Fisher-cetacean interactions in a coastal social-ecological system: Bycatch impacts on vulnerability and adaptation strategies for viability

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

This thesis aims to understand the critical linkages between cetacean bycatch and its impact on the vulnerability and viability of small-scale fisheries (SSF) communities. Cetacean bycatch is extremely complex, having serious social-ecological impacts on both fishers and cetacean populations. Fishers in small-scale fisheries (SSF) are not adequately supported through bycatch policies yet experience the brunt of the consequences and financial strains. Cetaceans are also not properly represented within bycatch policies, with definitions of bycatch failing to encompass the complexity of cetacean interactions with fishers. Such poor bycatch governance influences fisher-cetacean relationships and makes both fishers and cetaceans extremely vulnerable to external threats such as overfishing. Since many cetaceans and small-scale fishers share the same resources and habitats, the status of fisher-cetacean relationships can potentially impact the vulnerability and viability of SSF. This study utilizes a transdisciplinary methodological approach by focusing on bycatch and bycatch management impacts on natural, social, and governing systems to effectively assess the complexity of bycatch mitigation. Multi-stakeholder surveys (n = 50) were completed in the SSF communities of Chilika Lagoon in Odisha state, India to help deepen the understanding of fisher-cetacean interactions. Some SSF communities in Chilika Lagoon cooperatively fish with Irrawaddy dolphins (*Orcaella brevirostris*). Despite this mutually positive interaction, the Irrawaddy dolphin subpopulation in Chilika Lagoon is still considered to be endangered according to the IUCN Red List. Semi-structured interviews (n = 10) were also completed with key experts on bycatch to include a wider range of bycatch perspectives. Key bycatch experts interviewed were from a variety of countries to explore how different countries view cetacean bycatch and manage its impacts. The results of the surveys and interviews brought to light a disconnect between what fishers and key bycatch experts perceive to be bycatch, illustrating the lack of knowledge sharing between fishers and other stakeholders. Findings of the research also show that small-scale fisher perspectives must be incorporated in how bycatch is defined within fisheries policies as fishers are the ones directly dealing with bycatch interactions. Furthermore, the findings highlight that small-scale fishers must be given access power and decision making through appropriate cetacean bycatch governance which works together with adaptive bycatch

management strategies to make bycatch governance effective for both cetaceans and fishers to remain viable for the long-term.

Keywords: cetacean bycatch, adaptive management, adaptive governance, social-ecological systems, vulnerability, viability, bycatch governance, bycatch policies

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Chapter 1

Introduction

1.1 Background

As global populations continue to increase, so does the demand for food. This growing demand for food directly impacts fisheries since the world's oceans provide vital sources of protein from fishing, making fisheries a major contributor to global food security (Zhou et al. 2015). The demand for fish has continued to increase since 2012, causing overexploitation of fish stocks and allowing for unsustainable management of fisheries (Tickler et al. 2018). The global mismanagement of fisheries has continued because the pursuit of current profits has overpowered the pursuit of long-term sustainability (Tickler et al. 2018). However, unsustainable competition for fisheries resources not only effects marine fisheries but also human livelihoods (Rousseau et al. 2019). Small-Scale Fisheries (SSF) and the livelihoods of small-scale fishers are especially vulnerable to overfishing due to increased competition for both oceanic space and resources (Zhou et al. 2015). Small-scale fishers depend directly on their catches for their livelihoods and survival which impacts how they interact with wildlife (Panagopoulou et al. 2017).

Small-scale fishers interact with a wide range of marine species while out on fishing operations, including cetaceans (dolphins, whales, and porpoises). Many coastal cetaceans depend on the same fish stocks and oceanic habitat as small-scale fishers, potentially making them especially vulnerable to overfishing. Since space in the ocean is limited and oceanic ecosystems need sufficient time to replenish their resources for the long-term, increased conflicts for space and resources between fishers and cetaceans may become inevitable (Thilsted et al. 2016). These increased conflicts are concerning because if fisher-cetacean interactions are not managed properly by fisheries, negative interactions like bycatch may become more common.

For this thesis, bycatch of cetaceans includes fisher-cetacean interactions leading to cetaceans causing physical harm to either fisher gear, catches or to cetaceans themselves (Dolman & Brakes, 2018). Although the importance of acquiring knowledge on fish stocks has

become undeniable, the associated fishing processes themselves and their impacts on oceanic species can no longer be ignored (Rousseau et al. 2019). Cetaceans are important for our oceans as they are top predators with important roles in aquatic food webs, as well as in nutrient cycling by physically mixing ocean currents (Tynan, 2004). Yet, bycatch is still not properly managed in many countries with insufficient changes in fisheries management policies and inadequate efforts being made to effectively reduce the number of cetacean's caught during fishing operations (Dolman & Brakes, 2018). Even current "eco-labels" which are supposed to ensure sustainable fishing practices with no events of bycatch are inaccurate, with fisheries referring to fish stocks alone and cetacean bycatch being tolerated as a "by-product" of fishing (Dolman & Brakes, 2018).

An estimated 300, 000 cetaceans are killed due to global fishery interactions each year (Northridge, 2008; Hines et al. 2020). Current conservation efforts involving the protection of cetaceans continue to be ineffective at restoring population numbers worldwide due to their heavy focus on natural sciences and limited understanding of fisher-cetacean relationships and what influences them (Whitty, 2015). Therefore, social implications of fisher-cetacean interactions as well as bycatch management need to be further investigated to better understand cetacean-fishery conflicts and what factors catalyze these conflicts. This research attempts to investigate cetacean bycatch through a transdisciplinary social-ecological systems perspective by not only focusing on cetaceans, but also the fishers they regularly interact with.

1.2 Research Question and Objectives

Negative bycatch interactions impact both cetaceans and small-scale fishers, yet both are currently left with no effective support toward reducing bycatch events. With current cetacean research lacking investigation of the social context of bycatch, co-production of knowledge with small-scale fishers and fisheries management stakeholders on vulnerabilities faced by both fishers and local cetaceans has yet to be widely explored. This leads to question about the types of bycatch mitigation and adaptation strategies that may be effective in creating more of a balance between preserving both small-scale fisher livelihoods and cetaceans which share the same social-ecological system. This creates a basis for the research

question being investigated which is how can bycatch vulnerabilities of both cetaceans and small-scale fishers be assessed and common strategies for their viability be developed?

The goal of my proposed research is to understand the critical linkages between cetacean bycatch and its impact on vulnerability and viability of SSF. This is due to the lack of current transdisciplinary research on cetacean conservation, approaching the issue from a social-ecological systems perspective (Whitty, 2015). A transdisciplinary approach to cetacean bycatch research involves investigating the social, natural, and governance linkages of cetacean bycatch (Bundy et al. 2016). While a social-ecological systems perspective to cetacean bycatch focuses on social and governance obstacles in the way of cetacean bycatch governance (Whitty, 2015). The following research objectives were investigated using transdisciplinary and social-ecological systems concepts:

1. To understand the nature and extent of cetacean bycatch within the social-ecological system.
2. To examine how cetacean bycatch and its mitigation add to the vulnerabilities of the social-ecological system (SSF) by focusing on
   (A) cetacean bycatch impacts on the natural subsystem, and
   (B) cetacean bycatch impacts on the social subsystem.
3. To determine a set of mitigative and adaptive strategies that are most likely to increase social-ecological viability through appropriate cetacean bycatch governance.

1.3 Literature and Significance of the Study

To better interpret bycatch and its impacts it is also important to recognize SSF as a social-ecological system. Since bycatch involves fishers, it also involves social components that need to be further investigated. To help fishers and cetaceans remain viable for the long-term, the vulnerabilities faced by both need to be explored in order to find potential pathways for viability. A social-ecological systems perspective supports the notion of vulnerability to viability by providing new perspectives on bycatch and fisher-cetacean relationships. A social-ecological systems perspective will also bring to light the obstacles and vulnerabilities fishers and

cetaceans both face which could be the focus for building better solutions and viable pathways. However, the context specificity of bycatch also needs to be considered as different levels of bycatch occur depending on the gear used, and different species are caught in different types of gear. Also, the severity of bycatch impacts may be influenced by the species or specific populations, or subpopulations involved. Depending on the severity of bycatch, different mitigation or adaptive strategies may be used. Therefore, complexities involving bycatch mitigation and management need to be accounted for and thoroughly investigated when researching bycatch. Potential bycatch governance would need to build off current strategies used for fisheries governance as well as take into consideration current bycatch management issues and how obstacles in the way of effective bycatch management impact fisher-cetacean relationships. Bycatch governance could be a potential pathway for fisher-cetacean viability if it is used to address current bycatch management problems. However, we must first investigate current gaps of knowledge on bycatch policies and governance in order to better understand fisher-cetacean relationships which is the focus of this research.

1.4 Research Design and Methodology

The methodology of this research (see Chapter 3 for more detail) embraces a transdisciplinary and qualitative approach by investigating bycatch in SSF through a social-ecological systems perspective. This research works to bring together the social context of bycatch as well as the natural by investigating fisher-cetacean relationships and what impacts the status of their relationship. A case study was also incorporated to demonstrate the context specificity of bycatch, as well as the importance of talking directly with small-scale fishers on bycatch management and governance. An extensive literature review and policy analysis of cetacean bycatch guidelines and policies were completed to provide background information related to the objectives of this research. Concepts from the I-ADApT framework (Figure 1) were used to guide this research and investigate how the natural, social, and governance systems in SSF respond to bycatch vulnerabilities and bycatch management (Bundy et al. 2016) (See Chapter 3 for more detail). Concepts from the Conservationscapes framework (Figure 2) were also used to investigate social and governance obstacles faced by fishers, and how bycatch management impacts their relationships with cetaceans (Whitty, 2018) (See Chapter 3

for more detail). Multi-stakeholder surveys with fishers as well as semi-structured interviews with key bycatch experts were completed along with the literature review and policy analysis. The surveys and interviews were conducted in order to learn more about bycatch from various transdisciplinary perspectives, especially the on-ground experience of fishers in SSF.

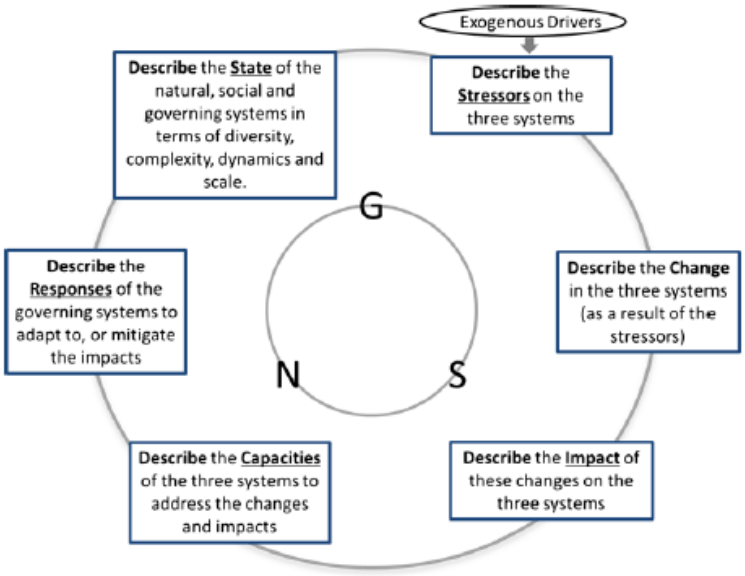

Figure 1. Outline of Description and Response component of I-ADApT framework. (N) is the Natural System, (S) is the Social System, while (G) is the Governing System. Stressors can be both anthropogenic or natural depending on the case-study context. The outer circle can be entered at any point with my research focusing on impacts of bycatch and capacities of SSF to address bycatch.

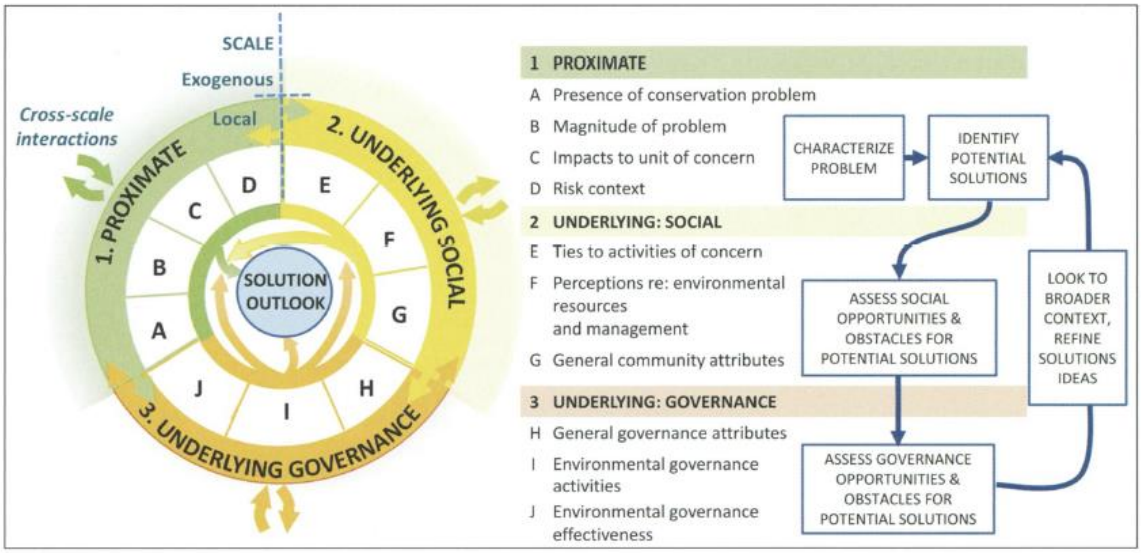

Figure 2. Outline of Conservationscapes framework which integrates proximate attributes with underlying social and governance attributes. (Whitty 2014, pg.34)

1.5 Gaps and Expected Outcomes

This study provides a new innovative perspective on cetacean bycatch and potential solutions for ineffective bycatch management. Looking for pathways for viability by better understanding vulnerabilities faced by both small-scale fishers and cetaceans needs to be further investigated within the academic literature. Finding potential pathways to increase social-ecological viability through appropriate cetacean bycatch governance have not been thoroughly investigated. Much research has been done on the natural aspects of bycatch issues as well as natural solutions. However, not enough research has been done on addressing the social obstacles impacting cetacean bycatch governance and using insights on vulnerabilities to create social solutions to empower fishers to be able to manage bycatch. This research takes a deep dive into the social context of bycatch to find better viable pathways that will help both small-scale fishers and cetaceans be more resilient against the impacts of bycatch and its mismanagement.

1.6 Thesis Organization

This thesis is comprised of six chapters in total – (1) Introduction, (2) Literature Review, (3) Methodology, (4) and (5) Results and Discussion, and (6) Conclusion.

Chapter 1 describes the background information of this study, its purpose and objectives, methods and methodology, significance, and gaps in knowledge. This chapter also provides a guideline of how the thesis was organized.

Chapter 2 investigates four areas of literature crucial to better understanding fisher-cetacean relationships and bycatch in SSF, including SSF as a social-ecological system, vulnerability to viability, bycatch (gear, technology, and species) as well as fisheries governance literature.

Chapter 3 explains the methodology and methods used for this research. The first part of this section explains the research design and methodology while the second part of the chapter explains the methods: literature review and policy analysis, multi-stakeholder surveys, and semi-structured interviews with key bycatch experts. This section also explains the data analysis used for both surveys and interviews.

