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TOWARDS A NORM OF COMPLIANCE IN RECREATIONAL FISHERIES

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Abstract

The activity of fishing can be traced back to prehistoric times. However, only in the last century has there been a focus on the management of fisheries. Fishery regulations are tools used by resource managers with the aim of protecting the long-term sustainability of fishery resources. Although there is an overwhelming amount of evidence demonstrating the decline of fisheries, non-compliance with these regulations by fishers continues to manifest, which can exacerbate the negative ecological impacts of fisheries. Popular methods towards the measurement of non-compliance in fisheries derived from previous human dimensions literature may be flawed. Theories on improving compliance behaviour have typically relied on theory, which has at times proved paradoxical. Addressing the issues of non-compliance within a fishery of interest requires measuring the levels of non-compliance within the fishery and determining the relevant socio-psychological drivers behind the non-compliant behaviour. The data collection methods used during these assessments are limited in human dimensions research and are often case and context specific, requiring researchers to identify which approach is most practical for the specific fishery of interest. By identifying relevant behavioural drivers of non-compliance, a more effective approach aimed at improving compliance can be tailored.

The recreational marine-based shore fishery (MBSF) in South Africa is not impervious to non-complaint behaviour. In fact, it has been estimated to have relatively high rates of non-compliance. This high level of non-compliance makes the South African MBSF a unique and optimal context in which to undertake research that aims to formulate a framework towards compliance assessments and that develops a suitable approach for improving compliance rates.

Using surveys to obtain compliance data can provide a range of details about violators, however they are susceptible to social desirability bias (SDB). Choosing the best method for controlling SDB required an assessment of existing methods for doing so. In this first part of the study, only fishers who were covertly observed breaking the rules were surveyed, using one of three methods for reducing SDB, to ground-truth the responses. Ground-truthing was done to determine which method would be most effective for a large-scale study within the same fishery. Of the methods used, which include the direct questioning method (DQM), the random response technique (RRT) and the ballot box method (BBM), all contained some level of SDB. However, the BBM provided a significantly higher level of response accuracy (79.6% ± 11.9) than the DQM (46.5% ± 14.9) and the RRT (44.3% ± 12.5).

Random-stratified roving creel compliance surveys that employed the BBM were then undertaken at various locations along South Africa's coastline to estimate current rates of non-compliance, and the face-to-face results were compared to results from an identical online survey to determine the suitability of online surveys as a replacement. The results indicated that online surveys only represent a subgroup of the fisher population within the MBSF, suggesting that face-to-face survey methods are required to obtain a more comprehensive sample and a more robust estimate of non-compliance.

The results, based on 453 face-to-face surveys, showed a high level of overall self-reported non-compliance (48.3%) within the fishery. Responses to Likert scale survey questions on various aspects of the fishery, including angler motivations for fishing, were then modelled to test the relationship between the anglers' responses and their compliance behaviour. In the South African MBSF context, the most significant behavioural drivers behind non-compliance related to normative concepts. Specifically, the poor perceptions of management and value-based legitimacy as well as low levels of moral obligation to adhere to the regulations appeared to contribute most to the observed non-compliant behaviour. Angler motivations for fishing also played a significant role in determining the compliance behaviour of anglers, with those fishing for food being more likely to violate regulations.

In most countries, regardless of economic context, interventions to improve recreational fishery compliance have been developed around the instrumental concept. However, these findings suggest that for recreational fisheries, managers would do well to evaluate the impact of normative concepts on compliance and to design interventions aimed at addressing these. In the case of the South African MBSF, interventions that address angler perceptions of legitimacy and aim to correct misperceptions about social norms of compliance may provide a more practical and cost-effective method for improving poor compliance behaviour.

Acknowledgements

Now, I am well aware that very few people will actually read the entirety of the thesis enclosed herein. I am even more aware that most people that actually read through this product of three years of blood, sweat and tears (mostly tears), will pass over this section, thinking it is irrelevant. However, without the people acknowledged within this section, there likely would not be a thesis to read through in the first place.

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Publications arising from this thesis

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Potts W.M., Rouhani Q., Bova C.S. (2017) Final research report to evaluate the potential of inshore linefish species for LED and to identify the role of Local Government (Report No. AG8762). Ethikweni, KZN: LGSETA.

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Thesis word cloud indicating the top 50 words used throughout this thesis, with their quantities scaled by size.

Contents

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Chapter 1: The regulatory compliance dimension of fisheries management

"...'fish', he said softly aloud, 'I'll stay with you until I am dead'."
– Ernest Hemingway, The Old Man and the Sea

Background

Since prehistoric times, humans have harvested fish for either food, income or recreation (Berners, 1496; Cowx, 2002; Henshilwood *et al.*, 2002; Arlinghaus and Cooke, 2009). The scale of participation in fisheries has increased exponentially in recent centuries, placing an increased burden on fishery resources (Jackson *et al.*, 2001; Coleman *et al.*, 2004; Granek *et al.*, 2008). Many of the world's fish stocks had been overexploited predominantly by commercial fisheries, to the point of collapse by the 20th century, which brought about calls for the sustainable management of fishery resources (Garcia *et al.*, 2003). This led to various forms of regulatory measures meant to reduce the negative impacts of fisheries on marine resources and prevent overexploitation.

The recreational fisheries of the world are not exempt from these dramatic increases in the level of fishery participation in recent decades. Although, these levels have seemingly plateaued in the last decade in many developed countries (Arlinghaus *et al.*, 2015), newly industrialised countries and developing countries have documented a rapid expansion of recreational fisheries (Pawson *et al.*, 2008; Mora *et al.*, 2009; Ihde *et al.*, 2011). While the developed world has had a long history of implementing comprehensive regulatory measures for recreational fisheries (Arlinghaus *et al.*, 2015), less developed nations have only recently realised the importance of these governance structures (Pitcher *et al.*, 2009). Therefore, it is important that these countries develop and implement management systems that can effectively ensure maintenance of desired levels of resource use.

The main objective of management policies is to delicately balance the socio-economic benefits of a fishery system with the ecological integrity of that system. Although governance systems vary considerably among industrialised countries, no management system provides a catchall for every recreational fishery (Pitcher *et al.*, 2009). It should come as no surprise that, based on the differences in socio-economic structures between the developed and developing world, management approaches also widely vary. Recreational fishery policies in developed countries may

place more emphasis on the leisure aspects of the activity and will likely employ an ecocentric approach, while developing countries may focus more on sustaining livelihoods.

No matter which approaches are implemented, a precondition for the success of these regulatory measures is that they can be effectively controlled and enforced (Nielson, 2003). Just as the management approaches fluctuate based on country-specific contexts, so might the ways in which these policies are controlled and enforced to ensure compliance by fishery participants. The traditional approach for ensuring compliance was based on strict rule-enforcement and legal action in the form of fines or imprisonment (for certain violations). These traditional sanctions are meant to act as a deterrent (Sutinen and Andersen, 1985; Gigliotti and Taylor, 1990; Sutinen and Kuperan, 1999; Keane *et al.*, 2008) but have been largely ineffective in some instances. More recently, researchers have found that this approach may be effective for ensuring regulatory compliance and that addressing socio-psychological factors relating to normative concepts, such as social norms, legitimacy and morality, may be more influential on compliance behaviours (Hatcher *et al.*, 2000; Bamberg and Möser, 2007; Hauck, 2008; Thomas, Milfont and Gavin, 2016; Bova *et al.*, 2017; Bergseth and Roscher, 2018). Nettle (2009) suggests that there is significant global diversity in terms of morals, norms and beliefs, which indicates that a normative approach towards compliance must also fit the context-specificity of individual fisheries to ensure compliance efficacy.

Failure to effectively ensure compliance using regulatory measures can undermine the ability of fishery managers to achieve their sustainability objectives and may lead to the over-exploitation and collapse of fishery resources. This would pose a serious threat to communities that depend on fishery resources as a source of food and income, such as those in developing countries. Therefore, it is pertinent to obtain a thorough understanding of non-compliance in a fishery, not only from the perspective of prevalence, but also from the perspective of the drivers behind its prevalence and persistence. This understanding will empower managers, and by addressing the drivers of non-compliance, they may be able to improve compliance. However, the success of a compliance intervention hinges on the accuracy and precision of the data on which it is based. Therefore, methods for obtaining these data should be carefully planned to ensure that they are compatible with the diverse characteristics of the fishery of interest. This study will therefore review existing methods for obtaining compliance estimates, introduce a new method for obtaining estimates and explore the relevant behavioural drivers behind this non-compliance. This

information can be used to inform improvements on the existing South African regulatory measures as well as national recreational fishery policies around the world.

A tradition of man and fish

Humans throughout the globe have been using fisheries resources since prehistoric times. Dependence on coastal resources in South Africa dates back to approximately 164,000 years ago (Jerardino and Marean, 2010). The earliest evidence of human fish exploitation using tools has been dated back to the Middle Palaeolithic Era, approximately 75,000 years ago, on the southwest coast of Africa (Henshilwood *et al.*, 2002). Prehistoric pelagic fishing practices date back as far as 42,000 years ago, while the methods of angling or the use of hook and line to catch fish has been traced back as early as 23,000 years ago off the coast of East Timor (O'Connor, Ono and Clarkson, 2011). Ancient Egyptian artwork dating back to approximately 5000 B.C. depicts scenes of anglers making use of early forms of fishing rods (Sahrhage, 2008*)*. Fishing with rod, line and hook received little technological advancement until the development of a reel, which featured in artwork by Ma Yuan circa 1160–1225 (Needham, 1965).

Based on current evidence, it is unclear whether these ancient anglers engaged in fishing for any purpose other than subsistence. It is uncertain when the motivations for angling began to include a recreational component as it is likely that fishing has always included aspects of both subsistence and recreation. Arlinghaus and Cooke (2009) define recreational fishing as "fishing for aquatic animals that do not constitute the individual's primary resource to meet essential physiological needs". The earliest reference point for fishing specifically as a leisure activity appeared in volume written by an English prioress titled "A Treatyse of Fysshynge wyth an Angle," in the year 1496, which acted as a comprehensive guide to sport angling for nobility in Europe (Berners, 1496). By the time "The Compleat Angler" had printed its several editions between the years 1653 and 1676, recreational fishing had become a popular pastime for many (Walton *et al.*, 1983). It was around this time that the fishing reel, which served as the foundation for modern reels, was developed in Nottingham, England (Payne and Crawford, 1989).

History of fishery management

Although the nature of angling had been evolving over millennia, little had been done by way of resource management of fisheries, aside from the Maori people, circa 1300, who prohibited the take of more catch than could be consumed (Barber, 2004). It wasn't until the impacts of

overfishing became noticeable in the 1950s that the possibility of stock-collapse and extinction by over-fishing were explicitly recognised and an era of resource use, which could best be summarized by Thomas Huxley's (1884) inexhaustible sea-fishery theory, reconsidered. The management of fisheries then became a priority of many areas of the world (Pitcher, 1998).

While the management of fishery resources was typically focussed on the exploitation of commercial fisheries (which had undeniable impacts on fish stocks and ecosystems), fisheries management generally ignored the potential impacts of recreational fisheries (Cooke and Cowx, 2004). The estimated participation rate of persons engaging in recreational fishing worldwide have been estimated to be between 220 million (World Bank, 2012) and 700 million (Cooke and Cowx, 2004). Other estimates suggest participation of up to 10% of the global population (Arlinghaus and Cooke, 2009) with an increasing trend. With an estimated annual harvest that exceeds 10 million tonnes of fish (Cooke and Cowx, 2004), the environmental impacts of this fishery are now being recognised by many countries around the world. It has been accepted that recreational fisheries can be as destructive as commercial fisheries (Coleman *et al.*, 2004; Hyder *et al.*, 2014).

Management tools and practices in recreational fisheries

The realised and potential impacts of recreational fisheries worldwide have resulted in management policies that mimic those of the commercial fisheries, which, in turn, parallel the management of terrestrial systems (Maxwell *et al.*, 2015). While these policies typically include quotas, permit requirements, marine protected areas (MPAs) and restrictions on gear and the sale of recreationally consumed species, they can vary significantly among countries (Pitcher *et al.*, 2009). Policies can also vary among species. Susceptible life history traits, such as slow growth, delayed maturity and predictable spawning aggregations, have led to declines in populations of specific species. The general response to this has been the promulgation of species-specific harvest regulations, which may include daily bag limits, size and slot limits, closed seasons and/or complete prohibition of harvest. Whether general or species-specific, some of these regulations, such as slot limits and some gear restrictions, are relatively new while other regulations, such as permit requirements, have been around for centuries. Recently, objectives have extended to managing invasive species or manipulating predator-prey interactions (Radomski *et al.*, 2001). All of these practices can be used to prevent overfishing.

Management tools that limit catch

Quota-based and other output regulations are employed by policy makers in an effort to protect resources from overexploitation. Because recreational fisheries are often open access and have little to no input controls in place, it is not possible to easily limit total catch. One potential type of input control is the restriction of certain fishing gears or the amount or size of the gear. Examples of this are the number of hooks per line or the amount of fishing rods allowed per individual (Cerda *et al.*, 2010). Policy makers for recreational fisheries may also introduce output controls, such daily bag limits, which are set quotas on the maximum number of fish an angler may keep per day. The limit can be a specific number of fishes that can be legally retained (in a day) for a particular species or a general amount applied to the number of all fish retained. It is assumed that in the absence of daily bag limits, recreational anglers may harvest quantities in excess of personal use, inviting commercial activity through economic incentive. Not only does this practice have the potential to undermine the economic contributions of the formal commercial fishery, but it can also degrade both the recreational and commercial fisheries (Attwood and Bennett, 1995). In addition to daily bag limits, policy makers may institute a possession limit, whereby an individual may not be in possession of an amount of fish exceeding a given limit regardless of whether or not they were caught and kept within a daily limit (Matlock, Saul and Bryan, 1988).

The harvest of many fish species has also been limited by implementing size regulations. These generally take the form of a minimum size limit (length) that the individual fish must attain before it can be harvested. Minimum size limits generally reduce the overall rate of mortality and protect a species from being harvested before it reaches maturity, thus allowing it to reproduce before capture (Gigliotti and Taylor, 1990). Slot limits, which only allow the harvest of species of fish if their length falls within a specified length interval, allow more species to reach maturity while also protecting larger, highly fecund (Gwinn *et al.*, 2015) and reproductively successful (Birkland and Dayton, 2005) fish. Slot limits increase population viability by maintaining the size structure of populations and increasing the abundance of larger, highly prized individuals in the recreational fishery (Post *et al.*, 2003).

One aspect determining the success of the abovementioned regulations is the survival of individuals after their mandatory release (Muoneke and Childress, 1994). To improve post-release survival, fishery managers may place restrictions on the allowable gear for catching certain species to reduce "hooking mortality". For example, treble hooks, a type of hook containing three hooks

and a single eye, do not target a specific species and can be used to "snag" fish by hooking it in a spot other than the mouth. Theses can cause high levels of hooking mortality for certain fish (Clapp and Clark, 1989; Dawson, Connelly and Brown, 1993). These types of hooks are often banned in areas requiring high rates of catch and release (Bendock and Alexandersdottir, 1993).

Management tools that regulate time or area

In cases when fish are vulnerable at specific times (e.g. during their spawning aggregations), the retention of fish may be regulated using closed seasons. This is a widely adopted tool that can refer to a period of time where no fishing is allowed or where a specific species or set of species may not be harvested. The rationale behind these types of regulations is to reduce the catch and potential bycatch of certain species during vulnerable stages in their lifecycle, such as spawning periods or migrations, and thus increase reproductive success (Arendse *et al.*, 2007). Even species that do not have distinct spawning periods may benefit from reduced effort during a seasonal closure (Zhou *et al.*, 2010). In extreme cases, where a fish stock is at a high risk of stock collapse or has already collapsed, moratoriums on the capture of a species may also be implemented (Kerwath *et al.*, in review).

A popular tool for resource managers to implement are closed areas or marine protected areas (MPAs). Closed areas are designated areas where no fishing may take place. They can be instituted for various reasons, including avoiding health risks of consuming a contaminated fish from that area (Mallin *et al.*, 2001) or reducing conflict with a non-consumptive sector competing for the resource (e.g. SCUBA diving) (Sobel and Dahlgren, 2007). However, most closed areas are ascribed to protect marine biodiversity (McClanahan and Mangi, 2001). MPAs and closed areas (no-take zones) differ, but they are not mutually exclusive. The primary difference is that the establishment of an MPA does not necessarily require an outright ban of recreational fishing activities and is instead used to limit the impacts of resource use. However, in many instances, the prohibition of all consumptive practices, such as fishing, are established or traditional fishing grounds are turned into "no-take" marine reserves (Hilborn *et al.*, 2004). MPAs are implemented to protect biodiversity whereas closed areas, including closed MPAs, serve as an insurance policy in the event of stock collapse. Both practices benefit ecosystems and fisheries management (Worm *et al.*, 2009).

Management tools that monitor and regulate use

The requirement of obtaining a fishing permit dates back to the Qing dynasty in China (ca. 1765) and was meant to limit the number of participants in the commercial fishery (Cooke and Li, 2004). In modern recreational fisheries, the requirement for holding a permit is not necessarily about restricting access but is instead used as a tool for monitoring the number of participants and public pressures on the natural environment (Scrogin *et al.*, 2004). In some instances, like in South Africa, permits have the additional benefit of generating income for continued management of the fishery (DAFF, 1998).

Permits given to recreational anglers often restrict them from selling their catches. This is to ensure that angling is maintained as a leisure activity and to protect the economic interests of the commercial fishery. The ability to sell one's catch could create an economic incentive to fish for profit, which could create an informal market. This informal market would not only be difficult to monitor, but any sale of fish by recreational anglers could have negative effects on the formal commercial fishery and place increased pressure on fish stocks (Attwood and Bennett, 1995).

Non-compliance in recreational fisheries

Any shortcomings in the management of recreational fisheries can have negative impacts on aquatic ecosystems as well as fish-dependent, anthropocentric communities. To reduce conflict and promote long-term sustainability, fishery managers have long implemented regulations meant to restrict the impact of recreational fishing. The combination of these regulations can make for a powerful management tool to ensure the long-term sustainability of fisheries. However, the biggest threat to the success of fisheries management policies is regulation non-compliance (Thomas, Milfont and Gavin, 2016).

Despite an overwhelming amount of data and literature indicating that ocean resources around the globe are in decline (Dulvy, Sadovy and Reynolds, 2003; Granek *et al.*, 2008; Worm *et al.*, 2013), non-compliance with regulations that are meant to ensure the long-term sustainability of fisheries is widespread (Schill and Kline, 1995; Viswanathan, 1999; Sumaila, Alder and Keith, 2006; Gavin, Solomon and Blank, 2010; Henderson and Fabrizio, 2013; Lewis, 2015; Bova *et al.*, 2017). Non-compliance, defined as any action (whether accidental or deliberate) that is in direct contravention of the laws set forth by fishery managers (Bova *et al.*, 2017), has been a problem in recreational fisheries for decades (Gabelhouse, 1980; Pierce and Tomcko, 1998; Hauck and Kroese, 2006).

While overexploitation and stock collapse may not be entirely attributed to non-compliance, it certainly undermines the sustainability goals set forth by fishery managers, and it could seriously affect the recovery of fishery resources in decline.

Aside from the threats to ecosystem biodiversity, non-compliance with fishery regulations can lead to undesirable social impacts (Arias *et al.*, 2016). There are important social costs associated with non-compliance as it can affect the livelihoods of fishing communities, particularly in developing countries. For example, the non-compliance of anglers can escalate competition between fishery sectors and jeopardise the economic survival of those who fish in accordance with the law and in compliance with relevant conservation and management measures.

Violations of recreational fishing regulations fall within the broader category of illegal, unreported and unregulated (IUU) fishing (United Nations General Assembly, 2006; Miller and Sumaila, 2016). Worldwide, IUU fishing results in estimated economic losses of up to $23.5 billion USD annually (Agnew *et al.*, 2009). This has resulted in calls to prioritise better data collection on illegal resource use, particularly on the proportion of non-compliant anglers (Smith and Anderson, 2004). There is still a large data deficiency on the global rates of non-compliance by recreational anglers, which results in the inability to assess the overall impact of this practice. However, there is a growing body of literature that attempts to estimate rates of localised non-compliance.

Estimating compliance in recreational fisheries

In order for the departments that implement fisheries management regulations to operate effectively, it is critical for them to understand the rate of non-compliance in their fisheries. There are numerous methods that researchers have employed to determine the extent of non-compliance with regulations pertaining to resource use. Methods such as data compiled from law enforcement records (Cowles, Beattie and Giles, 1979; Mann, 1995; Holmern, Muya and Røskaft, 2007), covert and direct behavioural observations (Agnew, 2000; Rowcliffe, de Merode and Cowlishaw, 2004; Davis *et al.*, 2017), crowd-sourcing and social media (Shiffman *et al.*, 2017), indirect observations (Williamson *et al.*, 2014), self-reported catch logs (Reddy *et al.*, 2014), forensics studies (Shivji *et al.*, 2005; Holmes, Steinke and Ward, 2009), modelling (Pitcher and Watson, 2000; Pitcher *et al.*, 2002) and the use of direct questioning through surveys (Mann, 1995; Blank and Gavin, 2009; Bova *et al.*, 2017), which can sometimes include an indirect questioning method (Schill and Kline, 1995; St. John *et al.*, 2010; Arias and Sutton, 2012; Diekmann, Hoeglinger and Jann, 2013), have all been used to measure non-compliance (Table 1.1). No method is perfect as they all have their own

caveats, but some methods may be more suitable than others under certain conditions (Gavin, Solomon and Blank, 2010). Due to the dynamic characteristics of recreational fisheries and their management systems, the utility of each of these methods may vary based on the context in which it is applies. Therefore, it is imperative to gain an understanding of which method may be provide the most utility within a particular fishery of interest.

Table 1.1: Methods used by researchers to estimate non-compliance to fisheries regulations.

Method	Study	Violations Assessed	Caveats to overall utility
Law enforcement records	Mann (1995)	Use of prohibited fishing gear/methods	Various methodological constraints, avoidance behaviour by violators, potential for bribes to bias data
Direct observation	McCrary *et al.* (2004)	Fishing in protected area (no-take)	Not feasible in a large-scale study due to the required human and financial capital
Indirect observation	Williamson *et al.* (2014)	Fishing in protected area (no take)	Can only provide information on locations of illegal activity and very little on violators
Self-reporting	Reddy *et al.* (2014)	Exceeding catch limits, harvesting undersized fish	Large incentives for individuals to not report illegal behaviour
Crowd-sourcing	Osterblom (2012)	Unreported harvest	Requires user literacy and somewhat advanced knowledge of scientific theory
Social media	Shiffman *et al.* (2017)	Harvesting prohibited species	Prone to sample error, especially in subgroups and areas with limited social media presence
Forensic studies	Shivji *et al.* (2005), Holmes, Steinke and Ward (2009)	Fishing prohibited species, fishing in closed areas	Cannot assess extent of non-compliance or provide information on the violators
Modeling	Pitcher and Watson (2000), Pitcher *et al.* (2002)	Misreporting catch, exceeding bag limits	Requires previous research on topic of non-compliance along with high-quality data.
Surveys	Mann (1995), Schill and Kline (1995), Arias *et al.* (2015), Thomas, Milfont and Gavin (2016), Bova *et al.* (2017)	Fishing in closed areas, fishing without permits, exceeding size limits, exceeding bag limits, keeping fish during closed seasons, keeping prohibited species, selling recreational catch, using prohibited gear/methods	Highly susceptible to social desirability and non-response bias

Lack of resources to dedicate towards management and research can be a limiting factor for determining which options to use. In developed countries, there are often records of law enforcement patrols and previous assessments or secondary data that can be used for analysis. In developing countries however, the importance of monitoring recreational fisheries has only recently begun to be recognised and little research has been undertaken. In many cases, the developing world will have to rule out the use of law enforcement records or modelling studies to determine the extent of non-compliance. Furthermore, the way in which data are gathered and the quality of that data will be limited by the technological and sociodemographic disparities between the developed and developing world. Unlike the developed world, significant portions of the population in developing nations lack personal access to phones and internet (Pearce and Rice, 2013; Goldstuck, 2017). Low digital literacy rates are likely to impact the ability to crowdsource data or mine social media.

In the absence of secondary data, surveys are a catchall method that can be used to collect primary data (Pitcher, 2007). The four ways surveys are typically administered are by mail, over the phone, online or face-to-face (Fowler, 2013). As phone and internet-based surveys are likely to omit proportions of the population in developing countries and mailing surveys can be costly with low response rates (Fox, Crask and Kim, 1988), face-to-face surveys at fishing locations are likely to provide the most representative sample for estimating compliance.

Behavioural drivers

While estimating rates of non-compliance is essential to ensure the sustainable management of fisheries, additional information is required so that non-compliant behaviour can be effectively discouraged in resource users (St. John *et al.*, 2012). Various models have been developed that aim to assess the drivers behind non-compliant behaviour. These models are generally conducted within an expected utility framework and are based on two compliance theories, instrumental theory and normative theory, generally used in the social sciences (Bova *et al.*, 2017). Instrumental theory postulates that an individual acts in their own self-interest and that their decisions to comply with regulations are based on a trade-off between financial incentive to violate and a perceived risk of their illegal behaviour being detected and the associated costs of the perceived sanctions (Becker, 1968; Keane, 2008). Normative theory typically suggests that beliefs, morality and social norms have an influence on compliance behaviour (Hatcher *et al.*, 2000; Gezelius, 2002; Arlinghaus

and Cooke, 2009; Bova *et al.*, 2017). However, normative theory frameworks have, on occasion, included some instrumental theory in their approach (Azjen, 1991).

All-inclusive approaches, which evolved from the initial instrumental approach, include the influence of norms, beliefs, self-interest, legitimacy, morality, attitudes and regulatory knowledge (Thomas, Milfont and Gavin, 2016, Bergseth and Roscher, 2018). Thomas *et al.* (2016) collated the various existing models in compliance behaviour literature, constructed from responses to their angler surveys, to test the ability of each model to best predict angler compliance with daily bag and size limits. The model of best fit for predicting non-compliant behaviour within their structural equation model only used psycho-social factors, indicating that the instrumental approach had little influence on explaining the compliance behaviour of anglers.

While this finding by Thomas *et al.* (2016) may be true for other recreational fisheries, it may be that the utility of models for predicting non-compliant behaviour (Sutinen and Kuperan, 1999; Keane *et al.*, 2008) and the data capturing methods from which they are based, will be largely context dependent (Bova *et al.*, 2017). To ensure that an intervention aimed at improving compliance behaviour will be effective, it is important to identify which behavioural drivers are relevant to the fishery of interest. This can be done by measuring potential behavioural drivers and modelling their influence on the outcome of non-compliance (Thomas, Milfont and Gavin, 2016; Bergseth and Roscher, 2018). Based on the outputs of the model, interventions can be tailored around the salient behavioural drivers.

Interventions for improving non-compliance

Suggested interventions for improving compliance behaviour have typically stemmed from the outputs of behavioural driver models. However, these interventions have primarily focussed on the instrumental model (Keane *et al.*, 2008). Using this paradigm, suggested interventions and those typically adopted by fishery managers involve increasing levels of enforcement and increasing penalties associated with convictions (Gigliotti and Taylor, 1990b; Kuperan and Sutinen, 1998; Keane *et al.*, 2008). While this approach may have some value in improving compliance, the theory has been found to be flawed in instances where there is relatively high compliance and low enforcement (Sutinen and Kuperan, 1999; Byers and Noonburg, 2007; Keane *et* al., 2008; Bova *et al.*, 2017). For example, whilst Bova *et al.* (2017) found little evidence of enforcement in a South African recreational fishery, nearly half of the participants were still compliant with the regulations.

The effects of normative behavioural drivers on recreational fisheries compliance have become more well known as normative behavioural research has increased (Hatcher *et al.*, 2000). Interestingly, the interventions associated with this paradigm, which include the activation of social norms, can be less resource intensive than those suggested by instrumental behavioural outcomes. Normative interventions generally aim to encourage compliance with regulations through manipulation of an individual's internal obligation to comply. Characteristically, these interventions address perceptions of legitimacy and reinforce the social and moral norms existent in the fishery. However, literature surrounding the success of any compliance interventions, whether normative or instrumental, is scarce.

South Africa's fisheries

South Africa's current marine environment is comprised of roughly 136 marine and coastal habitat types encompassing approximately 1,928 known fish species (Froese and Pauly, 2000). According to South Africa's National Biodiversity Assessment, most coastal and inshore habitat types (57%) are vulnerable, endangered or critically endangered (Republic of South Africa, 2014). The first historical record of angling (ca. 1655) is also the first evidence of it being regulated to some extent. At this time, the commander of the Cape Dutch Colony, Jan van Riebeeck, gave permission for residents to "fish with hooks anywhere in the Liesbeek river, but at first not for selling; only enough for themselves that agriculture may not suffer" (Leibrandt, 1897). Although there is evidence to suggest that the indigenous Khoi population had been angling for subsistence since the 1500s (Thompson, 1913), it wasn't until shortly after the arrival of the 1820 English settlers that it became a leisure activity in South Africa (Payne and Crawford, 1989). This was likely due to the removal of all Dutch fishing restrictions after the British capture of the Cape Dutch Colony (Thompson, 1913).

The first formal recreational fishing club, "The Umgeni Angling Club", was established in 1885 in the KwaZulu-Natal province (KZN) where the Scarborough reel was developed (Robinson and Dunn, 1923). The sport flourished and was typically dominated by "shore fishing" or "rock and surf" angling (Payne and Crawford, 1989). Recreational fishing was seen as accessible to all sectors of the community as it required minimal expenditure. It should be noted, however that many policies dating back to the colonial era, such as the Land Act, the Group Areas Act and subsequent policies implemented during the Apartheid regime, denied the majority of non-white South

Africans' ownership or use of certain stretches of the coastline and its resources (Hauck and Sowman, 2003). This restricted the participation of various demographic groups in recreational angling effort, or any angling effort for that matter.

Post-apartheid, participation in the recreational marine based shore fishery (MBSF) has continued to grow, extending to all demographic groups. In a comparison of angler participation over roughly 20 years after the regime change, a substantial increase in the participation of non-white anglers has been documented (Kramer *et al.*, 2017). In addition, several studies have identified that this fishery, which comprises both competitive and non-competitive subsectors, includes a diverse community with wide disparities in characteristics such as education, income and employment (Brouwer *et al.*, 1997; Mcgrath *et al.*, 1997; Penney *et al.*, 1999; Bova *et al.*, 2017; Kramer *et al.*, 2017).

