsible pro-environmental behavior: a meta-analysis. *The Journal of Environmental Education, 18(2):* 1–8.

Hunecke, M., Blobaum, A., Matthies, E., & Höger, R. 2001. Responsibility and environment: ecological norm orientation and external factors in the domain of travel mode choice behaviour. *Environmental Behaviour 33:* 830–852.

ICES. 2013. Report of the ICES Working Group on Recreational Fisheries Surveys 2013(WGRFS), 22-26 April 2013, Esporles, Spain. 49pp.

Jackson, J.B.C., Kirby, M.X., Berger, W.H., Bjorndal, K.A., Botsford, L.W., Bourque, B.J., Bradbury, R.H., Cooke, R., Erlandson, J., Estes, J.A., Hughes, T.P., Kidwell, S., Lange, C.B., Lenihan, H.S., Pandolfi, J.M., Peterson, C.H., Steneck, R.S., Tegner, M.J. & Warner, R.R., 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science 293:* 629–638.

Jerome, J.M., Gallagher, A.J., Cooke, S.J. & Hammerschlag, N. 2017. Integrating reflexes with physiological measures to evaluate coastal shark stress response to capture. *ICES Journal of Marine Science 75(2):* 796-804.

Johnson, C. Y., Bowker, J. M., & Cordell, H. K. 2004. Ethnic variation in environmental belief and behavior. *Environment and Behavior 36*: 157–186.

Johnston, F.D., Arlinghaus, R. & Dieckmann, U. 2010. Diversity and complexity of angler behaviour drive socially optimal input and output regulations in a bioeconomic recreational fisheries model. *Canadian Journal of Fisheries and Aquatic Sciences 67:* 507–1531.

Karpov, K.A., Albin, D.P. & Van Buskirk, W.H. 1995. The marine recreational fishery in northern and central California: a historical comparison (1958-86), status of stocks (1980-86), and effects of changes in the California current. California, Dept. of Fish and Game.

Kearney, R.E. 2001. Fisheries property rights and recreational/commercial conflict: implications of policy developments in Australia and New Zealand. *Marine Policy 25(1):* 49-59.

Keizer, K. & Schultz, P.W. 2018. Social Norms and Pro-environmental behaviour. In L. Steg, and J. de Groot (Eds) Environmental Psychology, An Introduction (Second Edition), Wiley- Blackwell, Malden, Massachusetts.

Kennedy, E.H., Beckley, T.M., Mcfarlane, B.L. & Nadeau, S. 2009. Why we don't "walk the talk":understanding the environmental values/behaviour gap in Canada. *Human Ecology Review 16(2):* 151-160.

Kirchner, C.H., , Sakko, A.L. & Barnes, J.I. 2000. An economic valuation of the Namibian recreational shore-angling fishery. *South African Journal of Marine Science 22 (1):* 17-25.

Kollmuss, A. & Agyeman, J. 2002. Mind the Gap: why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environmental Education Research 8:* 239– 260.

Kramer, R.J., Mann, B.Q., Dunlop, S.W., Mann-Lang, J.B. & Robertson-Andersson, D. 2017. Changes in recreational shore angler's attitudes towards, and awareness of, linefish management along the KwaZulu-Natal coast, South Africa. *African Journal of Marine Science 39(3):*327-337.

Larson, L.R., Stedman, R.C., Cooper, C.B. & Decker, D.J. 2015. Understanding the multi- dimensional structure of pro-environmental behaviour. *Journal of Environmental Psychology 43*: 112-124.

Lehman, P.K. & Geller, E.S. 2004. Behaviour analysis and environmental protection: accomplishments and potential for more. *Behavioral and Social Issues 13:* 13–32.

Lennox, R.J., Brownscombe, J.W., Cooke, S.J., Danylchuk, A.J., Moro, P.S., Sanches, E.A. & Garrone-Neto, D. 2015. Evaluation of catch-and-release angling practices for the fat snook *Centropomus parallelus* in a Brazilian estuary. *Ocean and Coastal Management 113:* 1– 7.

Lewin, W.-C., Arlinghaus, R. & Mehner, T. 2006. Documented and potential biological impacts of recreational angling: insights for conservation and management. *Reviews in Fisheries Science 14:* 305-367.

Llompart, F.M., Colautti, D.C. & Baigún, C.R.M. 2012. Assessment of a major shore-based marine recreational fishery in the southwest Atlantic, Argentina. *New Zealand Journal of Marine and Freshwater Research 46(1):* 57-70.

Mackay, M., Jennings, S., van Putten, E.I., Sibly, H. & Yamazaki, S. 2018. When push comes to shove in recreational fishing compliance, think 'nudge'. *Marine Policy 95:* 256–266.

Martins, C.L., Walker, T.I. & Reina, R.D. 2018. Stress-related physiological changes and post- release survival of elephant fish (*Callorhinchus milii)* after longlining, gillnetting, angling and handling in a controlled setting. *Fisheries Research 204:* 116-124.

Maslow, A.H. 1943. A theory of human motivation. *Psychological Review 50(4):* 370–396.

McGrath, M. D., Horner, C. C. M., Brouwer, S. L., Lamberth, S. J., Mann, B. Q., Sauer, W.H.H. & C. Erasmus. 1997. An economic valuation of the South African linefishery. *Southern African Journal of Marine Science 18:* 203-211.

McPhee, D., Leadbitter, D. & Skilleter, G.A. 2002. Swallowing the bait: Is recreational fishing in Australia ecologically sustainable? *Pacific Conservation Biology 8(1):* 40-51.

Milner-Gulland, E.J. 2012. Interactions between human behaviour and ecological systems. Philosophical Transactions: *Biological Sciences 367, 1586:* 270-278.

Nguyen, V.M., Rudd, M.R., Hinch, S.G. & Cooke, S.J. 2012. Differences in information use and preferences among recreational salmon anglers: implications for management initiatives to promote responsible fishing. *Human Dimensions in Wildlife 17:* 248-256.