The results and discussion have been separated into two chapters - chapter 4 focuses on objectives 1 and 2 of this research which provide information on the social-ecological context of bycatch in SSF as well as vulnerabilities of ineffective bycatch management. Chapter 5 focuses on objective 3 of the research by investigating potential mitigative and adaptive strategies for bycatch which would strengthen cetacean bycatch governance and provide a pathway for viability.

Chapter 6 provides conclusions on the findings and discussions presented throughout the thesis to provide suggestions on ways to increase social-ecological viability of both fishers and cetaceans through effective cetacean bycatch governance.

Chapter 2

Literature Review: Investigating Bycatch from all Angles

2.1 The Complexities of Cetacean Bycatch

The areas of literature investigated include SSF as a social ecological system, vulnerability to viability, bycatch (gear, technology, and species), as well as fisheries governance. Both peer-reviewed literature and grey literature related to cetacean bycatch, mitigation and/or adaptation strategies were investigated.

SSF as a social-ecological system demonstrate the interconnectedness between fishers and cetaceans (dolphins, whales, and porpoises), as well as emphasizes the need for interdisciplinary approaches to complex SSF issues (Whitty, 2018). Literature pertaining to vulnerability and viability provide valuable information on the state of vulnerability in SSFs as well as for cetaceans, providing a clearer understanding of the challenges they both face in order to find better solutions for bycatch (Pattanaik, 2021). This area of literature also includes ways to increase viability through adaptations and innovative opportunities, using information on vulnerabilities to strengthen pathways to viability (Cisse et al. 2015). Bycatch literature covers a wide range of topics and species. For the purpose of this thesis, fishing gear, technological innovations, and mitigative approaches for cetacean bycatch were the focus. There is currently very limited research on bycatch governance and policy analysis which is why fisheries governance was emphasized. Fisheries governance literature provides a variety of recommendations for adaptive approaches to fisheries governance (Bellido et al. 2011). This includes information from fishers on potential fisheries management approaches, empowerment of SSF communities, enforcement potential, along with interactive governance possibilities and challenges for SSF (Goetz et al. 2014; Whitty, 2015; Kelkar & Dey, 2020).

Each area of literature has overlapping topics which when considered together help to enhance understanding of the nature and extent of cetacean bycatch within social-ecological systems. Investigating topics from various disciplines also helps to examine how different levels of cetacean bycatch add to fisher-cetacean vulnerabilities. Gaps in knowledge pertaining to

cetacean bycatch policies and potential bycatch governance is also thoroughly investigated through this literature review.

2.2 Social-ecological Systems Perspective of SSF Fisher-cetacean Interactions

There is currently an imbalance between conservation of threatened species and meeting human needs and demands (Carman & Carman, 2018). The importance of integrating social-ecological perspectives to improve the long-term viability of natural resources is becoming increasingly emphasized by researchers and academic literature (Berkes et al. 2003; Ostrom 2009; Moon et al. 2016). A social-ecological system refers to combined social and ecological subsystems which interact with one-another in a two-way feedback relationship on all levels and scales (Nayak & Berkes, 2019). Components of both social and ecological subsystems are integrally linked to one another, influencing each other and catalyzing change in all environments (Nayak et al. 2015). Due to this highly integrated nature, human dimensions need to be incorporated into cetacean conservation efforts as there has been too much focus on the natural science perspective alone (Barz et al. 2020).

SSF communities are highly complex, with each having their own specific human dimensions and local environments. This complexity makes SSF difficult to define as they vary in many social and technological aspects including boat size, type of gear used, mode of fishing, local culture, state of local governance and more (Smith & Basurto, 2019). However, all SSF no matter their specific characteristics may experience interactions with cetaceans or other non-target marine species on some scale. These interactions occur in a context of interlinked existences between SSF and cetaceans, with overlapping resources and behaviours in space and time rooted in social-ecological drivers.

The type of fisher-cetacean interactions and whether they have positive relationships greatly depends on the fishers themselves and their attitudes towards cetaceans. For the purpose of this study, SSF will refer to any small, traditional craft and low-tech SSF which comes in direct contact with cetaceans while out on daily fishing operations (Smith & Bassurto, 2019). Small-scale fisher-cetacean interactions involve social, cultural, economic, and political factors that need to be better understood (Carman & Carman, 2018). Better understanding these

factors can provide clearer understanding of the role of politics and power relations, as well as understanding human behaviour, and support bycatch governance and policies (Moon et al. 2016). Encounters between cetaceans and SSF have been increasing due to spatial overlap between fishing grounds and cetacean habitats and migration patterns (Teh et al. 2015). Due to these increased encounters, there is a growing need to study the human dimensions of fisher-cetacean relationships to develop more useful and practical solutions for cetacean conservation (Whitty, 2018).

Fishers and cetaceans are highly interconnected due to their mutual dependency on the same marine resources. Fishers depend on fish stocks as a main source of income and a way of life. However, interactions with cetaceans may affect their fishing operations (Panagopoulou et al. 2017). Negative interactions between fishers and cetaceans (such as bycatch) are impacted by social-economic drivers since bycatch is influenced by the distribution, type, and magnitude of fishing effort (Lewison et al. 2018). This is because if fishers are putting in more fishing effort due to decreasing fish stocks, this may make interacting with cetaceans more frequent in the long-term and increase the chances of bycatch. This is why local community perceptions toward cetaceans are highly dependent on the direct measurable costs and benefits of fisher-cetacean interactions, with negative attitudes exacerbating negative impacts on cetacean populations (D'Lima et al. 2014).

Fisher-cetacean interactions can have negative impacts to SSF through damage of gear and catches, in addition to the broader view of cetaceans as direct competition for target prey/fish (Machado et al. 2019). This speaks to the social-ecological nature of SSFs and how cetacean bycatch interactions can impact fishing operations. However, current knowledge on the extent and underlying context of these interactions is limited due to substantial gaps in knowledge on these social and ecological aspects (Whitty, 2018). In order for cetaceans to be adequately protected and ocean environments to be sustainable for the long term, the complexity of their interactions with fishers needs to be accounted for within conservation policies, research, and education (Lewison et al. 2018). Due to rising climate change pressures, expanding markets, encroaching fisheries, and other non-climatic factors, it is becoming

increasingly crucial for main drivers of negative fisher-cetacean interactions to be better understood in order to find potential pathways for fisher-cetacean viability.

2.3 Unsustainable Fisheries and their Inability to Protect Cetaceans from Bycatch

Bycatch is defined as the "incidental capture of non-target species" during fishing activities and is a major threat to marine mammals, especially cetaceans (dolphins, whales, and porpoises) which are integral players in marine food webs (Berninsone et al. 2020). The term bycatch encompasses a wide range of species other then cetaceans including seabirds, sea turtles, juvenile fish, and even benthic invertebrates. Incidental capture refers to being unavoidable and a consequence of fishing operations. Therefore, bycatch is most commonly defined in fisheries policies as the unavoidable capture of non-target oceanic species (ranging in sizes and reproductive rates) which is a consequence of fishing operations. This definition does not capture the complexities of bycatch and the range of impacts, directly influencing the way bycatch has been managed. Bycatch of cetaceans is considered a major concern for successful conservation as well as being able to sustainably manage fisheries (Van Beest et al. 2017). In order to pursue any type of viable solutions for bycatch, the obstacles in the way of effective bycatch management need to be better understood.

Bycatch occurs in a variety of fishing gear including trawl, purse seine, longline, gillnet, and pot/trap (Hamilton & Baker, 2019). Marine mammal bycatch is especially challenging for developing countries to monitor and understand due to lack of data and documentation of both bycatch rates and their impacts (Komoroske & Lewison, 2015; Lewison et al. 2018; Hines et al. 2020). Cetacean species are long-lived with low reproductivity and high adult survival, meaning populations are slow to recover from decline, exacerbating the effects of bycatch (Hamilton & Baker, 2019; Omeyer et al. 2020). Bycatch can have lethal effects on cetaceans through interactions with boats and/or gear, resulting in strangulation, lacerations, infections, and limb loss (Tulloch et al. 2019). An estimated 300, 000 cetaceans are killed due to global fishery interactions each year (Northridge, 2008; Hines et al. 2020). Due to these extreme impacts, it is important for bycatch of cetaceans and other larger mammals to be distinguished from smaller oceanic species like juvenile fish and benthic invertebrates within fisheries management and

policies. For the purpose of this thesis, the focus will be on direct bycatch of cetaceans (e.g., unintended capture) including whether they are fully captured and killed, and also negative direct interactions with fishers and fishing gear which may impact cetacean survival (e.g., interactions that may indirectly harm cetaceans).

There are many approaches for mitigating bycatch including limiting fishing effort, and the modification of fishing practices (Cox et al. 2007). Fishing gear itself has also been modified through bycatch reduction technology (BRT) to increase selectivity in order to reduce the chances of catching non-target species such as cetaceans (Campbell & Cornwell, 2008). Fishing gear and practice modifications have increased worldwide due to a growing concern to limit fishing effort or interactions with bycatch species (Ward & Hindmarsh, 2007). Other efforts to reduce bycatch include limiting fishing effort with time-area closures, as well as using technological devices such as "pingers" (Berninsone et al. 2020). Pingers are acoustic alarms which take advantage of cetacean hearing by emitting low intensity sounds to deter cetaceans from coming too close to fishing operations (Omeyer et al. 2020). New and innovative GIS-based bycatch tools have also been developed such as the Bycatch Risk Asessment (ByRA) toolkit (Hines et al. 2020). Unfortunately, some of these mitigation strategies are too recent to accurately identify effects and few of these examples involve SSF, with majority of the focus being on industrial fisheries instead.

With the definition of bycatch being "unavoidable" and encompassing so many species, creating effective mitigative strategies across the whole spectrum of bycatch proves to be difficult. There have been a variety of reviews on bycatch mitigation strategies or gear type adaptations since there has been heightened awareness on the need to develop more effective bycatch solutions for cetacean conservation (Hamilton & Baker, 2019). However, whether or not these bycatch strategies are supported by local fishers may determine the success of implementation (Campbell & Cornwell, 2008). This is because usual approaches to reduce bycatch have at times cost fishers' their livelihoods and are highly context dependent due to varying political and social-ecological factors (Komoroske & Lewison, 2015). It is important to have the support of fishers because they can share beneficial local ecological knowledge on

cetacean bycatch, as well as provide realistic opinions on which bycatch mitigation or adaptation strategies could be most beneficial for the area (Liu et al. 2017).

Bycatch mitigation strategies tend to focus on avoiding and/or deterring cetaceans from fishing operations, while bycatch adaptation strategies can work to find ways to increase cooperation with cetaceans. Information on the social aspects of cetacean bycatch is growing, however still lacks in demonstrating a truly transdisciplinary approach. Cetacean bycatch has been a major concern for decades, but fisher-cetacean relationships and bycatch interactions are still poorly understood (Anderson et al. 2020). Strategies for reducing bycatch tend to be expensive to implement and monitor, adding to the extensive lack of data on accurate levels of bycatch and willingness to address the issue (Tulloch et al. 2019). A truly transdisciplinary approach to developing potential cetacean bycatch solutions needs to be established along with the support of fishers. Although there have been impressive advances in bycatch mitigation strategies, it needs to be acknowledged that there is no single solution to fisheries bycatch in our highly complex world (Komoroske & Lewison, 2015). This includes finding ways to better evaluate and incorporate bycatch adaptive innovations into action through adaptive management and governance with all stakeholders.

2.4 Vulnerabilities Faced by Small-Scale Fishers and Cetaceans and Pathways for Viability

Vulnerabilities to global drivers such as climate change and the ability to adapt to such stressors have become a dominant theme in conservation research (Bennet et al. 2013). Vulnerability refers to the level of susceptibility or inability of a system to cope with negative effects of climate change, as well as its capacity to adapt to such changes (IPCC, 2001). The vulnerability of a community is multidimensional and complex as it impacts wellbeing on both the community and individual level, access to capitals and/or resources, as well as overall resilience against disturbances (Nayak & Berkes, 2019). Global changes which impact vulnerable communities not only refer to the biophysical, such as climate change, but also economically and politically driven factors such as globalization of markets (Nayak & Berkes, 2014). Economically viable SSF are more likely to be better prepared against global drivers of change, however in SSF, social-ecological and governance aspects also play important roles in the

adaptive capacity of the coastal community (Schuhbauer et al. 2019). By better understanding these social-ecological and governance aspects of SSF, pathways of viability may be derived from the existing coping and adaptive responses of small-scale fishers (Pattanaik, 2021). Other non-climatic pressures impacting SSF include overfishing, pollution, and loss of habitat, with negative impacts being magnified by climate change (Islam et al. 2014). How vulnerable an SSF community is to these non-climatic pressures and their ability to adapt is influenced by both the nature and magnitude of the local changes (Bennet et al. 2013). Therefore, the local context and social-ecological aspects of an area must be understood before creating viability pathways.

By better understanding the vulnerabilities faced by both cetaceans and fishers, we may find viable pathways for both to remain viable for the long-term. Since SSF are very complex, social wellbeing as well as the maintenance of livelihoods are especially important to consider when evaluating the adaptive capacity of the fishery (Schuhbauer et al. 2019). The growing impacts of climate change on marine fisheries can have a variety of negative impacts on a wide range of social-economic factors including SSF food security (Blasiak et al. 2017). Food security is especially important to consider when analysing the economic viability of a coastal SSF community (Schuhbauer et al. 2019). In the Bay of Bengal there has been a drastic expansion in shrimp culture which not only destroys coastal habitats, but also leads to livelihood loss for fishers and SSF communities (Nayak & Berkes, 2014). In combination with pressures such as expanding shrimp culture, SSFs face exposures to floods and cyclones, sea-level rise, ocean acidification, and much more (Islam et al. 2014). Therefore, SSF communities are at the forefront of climate change, providing an informative lens to study climate adaptation processes and pathways for viability (Green et al. 2021).

Other important biota sharing the same resources and habitat as SSFs include cetaceans. The roles and interactions between SSF and cetaceans in the natural environment need to be better understood. Conserving biodiversity, especially in the face of climate change, is an integral part to protecting human life (Berry et al. 2013). Therefore, by helping conserve and protect important biodiversity such as cetaceans, fishers may indirectly benefit and increase the chances of viable interactions between fishers and cetaceans. Assessing species vulnerability helps to guide species-level conservation by providing a range of species and

habitat related adaptations, which can reduce overall vulnerability and enhance adaptive capacity (Berry et al. 2013). Therefore, by better understanding the vulnerabilities faced by both cetaceans and fishers, we may find better solutions for pursuing viable pathways for both.

Human activities such as overfishing, leading to high rates of bycatch, present problems for coastal cetaceans, emphasizing the drastic need for new and innovative approaches to their conservation (Thompson et al. 2000). Negative interactions with small-scale fishers are drivers for cetacean population declines, with very limited information on the main factors influencing these interactions and cetacean vulnerability to bycatch (Dewhurst-Richman et al. 2020). Therefore, it is especially important to analyze fisher-cetacean relationships as there are some SSF where fishers have managed to maintain a cooperative relationship with cetaceans. This relationship is considered cooperative since the cetaceans help the fishers catch more fish by driving fish into their nets (D'Lima et al. 2014). These SSF may possess greater adaptive capacity regarding the social context of cetacean bycatch. Any vulnerabilities impacting the status of fisher-cetacean relationships and obstacles in the way of cetacean bycatch governance may therefore be built upon to enhance viability.