MBSF participants contribute significantly to the corresponding infrastructure and employment associated with recreational fishing in terms of expendable tackle and bait, equipment and tourism, which adds considerable value to the sector (Mcgrath *et al.*, 1997; Saayman *et al.*, 2017). The gross expenditures of South African recreational participants, which includes all methods of fishing under a recreational permit (e.g. spearfishing, angling and net) have been estimated to be nearly 11 billion South African Rand (Saayman *et al.*, 2018). This activity also has more active participants than any other sport in the country (Parker et al., 2015), with the recreational MBSF containing an estimated 400,000 participants (Brouwer and Buxton, 2002; Saayman *et al.* 2017). The impacts of recreational fishing, however, are not always positive. The South African linefishery is considered to be largely responsible for many of the stock depletions of endemic reef fish species since as early as the 1940s (Griffiths, 2000) and the shore-based recreational anglers have been found to be widely responsible for fish mortality and contributing to stock decline in the nearshore zone (Coleman *et al.*, 2004).

Management of South African fisheries

Prior to the Coast Fisheries Act of 1906, which regulated licensing, netting, habitat destruction and the protection of juvenile organisms (van der Elst and Garratt, 1984), very little had been done to protect fisheries resources in South Africa. Provincial governments such as the Western Cape and Natal (now KwaZulu-Natal) enacted their own fisheries resource management ordinances in the following years. However, it wasn't until the Sea Fisheries Act of 1940 that the central government took control of managing their off-shore ocean resources at the national level (van der Elst and Garratt, 1984). The Sea Fisheries Act of 1940, which included the first

biologically based regulation of minimum size limits, was revised multiple times until a slightly more comprehensive Sea Fisheries Act of 1973 was promulgated. Even so, there was still no regulation of recreational fisheries. However, in a parallel process, provincial authorities began to actively manage the MBSF in the 1970s (Dunlop and Mann, 2012). Recreational angling didn't receive any recognition at the national level until December of 1984 under the Sea Fisheries Act no. 58 of 1973, which introduced a licensing scheme, categories for linefish species based on their perceived stock status, corresponding bag limits and closed seasons for both commercial and recreational offshore boat-based activities (Attwood and Bennett, 1995; Griffiths and Lamberth, 2002). This act was then replaced by the Sea Fishery Act of 1988, which had not changed much with regard to the management of recreational anglers aside from revisions to the restrictions set forth in 1984 based on changing perceptions of stock status. Following the democratic elections in 1994, South Africa's new government replaced the 1984 act with the Marine Living Resources Act of 1998 (MLRA), which provided a more comprehensive management of recreational MBSF and is still currently in effect.

The national management of recreational MBSF is relatively new with the first shore angling-specific regulations, including the requirement of a permit for recreational fishing in marine and estuarine environments, only established in 1999. Most of the regulatory management of the MBSF was based on the biology and abundance of recreational species and comprised technical measures such as limits on fish size, gear restrictions, closed areas, closed seasons, bag limits and no-take species. In addition, the prohibition of selling recreational catches was implemented. The national agency tasked with managing the MBSF and ensuring compliance with these regulations is the South African Department of Agriculture, Forestry and Fisheries (DAFF).

Fishery managers in South Africa have broadly disregarded the impacts of recreational fishing on fish stocks with the consensus that it is an innocuous activity (Parker *et al.* 2013). However, recent studies suggest that recreational anglers in South Africa have a significantly greater impact on certain species than commercial linefishing (Parker *et al.*, 2016). With increasing recreational participation and declining fish stocks, it is imperative that recreational anglers be closely managed in order to meet long term sustainability goals. Attwood and Farquhar (1999) stated that the management of linefisheries is one of the greatest challenges for marine conservation in South Africa. By the year 2000, following a period of serial overexploitation, the minister of the Department of Environmental Affairs and Tourism, the then-acting national management body, declared a state of emergency (Attwood, 2013). While the state of emergency had a major impact

on the effort and catch in the commercial linefishery, virtually no changes were made to the recreational fishery regulations. Therefore, it is not surprising that the number of fish stocks that are considered overexploited or collapsed have continued to rise (Sjöstedt and Sundström, 2015).

Unfortunately, the open access nature of the MBSF and its widely distributed participants limit the efficacy of monitoring and compliance efforts (Griffiths *et al.*, 1999). In addition, the budget constraints and a paucity of requisite personnel to enforce regulations and monitor fishing activities along the South African coast has, to a large extent, undermined effective management. Although participants of the recreational fishery generally agree that regulations are important (Brouwer *et al.*, 1997; Dunlop and Mann, 2012; Bova *et al.*, 2017; Kramer *et al.*, 2017), non-compliance remains high (Hauck and Kroese, 2006; Dunlop and Mann, 2012; Bova *et al.*, 2017).

South Africa's strategy for curbing non-compliance has been to follow the instrumental approach by increasing enforcement levels (Hauck and Kroese, 2006). Despite their efforts, there has been little improvement in the overall compliance rate over a long period of time (Kramer *et al.*, 2017). Until recently, the province of KZN had been co-managed by the Ezemvelo-KZN Wildlife Agency. Under their management, the shore-based fishery became the most effectively patrolled in the country (Dunlop and Mann, 2012), much to the chagrin of informal fishing communities. Despite the high levels of enforcement in this area, roughly 46% of participants still violated the minimum size requirements for fish, which is in line with areas of relatively low enforcement levels (Bova *et al.*, 2017). Based on these figures, it is critical that DAFF accept the notion that recreational fisheries can contribute to stock declines and develop a new approach for addressing non-compliance within the sector. Non-compliance undermines the ability of DAFF to sustainably manage coastal resources, it negatively impacts food security, it erodes economic opportunity and it disintegrates the quality of the fishery for compliant anglers.

In South Africa, as is the case for other developing countries, eliminating threats to food security is important. Currently, roughly 55.5% of the population lives below the poverty line (STATSSA, 2017). Nearly half of this population lives below the food poverty line. The food poverty line is the rand value below which individuals are unable to purchase or consume enough food to supply them with the minimum per-capita-per-day energy requirement for adequate health (STATSSA, 2017). At least 147 communities, which encompass proximately 28,000 people, on the coastline of South Africa practice fishing to meet food and basic subsistence needs (Hauck, 2009). DAFF has removed the classification "subsistence fishers" from its policies and replaced it with the term

"small-scale fishers" on the 2012 Policy for the Small-Scale Fisheries Sector in South Africa. Although the definition of subsistence anglers in encapsulated in the broader definition of small-scale fishers, the policy does little to address those fishing to meet basic food and livelihood needs and instead places emphasis on persons who "make a living from marine resources using little or no technology, usually on a day to day basis, on or near shore; and could be involved in the sale, barter or other commercial activity involving these resources" (DAFF, 2012). Lamentably, it is incredibly challenging for someone who was formally classified as a subsistence fisher to obtain small-scale fishing rights. Applicants are required to meet a specific set of criteria: they must live in a traditionally coastal resource-dependent community that has applied for community fishing rights. Consequently, many non-right holding "small-scale fishers" under the definition of subsistence fishers may still be classified as recreational anglers despite the fact that their motivations are not recreational at all. Non-compliance to recreational fishery regulations by this group may result in potentially far reaching consequences for overall compliance in the fishery.

Thesis objectives and chapter outline

To ensure food security, reduce inter-fishery conflicts and to ensure long-term sustainability of the recreational fishery, it is important to understand the level of non-compliance that exists within the recreational MBSF. Additionally, it is vital to interpret the potential drivers behind non-compliant behaviour in order to implement appropriate management strategies. Thus, the overall aim of this study is to gain an understanding of the complex nuances of non-compliance in the South African MBSF and to make practical recommendations for improvements in angler compliance behaviour. The objectives of this study are (1) to assess the best method with the most utility for obtaining honest responses during compliance surveys, (2) to determine which survey facilitation methods optimally estimate the rates of non-compliance to shore fishing regulations,(3) to construct a model to determine whether variables derived from normative and instrumental behavioural theories are relevant in the context of a developing country, (4) to make recommendations for improving compliance in recreational fisheries based on the context of the South African MBSF and (5) to use this information to demonstrate the need for designing fishery-specific compliance assessments and studies to suit the unique contexts of different fisheries in contrasting countries.

To achieve these objectives, this thesis is divided into five chapters. Chapter 1 has provided an introduction and has defined major concepts. Chapter 2, which has been published in the journal *Fisheries Research*, investigates the best method for obtaining accurate compliance behaviour data.

Chapter 3 is an application of the best method identified in Chapter 2 for estimating non-compliance and to determine the suitability of replacing face-to-face surveys with online surveys and to identify fishery-specific perspectives of anglers in the context of the South African MBSF. Chapter 4 develops a model to test the relevance of instrumental and normative variables in the recreational fishery of a developing country using the South African MBSF as a case study. Chapter 5 provides a summary of the findings and discusses them in terms of assessing and improving global and developing world recreational fisheries compliance, while making practical recommendations for the South African MBSF.

Chapter 2: Selecting the best method for obtaining honest responses during compliance surveys.

"Half a truth is often a great lie."
– Benjamin Franklin (1758)

Introduction

Determining the extent of non-compliance in recreational fisheries has been a challenge that researchers and fishery managers have approached in several different ways (Gavin, Solomon and Blank, 2010). Routine activities by law enforcement officials are a typical measure of compliance levels. However, limited levels of enforcement, such as in the case of South Africa, allow violators to conceal evidence of their criminal behaviour, rendering the data unreliable (Cowles, Beattie and Giles, 1979; Mann, 1995; Gavin, Solomon and Blank, 2010). Covert or direct behavioural observations are another method applied to estimate the proportion of violators (Agnew, 2000; Rowcliffe, de Merode and Cowlishaw, 2004); however, the capital-intensive nature of this approach has reduced its feasibility for use on a broad scale (Allard and Chouinard, 1997). A less capital-intensive procedure for obtaining compliance rates is through the administration of surveys. During these surveys, which are known in the industry as creel surveys, recreational anglers are subject to direct questioning on whether or not they have been compliant with regulations. Researches verbally assure anglers of the confidentiality of their responses to encourage honesty (Blank and Gavin, 2009; Bova *et al.*, 2017; Mann, 1995; Solomon *et al.*, 2007).

When requesting information that is subject to public disapproval in surveys, researchers must take care to ensure that the answers given by the respondent are truthful. Unfortunately, responses recorded through the direct questioning method (DQM) are most commonly subject to non-response (NRB) (Blair *et al.*, 2015) and social desirability bias (SDB) (Warner, 1965). This is due to the implication that the individual is guilty of a criminal action (Warner, 1965; St. John *et al.*, 2010; Thomas, Gavin and Milfont, 2014). Typically, due to self-preservation concerns, survey respondents will either refuse to answer or under-report socially undesirable activities and over-report socially desirable activities (Sjöström and Holst, 2002). Various techniques have been developed to mitigate non-response and SDB when requesting sensitive information by making the questions "less direct" (St. John *et al.*, 2010; Nuno and St. John, 2014). In surveys around environmental behaviour, these primarily include variations of the random response technique

(RRT) (Blank and Gavin, 2009; Coutts and Jann, 2011; Schill and Kline, 1995; Solomon *et al.*, 2007; Thomas *et al.*, 2014; Bergseth *et al.*, 2015; Bergseth *et al.*, 2018), the "unmatched count technique" (LaBrie and Earleywine, 2000; Ahart and Sackett, 2004; Nuno and St. John, 2014) and the "nominative technique" (Droitcour Miller *et al.*, 1983; Droitcour Miller, 1985; St. John *et al.*, 2010). However, the latter two methods seem less popular than the former, likely due to the circumstantial fundamental assumptions involved in the nominative technique (St. John *et al.*, 2010) and the literature that has highlighted the limitations of the unmatched count technique, such as its inability to effectively guarantee anonymity (Glynn, 2013; Matlala, 2014; Arentoft *et al.*, 2016; Tian and Tang, 2016).

Commonly applied methods for estimating angler non-compliance in recreational fisheries include the DQM (Brouwer *et al.*, 1997; Blank and Gavin, 2009; Bova *et al.*, 2017) and the RRT (Blank and Gavin, 2009; Coutts and Jann, 2011; Schill and Kline, 1995; Solomon *et al.*, 2007). While the DQM offers participants a verbal guarantee of confidentiality, the RRT was developed to improve this guarantee by cloaking participant responses with statistical noise, thereby concealing them from the interviewer. This is meant to further reduce the potential for SDB by offering a mechanism other than a verbal guarantee that a response to a sensitive question will not be used against the respondent.

The RRT was conceptualised by Warner (1965) and first used in a fishery context in surveys in the late 1980s (Lewynsky, 1986; Lewynsky and Bjornn, 1987). It rose to prominence in fisheries research after Schill and Kline (1995) used it as a viable response method for estimating non-compliance with fishing regulations in Idaho and has subsequently become the most widely used technique to obtain reliable responses from questionnaire data (Solomon *et al.*, 2007; Blank and Gavin, 2009; St. John *et al.*, 2010; Arias and Sutton, 2012; Thomas, Gavin and Milfont, 2014; Conteh, Gavin and Solomon, 2015; Lewis, 2015; Bova *et al.*, 2017). Although the application of the technique varies among studies, researchers typically present the respondent with a sensitive question that will be answered either honestly or with a predetermined response based on a randomising device. The probabilities of the randomising device are known and are used to determine whether the respondent gave the predetermined response or admitted to the sensitive behaviour (St. John *et al.*, 2010). Randomising devices used in revealing undesirable resource-use behaviour have been a six-sided die (Schill and Kline, 1995; St. John *et al.*, 2010), a two-sided coin (Solomon *et al.*, 2007; Blank and Gavin, 2009; Thomas, Gavin and Milfont, 2014; Lewis, 2015; Bova *et al.*, 2017) and a quantitative, forced alternative randomising device that contained 50 balls

of orange and green colour (Arias and Sutton, 2012; Conteh *et al.*, 2015). In a variation of the die device, typically the respondent will be forced to answer "yes" to the sensitive question if the die lands on the number one, regardless of their actual response, or "no" if the die lands on the number two, or simply answer honestly if it lands on any other number. For the coin device, a variation may be to answer truthfully if the coin lands heads-up or answer an automatic "yes" if it lands on tails. For the Conteh *et al.* (2015) study, if an orange ball was selected by the respondent, they answered truthfully and if a green ball was chosen, they replied with the number on that ball. For all of these techniques, the administrator does not observe the outcome of the device nor is the result ever divulged, and thus, the anonymity of the response and a reduction of SDB is ensured. After responses are gathered using the RRT, probabilistic logic is applied to them to obtain estimates of the actual rate of non-compliance after the statistical noise has been removed. The formula used for each nuanced method of the RRT can vary.

The RRT has been lauded as the best method for obtaining less biased responses to questions regarding compliance to fisheries regulations (Schill and Kline, 1995; Solomon *et al.*, 2007; Blank and Gavin, 2009; Lewis, 2015). Nonetheless, there is also a significant body of literature that identifies serious drawbacks to the use of the RRT (Chong, Chow and Rider, 1972; Umesh and Peterson, 1991; van der Heijden *et al.*, 2000; Gavin *et al.*, 2010; St. John *et al.*, 2010; Coutts and Jann, 2010; Moshagen *et al.*, 2014; Bova *et al.*, 2017). The most important claim of the benefits of using the RRT is that it produces more valid point estimates of sensitive behaviour. This has been concluded by many researchers who have compared the sensitive behaviour prevalence estimates from the RRT to estimates by other data collection modes, like the DQM (Schill and Kline, 1995; Lensvelt-Mulders *et al.*, 2005; Solomon *et al.*, 2007; Blank and Gavin, 2009; St. John *et al.*, 2010; Lewis, 2015). This conclusion relies solely on the assumption that higher estimates of non-compliance are more accurate (Umesh and Peterson, 1991). Since the RRT has not been confirmed against a known criterion (i.e. validity of direct response), the validations of this method are "weak", the assumption about accuracy is unknown and therefore the conclusion that it is a superior method cannot be drawn (Moshagen *et al.*, 2014).

An alternative bias reduction technique, the ballot box method (BBM), has been used in the health sciences for understanding sensitive sexual behaviours (Gregson *et al.*, 2002). This has yet to be applied in the context of estimating socially undesirable environmental behaviour. This method provides survey respondents anonymity by allowing them to respond in private by self-completing their responses to the sensitive survey questions on a secret ballot and submitting them to a locked

box. The interviewer has no knowledge of what is recorded on the secret ballot and does not have access to the lock on the box, providing obscurity to the responses and limiting the potential for SDB. However, a unique control number on each ballot allows the answers to be reunited with a corresponding questionnaire that contains less sensitive questions (Gregson *et al.*, 2002). The BBM sas been used to obtain estimates of sensitive sexual behaviours during an HIV prevention study (Gregson *et al.*, 2002).

Although the BBM's application for estimating the prevalence of behaviours has been limited, it has been applied extensively as a means of reducing SDB in various contingent valuation surveys (Lewicki, 1985; Carson *et al.*, 1996; Champ, 2003; Leggett *et al.*, 2003; Francisco, 2015). Leggett *et al.* (2003) found that the use of a ballot box substantially reduced SDB in their contingent valuation survey, although it did not fully eliminate it. Unfortunately, the claimed success of this method, like that of the RRT, also hinges on weak validation studies based on the assumption that higher prevalence estimates, when compared to direct questioning estimates, equate to higher efficacy (Tourangeau and Yan, 2007; Krosnick *et al.*, 2002).

A lack of resources available to South African fishery managers to effectively enforce recreational fisheries regulations has resulted in high levels of non-compliance within South Africa's MBSF (Dunlop and Mann, 2012, Bova *et al.*, 2017). For recreational anglers, these regulations include permit requirements, size limits, bag limits, closed seasons, protected areas, prohibited species and catch methods and limits on what anglers may do with their catch (i.e. no selling). Many anglers have perceived a generally low risk of being caught by law enforcement for fishing violations (Brouwer *et al.*, 1997; Lamberth *et al.*, 1997), and there is some evidence to suggest that these perceptions may exacerbate the lack of compliance in some areas (Bova *et al.*, 2017). From the perspective of fisheries compliance research, the high rates of non-compliance in South Africa's MBSF have provided a unique opportunity to rapidly collect information on the efficacy of the different techniques used to mitigate non-response bias (NRB) and SDB during surveys.

In this chapter, the efficacy of the DQM, RRT and BBM are compared for their success at obtaining realistic estimates of non-compliance in a recreational fishery. Due to the lack of literature and the various limitations expressed within the existing literature of the nominative and unmatched count techniques, these methods were excluded from the study. To conduct this assessment, a direct ground-truthing approach was used that involved covertly observing the compliance behaviour of anglers in the South African MBSF and then randomly selecting one of

the three techniques (DQM, RRT and BBM) to interview the non-compliant anglers. It was hypothesised that the reported non-compliance by anglers would equate to the level of observed non-compliance (100%), as all of the participants interviewed were observed violating a regulation. The purpose of this research was not to estimate or evaluate non-compliance, but rather to compare the accuracy of the responses of each technique about compliance behaviour to the respondents' actual (observed) behaviour.

Materials and methods

Study area

The study took place at three popular recreational fishing locations along South African coastline, namely Port Elizabeth (PE), eThekwini (ET) and Richard's Bay (RB; Figure 2.1). PE, which lies on the southern coast, is a densely populated Eastern Cape metropolis that hosts a diverse range of both anglers and fish species. ET is situated in KZN. The municipality includes South Africa's largest coastal city, Durban, as well as the popular fishing towns of Umhlanga Rocks and Umdloti Beach, with the latter incorporating a municipal area closed to fishing. RB is located approximately 200 km north of the ET boundary, and its harbour is a popular hotspot for upcountry anglers due to its proximity to the most densely populated province in the country, Gauteng.

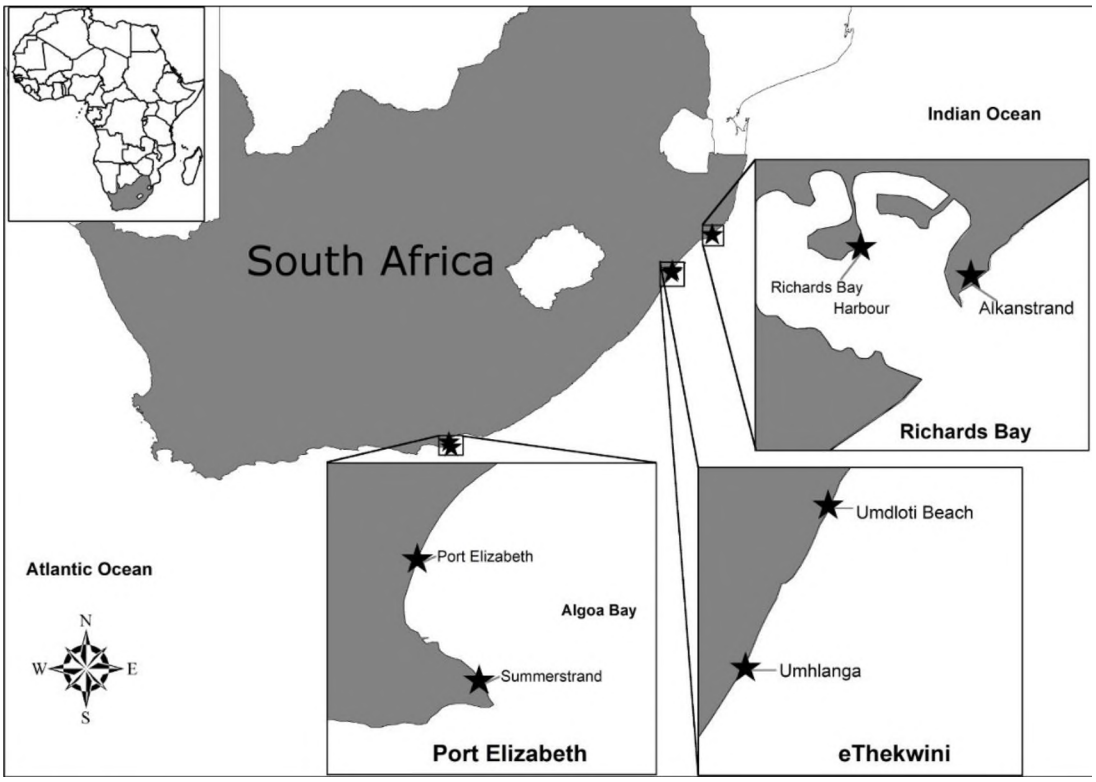

Figure 2.1: Study areas showing where anglers were covertly observed and surveyed in each region.

Data were collected in PE between January 2017 and February 2017, in ET between February 2017 and March 2017 and in RB between March 2017 and May 2017. Observations were made on both weekdays and weekends. Daytime observations were conducted between approximately 06:00 and 16:00 hours, while night time observations began after sunset (approximately 20:00) and concluded around 00:00. Observations took place from a distance, typically the parking lot of a fishing area where observers could blend in and make use of long-range surveillance equipment, such as spotting scopes and binoculars, to avoid being seen by the anglers. In some instances, the use of a night vision monocular with zoom functionality was employed to observe night-time behaviour. When there was no parking lot available for use as an observation point, observers would wear camouflaged clothing and would conceal themselves in nearby foliage.

Once observers located the optimal observation point, they assigned a control number to each observed fisher. They recorded a brief physical description of the angler, the time they began fishing, the number of fish caught and whether they had contravened any observable regulation. To this end, any obvious form of observable non-compliance by individual anglers was noted. This included retaining undersize fish (only fish that were well below the minimum size limits were noted), exceeding the bag limits, flouting the bait and tackle specifications, capturing prohibited

species or selling fish. Since fishing without a permit could not be quantified, this regulation was not considered in the study. Each time illicit behaviour was observed, the time and description of the infraction was recorded alongside the control number of the observed angler. The time was recorded when an angler's fishing session ended.

As the observed anglers departed the fishing area, they were intercepted by an interviewer. Every effort was made to ensure that the angler was intercepted away from other anglers. The interviewer introduced themselves and explained that they were conducting research on compliance in recreational fisheries. They verbally assured respondents that the interviewers had no affiliation with law enforcement and that any answers given would remain confidential and anonymous and in no way could they be used against the angler. Once the anglers had consented to the interview, the interviewer followed a script that corresponded with one of the randomly selected techniques (DQM, RRT and BBM; Appendix A) and asked the angler to report on their compliance behaviour for the present fishing trip. The random selection of each method was based on the results of a random number generator. The intention of the random selection was to minimise the likelihood of bias in the sociodemographic characteristics, knowledge of regulations, time of day and location of interview. Participation in the study questionnaire was incentivised to increase the participation rate by entry into a lucky draw competition where the participant could win fishing tackle.

For the DQM, the interviewer read the sensitive questions about compliance behaviour aloud to the participants. The interviewer then recorded the respondents' verbal responses to the sensitive questions about compliance behaviour on a hard-copy questionnaire marked with a unique control number. For the RRT, the interviewer explained the anonymising nature of the RRT. This required a detailed breakdown of how it worked as well as demonstrations until the participant acknowledged their understanding of the procedure. The randomising device was a two-sided coin. The respondent flipped this coin out of sight of the interviewer for each question. If the coin-flip resulted in "heads", the respondent was requested to answer the sensitive questions truthfully. A coin-flip of "tails" required the respondent to answer "yes", regardless of the accuracy of a "yes" response. The answers to each question were recorded by the participant out of sight of the interviewer. Participants that were selected for the BBM were presented with a description of the method. This method involved the use of a locked wooden box with a slot on the top where respondents would place anonymous, self-completed "ballots" containing the sensitive answers. The ballot form did not contain any questions on it, only question numbers and

a corresponding "yes" or "no" under each number (Appendix). The interviewer read each question aloud to the respondent who would record their sensitive answer by circling either the "yes" or "no". This was meant to further anonymise the responses as they were not directly recorded next to a question that may implicate them in a criminal offense. Upon completion of the questionnaire, respondents were asked to fold the ballot in half, further concealing responses from the interviewer, and place it in the locked box (Figure 2.2). In all cases, the interviewer also recorded the length of the survey administration using a stopwatch.

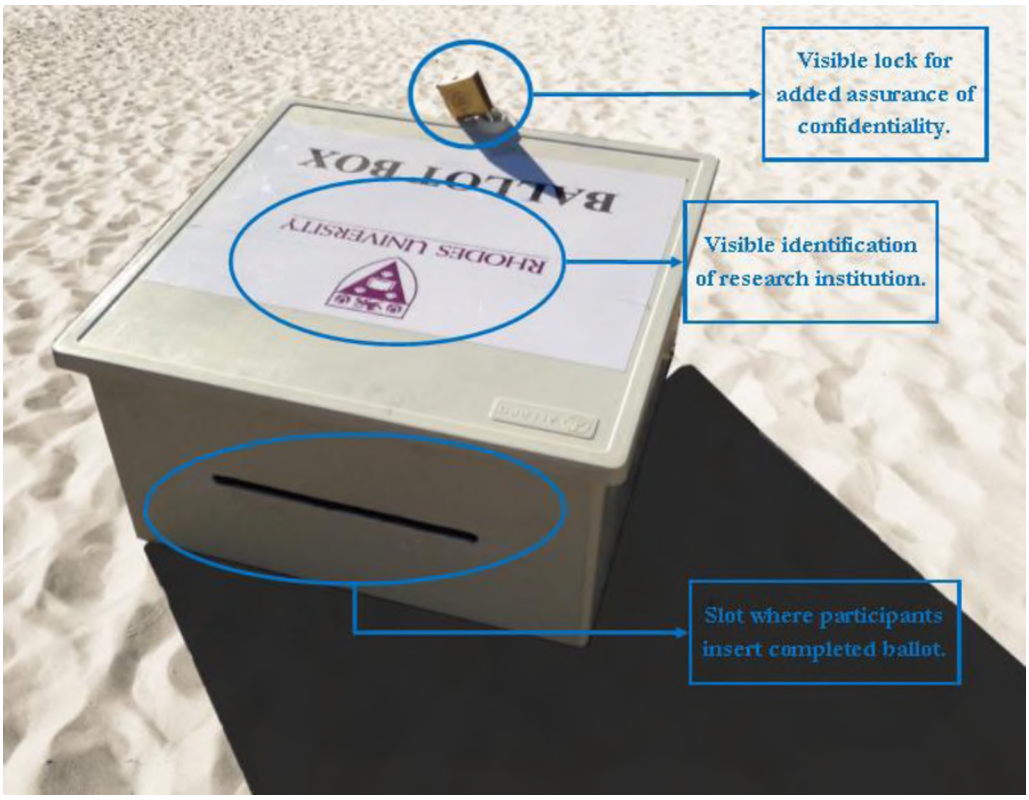

Figure 2.2: Diagram of the locked ballot box used during compliance surveys to reduce social desirability bias (SDB).

Informed consent was not given to anglers prior to observation due to the special circumstance that knowledge of the observation would likely influence their behaviour. Ethical concerns are often raised about covert observations (Homan, 1980), however, the methods can be justified in experiments where informed consent would compromise the objective of the research, where there is no expectation of privacy by those being observed and where no personal data are collected, such as in-group observations (Kraut *et al.*, 2004). All covert observations for this study took place in public spaces and the data are comprised of anglers that agreed to participate in the study post-observation. In addition, no personal information was recorded from participants that

could be used in any way to identify them or put them in any harmful circumstance. This research was granted ethics approval (RU-HSD-16-04-0023).

Calculations

To test the accuracy of the three techniques, the percentage of non-compliant anglers that admitted to an observed offence were compared. The percentage of anglers who admitted to their observed non-compliant behaviour was estimated directly from the DQM and BBM responses. However, the estimate of the percentage of anglers who admitted to their non-compliant behaviour for the RRT required an additional calculation:

$$\pi a=(\lambda-(1-P1)\pi f)/P1$$

where πa is the estimated rate of non-compliance, λ is the proportion of "yes" responses, P1 is the probability of truth and πf is the probability of a forced "yes".

The proportion of accurate responses (answers that corresponded with the observations) among techniques were compared using a chi-square test ($\alpha = 0.05$). This proportion of admitted violators (from an observed non-compliant population) was assumed to be positively correlated with the effectiveness of the method in reducing SDB. Finally, the mean length of the interview for each method was compared using a one-way ANOVA.

Results

A total of 326 individual anglers were covertly observed for the entirety of their fishing trip, of which 104 anglers were observed committing at least one violation. The geographic distribution of these 104 anglers were roughly equal (PE = 35, ET = 36, RB = 33). A total of 148 violations were observed with the most commonly observed violation being the keeping of undersized fish (61.5%), typically black tail (*Diplodus capensis*), followed by the use of illegal bait or tackle (18.9%), which consisted mostly of the use of undersized fish as bait (Table 2.1). Additional violations that were observed were anglers fishing in closed areas (10.8%), exceeding the specified bag limits (6.8%) and selling their catch (2.0%). There were no observed instances of anglers keeping a prohibited species, not including those that may have been used for bait (illegal bait). Although these were the only violations that could be used for validation, many survey participants admitted to fishing without a permit.

The accuracy of the reported responses was not dependent on the location of the survey (X^2[2, N=140] = 2.22, p = 0.33), and the responses were therefore aggregated for further analyses. The proportion of observed violators that reported their violations using the BBM, DQM and RRT were 79.6% (±11.9%), 46.5% (±14.9%) and 44.3% (±12.5%), respectively, without correcting for forced admissions (Table 2.1). There was a significant difference between the accuracy of the BBM and the other two methods (X^2[2, N=140] = 16.02, p < 0.01). Once the RRT data were corrected to account for the probability of forced admissions (πf = 0.5), the potential accuracy of the responses declined to 38.5% (Figure 2.3).