Pawson, M.G., Glenn, H., & Padda, G. 2008. The definition of marine recreational fishing in Europe. *Marine Policy 32*: 339-350.

Pelletier, C., Hanson, K.C. & Cooke, S.J. 2007. Do catch-and-release guidelines from state and provincial fisheries agencies in North America conform to scientifically based best practices? *Environmental Management 39:* 760-773.

Peterson, M.N., Chen, X.D. & Liu, J.G. 2008. Household location choices: Implications for biodiversity conservation. *Conservation Biology 22:* 912-921**.**

Post, J.R., Sullivan, M., Cox, S., Lester, N.P., Walters, C.J. & Parkinson E.A.. 2002. Canada's recreational fisheries: the invisible collapse? *Fisheries 27:* 6–17.

Prince, E.D., Ortiz, M. & Venizelos, A. 2002. A comparison of circle hook and 'J' hook performance in recreational catch-and-release fisheries for billfish. *American Fisheries Society Symposium 30:* 66-79.

Quinn, S.P. 1989. Recapture rates of voluntarily released Largemouth Bass. *North American Journal of Fisheries Management 9(1):* 86-91.

Raby, G.D., Donaldson, M.R., Hinch, S.G., Patterson, D.A., Lotto, A.G., Robichaud, D., English, K.K., Willmore, W.G., Farrell, A.P., Davis, M.W. & Cooke, S.J., 2012. Validation of reflex indicators for measuring vitality and predicting the delayed mortality of wild coho salmon bycatch released from fishing gears. *Journal of Applied Ecology 49:* 90–98.

Raby, G.D., S.J. Cooke, K.V. Cook, S.H. McConnachie, M. R. Donaldson, S. G. Hinch, C.K. Whitney, S. M. Drenner, D. A. Patterson, T. D. Clark, & A. P. Farrell. 2013. Resilience of Pink Salmon and Chum Salmon to simulated fisheries capture stress incurred upon arrival at spawning grounds. *Transactions of the American Fisheries Society 142:* 524–539.

Raby, G.D., Packer, J.R., Danylchuk, A.J. & Cooke, S.J., 2014. The understudied and underappreciated role of predation in the mortality of fish released from fishing gears. *Fish and Fisheries 15:* 489–505.

Rajecki, D.W. 1982. Attitudes: themes and advances (Sunderland, MA, Sinauer).

Sauls, B. & Ayala, O. 2012. Circle Hook requirements in the Gulf of Mexico: application in recreational fisheries and effectiveness for conservation of reef fishes. *Bulletin of Marine Science 88(3):* 667–679.

Schofer, E. & Hironaka, A. 2005. The Effects of World Society on Environmental Protection Outcomes. *Social Forces 84(1):* 25-47.

Schreck, C. B., Olla, B. L., & Davis, M. W. 1997. Behavioral responses to stress. In Fish Stress and Health in Aquaculture, pp. 145e170. Ed. by G. K. Iwama, A. D.

Pickering, J. P. Sumpter, and C. B. Schreck. Cambridge University Press, New York

Schultz, P.W. 2011. Conservation means behaviour. *Conservation Biology 125(6):* 1080-1083.

Scott, D., Willits, F. K. 1994. Environmental attitudes and behavior: A Pennsylvania survey. *Environment and Behavior 26(2):* 239–260.

Shove E. 2010. Beyond the ABC: climate change policy and theories of social change. *Environment and Planning 42:* 1273-1285.

Sims, B. & Danylchuk, A.J. 2017. Characterizing information on best practice guidelines for catch-and-release in websites of angling-based non-government organizations in the United States. *Fisheries Research 186:* 688–692.

Smallwood, C.B., Pollock, K.H., Wise, B.S., Hall, N.G. & Gaughan, D.J. 2011. Quantifying recreational fishing catch and effort: a pilot study of shore-based fishers in the Perth Metropolitan area. Fisheries Research Report No. 216. Final NRM Report - Project No. 09040. Department of Fisheries, Western Australia. 60pp.

Smith, M.L. & Jehlička, P. 2012. Environmental Values in Central and Eastern Europe. *Czech Sociological Review 48(3):* 409-419.

Smith, B.D., Zeder, M.A. 2013. The onset of the Anthropocene. *Anthropocene 4:* 8-13.

Steffen, W., Crutzen, P.J., McNeill, J.R. 2007. The Anthropocene: Are Humans now overwhelming the Great Forces of nature. *Ambio 36(8):* 614-621.

Steg, L. & Vlek, C. 2009. Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology 29*: 309–317.

Stern, P.C. 2000. Toward a Coherent Theory of Environmentally Significant behaviour.

Journal of Social Issues 56(3): 407-424.

Stern, P.C., Dietz, T., Kalof, L. & Guagnano, G. 1995. Values, beliefs and pro-environmental action: Attitude formation toward emergent attitude objects. *Journal of Applied Social Psychology 25:* 1611-1636.

Sutinen, J.G. 1993. Recreational and Commercial Fisheries Allocation with Costly Enforcement. *American Journal of Agricultural Economics 75(5):* 1183-1187.

Sutton, S.G. 2006. An Assessment of the Social Characteristics of Queensland's Recreational Fishers. CRC Reef Research Centre Technical Report No.65.

Thøgersen, J. 2005. How may consumer policy empower consumers for sustainable lifestyles? *Journal of Consumer Policy 28(2):* 143-177.

Tindall, D.B., Davies, S., & Mauboules, C. 2003. Activism and conservation behavior in an environmental movement: The contradictory effects of gender. *Society and Natural Resources 16:* 909-932.

Thomas, C. & Sharp, V. 2013. Understanding the normalisation of recycling behaviour and its implications for other pro-environmental behaviours: a review of social norms and recycling. *Resources, Conservation and Recycling 79:* 11–20.