Small-scale fishers in Chilika Lagoon, India fish cooperatively with the Irrawaddy dolphin (*Orcaella brevirostris*) and have neutral to positive attitudes towards them (D'Lima et al. 2014). Observations of cooperative fishing between mullet (*Mugil spp*.) fishers and dolphin species dates as far back as 1856, with the presence of dolphins increasing the efficiency of capture (Simoes-Lopes et al. 1998). Cooperative fishing involves mutual responses between both fishers and dolphins where fishers are able to easily catch more fish due to the presence of the dolphins, however these types of favourable relationships are influenced by local conditions which need to be further investigated (Simoes-Lopes et al. 2016). Cooperative interactions with dolphins allow fishers to have more positive views of cetaceans and better understand their role in both ecological and social systems, providing value for cetaceans and the ecosystem services they provide (Machado et al. 2019). Cooperative fishing in areas like Chilika Lagoon show that fishers can have positive relationships with cetaceans and possibly work with them depending on the local context. Whether or not these types of fisher-cetacean relationships

possess long-term strengths against cetacean bycatch vulnerabilities and could provide information on potential pathways for SSF viability need to be further investigated.

2.5 Fisheries Governance verses Bycatch Management

Over two decades ago there was a public consensus that bycatch should be minimized to levels of almost zero (Crowder & Murawski, 1998). However, knowledge of bycatch species and local threats as well as related social, economic, political, and cultural factors need to be better understood for effective conservation planning (Whitty, 2018). Fisheries management has evolved from being concerned with single stocks and quotas to now being more aware of their effects on, and interactions with marine mammals (Bellido et al. 2011). However, there is still a disconnect between trying to solve bycatch problems and the social implications of bycatch management.

The unintended capture of cetaceans through bycatch due to interactions with fishers and gear includes discarding marine life/waste (throwing the carcass overboard) which has become a resource management concern for fisheries worldwide (Crowder & Murawski, 1998). Trying to control the discarding and capture of bycatch species requires management changes in fishing practices through gear restrictions, or technological alterations to gear (Whitty, 2015). Some countries and their fisheries are starting to gather more information and outreach with fishers to collect bycatch information and strengthen ongoing research and monitoring (Huang, 2011). However, these transitions have been too slow with true rates of cetacean bycatch being unknown. Fisheries and conservation need to approach cetacean bycatch with a holistic management perspective to create acceptable solutions for both cetaceans and fishers, starting with a clear identification of specific problem interactions (Goetz et al. 2014).

Although there have been growing attempts from governments to actively manage bycatch, they still fail to address the complexities of bycatch. Even within Canada's Policy on Managing Bycatch and their Sustainable Fisheries Framework, cetaceans are lumped within the "non-retained catch" category which includes both target and non-target species with only one distinction of "marine mammals" within the whole document (DFO, 2019). These types of inadequate bycatch policies which do not recognize the unique characteristics of cetaceans and

their interactions with fishers show the currently drastic disconnect between how cetaceans are viewed through conservation initiatives verses fishing operations. Critically reviewing and updating fisheries laws could help identify gaps in knowledge when dealing with bycatch of endangered cetacean species (Kelkar & Dey, 2020).

In the realm of conservation cetaceans are valued for being unique charismatic species, yet within the definition of bycatch in fisheries policies they are grouped with benthic invertebrates. If there is to be a viable future for both fishers and cetaceans, both need proper representation within fisheries policies. Cetaceans should not be grouped with target species and need to be adequately distinguished within fisheries management policies for them to have a viable future. This is because cetaceans and fishers have complex relationships impacting fishing operations which need to be accounted for within policies. Mitigating against bycatch has been considered mainly a fisheries management issue, however research into cetacean bycatch and fisheries governance is severely limited (Whitty, 2015). Conservation interventions based on the enforcement of fisheries laws are not effective in reducing bycatch since fisheries laws were never intended to address bycatch issues when they were first created (Kelkar & Dey, 2020). This is evident within many policies and bycatch management guidelines where fishers are expected to minimize capture of unwanted species while not affecting the fishing operation's profitability (DFO, 2019). Fishers may also face punishment if found to have bycaught cetaceans in certain countries, deterring fishers from sharing bycatch data (Basran &Sigurosson, 2021). For fishers living in higher income countries with greater quality of life and access to resources, self financed conservation may be possible, but for fishers in lower income SSF whose wellbeing and livelihoods depend directly on the fish they catch, circumstances change.

While fisheries management focuses on the gear, technology, and daily fishing operations, fisheries governance focuses on giving fishers a voice in decision making which may empower SSF communities and provide them with the institutional support they need to protect their resources. Current management practices tend to overlook that managing fisheries is more about governing highly complex social-ecological systems then just managing fish (Alava et al. 2019). Fishing is an integral part of life for both small-scale fishers and

cetaceans, emphasizing the need to learn from fishers about their relationships and interactions with cetaceans. Examples of fisheries governance attributes can include community groups, local governments, bridging of organizations and local involvement, as well as enforcement bodies (Whitty, 2015). Fishers need to be given the institutional support they need to organize community groups and have discussions on bycatch issues. Respecting community groups and their perspectives on bycatch, as well as helping bring together local communities, governments, and enforcement bodies can potentially empower small-scale fishers and their communities. Providing institutional support and improving communication between all stakeholders involved in bycatch management by giving fishers a stronger voice in decision making could potentially better support SSF communities in protecting their resources and overall viability. Proper fisheries governance which actively supports small-scale fishers through strong institutional support emphasizes how access to power is essential to understanding the management of resources (Nayak et al. 2015).

Unfortunately, cetacean bycatch is yet to be taken seriously enough by country governments to make effective solutions, with some countries lacking any bycatch data, bycatch policies, and/or preventative measures at all (Khan, 2018). The lack of accurate bycatch data is apparent throughout the literature, with little action towards adequately solving this issue. Bycatch is a complex legislative issue which needs the support of both fisheries management and governance as it affects both protected species and fishery resources (Crowder & Murawski, 1998). Without the support of governments and other institutions, fishers lack access to power when trying to have a say in how bycatch is managed. Fisheries governance takes place at both the national and local level, which impact one another. Local governance refers to institutions which influence resource management on the village and community level, while national governments operate on a global scale which can have cascading affects at the local level and vice versa (Whitty, 2015). Therefore, cetacean bycatch initiatives in SSF need the support of governments on both the local and national scale in order to allow for a viable future and cannot depend on the local community alone.

2.6 What about Bycatch Governance and Policies?

Globally, current governments and regional authorities struggle to adequately address cetacean bycatch and interactions with fisheries due to its' high complexity. By focusing on creating a viable future for both fishers and cetaceans, bycatch may be approached in a new and innovative way. A review of cetacean bycatch reduction methods found that progress towards bycatch solutions has been limited, especially with cetacean bycatch being approached as a separate management issue instead of intrinsic to fisheries management and governance (Leaper & Calderan, 2018). The Voluntary Guidelines for Securing Sustainable SSF in the Context of Food Security and Poverty Eradication are the first internationally agreed upon recommendations for the SSF sector, yet fail to mention bycatch of any kind, defining "fishery resources" as all aquatic living resources which are commonly harvested (FAO, 2018). This is a prime example of the need for greater coherency between fisheries policies that impact cetaceans and the nature of their interactions with fishers.

There is a growing need and urgency for bottom-up approaches to fisheries management and governance, emphasizing the importance of respecting fisher perceptions and supporting community-based conservation programs by empowering SSF communities (Alava et al. 2017). Minimizing harmful fisher-cetacean interactions requires case-specific strategies that mandate fisher participation (Goetz et al. 2014). Enforcement as well as compliance are considered crucial to the success of any bycatch mitigation or adaptation measure (Leaper & Calderan, 2018). Governance involvement is more likely to be effective when all integrated aspects of social-ecological systems are clearly addressed (Nayak et al 2015). Once all aspects of bycatch and its social-ecological system are better understood, then perhaps true bycatch governance will be possible.

With SSF being more vulnerable to external drivers such as overfishing and overexploitation, not having appropriate cetacean bycatch governance may potentially exacerbate their effects on the vulnerability of SSF. Fisher values and attitudes must be accounted for in current fisheries policies (Alava et al. 2019). This is especially true regarding cetacean bycatch policies which tend to focus on cetacean impacts alone, while providing

minimal support for fishers. This lack of support for fishers in policies greatly impacts their ability to be actively engaged in bycatch mitigation and may increase their vulnerability in the face of major fisheries changes put in place for bycatch management. Overfishing and increased competition for fisheries resources hinder the work of professional fishers, decreasing market value all while forcing fishers to more intensive practices such as trawling (Monaco et al. 2019). Lack of enforcement and support from institutions add to the vulnerabilities of overfishing and illegal fishing faced by SSF communities, potentially making these SSF more vulnerable to bycatch management implementations such as fishery shutdowns. Therefore, to sustain cetaceans and viable aquatic environments for the long-term, there needs to be improved monitoring and assessment of SSF vulnerabilities and how they are impacted by bycatch governance regulations to find potential pathways for viability (Temple et al. 2018).

Fisheries governance has the potential to support SSF against illegal, unreported, and unregulated (IUU) fishing and other vulnerabilities, helping them remain viable for the long-term (Drammeh, 2000). IUU fisheries are often connecting to negative impacts on the productivity due to excessive harvesting, increase in detrimental fishing activities (ex. dynamite or poison), as well as societal impacts such as increased crime (Kelkar & Dey, 2020). By establishing sustainable community groups and creating greater access to decision making and engagement, this can allow for SSF community members to play more active and adaptive roles in monitoring and enforcement (Whity, 2015). Proper bycatch governance on all scales, allowing for fishers to be empowered and directly involved in cetacean bycatch discussions may be the missing piece when trying to successfully implement fisheries management operations such as bycatch adaptation strategies for long-term viability.

2.7 Summary of Key Insights

The areas of literature investigated helped to better understand the nature and extent of cetacean bycatch in SSF. Investigating each area of literature also helped provide more information on how differing levels of cetacean bycatch can add to the vulnerability of SSF communities. SSF as a social-ecological system literature was extremely beneficial to learn

more about fisher-cetacean relationships and how the social and natural subsystems are linked and influence one another. Looking at SSF through a social-ecological systems perspective helped bring to light the imbalances between conservation and being able to meet human needs. Vulnerability to viability literature helped highlight the challenges faced by both small-scale fishers and cetaceans, especially in terms of trying to conserve biodiversity along with the impacts of climate change and other external drivers. Vulnerability to viability literature also provided new insights on how to increase viability by learning more about the social context of bycatch and the vulnerabilities faced by both small-scale fishers and cetaceans. Bycatch (gear, technology, and species) literature was beneficial for learning about past and current mitigation and adaptation strategies used to try and manage cetacean bycatch. This way the research was able to focus on new innovative ideas for better managing cetacean bycatch. Fisheries governance literature brought to light the lack of literature on bycatch governance, especially for cetaceans. Fisheries governance literature also highlighted management issues involving the lack of empowerment of SSF, enforcement, as well as interactive governance. Bycatch governance would need to address all these current fisheries management and governance issues to be effective. Fisheries governance literature also highlighted different adaptive responses for bycatch such as combating both IUU and bycatch together. As shown, all areas of literature helped to investigate the three research objectives, providing more background knowledge to better understand the problem of bycatch and its social-ecological components.

Chapter 3

Methodology

3.1 Summary of Research Approach

This research was completed with a strong emphasis on a transdisciplinary perspective: bringing together different academic disciplines (social, natural, and governing) with non-academic collaborators (small-scale fishers) to share knowledge (Kelly et al. 2019). A social-ecological systems approach (Berkes, 2003; Whitty, 2018) was also incorporated: thoroughly investigating both the natural and social subsystems of the case study site. Approaching bycatch with transdisciplinary perspective allows for more thorough and integrated analysis of this complex issue in which factors across sectors are interlinked, helping provide new insights on bycatch. The I-ADApT framework was used to guide this research to ensure a transdisciplinary approach by helping create the research objectives and making sure they capture all the natural, social, and governing systems of bycatch (Bundy et al. 2016). The Conservationscapes framework was also incorporated in this research to better identify potential bycatch solutions by looking at the broader context of bycatch issues. The concepts used for this research from both frameworks will be further explained in this section.

3.1.1 I-ADApT Methodology and Conservationscapes Framework

The conceptual framework used to guide this research was the I(MBER)-ADApT (Assessment based on Description, Responses and Appraisal for a Typology) framework (Figure 1). This framework focuses on governance factors and helps to identify what governance responses may be successful, as well as what factors help facilitate effective change and preventative options (Bundy et al. 2016). Concepts from the Conservationscapes interdisciplinary framework (Figure 2) which focuses on social-ecological systems and species-focused conservation was also used (Whitty, 2018). This framework was incorporated as this research focuses on the Irrawaddy dolphin (*Orcaella brevirostris*) in Chilika Lagoon, with the social-ecological system investigated being fisher-cetacean relationships. Effective conservation

of a species requires not only the understanding of the ecological system and threats, but also the social and governance contexts of such threats (Whitty, 2018).

Since the I-ADApT framework works to provide lessons on how the natural, social, and governance systems respond to vulnerabilities it is extremely beneficial for this research as the focus was on finding governance and policy solutions to cetacean bycatch (Bundy et al. 2016). This framework will allow the research to better guide policy and governance decisions, improve responses to global drivers, as well as evaluate the most effective allocation of resources to reduce vulnerability and enhance viability of both cetaceans and fishers (Bundy et al. 2016). The Conservationscapes framework involves outlining the basic characteristics of both the species and their threats, social drivers that influence human activities linked to those threats, as well the governance context/how human activities are managed (Whitty, 2018). By integrating I-ADApT and Conservationscapes concepts a more operational framework for this research and its' objectives was created as seen in Figure 3. This is especially important as it builds on concepts related to fisheries governance – providing more insight into bycatch governance possibilities.