Table 2.1: Accuracy of reported violations vs. observed violations for the direct questioning method (DQM), the random response technique (RRT) and the ballot box method (BBM) at the three different study locations.

	PE		ET		RB		Overall		
	Observed	Reported	Observed	Reported	Observed	Reported	Observed	Reported	%
DQM									
Undersized	7	2	10	6	7	2	24	10	41.67%
Illegal Bait	4	1	3	1	4	2	11	4	36.36%
Closed Area	0	0	0	0	5	4	5	4	80.00%
Bag limit	1	1	1	0	0	0	2	1	50.00%
Selling	1	1	0	0	0	0	1	1	100.00%
Total	**13**	**5**	**14**	**7**	**16**	**8**	**43**	**20**	**46.51%**
RRT									
Undersized	20	10	12	5	8	5	40	20	50.00%
Illegal Bait	2	0	5	2	2	0	9	2	22.22%
Closed Area	0	0	0	0	5	2	5	2	40.00%
Bag limit	2	0	2	1	2	1	6	2	33.33%
Selling	0	0	1	1	0	0	1	1	100.00%
Total	**24**	**10**	**20**	**9**	**17**	**8**	**61**	**27**	***44.26%**
BBM									
Undersized	9	9	6	4	12	11	27	24	88.89%
Illegal Bait	2	3	3	2	3	2	8	5	62.50%
Closed Area	0	0	0	0	6	4	6	4	66.67%
Bag limit	2	1	0	0	0	0	2	1	50.00%
Selling	1	1	0	0	0	0	1	1	100.00%
Total	**14**	**14**	**9**	**6**	**21**	**17**	**44**	**35**	**79.55%**

*Not accounting for probability of forced yes responses (πf= 0.5)

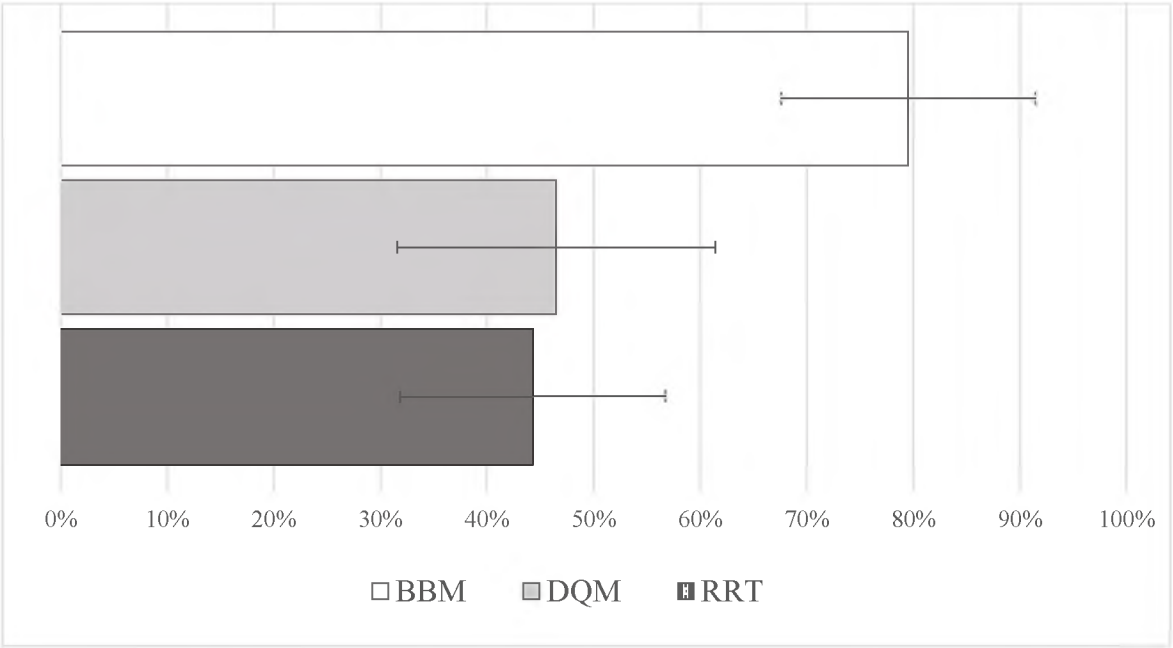

Figure 2.3: Percentage of observed violations admitted by participants surveyed using the ballot box method (BBM), direct questioning method (DQM) and the random response technique (RRT).

All of the 104 non-compliant anglers that were observed agreed to be interviewed. Of these, 33 were interviewed using the DQM, 35 using the BBM and 36 using the RRT. All interviewees agreed to continue participation in the survey once presented with the DQM and BBM, but three participants (7.7%) chose to terminate the interview after the RRT method was explained. The mean number of observed violations per angler was not significantly different ($X^2[4, N=104]= 0.392$, $p = 0.98$) among the three methods (Table 2.2).

Table 2.2: Proportion of individuals with one, two or three or more observed violations in the South African marine based shore fishery for each survey technique.

Method	1 violation	2 violations	3 or more violations	Observations
Ballot Box	68.6%	25.7%	5.7%	35
Direct Questioning	66.7%	24.2%	9.1%	33
Random Response	69.4%	22.2%	8.3%	36
Total Participants	71	25	8	104

The average time taken to complete a questionnaire for the different methods was 169.66 sec (± 37.77 sec) for the DQM, 221.28 sec (± 69.11 sec) for the BBM and 500.42 sec (± 152.47 sec) for the RRT. These times were significantly different ($F[2, 104] = 67.21$, $p < 0.01$). A Tukey's post-hoc test ($p < 0.01$) indicated that the RRT interviews were significantly longer than the DQM and

the BBM. Several participants who were selected for the RRT, including some of those that chose to terminate the interview, stated that they felt interviewers were attempting to trick them into an admission of guilt.

Discussion

The BBM was the best method for obtaining accurate responses from the participants. With this method, there was nearly 80% alignment between the observed and reported violations. In contrast, the DQM and the RRT provided a relatively low response accuracy. The DQM slightly outperformed the RRT by approximately 8 percentage points (p.p.) in accuracy, which was surprising as the RRT was developed to improve the accuracy of the DQM (Table 2.1). Unlike the DQM and BBM, several participants refused to participate further once presented with the RRT. This suggests that the RRT did not achieve a desired reduction in NRB or SDB compared to DQM.

The poor overall performance of the RRT in this validation study is somewhat surprising, given the popularity of its applications within recreational fisheries literature (e.g. Schill and Kline, 1995; Blank and Gavin, 2009; Thomas, Gavin and Milfont, 2014; Lewis, 2015). It is unclear why many of the shortfalls associated with the RRT (Edgell, Himmelfarb and Duchan, 1982; Lensvelt-Mulders *et al.*, 2005; John *et al.*, 2013) have been largely ignored. Interestingly, Umesh and Petersen (1991), in their detailed meta-analysis of RRT validation studies, concluded that, "the validity of the randomised response method does not appear to be very good", which, based on the results of the present study, can also apply to a fisheries research context.

One of the reasons for the continued use of the RRT in recreational fisheries in particular may be the relatively slow pace at which social science research has been incorporated into applied sciences and management (Cooke *et al.*, 2013; Hunt *et al.*, 2013). Although human dimensions research has been describing angler characteristics and their actions since the mid-20th century, researchers have called for a greater integration of observable human behaviour into recreational fisheries analyses (Arlinghaus *et al.*, 2008; Hunt *et al.*, 2013; Arlinghaus *et al.*, 2016; Ward *et al.*, 2016; Bergseth *et al.*, 2017). Perhaps the lack of engagement with social sciences literature has resulted in an overdependence by recreational fisheries researchers on the limited number of methods recommended in the existing human dimensions literature for understanding angler behaviour. Up to now, only a few techniques, including the RRT, the unmatched count and the nominative

method, have been used to reduce SDB in fisheries compliance surveys (Gavin, Solomon and Blank, 2010).

Another potential reason for the continued use of the RRT is the lack of direct validation studies of this method. Until now, most studies employing the RRT have used comparisons between various methods as a form of validating a particular method (Schill and Kline, 1995; Lensvelt-Mulders *et al.*, 2005; Solomon *et al.*, 2007; Blank and Gavin, 2009; St. John *et al.*, 2010; Lewis, 2015; Bergseth *et al.*, 2017). The implicit assumption in these studies, however, has been that the method that produces the higher estimate is more valid, regardless of any actual ground-truthing of the assumption. In these studies, the RRT has sometimes performed "better" (i.e. yielded higher estimates) when compared with other methods (Schill and Kline, 1995; St. John *et al.*, 2010), and researchers have tended to lean towards this measure to support their approach. While this study found that the more accurate methods would have likely obtained higher estimates of non-compliance, this assumption that this is always valid is inherently flawed. The validation of methods should always be compared against tangible data and not based on such precarious assumptions. In this study, while the DQM proved superior over the RRT, the DQM still performed poorly indicating that although "more is better", it is not necessarily valid.

Despite support for the use of the RRT in previous "validation" studies, other studies have reported no benefit in the quality of estimates to using the RRT over the DQM, and in some cases, the RRT has produced lower estimates of the prevalence of an undesirable behaviour (Locander, Sudman and Bradburn, 1976; Goode and Heine, 1978; Bégin and Boivin, 1980; Coutts and Jann, 2011; Höglinger, Jann and Diekmann, 2016). These findings suggest that the RRT may be subject to a range of biases that are largely ignored by researchers. Indeed, there were a number of potential sources of bias that may have resulted in the poor performance of the RRT in this study. In a hypothetical scenario where all anglers interviewed with RRT and none had knowingly violated a regulation, the RRT should have produced a minimum admission rate of 50% for each regulation, based on the 50% probability of a forced "Yes" response. However, in this study, where the admission rate should have been 100%, since all respondents had been observed committing a crime, the method produced an admission rate of 44.3%, which is less than the probability of a forced admission. When this number is applied to the formula used for estimating non-compliance with the forced response RRT, the number drops to 38.5%.

This paradoxical finding is most likely related to both psychology and statistics. The main feature of the RRT is that the forced response, which introduces statistical noise, is intended to conceal an individual's positive response to participating in an illegal behaviour. However, Edgell *et al.* (1982) suggested that the same forced "yes" responses meant to conceal "guilty" individuals may come across as a forced admission of guilt for those that are not guilty. This makes them likely to ignore the instructions and instead answer truthfully (John *et al.*, 2016). Bockenholt and Van der Heijden (2007) refer to this phenomenon as "self-protective behaviour". Based on the findings in this study, it is likely that the combination of the statistical method and the "self-protective behaviour" bias of those who do not break certain regulations are likely to result in unrealistic estimates of compliance when implementing the RRT.

While the BBM and DQM interviews were relatively simple to facilitate, the RRT often required several demonstrations during the interviews. Even after these demonstrations, it was not always obvious that the participants fully understood the technique. It is therefore possible that respondents may have only claimed to understand the instructions. Other studies have also found that the RRT may be too complicated for some respondents to understand (Bockenholt and Van der Heijden, 2007; Coutts and Jann, 2011; Bova *et al.*, 2017). Since this technique requires that all participants follow the exact instructions, even a single respondent that does not understand the instructions is a potential source of bias (Lensvelt-Mulders *et al.*, 2005).

Several respondents suggested that the RRT was being used to "trick" them. There were no statements of this nature made during the DQM and BBM interviews. This revealed an obvious lack of trust in the RRT. Other research has also documented this lack of trust in RRT (Cheng, Chow and Rider, 1972; Van Der Heijden *et al.*, 2000; Coutts and Jann, 2011). Brewer *et al.* (1981) suggested that the RRT can "introduce a sinister element into the proceedings and put people on their guard". This lack of trust may stem from a poor understanding the elaborate instructions that accompany the RRT and may lead participants to intentionally disobey them. Additionally, there may exist a general lack of trust in the researchers or research, across all three methods. This study failed to obtain the necessary information to conclude the levels of trust across the methods. Future research attempting to compare methods for eliciting accurate compliance data should include some measure of participant trust in the researchers and research methods in order to increase the accuracy of the assessments.

Along with observed bias and the intensive description associated with the RRT in this study, it took nearly twice as long (on average) to administer as the BBM, which only required about one minute more per interview than the DQM, mostly as a result of administering practice rounds until respondents acknowledged an understanding of the task at hand. Due to the addition of random statistical noise to the data in the RRT (due to the forced YES and NO responses), significantly larger samples are needed to obtain estimates with acceptable errors (St. John *et al.*, 2010). For example, the use of a coin as a randomising device, with a probability of 0.5, will require a sample twice the size of a DQM study. As this study did not attempt to estimate non-compliance, these larger samples were not required.

The DQM was easy for the respondents to understand and required the least amount of effort to administer, as the interviewer did not require any sort of device meant to conceal the participants' responses. While the DQM may not have effectively reduced SDB in this study, it still performed better than the RRT in both accuracy and efficiency, requiring significantly less capital and effort. In a previous study (Bova *et al.*, 2017), it was found that respondents preferred to answer directly over using the RRT. Additionally, other researchers have found there is no feasible benefit in implementing the resource-intensive RRT over DQM (Locander, Sudman and Bradburn, 1976; Goode and Heine, 1978; Bégin and Boivin, 1980; Umesh and Peterson, 1991; Coutts and Jann, 2010).

Compared to the DQM and the RRT, the BBM produced far more realistic estimates of compliance, with high agreement (~80%) between the survey results and the observations of non-compliance. Leggett *et al.* (2003) concluded that the use of a ballot box significantly reduces SDB over DQM during contingent valuation surveys. An additional strength of the BBM when compared with the RRT is that true answers to compliance questions from the ballot can be matched to the relevant respondents in surveys that aim to investigate the potential drivers of compliance behaviour. Connecting the ballot to its corresponding survey allows individual traits of compliant and non-compliant individuals to be understood and may be useful when designing measures to improve compliance.

The BBM was easily understood by participants when compared with the RRT, as it offered a familiar sense of confidentiality that participants may have experienced previously (e.g. electoral voting). The BBM, like the DQM, also required significantly less time and effort to administer than the RRT. The BBM required a smaller sample than the RRT to obtain robust compliance estimates.

Despite the significantly more accurate results obtained using the BBM, the findings were not perfect, which is inherent to this type of social science research. Similar to the results from Leggett *et al.* (2003), the method substantially reduced SDB but may not have altogether prevented it. This could either be due to SDB or to a genuine misunderstanding of the rules by anglers. Anglers were requested to answer "truthfully" under the assumption that all anglers have a comprehensive understanding of the regulations. In this case, it is conceivable that some anglers did not have full knowledge of the specific regulations and were therefore unaware that they had violated said regulations. There is some evidence to support this. In the current study, the majority of violations related to keeping undersized fish; the dominant species retained was black tail, *D. capensis*. A separate survey of the regulatory knowledge of 252 South African MBSF anglers found that only one participant correctly identified all regulations (Bova, unpublished data). Results from the same survey found that only 74.6% of respondents were aware of the minimum size limit for *D. capensis*. This highlights a potential link in the gap between observed violations and stated violations. Assuming the anglers' knowledge of the regulations regarding the size limit of that species matches the angler knowledge in the aforementioned study, it is possible that the anglers did not respond "yes" to the question: "Did you keep any undersized fish today?" as they were unaware of the size limit for the relevant species. This highlights the importance of obtaining a concurrent understanding of angler knowledge of the regulations when conducting compliance studies using surveys.

Conclusion

This chapter is the first of its kind to compare the results of different survey methods to actual, observed data, and it highlights the dire need for actual ground-truthing of compliance estimates in future studies of resource-use behaviour. The use of a secret ballot and ballot box shows significant improvement over the DQM and the RRT in reducing SDB in face-to-face questionnaires. It is a method that is easily understood by participants and does not require a larger sample size than other baseline methods, making it the ideal application for SDB reduction. Finally, the findings of this chapter may also have relevance to managers in gauging the relative accuracy of previous studies using the DQM and the RRT for their fisheries, as these previous studies may have produced incorrect compliance estimates. The BBM is used in the following chapter to assess the current state of non-compliance within the South African MBSF.

Chapter 3: Evaluating angler non-compliance levels and perceptions in a developing country

"Why do you need to know this stuff? What if I just cut you with this knife, then what?"
– Angry fisherman (Participant ID: 2YXNB)

Introduction

Fishing regulations are part of a set of tools employed by fishery managers for achieving long-term sustainability goals. These typically come in the form of input controls, which limit effort, output controls, which limit take, and technical measures, which can provide protection for vulnerable components of a marine ecosystem. Non-compliance with these regulations by fishers is a leading cause of failures in fisheries management (Sumaila, Alder and Keith, 2006). Evaluating the extent of regulation non-compliance and then addressing this issue is crucial to maintaining the goals that these regulations have set out to achieve (Kuperan and Sutinen, 1998). However, the methods used for obtaining compliance data must be suitable for the context of the fishery of interest to ensure the sample is representative of its fishing population.

Worldwide, recreational fisheries are enjoyed by hundreds of millions of participants (Cooke and Cowx, 2004, Arlinghaus and Cooke, 2009). Fish mortalities associated with recreational anglers are significant (Cooke and Cowx, 2004), and it has recently been accepted that recreational fisheries can be as destructive as commercial fisheries (Coleman *et al.*, 2004; Hyder *et al.*, 2014). This impact is exacerbated by poor compliance to fisheries regulations; while the majority of studies in the developed world have found high levels of compliance (Sutinen and Kuperan, 1985; Thomas *et al.*, 2016; Schill and Kline, 1995), the few studies in the developing world, specifically in South Africa, have identified far lower levels of compliance (Brouwer *et al.* 1997; Dunlop and Mann, 2012; Bova *et al.*, 2017).

There are a range of methods that have been applied for estimating the extent of non-compliance (Bova *et al.*, 2018, Chapter 2). Law enforcement records, which include records of official warnings, fines, arrests and seizures of illegal products, can be used to estimate the extent of non-compliance (Mann, James and Beckley, 2002) and the spatial distribution of illegal activities (Holmern, Muya and Røskaft, 2007). Where data are deficient and when there is limited funding to employ traditional methods, researchers have relied on crowd-sourcing, which requires the help of "citizen scientists", to capture various forms of data (Osterblom, 2012). This has become a popular

method for capturing real-time data and has been facilitated by recent technological advancements such as smart phone applications (Gibbons, 2015). The surge in the use of social media platforms has allowed scientists to mine data from billions of users around the globe. These data have been used to determine potential hot-spots for illegal activities (Malleson and Andresen, 2015) and to identify illegal fishing practices and angler behaviour (Shiffman *et al.*, 2017). Other researchers have relied on both covert and direct behavioural observations to estimate overall proportions of non-compliant anglers by viewing their contraventions first-hand (Agnew, 2004). This allows for the development of non-compliant user profiles (McCrary *et al.*, 2004) and spatial assessments (Rowcliffe, de Merode and Cowlishaw, 2004), and it provides useful information on species targeted and species kept as well as techniques of extraction (Allard and Chouinard, 1997).

Indirectly observed signs of non-compliance, such as evidence left behind from illegal resource users, is a method that can be used as a proxy to examine the presence of non-compliant activities (Free, Jensen and Mendsaikhan, 2015). For example, researchers can estimate the extent of non-compliance by measuring the accumulation of derelict fishing gear. In fisheries where users are required to keep a log of their fishing activities, researchers can mine the data to examine the distribution and prevalence of non-compliance (Gavin, Solomon and Blank, 2010). *Ex situ* observations of non-compliance can be made in the form of forensic studies, such as serology, genetic analysis and entomology, to help identify whether confiscated materials or products at markets are from a prohibited source (Shivji *et al.*, 2005; Holmes, Steinke and Ward, 2009). Large amounts of historical compliance data allow researchers to estimate non-compliance levels using regression models (Pitcher *et al.*, 2002).

The most common method for obtaining estimates of angler non-compliance is through surveys. These are often administered online or face-to-face and can provide a plethora of useful details about compliance behaviour. These details can include the proportion of violators (Mann, 1995; Bova *et al.*, 2017), the socio-demographics of potential violators (Bova *et al.*, 2017), targeted resources (Mann, 1995), the distribution of violations, the potential drivers behind non-compliance (Thomas, Milfont and Gavin, 2016) and the trends in illegal activities (Smethurst and Nietschmann, 1999).

Each of the available methods for estimating compliance have their inherent drawbacks (Gavin, Solomon and Blank, 2010) and may only be relevant or appropriate in certain fishery contexts. Law enforcement records often do not provide the requisite information to control for patrol

effort (Holmern, Muya and Røskaft, 2007) nor can they account for departmental corruption or avoidance behaviour by violators. Crowd-sourcing may only be relevant in the context of developed countries as the organisation of citizen science requires significant marketing, user literacy, commitment and somewhat advanced technological skills (Kennett, Danielsen and Silvius, 2015). Sourcing data is subject to the impacts of SDB and sampling bias error. Direct observations, while they can provide very accurate point estimates at a given location, require a significant amount of resources and effort however to avoid sampling effort bias and to cover a large area (Agnew *et al.*, 2009). Indirect observations (signs of illegal activities) are limited by the complacency of the violators which have left evidence, and this method can't reveal the extent of violations and who in particular has committed them (Gavin, Solomon and Blank, 2010). Data from log books are prone to bias stemming from an incentive to misreport actual fishing activities to avoid facing penalties (Reddy *et al.*, 2014). Forensic studies fail to account for illegal activities in which goods are not confiscated and, therefore, does not provide valid estimates as to the extent of illegal activity (Holmes, Steinke and Ward, 2009). Models that estimate non-compliance are essentially hypothetical, and their accuracy relies on the existence of previous measures of resource use and compliance, which may be unavailable (Pitcher *et al.*, 2002). Surveys are prone to bias, including SDB, sample bias, interviewer bias and response bias (Podsakoff *et al.*, 2003).

Despite the potential biases inherent to face-to-face surveys on non-compliance, this method has a number of advantages over other available methods. Face-to-face surveys allow for the collection of additional information, such as the socio-demographic profile of anglers and the potential behavioural drivers behind their non-compliance. This method typically yields higher rates of cooperation than other contact methods and can aid in the conversion of participatory refusal often encountered using other survey methods. If used properly, it can also provide a better representation of a target population (Donsbach and Traugott, 2008). Furthermore, some of the biases inherent in surveys can be controlled (see Chapter 2).

These advantages make face-to-face surveys the most commonly used method for assessing non-compliance worldwide (Dunlop and Mann, 2012; Thomas *et al.*, 2016; Bergseth and Roscher, 2017). However, face-to-face surveys can be extremely capital intensive and not feasible for use by researchers with time and budgetary constraints. This makes it a difficult method to apply in underfunded studies in developing countries. To circumvent this constraint, online surveys are sometimes used as a substitute. Online surveys allow for the collection of socio-demographic data and behavioural drivers while requiring significantly less capital. They can also have a relatively fast

turnaround time for data collection (Duffy *et al.*, 2005). However, since developing countries are also faced with low levels of digital literacy and access (Goldstuck 2017), their exclusive use may bias the results towards overrepresenting individuals with high levels of digital literacy (Couper, 2000). This bias is potentially enhanced by the poor response rate to online surveys, which typically results in data that only explain a population subgroup (Szolnoki and Hoffmann, 2013). Additionally, online surveys can be susceptible to SDB. This can be more difficult to control in online surveys than in face-to-face surveys (Whelan *et al.*, 2015) since face-to-face methods can employ indirect techniques, such as the BBM (Chapter 2) or the RRT (Schill and Kline, 1995; Thomas, Gavin and Milfont, 2014). Thus, while a face-to-face survey can be more costly, it is a more valid method than an online survey, particularly in developing countries.

One such developing country, which provides the study area for this chapter is South Africa. DAFF is the governmental agency tasked with the management of South Africa's MBSF. All fishers are bound to the regulations established in the Marine Living Resources Act of 1998. For recreational anglers, the act introduced permit conditions that set minimum size limits for fish species, bag limits, closed seasons, prohibited species, closed areas and the prohibition of recreational anglers from selling their catch. Despite the promulgation of a host of recreational regulations, assessments of the stocks of the ten dominant species in the MBSF showed that five had collapsed (less than 25% of pre-exploitation levels), three were overexploited (between 25% and 40% of pre-exploitation levels), one was optimally exploited (between 40% and 60% of pre-exploitation levels) and one was underexploited (more than 60% of pre-exploitation levels) (Mann, 2013).

One of the primary reasons for the poor stock status of recreational species in South Africa is thought to be the non-compliance of anglers to the regulations (Whitfield and Cowley, 2010). During a national survey of South African MBSF, Brouwer *et al.* (1997) found that 32% of anglers disobeyed regulations. Dunlop and Mann (2012) revealed that anglers in KZN flouted regulations at various levels, ranging from 9.2% for those fishing in closed areas to 46% for those retaining undersized fish. Similarly, Bova *et al.* (2017) estimated that roughly half of the anglers they surveyed in the Eastern Cape were non-compliant with the regulations. This finding was similar to Eastern Cape estimates by Mann *et al.* (2003). These proportions reflect much higher levels of non-compliance than levels observed in developed countries; examples include 29.0% non-compliance in a recreational fishery in the United States (Blank and Gavin, 2009) and 18.4% non-compliance in a Canadian fishery (Sullivan, 2002). Ultimately, understanding the contemporary distribution

and extent of non-compliance in the South African MBSF is critical to counter illegal behaviour and ensure the long-term sustainability of the fishery.

The aims of this chapter are to employ the BBM for the first time in a recreational fisheries context to obtain estimates of non-compliance using the South African recreational MBSF as a case-study, to assess the utility and suitability of online surveys for assessing non-compliance as a replacement for face-to-face surveys and to identify angler perceptions of various aspects of the fishery. To do this, nationwide online surveys and random-stratified, roving, scripted, face-to-face creel surveys that employed the BBM for controlling interviewer bias were conducted.

Materials and methods

Survey administration

Random-stratified, roving, scripted, face-to-face creel surveys were administered to between December 2015 and January 2017. A random-stratified sampling method was used, with randomly sampled days and at randomly selected times within this period, and the number of anglers who declined participation were recorded. Surveys were delivered by four researchers who had received specialized training and practice in survey administration. A concurrent online survey was disseminated to anglers on various angling forums, social media pages and via email.

The face-to-face questionnaires covered rock and surf fishing areas along the South African coastline from Langebaan on the West Coast through to Cape Vidal on the eastern coastline. Fishing locations were identified through social media, personal communications with local anglers, internet search results and direct observations. The online survey targeted anglers fishing along the coastline from Port Nolloth to Kosi Bay. Study sites were selected to ensure representation in all five of the DAFF management regions (Griffiths and Hecht, 1995). These regions included the West region (Zone 5), stretching from Port Nolloth in the Northern Cape to Yzerfontein in the Western Cape; the Southwest region (Zone 4), covering the area south of Yzerfontein to Arniston; the Southeast region (Zone 3), encapsulating the area east of Arniston to Port Alfred; the Northeast region (Zone 2), extending north from Port Alfred to Port Edward; and the KZN region (Zone 1), formerly managed by Ezemvelo-KZN Wildlife Agency, covering the coastline from Port Edward to Kosi Bay on the northern border between South Africa and Mozambique (Figure 3.1).

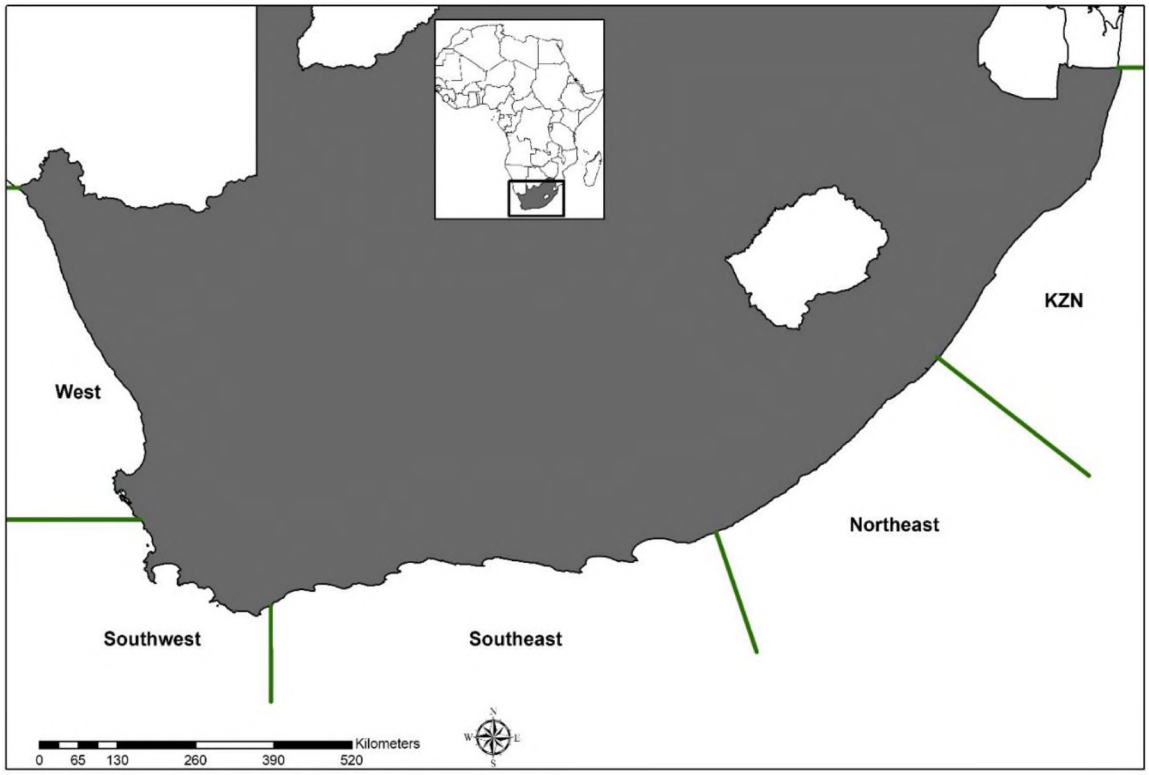

Figure 3.1: Partitioning of South Africa's coastal zone into five coastal fisheries management regions.

Face-to-face surveys were conducted using a sweep strategy. On randomly selected days, researchers walked from access points through each fishing area and intercepted all anglers that were encountered. Anglers that were in groups were interviewed apart from one another to reduce any peer influence on their responses. Random interview times were stratified between 05:00 and 19:00; however, on some occasions anglers were interviewed during night fishing sessions between the hours of 22:00 and 01:00 to ensure a more representative sample of the fishing population. Due to the limitation of available research assistants, DAFF management zones were sampled one at a time throughout the survey period. Fishing locations surveyed were selected based on knowledge of the fishing location and the presence of anglers during the sampling time. Only participants of the recreational MBSF were interviewed. Those that stated they were subsistence or small-scale anglers were not asked to participate in the survey. Angler participation in the survey was further motivated by entry into a "lucky-draw" competition, where they stood the chance to win R3000 cash and high-end fishing gear.