Twardek, W.M., Gagne, T.O., Elmer, L.K., Cooke, S.J., Beere, M.C. & Danylchuk, A.J. 2018. Consequences of Catch and Release angling on the physiology, behaviour and survival of wild steelhead *Oncorhynvhus mykiss* in Bulkley River, British Columbia. *Fisheries Research 206:* 235 -246.

Van Liere, K.D. & Dunlap, R.E. 1980. The Social Bases of Environmental Concern: A Review of Hypotheses, Explanations and Empirical Evidence. *Public Opinion Quarterly 44:* 2.

Vaske, J.J., Donnelly, M.P., Williams, D.R. & Jonker, S. 2001. Demographic influences on environmental value orientations and normative beliefs about national forest management. *Society and Natural Resources 14(9):* 761-776.

Vikan, A., Camino, C., Biaggio, A. & Nordvik, H. 2007. Endorsement of the New Ecological Paradigm: A Comparison of Two Brazilian Samples and One Norwegian Sample. *Environment and Behavior 39:* 217-228.

Volpato, G.L. 2009. Challenges in Assessing Fish Welfare. *ILAR 50,* 4: 329-337.

Weltersbach, M.S., Ferter, K., Strehlow, H.V. & Sambraus, F. 2016. Hook shedding and post- release fate of deep-hooked European eel. *Biological Conservation 199:* 16-24.

Weltersbach, M.S., Strehlow, H.V., Ferter, K., Klefoth, T., de Graaf, & Dorow, M. 2018. Estimating and mitigating post-release mortality of European eel by combining citizen science with a catch-and-release angling experiment. *Fisheries Research 201:* 98–108.

Whitmarsh, L. & O'Neill, S. 2010. Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. *Journal of Environmental Psychology 30:* 305–314.

Whittaker, R.J., Araujo, M.B., Jepson, P., Ladle, R.J., Watson, J.E.M. & Willis, K.J. 2005.

Conservation Biogeography: assessment and prospect. *Diversity and Distributions 11:* 3-23.

Wilde, G.R., Riechers, R.K. & Ditton, R.B. 1998. Differences in attitudes, fishing motives, and demographic characteristics between tournament and nontournament Black Bass anglers in Texas. *North American Journal of Fisheries Management 18:* 422–431.

Wulff, L. 1939. Lee Wulff's handbook of freshwater fishing. Frederick A. Stokes Company.

Xiao, C.Y. & Hong, D.Y. 2010. Gender differences in environmental behaviors in China. *Population and Environment 32:* 88-104.

Zelezny, L.C., Chua, P.P. & Aldrich, C. 2000. Elaborating on gender differences in environmentalism. *Journal of Social Issues 56:* 443–457.