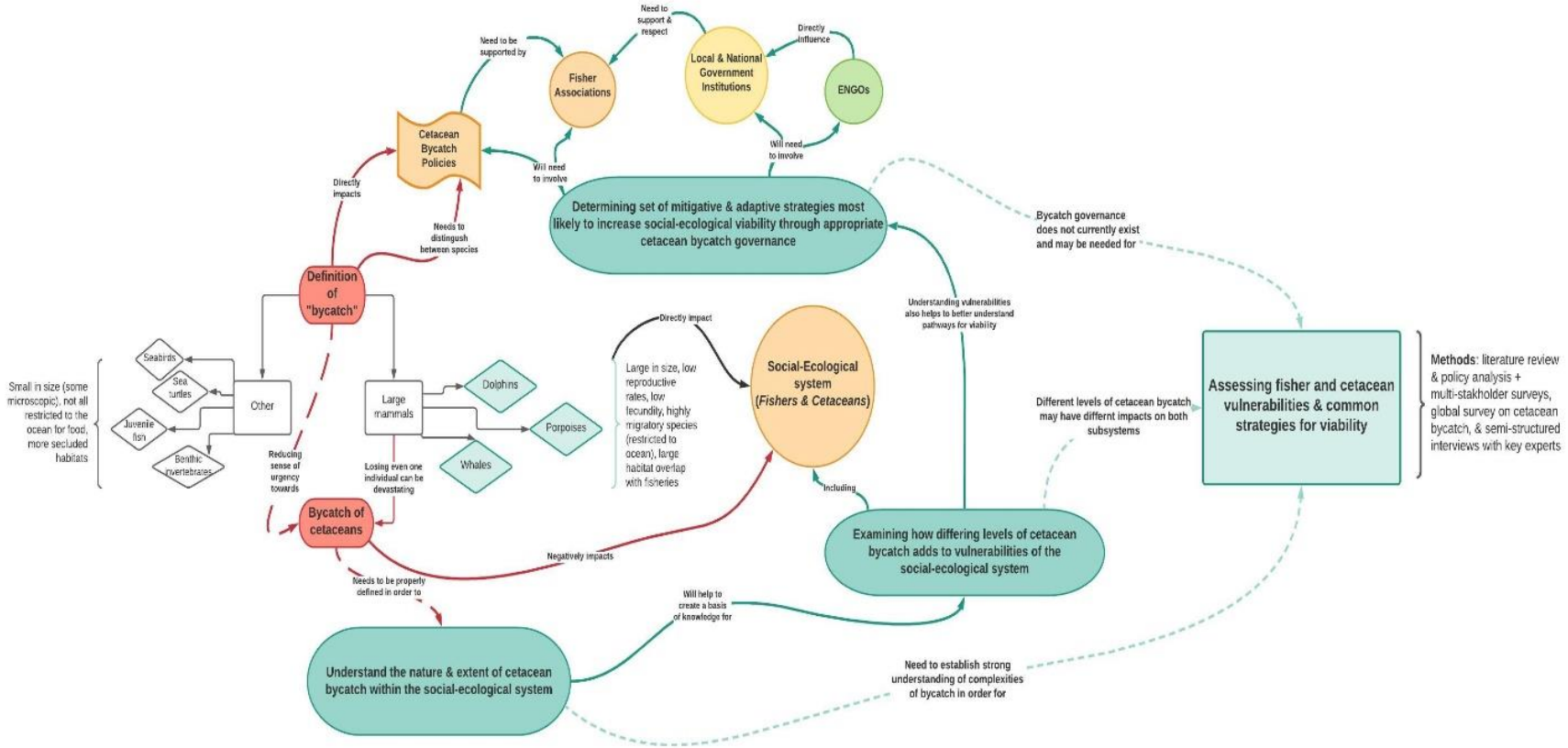

Figure 3. Outline of operational research framework. Starting with the definition of bycatch – depicting the range of species it includes and properly distinguishing cetaceans (dolphins, whales, and porpoises) from the others. This visualizes the implications of bycatch on cetaceans and the need for a social-ecological systems perspective. Key components for viable cetacean bycatch governance – social-ecological system (fishers and cetaceans), cetacean bycatch policies as well as Fisher Associations are depicted. *Due to time constraints and lack of data the global online survey on cetacean bycatch was not completed*

In addition to aspects on governance, the I-ADApT framework involves describing six elements of a global change affecting SSF including state, stressors, change, impact, adaptive capacities, and responses of the natural (N), social (S), and governing (G) systems (Bundy et al. 2016). The case study used for this research focuses on bycatch impacts on the vulnerabilities of both small-scale fishers and cetaceans, making bycatch the stressor central to the case study. As seen in Figure 1, overfishing and increased fishing effort could be considered exogenous drivers which directly impact bycatch and how it's managed – the stressor investigated for this research. Bycatch as well as how it's managed could be considered vulnerabilities faced by SSF as small-scale fishers are currently unable to cope with its negative effects due to bycatch policies not being appropriate for its complexity. This research aims to describe the impact of bycatch and its' management on all N, S, and G systems, as well as the capacities of all three systems to address the impacts of bycatch through appropriate cetacean bycatch governance.

Any responses of governing systems to adapt to or mitigate the impacts of bycatch – focusing on bycatch policies and potential bycatch governance processes are investigated throughout this report. Responses of governing systems to bycatch may be different depending on the nature and extent of cetacean bycatch within the social-ecological system (Bundy et al. 2016). This research focuses on main factors inhibiting the success of bycatch policies which is an important detail captured in the I-ADApT framework by recognizing different scales and institutional levels of action (Bundy et al. 2016). The choice of response depends on the characteristics of all three systems as well as their adaptive capacities – with outcomes determining the ability of the social-ecological system to deal with the stressor (Bundy et al. 2016). In this case, the stressor is bycatch and therefore in order to achieve a desired outcome for both SSF fisher and cetaceans all three systems need to be investigated as seen in Figure 1.

The Conservationscapes framework provides more focus on the local scale with identifying proximate attributes characterizing the seriousness of the conservation threat (bycatch), as well as the behaviours of resource users causing the threat (SSF fishers) (Whitty, 2018). As seen in Figure 2, the Conservationscapes framework investigates the social and governing systems with more focus on motivations of resource users as well as how governance and regulations impact resource user behaviour (Whitty, 2018). Since fisher-cetacean

interactions are so complex and impacted by the motivations of fishers it is important to integrate behavioural aspects into this research on how bycatch is defined. This is especially important as this research aims to determine mitigative and adaptive strategies for effective cetacean bycatch governance and policies which need support from fishers and proper representation of cetaceans as seen in Figure 3.

3.1.2 Case Study Approach

The purpose of this research was to determine how bycatch vulnerabilities of both cetaceans and fishers can be assessed and common strategies for their viability be developed. By adopting a transdisciplinary perspective this research will hopefully offer useful and holistic insights into this issue from both social and ecological perspectives. Due to the high complexity of bycatch impacts, the overarching methodological approach for my research will be a qualitative case-study approach. Case studies allow for an interpretive and qualitative approach to research, trying to find knowledge "inside" individuals instead of beyond them and learning through people's interactions and senses (Creswell & Miller, 1997). Case study research is debating upon due to case studies being very context specific with differing definitions and disagreements on both design and implementation (Yazan, 2015). This is also because everyone interprets the world and global events through their own lens, which is impacted by their beliefs and values, making case studies even more context specific depending on the individuals involved. However, they also enable researchers to see potential patterns and themes when compared across various case study sights (Barnett et al 2016). Case studies represent "bounded" systems such as an event or process, exploring participant views and what they experience (Creswell & Miller, 1997). They also help to provide general insights into factors influencing both collective action and governance outcomes (Barnett et al. 2016).

SSF in Chilika Lagoon which interact with the Irrawaddy Dolphin are the focus of this study. Chilika Lagoon in India was chosen due to the existing foundation of data on the Irrawaddy Dolphin population distributions in Chilika Lagoon as well as documentation of cetacean-fisher interactions (D'Lima et al. 2014). The Irrawaddy dolphin was specifically chosen as bycatch data and cetacean population data is very scarce and not recent for many other

cetacean species (Snape et al. 2018). Another reason this species was chosen is because their interactions with SSF and fishers have been investigated to a comparatively greater extent in some academic literature compared to other cetacean species, helping provide a holistic understanding of fisher-cetacean interactions (Whitty, 2018). Focusing on a single species has its limitations, as different species experience different levels of bycatch and due to their range in size are entangled in different types of fishing gear. However, since many cetaceans lack useable data and since this research was unable to complete field surveys for cetacean populations due to time constraints it is important for there to be available population information. The Chilika Lagoon case study and its natural and social subsystems will be explained in further detail below.

3.1.2.1 Chilika Lagoon Case Study

Chilika Lagoon is a brackish water located in Odisha State on the east coast of India close to the Bay of Bengal and is the largest lagoon in India (Nayak and Berkes, 2014) (Figure 4). A unique combination of biological and human systems characterizes the lagoon ecosystem (Nayak, Oliveira, & Berkes, 2014). Over 400,000 caste-based fishers and approximately 150 villages make up the human system of the lagoon with 225 fish species, 800 other species of fauna, and around 710 species of plants (Nayak, Oliveira, & Berkes, 2014). The Chilika Lagoon ecosystem is also unique due to Chilika environments ranging in salinity from fresh to brackish to saline which helps to form a very productive ecosystem (Ghosh et al. 2006). This ecosystem faced a major shock in 2001 with the creation of an artificial seamouth opening into the Bay of Bengal, this intervention caused dramatic changes to the ecosystem (Nayak, Oliveira, & Berkes, 2014). Despite this shock to the ecosystem Chilika lagoon is still considered to be high in productivity as well as a biodiversity hotspot and designated Ramsar site (D'Lima, 2014). The lagoon also encompasses a migratory bird sanctuary for water birds and is home to a number of animals on the IUCN Red List of Threatened Species including the Irrawaddy dolphin (*Orcaella brevirostris*) (D'Lima, 2014, Ghosh et al. 2006). A social-ecological systems approach was used to evaluate this case study area further, focusing on economic and cultural elements within the social subsystem, as well as biotic and abiotic processes impacting food webs and climatological

characteristics of the natural subsystem (Nayak, 2014). The details of the natural and social subsystem in Chilika Lagoon will be explained in further detail below.

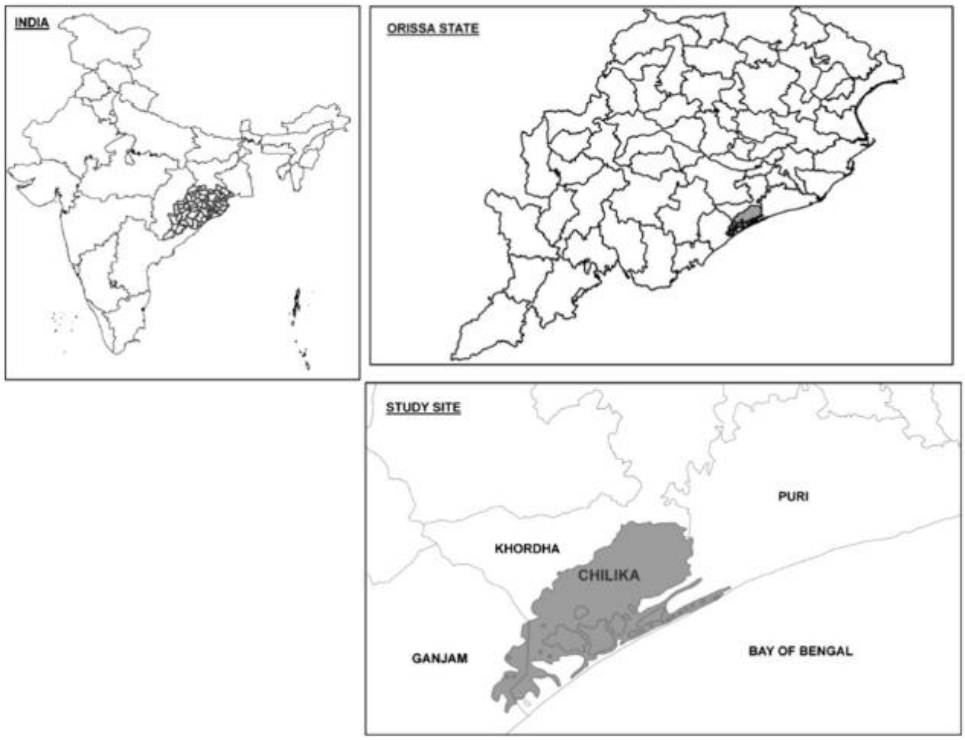

Figure 4. Location of Chilika Lagoon, Odisha, India (Nayak & Berkes, 2014, pg.2070).

3.1.2.1.1 Natural subsystem

A major component of the natural subsystem in Chilika Lagoon is the presence of the Irrawaddy dolphin as it is considered a flagship species for the area (Sarkar et al. 2012). The Irrawaddy dolphin population in Chilika is one of five subpopulations of freshwater Irrawaddy dolphins in Asia (Smith et al. 2007). Small populations of Bottlenose dolphins (*Tursiops*) and Indo-Pacific humpback dolphins (*Sousa chinensis*) have been seen venturing into the mouth of the lagoon from the sea, however Chilika fishers explain that the Irrawaddy dolphins usually get frightened by these populations and retreat back to the lagoon (Sarkar et al. 2012; Smith & Tun, 2007). In Chilika Lagoon, the Irrawaddy dolphin falls under Schedule 1 of the Indian Wildlife (Protection) Act, 1972 and is also considered Endangered by the IUCN Red List Authority (Minton et al. 2018). Entanglement in fishing gears and collisions with mechanized boats are the main threats faced by this population (Smith & Tun, 2007).

The Chilika Lagoon Irrawaddy dolphins are very isolated with the dolphins occupying two core areas of the lagoon, with the main core area being the Outer Channel of the lagoon as these areas are important feeding grounds for the dolphins (Figure 5) (D'Lima, 2014). No dolphins have been located in the Northern sector of the lagoon, with dolphins staying close to the Outer Channel as this is where the sea mouth connects to the main lagoon (Sutaria & Marsh, 2011). Irrawaddy dolphins in Chilika Lagoon continue to be vulnerable to human communities due to their high overlap with resource extracting human activities like fishing (D'Lima, 2014). Dolphins forage in the areas fishers deploy their gear because the dolphins hunt after the same fish and invertebrate resources as local fishers: Irrawaddy dolphins in Chilika are particularly drawn to permanently installed stake nets in the lagoon (D'Lima et al. 2014).

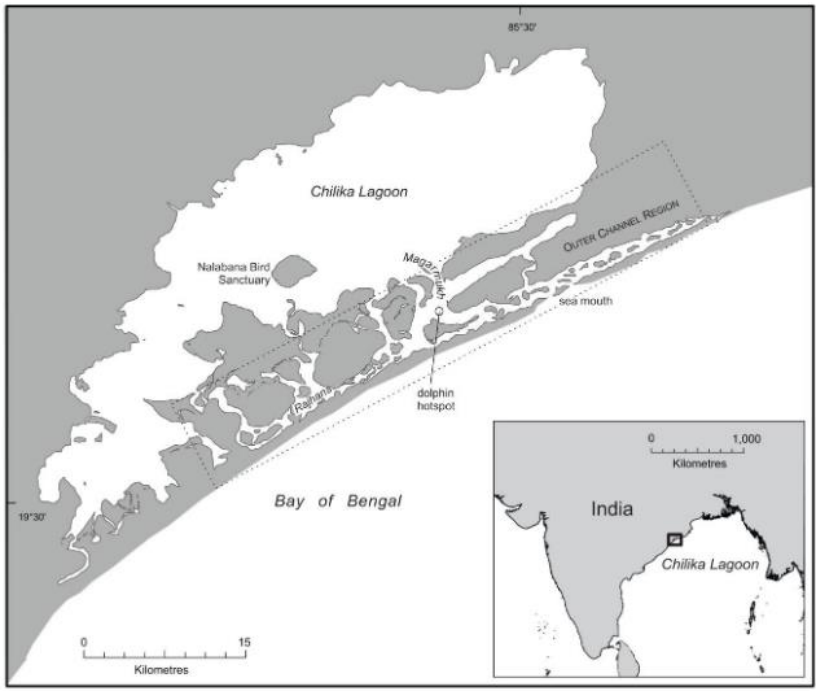

Figure 5. Map of Chilika Lagoon, showing the dolphin hotspot in the Outer Channel (D'Lima 2014, pg.15).

As previously mentioned, the ecosystem in Chilika is very unique and the primary productivity of the area is highly dynamic, seasonally high only close to the shore and can be very unstable due to climatic events such as cyclones (Sutaria, 2009). The salinity of the Chilika Lagoon ecosystem is an important factor in determining the lagoon's ecology with reduced salinity causing significant changes in fish catch composition and quantity (Ghosh et al. 2006). Much of the lagoon is made up of muddy substrate, however it is also made up of important

sea grass beds (Sutaria, 2009). The seagrass ecosystems in Chilika Lagoon are considered one of the two major seagrass ecosystems on the east coast of India (Ganguly et al. 2017). Coastal vegetative seagrass ecosystems have high effective rates of annual carbon sequestration as well as storage of sequestered carbon (Singh et al. 2015). With both SSF fisher livelihoods and the Irrawaddy dolphin subpopulation being dependent on the productivity of the Chilika Lagoon ecosystem, it is important to understand the characteristics of its' natural subsystem as well as social subsystem.