Before commencing the survey, all participants were read a brief description of the research aims, the data requested, the potential time it would take to complete the survey and the privacy policy related to their responses (i.e. full confidentiality and anonymity). All participants were required to be at least 18 years old. Once anglers agreed to voluntarily participate in the survey, interviewers proceeded with the data collection. This research was approved by the Rhodes University Ethical Standards Committee (RU-HSD-16-04-0023).

The online surveys were identical to the face-to-face surveys in terms of structure and questions. Participants were recruited through social media and online fishing forums associated with the MBSF. The survey was in the format of a Google Form that was allowed to be shared by participants to encourage higher levels of participation. Additional participation was encouraged through the same incentivisation method as the face-to-face surveys. Responses were recorded from the online surveys for a four-month period from June 2016 to October 2016.

Questionnaires

The questions in the online and face-to-face surveys closely mirrored each other to ensure responses comparable (see Appendix). The surveys requested information on angler demographics, fishing activity and compliance behaviour as well as their perceptions of the behaviours of other anglers, the effectiveness of law enforcement, any social and formal sanctions and perceptions of the regulations themselves; however, no personal identifying information was captured.

Standard demographic questions regarding gender, age, race, education and income level were included. Participants were also asked to give the approximate number of times they participate in shore fishing on a yearly basis to assess avidity. To separate competitive anglers from casual participants, respondents were asked if they were members of an angling club. Motivations for participating in angling were also queried to categorise those with recreational intentions from those with subsistence motives. To avoid double counting, anglers were required to recall whether or not they had previously participated in the survey.

When soliciting information on compliance behaviour, participants were asked to answer "yes" or "no" to a series of questions regarding whether or not they had violated a given fishing regulation at any point in the previous 12 months before being interviewed. These violations were: fishing without a permit, keeping fish that were undersized, exceeding specified bag limits, keeping a

species during its closed season, fishing in a closed area, selling recreational catch and using prohibited bait, tackle or fishing methods. Care was taken to reduce bias during the face-to-face surveys in two ways. First, interviewers were required to follow a script that ensured consistent interviewing, thereby reducing interviewer bias. In addition, the BBM was employed to reduce the effect of SDB for questions regarding compliance behaviour (see Chapter 2). This method used a script that requested that respondents self-complete a "secret ballot" containing the sensitive questions away from the interviewer and submit their completed ballot to a visibly locked "ballot box," providing perceived anonymity to the anglers' responses (Chapter 2).

Statistical analyses

For the face-to-face surveys, the violation responses obtained by each interviewer were tested for interviewer effects using a Pearson's chi-squared test. This revealed potential influences that multiple interviewers may have had on the data. Surveys were combined with their corresponding "ballot" by matching unique control numbers discretely imbedded on each item. Data were compared by method of survey administration (online vs. face-to-face) and by DAFF management region to determine whether these variables caused any significant variation in responses. The overall proportions of violators for each regulation in a given region or methodology were compared using a Pearson's chi-squared test. Demographic differences among DAFF regions were tested using a Pearson's chi-squared test. To determine whether there were variations between the normative perceptions of participants and the actual norms, Pearson's chi-squared tests were performed on Likert-type responses and one-way ANOVAs were conducted for continuous variables. To test for differences in angler perceptions of various aspects of the MBSF, the responses from online and face-to-face surveys were aggregated and then compared using a Pearson's chi-squared test.

To determine the representativeness of the online surveys, the sociodemographic information was compared for the face-to-face and online methods using a Pearson's chi-squared test. It was assumed that the face-to-face surveys adequately represented the MBSF angling community. To examine whether the differences in survey administration had an impact on the estimates of non-compliance, a stratified sample (n = 70) of individuals with sociodemographic characteristics representing the online survey were randomly selected from the face-to-face (termed "comparative face-to-face surveys") dataset and the proportion of overall violators for the comparative face-to-face and online surveys were compared using a Pearson's chi-squared test.

Results

Of the 479 South African MBSF anglers that were approached during the face-to-face surveys, 453 consented and completed the survey at 62 different fishing spots (Figure 3.2), which were relatively evenly distributed within the five DAFF management regions (Table 3.1) with the exception of the West region. There were 243 online responses to the survey. Two of the completed online surveys and two face-to-face surveys were omitted from the study as participants indicated they had previously participated in the survey.

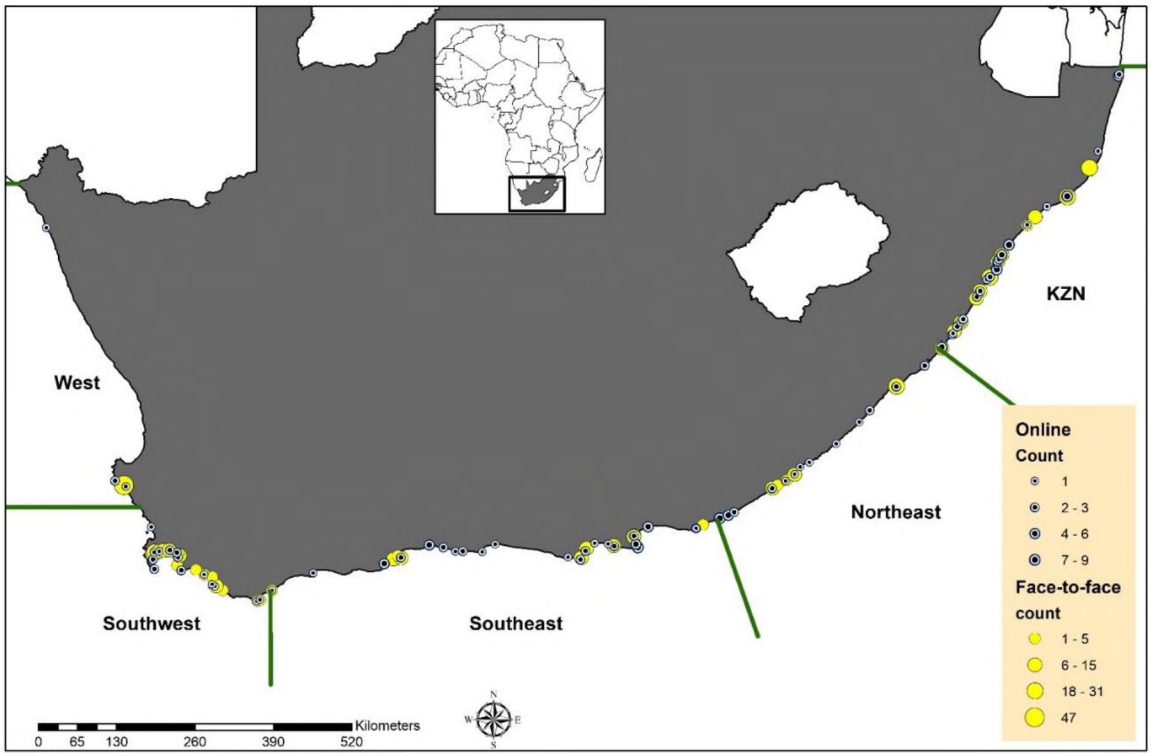

Figure 3.2: Distribution of the face-to-face surveys and dominant angling locations of online respondents belonging to the South African recreational MBSF.

Table 3.1: Total number of surveys completed by South African MBSF anglers in each fisheries management region for face-to-face and online surveys.

DAFF Region	**West**	**Southwest**	**Southeast**	**Northeast**	**KZN**	**Total**
Face-to-face	47	114	88	53	149	**451**
Online	9	44	55	33	74	**243**
Total	**56**	**158**	**143**	**86**	**223**	**694**

A total of four different interviewers administered the face-to-face questionnaires, although three of them represented a small portion of the overall survey count (N = 62). A Pearson's chi-squared test was conducted to compare the effect each interviewer had on admitted violations, which revealed no significant differences among the interviewers (χ^2[3, N = 92] = 1.66, p = 0.65).

Demographic profiles

The sociodemographic profiles of the anglers who responded to the face-to-face surveys were diverse with the majority of anglers interviewed identifying themselves as White (53.8%) followed by Coloured (26.3%), Indian (18.2%) and African (1.8%); however, there were significant differences (χ^2[12, N = 451] = 215.3, p < 0.001) in the racial make-up of the fishery among DAFF regions. The West region was predominately comprised of Coloured anglers (66%), the Southwest region was equally dominated by Coloured and White anglers (48.7%), the KZN region was relatively split between Indian (47%) and White (49%) anglers and the Northeast and Southeast regions were primarily comprised of White anglers (73% and 68%, respectively). Approximately half of the angling population (49.8%) held a matric (high school) education while the remaining participants held a tertiary (31.9%) or postgraduate education (5.7%) or less than matric (12.5%). The mean age of the anglers was 40 years old and 96.7% were male. On average, the participants fished 77 days per year. Most of the participants were employed (68.5%) and earned an income higher than R10,000 per month (60.1%). However, 15.8% made less than R2,500 per month and 9.7% were unemployed with 1.1% categorised as discouraged workers.

Anglers who responded to the online questionnaire were predominantly white males (77%) and fished an average of 55 days per year. Most held at least a tertiary degree (61%) and were employed, students or retirees (97.9%). Several respondents indicated they were unemployed but looking for work (2.1%). The characteristics of the online participants did not vary much across the DAFF management regions.

The respondents for the two survey methods had significantly different socio-demographic characteristics (Table 3.2). Significant differences were noted for race (χ^2[3, N = 694] = 40.40, p < 0.001), employment status (χ^2[4, N = 694] = 43.36, p < 0.001), education level (χ^2[3, N = 694] = 53.34, p < 0.001) and age (χ^2[63, N = 694] = 130, p < 0.001) (Table 3.2).

Table 3.2: Comparison of leading sociodemographic characteristics of South African MBSF compliance survey participants from both online and face-to-face methods.

Survey Method	Race[1]	Education Level[1]	Age[1]	Employment[1]	Gender
Online	77.1% White	39.0% Tertiary	40 Years	81.4% Employed	97.0% Male
Face-to-face	53.8% White	49.8% Matric	48.5 Years	68.5% Employed	96.7% Male

[1] Significant difference noted between methods.

Compliance

The results of the face-to-face surveys indicated that 48.3% of anglers admitted to violating at least one regulation in the 12 months prior to the interview. The Southeast region had the highest prevalence (53.4%) of self-reporting, non-compliant anglers, followed by the West region (51.1%), the Southwest region (47.4%), the KZN region (46.3%) and the Northeast region (45.3%; Table 3.3). However, these regional differences were not significantly different (χ^2[4, N = 451] = 1.53, p = 0.82).

The percent of non-compliance per regulation varied by region (Figure 3.3). Most variations in regulation non-compliance were not significantly different. Anglers in the Northeast region were the least compliant to the permit regulation (28.3% non-compliance) while anglers in the West region were most non-compliant (12.8% non-compliance); however, the regional differences in permit non-compliance were not significant (χ^2[4, N = 451] = 8.53, p = 0.074) (Table 3.4). Similarly, although anglers in the Southeast region were the least compliant to minimum size regulations (28.4%), their non-compliance was not significantly different from anglers in any other region (χ^2[4, N = 451] = 2.99, p = 0.56). Bag limits were violated by between 3.8% (Northeast) and 19.1% (West) of anglers, and this was also not significantly different by region (χ^2[4, N = 451] = 9.35, p = 0.053). The Northeast region held the highest percentage of anglers that were non-compliant with the prohibited species regulations (11.3%) and the West region held the lowest (4.3%) (χ^2[4, N = 451] = 2.27, p = 0.69). Anglers in the KZN region were least compliant to the bait and tackle restrictions (16.8% non-compliance) and anglers in the West region were most compliant (2.1% non-compliance). There was no significant difference in the prevalence of non-compliance to these restrictions among the regions (χ^2[4, N = 451] = 7.84, p = 0.10).

Only two regulation categories in the face-to-face survey yielded significant regional differences. Although fishing in closed areas was not very prevalent, it was most prevalent in the West region (10.6%). In the Northeast and Southwest regions, no anglers admitted to this violation, which represented significant variation among the regions (χ^2[4, N = 451] = 19.65, p < 0.001). Anglers

sold their catch most in the West region (12.8%) and least in the Southeast and Southwest (3.4% and 3.5%, respectively). There were significant differences in the percentage of anglers that sold their catch between regions ($\chi^2(4, N = 451) = 11.10, p < 0.05$).

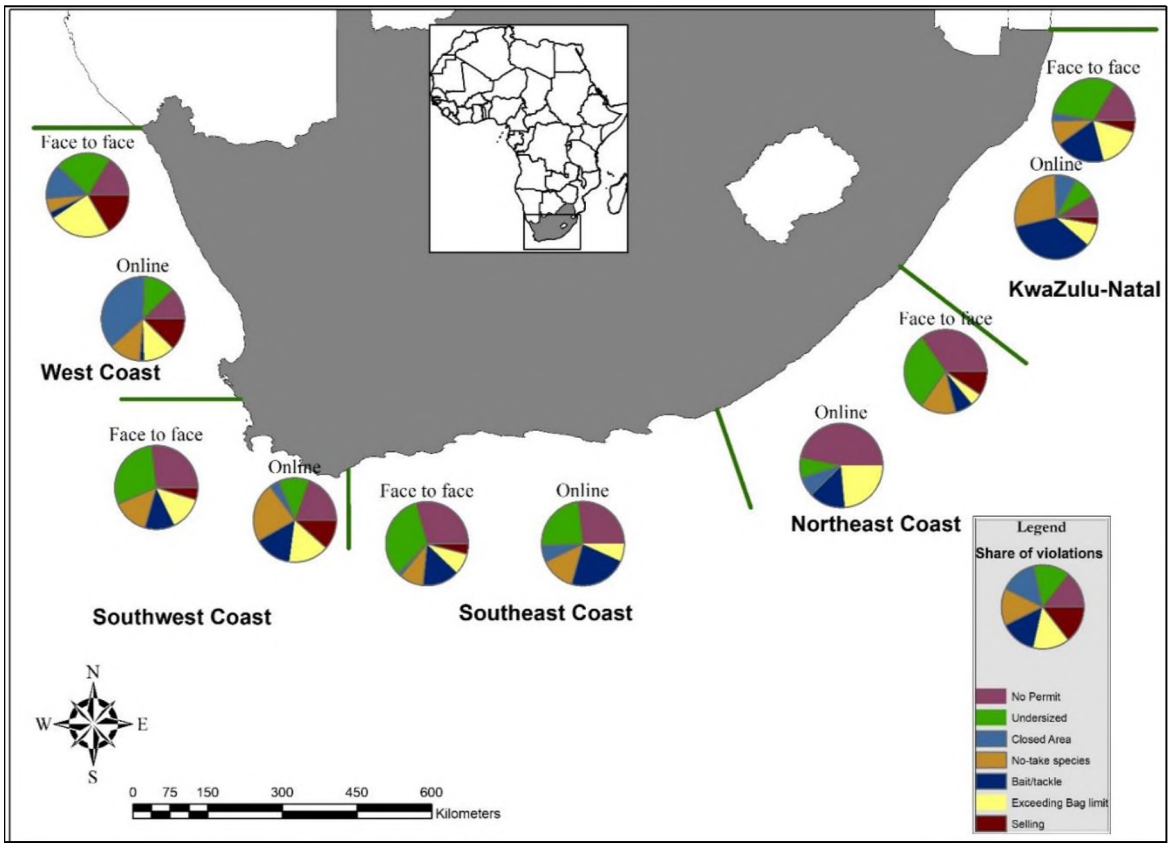

Figure 3.3: Proportion of the different types of violations in each Department of Agriculture Forestry and Fisheries management region for the South African marine based shore fishery. Data based on face-to-face and online surveys.

Table 3.3: Regional non-compliance for the current recreational fisheries regulations estimated using online and face-to-face survey methods.

	KZN		Northeast		Southeast		Southwest		West	
	Face-to-face (%)	Online (%)	Face-to-face (%)	Online (%)	Face-to-face (%)	Online (%)	Face-to-face (%)	Online (%)	Face-to-face (%)	Online (%)
Permit	14.1	4.1	28.3	18.8	25.0	14.8	20.0	11.6	12.7	14.3
Undersized	26.8	4.1	24.5	3.1	39.4	13	21.9	7.1	17.0	14.3
Closed Area	2.7	4.0	0.0	3.0	1.1	3.6	0.0	2.3	10.6	42.9
Prohibited Species	8.1	13.5	11.3	0.0	8.0	7.4	10.5	13.6	4.3	14.3
Prohibited Bait	16.8	15.1	5.7	15.2	12.5	18.2	8.8	4.5	2.1	42.9
Bag Limit	14.1	4.1	3.8	9.4	6.8	3.7	9.6	9.3	19.1	14.3
Selling	4.0	1.3	7.5	0.0	3.4	0.0	3.5	6.8	12.8	14.3
Any	46.3	29.7	45.3	42.4	53.4	41.8	47.4	31.8	51.1	71.4

For the online survey, 35.0% of respondents indicated that they had violated at least one regulation on at least one occasion in the previous 12 months (Table 3.4). Non-compliance was most prevalent in the West region (71.4%), followed by the Northeast (42.4%), Southeast (41.8%), Southwest (31.8%) and KZN (29.7%) regions (χ^2[4, N = 213] = 0.672, p = 0.15). The most common violation among all respondents was the use of prohibited bait or tackle (14.0%). This was significantly different (χ^2[4, N = 213] = 8.63, p < 0.05) among the management regions, ranging from 42.9% in the West region to 4.5% in the Southwest region. The next most prevalent violations among all online respondents include, depending on DAFF region (Table 3.4), failing to hold a valid permit (11.1%), which was most prevalent in the Northeast (18.8%) and least prevalent in KZN (4.1%) and not significantly different among the management regions (χ^2[4, N = 213] = 9.07, p = 0.059). Keeping undersized fish was admitted by 6.9% of participants and was highest in West (14.3%) and Southeast (13.1%) regions and lowest in the Northeast (3.1%) region (χ^2[4, N = 213] = 9.07, p = 0.078). Of the total anglers that admitted to exceeding bag limits (6%), the West region had the highest proportion of offenders (14.3%) and the Southeast region had the lowest (3.7%). Overall, 5% of respondents admitted to retaining a fish that was prohibited, with the West (14.3%), Southwest (13.6%) and KZN (13.5%) regions having a similarly high prevalence of violators. This was significantly more than the Northeast region, which had no admitted violators (χ^2[4, N = 213] = 11.08, p < 0.05). Overall, the proportion of anglers that fished in closed areas was low (4.6%) and least prevalent in the Northeast (3%), however, in the West coast there was a high prevalence (42.9%), a difference that was significant (χ^2[4, N = 213] = 23.65, p < 0.001). Only 2.1% of participants admitted to selling fish, but this varied significantly between regions with 14.3% violation rate in the West region and no violations in the Northeast and Southeast regions (χ^2[4, N = 213] = 10.62, p < 0.05).

Anglers who were interviewed face-to-face reported significantly less compliance overall (48.3%) than those who filled in the online questionnaire (35.0%) (χ^2[1, N = 694] = 10.92, p < 0.001). This was also the case for most regulations. However, anglers who completed the online surveys reported less compliance with the closed area and prohibited bait regulations (Table 3.4). When the effect of different sociodemographic characteristics was removed from the comparison (based on the stratified random sampling of face-to-face vs. online results), overall non-compliance estimates from the face-to-face surveys remained higher (48.6%) than the online surveys (35.0%), although this difference was not significant (χ^2[1, N = 313] = 3.70, p = 0.054). However, there were significant differences in the proportion of compliant anglers for some regulations which were higher in face-to-face questioning, such as fishing without a permit (χ^2[1, N = 313] = 13.30, p < .001) and keeping undersized fish (χ^2[1, N = 313] = 4.15, p < 0.05) using the two survey methods (Table 3.4).

Table 3.4: Comparison of the proportions of admitted violations of the South African marine based shore fishery regulations from different sampling methods.

Survey Method	Permit (%)	Undersized (%)	Closed Area (%)	Prohibited species (%)	Prohibited bait (%)	Bag limit (%)	Selling (%)	All (%)
Face-to- Face	19.3**	24.6***	2.2	8.6	11.1	10.9	5.1	**48.3*** **
Online	11.1	6.9	4.6	5.0	14.0	6.0	2.1	**35.0**
Comparative Face-to-Face	30.0***	15.7*	1.4	7.0	11.4	8.6	2.9	**48.6**

When compared to responses from the online survey, * indicates p<.05, ** p<.01 and *** p<.001.

Angler perceptions

Using face-to-face survey data indicated that anglers generally held unfavourable perceptions of the performance of the fishery managers with regards to their handling of recreational fisheries resources (Figure 3.4). Figure 3.4 shows that 48.6% and 37.5% rated manager performance as "Very Poor" and "Poor". respectively. Only 10.7% perceived fisheries management to be doing a "Good" job managing the resources, while 3.3% felt they were doing a "Very Good" job. Although perceptions were typically negative, they did vary significantly by DAFF region (χ^2[12, N = 1388] = 60.57, $p < 0.001$) with approximately 22.0% of participants in the KZN region indicating that the resource management was either "Good" or "Very Good". In contrast, only 6% of the respondents in the Southwest region shared this sentiment.

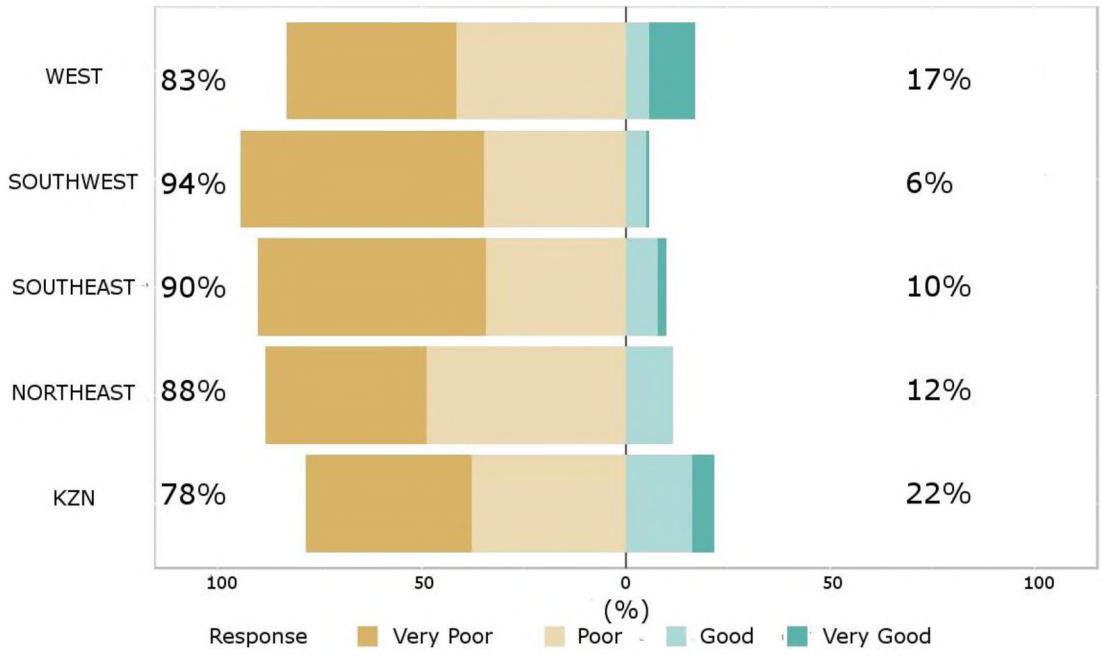

Figure 3.4: South African marine based shore anglers' performance rating of recreational fishery management in each DAFF management region based on the question: "How good or bad of a job are South African fishery managers doing at maintaining the recreational fishery?"

Overall, the majority of anglers indicated they "rarely" (37.8%) or "never" (18%) saw the recreational fisheries regulations being enforced. However, there were significant differences between the DAFF regions (χ^2[16, N = 1388] =168.4, $p < 0.001$) (Figure 3.5) with anglers in the West region indicating that enforcement levels were the highest; these anglers reported that they encountered law enforcement officials "Frequently" (31.9%) or "Every Time" (48.9%). In contrast, ~70% of the anglers in the Northeast, Southeast and Southwest regions stated that they "Never" or "Rarely" encountered law enforcement officials. The Southeast region had the highest incidence of anglers "Never" observing enforcement of angling regulations (39.8%).

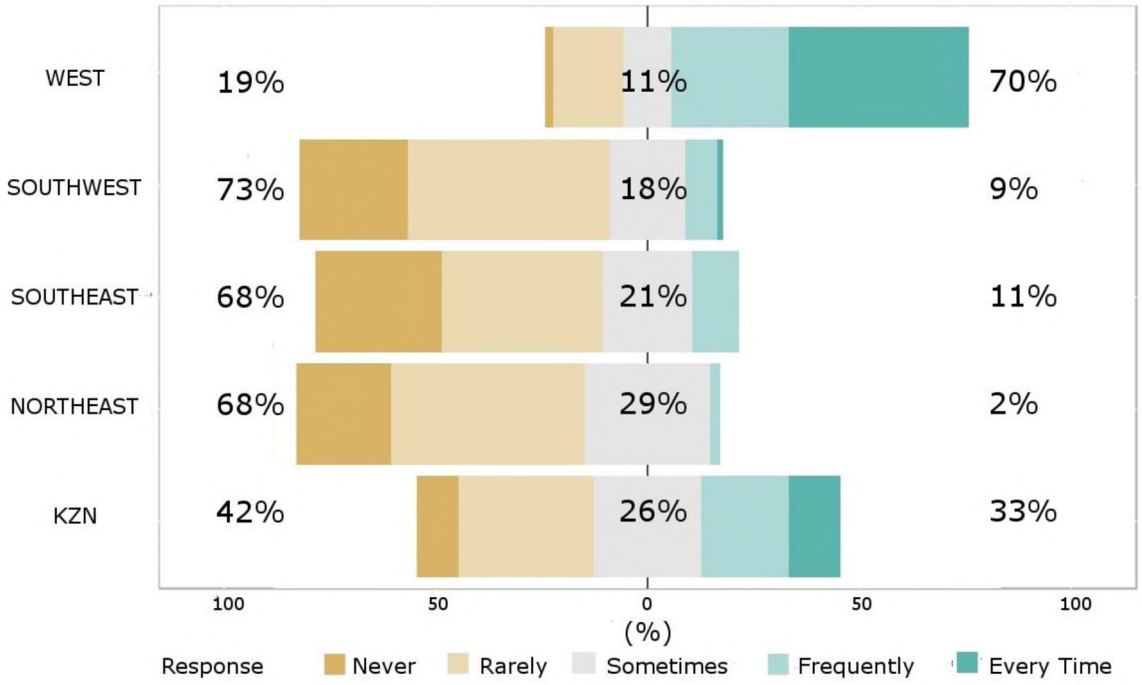

Figure 3.5: Frequency of compliance inspections as observed by South African marine based shore anglers in the five DAFF management regions based on the Likert-type question: "Choose the response that best applies to your view of recreational fishery law enforcement: I have seen recreational fisheries laws being enforced (Never, Rarely, Sometimes, Frequently, Every time)."

Angler perceptions on the likelihood of being caught violating the various regulations were generally split, with a slightly higher number of participants feeling that they had a low or very low likelihood of being caught violating any regulation (Figure 3.6). However, 52% felt that there was a high or very high likelihood that they would be caught fishing in a closed area (Figure 3.6). Interestingly, the perceived levels of detection for themselves were higher than their perceptions of whether other anglers would get caught when fishing without a permit (23.25%), keeping undersized fish (19.2%) and keeping prohibited species (18.3%).

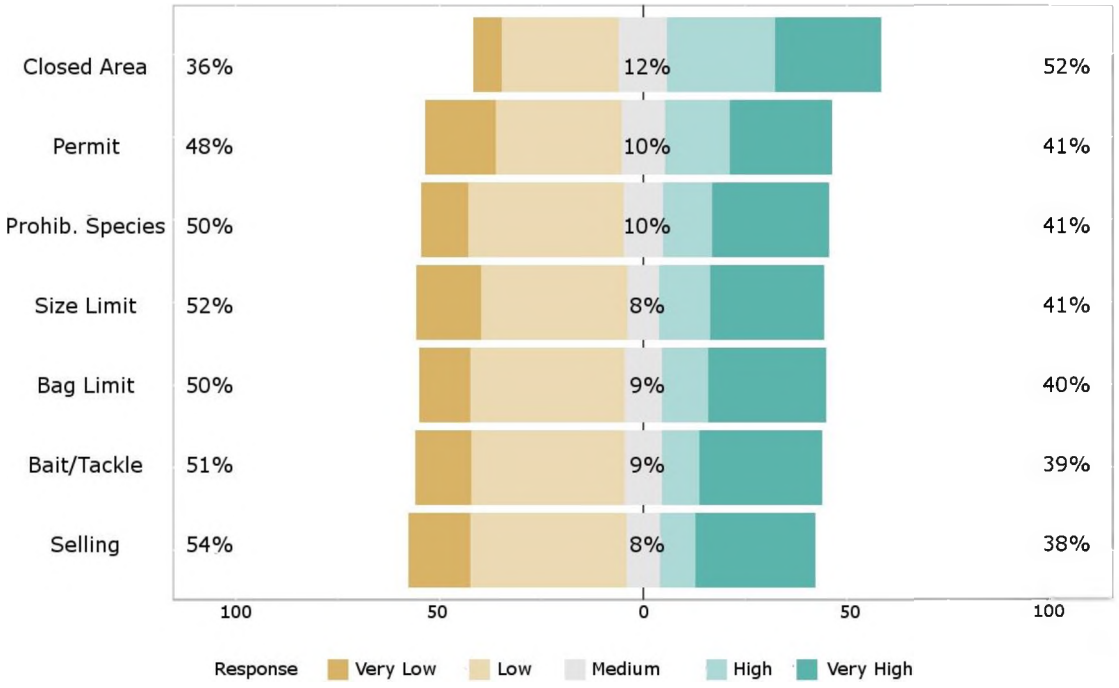

Figure 3.6: The perceived probability that South African marine based shore anglers would be caught by fisheries law enforcement for violating the fisheries regulations based on the question: "Please indicate whether your chances of being caught for violating the following regulations are: Very Low, Low, 50/50, High or Very High."

Although nearly half of the anglers surveyed admitted to being non-compliant, the majority of anglers (between 78% and 95%) agreed that the existing regulations were necessary to maintain the sustainability of the fishery (Figure 3.7). The "prohibited species" and "closed areas" regulations received the most (> 90%) support and the "no selling" and "permit" regulations received the least support (< 80%) (Figure 3.7).