Appendices

Appendix A. All species data from 2015 intervention assessment

All fish 2015 Family	Column2 Species	Column3 Length (mm) mean ± SD [range](n)	Column4 Distance from Bucket (m) mean ± SD [range] (n)	Column5 Time into bucket (s) mean ± SD [range] (n)	Column6 Air Exposure (s) mean ± SD [range] (n)	Column7 RAMP score mean ± SD [range] (n)	Column8 Blood Glucose (mmol ml^{-1}) mean ± SD [range] (n)	Column9 Blood Lactate (mmol ml^{-1}) mean ± SD [range](n)
All Species		445.83 ± 179.5 [100–1585](206)	34.65 ± 34.57 [2–250](204)	105.86 ± 69.47 [18–672](189)	101.93 ± 64.34 [5–410](223)	0.25 ± 0.23[0–1] (113)	2.94 ± 1.65 [0.7–8.5](45)	6.1 ± 3.23 [2.1–15.2](38)
Elasmobranchs								
Dasyatidae	*Dasyatis chrysonota*	680 (1)	–	–	360(1)	–	–	–
Myliobatidae	*Pteromylaeus bovinus*	700 (1)	–	–	410(1)	–	–	–
Rhinobatidae	*Rhinobatos annulatus*	600.77 ± 134.56 [370–860] (13)	116.76 ± 66.54 [50–226](13)	36 ± 24.32[2–80] (15)	115.25 ± 77.87 [10–289](16)	0.33 ± 0.24 [0–0.75]	2.4 ± 0.57 [2–2.8](2)	–
Scyliorhinidae	*Haploblepharus* spp.	523.16 ± 91.21 [350–700](38)	101.11 ± 49.51 [18–275](38)	44.025 ± 48.93 [5–250](40)	99.558 ± 54.987 [12–242](43)	0.15 ± 0.18 [0–0.5](24)	3.4 ± 1.13 [1.6–5.9](14)	4.25 ± 1.89 [2.1–8.8](10)
	Poroderma africanum	1070(1)	4(1)	–	297(1)			
	Poroderma pantherinum	572 ± 70.14 [490–560](5)	21 ± 10.25[5–30] (5)	101.6 ± 30.71 [60–132](5)	70.20 ± 19.63 [48–94](5)	0.19 ± 0.13 [0–0.25](4)	1.2 ± 0.42 [0.9–1.5](2)	6.1(1)
Triakidae	*Triakis megalopterus*	650.56 ± 249.2 [470–1585](18)	36.05 ± 34.89 [5–150](19)	118.44 ± 51.98 [55–243](16)	119.21 ± 43.77 [54–193](19)	0.15 ± 0.24 [0–0.75](13)	6.9 ± 1.08 [6.2–8.5](4)	5.83 ± 1.5 [4.10–7.4](4)
Teleosts								
Arridae	*Galeichthys feliceps*	301.2 ± 63.07 [200–450](25)	28.74 ± 28.95 [2–150](34)	103.03 ± 64.69 [31–355](29)	83.65 ± 55.61 [16–200](37)	0.33 ± 0.38 [0–0.75](3)	–	–
Clinidae		170(1)	5(1)			0.5(1)	–	–
Dichistiidae	*Dichistius capensis*	355(1)	15(1)	62(1)	43(1)	0.25(1)	–	–
Haemulidae	*Pomadasys commersonni*	390 ± 81.34 [310–465](4)	52.2 ± 35.94 [20–100](4)	100.5 ± 34.51 [50–125](4)	196 ± 77.1 [120–301](4)	0.25 ± 0.00[0.25] (2)	0.7(1)	–
Plotosidae	*Plotosus limbatus*	610(1)	30(1)	120(1)	56(1)		0.8(1)	2.9(1)
Sciaenidae								
	Argyrosomus japonicus	528.89 ± 89.66 [365–740](27)	24.45 ± 16.66 [3–60](22)	94.91 ± 41.54 [45–200](23)	83.77 ± 29.65 [31–136](26)	0.38 ± 0.23 [0–0.75](15)	2.25 ± 0.74 [0.9–3.1](8)	5.72 ± 4.42 [2.7–13.2](5)
	Umbrina Robinsoni	370 ± 70.71 [320–420](2)	17.5 ± 10.61 [10–25](2)	70.5 ± 40.31 [42–99](2)	67 ± 5.66[63–70] (2)	–	2.6 ± 0.42 [2.3–2.9](2)	5.65 ± 3.89 [2.9–8.4](2)
Serranidae	*Epinephelus marginatus*	340(1)	150(1)	120(1)	170(1)	–	–	–
Sparidae								
	Cymatoceps nasutus	277.5 ± 41.13 [240–330](4)	30 ± 20[10–50](3)	90.33 ± 30.01 [60–120](3)	115.33 ± 62.29 [65–185](3)	0.5(1)	3(1)	3.4(1)
	Diplodus cervinus	283 ± 63.80 [230–390](5)	16.67 ± 5.77 [10–20](3)	105.67 ± 68.13 [51–182](3)	124.75 ± 72.92 [40–199](4)	0.17 ± 0.14 [0–0.25](3)	–	8.8(1)
	Diplodus sargus capensis	268.85 ± 36.45 [210–350](26)	31.8 ± 22.36 [5–100](25)	94.17 ± 62.71 [30–240](23)	88.22 ± 50.45 [25–246](27)	0.28 ± 0.22 [0–1](16)	2.3 ± 0.8[1.1–3.1] (6)	9.46 ± 3.8 [3.6–15.2](7)
	Lithognathus lithognathus	537.22 ± 167.28 [330–770](9)	36.25 ± 30.09 [10–100](8)	163.11 ± 92.36 [76–361](9)	150.67 ± 84.47 [63–278](9)	0.45 ± 0.33 [0.25–1](5)	–	9.4(1)
	Pachymetopon grande	348.21 ± 48.22 [270–450](14)	40.42 ± 41.64 [5–150](12)	124.08 ± 167.62 [45–672](13)	79.64 ± 42.82 [6–156](14)	0.28 ± 0.16 [0–0.5](8)	1.83 ± 0.42 [1.5–2.3](3)	5.65 ± 2.22 [3.5–8.7](4)
	Rhabdosargus holubi	270 ± 46.37 [230–350](5)	32 ± 22.86[8–60] (4)	84 ± 18.04 [70–110](4)	135.25 ± 33.88 [98–180](4)	0.13 ± 0.14 [0–0.25](4)	3.1(1)	6.8(1)
	Sparodon durbanensis	290 ± 44.44 [240–325](3)	58.67 ± 79.15 [10–150](3)	58(1)	72.67 ± 49.08 [22–120](3)	0.13 ± 0.18 [0–0.25](2)	–	–
Tetraodontidae	*Amblythynchotes honckenii*	100(1)	–	–	–	0 (1)	–	–