3.1.2.1.2 Social subsystem

Due to its high productivity, Chilika Lagoon provides the main livelihood to over 200,000 fishers across 150 fishing villages located around the lagoon (Nayak, 2014; Nayak & Berkes, 2010). Fishing has become the main livelihood for local community members in Chilika, with many locals changing their occupations to fish since it was a very profitable livelihood option (D'Lima, 2014). Prior to 1980 fishing in Chilika was mainly based on capture fisheries, and traditional fishers were allowed to extract resources from the lagoon (Nayak, 2014). However, after 1980 due to the growth of the international tiger prawn market, fishing in the lagoon became even more profitable which led to the development of prawn aquaculture, and consequently, the fishing culture in Chilika shifted from capture to culture (D'Lima, 2014; Nayak, 2014). The encroachment of traditional fishing areas by non-traditional fishers was challenged by traditional fisher cooperatives, leading to the ban of shrimp aquaculture in 1997 (D'Lima, 2014). However, illegal shrimp aquaculture continues in Chilika and has led to the marginalization of traditional fishers as well as the "decommonisation" of Chilika Lagoon (D'Lima, 2014; Nayak, 2014; Nayak & Berkes, 2010).

As previously mentioned, in 2001 the creation of an artificial seamouth opening into the Bay of Bengal caused dramatic changes to the Chilika Lagoon ecosystem (Nayak, Oliveira, & Berkes, 2014). This opening of the new sea mouth also impacted fisher livelihoods and out-migration due to sudden, excessive salinization of their fishing areas (Nayak, 2014). In order to cope with both the growth in shrimp aquaculture and the opening of the sea mouth, fishers in Chilika turned to intensification of fishing (ex. changing gear, no fishing restrictions, etc.) as well as extensification of fishing (ex. travelling farther distances, catching all available species, selling

both sea and freshwater species, etc.) to protect their livelihoods (D'Lima, 2014). These strategies used by fishers to cope with their marginalization are likely to impact the endangered subpopulation of Irrawaddy dolphins and their conservation in Chilika Lagoon (D'Lima, 2014).

3.2 Transdisciplinary Research, Social-ecological Systems Perspective, and Knowledge Sharing

This research aims to provide a transdisciplinary as well as bottom-up approach to analysing the drivers impacting both fishers and cetaceans, specifically within SSF. Transdisciplinary and social-ecological systems perspectives work hand in hand by focusing on natural and social subsystems as well as the governance factors that influence both subsystems and how they interact with one another. Small-scale fishers and cetaceans are both extremely vulnerable to outside drivers and strongly connected due to their closely shared environment and resources (Whitty, 2018). A social-ecological systems perspective recognizes the role humans play in shaping ecosystems as well as examining economic, cultural, institutions and policies within the social subsystem and biotic and abiotic processes impacting the natural subsystem like food webs (Nayak, 2014). If both fishers, cetaceans, and their shared environment are to remain viable for the long-term, social-ecological complexities of bycatch interactions need to be evaluated for effective solutions to be developed. Potential solutions will focus on direct involvement of small-scale fishers in both fisheries management and governance, as well as innovative policies and governance for bycatch of cetaceans as this is severely lacking.

This research approaches cetacean bycatch with the intent of finding ways to work with and adapt to cetacean interactions in a dynamic social-ecological system context, instead of solely focusing on avoidance and mitigation which is the current widespread mindset when dealing with bycatch. The findings of this research will be shared with local communities in Chilika Lagoon, allowing fishers and other local stakeholders to evaluate the research findings and provide further insights on bycatch issues. This research is meant to be easily understood by all who read it, no matter their scientific background. In order for effective knowledge sharing to take place all social, natural, and governance aspects of bycatch must be better understood by all stakeholders involved.

3.3 Data Collection Methods

The methods used will aid in helping to understand the critical linkages between cetacean bycatch and its impact on vulnerability and viability of SSF. Three methods were used, including an extensive literature review in combination with a policy analysis, followed by multi-stakeholder surveys and semi-structured interviews with key experts on cetacean bycatch. The literature review as well as policy analysis helped to better understand the nature and extent of cetacean bycatch as well as investigate current bycatch management and policies. Multi-stakeholder surveys with fishers and fisheries management helped cover a broad scope of perspectives on the state and urgency of cetacean bycatch in SSF. Semi-structured interviews allow for a co-production of knowledge on cetacean bycatch impacts by collecting information from key bycatch experts. The case study was thoroughly investigated – collecting policy, survey, and interview data. This data will help to support the overall complexity and urgency of bycatch fisher-cetacean vulnerabilities.

3.3.1 Literature Review and Policy Analysis

A detailed literature review was completed (see Chapter 2 for more details) investigating four areas of literature with many overlapping concepts which aid in determining critical linkages between cetacean bycatch and its impact on vulnerability and viability of SSF. These areas of literature include vulnerability to viability, SSF as a social-ecological system, bycatch, and fisheries governance. Both peer-reviewed and grey literature were investigated. Vulnerability to viability literature provides important information on the drivers which impact both small-scale fishers and cetaceans. Investigating SSF through a social-ecological system approach aids in illustrating the increased connectivity and complexity of fisher-cetacean interactions and relationships. Bycatch literature contains vast information on bycatch mitigation techniques and technologies. However, much of this research is focused on natural sciences and does not provide a political or social context. This is where grey literature including reports on bycatch workshops, bycatch policy recommendations, as well as fisheries management guidelines provide a wider scope of information on how bycatch is being managed. However, this review is limited as literature on bycatch governance is severely lacking which is why fisheries governance was chosen as the fourth area of literature. Fisheries

governance literature provides useful information on management techniques and how fisheries management decisions or policy changes may impact cetaceans.

A policy analysis of current fisheries cetacean bycatch policies at both the industrial and SSF level was completed to understand potential strengths, areas of improvement as well as weaknesses. Policy analysis involves providing advice to transform existing policies in order to better solve problems, using the results to inform decision-making (Coulthart, 2017). This involved the analysis of grey literature and government reports as academic literature on cetacean bycatch governance data is severely limited and/or not available for some areas. Government reports of all scales (local and national) pertaining to fisheries management were investigated – especially any directly related to bycatch mitigation strategies as well as any bycatch guidelines. How bycatch is defined and whether or not cetaceans are properly represented was also investigated. How bycatch is managed and what is expected of fishers when bycatch occurs was also investigated. This will help determine potential strategies for bycatch governance and policies as there needs to be a thorough understanding of how bycatch is currently represented within global fisheries policies and guidelines. Although bycatch is very complex, it is assumed that general bycatch policy guidelines and advice may still be applicable and useful as an in-depth analysis of bycatch policies for cetaceans is currently lacking.

3.3.2 Multi-stakeholder Surveys

Surveys took place in Chilika Lagoon, India within SSF communities which interact with Irrawaddy dolphins. The villages involved in the surveys included: Brahmapur, Khatisahi, Sipakuda, Satapada, Mayensha, Alu Patana, Mirjapur, and Gabakunda. All these villages are in the Outer Channel of Chilika Lagoon as this area is the preferred habitat for Irrawaddy dolphins (Figure 6) (Sutaria & Marsh, 2011). Surveys helped in capturing a wide range of perspectives on cetacean bycatch including fishers, tourism, and fisheries management. Surveys seek to create meaning just as interviews do, however they involve standardization procedures which restrict interviewee responses (Kelley-Quon, 2018). This allowed for the surveys to be completed with a wider range of participants and took less time compared to interviews. Surveys can take place

with interviewers however, they are not allowed to influence answers in any way and are given standardized questions they need to follow exactly (Sue & Ritter, 2011).

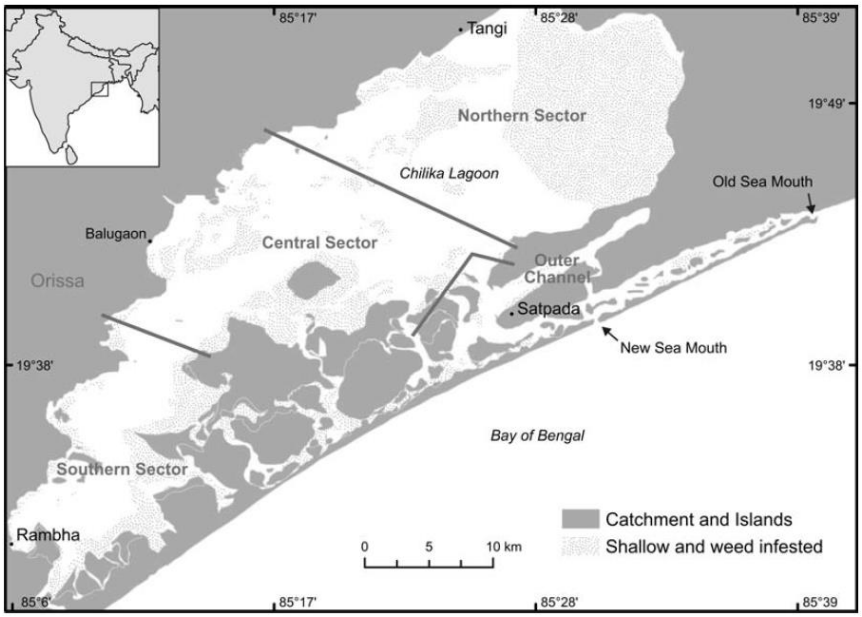

Figure 6. Chilika Lagoon, Orissa India showing different sectors of the lagoon and the location of Satpada which was one of the villages involved in this study. (Sutaria 2009, pg.26).

Due to pandemic related travel restrictions all surveys took place in an online format, as well as through a community researcher hired through the V2V Global Partnership. Community researchers taking part in questionnaires went through two rounds of training. They were trained remotely by the lead researcher on methodology as well as the goal of the research and questionnaires. Each question was examined, creating a clear understanding of its intended purpose. The answer options were created by the main researcher based on information learned from the literature review as well as the insights of the community researchers. Community researchers also took part in mock surveys to find any discrepancies or issues with the questionnaire and its delivery. The community researchers were also responsible for translating questionnaire data after it was recorded for interpretation by the lead researcher.

Survey participants were sampled from SSF local community households, using random sampling and snowball sampling techniques. Random sampling was utilized by choosing phone-numbers from a curated list provided by the V2V Global Partnership when selecting individual

respondents. Snowball sampling was also used through fisher and other stakeholder networks – taking advantage of any connections with useful knowledge on cetacean bycatch. Criteria for survey participants included anyone with an active role in the fisher-cetacean social-ecological system (either as a fisher or through management, policies etc.) as cetacean bycatch is the focus of this research. Participants selected have been fishing in the area for 10 years or more (or have historical knowledge through other family members) as the purpose of this research is to investigate any changes/adaptations in interactions with cetaceans. Participants also had to have historical knowledge of or be personally familiar with fisher-cetacean relationships in the area.

Surveys (n = 50) were completed with fishers and other local stakeholders in the SSF villages previously mentioned. A questionnaire using the I-ADApT Case Study Template as a guide for questions was used for surveys (see Appendix A). This allows for this research to be more easily compared among V2V Global Partnership case studies/sites as well as helped the research provide new insights on bycatch. Closed-ended questions were used however notes were taken on more in-depth answers to collect both quantitative and qualitative data. Currently it is unknown what strategies are possible for both cetaceans and small-scale fishers to remain viable for the long-term, especially with human-dimensions of bycatch not being well understood. Therefore, the descriptive survey design was used to collect data for better understanding the bycatch phenomenon being researched (Kelley-Quon, 2018).

3.3.3 Semi-Structured Interviews

To deepen understanding of cetacean bycatch impacts and engage SSF communities, online interviews were conducted with key bycatch researchers. Key bycatch researchers included researchers with both natural and social perspectives on bycatch issues. Completing these interviews helped in determining appropriate cetacean bycatch policy and governance implementation strategies. Semi-structured interviews do take more time and effort compared to other methods such as surveys, however they also allow for the interviewee to be more engaged and provide more detailed answers (Machado et al. 2019). More detailed responses on bycatch issues are important for this research as one if its main goals are to provide new

innovative insights on potential bycatch solutions using a transdisciplinary lens. Online interviews through Microsoft Teams were used since travel was highly restricted to due the COVID pandemic. Online alternatives for interviews include using Skype and/or phones depending on levels of internet accessibility. Conducting Skype or FaceTime interviews allow for participants to be contacted worldwide in both a time efficient and affordable manner (Lo Iacono et al. 2016). Semi-structured interviews with registered fishers are a common method in cetacean-fisher research, allowing for both open-ended and closed-ended questions and/or multiple choice (Machado et al. 2019, Paudel et al. 2016, Mustika et al. 2014). Due to COVID pandemic restrictions only key bycatch experts were involved in the online semi-structured interviews. As interviews do take longer compared to surveys, semi-structured interviews followed more specific criteria for key informants, trying to cover bycatch perspectives from various countries.

Sampling for key informant interviews involved reaching out to key bycatch researchers through their published papers as well as through online researcher groups. Participants chosen have strong background knowledge on cetacean bycatch as well as talking directly with fishers in the case study area(s) they have researched, in order to provide more in-depth insights. Interviews with international experts outside of India (n = 5) included bycatch researchers from Canada, US, AUS, Bangladesh, and Brazil. Bycatch researchers from India (n = 5) were a focus due to the case study of Chilika Lagoon being in India. Therefore, a total of 10 online semi-structured interviews were completed with half the research participants being key bycatch experts from India. The participants are considered bycatch experts either through their own research, community experiences, or role in fisheries management etc. The semi-structured interview questionnaire was more focused on the research objectives, following the framework in Figure 3 as well as relevant fisher-cetacean interaction studies and their methodological approaches (see Appendix B).

3.4 Data Analysis

Qualitative data analysis is a “dynamic and creative process of inductive reasoning, thinking and theory” (Basit, 2003). Due to the COVID pandemic and not being able to travel, I

analysed the data based off knowledge acquired from the literature review and policy analysis, as well as information learned from community researchers.

3.4.1 Multi-stakeholder Survey Analysis

While the multi-stakeholder surveys were taking place, I received updates from community researchers on any insights or observations while conducting surveys. When survey data was received, the answers provided by survey participants were calculated into percentages using Microsoft Excel spreadsheet according to the category chosen. This was possible since the survey was completed with closed-ended questions and community researchers documented the categories of answers chosen by each survey participant. Additional notes were also taken during surveys to capture any in-depth responses not captured by the response options. Calculating percentages of responses for each survey question helped to analyse the data and reveal patterns in responses from all survey participants. Some quotes were also recorded to provide more direct insights from fishers as well as help to better tell their stories and opinions on bycatch.

3.4.2 Semi-Structured Interview Analysis

Data collected from semi-structured interviews with key bycatch experts were categorized into themes based on common bycatch related research findings I learned from the literature review. Each answer provided by interview participants for each question was analysed line by line, coded and grouped into categories and subcategories based off the answers of interview participants using the NVivo software. The NVivo software helps to conceptualize data by allowing the researcher to select text from interview responses and easily link the text to significant themes and recording them through codes (Azeem & Salfi, 2012). Some interview responses from participants provided more than one theme of answer for a question, increasing common themes of responses. It is important to link similar ideas from different interview participant responses (Azeem & Salfi, 2012). With multiple themes emerging from interview responses, valuable data was collected and analysed. Comparing all the interview respondents' answers helped to identify similarities and differences in their responses for each question (Azeem & Salfi, 2012). The data analysis from key bycatch expert

interviews helped to determine the critical linkages between cetacean bycatch and its impact on vulnerability and viability of SSF. This was especially evident when fisher survey responses were compared to key bycatch expert interview insights.