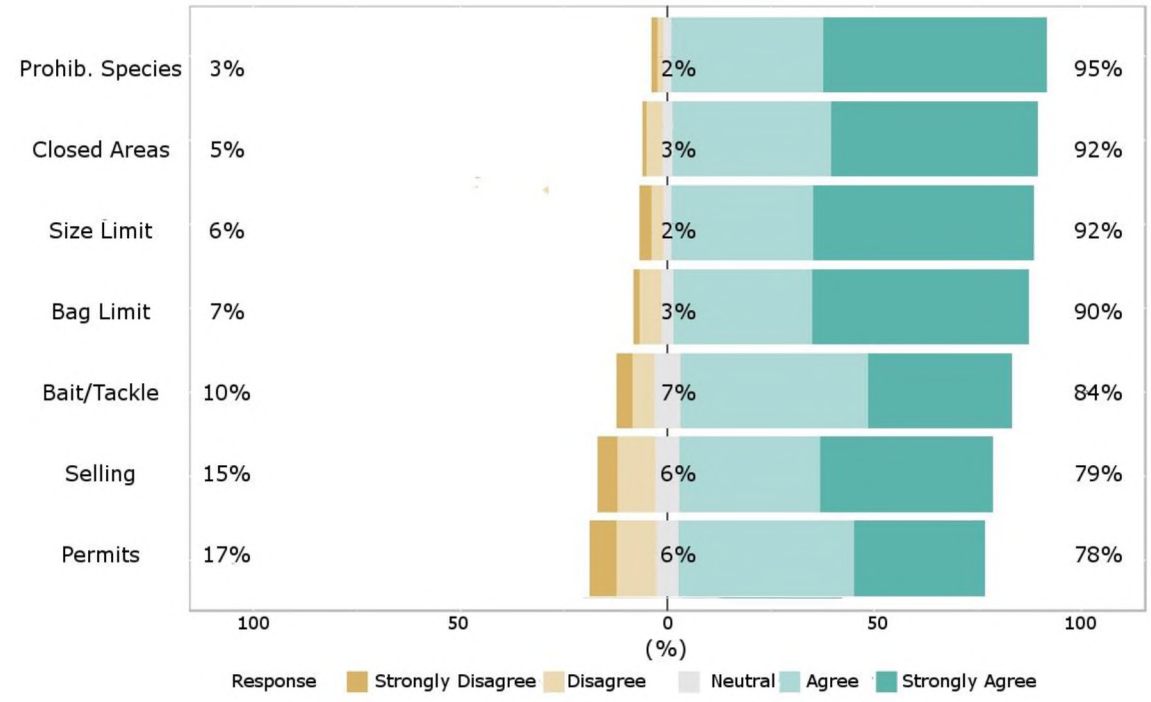

Figure 3.7: Agreement levels of South African marine based shore anglers with the question: "Please clarify whether you Strongly Disagree, Disagree, neither Agree nor Disagree, Agree or Strongly Agree that the following regulation is a necessary measure in order to sustainably maintain the recreational fishery."

The attitudes of anglers towards non-compliant behaviour generally mirrored the perceived legitimacy of the regulations (Figure 3.8) with the overwhelming majority (77% or greater) feeling that violating the existing regulations was unacceptable or totally unacceptable (Figure 3.8). Violation of the size limits, closed areas and prohibited species regulations were considered to be particularly unacceptable.

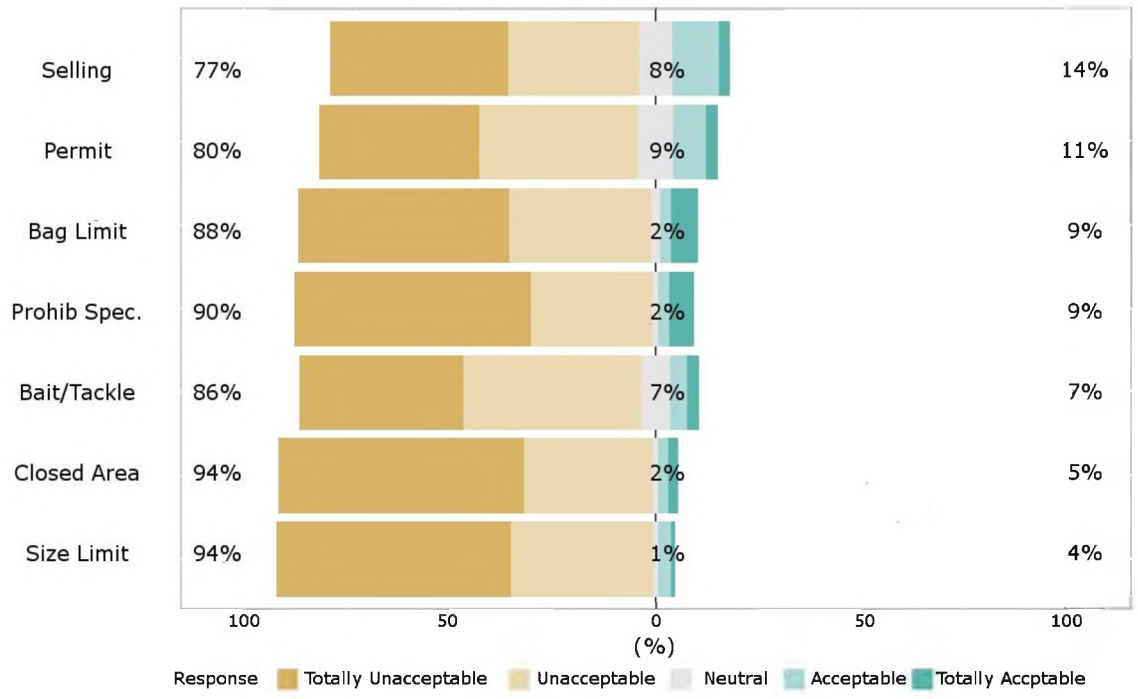

Figure 3.8: The attitudes of South African MBSF anglers towards non-compliant behaviour in response to the question: "Please indicate whether you feel it is Totally Unacceptable, Unacceptable, 50/50, Acceptable or Totally Acceptable for a recreational angler to violate the following regulations."

The relative morality of participants regarding the justification of violating regulations was split with 38% generally agreeing that sometimes rule breaking behaviour is justified, while 47% were in disagreement with the justification. There were several participants that held "indifferent" opinions of the morality of violating regulations (14%), which, when combined with those that agreed that violations are sometimes morally justified (38%), comprised the majority of the surveyed population (52%) not disagreeing with the justification of violations.

Angler perceptions of the extent of non-compliance within the fishery were generally grossly overestimated compared to stated non-compliance (Figure 3.9). A total of 81.3% of anglers overstated the number of other anglers fishing without a permit, while 83.7% and 90.5% overestimated the number of anglers that keep undersized fish and prohibited species, respectively. The percentage of participants that overestimated non-compliance (shaded area) to three separate regulations: permit requirement, size limits and prohibited species can be viewed in Figure 3.9. The mean levels of non-compliance estimated by anglers were 43.8% for fishing without a permit, 54.1% for keeping undersized fish and 45.9% for keeping prohibited species, which were all much higher than the reported non-compliance levels from the face-to-face surveys (Table 3.4).

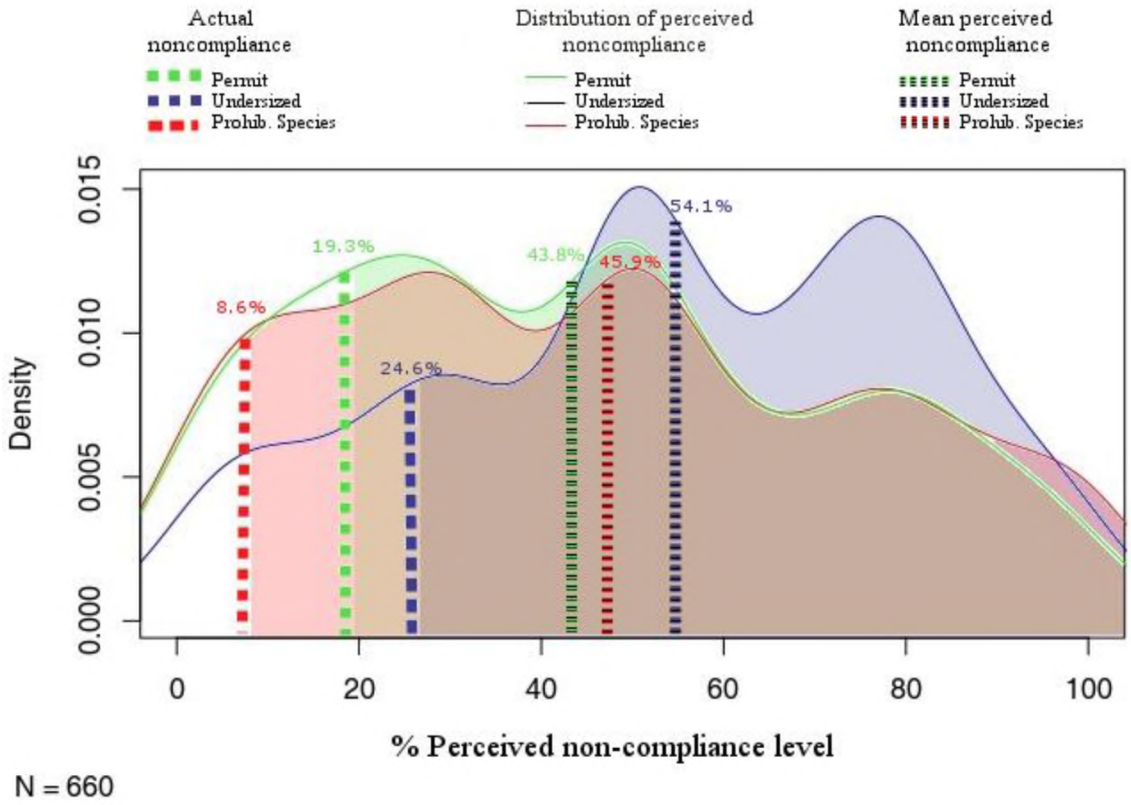

Figure 3.9: Distribution of South African marine based shore fishery angler estimates of the proportions of anglers that fish without a permit, keep undersized fish and keep prohibited species. The shaded area to the right of the dashed line is the population that estimated a higher prevalence of non-compliance than what was reported.

Anglers misperceived the levels of action that other anglers would take against them for violating a series of regulations (Figure 3.10). On average, anglers believed that other anglers would merely disapprove verbally if they observed them breaking a regulation. However, based on the responses

of anglers on how they would react to someone breaking a regulation, the average angler was most likely to threaten them with corrective action (Figure 3.10). The dominant modes of the bimodal distributions and means of the percieved level of actions mostly fell to the left (underestimate) of the dominant modes and mean level of actions that anglers specified they would take against a non-compliant angler for the same set of regulations. The differences in response levels between the perceived norm of action and the descriptive (actual) norm were statistically significant for every regulation (χ^2[5, N = 1388] = 111.23, $p < 0.001$).

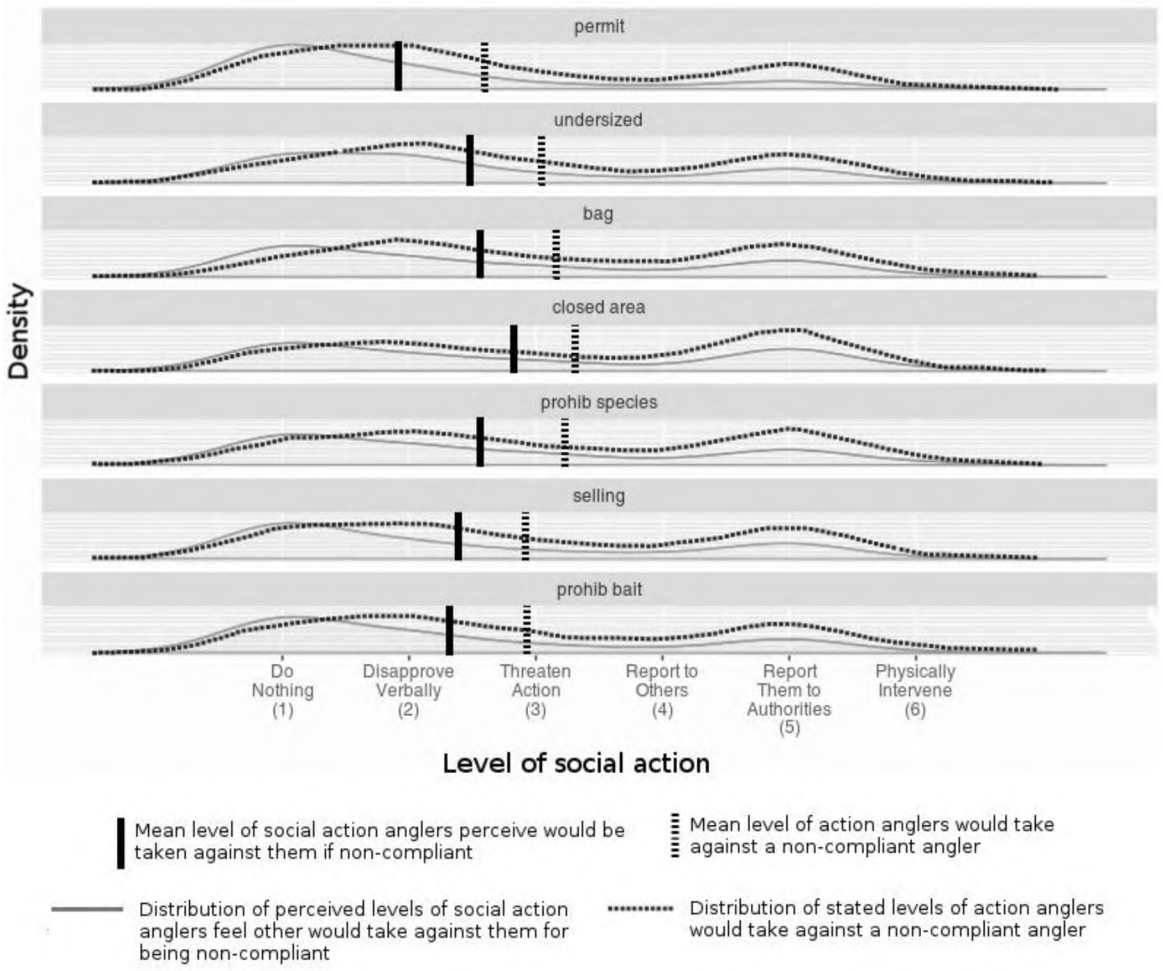

Figure 3.10: Ranked, quasi-Likert scale of the perceived level of action that other South African marine based shore anglers would take against fellow participants for violating each fishing regulation and the mean levels of action that South African marine based shore anglers stated they would take against a non-compliant angler within the fishery.

Discussion

Estimates of compliance varied depending on the method of survey administration. Based on the results, it is clear that the online surveys are not a suitable replacement for face-to-face surveys. The face-to-face questionnaire incorporated a significantly broader demographic than the online survey and was considered to provide a better representation of the angling population as a whole. It is likely that the online survey results represent a subgroup of the overall fishery population rendering its utility to be lower than face-to-face surveys and an inadequate substitute. In the context of a developing country, this is most likely due to low internet access and low digital literacy, which was reported by Goldstuck (2017) to be roughly 40% of the population in South Africa. Thus, the utility of online surveys in developing countries is likely to remain low until digital literacy and internet accessibility are available to more of the population.

Once the effect of the sociodemographic bias was removed it was interesting to find that there were significant differences in the estimates of compliance to size limits and the possession of a permit between the standardised face-to-face and online survey results. It is possible that the significantly higher compliance estimates in the online survey may be a result of SDB, particularly as there was no attempt to mitigate for SDB bias using this method. It is conceivable that this may have resulted in reduced admissions of non-compliance by participants. Interestingly, Kreuter *et al.* (2008) suggested that online surveys generally have reduced SDB relative to the DQM that do not control for SDB. However, since SDB was controlled by what was found to be the most efficient method (BBM, Chapter 2), it appears that the participants' fears of internet privacy may have influenced them to respond "desirably" (Stoughton *et al.*, 2015). This suggests that every effort should be made to convince respondents of their privacy when employing online compliance surveys.

While SDB may be a cause for the difference in the overall compliance between the online and standardised face-to-face surveys, it is also possible that the methods of dissemination of the online survey may have resulted in another, less quantifiable kind of representation bias. In this study, the online survey was disseminated through recreational fishing forums and social media sites. These sites generally encourage progressive conservation practices, including compliance with fishing regulations, and thus it is possible that a subgroup of pro-environmental anglers with higher compliance rates were sampled. Future studies that aim to use online surveys to estimate compliance should ensure that the dissemination is not focussed towards one social sub group. In a South African MBSF context, there are many fishing forums and websites that are less

conservation-conscious. These should ideally be included into the dissemination of future compliance surveys in a systematic way.

This was the first study of its kind to apply the BBM for obtaining honest responses to questions regarding socially undesirable behaviour in a fishery context. The only other non-compliance study performed at the national level in South Africa (Brouwer *et al.*, 1997) did not incorporate any measures for reducing SDB. The results in the current study produced a much higher estimate of overall non-compliance compared to the previous research. The results from Brouwer *et al.* (1997) used a basic DQM to estimate compliance and revealed that 32% of the participants admitted to violating a regulation. The current research found that nearly half (48.3%) of participants engaged in illegal activities. The higher proportion of admitted violators in the current study could be a result of the use of the BBM, which may have revealed more honest responses than the DQM employed by Brouwer *et al.* (1997), although this does not serve as an appropriate validation. The similarly high estimates in this study and other recent, albeit localised, studies (Dunlop and Mann, 2012; Bova *et al.*, 2017) compared to the previous study by Brouwer *et al.* (1997), all of which utilised DQM, may also indicate a decline in compliance behaviour in the fishery.

A main contributor in an individual's likelihood of participating in a particular behaviour, in this case a non-compliant behaviour, is their ability to do so (Ajzen, 1991). In the period since the previous national survey by Brouwer *et al.* (1997), South Africa has adopted several regulations aimed at ensuring the sustainability of the fishery. The addition of more regulations affords an individual more opportunity to engage in non-compliant behaviour (Chambliss, 1967), which could also influence the overall level of non-compliant individuals.

Overall, if one considers the findings of the face-to-face surveys only, which cover a more representative demographic, regulation compliance in the South African recreational MBSF is low with nearly half (48.3%) of the population admitting to violating at least one regulation on at least one occasion in the 12 months prior to being surveyed. Indeed, several recent localised studies have found similar compliance levels to this study. Research on the KZN MBSF found high levels of non-compliance with size limits (46%) (Dunlop and Mann, 2012). While the current study only found the regulation to be violated 26.8% of the time, Dunlop and Mann (2012) indicate that their assessment included the use of undersized fish as bait. In this study, undersized fish that were used as bait were reported as "illegal bait". When the proportions of size limit violations and illegal bait use were combined in the KZN region, the percentage of violators (43.6%) closely mirrors the

findings by Dunlop and Mann (2012). However, it should be noted that the nature of random-stratified roving creel surveys may result in an overrepresentation of the attributes of "avid" anglers (Pita *et al.*, 2018). Studies that aim to use creel surveys to estimate angler attributes should be aware of this and attempt to account for the bias through some additional weighting techniques (National Academies of Sciences, Engineering, and Medicine, 2017).

There were several differences in non-compliant behaviours across the various DAFF regions. Some of the differences can be also be attributed to the ability of an angler to violate various regulations. For instance, fishing in a closed area was admitted by significantly more people in the West Coast region that in any other region. Langebaan Lagoon, which lies within the West Coast region, is one of the most popular fishing areas in the country and is relatively close to the densely populated city of Cape Town. The lagoon and the corresponding coast have been designated as an MPA within which is a large no-take zone. The majority of face-to-face surveys in the West Coast region were conducted near this zone (Figure 3.11). Thus, the ability to have fished in a closed area was significantly higher than in the KZN region where relatively few anglers were encountered in close proximity to closed fishing areas. This low reported prevalence of MPA violation in this study is supported by previous assessments of South African MBSF compliance that also found the occurrence of anglers that admitted to fishing in closed areas to be relatively low (~9%) in KZN (Brouwer *et al.*, 1997; Dunlop and Mann, 2012).

Figure 3.11: Comparison of surveyed South African marine based shore anglers and their proximity to no-take MPAs along the West Coast and KwaZulu-Natal (KZN) management regions.

The ability to violate regulations, such as exceeding bag limits or keep a prohibited species, will also be dependent on fishing location. The means of exceeding a bag limit depends on the capacity to catch fish. However, in this study, a much higher proportion of anglers in the West Coast region, which is characterised by a low catch per unit effort (CPUE) (Brouwer *et al.*, 1997), admitted to exceeding their bag limit when compared to the Southeast Coast region, which typically attains a high CPUE (Brouwer *et al.*, 1997). This may be the result of species-specific bag limits implemented by DAFF. Most of the species that are targeted by anglers in the West Coast region have bag limits of only one or two fish per species (Mann, 2013). Due to the typically low CPUE of fish in this region, this may make it more likely for anglers to keep as much as they can catch. Thus, anglers who only catches two fish (of the same species) in one region are more likely to break a bag limit regulation than anglers who catch five fish (of three species) in another region.

The current study found that overall non-compliance to bag limit regulations was (10.1%). However, the current study revealed a lower (4.1%) proportion of non-compliance to bag limits in KZN than previously assessed (23% for the KZN regional study by Dunlop and Mann, 2012).

It is possible that this low number may be attributed to declines in fish stocks and a reduced likelihood of anglers attaining their bag limits. Indeed, Mann *et al.* (1997) indicated that there had been a steady decline in linefish catches in KZN, a result echoed by the CPUE results in the Dunlop and Mann (2012) study. Another possible explanation for the differences is an effect from improved enforcement of the regulations. From 1984 to 2016, Ezemvelo-KZN Wildlife Agency was tasked with enforcing recreational fishing regulations along the KZN coast, making it the only coastal province in the country with infrastructure and staff designated specifically for the recreational fishery (Kramer *et al.*, 2017). Previous studies have found much higher rates of inspection in KZN as well as a correlation between frequency of inspections and improved compliance (Brouwer *et al.*, 1997; Dunlop and Mann, 2012). The higher observed levels of inspections on the KZN coastline were also indicated by survey respondents in this study which took place within a short period after the Ezemvelo-KZN Wildlife Agency ceased enforcement. The increased and residual presence of law enforcement officers may also indicate why the province received more favourable fishery manager approval ratings, which lend to the legitimacy to the agency.

In the current study, areas that had higher perceived levels of law enforcement generally had reduced non-compliance for fishing without a permit. However, there were no significant differences in the rates of other violations. This may be a result of the ease with which the permit regulation can be enforced compared to other violations, which may be much more difficult to detect and may therefore present a lower risk to potential violators. An assessment of risk preference in South African fishing communities found that risk attitudes are correlated with regulation compliance (Brick, Visser and Burns, 2011). Anglers that were risk averse generally tended to be more compliant with the regulations. However, following a paradox, a high proportion of anglers had permits in fishing spots where there was relatively no observed enforcement and therefore little risk. This suggests that risk aversion may not be the main driver behind non-compliance with permit possession in this fishery.

When compared to some studies undertaken in developed countries (Bergseth *et al.*, 2018; Lancaster *et al.*, 2015; Arias and Sutton, 2013), the non-compliance levels in South Africa's MBSF are high. For example, Bergseth *et al.* (2018) found that only 3% of anglers admitted to poaching in Australian waters, while Lancaster *et al.* (2015) revealed that only 7% of anglers knowingly violated rockfish regulations in Canada. It is worth noting that compliance behaviour is not the only dramatically different characteristic between South Africa and developed countries such as

Canada and Australia. Management effectiveness and governance quality of South African fisheries are ranked substantially lower than those in the developed world (Pitcher *et al.*, 2009). South African governance in general has been plagued by corruption, with fisheries governance in South Africa singled out as a serious threat to marine resource management (Sundström, 2012). This corruption within fisheries law enforcement drastically reduces the efficacy of enforcement activities. The reduced efficacy of enforcement is illustrated by the lack of perceived probability of being caught violating a regulation in the South African MBSF (Figure 3.6). However, ineffective enforcement is not confined to the South African context. Many studies in developed countries have found enforcement levels to be inadequate (Sutinen, Rieser and Gauvin, 1990; Raakjær Nielsen, 2003; Thomas, Gavin and Milfont, 2014; Bergseth, Russ and Cinner, 2015). Despite this, researchers have typically found high levels of compliance (Sutinen and (Sutinen *et al.*, 1989; Nielsen and Mathiesen, 2003). In these studies, various social norms relating to angler attitudes, perceptions of legitimacy, morality and the expectations of others were determined to be more influential on compliance behaviour than perceived probabilities of being caught by violating a regulation.

Most anglers expressed the attitude that any non-compliance unacceptable (Figure 3.7). Anglers showed higher levels of disdain for non-compliance with regulations that were biologically based. These included size limits, prohibited species and bag limits which, interestingly, were amongst the most common violations. In addition, anglers' attitudes generally mirrored their perceptions of the legitimacy of the regulations. Nielsen (2003) argued that attitudes towards non-compliant behaviour of some regulations directly related to anglers' perceptions of the meaningfulness of that regulation. He also suggested that fishers generally accept that regulations need to be based on scientific advice, which increases the meaningfulness of that regulation. The meaningfulness of a regulation is then considered to be a component of the content legitimacy of that regulation (Tyler, 1990). This could explain the relationship between measured attitudes towards non-compliance and regulation legitimacy in this study, especially in cases where regulations have been implemented based on scientific evidence.

Even though compliance with regulations was relatively low, most anglers agreed that the regulations were necessary measures for ensuring the sustainability of the MBSF (Figure 3.6). Remarkably, some of the regulations that anglers were generally in most agreement with were the very ones that they admitted to violating, such as keeping undersized fish and exceeding bag limits. This contradicts findings and assumptions made by other studies. Nielsen and Mathiesen (2003)

suggest that the perception of regulations as meaningful is an essential incentive for ensuring fisheries compliance. They also reiterate the theory of Axelrod (1986), that attitudes towards non-compliance are directly related to compliance behaviour. Although agreement with the regulations was high, actual compliance was low. Tyler (1990) suggests that the perceived legitimacy of decision-making authorities, in this case DAFF, also plays a crucial role in compliance behaviour. Angler ratings of DAFF's ability to effectively manage the fishery were generally low to very low (Figure 3.4). These findings suggest that the low perceived legitimacy of the fisheries management authority may be more influential on rule-breaking behaviour than the legitimacy of the regulations themselves.

The seeming paradox of a strong agreement with the legitimacy of the regulations coupled with a high rate of non-compliance may suggest that personal morality, another form of internal obligation highlighted by Tyler (1990), may also influence behaviour. Indeed, Tyler (1990) and Gezelius (2002) suggested that a fisher's incentives to comply with regulations are the risk of social sanctions and their own moral convictions. This intrinsic or personal morality is expected to be an influential factor in an individual's decision to be non-compliant (Tyler, 1990; Gezelius, 2002). The anglers in this study had mixed levels of morality regarding whether or not it is ever acceptable to violate the fishing regulations. A fairly large percentage of the population (38%) stated that it may be acceptably justified to violate a fishing regulation. Gezelius (2002) found that individuals justify non-compliance based on the motivation behind it, with the majority of individuals finding it more acceptable if illegal fishing is done to provide an individual with basic nutritional requirements. South Africa is characterised by a high percentage of the population living below the poverty line, specifically the food poverty line. The high level of justification in this study may stem from the societal awareness of the poverty level in South Africa and may be a sympathetic reaction to those requiring fisheries resources for their livelihood.

Anglers generally held misperceptions of various norms within the MBSF. Most participants overestimated the levels of non-compliance with various regulations within the fishery and underestimated the level of social action that other anglers would take against them for violating a regulation. These misperceptions of the actual norms have been referred to in the literature as pluralistic ignorance (Berkowitz, 2003). Perceptual overestimations of the norm of undesirable societal behaviour can lead to levels of undesirable behaviour that align closely with those perceptions (Perkins and Berkowitz, 1985). Bova *et al.* (2017) found that there were high levels of pluralistic ignorance in an Eastern Cape MBSF, results that align closely with the current research,

and they suggested that it may be suitable for a social norm approach (SNA) intervention. The SNA aims to reduce undesirable behaviour by correcting societal misperceptions of the actual norm. In this instance, the SNA could be used not only to potentially improve the levels of compliance in this fishery, but to encourage stronger levels of social action against non-compliant anglers. This could deter non-compliant behaviour through correcting the misperceptions of non-compliant individuals that their behaviour will face no repercussions.

When assessing compliance with regulations, it is also important to identify these socio-demographic characteristics within the fishery. However, future studies should aim to assess the role that these socio-demographics play in determining preferences. The socio-economic and demographics of user groups have the potential to influence rates of non-compliance with laws (Buonanno and Montolio, 2008). This can be viewed in the differences between population representation in the online versus face-to-face surveys and their corresponding compliance levels. These data can be crucial in helping identify potential trends in non-compliance. The normative theory of compliance often references an individual's perceptions as determinants for compliance behaviour (Nielsen and Mathiesen, 2003). However, perceptions can vary based socio-demographics such as age, race, income-level and education (Avery *et al.*, 2008). Identifying the socio-demographics and their corresponding perceptions of compliance and management, can potentially help to identify key drivers behind non-compliance.

Estimates of the extent and distribution of non-compliance are critical for understanding the impacts of illegal fishing and its consequences on fish stocks. Data from compliance estimates can be used by fishery managers to assess hidden fish mortality caused by illegal fishing, which can undermine conservation goals. For instance, in the KZN region, 26.8% of the population admitted to violating size limits. This region has an estimated angler effort of between 759,682 and 843,702 angler-days per year, with a CPUE of 0.82 fish per angler-day (Dunlop and Mann, 2012), meaning that between 622,939 and 691,836 fish are caught annually. In a scenario where 50% of those fish that are caught are undersized (311,470 to 345,918), non-compliant anglers could be keeping as much as 26.8% of these or 92,706 undersized fish in the KZN region annually. As size limits are specifically designed to allow a species to reach maturity, thus affording it the opportunity to reproduce, this potential scenario represents a critical threat to the sustainability of fish stocks.

Aside from providing estimates of illegally harvested fish, compliance data can give managers an indication of the extent and locations of non-compliant behaviour in which to apply intervention.

In this study, it was clear that the types of regulations violated differed by DAFF region, and this will influence the types of compliance activities required. For example, compliance interventions aimed at reducing illegal fishing in closed areas will be different to those aiming to improve size-limit compliance.

Conclusion

Estimating non-compliance in a fishery of interest can be performed in many ways. Choosing the most effective method for measuring non-compliance requires a thorough understanding of the dynamic characteristics of the fishery of interest. While many methods may be successfully utilised within the context of industrialised countries, the characteristics of developing countries may present different levels of efficacy. In this chapter it was demonstrated that the method of survey administration used in a developing country is directly related to the quality and accuracy of the obtained data, with face-to-face surveys providing the most diverse and representative fishing population and therefore the most utility.

This study is the first to have applied the BBM for reducing SDB during questions regarding regulation compliance behaviour in fisheries. This revealed a relatively high rate of non-compliance among MBSF anglers. The levels of non-compliance and for which violations varied depending on which region anglers were fishing and their various perceptions on various aspects of the fishery were also often location dependent. While these findings are useful, a better understanding of the drivers of non-compliance is critical for designing interventions to improve compliance in the fishery. The questionnaire for this survey also contained various questions regarding angler perceptions of various aspects of the fishery. These data can be used to assess the potential reasons for the variations among the management regions and the different population groups. Angler perceptions will be the focus of Chapter 4.