Appendix B. All species data from 2016 intervention assessment

Column1 Family	Column2 Species	Column3 Length (mm) mean ± SD [range] (n)	Column4 Distance from Bucket (m) mean ± SD [range] (n)	Column5 Time into bucket (s) mean ± SD [range] (n)	Column6 Air Exposure (s) mean ± SD [range] (n)	Column7 RAMP score mean ± SD [range] (n)	Column8 Blood Glucose (mmol ml^{-1}) mean ± SD [range] (n)	Column9 Blood Lactate (mmol ml^{-1}) mean ± SD [range](n)
All Species		447.28 ± 228.26 [30–1200] (193)	17.11 ± 17.25 [1–150] (189)	32.32 ± 27.52 [2–151] (188)	87.57 ± 49.37 [8–370] (199)	0.2 ± 0.22 [0–0.75] (92)	2.08 ± 0.69 [0.7–3.7] (39)	5.19 ± 2.42 [0.7–11.7] (48)
Elasmobranchs								
Myliobatidae	*Aetobatus narinari*	690 ± 14.14 [680–700] (2)	9 ± 8.49 [3–15] (2)	58.5 ± 72.83 [7–110] (2)	160 ± 28.28 [140–180] (2)	0(1)	–	–
Rhinobatidae	*Rhinobatos annulatus*	781.59 ± 100.86 [540–1000] (22)	18.33 ± 23.58 [2–100] (15)	27.79 ± 25.32 [7–99] (19)	112.24 ± 51.1 [31–205] (21)	0.09 ± 0.15 [0–0.5] (20)	–	3.6(1)
Scyliorhinidae	*Haploblepharus* spp.	437.68 ± 186.56 [45–650] (17)	10.65 ± 10.74 [1–40] (17)	29.31 ± 29.55 [4–125] (16)	58.22 ± 33.07 [8–119] (18)	0.14 ± 0.2 [0–0.5] (7)	2.68 ± 0.73 [1.8–3.7] (6)	4.34 ± 2.18 [1.7–8.7] (9)
	Poroderma africanum	907 ± 50.7 [820–950] (5)	17 ± 6.71 [10–25] (5)	52.4 ± 41.61 [7–111] (5)	165.6 ± 131.77 [44–370] (5)	0.13 ± 0.18 [0–0.25] (2)	1.5(1)	1.7(1)
	Poroderma pantherinum	558.18 ± 123.84 [270–700] (11)	18.46 ± 13.25 [2–40] (13)	24.75 ± 9.43 [11–49] (12)	102.69 ± 42.45 [41–179] (13)	0.07 ± 0.12 [0–0.25] (7)	1.76 ± 0.79 [0.8–2.8] (5)	4.2 ± 2.75 [0.7–7.3] (5)
Triakidae	*Mustelus mustelus*	629.82 ± 333.2 [106–1200] (11)	31.78 ± 46.62 [1–150] (9)	60.2 ± 37.67 [20–123] (10)	127.3 ± 62.77 [47–229] (10)	0.08 ± 0.2 [0–0.5] (6)		4.8 ± 0.71 [4.3–5.3] (2)
	Triakis megalopterus	652.5 ± 159.1 [540–765] (2)	15 ± 7.07 [10–20] (2)	37.5 ± 24.75 [20–55] (2)	161 ± 41.01 [132–190] (2)	0(2)		
Teleosts								
Arridae	*Galeichthys feliceps*	265.71 ± 63.99 [170–350] (7)	23.78 ± 15.93 [7–50] (9)	26.25 ± 15.33 [12–58] (8)	85.5 ± 51.97 [12–168] (8)	0(2)		
Clinidae			39(1)	290(1)	1(1)	67(1)	–	–
Dichistiidae	*Dichistius capensis*	300.18 ± 93.14 [30–420] (25)	19.48 ± 14.4 [1–50] (25)	31.58 ± 24.49 [7–89] (24)	73.85 ± 26.55 [28–152] (26)	0.35 ± 0.22 [0.25–0.75] (5)	2.25 ± 0.52 [1.5–3.4] (14)	6.73 ± 2.28 [3.2–10.4] (13)
Haemulidae	*Pomadasys olivaceus*	210 ± 14.14 [200–220] (2)	13.5 ± 9.19 [7–20] (2)	49 ± 2.83 [47–51] (2)	113.5 ± 13.44 [104–123] (2)	0.5(1)		
Kyphosidae	*Neoscorpis lithophilus*	385 ± 49.5 [350–420] (2)	1.5 ± 0.71 [1–2] (2)	6 ± 2.83 [4–8] (2)	74 ± 0 [74–74] (2)			
Mugilidae	*Mugil cephalus*	390(1)	2(1)	7(1)	47(1)	0(1)		
Serranidae							1.7(1)	
	Argyrosomus japonicus	557.63 ± 110.11 [450–890] (19)	17.89 ± 13.52 [1–60] (19)	33.78 ± 16.67 [11–78] (18)	97.89 ± 37.01 [48–182] (19)	0.39 ± 0.26 [0–0.75] (11)		3.9 ± 2.52 [1–5.5] (3)
	Umbrina Robinsoni	378.57 ± 32.24 [345–425] (7)	17.71 ± 10.16 [4–35] (7)	24.71 ± 10.78 [8–35] (7)	83.57 ± 25.28 [52–116] (7)	0.46 ± 0.19 [0.25–0.75] (6)	–	–
Sparidae	*Boopsoidea inornata*	240 ± 0 [240–240] (2)	10 ± 0 [10 – 10] (2)	14 ± 5.66 [10–18] (2)	49.5 ± 21.92 [34–65] (2)		1.2(1)	2.8(1)
	Diplodus capensis	262.04 ± 25.73 [200–320] (27)	15.5 ± 17.06 [1–50] (28)	39.48 ± 39.17 [4–151] (27)	73.7 ± 45.82 [27–177] (27)	0.23 ± 0.16 [0–0.5] (13)	2.06 ± 0.86 [0.7–2.9] (5)	7.15 ± 3.39 [3.8–11.7] (4)
	Diplodus cervinus	292.5 ± 14.4 [270–310] (6)	22.5 ± 6.89 [15–35] (6)	22 ± 12.85 [6–37] (6)	71.67 ± 14.69 [57–100] (6)	0.17 ± 0.14 [0–0.25] (3)		
	Lithognathus	388.56 ± 222.46	10.13 ± 7.38	30.75 ± 30.13	96.75 ± 35.8	0.13 ± 0.18		4.8(1)
	Lithognathus	[44–620] (8)	[1–20] (8)	[2–80] (8)	[48–134] (8)	[0–0.25] (2)		
	Lithognathus mormyrus	295(1)	15(1)	23(1)	60(1)	0.25(1)		
	Pachymetopon blochii	316.67 ± 39.45 [250–370] (6)	23.33 ± 14.02 [5–40] (6)	26 ± 15.81 [2–48] (6)	76.83 ± 39.28 [35–145] (6)		1.82 ± 0.4 [1.4–2.4] (5)	4.76 ± 1.01 [3.8–6] (5)
	Rhabdosargus holubi	190(1)	10(1)	28(1)	69(1)	–	–	4.1(1)
	Sarpa salpa				58(1)			
	Sparodon durbanensis	233.6 ± 101.27 [58–310] (5)	10 ± 8.34 [2–20] (5)	16.8 ± 11.12 [6–32] (5)	46.6 ± 30.57 [18–98] (5)			
Tetraodontidae	*Amblythynchotes honckenii*				20(1)			
	(suckerfish)				40(1)			