3.5 Limitations

The limitations of this study include context specificity of case studies, sampling, biases, as well as COVID pandemic restrictions. The case study approach used has its own limitations as it is very context specific which can make comparing case studies difficult (Yazan, 2015). With bycatch itself being very context specific and highly dependent on fisher-cetacean relationships the issues of cetacean bycatch add to the context specific nature of a case study approach. Also, the Irrawaddy dolphin subpopulation in Chilika Lagoon has a unique relationship with fishers since they cooperatively fish with one another (D'Lima, 2014). Since cooperative fishing with cetaceans is a rare practice and is the focus of the case study it could be seen as a limitation.

The sample size for key bycatch experts involved in semi-structured interviews was small, with only 10 participants. This small sample size was due to time constraints. It is common for single case studies to have fewer than 20 interviews, however this may impact whether theoretical saturation is reached (Marshall et al. 2013). Therefore, it is important to note that the perspectives of key bycatch experts explained in this research only refers to the 10 bycatch experts interviewed for this study. The key bycatch experts interviewed for this study do not represent the views of all key bycatch experts globally. Also, it should be noted that half the bycatch experts interviewed specialize in bycatch research in India. It is important to note that there are many differing perspectives on bycatch and how it should be managed. This is especially true as everyone interprets the world and global events through their own lens, which is impacted by their beliefs and values (Galdas, 2017). The fact that ecological, social, economic, and cultural drivers also influence local perceptions and worldviews (D'Lima et al. 2014). Bias is inevitable when completing qualitative research and instead of trying to convince that qualitative work is opinion-free and neutral, the unique value of knowledge acquired from qualitative research could be incorporated within systems operating through an "evidence-based decision-making lens" (Galdas, 2017).

This research took place during the COVID pandemic which could have impacted the results of this study in a unique way. This research may have been impacted since it is qualitative and focuses on fishers. The COVID pandemic has had extensive social and economic effects, especially for small-scale fishers and their communities as there were complete shutdowns of fisheries, negative effects from market disruptions, increased health risks for fishers, as well as an increase in Illegal, Unreported, and Unregulated (IUU) fishing (Bennett et al. 2020). COVID pandemic impacts on SSF in India could have impacted Irrawaddy dolphin abundances and distribution in Chilika Lagoon since the dolphins' forage at stake nets by herding fish from deeper channels, using the nets as a physical barrier (D'Lima et al. 2014). Therefore, with fisheries being directly influenced by the COVID pandemic the results of this study may have also been impacted.

3.6 Ethics

This research project received full ethics clearance from the University of Waterloo Office of Research Ethics under ORE #43532 on August 24, 2021 (Appendix C).

3.7 Researcher's Reflections

Being the main researcher and not being able to work in the field was difficult since I was not able to experience the local culture and environment. Working remotely made me feel disconnected from the research. Working directly with fishers would have been beneficial for this research for the main researcher to have a better understanding of Chilika fisher stories and experiences. However, I feel as though it was beneficial for data collection as Chilika Lagoon is rich in its culture so fishers would have been more comfortable interacting with the community researchers' verses someone outside of their community who does not speak their language. The community researchers did an amazing job transcribing and collecting survey data, and it was straightforward for me to analyze the data and understand the opinions of Chilika fishers. Working remotely also allowed me to complete semi-structured interviews with key bycatch experts from different countries around the globe which may have not been possible if I was completing field work. Therefore, although it was difficult for me as the main researcher to feel connected to the Chilika fishers and Irrawaddy dolphins since I could not

interact with them in the field, I do believe that due to the community researchers and their hard work as well as being able to complete online interviews, the quality of this study and its results improved.

Chapter 4

Understanding Cetacean Bycatch and its Social-Ecological Linkages

4.1 Introduction

This chapter will investigate the nature and extent of cetacean bycatch and its social-ecological impacts within a fishery (D'Lima et al. 2014; Komoroske & Lewison, 2015; Lewison et al. 2018). The term "social-ecological" will be used in this report to replace the phrase "social, political, and ecological" factors. There can be no single solution to bycatch since the management of bycatch is linked to local (and global) conditions (Komoroske & Lewison, 2015). This means that certain adaptation strategies for bycatch may work for one SSF community but not another (Alava et al. 2019). Adaptation strategies which target unjust decision-making processes and lack of proper access may be useful in some SSF areas to help small-scale fishers protect their local resources and natural systems (Nayak et al. 2016). However, this may not be the case for all SSF which is why we must first understand the nature and extent of the bycatch problem as well as the social-ecological connections which will be discussed in further detail below.

Whether or not cetaceans are highly valued by the local community can greatly impact efforts for their conservation (Bashir, 2010). Societal linkages of cetacean bycatch issues can be particularly complicated since the value of cetaceans is influenced by a variety of factors including their aesthetic, ecosystem services, as well as cultural and religious significance (Bashir, 2010). Cultural and traditional values and benefits sometimes outweigh profitability in some SSF (Schuhbauer et al 2019). However, this is not the case in all SSF communities as cetaceans are not so highly valued in all areas, even where they have local cultural significance. The Ganges River dolphin (*Platanista gangetica*) in India is revered by some fishers but is still poached for their oil, while the Irrawaddy dolphins in Chilika Lagoon are also considered a religious symbol and are not intentionally harmed by any fishers in Chilika (Bashir, 2010). This difference in value and fisher-cetacean relationships shows that although cultural and religious significance are important in some SSF areas for protecting cetaceans against bycatch, there are other local social-ecological factors that must be considered.

Other social-ecological factors which must be taken into consideration when investigating bycatch include societal wellbeing. Components of social wellbeing are important to analyse as they are a critical element of SSF as well as the maintenance of livelihoods (Weeratunge et al. 2013;). This is especially true as the coastal wellbeing of fishers is intrinsically linked to ecosystem services (Blythe et al. 2020; Schuhbauer et al. 2019). The concept of wellbeing involves three key components including material, relational, as well as subjective dimensions which are relevant to social-ecological systems and can help to better assess social-economic issues within the context of fisheries governance (Weeratunge et al. 2013). Cetacean bycatch may impact the wellbeing of fishers and SSF communities, especially in areas with cooperative fishing due to the ecosystem services they provide, and efforts to mitigate cetacean bycatch also have potential to impact SSF well-being through disruption of fishing practices (Machado et al. 2019).

Political aspects of cetacean bycatch issues are highly connected to the social-ecological linkages discussed above. Policies will not remain effective for the long-term if they do not align with societal values and lack the support of the local community they impact (Alava et al. 2017), especially if there are insufficient means for broad enforcement. This is especially true for policies used for cetacean protection against human activities like bycatch. There have been many cases where a specific fishing area is closed off, or a certain fishing practice is banned to protect cetaceans, without any discussion with the local community (Alves et al. 2012). The most well-known example of this is the attempt to protect the Vaquita (*Phocoena sinus*) which did not involve the broader local community, resulting in conflicts among stakeholders which debilitated efforts for conservation, with the Vaquita remaining Critically Endangered to this day (Cisneros-Montemayor & Vincent, 2016). It does not make sense to expect small-scale fishers to cooperate with bycatch management strategies when their main livelihood and source of income is negatively impacted with no type of compensation or support for alternative livelihood pathways that meet their needs and priorities. This becomes increasingly complicated since bycatch can also occur in legal nets, which makes proving the intent or motive of the fishers more difficult (Kelkar & Dey, 2020). Due to such unjust decision-making

processes and lack of proper access rights, small-scale fishers are unable to effectively protect their local resources and natural systems (Nayak et al. 2016).

Ecological components of cetacean bycatch issues on the natural system are hard to identify with so many external factors influencing local ecology and the vulnerability of SSF. Bycatch is linked to many external factors increasing the vulnerability of SSF including overfishing and the encroachment of industrial fisheries (Nayak et al. 2016). This makes it difficult to understand and pinpoint which exact ecological impacts on SSF are because of cetacean bycatch alone. Cetaceans are part of the natural system and are considered top predators as they help to control smaller populations through their diet (Spitz et al. 2018, Heithaus et al. 2013, Dans et al. 2010). Large cetaceans (baleen whales and large toothed whales) are especially important for nutrient cycling due to their larger sizes and migration patterns which help to physically mix our oceans by bringing up nutrients from the ocean deep (Lavery et al. 2014, Roman & McCarthy, 2010). However, there are still large gaps of knowledge pertaining to small cetaceans (dolphins, porpoises, and small toothed whales) and the importance of their roles in aquatic ecosystems, making relying on this form of "value" risky as endangered subpopulations may be too small to have any substantial ecosystem impacts (Kiszka et al. 2022).

However, although the impacts of bycatch and loss of cetaceans in aquatic ecosystems is uncertain, the precautionary principle involves taking preventative action in the face of uncertainty. The precautionary principle should be incorporated when addressing bycatch issues to create opportunities for scientists and policy makers to think differently about the ways to try and manage bycatch (Kriebel et al. 2001). Due to the uncertainty of the natural system impacts of bycatch, the precautionary approach will help to highlight challenging social-ecological linkages and stop delaying decisions on the management of endangered species (Slooten & Davies, 2012; Kriebel et al. 2001; Slooten et al. 2001).

The following subsections will go through the results of both Objectives 1 and 2 of this study: (1) understanding the nature and extent of cetacean bycatch, and (2) how cetacean bycatch and its' mitigation add to the vulnerabilities of the social-ecological system. Fisher-

cetacean relationships are investigated through a social-ecological systems perspective since the relationship fishers have with cetaceans influences how fishers view bycatch, and species-focused conservation must connect to broader human dimensions (Whitty, 2018). The results discussed will focus on both the natural and social subsystems of the fisher-cetacean relationship. This was investigated in the case study site in Chilika Lagoon through surveys with fishers, as well as semi-structured interviews with key bycatch experts from both India and other countries around the world. Perspectives from both research groups will be compared below in order to provide new multi-dimensional insights on bycatch issues. It is important to identify whether fishers and key bycatch experts share the same understanding of bycatch and its social-ecological linkages because researchers/key experts and their opinions are often used to inform policies (Kriebel et al. 2001). Since key bycatch experts are the ones with more power to influence policies and fishers lack access rights and access to decision making (Nayak et al. 2016), it is important for those implementing fisheries policies to engage with local fishers. By comparing knowledge of fishers with key bycatch experts we will better understand the nature and extent of cetacean bycatch, as well as how differing levels of cetacean bycatch add to the vulnerabilities of fisher-cetacean relationships.

4.2 Results: Understanding the Nature and Extent of Cetacean Bycatch within SSF

To understand the nature and extent of cetacean bycatch with the social-ecological system (SSF) it is important to talk directly with the fishers who interact with cetaceans. Focusing on areas of Chilika Lagoon with Irrawaddy dolphins and cooperative fishing provided unique insights on fishers and their relationships with cetaceans. These findings offer an interesting exception to the widely accepted notion that all SSF greatly contribute to cetacean bycatch (Dewhurst-Richman et al. 2020; Mangel et al. 2010; Jarmillo-Legorreta et al. 2007). Through the completion of the literature review it seemed that bycatch incidents of cetaceans are common and bycatch rates have continued to increase worldwide (Thompson et al. 2000). However, in Chilika Lagoon this does not seem to be the case.

The following section will go through social-ecological survey questions which were completed with fishers in Chilika Lagoon. These questions were created using the I-ADApT template (see Appendix A). This section will also include insights from key bycatch experts who

participated in semi-structured interviews with questions tailored to Objective 1 (see Appendix B). Both responses will be compared to provide new multi-dimensional insights on bycatch and embrace the wide range of perspectives on the issue. By comparing answers from both groups, it will also show whether there is a connect or disconnect between what fishers perceive to be bycatch and what the interviewed key bycatch experts believe. As previously explained, the opinions of the key bycatch experts interviewed are not representative of all key bycatch experts around the globe since there are many differing perspectives on bycatch.

4.2.1 Defining bycatch and what fisher-cetacean interactions are involved

Depending on who you ask, bycatch can mean a variety of things. The most common way to describe bycatch is the "incidental capture of non-target species" (Berninsone et al. 2020). However, as previously explained, this definition does not do well in capturing the complexity of bycatch. Some also explain bycatch to be "accidental" verses "incidental" (Votier & Sherley, 2017, Souza 2013). Looking into the definition of "accidental", this word may suggest that there was a level of carelessness, while "incidental" means that bycatch would have happened no matter what was done. Because of these varying definitions it is important to have a proper understanding of the word bycatch and what exactly it implies in the real world.

Both fishers and key bycatch experts were asked what bycatch of cetaceans means to them. This was an important question since the way bycatch is defined impacts the way it is managed which will be discussed in further detail in Chapter 6. As seen in Figure 7, both fishers and the interviewed key bycatch experts explained bycatch to be accidental and unavoidable, as well as involve non-target/unwanted species. Figure 7 also shows how some fishers consider bycatch to be a source of income, however key bycatch experts explain that bycatch species cannot be used for economic gain and must be discarded. Bycatch species cannot be used for economic gain because they cannot be caught intentionally, especially as a source of income. Also, fishers mainly consider bycatch as interactions causing death. However, key bycatch experts not only consider death to be a feature of bycatch, but also the injuring of the animal. Many injuries sustained from bycatch interactions can lead to cetacean death.

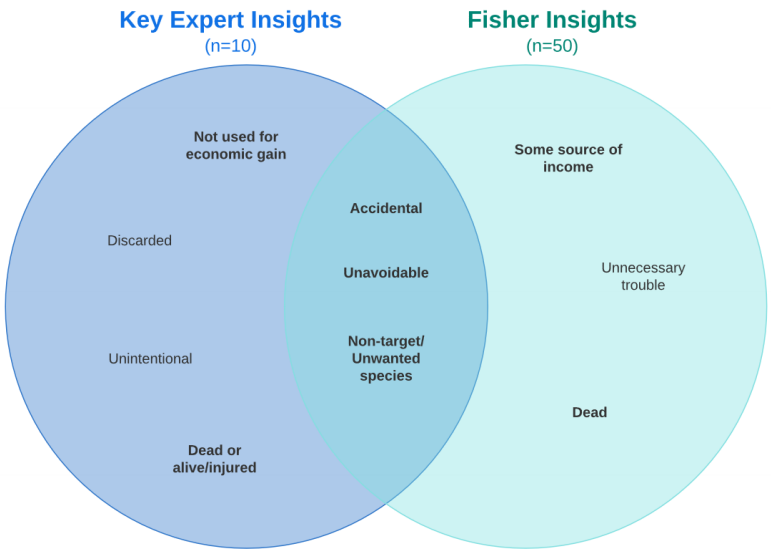

Figure 7. Venn diagram comparing themes which emerged from key bycatch expert interviews (n=10) and fisher surveys (n=50) on the question: what does the word "bycatch" mean to you? Bolded answers were the most common themes analyzed from each separate groups of participants. The overlapping terms represent commen themes mentioned by both fishers and key experts interviewed.