Chapter 4: Understanding the impact of instrumental and normative constructs on anglers' behavioural intentions towards compliance

"In a closed society where everybody's guilty, the only crime is getting caught."
– Hunter S. Thompson, Fear and Loathing in Las Vegas

Introduction

Effectively addressing recreational angler non-compliance with fishery regulations is an ongoing challenge that fishery managers face. Neglecting to appropriately ameliorate non-compliant behaviour can result in the negation of decades of conservation measures. In the last chapter, it was revealed that the South African MBSF has a generally high level of non-compliance with regulations. In the same survey that assessed these rates of non-compliance, various other data were captured, such as perceptions of the social dimension of non-compliant fishing behaviour. These data can be used to effectively direct specific behavioural interventions with the objective of reducing non-compliance (Thomas, Milfont and Gavin, 2016; Bova *et al.*, 2017; Bergseth and Roscher, 2018). In South Africa, little emphasis is placed on compliance research and no attempts have been made to understand the behavioural drivers behind non-compliance with recreational fisheries regulations. This lack of research has resulted in a limited understanding of what drives compliant behaviour and in repeated calls by researchers for the government to follow an instrumental paradigm often implemented by developed countries. With limited resources to effectively maintain an instrumental approach in a developing country context, new frameworks for improving compliance must be investigated, such as identifying constructs from normative theory.

Over time, the theories for improving regulation compliance have emerged from economic to socio-psychological principles or a combination of both. Theoretical frameworks have advocated for influencing the decision-making processes of individuals by targeting a series of key behavioural drivers (Sutinen and Andersen, 1985; Kuperan and Sutinen, 1998; Viswanathan, 1999; Thomas, Milfont and Gavin, 2016; Bova *et al.*, 2017; Bergseth and Roscher, 2018). Initially, models attempting to understand compliance behaviour in the recreational fishery were based on the assumption that individuals are rational decision-makers that weigh the associated risks (costs) of formal and informal sanctions, such as fines or imprisonment, against the potential financial gain

(benefits) from committing the violation (Thomas and Bishop, 1984; Anderson, 1989; Sutinen and Gauvin, 1989). These assumptions were based on Becker's (1968) theory of deterrence, which argued that an individual's decision of whether or not to participate in illegal behaviour is based on perceived risks. These risks include the likelihood of a person's non-compliant acts being detected by law enforcement, the likelihood of conviction and penalties associated with a conviction.

In this theory, an increase in cost, such as higher monetary fines, longer imprisonment terms or greater probability of detection, will create a linear decrease in the probability of an offense. Many researchers have argued that this type of "command and control" governance, i.e. the instrumental approach, is essential to the success of conservation and natural resource management (Sutinen and Andersen, 1985; Anderson and Lee, 1986; Anderson, 1989; Sutinen, Rieser and Gauvin, 1990; Akpalu, 2008). However, in application, the instrumental approach has followed the Allais paradox, an inconsistency of actual observed choices with predictions of expected utility theory (Allais, 1953). For example, a study by Sutinen *et al.* (1990) indicated that even though the chances of detection were below 1% and the benefits from illegal activity far outweighed the potential penalties, between 50% and 90% of fishers were still compliant with regulations.

Rational choice models, such as those used in the instrumental approach, have attracted considerable criticism, primarily because of their empirical shortcomings and failure to understand how normative concepts can sway decision-making (Simon, 1972). These criticisms gave rise to the normative theory of compliance behaviour, which relies on the conformation to social norms, attitudes, personal morality, legitimacy, relative difficulty in performing a behaviour and corresponding beliefs within the fishery that reflect an individual's decision-making process (Gezelius, 2002; Hauck, 2008). The variables considered under normative theory that have been identified as salient within a fisheries compliance context involve legitimacy (Tyler, 1990; Nielsen and Mathiesen, 2003), social norms (Bova *et al.*, 2017), attitudes and beliefs (Hatcher *et al.*, 2000; Salz and Loomis, 2005), morality (Jentoft *et al.*, 1998) and behavioural intention (Bergseth and Roscher, 2018. Each of these variables had been derived from existing theories in the social sciences regarding behavioural influence (Fishbein and Ajzen, 1975; Schwartz, 1977; Stern, Dietz and Black, 1985; Elster, 1989; Ajzen, 1991).

The models used to assess compliance behaviour have either been completely adapted or contain carefully selected variables from existing sociological theories. For instance, compliance models

that investigate the role that social norms play, stem from several different theories surrounding the influence of social norms on behavioural decision making, such as Ajzen's (1991) theory of planned behaviour (TPB), norm-activation models (NAMs) (Schwartz, 1977), the focus theory of normative conduct (Cialdini, Kallgren and Reno, 1991) and the social norms approach (SNA) (Perkins and Berkowitz, 1986). While compliance behaviour models that focus on how perceptions of legitimacy of fisheries management stem from Tyler's (1990) theory on "Why people obey the law" or in this case disobey it (Nielsen, 2003; Gezelius and Hauck, 2011). The inclusion of attitudes as a potential determinant of compliance behaviour is rooted in the theory of reasoned action (Fishbein and Ajzen, 1975). Theory on how individual beliefs can influence compliance behaviour stems from value-belief-norm (VBN) theory (Stern, Dietz and Black, 1985). While these models may vary in their measurement of compliance behaviour attributes, many of them contain similar theoretical bases.

The theory of reasoned action (TRA), formulated by Fishbein and Ajzen (1975), assumes the best predictor of a behaviour is behavioural intention, which is determined by attitudes towards the behaviour and social normative perceptions regarding it. Social norms relate to many of the normative theories and refer to individual perceptions of particular group conduct. The TPB is an extension of the TRA and posits that, in addition to the constructs associated with the TRA, an individual's behaviour is influenced by their capability of performing a given behaviour (Ajzen, 1991). Central to the TPB is the assumption that an increase in this capability, or perceived behavioural control, will result in an increased likelihood of participation in the behaviour of interest. In some instances, the risks assessed in the instrumental approach are included in an individual's perceived behavioural control. However, TPB has been criticised for its reliance on perceptions of both control and difficulty performing a behaviour, and it has been proposed that measures of capability should not be limited to an individual's perceptions (Armitage and Conner, 2001). In the context of fisheries compliance, Bergseth and Roscher (2018) further suggest that the TPB may overlook fisheries-specific drivers of behaviour and should be extended to include perceptions of regulatory legitimacy and a more inclusive measure of social normative influence. For instance

Sometimes an individual's perceptions of fairness and validity or legitimacy of a regulation sway their decision-making when threats of formal sanctions are insufficient to do so (Keane *et al.*, 2008). The higher the perceptions of fairness, morality and validity of the regulations and regulating body, the higher the likelihood of compliance (Tyler, 1990; Viteri and Chávez, 2007). Levi, Sacks and

Tyler (2009) postulated that attitudes towards non-compliant behaviour and an internal moral obligation to comply relate to value-based legitimacy of regulations, another measure of perceived legitimacy that may influence regulatory compliance. Thus, in a fishery context, the legitimacy of authorities and the acceptance of the applied regulations are assumed to correlate with compliance. In other words, if there is high correlation between legitimacy and compliance within a fishery, fishers will create an internal obligation for compliance. This internal obligation is thought to be strong; Nielson (2003) proposed that even in situations where individuals can personally gain through engaging in non-compliant behaviour, internal obligation can maintain compliance (Nielsen, 2003). The legitimacy that drives internal obligation can be split into procedure and outcome fairness as well as moral and social norms (Jentoft, 2000). Procedure relates an individual's perceptions of and involvement in the regulation making process. Outcomes can refer to the distributional effects and representation of stakeholder interests inherent in the regulations. Morals and social norms refer to perceptions of the actions, attitudes and expectations among anglers.

The moral obligations to comply also relate to NAMs. In NAMs, moral and personal norms are assumed to be based on an interaction between cognitive, emotional and social factors, rather than just perceptions of legitimacy (Schwartz, 1977). It is closely linked with an individual's morality. Hence, the strength of a person's morality determines the degree of their pro-social normative behaviour (Schwartz, 1977). Compliance with environmental regulations, to some extent, relies on pro-environmental behaviour in the Value Belief Norm (VBN) theory (Stern, Dietz and Black, 1985). In assessing pro-environmental behaviour, a cognitive precondition may be an individual's awareness of environmental problems or, in the context of compliance, their awareness of the reasons behind regulations. Emotions may relate to levels of guilt that some individuals feel when engaging in a behaviour that is in conflict with their perception of the social norm. These perceptions of the social norm stipulate to the individual the standard behaviour of a social reference group in a specific context (Bamberg and Möser, 2007).

The social norms approach (SNA) is a theory that identifies the role of social norms in directly influencing decision making behaviour (Berkowitz, 2004). This theory postulates that a misinterpretation of the actual societal norm can lead to an inaccurate norm following behaviour by the individual. It further attempts to correct misinterpretations of the norm that result in undesirable social behaviour through targeted informational campaigns which present the actual norm.

Elster (1989) examined the existence of norm-following behaviours, where people act not because of their self-interest but because it is required by social norms as well as rational action. He theorized that people's choices are determined by self-interest as well as the social norms to which they subscribe. Based on this theory, a combination of the conventional rational choice models of instrumental theories towards compliance behaviour alongside perceptions of legitimacy and suasion of moral development could be applied to achieve desired compliance levels with environmental regulations.

The identification of potentially relevant drivers behind human behaviour has led to their application in models in a variety of disciplines, such as health behaviour research (de Vries, Dijkstra and Kuhlman, 1988; Conner and Norman, 1996), criminology (Wikström and Svensson, 2010), psychology (Carrus, Passafaro and Bonnes, 2008), sociology (Vincent, Peplau and Hill, 1998) and resource management (Bamberg and Möser, 2007), including the management of fisheries (Thomas, Milfont and Gavin, 2016; Bergseth and Roscher, 2018). These models include factors from either the instrumental or normative approaches and some incorporate constructs from both theories. Using these models and theories, researchers have attempted to predict the likelihood of influencing a behaviour of interest based on predetermined behavioural drivers (Thomas, Milfont and Gavin, 2016). They have also attempted to determine which variables are relevant in their fishery of interest (Bergseth and Roscher, 2018).

Using a structural equation model that incorporated several models from behavioural theory as well as a "fully-inclusive" model, Thomas *et al.* (2016) determined that the model of best fit for determining compliance with fishing regulations relates to normative constructs closely aligned with those from NAMs. Interestingly, the top three models of best fit did not contain components from instrumental theory. Other authors have recently employed a combination of normative constructs from the TPB and factors from legitimacy theory to determine their effects on compliance with recreational fisheries regulations in Australia (Bergseth and Roscher, 2018). Due to the complexities in understanding rule-breaking behaviour, hybrid (instrumental/normative) modeling approaches have been especially useful. Hybrid approaches have allowed researchers to explore behavioural drivers at individual, group and institutional levels. However, they have yet to capture all potential drivers behind non-compliant behaviour and the contextual relevance of these drivers.

Some literature suggests that motivation may influence an individual's decision to comply with regulations (Hauck and Kroese, 2006). The motivation for participating in recreational fisheries is not limited to leisure (Cooke *et al.*, 2017). In a developing country context (and in some developed countries), a main motivation for fishing is to obtain or supplement an individual's dietary nutritional requirements (Cooke *et al.*, 2017). Reliance on a resource to alleviate a lack of food, particularly protein, is a major factor affecting the frequency of illegal resource use (Grey-Ross, Downes and Kirkman, 2010). Those who rely heavily on the recreational fishery for food may be less compliant as their decision-making is potentially influenced by a tradeoff between punishment and survival. Despite the role motivation may play in driving compliance behaviour, no recreational fisheries models have incorporated angler motivations for participation.

The high levels of non-compliance in the South African MBSF found in the previous chapter offer a unique opportunity to test the competing theories of normative and instrumental behavioural drivers. Understanding the role that behavioural drivers selected from these theories play in influence angler compliance can contribute to a more effective management strategy to address non-compliance. Much of the research around non-compliance behaviour in fisheries within South Africa has focused on small-scale and commercial fishers (Hauck and Kroese, 2006; Brick, Visser and Burns, 2011; Gezelius and Hauck, 2011). These studies have typically investigated legitimacy surrounding small-scale fishing regulations from a social justice standpoint (Hauck, 2008) or have made assumptions on the influence of an instrumental approach towards improving compliance based on the risk preference of small-scale fishers (Brick, Visser and Burns, 2011). The championing of increased enforcement based on instrumental theory has been resounded by many recreational fishery researchers since a potential relationship between observed enforcement and levels of compliance was presented by Brouwer *et al.* (1997) during a national MBSF survey (Mann *et al.*, 2003; Pillay, 2004; Potts *et al.*, 2005; Kuentzel *et al.*, 2008; Sjöstedt and Sundström, 2015). However, South Africa's ability to effectively increase enforcement is constrained by the limited availability of dedicated resources allocated to the enforcing agency (Childs, 2013). For this reason, new approaches for improving compliance behaviour that do not require large amounts of capital are likely to be the most feasible in developing country contexts.

To date, little has been done to explore an approach that can influence angler behaviour rather than tailoring the regulations to meet current behaviours and the perceptions of participants (Gezelius and Hauck, 2011). The first step towards identifying an approach for improving compliance behaviour involves identifying the relevant drivers behind non-compliant behaviour.

The aim of this chapter is to develop a theoretical model to understand the relative influence of normative and instrumental variables on overall compliance behaviour based on the attitudes and preferences assessed in Chapter 3. Unlike previous models, this is the first of its kind to include angler motivations for participating in fishing to determine if it is a relevant driver behind non-compliant behaviour. Based on the results of the model, recommendations for approaches towards improving compliance, aside from those typically included in the instrumental approach, can be given.

Materials and methods

Data collection

This chapter used an aggregation of the survey results from both the face-to-face and online questionnaires from the previous chapter. The survey was designed to provide the appropriate variables to fit a model that had been constructed based on previous literature in fishery compliance behaviour (Appendix). In addition to the measures discussed in Chapter 3, ordinal, Likert scale and quasi-Likert scale questions were used to measure normative and social behaviour. The scales varied according to the variable being measured (Table 4.1). Questions relating to the anglers' perceptions of the scale of social norms relating to compliance were requested as percentages. Questions that revealed non-compliant behaviour required anglers to recall whether or not they had been fully compliant with the fishery regulations within the previous 12 months prior to the survey. This was done using the BBM to reduce SDB. However, there were no control measures in place to limit recall bias, which can potentially affect retrospective studies which rely on respondents to recall events from their memory.

The measure an individual's perceptions of the severity of the social sanctions imposed on a non-compliant angler, required a quasi-Likert scale to be developed with a series of perceived social actions ranking from low to high severity. Assigning rank to the actions required an additional pilot study, which was undertaken on in a fishing forum on social media. In this study, anglers (N=41) were asked what actions they felt others would take against them for participating in non-compliant behaviour for three separate regulations (Appendix). The responses were open ended and resulted in 123 total responses (3 responses per participant). Similar responses were consolidated and unique actions that were identified on less than four occasions were deemed insufficient to form a categorical action and were omitted (Appendix). This resulted in seven separate actions participants expected others to take in response to non-compliant behaviour: do

nothing, verbally disapprove, threaten to take action, report them to others (society), report them to authorities and physically intervene. A follow-up pilot survey undertaken in a separate fishing forum and using face-to-face interviews requested a group of participants (N=47) to rank the given responses in level of severity from not severe to very severe (Appendix). The levels of action were scaled and ordered based on the mean severity ranking of the participants in the second survey, which were applied to the responses of the final questionnaire that was used in Chapter 3 (Appendix).

Table 4.1: Descriptions of South African marine based anglers' compliance behaviour, perceptions of fisheries management, social norms, behavioural controls, attitudes and motivations.

Variable	Description	Survey Response Levels	Model Response Levels
	Instrumental		
Informal sanction (action)	Level of sanctions anglers would impose on non-compliant anglers. Measured for each regulation.	Interval (quasi-Likert 1-7)	Interval (quasi-Likert 1-7)
Formal sanction (penalties)	Perceptions of the severity of formal penalties from law enforcement. Repeated measure for each regulation.	Ordinal (Likert 1-5)	Ordinal (Likert 1-5)
Detection	Perceptions of likelihood of being caught violating regulations. Repeated measure for each regulation.	Ordinal (Likert 1-5)	Ordinal (Likert 1-5)
	Normative		
Legitimacy			
Management	Perceptions of the performance of fishery managers in ensuring the long-term sustainability of the fishery.	Ordinal (Likert 1-4)	Dichotomous ("Good or better", "Poor or worse"
	Perceptions of the legitimacy of a given regulation. Repeated measure for each regulation.	Ordinal (Likert 1-5)	Ordinal (Likert 1-5)
Value Based (benefit)	Participants stated willingness to violate a regulation if there was a guarantee of benefit.	Ordinal (Likert 1-5)	Dichotomous ("Unlikely", "Likely")
	Justification of rule breaking behaviour.	Ordinal (Likert 1-5)	Dichotomous ("Justified", "Unjustified")
Attitude	Perceived social acceptability of rule breaking for a given regulation. Repeated measure for each regulation.	Ordinal (Likert 1-5)	Ordinal (Likert 1-5)
Social Norms			
Violation (descriptive norm)	Stated compliance with a given regulation in the previous 12 months.	Dichotomous (Yes or No)	**Response Variable**
Perceived Norm	Percentage of the angling population perceived to violate a given regulation. Repeated measure for three regulations	Nominal (Percentage)	Principle Component Decomposition. (3 Principle Components)
Motivation	Main reason for participating in angling (nutrition or leisure)	Categorical (Closed Question)	Dichotomous ("Food", "Recreation")

Statistical analyses

Variables

The variables for the model were selected based on existing theory surrounding behavioural influence that are relevant to the South African MBSF. The measurements of variables drawn from these theories, however, were not operationalised in the same format as they were initially intended to the conglomeration of diverse theories in a single survey format. The independent variables, which were measured in Chapter 3 assumed to be relevant for influencing compliance behaviour are: the role that social norms play as well as misinterpretations of the norm based on the SNA; angler attitudes relating to TRA and TPB; perceptions of legitimacy relating to Tyler's (1991) theory; morality, which is linked to a justification of rule breaking behaviour, drawn from the NAM; whether the an individual would violate if they were guaranteed to benefit which is rooted in legitimacy and VBN; motivation for angling which has been previously found to sway fisher behaviour within the South African context; and instrumental variables such as the risk level and threat of sanctions (Table 4.1). The dependent variable is a dichotomous response of whether or not the respondent had violated any of the regulations in the 12 months prior to being surveyed.

Due to a lack of midpoint category (neutral) responses by participants in the individual measures, such as the performance rating of fisheries management and measures of value-based legitimacy, the variables were reduced from Likert scales to mutually exclusive response categories by combining the terms on each side of the mid-point response and omitting the midpoint responses (Table 4.1). For example, the category variable "Agree" and "Strongly Agree" were combined into the singular category variable "Agree or Strongly Agree" and "Disagree" and "Strongly Disagree" were combined into "Disagree or Strongly Disagree".

Measures of a variable that were "repeated" for each individual regulation were expected to be highly co-linear. In the repetitive question types that obtained a categorical response, based on the Likert scales, the variables were reduced using a weighted factor scoring method that assigned a mean factor level for each participant. For questions of the same nature that obtained a nominal response, a principle component decomposition (PCD) was performed as a dimensional reduction method to produce a set of uncorrelated component indices that summarised the data (Izenman, 2008).

Building and understanding the principle component decomposition variables

A PCD was performed on the participants' perceptions of the percentage of anglers that were non-compliant with the permit, size limit and prohibited species regulations (perceived norms), which would likely be colinear. This process was expected to reduce the multiple factors to component indices that explain the underlying data and could be used as individual factors within the model. The PCD resulted in three independent components, the loadings of which can be seen in Table 4.2. The components were centered, but as the units (percentage points) were common to all three of the input variables, no scaling (dividing by the variance) was required.

Table 4.2: Mean response levels of South African marine based shore angler perceptions of non-compliance with permit, size limit and prohibited species regulations and their loadings in principle component variables.

		PC Loadings		
Input Variables	Mean	PC1	PC2	PC3
Permits (%)	43.81	0.42	-0.91	0.06
Size Limits (%)	54.07	0.58	0.21	-0.79
Prohibited Species (%)	45.98	0.70	0.36	0.61

Interpreting the loadings for the different principle components gives insight into what effect (or combination) the different principal components explain. In this instance, the first principle component (PC1) is loaded by roughly the same amount for the permits and size limits variables and more for the prohibited species variable. The participants with perceptions of high levels of non-compliance (i.e. higher than the mean values that relate to the overall mean estimates of non-compliance, Table 4.2) for the input variables would have a large, positive component score. Those with perceptions of low non-compliance would have a large, negative component score. If a respondent had answered the mean level for each of the independent component, the principal component score would be zero. Thus, the first principal component essentially represents a weighted average of the inputs. The component score x_{ij} of component *i* (PC1, PC2 and PC3) for the *j-th* respondent in in which the component is centred but not scaled is given by:

$$x_{ij} = \text{loading}_{i_{v_1}}[v_{1j} - \text{mean}(v_1)] + \text{loading}_{i_{v_2}}[v_{2j} - \text{mean}(v_2)] + \text{loading}_{i_{v_3}}[v_{3j} - \text{mean}(v_3)]$$

where the input variables 'permits' is v_1, 'size limits' is v_2 and 'prohibited species' is v_3. For example, for the first respondent (i=1) and the first principal component (j=1), the value of x_{11} (i.e. the value of the principal component score for the first respondent) is:

$$-65.922 = 0.416407[0 - 43.8146] + 0.575586[3 - 54.06861] + 0.70378[20 - 45.9781]$$

Since this component score is negative, this particular participant's perceptions are that compliance is generally high in the MBSF.

The second principal component (PC2) is more interesting to interpret. This component loads heavily on those with perceptions of high non-compliance for permits. In PC2, these perceptions for permits lead to a negative component score. The loading on size limits and prohibited species are comparatively small. Thus, the second principal component essentially represents perceptions of permit behaviour. The third principal component (PC3) has almost no loading on the permits variable while it loads heavily negatively on the size limits variable and heavily positively on the prohibited species variable. The absolute values of these loadings are similar. Therefore, the PC3 represents the discrepancy between the strength of response for size limits and prohibited species variables.

Model

The model is based on a non-probability sample of anglers with known compliance. As the dependent variable in the model is binomial (individuals are either compliant or non-compliant), a logistic regression was fitted to the combination of observed, index and factor variables. These types of models are common in the social sciences (Cohen, West and Aiken, 1984), and in this case, they allow for the determination of relationships between non-compliant behaviour and a set of *a priori* instrumental and normative constructs. The logistic regression model underlying the analysis can be denoted simply as:

$$y_i = \beta x_i + \varepsilon$$

where y_i measures the i-th individual's compliance with any regulation and x_i is a vector of conditions that reflects measures of the individual's perceived risk of detection, moral development, institutional legitimacy, social influence and their motivation for fishing and includes the index variables constructed during the PCD. β is a matrix of coefficients comprised of log-odds. The model was run using the package *glm* in R 3.3.3 open source statistical software.

In models where the response variable is dichotomous, there is often a problem of separation or monotone likelihood. This separation problem is encountered during the fitting process, where the likelihood converges but at least one of the parameter estimates diverges to infinity. To reduce bias in the estimates, the model was fit using an adjusted quasi-Fisher scoring iteration with the package *brglm2* (Kosmidis, 2017) in R 3.3.3 open source statistical software.

To more straightforwardly interpret the impacts of the regressors on the response variable, there must be a measurement of the marginal effects, as opposed to interpreting the model in log-odds. Marginal effects measure the expected instantaneous change in the dependent variable as a function of a change in a certain explanatory variable while keeping all other covariates constant. Average marginal effects (AME) allow for the interpretation of the variables in their natural units of measure. To determine the AME on the regressors, the package *margins* (Leeper, 2017) in R 3.3.3 open source statistical software was applied to the logistic model.

Results

The results of the logistic regression of the different variables expected to influence behaviour identified six statistically relevant drivers and two potentially relevant drivers (Table 4.2). The most

significant behavioural driver was an angler's willingness to engage in non-compliant behaviour if they were guaranteed to personally benefit from it ($p < 0.0001$). Anglers were significantly more likely to be non-compliant if they were motivated to fish based on nutritional requirements ($p < 0.01$), if they rated management poorly ($p < 0.01$) or if they held attitudes that found non-compliant behaviour to be acceptable ($p < 0.05$). On the other hand, individuals were significantly more likely to be compliant if they perceived severe levels of social actions taken against non-compliant anglers ($p < 0.05$) or if they perceived there to be no justification in ever violating a fishing regulation ($p < 0.01$). The amount of days an angler fished may have increased their likelihood of non-compliance as did negative perceptions of the legitimacy of the regulations. However, these factors were not significant at the 95% confidence interval (CI). Factors relating to detection, enforcement and perceptions of social norms of compliance were not found to significantly influence the outcomes of compliance behaviour (Table 4.3).

Table 4.3: Results of the logistic regression model showing log-odds of the contribution of a specific behavioural driver (conditional on all the other drivers) to non-compliance in the South African marine based shorefishery and its statistical significance.

Factor	Estimate	Standard error	z-value	p-value
(Intercept)	0.3552	0.8326	0.4266	0.6697
Actions	-0.1214	0.0541	-2.2440	0.0248*
Attitudes	0.1941	0.0977	1.9880	0.0468*
Benefit – likely	0.8830	0.1918	4.6030	0.0000***
Management rating – poor	0.6760	0.2593	2.6072	0.0091**
Detection	-0.0489	0.0474	-1.0323	0.3019
Fishing days	0.0023	0.0013	1.8234	0.0682
Motivation – food	0.8146	0.3121	2.6101	0.0091**
Legitimacy	-0.1918	0.1043	-1.8388	0.0660
Morality – not justified	-0.4935	0.1829	-2.6974	0.0070**
Social Norm PCA1	-0.0029	0.0025	-1.1659	0.2437
Social Norm PCA2	-0.0030	0.0034	-0.8615	0.3890
Social Norm PCA3	-0.0039	0.0041	-0.9473	0.3435
Penalties	-0.0466	0.0403	-1.1543	0.2484

Levels of significance indicated by * (95% CI) α=.05, ** (99% CI) α=.01 and *** (99.9% CI) α=.001

The conversion of the log-odds of a variable to marginal effects reveals how the probability of engaging in non-compliant behaviour is affected by each variable. All of the behavioural drivers previously deemed significant remained significant after adjusting for marginal effects (Table 4.4). The amount of days fished and the perceived legitimacy of regulations were not significant (Table 4.4).

Table 4.4: Average marginal effects (AME) of behavioural drivers (conditional on the other variables) on compliance behaviour of South African marine based shore anglers.

Factor	AME	Standard error	z-value	p-value
Actions	-2.5710	0.0113	-2.2767	0.0228*
Attitudes	4.1106	0.0204	2.0116	0.0443*
Benefit – likely	19.6932	0.0426	4.6236	0.0000***
Management rating – poor	13.9198	0.0507	2.7439	0.0061**
Detection	-1.0363	0.0100	-1.0335	0.3014
Fishing days	0.0492	0.0003	1.8355	0.0664
Motivation – food	17.7044	0.0666	2.6574	0.0079**
Legitimacy	-4.0610	0.0219	-1.8531	0.0639
Morality – not justified	-10.4767	0.0384	-2.7264	0.0064**
Social Norm PCA1	-0.0622	0.0005	-1.1688	0.2425
Social Norm PCA2	-0.0628	0.0007	-0.8632	0.3880
Social Norm PCA3	-0.0816	0.0009	-0.9505	0.3419
Penalties	-0.9857	0.0085	-1.1621	0.2452

Levels of significance indicated by * (95% CI) α=.05, ** (99% CI) α=.01 and *** (99.9% CI) α=.001

The details of each of these factors and their significant effect on the compliance behaviour of anglers can be viewed in Figure 4.1. Each effect is measured in the change in percentage points (p.p.) of compliance behaviour conditional on the other variables. Of the six significant variables effecting compliance behaviour, an individual's willingness to participate in non-compliant behaviour if they were guaranteed to personally benefit from the action had the most significant influence on compliance behaviour. This variable represented the highest increase in the probability (20.0 p.p.) of a participant engaging in non-compliant behaviour. Anglers that stated an unlikely willingness to engage in non-compliant behaviour if guaranteed to benefit, had a significantly lower likelihood of violating regulations when compared with anglers that stated they would likely be willing to do so (Figure 4.1).

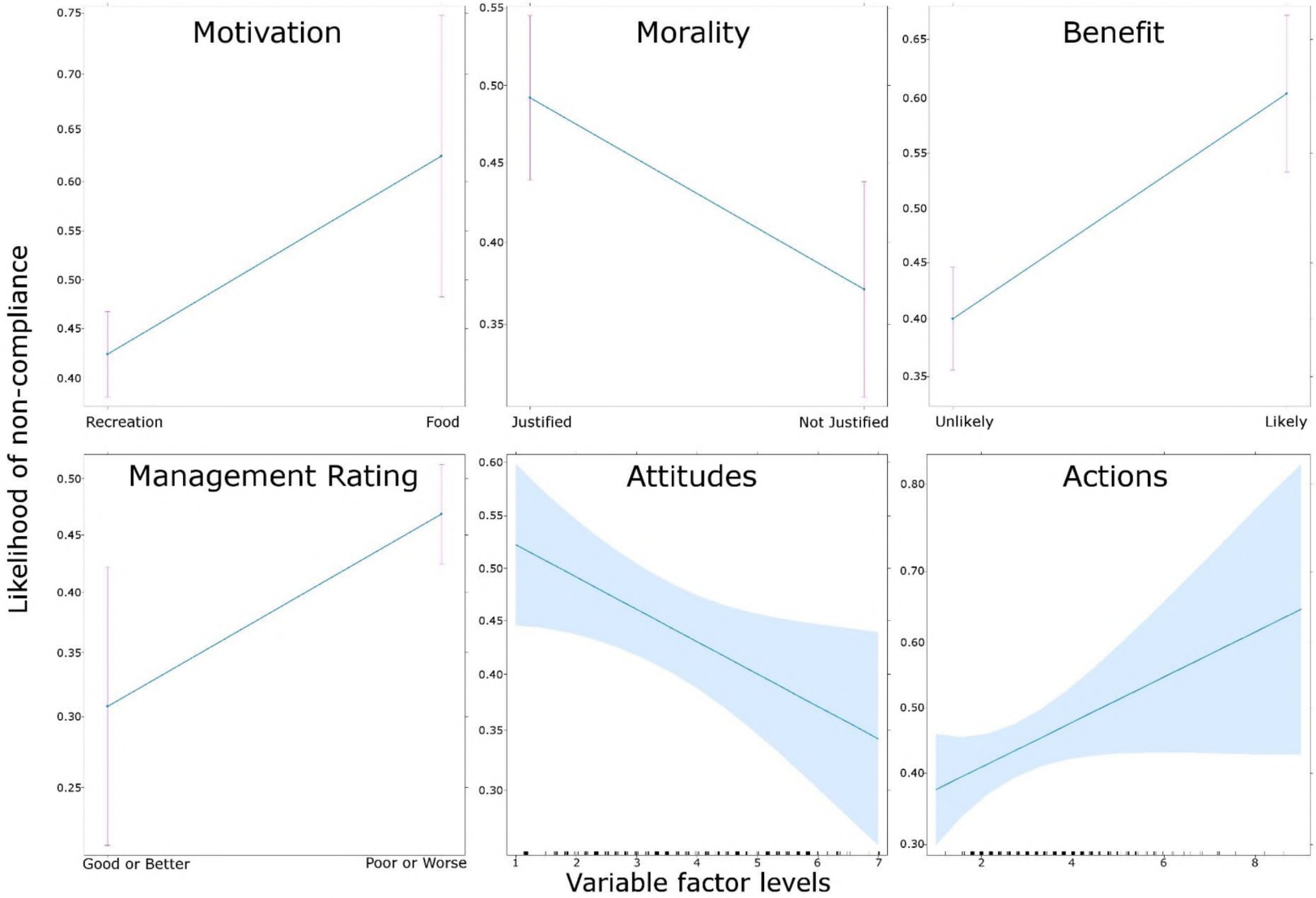

Figure 4.1: Average marginal effects (AME) of behavioural drivers on South African marine based shore anglers' overall compliance behaviour conditional on the other variables. The x-axis represents the levels of each independent variable while the y-axis represents an individual angler's likelihood of participating in non-compliant behaviour. This is represented as a scale from 0 to 1 due to the nature of the logistic regression, with 0 representing compliance and 1 representing non-compliance. For dichotomous categorical variables, standard errors are presented. For ordinal and nominal data, the standard errors are represented by the blue shading. Black marks on the x-axis represent the individual values of the participants.