Appendix C. All species data from 2017 intervention assessment

Column2 Family	Column3 Species	Column4 Length(mm) mean ± SD [range] (n)	Column5 Distance from Bucket(m) mean ± SD [range] (n)	Column6 Time into bucket(s) mean ± SD [range] (n)	Column7 Air Exposure(s) mean ± SD [range] (n)	Column8 RAMP score mean ± SD [range] (n)	Column9 Blood Glucose (mmol ml^{-1}) mean ± SD [range] (n)	Column10 Blood Lactate (mmol ml^{-1}) mean ± SD [range](n)
All Species		485.82 ± 324.38 [145–1760] (188)	29.4 ± 31.01 [1–335] (187)	23.05 ± 24.13 [1–200] (192)	77.37 ± 60.52 [3–412] (199)	0.23 ± 0.25 [0–1] (68)	3.03 ± 1.71 [0.8–7.7] (80)	4.72 ± 3.69 [0.5–18.4] (69)
Elasmobranchs								
Dasyatidae	*Dasyatis chrysonota*	412.86 ± 53.76 [350–500] (7)	32.86 ± 24.75 [4–68] (7)	24.71 ± 25.91 [1–70] (7)	149.57 ± 129.61 [43–412] (7)		1.6 ± 0.2 [1.4–1.8] (3)	1.35 ± 0.92 [0.7–2] (2)
Odantaspididae	*Carcharias taurus*	1625 ± 123.96 [1510–1760] (4)	–	267.5 ± 72.85 [177–329](4)	267.5 ± 72.85 [177–329] (4)	–	–	–
Rhinobatidae	*Rhinobatos annulatus*	758.72 ± 222.35 [300–1400] (43)	33.14 ± 17.87 [1–80] (43)	29.73 ± 22.02 [1–100] (46)	78.22 ± 37.74 [4–220] (46)	0.16 ± 0.27 [0–0.75] (8)	1.91 ± 0.55 [0.9–3.3] (15)	2.55 ± 1.83 [0.5–7.1] (12)
Scyliorhinidae	*Haploblepharus* spp.	581.43 ± 45.98 [520–620] (7)	25.63 ± 16.37 [7–55] (9)	12.44 ± 6.5 [1–20] (9)	65.8 ± 35.05 [12–125] (10)		3.16 ± 0.33 [2.7–3.7] (7)	1.76 ± 0.78 [1–3.2] (7)
	Poroderma africanum	730 ± 40.62 [670–780] (5)	39.8 ± 21.65 [22–77] (5)	14 ± 2.24 [10–15] (5)	90.6 ± 38.9 [53–142] (5)		1.25 ± 0.39 [0.8–1.7] (4)	2.34 ± 1.1 [1–3.3] (5)
	Poroderma pantherinum	512.5 ± 59.65 [470–600] (4)	35 ± 2.65 [32–37] (3)	13.75 ± 4.79 [10–20] (4)	96 ± 25.14 [74–128] (4)	–	1.38 ± 0.68 [0.8–2.1] (4)	2.83 ± 1.48 [0.8–4.3] (4)
Triakidae	*Mustelus mustelus*	1450 ± 62.45 [1400–1520] (3)	184.33 ± 143.2 [50–335] (3)	33 ± 33.72 [4–70] (3)	239.33 ± 84.48 [175–335] (3)		5.05 ± 2.33 [3.4–6.7] (2)	5.15 ± 3.18 [2.9–7.4] (2)
	Triakis megalopterus	–	22(1)	–	153(1)	–	–	–
Teleosts								
Arridae	*Galeichthys feliceps*	323.33 ± 64.66 [205–380] (9)	25.55 ± 27.79 [1–95] (11)	21.55 ± 13.31 [2–40] (11)	100.77 ± 86.22 [32–339] (13)	0.36 ± 0.25 [0–0.75] (9)	1.68 ± 0.54 [1.1–2.4] (4)	6.47 ± 5.35 [2–12.4] (4)
Cheilodactylidae	*Chirodactylus grandis*	–	26.47(1)	20(1)	26.47(1)	–	2.2(1)	3.6(1)
Dichistiidae	*Dichistius capensis*	310(1)	16(1)	1(1)	30(1)	0(1)	–	–
Haemulidae	*Pomadasys olivaceus*	182.5 ± 45.96 [150–215] (2)	–	12(1)	36 ± 22.63 [20–52] (2)	–	2.6(1)	3.3(1)
Pomatomidae	*Pomatomus saltatrix*	380 ± 47.85 [330–540] (16)	16.14 ± 10.4 [3–38] (16)	34.81 ± 51.22 [5–200] (16)	53.8 ± 19.81 [11–89] (15)	0.25 ± 0.35 [0–1] (7)	6.61 ± 0.75 [5.7–7.7] (9)	11.82 ± 4.52 [6.9–18.4] (6)
Sciaenidae	*Argyrosomus japonicus*	423.75 ± 84.59 [370–550] (4)	24 ± 22.29 [2–51] (4)	16.25 ± 4.79 [10–20] (4)	68.95 ± 25.2 [40–92] (4)		3.3(1)	5.3(1)
Serranidae	*Acanthistius sebastoides*	225(1)	67(1)	15(1)	183(1)	–	–	–
	Umbrina Robinsoni	431.11 ± 47.49 [370–500] (9)	21 ± 13.16 [7–43] (9)	20.56 ± 13.65 [2–40] (9)	58.44 ± 21.84 [25–88] (9)	0.36 ± 0.38 [0–0.75] (7)	–	–
Sparidae	*Boopsoidea inornata*	200 ± 28.28 [180–240] (4)	28.4 ± 15.98 [5–48] (5)	16 ± 8.22 [10–30] (5)	56 ± 26.14 [30–96] (5)		3.1 ± 0 [3.1–3.1] (2)	3.85 ± 0.64 [3.4–4.3] (2)
	Cheimerius nufar	279.17 ± 46.02 [210–360] (12)	18.82 ± 10.68 [5–42] (11)	21.25 ± 31.59 [2–120] (12)	59.64 ± 31.51 [23–127] (11)	0.22 ± 0.28 [0–0.75] (8)	2.47 ± 1.07 [1.3–3.4] (3)	3.4 ± 0.42 [3.1–3.7] (2)
	Diplodus capensis	259.41 ± 31.52 [200–340] (34)	23.21 ± 20.08 [2–105] (34)	20.62 ± 18.57 [2–100] (34)	52.06 ± 33.31 [3–161] (34)	0.19 ± 0.17 [0–0.5] (17)	2.94 ± 0.37 [2.4–3.6] (13)	6.69 ± 2.99 [3.1–12] (11)
	Diplodus cervinus	281 ± 55.5 [200–335] (5)	31.25 ± 18.5 [7–50] (4)	8.6 ± 3.85 [4–12] (5)	62.4 ± 47.94 [19–137] (5)		1.9(1)	2.4(1)
	Gymnocrotaphus curvidens	290(1)	48(1)	10(1)	78		2.2(1)	3.3(1)
	Lithognathus lithognathus	246.67 ± 56.86 [200–310] (3)	27.33 ± 18.72 [6–41] (3)	44 ± 50.48 [2–100] (3)	73 ± 40.26 [29–108] (3)		5.15 ± 1.34 [4.2–6.1] (2)	7.45 ± 1.77 [6.2–8.7] (2)
	Lithognathus mormyrus	200(2)	30 ± 2.83 [28–32] (2)	30(2)	69.5 ± 14.85 [59–80] (2)		4 ± 0.57 [3.6–4.4] (2)	8.5(1)
	Pagellus natalensis	–	–	–	94(1)	0.25(1)	–	–
	Rhabdosargus holubi	223.33 ± 58.79 [145–280] (6)	16.17 ± 10.76 [1–30] (6)	10.67 ± 6.44 [1–20] (6)	45 ± 18.65 [17–68] (6)	0.17 ± 0.14 [0–0.25] (3)	2.63 ± 0.35 [2.3–3] (3)	5.1 ± 1.68 [3.2–6.4] (3)
	Sarpa salpa	213.33 ± 32.15 [190–250] (3)	47 ± 19.67 [26–65] (3)	23.67 ± 12.06 [11–35] (3)	67.5 ± 2.12 [66–69] (2)	–	6.5(1)	7(1)
Tetraodontidae	*Amblythynchotes honckenii*	–	35(2)	22.5 ± 10.61 [15–30] (2)	41 ± 8.49 [35–47] (2)	–	3.1(1)	–
Soleidae	*Solea solea*	–	15(1)	10(1)	50(1)	–	–	–