Fishers were asked what fisheries interactions they would consider to be bycatch, with 78% of fishers considering catching aquatic animals of considerable size to be bycatch (Table 1). "Of considerable size" included species such as water snakes, dolphins, and stingrays. However, some fishers still consider catching "commercially valuable" species to be bycatch (Table 1). Specifically, fishers explained how they have started to sell shark bycatch in black markets as well as some small fish species as a source of income. Fishers were also asked how frequently they face these types of bycatch interactions with 86% of fishers stating they rarely (maybe once a year) face such interactions as seen in Table 1.1.

Table 1. **What fisheries interactions would you consider to be bycatch? (Fisher surveys, n=50)**	
	% Of respondents
Catching water snakes, dolphins, stingrays, or other aquatic animals of considerable size	78
Catching commercially valuable species of secondary preference while targeting the primary preference (ex. Like catching small fish species while targeting shrimp)	14
Catching unwanted (and useless) juveniles of other valuable fish species while catching prawn juveniles	8

Table 1.1 **Of the above responses, how frequently do you face it? (Fisher surveys, n=50)**	
	% Of respondents
Rarely	86
Frequently	2
During certain seasons only	12
Never	0

4.2.2 How do bycatch interactions impact fisher-cetacean relationships?

Depending on the frequency and types of interactions, fishers may develop different relationships with cetaceans. In the context of Chilika, fishers were asked how often they interact with Irrawaddy dolphins (e.g., see the dolphins close to boats) while fishing. Around 86% of fishers stated that they interact with the dolphins every time they go fishing (Table 2). Some fishers (14%) stated that they only sometimes or rarely (maybe once a year) interact with the dolphins, or that they only interact with the dolphins in certain areas (Table 2). However, it is clear that most fishers surveyed in Chilika Lagoon interact with Irrawaddy dolphins on a regular basis while out fishing.

Table 2. **How often do you interact with Irrawaddy dolphins while fishing? (Fisher surveys, n=50)**	
	% Of respondents
Every time you go fishing	86
Only during certain seasons	0
Once every week	0
Never directly interact with the dolphins	0
Other… (ex. sometimes, ¾ times in a day, rarely, in certain areas, etc.)	14

Fishers in Chilika were also asked about their relationship with the Irrawaddy dolphins, with 100% of fishers stating they have a positive/good and friendly relationship with the dolphins. Key bycatch experts were also asked to describe the relationship fishers have with dolphins. All bycatch experts interviewed explained how highly contextual the relationship fishers have with cetaceans is (Figure 8). Interviewed bycatch experts brought to light how culture and religion, local environmental factors, and government interventions/restrictions greatly impact fisher-cetacean relationships (Figure 8). In areas like Chilika, fishers have traditional relationships with dolphins and consider them to be their Laxmi (goddess of wealth and prosperity) as seen in Figure 8. “Dolphin is Chilika's Laxmi and fishers' friend” explained one

fisher. Fishers in Chilika also consider Irrawaddy dolphins to be their livelihood (Figure 8) since they are friends and help each other fish. One fisher explained their relationship in further detail, "Since dolphin is bycaught, we get less income from fishing. Dolphins help us fish more. Dolphins rout fish out from deep water source, so it is easy to fish more and get more income. But now bycatch of dolphins or being injured, not possible to get more fish. We do more hard work but catch less fish." Key experts interviewed also pointed out how there are other SSF areas where fishers have negative and hostile relationships with cetaceans, making Chilika Lagoon a unique exception (Machado et al. 2019).

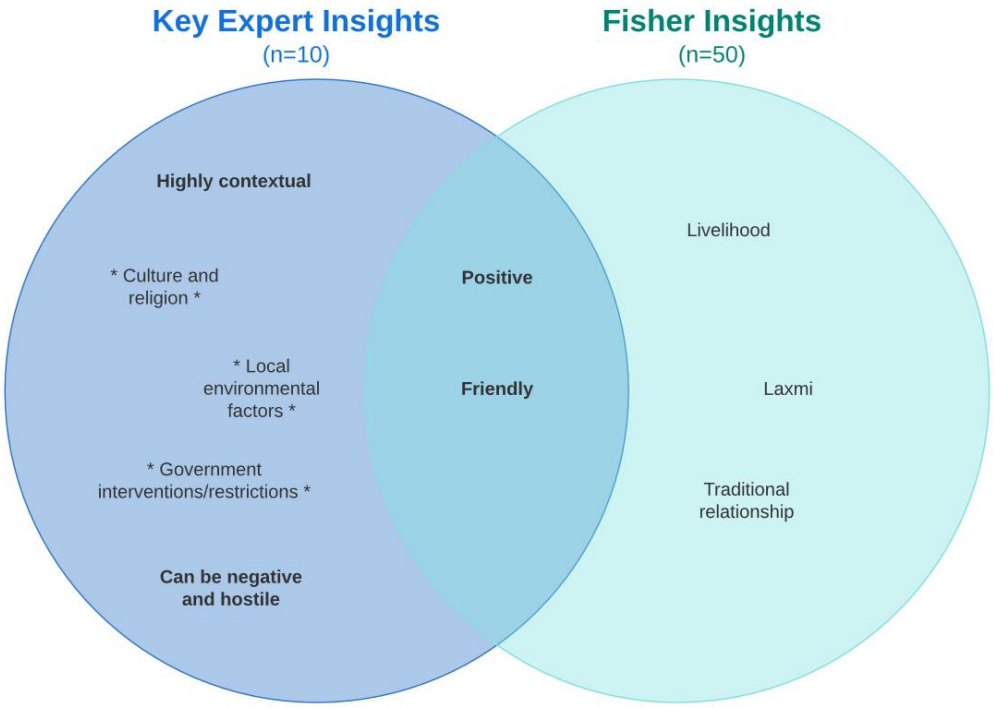

Figure 8. Venn diagram comparing themes which emerged from key bycatch expert interviews (n=10) and fisher surveys (n=50) on the question: can you explain the relationship fishers have with dolphins? (Case study site for fisher surveys: Chilika Lagoon, Odisha, India) Bolded answers were the most common themes analyzed from participants. The overlapping terms represent commen themes mentioned by both fishers and key experts interviewed. *Starred answers are common themes which impact whether fisher-cetacean relationships are positive or negative.

To assess the difference between unintentionally catching smaller sized bycatch species and larger species like cetaceans, fishers were asked whether they consider accidentally catching a seabird to be the same as catching an Irrawaddy dolphin. As seen in Table 3, majority of fishers (72%) consider catching a seabird to be the same as catching a dolphin. Fishers

surveyed in Chilika consider them to be the same since "we are heartedly connected with Dolphins and have traditional relation. We are sympathetic towards birds also. We let them be free hurting none of them." Another fisher explained that it is because "both lives are equally important." Other fishers surveyed (17%) do not consider accidentally catching seabirds to be the same as dolphins since dolphin bycatch events are so rare. The remaining fishers (11%) claim that bycatch of dolphins does not occur at all and that is why they cannot be compared to seabirds (Table 3).

Table 3. **Do you consider accidentally catching a seabird to be the same as catching an Irrawaddy dolphin during fishing operations? (Fisher surveys, n=50)**	
	% Of respondents
Yes	72
No	17
Other… (ex. Bycatch birds but not dolphins)	11

As previously explained, the *types* of interactions fishers have with cetaceans also impacts their relationship and vice versa. Fishers in Chilika were asked whether they felt as though Irrawaddy dolphin bycatch has become a threat to fishing operations. As seen in Table 4, 40% of the fishers surveyed believe that dolphin bycatch has become a threat to fishing operations. Fishers explain that this is because they face financial losses (damages to gear and catches) when dolphin bycatch occurs. However, 60% of fishers surveyed in Chilika do not believe dolphin bycatch to be a threat to their fishing operations (Table 4). These fishers (60%) do not consider dolphin bycatch to be a threat to fishing operations since bycatch events are so rare, and they consider dolphins to be their friends (Table 4).

Table 4. **Do you feel as though Irrawaddy dolphin bycatch has become a threat to fishing operations? (Fisher surveys, n=50)**	
	% Of respondents
Yes	40
No	60

4.2.3 How does bycatch *management* impact fisher-cetacean relationships?

The way bycatch is managed in an area tends to strongly impact the relationship fishers have with cetaceans as seen with the Vaquita (Cisneros-Montemayor & Vincent, 2016). Policies

are a big component of management and can potentially have a lot of power in terms of conservation and protecting oceanic species (Kelkar & Dey, 2020). However, this is only if policies are appropriately tailored to the area in question as well as the problem being addressed. Unfortunately, bycatch policies have yet to become effective in most countries (Moore et al. 2009). Some countries (ex. India, Brazil, Bangladesh) still do not have bycatch policies as noted in the key bycatch expert interviews. This is why fishers in Chilika were asked if they think it would be beneficial for fisheries policies to address different scales of bycatch and distinguish between bycatch of large mammals like Irrawaddy dolphins and smaller species like turtles and seabirds. As seen in Table 5, a significant 96% of fishers stated yes in support of such policies being implemented and adapted.

Table 5. **Do you think it would be beneficial for fisheries policies to address different scales of bycatch in policies and distinguish between bycatch of large mammals like Irrawaddy dolphins and smaller species like turtles and seabirds? (Fisher surveys, n=50)**

	% Of respondents
Yes	96
No	4

When key bycatch experts were asked whether they thought it would be beneficial for the definition of bycatch in fisheries policies to distinguish between different species there was a mix of responses. Over half of the key experts interviewed responded saying it would be good for management as bycatch needs to be defined much more clearly. The key experts interviewed also stated that since bycatch is so context specific it may not work for fishers in the real world. However, as seen in Table 5, fishers in Chilika are open to bycatch policies being adapted to distinguish between species. Although there was some skepticism from interviewed key experts if this specific adaptation to bycatch policies would be beneficial, it was agreed that how bycatch is defined in fisheries policies is very important and plays a big role in the management of bycatch. The need for bycatch policies to be adapted is also support by Chilika fishers (Table 5), with one fisher stating, “there should be government guidelines for safety of dolphins.”

Key bycatch experts were also asked how they think fishers view dolphin bycatch. Many respondents explained an unsustainable loop of harsh punishments on fishers for bycatch and

how it impacts reporting of bycatch incidents (Figure 9). An unclear understanding of the social-ecological impacts of bycatch and its mismanagement typically involves harsh punishments, including fines and/or jail time. In Chilika Lagoon, the Irrawaddy dolphin falls under Schedule 1 of the Indian Wildlife (Protection) Act, 1972 and is also considered Endangered by the IUCN Red List Authority (Minton et al. 2018). Therefore, if a fisher kills an Irrawaddy dolphin in Chilika they are "liable to the harshest penalties for violation of the law under this Schedule" (Wildlife Protection Act, 1972). These penalties involve imprisonment for 3-7 years as well as a fine no less than 10,000 Rupees (US$220) (Pattnaik et al. 2007). Because of harsh punishments, fishers are scared to report bycatch incidents (Basran &Sigurosson, 2021). Since fishers are not reporting, this has caused very low and sometimes no reporting of bycatch. With such little reporting from fishers on bycatch incidents, many countries do not have data on bycatch levels and if they do it is not reliable and very underestimated (Borges et al. 2002). As explained by the interviewed key bycatch experts, unreliable data on bycatch and its levels adds to the mismanagement of bycatch (Figure 9).

Figure 9. Diagram explaining a bycatch mismanagement loop involving harsh punishments (fines and jailtime) on fishers for the occurrence of bycatch and the death or injury of a cetacean (dolphin, whale, or porpoise). Harsh punishments cause fishers to be scared to report bycatch incidents. With fishers not reporting bycatch, bycatch estimates are severely underestimated. This has led to unreliable and severely under reported data on bycatch rates of cetaceans. The unreliable data on bycatch adds to the unclear understanding and mismanagement of bycatch. (Source: Analysis of themes from Key Bycatch Expert Interviews, n=10)

4.2.4 Is bycatch of cetaceans considered to be an urgent problem?

Many governments are aware of bycatch issues but do not want to deal with managing bycatch because of its' high complexity. This is especially true with the precautionary approach not being incorporated effectively towards bycatch management, using the uncertainty of scientific data to excuse inaction (Slooten et al. 2001). This is very concerning as fishers are

facing the greatest impacts of bycatch. When fishers in Chilika were asked whether changes have occurred in the Lagoon ecosystem due to Irrawaddy dolphin bycatch 72% of fishers surveyed in Chilika stated that with less dolphins in the area there is less biodiversity and fish stocks (Table 6). These fishers explained how with increased tourism and coastline development, dolphin numbers have decreased as well as fish. However, some fishers (12%) stated that no changes have occurred in the lagoon ecosystem due to bycatch of dolphins since dolphin bycatch is so rare. Other fishers (14%) stated there is no relation between the amount fish and dolphins in Chilika since the decreasing fish is due to other factors such as continuous cyclones (Table 6).

Table 6. **Have changes occurred in the Lagoon ecosystem due to Irrawaddy dolphin bycatch? (Fisher surveys, n=50)**

	% Of respondents
Although rare, bycatch incidents with dolphins have increased	2
With less dolphins there is less biodiversity and fish	72
No changes have occurred	12
Dolphin bycatch is not an issue for the Lagoon ecosystem	0
Other… (ex. No relation between fish and dolphins)	14

Cetaceans themselves are greatly impacted through bycatch interactions with fishers, both on the individual level and population level (Raby et al. 2011). Interviewed key bycatch experts were asked how dolphins are impacted by bycatch interactions with fishers. As seen in Figure 10, key experts explained how dolphins are impacted on both an individual level and population level. Bycatch events are very traumatic for an individual dolphin to experience and can lead to their mortality (Figure 10). A study by Wilson et al. 2014 investigated the sublethal effects of bycatch interactions which include: physiological disturbance, impairment of behaviour, reflex impairments, as well as impacts on reproduction, growth, and feeding. Sublethal effects of bycatch can have both short-term and long-term outcomes which could have population-level effects as they increase stress on reproduction and can reduce cetacean fitness (Wilson et al. 2014, Raby et al. 2011). These bycatch traumas experienced through

survived fishing interactions make cetaceans like Irrawaddy dolphins especially vulnerable to bycatch as they only have 1-2 calves a year, which is why bycatch of cetaceans should be considered an urgent problem (UNEP, 2019). It must also be considered that the amount of fishing taking place directly impacts the occurrence of bycatch incidents since increased fishing effort leads to increased bycatch interactions (Davies et al. 2009). The potential of increased bycatch interactions should be a concern for both fisheries and conservation management.

This is especially true as the death of an individual dolphin due to bycatch can negatively impact the population, especially if the dolphin is an adult and/or female (Figure 10). This is because female reproductive success is especially important for long-lived mammals like dolphins which produce only one to two infants at a time which impacts population health (Robinson et al. 2017). However, with the lack of accurate bycatch data in most countries it is difficult to estimate population levels and truly know the long-term impacts of bycatch incidents (Borges et al. 2020, Wilson et al. 2014, Moore et al. 2009). This is especially concerning as population levels help to inform both conservation and management (Robinson et al. 2017).