The next largest effect on the outcome of compliance behaviour was motivation (Table 4.3). As their motivation for participating in the South African MBSF moved from recreational to meeting basic nutritional requirements, their likelihood of non-compliance increased by 17.7 p.p. (Fig 4.1). Anglers who rated fisheries management poorly were significantly less likely to be compliant (14 p.p.) ($p = 0.0061$) (Fig. 4.1) representing the third largest marginal effect on compliance behaviour (Table 4.3). The behavioural driver with the next highest level of marginal effect, relates to an individual's moral justification of violating regulations (Table 4.3). Those that stated that violations were sometimes or always justified were statistically more likely to violate the fishery regulations than those that disagreed with this justification (10.5 p.p.) ($p = 0.0064$) (Fig. 4.1).

The level of social action that would be taken against a non-compliant angler also had a significant influence on compliance behaviour ($p = 0.0228$). As an individuals' severity of social action increased in response to witnessing non-compliance, the likelihood of non-compliant behaviour decreased by ~2.5 p.p. per factor level (Figure 4.1) This equated to a change in the likelihood of non-compliance by nearly 18 p.p. between factor levels one and seven. The attitude towards the non-compliant behaviour of others also had a significant impact on compliance behaviour, with anglers with negative views of non-compliant anglers (lower factor scores) being significantly less likely to engage in non-compliant behaviour ($p = 0.0443$). As an angler's level of acceptance towards non-compliant behaviour increased, the likelihood of non-compliance increased by 4.1 p.p. per factor level. As attitude towards non-compliant activities shifted from totally acceptable to totally unacceptable, the likelihood of being non-compliant decreased by 28.8 p.p. (Figure 4.1).

Discussion

Understanding the psychosocial drivers behind non-compliance is paramount when implementing an approach for improving compliance behaviour. This study is the first study to provide insight into the drivers behind non-compliant behaviour in a recreational fishery in a developing country. It is also the first compliance model to incorporate angler motivation for fishing as a driver behind compliance behaviour. The instrumental approach often utilised and found relevant in developing was shown to be irrelevant in the context of a developing country. As recreational fisheries in developing countries are often characterised by poor governance, monitoring and enforcement and have a participant population strongly motivated to fulfill their nutritional needs (Sauer *et al.* in prep.), it was not surprising that the most influential variables on compliance behaviour all related to normative constructs. These included behavioural drivers from the VBN, TPB and

legitimacy models. Of the six variables tested, four were found to be significant in influencing behaviour. These four variables corresponded with values of legitimacy.

Anglers' perceptions of instrumental factors, such as detection and enforcement, did not play a significant role in influencing compliance behaviour. Like the rest of the developing world, poor compliance in the recreational fishery has been met with calls to increase levels of enforcement. However, based on these findings, this costly and difficult option may not be the best method for reducing non-compliance in developing nations, particularly in situations where recreational fisheries are not well recognised by governments and where there are limited resources for general fishery compliance. Ultimately, recreational fishery managers in the developing world should consider exploring alternative options for improving compliance.

The insignificance of rational choice variables included in the instrumental approach on the outcomes of compliance behaviour is not unique to the South African MBSF context. Thomas *et al.* (2016) found that the models of best fit for their structural equation models related to normative constructs from the VBN theory when assessing the drivers behind non-compliance with recreational fishing regulations in New Zealand. In fact, the three models of best fit did not include an instrumental component. Bergseth and Roscher (2018) identified variables from the TPB as being important in influencing compliance to fishery regulations around Australia's Great Barrier Reef. These variables related mainly to perceptions of perceived behavioural control contributing to an internal moral obligation to comply. However, the authors also identified traditional coercive deterrence approaches relating to instrumental theory as a possible influence on compliance behaviour. Nonetheless, questions surrounding the validity of the instrumental approach in improving fishery compliance date back to Sutinen and Gauvin (1989) who observed a generally high compliance rate even though enforcement was very low.

Until now, little has been done to inform fishery managers and researchers of the efficacy, or lack thereof, of the instrumental approach in South Africa. Instead, there has been a continued call for increased enforcement, more regulations and more influential penalties (Mann *et al.*, 2003; Pillay, 2004; Potts *et al.*, 2005; Hauck and Kroese, 2006; Dunlop and Mann, 2012; Sjöstedt and Sundström, 2015; Bova *et al.*, 2017). Globally, the command and control approach to fisheries management regimes can require a large share of available resources for improving compliance (Hatcher *et al.*, 2000). In a developing country such as South Africa, this approach could result in the inefficient allocation of these limited resources as they are not likely to generate a significant

reduction in non-compliance. On the other hand, since this study has demonstrated that the salient behavioural drivers behind non-compliance fall predominantly into the normative paradigm, it is necessary to employ a more holistic approach that aim to influence an individual's perceptions of legitimacy, social norms and intrinsic morality.

An individual's willingness to violate a regulation if there is guaranteed personal gain is said to be influenced by an internal moral obligation (Nielsen, 2003). This obligation is the construct of two factors, individual morals and norms as well as perceptions regarding the legitimacy of the regulatory body and regulations. In this study, this internal moral obligation had the most significant impact on individual non-compliance. Anglers that stated they would be unwilling to violate a regulation, even if they were guaranteed to benefit personally, were much less likely to engage in illegal activity. Tyler (1990) argued that this personally recognised obligation to comply is the most important element in relation to legitimacy and compliance and that the legitimacy of the actual regulation is less important. This was reinforced in this study, as regulation validity was not significant ($p = .064$). Thus, interventions that focus on shifting this personal obligation to comply may be useful in both developing and developed countries.

The VBN theory suggests that moral norms to comply can be influenced by interactions between cognitive, emotional and social factors (Stern *et al.*, 1999). An example of a cognitive precondition would be angler perceptions of the capacity of the regulatory institution. In this study, the perceived ability of recreational fishery managers to perform their duties was found to significantly influence angler behaviour. As angler perceptions of the management's performance moved from good to bad, their likelihood of non-compliance increased significantly. While there were no measures that could indicate emotional preconditions in this study, angler's attitudes towards rule breaking behaviour may provide insight into the social factor. Attitudes were generally negative towards non-compliant anglers (Chapter 3). However, as this negativity decreased, the angler became more likely to engage in rule-breaking behaviour.

Another potential insight into the social factor relates to social justice and the justification of rule breaking. Anglers who never found it justifiable to violate any of the regulations were significantly less likely to violate a regulation than those that felt that violations may sometimes be justified ($p < 0.01$). Like many developing countries, South Africa is characterised by relatively high levels of poverty (55.5%; STATSSA, 2017) and has a large coastal population that competes with recreational anglers for coastal resources, which they require in to meet basic nutritional needs

(Hauck and Sowman, 2001). It is conceivable that anglers who found any justification in rule-breaking behaviour may have considered these individuals' reliance on these resources. Furthermore, since Saayman *et al.* (2017) found that about 25% of recreational anglers earned less than R140 000 per annum (~USD 10 000), it is likely that many of the individuals who participated in this survey would require fish to meet their and their families' nutritional requirements. Nielsen (2003) suggested that a management system must be justified according to some moral principle and values. No matter how solid the legal foundation of the system, if it cannot be defended on the grounds of social justice, it is likely to be challenged. This is further supported by the significant role that motivations for participating in the MBSF play in influencing compliance behaviour. Interestingly, only 10% of participants stated that they went fishing for reasons other than recreation. However, the high apparent dependence on the resource to meet the nutritional needs of the families of many recreational anglers appears to have increased their likelihood of violating regulations. Unfortunately, the sample size and the nature of the research makes drawing comparisons between subsistence and recreational anglers difficult. Future research should aim to identify the differences in the behavioural drivers of subsitence anglers compared to recreational anglers.

By definition, recreational fishing is a leisure activity where the primary motivation for participation is not the consumption of fish for meeting basic nutritional requirements (Cooke and Cowx, 2004). However, in South Africa, as mentioned, this distinction has been blurred by the broad economic status of the participants (Saaymen *et al.*, 2017) and is likely to be similar in other developing countries. In addition, the introduction of the small-scale fishery policy, which no longer recognises the subsistence sector, has disenfranchised subsistence anglers and forced them to participate in the fishery as recreational anglers (Sowman *et al.*, 2014). Not only does this reduce general compliance in the recreational fishery, it is likely to shift the norms of compliance in favour of non-compliance and reduce the perceptions of legitimacy of the management authority. Ultimately, the recognition of a subsistence fishery with its own specific rules and regulations is necessary to improve compliance, shift the social norm and improve legitimacy of recreational and other regulations. Failure to acknowledge the circumstances of these anglers may lend to perceptions of unfairness, which relate to perceptions of illegitimacy and can negatively affect the internal obligation to adhere to the regulations (Jentoft, 2000).

Aside from factors relating to regulatory legitimacy, the severity of societal actions or informal sanctions that would be taken against a non-compliant angler held significant sway in the outcome

of compliance. Anglers who indicated they would enforce more severe social sanctions were less likely to engage in non-compliant activities than those who were more likely to do nothing. These sanctions included informal sanctions (e.g. verbally disapprove, physically intervene, etc.) to more formal sanctions (e.g. report to authorities). Becker (1963) defined "moral entrepreneurs" as individuals or groups who aim to influence other individuals to adopt or maintain a norm, often by publicising and problematising "wrongdoing". This is central to NAM, which suggests that individuals' internal obligations can be influenced by the activation of norms (Schwartz, 1977), i.e. the beliefs held by the moral entrepreneurs. Again, this variable could contribute to the moral obligations to comply with regulations that tie in with the TPB, legitimacy, NAM and VBN theory. The individual's perception of the moral norm reflects their need to enforce it and abide by it, resulting in a higher level of compliance. Guckian *et al.* (2018) identified the existence of a willingness in individuals to sanction their peers in catch and release recreational fisheries based on their personal environmental beliefs, which represents an opportunity to exploit this willingness to follow a norm in the context of compliance.

It should be noted that although the variables used in this model are a subset derived from various behavioural theories, they were not necessarily measured in the way that the initial theories may have intended. Additionally, certain variables from those theories were not tested as they were assumed irrelevant. The interactions between the variables measured in the original models may play a bigger role in determining actual behavioural outcomes. However, this model provides a framework which is more inclusive all relevant variables drawn from the various theories as they pertain to the fishery. Nonetheless, future studies may want to test the utility of this framework against existing models.

Conclusion

Designing a fisheries management strategy that reduces non-compliance requires effective measurement of non-compliant behaviours and the potential drivers behind these behaviours. These strategies may vary based on the social climate of the region being managed. Historically, the assumption was that perceptions of detection and enforcement of regulations held the most sway in influencing the compliance behaviour of individuals. The results of this study do not support this assumption and have rather identified normative factors to be more significant in influencing behaviour. In South Africa, the main drivers behind non-compliance relate to perceptions of legitimacy and an internal obligation to comply with the regulations. This internal obligation relates to morality and perceptions of the social norm. Unfortunately, the way these

traits manifest has resulted in a relatively high level of non-adherence to the regulations in the South African MBSF (~50%).

This study was the first of its kind to investigate a heterogenous group of potential behavioural drivers of non-compliance in a developing country's recreational fishery. The findings highlight the need for a shift in the approach used to improve the compliance behaviour of anglers. The final chapter will look at potential interventions for addressing these particular drivers of non-compliance.

Chapter 5: Holistic approaches for improving recreational fishery compliance in the developing world

"...if the legal system is useful in certain ways but deleterious in others, then this condition cries out for changes to increase its effectiveness while maintaining those aspects found to have desirable consequences."
– William J. Chambliss (1967)

Promoting compliance with fishery regulations

Globally, societies contain considerable structural variation in terms of morals, norms, beliefs, literacy and many other dynamic complexities (Nettle, 2009). As a result, a simple solution applicable to a localised societal defect is not likely to maintain its effectiveness in a global context. Therefore, a thorough understanding of the society of interest is imperative before any generally accepted approaches are applied. The compliance behaviour of anglers to fishery regulations is an example of the often case-specific nature of social science research. The measurement of levels of non-compliance requires an approach that the designated fishery of interest will be able to provide the requisite data for, whether through observation, records or survey data. Interventions to influence the levels of compliance within that population cannot be undertaken without first understanding the drivers behind non-compliance specific to that population (rather than drivers derived from theories based on other populations). The method of influencing these identified behavioural drivers, as a means of improving the assessed compliance levels, then relies on interventions that have been identified as contextual and applicable to that society.

Until now, the range of interventions for influencing compliance behaviour in recreational fisheries have been limited. As the potential for normative behavioural influence has only recently been realised in fisheries (Bova *et al.*, 2017; Bergseth and Roscher, 2018; Guckian *et al.*, 2018), these interventions have typically involved instrumental drivers, such as increased levels of enforcement and higher penalties for engaging in non-compliance (Kuperan and Sutinen, 1998; Viswanathan, 1999). This focus on the instrumental approach is rooted in theory surrounding outputs of statistical models that indicate that this approach is the most likely to influence the compliance behaviour of fishers (King and Sutinen, 2010). Normative interventions suggested for targeted behavioural drivers are based on a similar theory but involve the manipulation of societal norms and perceptions. It is difficult to gauge the success of either normative or instrumental

interventions in improving compliance behaviour as neither approach has been substantiated through validation. Considering interventions are case-specific, it is not recommended to apply either without first understanding the relevant drivers influencing compliance behaviour.

Instrumental intervention in developing world recreational fisheries

Suggested instrumental interventions, which are most frequently adopted by fishery managers (Keane *et al.*, 2008), disincentivise non-compliant behaviour by increasing the risk of associated costs to the non-compliant fisher. These interventions should be designed based on model outputs that show that compliance is most dependent on levels of detection by law enforcement, conviction rates and severity or existence of fines. Many studies have recommended increasing the levels of enforcement (Kuperan and Sutinen, 1998; Viswanathan, 1999; Mann *et al.*, 2003; Sutinen and Johnston, 2003; Potts *et al.*, 2005; Hauck, 2008; Arias *et al.*, 2016), although at times there have been calls for increased penalties (Sutinen and Gauvin, 1989; Viswanathan, 1999; Bergseth and Roscher, 2018). These types of formal interventions typically require significant amounts of resources to be effectively implemented (Hatcher *et al.*, 2000). Increasing enforcement requires additional staffing of dedicated law enforcement officials as well as significant increases in operational costs as a means of guaranteeing full coverage. Likewise, increasing penalties requires similar inputs with the addition of taxpayer money spent on litigation and potential increases in incarceration of non-compliant individuals. It has been found that the certainty of a penalty is more effective than the severity of a penalty (Grogger, 1991), indicating that the effectiveness of penalties relies on enforceability. Polinsky and Shavell (1992) suggest that optimal fines should equal "the harm, properly inflated for the chance of not being detected, plus the variable enforcement cost of imposing the fine". However, if penalties are established that seem unjustly high, perceptions of illegitimacy (which relate to normative constructs) may be fostered that may have the opposite effect on compliance behaviour (Keane *et al.*, 2008).

The application of instrumental approaches in the developing world is often not feasible. Characterised by large poverty classes and a relatively small tax base, these nations lack the financial capital to increase levels of enforcement (Chu *et al.*, 2000). The success of increasing the severity of penalties as a deterrent in these countries will likely be limited by the ineffectiveness of enforcement measures as well as the adequacy of judicial systems. In developing countries, the judiciary systems are often typified by corruption (Buscaglia, 1999) and are not capable of applying and enforcing laws, which are often not subject to predictable interpretation, in an equitable and efficient manner (Jiang, 2006). In addition to the drawbacks of increasing fines in these contexts,

fines in a recreational fishery may be difficult to establish due to the disparate income distribution within the fisheries (Saayman *et al.*, 2017). Fines high enough to deter the higher income earning groups of anglers may cause disdain and perceptions of illegitimacy in those with lower incomes for whom the penalties seem much more severe.

Normative intervention

At times, normative interventions on compliance behaviours can involve revisiting instrumental interventions that can lead to improved perceptions of legitimacy. Improving perceptions of legitimacy can influence an individual's moral obligations to comply (Levi, Sacks and Tyler, 2009). Other normative interventions can involve activation of personal and social norms (Stern *et al.*, 1999). As with instrumental interventions, these types of social interventions will only be successful if the behavioural drivers they are meant to address are found to significantly influence compliance. Influencing perceptions of legitimacy depends on whether it relates to the regulations themselves or the regulatory body. Regardless, improving legitimacy typically focusses on influencing societal perceptions of fairness and validity (Jentoft, 2000). Jentoft (2000) suggests that the most important approach for ensuring perceptions of procedural fairness and regulation legitimacy is through stakeholder participation in the management decision-making process. Perceptions of legitimacy are said to contribute to personal moral obligations to comply with regulations (Tyler, 1990). Personal norms, morals and beliefs are typically steered by societal norms. Influencing or activating these norms typically involves a social movement. This can take various forms, from protests to knowledge campaigns (Stern, Dietz and Black, 1985; Berkowitz, 2004).

Legitimacy

Levi, Sacks and Tyler (2009) posit that contributions towards individuals' trust in government and perceptions of the procedural fairness and validity of the regulations comprise an intrinsic, value-based legitimacy construct of normative theory. Improving perceptions of the regulatory legitimacy in fisheries therefore involves improving perceptions of the performance of the regulatory institution and allowing for societal inputs on the decision-making processes of this institution. The performance of regulatory institutions can relate to the confidence of citizens in government competence based on a demonstrated capacity to monitor and enforce regulations. In fisheries, this can relate to visible observations of enforcement by participants. While visible enforcement may relate to the instrumental approach to some extent in that it increases fear of

detection, Levi *et al.* (2009) suggest that it contributes to belief in the capability of fishery managers to carry out their prescribed duties.

Increasing perceptions of the enforcement of regulations is an approach that can either involve increased levels of enforcement, a costly measure, or increased visibility of enforcement. Increased visible enforcement relates to the manipulation of perceptions of enforcement based on observed enforcement. This can be done by making enforcement practices more transparent through the use of social media (Bertot, Jaeger and Grimes, 2010). Using social media to create transparency involves public displays of enforcement effort, which has the effect of increasing the visibility of enforcement in the public sphere. In addition to publicising enforcement on social media, social media can be used to identify non-compliance in fisheries (Mateescu *et al.*, 2015). Involvement in the regulatory process is crucial for improving perceptions of the fairness and validity of regulations (Nielsen, 2003). Fairness and validity correspond with the representation and outcome of the regulations and whether they are based on any scientific evidence. Angler participation in the regulatory decision-making process is said to encourage perceptions of legitimacy by ensuring that individuals receive fair representation, that outcomes of the regulation are equitable among various populations and that the regulations themselves are moral (Jentoft, 2000).

Developing countries have only recently begun to develop management strategies for recreational fisheries (Pitcher *et al.*, 2009). Generally, the impact recreational fisheries have on ecosystems and the economy are still poorly acknowledged by fishery managers (Arlinghaus and Cooke, 2009; Parker *et al.*, 2015). The structure of these management systems generally includes top-down regulatory measures with limited resources for monitoring or enforcement (van der Heijden, 2010). An inability to enforce the regulations can reflect negatively on perceptions of legitimacy of the fishery managers. Additionally, top-down approaches can alienate groups of people participating in the fishery (Arceo *et al.*, 2013). To prevent alienation, cooperative management strategies have been employed in developing countries, which can result in more equitably distributed regulatory outcomes and improved perceptions of legitimacy (Gezelius and Hauck, 2011).

Norm Activation

As perceptions of legitimacy comprise just one component of an individual's internal obligation to comply with regulations, it is important to identify methods of promoting a norm of compliance through the manipulation of the values, beliefs and norms of a society. Moral norms relate to injunctive norms, the behaviour that members of society deem acceptable. Theory surrounding

the activation of moral norms suggests that compliant behaviour occurs in response to personal moral norms about this behaviour and that these are activated in individuals that believe that non-compliant behaviour poses a threat to them, other people, the environment or the quality of the fishery (Schwartz, 1977). Becker (1968) referred to an individual that attempts to influence moral norms, particularly in their own self-interest, as moral entrepreneurs. In fisheries, the activation of moral norms typically manifests as an environmental movement promoting collective responsibility of sustaining the fishery for the future (Thomas, Milfont and Gavin, 2016). Thomas *et al.* (2016) suggest these movements can be started and promoted through "block leaders," knowledgeable and influential members of the fishing community.

The descriptive norm is the actual and perceived behavioural norm of compliance in the fishing community. The descriptive norm is said to compel individuals to follow, or in some cases disobey, the rules. Using descriptive norms to encourage compliance requires compliance from the majority of individuals in the fishery (Berkowitz, 2004). An individual's perceptions of the descriptive norm are said to steer their behaviour in the direction of that perceived norm (Cialdini, Reno and Kallgren, 1990). Therefore, misperceptions of the norm of compliance have the potential to steer an individual towards a false consensus effect (Perkins and Berkowitz, 1986). These often-present misperceptions of the descriptive norm, referred to as pluralistic ignorance (Berkowitz, 2004), can be targeted using the SNA. Targeted marketing campaigns are used to educate the public on the descriptive norms, thus closing the ignorance gap. A high level of pluralistic ignorance regarding recreational fisher compliance is not limited to the development status of a country (Bova *et al.*, 2017; Bergseth and Roscher, 2017), indicating that this strategy could be suitable in influencing the norm of compliance within fisheries.

Recommendations for improving compliance in the South African MBSF

This study has introduced a progressive method for measuring compliance levels, as well as a way to model data from compliance behaviour surveys, to determine what drives non-compliant behaviour in the South African MBSF. The combination of these techniques must be used (*i.o.*) to constructively adapt an intervention that can successfully improve compliance behaviour. The behavioural drivers identified as most influential in the previous chapter related predominately to moral norms and perceptions of legitimacy. Therefore, a holistic approach for improving compliance in the South African MBSF must specifically target these drivers. Shaping angler

perceptions of regulatory legitimacy is not a quick fix and the approach must be continually updated as moral and social norms change.

Angler perceptions of the legitimacy of the specific MBSF regulations did not play a significant role in their compliance behaviour (Chapter 3). There was a general consensus that the regulations were legitimate and that biologically based regulations were afforded the highest agreement of legitimacy. Instead, it is more important to address legitimacy in a way that improves the perceptions of fisheries management and the fairness of current management outcomes. There appeared to be a link between observed enforcement of the regulations and anglers' performance rating of fishery managers as they followed a similar trend where higher observed enforcement resulted in higher management performance ratings (Chapter 3). Observed enforcement, however, did not have a significant influence on violators while their perceptions of management's performance were highly significant. Observed enforcement of the regulations has been suggested to contribute to the performance ratings of a regulatory institution, which contributes to the overall perception of legitimacy (Levi, Sacks and Tyler, 2009). As licensing fees are required to participate in the South African MBSF, license holders may associate this lack visible operation as a misallocation of funds. Based on DAFF's budget reports, over the last five years, there has been no mention of the recreational fishery in the programme objectives associated with these funds (National Treasury, 2014; 2015; 2016; 2017; 2018). Whitehead *et al.* (2001) found that anglers only find paying licensing fees acceptable if the revenue generated from them is used to improve the quality of the fishery, which includes enforcing non-compliance. As there is a relationship between observed management (enforcement) and perceptions of legitimacy, increasing enforcement levels as in instrumental theory would seem like the most effective strategy. However, with limited resources to do so, the South African fishery managers may have to take an alternative approach to maintain an observable presence.

A less costly alternative to maintaining an observable presence may be to use social media platforms that reach large numbers of the angling population as a form of visible and transparent enforcement. Bertot *et al.* (2010) suggest using information and communication technologies to provide transparency that can lead to improved public perceptions of regulatory agencies. There are several popular ways this can be implemented, namely forums and social media pages relating to the South African MBSF. Some of these platforms reach nearly 50,000 members (e.g. Sealine.co.za; Salt Fishing South Africa). Often, there are "moral entrepreneurs" that share photos of observed non-compliance behaviour as a form of social enforcement on these forums. Shiffman

et al. (2017) found a similar phenomenon of angler behaviour being shared on social media. A social media presence by fishery managers that follows up on these "reported" violations may result in a significant increase in observable enforcement. Bergseth and Roscher (2018) recommended a similar approach, suggesting that behaviour can be influenced by this perceived threat of increased enforcement as anglers do not know the actual risk of detection. Additionally, these forums are a good place to provide transparency to the broader fishing community on how the license fees are being used. These social media communications can be handled by the employment of one full-time social media liaison as opposed to the countless number of enforcement officers required to physically increase enforcement. In addition, this liaison could be used to keep anglers up to date on changing regulation specifics. This increased visibility and transparency of enforcement may lead to improved perceptions of the performance of the fisheries management agency (Levi *et al.*, 2009; Chapter 3), which may in turn lead to improved compliance. However, it should be noted that of the total South African population only 30% are active on social media (Goldstuck, 2018) and that this type of intervention may only address a subgroup of the overall fishing population.

The internal moral obligation of anglers to comply must also be addressed. If the process of establishing regulations is not transparent and inclusive, there is likely to be conflict (Levi *et al.* 2009). Additionally, if the distributional effect of the outcome of these regulations neglects a certain population that is involved in the fishery, there is likely to be little moral obligation for them to comply (Nielsen, 2003). The procedure for establishing regulations in the linefisheries of South Africa follows a protocol of regulations proposed and convened by an established group of academics and fishery managers, known as the linefish scientific working group (LFWG). The recommendations made by this group are assessed and modified by fishery managers before draft policies are published in government gazettes for a period of public comment. However, few modifications (if any) have been made to existing recreational fishery regulations since the promulgation of the LFWG. In 2000, a state of emergency in the linefish sector was declared by the Minister of Environmental Affairs and Tourism using a provision in the Marine Living Resources Act (Parker *et al.*, 2015). This provision afforded the minister extraordinary powers to impose regulations on the fishery, eliminating the transparency of the development of regulations. Public comment on proposed regulations has been closed ever since (Parker *et al.*, 2015). Instead, proposed regulations are "forced" through to legal instruments at the discretion of the minister. This lack of a transparent process could be seen as exclusionary by fishery participants which may influence their perceptions of legitimacy of the regulatory process.

Since 2002, the management strategy of DAFF has been based on the Ecosystem Approach to Fisheries (EAF) (Shannon, Jarre and Petersen, 2010). One of the criteria for the successful implementation of the EAF is the incorporation of structures to facilitate a co-management process with relevant stakeholders (Cochrane *et al.*, 2004). For the recreational MBSF, this resulted in the inclusion of a representative from this fishery in a Recreational Fisheries Forum, which aimed to act as a conduit for communication between the management authority and recreational anglers. However, this forum is now defunct, with the final meeting held in 2016, giving recreational anglers the distinct impression that the forum was merely created as a box-ticking exercise of policy guidelines. Public comment on potential regulatory changes should be re-opened and regular engagement with fishery stakeholders should be undertaken before additional regulations are established, to clarify the moral and fact-based legitimacy perceptions of participants. Providing transparency of the establishment of regulations is a must to ensure perceptions of their legitimacy (Levi, Sacks and Tyler, 2009).

If the regulations are not socially or morally just, they are likely to be challenged. Hauck (2008) recommends that fishery managers and researchers must address social justice by questioning the validity of certain regulations and whose interests they serve. The policy for small-scale fishing in South Africa may have eliminated the term "subsistence" and incorporated it into the term "small-scale", but the policy did little to incorporate nutritional needs of subsistence anglers. This has forced subsistence anglers to fish informally as recreational anglers, beholden to the same rules as those fishing as a recreational activity. Many anglers who perceived it to be "sometimes justified" to violate a regulation (Chapter 3) likely considered the population of individuals that rely on the fishery resources for survival. The lack of representation for subsistence anglers in the current fisheries management strategy is a significant oversight and reflects heavily on the perceived validity of the management institution. Furthermore, it can impact the levels of compliance in the recreational fishery in various ways. Anglers in the recreational MBSF identified as informal anglers (fishing for food) were significantly more likely to engage in non-compliant behaviour. Aside from the impact of the compliance of these anglers on the overall compliance level, their actions, observed by others, may skew perceptions of the compliance norm existing in the fishery. As seen in Chapter 3, angler perceptions of the levels of non-compliance existing in the fishery were much higher than the actual norm of compliance. This could be due to informal anglers being observed in open, and perhaps frequent, violation of the regulations. This warped view of the norm,

according to the SNA, could be steering individuals towards a norm of non-compliance (Bova *et al.*, 2017).

In order to implement a management strategy that can simultaneously address the long-term sustainability of inshore resources and the human rights issues of sustaining livelihoods and food security, managers should consult with subsistence anglers, currently identified as recreational anglers, on a framework that can address their needs alongside management goals. This community engagement is key to influencing perceptions of procedural fairness, and it can contribute to a more inclusive regulatory outcome (Tyler, 1990). This should contribute significantly to the legitimacy component of an individual's internal obligation towards compliance.