Appendix D. Letter from RASSPL Chairman approving survey

Jacques Ackhurst
072 066 9554
ackhurstjacques@yahoo.co.uk

9nd May, 2018.

Dear Warren Potts and team

On behalf of RASSPL Africa I am pleased to give the South African Fisheries Ecology Research (SAFER) lab's research team permission to contact our anglers to complete surveys to assess reasons behind changes in recreational angler's behaviour with regard to Catch and Release angling.

We are always happy to be involved in research that has the potential to improve sustainable fishing.

Yours sincerely

Jacques Ackhurst

RASSPL Africa Chairman

Appendix E. Ethical approval from the Rhodes University Ethics committee

RHODES UNIVERSITY
Where leaders learn

Science Faculty Ethics Sub-committee
Biological Science Building, Grahamstown, 6139, South Africa
PO Box 94, Grahamstown, 6140, South Africa
t: +27 (0) 46 603 8443
f: +27 (0) 46 603 7576
e: j.dames@ru.ac.za

www.ru.ac.za

28 August 2018

Dear Prof Warren Potts, Dr Amber Childs and Samantha Mannheim

Tracking Number	SCI2018/036
Date Submitted	16 July 2018
Proposal title	**Identifying key drivers behind pro-environmental behavioural changes in rock and surf competitive angling**

This letter serves to notify you of the outcome of your ethics application submitted to the Science Faculty Ethics Sub-committee.

	Outcome	Comments
Approved		
Approved with stipulations	X	Requires a letter from RASSPL chair giving permission to contact members.
Refer to RUESC-HE/RUESC-AE		
Does not require ethics approval:		
Referred back to applicant		
Rejected		

Please ensure that the Science Faculty Ethics Committee is notified should any substantive changes be made, for whatever reason, during the research process. An annual progress report is required in order to renew approval for the following year. The purpose of this report is to indicate whether or not the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethics committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloguing number allocated.

Prof Joanna Dames
(Chair)

RASSPL Nationals Angler Survey

The purpose of this research project is to assess the reasons behind the changes of recreational angler's behaviour. This project is being undertaken by the Department of Ichthyology and Fisheries Science at Rhodes University. You have been chosen to participate in this research since you are participating in RASSPL Nationals. Your participation in this research study is voluntary. You may choose not to participate. If you decide to participate in this research survey, you may withdraw at any time. You may refuse to answer any questions.
The procedure involves asking questions about yourself, including your age, education, income and various behaviours and beliefs involving recreational fishing regulations and takes approximately 15 minutes to complete.
The results of this study will be used for scholarly purposes only.
If you have any questions about the research study, please contact Samantha Mannheim (manthamann@gmail.com) or Warren Potts (w.potts@ru.ac.za).
This research has been reviewed according to Rhodes University ethics procedures for research involving human subjects.
Choosing the "agree" option below indicates that:
• you have ready the above information
• you voluntarily agree to participate
• you are at least 18 years of age

1. Do you agree to participate?
Mark only one oval.
- ◯ agree
- ◯ disagree

2. Name:

3. Franchise:

4. Did you attend either of the educational presentations "The science of C&R angling" and "RASSPL and science: working together for a sustainable fishery"?
Mark only one oval.
- ◯ Yes
- ◯ No

5. Have you watched any of the educational videos that demonstrated best-practice for C&R with the RASSPL rule framework?
Mark only one oval.
- ◯ Yes
- ◯ No

6. How important do you believe C&R angling is for the sustainability of recreational angling?
Mark only one oval.

	1	2	3	4	5	
Not at all Important	◯	◯	◯	◯	◯	Extremely Important

7. Of the fish that you release, what percentage do you think survives?

8. Would you say this is more than when you started fishing RASSPL?
Mark only one oval.
- ◯ Yes
- ◯ No

9. How many RASSPL competitions do you fish per year?

10. Besides RASSPL competitions, how many days do you fish per year?

11. How many years have you been fishing RASSPL Nationals?

12. Do you take part in other Rock and Surf fishing competitions?
Mark only one oval.
- ◯ Yes
- ◯ No

13. If yes which ones?

Why do you participate in the RASSPL?

indicate how much you agree or disagree with the following reasons for participation in the RASSPL

Appendix F. RASSPL National Angler Survey

14. To participate in a 100% C&R league
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

15. For the competition
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

16. For the prizes *Mark only one oval.*

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

17. For the challenge of the specific format
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

18. Other

19. How has the presence of the research team affected your RASSPL experience?
Mark only one oval.

	1	2	3	4	5	
extremely negatively	◯	◯	◯	◯	◯	extremely positively

20. Elaborate on previous answer

21. How have the populations of the targeted species captured in RASSPL competitions changed over the years?
Mark only one oval.