Addressing moral and social norms may require a slightly different approach, which can be done concurrently through methods of norm activation. Based on the results of stated actions participants said they would take against non-compliant anglers (Chapter 3), some anglers engage in "moral entrepreneurship" and attempt to influence the norm towards a standard of compliant behaviour by stating their disapproval of the action. Influencing the morals and norms of the fishery may rely on encouraging more moral entrepreneurship through the activation of norms. These moral entrepreneurs could be the "block leaders" of a social movement towards compliance, as suggested by Thomas *et al.* (2016). Personal norms are also influenced by perceptions of the norm. Chapter 3 showed there was a "pluralistic ignorance" between the actions that individuals expected other anglers to take versus that actions that anglers stated they would actually take against non-compliant anglers as well as the number of perceived violators versus actual violators. The implementation of Berkowitz's (2004) SNA, which aims to correct this ignorance through targeted marketing, could help encourage individuals to gravitate towards the actual moral norm and engage in "block leadership". This marketing could be presented in the form of informational posters that use environmental psychology to steer the perceptions and attitudes of individuals towards the norm or the agenda of a moral entrepreneur or block leader, thereby encouraging more compliant behaviour (e.g. Figure 5.1). The rationale behind this poster is that it effectively informs the angling community what others perceive is the "right" thing to do (also known as the injunctive norm) with regards to keeping within bag limits. Since the information presented states that there is an overwhelming percentage of individuals that feel this way, the SNA suggests that individuals will adjust their behaviour to adhere to this norm (Berkowitz, 2004). The additional inclusion of the percentage of individuals that would take an action as severe as reporting other anglers for violating this regulation helps to close the gap between what anglers think others will

do and what they will actually do, thereby encouraging them to increase their level of moral entrepreneurship. The degree to which anglers sanction other anglers depends largely on whether those anglers believe that compliance can be improved through sanctioning (Guckian *et al.*, 2018).

Figure 5.1: Example of a potential poster that can influence the moral norm of compliance in recreational fisheries using Berkowitz's (2004) social norms approach (SNA).

Improving compliance in South Africa's MBSF, will require fishery managers to dedicate resources towards improving perceptions of their legitimacy rather than using the traditional instrumental paradigm. As suggested by Tyler (1990), improving legitimacy perceptions can be done through more transparent procedures for setting management strategies that include engagement with the potentially affected anglers. This transparency can also help ensure that the needs of all affected individuals are appropriately considered and the outcome of the regulation does not exclude any of these needs, ensuring that the regulations are morally justified. Perceptions of the legitimacy of the regulatory body are also influenced by their observed presence. As there has been a dramatic increase in the user populations of social media platforms, fishery managers should increase their observable presence by engaging with anglers on these platforms. This is especially true on social media platforms where "moral entrepreneurs" readily engage in attempting to influence compliance norms by exposing non-compliant individuals. As the South African MBSF is a potential candidate for the activation of social norms through the SNA (Chapter 3, Bova *et al.*, 2017), a marketing campaign could be used as part of a social movement to improve the norms of compliance.

Adapting compliance research to diverse global social dynamics

The level of non-compliance in a fishery context refers to the adherence of participants to the fishery-specific regulations. Many theories have been developed for the practical estimation of non-compliance in fisheries (Sutinen, Rieser and Gauvin, 1990; Gavin, Solomon and Blank, 2010; Boonstra, Birnbaum and Björkvik, 2017; Chapter 2). However, the accuracy and feasibility of such methods may rely heavily on the context in which they have been or will be applied. In fishing areas with regular observation by law enforcement, law enforcement records may provide a good indication of the compliance levels of participants at that location (Hilborn *et al.*, 2006). Law enforcement levels are typically higher in developed countries where more access to resources are generally available (Gramckow *et al.*, 2016). Conversely, the lack of required capital in developing countries may limit the feasibility of using law enforcement records. For larger scale compliance studies or studies that do not have an effective or consistent law enforcement presence, this method is unlikely to provide valid results. Alternative options include relying on previous assessments of compliance behaviour to model for estimations of current levels of compliance. Again, access to these data can be scarce in developing countries or even in developed countries, depending on the fishery (Ogden, 2008).

In the absence of existing data, surveys can be used for estimating compliance. However, the type of method for applying surveys may be case-specific. Administration of surveys over the phone or online may only target small subgroups of a population, as seen in Chapter 3. Face-to-face surveys had been considered to provide reasonable estimates of compliance levels, until the effects of SDB were found to influence the accuracy of these responses. Consequently, methods for reducing this bias were applied to fishery compliance surveys based on novel methods used in other sensitive behaviour studies (Schill and Kline, 1995; St. John *et al.*, 2010; Chapter 2). While these methods may have provided a representation of the fishery in which they were initially used, they may not be applicable in all fishery scenarios. For instance, in Chapter 2, it was found that the randomised response technique (RRT), which is heavily used in compliance research in fisheries, failed to hold up to ground-truthing observations. This may have been because it had never been appropriately validated. Alternatively, there may have been significant variations in the social composition of the participants in comparison to the initial fishery in which the RRT was applied. This conclusion can be drawn from the fact that many participants had difficulty understanding the complex instructions of the RRT and its ability to provide anonymity, resulting in a distrust of the method. Future studies should consider the ability of their participants to understand complex concepts surrounding their method of estimation. In the South African MBSF, low-literacy rates and a distrust in the RRT resulted in the development of an approach that provided an identity concealment method in which the population was more familiar with. This method should also be suitable for other developing countries, particularly those with a practicing democracy.

The methods used for compliance research depend on the overall goal of the research as well as the context for which it is set. In this study, the South African MBSF required a measurement of the levels of non-compliance, as previous measures were outdated, and an understanding of what drives non-compliant behaviour in order to implement the best approach for improving compliance. An inability to adapt pre-existing compliance research methods to the South African MBSF demanded that new approaches be attempted. This is something that future compliance researchers in fisheries should consider before following a framework from a context that differs, even slightly, from the conditions of the fishery of interest.

Conclusion

This thesis has presented an approach for assessing and improving compliance behaviour in a developing country, and while this appeared suitable for the South African MBSF, it is unlikely that this approach, or any other approach, will be applicable to all fishery contexts. The dynamics and

complexities existing in every fishery will ultimately dictate the methods required for a valid assessment of angler compliance behaviour and the best methods for addressing non-compliance. Research that aims to improve compliance must first obtain valid estimates of non-compliance levels existent in that fishery and the potential motivations, of which there could be many, behind non-compliant behaviour. The BBM, which was introduced and used in this study, provided the most accurate estimates of the levels of non-compliance with regulations and could be of great use to future compliance research.

Improving compliance behaviour required an understanding of behavioural drivers and involved the use of a model that determined the relevance of behavioural drivers. The model used here was based on pre-existing hybrid (normative and instrumental) models and frameworks. These types of models are becoming more pervasive in the social sciences (Cohen, West and Aiken, 1984). The outputs of the model do not align exactly with traditional economic theory but give due consideration to the normative influences that effect angler behaviour. Any compliance study aiming to influence behaviour must ensure that both instrumental and normative paradigms are included if these studies are expected to have an effective impact on understanding and potentially improving fishery compliance.

Interventions, including those suggested in this study, which aim to influence compliance behaviour have yet to be assessed for their impacts. Although suggestions for normative-based interventions exist, there is a lack of evidence supporting their efficacy. Now that compliance behaviour has been assessed for the South African MBSF and now that it is generally understood that normative approaches towards improving compliance behaviour are likely to be the most effective, the suggested approaches can be implemented and their impacts can be assessed by future studies.

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Appendix

i. Questionnaire for pilot study on possible social actions taken against non-compliant anglers.

Actions against illegal fishing

If people are violating fishing regulations what actions would be taken against them?

1. **What action do you think anglers would take against someone who fishes without a permit?**

2. **What action do you think anglers would take against someone that keeps undersized fish?**

3. **What action to you think anglers would take against someone that keeps more than their bag limit or a prohibited species?**

ii. Consolidated and omitted responses from open-ended pilot study asking anglers what actions they would take against non-compliant anglers.

Do Nothing	Verbally Disapprove	Threaten to take action	Report them to others	Report them to authorities	Phyically intervene	Omitted and uncategorisable responses
Nothing	tell them to get one	tell them they had better get one or they gonna be sorry	take a picture and post it online	report them	bliksem them	Accidentally cast an 8 oz sinker at them
shake my head and do nothing	Tell them to get one	threaten to tell daff	report them to DAFF and post pictures online	call the parks board	slap them	buy their catch
Nothing	tell them its not cool	threaten to report them if they dont put it back	Name and shame	report them	steal their gear when they arent looking	Phone up some friends and deal with them
Nothing	Tell them to go to the post office like everyone else	tell them they better put it back	report them on social media	report them	throw them and the fish in the water	give them a dirty look
not much	talk to them bout it	tell them to put it back or ill report them	share a post on FB	report them	confiscate their gear	buy it from them
Nothing	shout at them	threaten them to put it back	report them to DAFF and post pictures online	call the parks board	punch them in the head	depends how many
Nada	Tell them put it back	tell them to put it back or they are in trouble	take a picture and report them to fishing group	call the police	cut their lines and throw the fish back	how would they know?
Not a thing	tell them to put it back		record them	report them to DAFF and post pictures online	bliksem them	give them a high five
Nothing	tell them they better put it back			tell daff	Take their fish and throw it back	How can you tell?
Nothing	say something and get stabbed			report them	throw them back	dont know
Nothing	tel them why its bad for the fishery			call the authorities	break their gear	They probably don't have one either
Nothing	yell at them to put it back			report them	throw it back for them	complain about it
complain to their friends	tell them to stop			call the parks board	bliksem them	complain about it
Nothing	hopefully say something			call DAFF		
Nothing	Tell them to put it back			report them to DAFF and post pictures online		
Nothing	Tell them to throw it back			report it		
cant do anything	tell them its not on			report them		
theyll do nothing				Phone law enforcement		
do nothing				tell daff		
Nothing						
Nothing						
Nothing						
Nothing						
Nothing						
Nothing						
Nothing						
Nothing complain and do nothing						
not a thing						
cant do anything						
theyll do nothing						
do nothing						
Nothing						
Nothing get mad but do nothing						
Nothing						
Nothing						
Nothing						
Nithing						
not a thing						
cant do anything						
Nothing						
do nothing						
Nothing						

iii. Questionnaire for ranking the responses consolidated from the open-ended pilot study asking what actions an angler would take against a non-compliant angler.

Normative Actions Against Non-Compliant Anglers

1. **Please rank the actions that someone would take against another angler for violating a fishing regulation from what you feel to be not severe or harsh to what you feel is most severe or harsh.**
Mark only one oval per row.

	Not Severe at all (0)	1	2	4 (severe)	5	6	7 (most Severe)
Do Nothing	◯	◯	◯	◯	◯	◯	◯
Tell them you do not approve	◯	◯	◯	◯	◯	◯	◯
Threaten to take action against them	◯	◯	◯	◯	◯	◯	◯
Stop Associating with them	◯	◯	◯	◯	◯	◯	◯
Report Their actions to others	◯	◯	◯	◯	◯	◯	◯
Report them to authorities	◯	◯	◯	◯	◯	◯	◯
Physically Intervene by cutting their lines or confiscating their gear/catch	◯	◯	◯	◯	◯	◯	◯

iv. Results of ranked severity of consolidated actions against non-compliant angler (n = 83).

Action	Do Nothing	Verbally Disapprove	Threaten Action	Report them to others	Report them to authorities	Physically Intervene
Mean Severity Rank	0	0.976	2.329	3.963	5.207	6.732

v. Questionnaire for assessing the behavioural drivers behind non-compliance.

Shore Angler Questionnaire

Department of Ichthyology and Fisheries Science

RHODES UNIVERSITY
Where leaders learn

Consent

The purpose of this research project is to identify various factors involved in the compliance of recreational fisheries regulations. 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 participate in recreational angling.

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. Your responses will be confidential and we do not collect any information that can be used to identify you personally.

Your privacy is important and all data are kept confidential. To help protect your confidentiality, the surveys will not contain information that will personally identify you. The results of this study will be used for scholarly purposes only. This research is not affiliated with any law enforcement agency and this information will not be used in any way that could cause harm to you.

If you have any questions about the research study, please contact Christopher Bova (csbova@gmail.com). This research has been reviewed according to Rhodes University ethics procedures for research involving human subjects.

Choosing the "agree" box below indicates that:

- you have ready the above information
- you voluntarily agree to participate
- you are at least 18 years of age

1. I _____ **with the conditions provided above**
   Mark only one oval.
   - ◯ Agree
   - ◯ Disagree

2. **CONTROL #**

3. **Fishing Location**
name of site/beach

4. **Is fishing the main reason for visiting this location?**
Mark only one oval.

- ◯ yes
- ◯ no

5. **what is you MAIN reason for fishing?**
Check all that apply.

- ☐ Sport/Competition
- ☐ Socializing with friends
- ☐ To sell fish to supplement livelihood
- ☐ To feed family
- ☐ To get out of the house
- ☐ Other: _____

6. **How many times do you go rock and surf fishing per year?**
estimate if unsure

7. **Which angling magazines to you read?**
check all that apply
Check all that apply.

- ☐ I don't read angling magazines
- ☐ Rock Surf and Deep
- ☐ Go Fish
- ☐ Fishing SA
- ☐ SA Baars-Bass
- ☐ INWATER
- ☐ Anglers Talk
- ☐ The Bank Angler - Die Oewerhengelaar
- ☐ The Fishing and Hunting Journal
- ☐ Tight Lines
- ☐ Other: _____

Proceed to Ballot Questions

Hand angler the questionnaire, ask them to fill it out truthfully and place it in the box, assuring them that nobody will know their answers as there is no identifying information on the ballot.

8. **Fished without license**
Mark only one oval.

- Yes
- No

9. **Kept Undersized**
Mark only one oval.

- Yes
- No

10. **Exceed Bag Limit**
Mark only one oval.

- Yes
- No

11. **Kept during Closed Season**
Mark only one oval.

- Yes
- No

12. **Fished in MPA**
Mark only one oval.

- Yes
- No

13. **Sold Fish**
Mark only one oval.

- Yes
- No

14. **Prohibited Bait/Tackle**
Mark only one oval.

- Yes
- No

Knowledge of regulations

True or False

15. **You can keep Shad "Elf"/Galjoen all year around**
Mark only one oval.

- true
- false
- don't know

16. **You may only keep a maximum of 10 fish per day**
Mark only one oval.

- true
- false
- don't know

17. **It is okay to catch and keep any species of fish while shore angling**
Mark only one oval.

- true
- false
- don't know

18. **You may not sell your catch**
Mark only one oval.

- true
- false
- don't know

19. **It is okay to catch a great white shark, as long as it is released**
Mark only one oval.

- true
- false
- don't know

20. **Some species of fish must be a certain size to be kept**
Mark only one oval.

- true
- false
- don't know

21. **Fishing permits must be renewed annually**
Mark only one oval.

- true
- false
- don't know

22. **You may only use up to 15 hooks on a line at a time**
Mark only one oval.

- true
- false
- don't know

Compliance

23. **Choose the response that best applies to your view of recreational fishery law enforcement**

Mark only one oval per row.

	Never	Rarely	Sometimes	Frequently	Every Time
I have seen recreational fisheries laws being enforced	◯	◯	◯	◯	◯

24. **Please indicate which actions you believe others would take against you for breaking the following fishing regulations?**

Your choices are to DO NOTHING, TELL YOU THEY DO NOT APPROVE, THREATEN TO TAKE ACTION AGAINST YOU, STOP ASSOCIATING WITH YOU, REPORT YOUR ACTIONS TO OTHERS, REPORT YOUR ACTIONS TO AUTHORITIES, PHYSICALLY INTERVENE BY CONFISCATING YOUR CATCH/GEAR.

Mark only one oval per row.

	Physically intervene by confiscating catch/gear or cutting lines	Report YOU to authorities	Report YOUR actions to others	Stop Associating with YOU	Threaten to take action against YOU	Tell YOU they do not approve	Do Nothing
Fishing without a license	◯	◯	◯	◯	◯	◯	◯
Keeping undersized fish	◯	◯	◯	◯	◯	◯	◯
Exceeding your bag limit	◯	◯	◯	◯	◯	◯	◯
Fishing in closed areas	◯	◯	◯	◯	◯	◯	◯
Keeping a fish that is prohibited, including during its closed season	◯	◯	◯	◯	◯	◯	◯
Selling your catch	◯	◯	◯	◯	◯	◯	◯
Using prohibited bait and/or tackle	◯	◯	◯	◯	◯	◯	◯

25. **Please indicate which actions you believe other SHOULD take against another angler for breaking the following fishing regulations?**

Your choices are to DO NOTHING, TELL YOU THEY DO NOT APPROVE, THREATEN TO TAKE ACTION AGAINST YOU, STOP ASSOCIATING WITH YOU, REPORT YOUR ACTIONS TO OTHERS, REPORT YOUR ACTIONS TO AUTHORITIES, PHYSICALLY INTERVENE BY CONFISCATING YOUR CATCH/GEAR.

Mark only one oval per row.

	Physically intervene by confiscating catch/gear or cutting lines	Report them to authorities	Report their actions to others	Stop Associating with them	Threaten to take action against them	Tell them they do not approve	Do Nothing
Fishing without a license	◯	◯	◯	◯	◯	◯	◯
Keeping undersized fish	◯	◯	◯	◯	◯	◯	◯
Exceeding your bag limit	◯	◯	◯	◯	◯	◯	◯
Fishing in closed areas	◯	◯	◯	◯	◯	◯	◯
Keeping a fish that is prohibited, including during its closed season	◯	◯	◯	◯	◯	◯	◯
Selling your catch	◯	◯	◯	◯	◯	◯	◯
Using prohibited bait and/or tackle	◯	◯	◯	◯	◯	◯	◯

Compliance drivers

Please Clarify whether you STRONGLY DISAGREE, DISAGREE, SLIGHTLY DISAGREE, NEITHER AGREE OR DISAGREE (50/50), SLIGHTLY AGREE, AGREE, STRONGLY AGREE with the following regulations

26. **Please clarify whether you STRONGLY DISAGREE, DISAGREE, SLIGHTLY DISAGREE, 50/50 AGREE AND DISAGREE, SLIGHTLY AGREE, AGREE OR STRONGLY AGREE that the following fishing regulations are necessary measures in order to sustainably maintain the recreational fishery**

Mark only one oval per row.

	Strongly Disagree	Disagree	Neither agree or Disagree	Agree	Strongly Agree
Fishing License Requirement	◯	◯	◯	◯	◯
Releasing Undersized Fish	◯	◯	◯	◯	◯
Closed Seasons	◯	◯	◯	◯	◯
Bag Limits	◯	◯	◯	◯	◯
Selling Fish	◯	◯	◯	◯	◯
Closed Areas	◯	◯	◯	◯	◯
Prohibited Species	◯	◯	◯	◯	◯
Bait and Tackle restrictions	◯	◯	◯	◯	◯

27. **Please clarify whether you STRONGLY DISAGREE, DISAGREE, 50/50, AGREE, STRONGLY AGREE or DON'T KNOW that the penalties for the following actions are severe?**
Mark only one oval per row.

	Strongly Disagree	Disagree	Neither agree or Disagree	Agree	Strongly Agree	DON'T KNOW
Fishing without a LICENSE						
Keeping UNDERSIZED fish						
Exceeding you BAG LIMIT						
Fishing in a CLOSED AREA						
Keeping a fish that is prohibited, including during a closed season						
SELLING fish						
Using PROHIBITED BAIT and Tackle						

28. **How good or poorly do you believe of a job do you believe DAFF is doing at managing the fishery?**
Mark only one oval.

	1	2	3	4	5	
Very Poor						Very Good

29. **Do you agree that it is sometimes justified to violate a fishing regulation?**
Mark only one oval.

	0	1	2	3	4	
Strongly Disagree						Strongly Agree

30. **Please indicate whether your chances of being caught for the following regulations are: VERY LOW, LOW, 50/50, HIGH or VERY HIGH**
Mark only one oval per row.

	Very Low	Low	Not high or low	High	Very high
Fishing without a license					
Keeping undersized fish					
Exceeding your bag limit					
Fishing in a closed area					
Keeping a fish that is prohibited, including during a closed season					
Selling fish					
Using prohibited bait or tackle					

31. **Please indicate whether you feel it is TOTALLY UNACCEPTABLE, UNACCEPTABLE, 50/50, ACCEPTABLE or TOTALLY ACCEPTABLE for an angler to violate the following regulations.**

Mark only one oval per row.

	Totally Unacceptable	Unacceptable	Neither Acceptable or Unacceptable	Acceptable	Totally Acceptable
Fishing without licenses					
Keeping undersized fish					
Exceeding your bag limit					
Fishing in a closed area					
Keeping a fish that is prohibited, including during a closed season					
Selling fish					
Using prohibited bait or tackle					

32. *Mark only one oval per row.*

	Highly Likely	Likely	Neither Likely or Unlikely	Unlikely	Highly Unlikely
How likely would you be to commit a violation if the benefits from doing so outweighed the potential penalties?					

33. **If 100 fisherman were checked for a license, how many would not have one?**

34. **If 100 people fish without a license, how many do you think will get caught by law enforcement?**

35. **If 100 people were able to catch undersized fish, how many would keep them?**

36. **If 100 people keep undersized fish, how many do you think will get caught by law enforcement?**

37. **If 100 people caught a prohibited species, including fish that are only prohibited during certain seasons, how many do you think will keep the fish?**

38. **If 100 people keep a prohibited species, including fish that are only prohibited during certain seasons, how many do you think will be caught by law enforcement?**

39. **For each regulation, indicate which actions you would take against someone who violates them**

Mark only one oval per row.

	Do Nothing	Tell them you do not approve	Threaten to take action against them	Stop associating with them	Report actions to others	Report them to authorities	Physically intervene by confiscating their gear/catch
Fishing without a License							
Keeping undersized fish							
Exceeding bag limit							
Fishing in closed area							
Keeping a fish that is prohibited, including during a closed season							
Selling fish							
Using prohibited bait or tackle							

40. **Have you ever been caught breaking a regulation by law enforcement?**

Mark only one oval.

- Yes
- No
- prefer not to answer

41. **If Yes, which one(s)?**

Check all that apply.

- Licenses
- Undersized fish
- Bag limits
- Closed Areas
- Closed Season
- Prohibited species
- Selling fish
- Prohibited bait or tackle

Demographic Information

42. **Nationality**

what citizenship do you claim

43. **In which city/town do you reside?**

44. **Which Fishing Clubs do you belong to?**
Eg. RASSPL, SASAA
Mark only one oval.

- I Don't belong to a fishing club
- Other: _____

45. **Race**
Mark only one oval.

- Black (African)
- Coloured
- Indian
- White
- Other: _____

46. **Gender**
Mark only one oval.

- Male
- Female
- Other: _____

47. **Age**
round to nearest year

48. **Employment Status**
Mark only one oval.

- Employed
- Unemployed and looking for work
- Unemployed and not looking for work
- Retired
- Student
- Other: _____

49. **What is the highest level of education you have completed?**
Mark only one oval.

- Pre-matric
- Matric
- Tertiary
- Postgraduate
- Other: _____

50. **What is your personal monthly income?**
Mark only one oval.

- 0 - 4999
- 5000 - 9999
- 10000 - 24999
- 25000 or more

51. **What is your personal monthly income?**
Mark only one oval.

- 0 - 499
- 500 - 9999
- 1000 - 2499
- 2500 - 4999
- 5000 - 9999
- 10000 or more

52. **Have you taken this questionnaire before?**
Mark only one oval.

- Yes
- No

53. **If Yes, When?**
Mark only one oval.

- Less than a year ago
- Over a year ago

54. **Comments**
Note the Comments throught and the section which they are in.

vi. Form used for estimating the overall levels of non-compliance.

Anonymous Fisherman Survey

The answers are this form are completely anonymous and can't be used in any way to identify you or your actions. Please answer the following questions as honestly and accurately as possible.

1. **In the last 12 months, have you rock and surf fished without a valid fishing permit?**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

2. **In the last 12 months, have you kept any fish that were under the minimum size limit?**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

3. **In the last 12 months, did you exceed any bag limits?**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

4. **In the last 12 months, did you fish in a closed area? (Area where no fishing is allowed)**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

5. **In the last twelve months, did you keep any species that were prohibited, including certain species during their closed seasons?**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

6. **In the last 12 months, did you sell any of the fish you caught?**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

7. **In the last 12 months, did you use any prohibited bait or tackle?**
   (Including undersized fish)
   Mark only one oval.
   - ◯ Yes
   - ◯ No

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vii. Form used for validation of ballot box method (BBM).

Anonymous Fisherman Survey

The answers are this form are completely anonymous and can't be used in any way to identify you or your actions.

1. **Are you a subsistence fisherman or a recreational fisherman?**
   Mark only one oval.
   - ◯ Recreational
   - ◯ Subsistence

2. *Mark only one oval.*
   - ◯ Yes
   - ◯ No

3. *Mark only one oval.*
   - ◯ Yes
   - ◯ No

4. *Mark only one oval.*
   - ◯ Yes
   - ◯ No

5. *Mark only one oval.*
   - ◯ Yes
   - ◯ No

6. *Mark only one oval.*
   - ◯ Yes
   - ◯ No

7. *Mark only one oval.*
   - ◯ Yes
   - ◯ No

8. *Mark only one oval.*
   - ◯ Yes
   - ◯ No

viii. Survey for the validation of the direct questioning method (DQM).

Face to Face survey

Please respond to the reviewer with a "Yes" or a "No" with regard to the questions they ask. Please answer honestly

1. **Did you keep exceed your bag limit during todays fishing trip?**
   What did you see in the bag?
   Mark only one oval.
   - ◯ Yes
   - ◯ No

2. **Did you sell any of the fish you caught today?**
   If "Yes" ask which species.
   Mark only one oval.
   - ◯ Yes
   - ◯ No

3. **Did you fish without a permit today?**
   Ask to see their permit if they respond "No"
   Mark only one oval.
   - ◯ Yes
   - ◯ No

4. **Did you fish in a closed area during todays fishing trip?**
   What did you see in the bag?
   Mark only one oval.
   - ◯ Yes
   - ◯ No

5. **Did you keep any undersized fish during todays fishing trip?**
   Ask to see their catch if they respond "no". At this time also check and note the species and the amount of fish if possible.
   Mark only one oval.
   - ◯ Yes
   - ◯ No

6. **Did you keep any fish species that are currently prohibited to keep during todays trip?**
   (includes closed season species) What did you see in the bag?
   Mark only one oval.
   - ◯ Yes
   - ◯ No

7. **Did you use any illegal baiting methods while fishing today?**
   Ask what bait they used.
   Mark only one oval.
   - ◯ Yes
   - ◯ No

ix. Survey for the validation of random response technique.

RRT survey

Flip a coin. If the answer is heads, the participant must answer truthfully. If Tails they must just reply with a "Yes".

1. **Did you keep exceed your bag limit during todays fishing trip?**
   If HEADS answer TRUTHFULLY. If TAILS answer "Yes".
   Mark only one oval.
   - Yes
   - No

2. **Did you sell any of the fish you caught?**
   If HEADS answer TRUTHFULLY. If TAILS answer "Yes".
   Mark only one oval.
   - Yes
   - No

3. **Did you fish without a permit today?**
   If HEADS answer TRUTHFULLY. If TAILS answer "Yes".
   Mark only one oval.
   - Yes
   - No

4. **Did you fish in a closed area during todays fishing trip?**
   If HEADS answer TRUTHFULLY. If TAILS answer "Yes".
   Mark only one oval.
   - Yes
   - No

5. **Did you keep any undersized fish during todays fishing trip?**
   If HEADS answer TRUTHFULLY. If TAILS answer "Yes".
   Mark only one oval.
   - Yes
   - No

6. **Did you keep any fish species that are currently prohibited to keep during todays trip?**
   If HEADS answer TRUTHFULLY. If TAILS answer "Yes".
   Mark only one oval.
   - Yes
   - No

7. **Did you use any illegal baiting methods while fishing today?**
   If HEADS answer TRUTHFULLY. If TAILS answer "Yes".
   Mark only one oval.
   - Yes
   - No

x. Script for ballot box method (BBM).

Hello, my name is _____ . I'm a researcher from Rhodes University conducting a study on recreational anglers. The research involves questions about your angling behaviour and can include questions that may be sensitive. This study, including myself have no affiliation to any law enforcement and any responses you give are completely anonymous and will not be shared with anyone or used against you in any way. In addition, we will be using a secret ballot and a locked ballot box to improve the anonymity of your responses. If you agree to participate, there is also an opportunity to win a cash prize, a fishing reel or a new rod based on a lucky draw competition. Do you agree to participate? – If "yes", explain the BBM procedure.

"Yes" – I have here a sheet of paper that will be your ballot for answering questions on. As you can see, there are no questions written on the ballot, just questions numbers and check boxes that have a "yes" or a "no" next to them. I am going to ask you to fill out this ballot by responding either "yes" or "no" to each of the questions I will read aloud to you. I will have no idea what your responses are and I do not want you to tell me. This provides you with further protection against any possible detriment. After you complete the ballot, please fold the sheet in half and place it in the locked box. I do not have the key to this box and will not be able to know what your specific answers were. Please answer as honestly as possible. Again, I have no affiliation to law enforcement and your responses will remain completely anonymous and not used in any way against you. You may skip any questions you do not want to answer. Do you understand the instructions?

Begin questions.

xi. Script for direct questioning method

Hello, my name is _____ . I'm a researcher from Rhodes University conducting a study on recreational anglers. The research involves questions about your angling behaviour and can include questions that may be sensitive. This study, including myself have no affiliation to any law enforcement and any responses you give are completely anonymous and will not be shared with anyone or used against you in any way. If you agree to participate, there is also an opportunity to win a cash prize, a fishing reel or a new rod based on a lucky draw competition. The questionnaire takes approximately 2 minutes to complete and your participation is entirely voluntary. Do you agree to participate? – If "yes", tell them they may skip any questions they do not want to answer and continue with questions.

xii. Script for random response technique

Hello, my name is _____ . I'm a researcher from Rhodes University conducting a study on recreational anglers. The research involves questions about your angling behaviour and can include questions that may be sensitive. This study, including myself have no affiliation to any law enforcement and any responses you give are completely anonymous and will not be shared with anyone or used against you in any way. In addition, we will be using a randomizing device which will help conceal and improve the anonymity of your responses. If you agree to participate, there is also an opportunity to win a cash prize, a fishing reel or a new rod based on a lucky draw competition. Do you agree to participate? – If "yes", explain the RRT procedure.

"Yes" – I have here a randomizing device (show them the coin – "this is heads, this is tails"). I am going to give you a sheet of paper and this coin which we will use to complete this short survey. I am going to read you questions aloud and for each question, I want you to first flip the coin. Do not let me know the result of the coin flip. If the coin lands on "heads" please answer the question honestly. If the result is a "tails", I want you to check the "yes" response, regardless of the truth. Do not let me know your answers or the results of the coin flip. This way, nobody will know if your yes response was due to a coin flip or your actual admission to a potentially sensitive question. This helps improve the anonymity of your responses and conceal any potentially undesirable behaviour you may have participated in. Let's do an example: the first question on your ballot is a practice question. "Are you a elephant?" (watch them flip coin or tell them to flip coin and record their response). "If you answered "Yes" to this question, the coin either landed on tails or you are an elephant. You should have only answered "No" if the coin landed on heads, that is if you are not in fact a elephant."

Do you understand the instructions? If unsure – do another demonstration. If "yes" tell them they may skip any question they do not want to answer as their participation is entirely voluntary and proceed with RRT.