	1	2	3	4	5	
increasing	◯	◯	◯	◯	◯	decreasing

What do you think the biggest threat to these coastal fish populations is?

Indicate how much you agree or disagree with following potential threats to coastal fishes

22. Trawl Fishery *Mark only one oval.*

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

23. General rock and surf anglers
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

24. Competitive rock and surf anglers
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

25. Commercial linefishers
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

26. Recreational ski boaters
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

27. Spearfishers
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

28. Pollution
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

29. Climate change
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

30. Other, expand...

How important is each of the following in determining the fate of a fish and whether it survives:

Indicate how important or unimportant you think the following are in determining fish survival after a C&R event

31. Where it is hooked
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

32. How long the fight is
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

33. How long the fish is exposed to air
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

34. How a fish is handled
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

35. Weather
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

36. How a fish is released
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

37. Water temperature
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

How likely do you think it is that a fish will be disqualified if:

Indicate how likely or unlikely you think it is that a fish will be disqualified in the following situations

38. It is under the prescribed minimum 500 g / 1 kg size limit
Mark only one oval.

	1	2	3	4	5	
very unlikely	◯	◯	◯	◯	◯	very likely

39. It is captured while the angler has an empty C&R bucket
Mark only one oval.

	1	2	3	4	5	
very unlikely	◯	◯	◯	◯	◯	very likely

40. It is captured more than 50 m away from the C&R bucket
Mark only one oval.

	1	2	3	4	5	
very unlikely	◯	◯	◯	◯	◯	very likely

41. It is captured while another fish is in their C&R bucket
Mark only one oval.

	1	2	3	4	5	
very unlikely	◯	◯	◯	◯	◯	very likely

42. It (despite being over the prescribed minimum size) is not placed into the C&R bucket
Mark only one oval.

	1	2	3	4	5	
very unlikely	◯	◯	◯	◯	◯	very likely

43. How much do you think that your handling practice has improved since joining RASSPL?
Mark only one oval.

	1	2	3	4	5	
stayed the same	◯	◯	◯	◯	◯	extreme improvement

44. If your handling practice has changed since joining RASSPL, why do you think that is?

45. How important were the conservation prizes in improving your fish handling practices?
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

46. How important were the rule changes (eg. Introduction of the C&R bucket) in improving your fish handling practices?
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

47. How important were the informative presentations on good handling practices and the educational posters in improving your fish handling practices?
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

48. How important were the videos demonstrating best handling practices in improving your fish handling practices?
Mark only one oval.

	1	2	3	4	5	
unimportant	◯	◯	◯	◯	◯	important

How much do you agree/disagree with the following rule changes that have been put into place in the RASSPL?

Indicate how much you agree or disagree with the following RASSPL rules

49. Introduction of the smooth gully rule (all spotted gully and smooth hound sharks below xx cm (TL) are considered to be one species)
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

50. Introduction of the C&R bucket
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

51. Introduction of the 50m from the bucket rule
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

52. Introduction of the full bucket before casting rule
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

53. Introduction of the rule that prohibits you from handling your second rod if you already have a fish in the RASSPL bucket
Mark only one oval.

	1	2	3	4	5	
strongly disagree	◯	◯	◯	◯	◯	strongly agree

54. Do you think it should be acceptable to take a fish if after all your efforts to release it, it has died anyway?

55. What additional rules/changes do you suggest may improve the health and survival of fishes in the RASSPL?

56. How frequently do you utilize RASSPL fish handling techniques when angling outside of competitions?
Mark only one oval.

	1	2	3	4	5	
never	◯	◯	◯	◯	◯	often

57. How frequently do you educate or attempt to educate other anglers RASSPL fish handling techniques when angling outside of competitions?
Mark only one oval.

	1	2	3	4	5	
never	◯	◯	◯	◯	◯	often

58. Do you have a fishing partner that you fish with regularly?
Mark only one oval.

- ◯ Yes
- ◯ No

59. If yes how would you describe you partners' practices with regard to fish air exposure?
Mark only one oval.

	1	2	3	4	5	
horrible	◯	◯	◯	◯	◯	excellent

60. How would you describe you partners' practices with regard to the rule on the distance one can be from their C&R bucket?
Mark only one oval.

	1	2	3	4	5	
horrible	◯	◯	◯	◯	◯	excellent

61. How would you describe you partners' practices with regard to the rule on having a bucket full of water before casting?
Mark only one oval.

	1	2	3	4	5	
horrible	◯	◯	◯	◯	◯	excellent

62. Does the partner that you fish with influence the way that you handle your fish?
Mark only one oval.

	1	2	3	4	5	
no influence	◯	◯	◯	◯	◯	strong influence

63. How old are you?

64. Gender

Mark only one oval.

- Male
- Female

65. What is your Ethnicity?

66. What is the highest level of education you have completed?

Mark only one oval.

- Pre-matric
- Matric
- Diploma
- Tertiary (University)
- Postgraduate

67. What is your employment status?

Mark only one oval.

- Unemployed and not looking for work
- Unemployed and looking for work
- Employed
- Student
- Retired

68. What is your ANNUAL income before taxes?

Mark only one oval.

- No income
- R1 - R9,600
- R9,601 - R38,400
- R38,401 - R76,100
- R76,101 - R153,600
- R153,601 - R307,200
- R307,201 - R614,400
- R614,401 - R1,228,800
- R1,228,801 or more