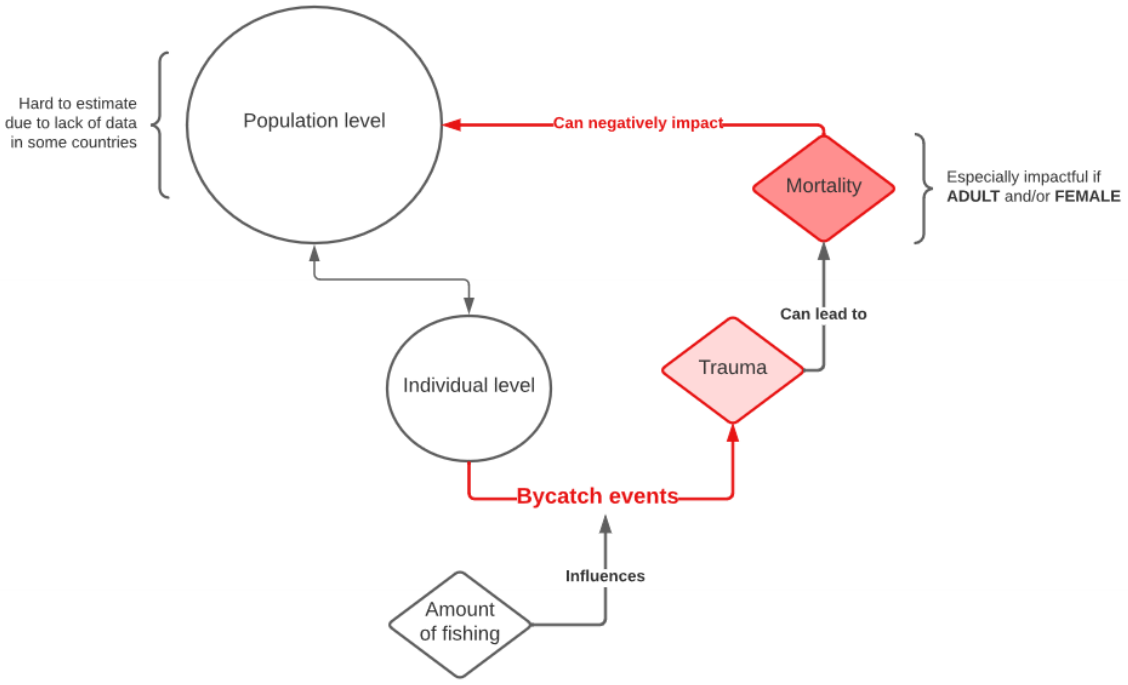

Figure 10. Diagram explaining how dolphins are impacted by bycatch on both the individual and population level. On the individual level bycatch interactions are very traumatic and can lead to the death of the dolphin. This can be negatively impactful on the population (smaller sized populations especially). Another important factor to consider is if the individual is an adult and/or a female. These types of bycatch events and their frequency are directly influenced by the amount of fishing taking place in the area. (Source: Analysis of themes from Key Bycatch Expert Interviews, n=10)

An unclear understanding of the true extent of bycatch and the intensity of its impacts has negatively influenced government perceptions on the urgency of bycatch and the need to address bycatch issues (Moore et al. 2009). Interviewed key bycatch experts were asked how dolphin bycatch is represented/explained by governments in a local vs national context and whether it is considered an urgent problem on either scale. As seen in Table 7, all key experts interviewed agreed that it is very contextual and depends on the country. This is because the way governments are structured, as well as the way fisheries and conservation are managed, greatly differ between countries (Bering et al. 2022).

Table 7. **How is dolphin bycatch represented/explained by governments in a local vs national context? Is it considered to be an urgent problem on either scale? (Key bycatch expert interviews, n=10)**
- Very contextual and depends on the country - Recognized as a problem by governments but not being dealt with - Lack of connection between fisheries management and conservation management - Human dimensions are not considered - More action taken in developed countries (ex. US, AUS, Canada, etc.) due to factors such as higher quality of life and economic incentives

Key experts interviewed explained how there is a lack of connection between fisheries management and conservation management in many countries, with human dimensions not being considered in either. Key experts who have done research in more westernized countries explained how there is more bycatch management, potentially due to higher quality of life and greater capacity for research and management, as well as economic incentives. Fishers in westernized countries may have higher quality of life since they can afford to spend more time and effort on conservation strategies while fishers in developing countries do not have the financial means or access rights to do so (Nayak et al. 2016; Whitty, 2015). Economic incentives that impact trade between countries have started to play a role in bycatch management with the US imposing conservation standards on other countries (Bering et al. 2022). This was done with the US Marine Mammal Protection Act being implemented in 2017 containing a provision requiring imported fisheries products from other countries to be captured without resulting in greater incidental mortality or serious injury of marine mammals (Bering et al. 2022).

4.3 Results: How Cetacean Bycatch and its' Mitigation Add to SSF Vulnerabilities

Not all SSF experience high levels of cetacean bycatch, with some small-scale fishers never experiencing bycatch interactions with cetaceans or extremely rarely as learned through surveys with fishers in Chilika Lagoon. The level of cetacean bycatch taking place in an area depends on a variety of factors. As explained by key bycatch experts interviewed, some of these factors include the amount of fishing taking place, the number of boats and space available, the number of fish, the types of boats and gear used, and many other factors which may still be unknown. Differing levels of cetacean bycatch impact the vulnerability of fisher-cetacean

relationships and their social-ecological system in various ways which will be explained in further detail below.

The following section will examine how bycatch of cetaceans and bycatch mitigation impacts the vulnerability of SSF and fisher-cetacean relationships by focusing on both the natural and social subsystems. This section will include social-economic survey questions completed with the fishers in Chilika Lagoon using the I-ADApT template (see Appendix A). This section will also include insights from interviewed key bycatch experts on questions tailored to Objective 2 (see Appendix B). Both response groups will be compared as in the previous section.

4.3.1 How does bycatch of cetaceans impact the vulnerability of the *natural subsystem*?

Fishers in Chilika Lagoon were asked about the impacts of Irrawaddy dolphin bycatch on the environmental/natural system. 82% of fishers stated that the impacts of dolphin bycatch in Chilika have been negative, causing there to be less biodiversity (Table 8). Fishers explain how there are less fish coming in from the sea due to bycatch of Irrawaddy dolphins and how they face problems trying to get fish out of nets when dolphins are bycaught. However, some fishers (4%) still insisted that dolphin bycatch does not occur in the area (Table 8). Other fishers (12%) stated how bycatch of Irrawaddy dolphins is extremely rare, and because of this bycatch has little impact on the natural system (Table 8). No fishers considered dolphin bycatch to be creating positive changes in the ecosystem (Table 8).

Table 8. **What have been the impacts on the environmental/natural system of Irrawaddy dolphin bycatch? (Fisher surveys, n=50)**

	% Of respondents
Negative, less fish and biodiversity	82
Positive, more fish and other species	0
Dolphin bycatch does not occur	4
Dolphin bycatch extremely rare, having little impact on natural system	12

4.3.1.1 How is bycatch of cetacean's linked to SSF productivity?

Fishers in Chilika were asked about what the productivity of the system (fish stocks – low, medium, high) prior to the occurrence of Irrawaddy dolphin bycatch events. As seen in Table 9, majority of fishers (98%) stated that the fish stocks were high before bycatch of dolphins started to occur. Fishers explained hearing stories from their older community members of higher fish stocks prior to increased Irrawaddy dolphin bycatch. One fisher stated, "I have listened from my father and older people that more fishes were available in Chilika for having Dolphins or Kheranka. The fishers were fishing more because fishes were being brought together in fear of Dolphin." Only 2% of fishers think that dolphin bycatch does not impact fish stocks/productivity (Table 9). These fishers explain how the decreased fish stocks are due to increased fishing efforts in a small area and not bycatch.

Table 9. **What was the productivity of the system ex. Fish stocks (low, medium, high) prior to Irrawaddy dolphin bycatch events? (Fisher surveys, n=50)**

	% Of respondents
Low fish stocks	0
Medium/Average fish stocks	0
High fish stocks	98
Dolphin bycatch does not impact fish stocks/productivity	2

Interviewed key bycatch experts were asked if the rate of current cetacean bycatch were to continue without effective interventions, how they see this impacting SSF productivity and the ability of SSF to provide enough food for global food security. There was a mix of responses as seen in Table 10. Some experts interviewed think there could be long-term impacts of cetacean bycatch on the oceanic ecosystem due to their roles in nutrient cycling and food webs, especially if all cetaceans become extinct (Table 10). Some of these experts also think there might be more local impacts, however it is still very contextual (Table 10). Other experts interviewed explained how there is not enough data available to answer this question with there potentially being no impact on SSF productivity.

Table 10. **If the rate of current cetacean bycatch were to continue without effective interventions, how do you see this impacting SSF productivity and ability to provide enough fish for global food security? (Key bycatch expert interviews, n=10)**
- Could have long-term impacts on oceanic ecosystem (ex. Nutrient cycling, cetacean extinction) - Not enough data - Have more local impacts but also very contextual - No impact

4.3.2 How does bycatch of cetaceans impact the vulnerability of the *social subsystem*?

Fishers in Chilika were asked about any changes which have occurred involving their material wellbeing due to Irrawaddy dolphin bycatch. As seen in Table 11, 68% of fishers explained how they cannot afford good fishing gear as well as other material goods such as clothes, cellphones, and more. Keeping this in mind it is not surprising that small-scale fishers do not have the financial means to afford bycatch mitigation technologies. Other fishers (22%) explained how along with not being able to afford good fishing gear, they are forced to work with damaged gear (Table 11). One fisher explained, "in case a dolphin dies, that impacts our livelihood." Since fishers are already going out fishing with damaged gear, entangling a dolphin would only cause more damage and potentially stop fishers from being able to take part in fishing operations. Only 4% of fishers said that they can still afford good fishing gear when dolphin bycatch events occur, with 6% of fishers stating that dolphin bycatch does not impact their material wellbeing since it is such a rare event (Table 11).

Table 11. **Have changes occurred involving your material wellbeing due to Irrawaddy dolphin bycatch? (Fisher surveys, n=50)**	
	% Of respondents
Can still afford good fishing gear	4
Cannot afford good fishing gear, forced to work with damaged gear	22
Can afford fishing gear but not other material goods (ex. clothes, cellphone, etc.)	0
Cannot afford good fishing gear or other material goods	68
Dolphin bycatch does not impact my material wellbeing	6

Fishers in Chilika were also asked if Irrawaddy dolphin bycatch interactions have impacted their mental wellbeing. This question had a mix of responses with 48% of fishers stating they are impacted in a positive way since they are happy to see Irrawaddy dolphins (Table 12). These fishers also continued to state how bycatch events do not occur or are extremely rare. However, 44% of fishers explained how their mental wellbeing is impacted negatively when dolphin bycatch interactions occur (Table 12). Fishers explained, “we feel sad if dolphin gets injured and our heart get pained. We inform to CDA soon if Dolphin gets injured." Only 8% of fishers stated that they do not care for the dolphins/are unbothered by their presence and bycatch incidents (Table 12). These fishers continued to explain how dolphins are never bycaught, which is why they do not care for the dolphins.

Table 12. **Has Irrawaddy dolphin bycatch interactions impacted your mental wellbeing in any way? (Fisher surveys, n=50)**

	% Of respondents
Yes, and in a negative way (ex. Frustrated with having to fix and buy fishing gear, sad if dolphin dies)	44
Yes, and in a positive way (ex. Happy to see the dolphins)	48
No, do not care for the dolphins/unbothered by them	8

4.3.2.1 How does cetacean bycatch impact the vulnerability of small-scale fisher livelihoods?

Fishers in Chilika were asked about the livelihood impacts of Irrawaddy dolphin bycatch. As seen in Table 13, the majority of fishers (94%) stated that with bycatch occurring there has been low fishing productivity. Chilika fishers explained how there is lower fishing productivity since they need to spend more effort on fishing, while catching less fish. This is especially true when dolphin bycatch occurs as they must spend more time untangling the dolphin while trying to salvage the fish they have caught. Another factor to consider is that on top of increased competition for fish between fishers in a small highly populated area like Chilika Lagoon, there is also increased competition for fish from cetaceans themselves. Only 4% of fishers had to change their occupation because they could no longer fish (Table 13). One fisher stated, "Some people left their own occupation for not having more fish from fishing, migrated to other places in search of work.” However, all fishers surveyed in Chilika agreed that dolphin bycatch impacts

their livelihoods in some way. This is especially true for small-scale fishers in Chilika Lagoon and Irrawaddy dolphins as they have a cooperative relationship, depending on the same source of fish for their survival.

Table 13. **What have been the livelihood impacts of Irrawaddy dolphin bycatch? (Fisher surveys, n=50)**

	% Of respondents
Low fishing productivity – more effort spent on fishing with less fish being caught	94
Change of occupation/loss of job	4
Loss of access rights due to dolphin "protection"	2
Loss of rights to decision making on dolphin bycatch events	0
No impact on livelihoods	0

Key bycatch experts interviewed were asked about the connection between SSF with higher levels of cetacean bycatch and the occurrence of Illegal, Unreported, and Unregulated (IUU) fishing. As seen in Table 14, interviewed experts explained how IUU is already hard to manage on its own, let alone trying to manage both IUU and bycatch. IUU management (similar to bycatch) depends on how IUU is defined as well as how SSF are defined. The definition of IUU is especially important since bycatch can still occur in what are considered to be legal nets (Kelkar & Dey, 2020). Experts interviewed also eluded that top-down management which causes banning and forbidding actions could be a connection between areas with high bycatch and high IUU (Table 14). This is especially true if there has been miscommunication or no communication with fishers and local communities (Alves et al. 2012). Key bycatch experts interviewed from India explained how there are also conflicts in some countries between Wildlife protection laws and Fisheries laws which can add to the mismanagement of bycatch and IUU. They have conflicting objectives as the Forestry Department and central Ministry of Environment and Forests in India focuses on restricting and banning the harvest of specific marine mammals while the Fisheries Department and Ministry of Agriculture focuses on maximizing fisheries production (Lobo, 2012).

Table 14. **How are SSF with higher levels of cetacean bycatch and the occurrence of Illegal, Unreported and Unregulated (IUU) within local fishing communities connected? (Key bycatch expert interviews, n=10)**
- IUU already hard to manage on its own; depends on how you define both IUU and SSF - Top-down management causing banning and forbidding actions - Miscommunication or no communication with fishers and local communities - Conflicts in some countries (ex.India) between Wildlife protection laws and Fisheries laws

4.4 Discussion

This section will discuss the results and explain their significance. It will go through common and conflicting themes discussed by both fishers and key experts while completing the surveys and interviews. As previously explained, comparing both insights on bycatch will help to provide a new multi-dimensional perspective on bycatch and its management. Since small-scale fishers do not have reliable and effective access to decision making while key experts and their research are used to inform policies, it is especially important to analyze SSF fisher perspectives on bycatch issues and the social-ecological linkages (Nayak et al. 2016).

4.4.1 Understanding the complex reality of bycatch and its' management

As previously explained through the literature review, the definition of bycatch needs to be adapted. Currently the most common definition of bycatch ("incidental capture of non-target species") does not capture the complexity of this issue (Machado et al. 2019). The fact that bycatch can still occur in what are considered "legal nets" makes it even more crucial to have a clearer definition of what bycatch is (Kelkar & Dey, 2020). This is because the way bycatch is defined determines which species are bycatch and therefore cannot be intentionally caught by fishers, making their intentional capture illegal.

How bycatch is defined can also impact the fisher's role in bycatch management as they are the driving force able to address conflicts that arise from their bycatches and are responsible for implementing bycatch solutions into their day-to-day fishing operations (Borges et al. 2002). Therefore, fisher perspectives on what bycatch is must be incorporated into how bycatch is defined in policies. Especially since there is a disconnect between what fishers in

Chilika Lagoon consider to be bycatch and what the key experts interviewed consider bycatch (Figure 7). Key experts who inform fisheries policies and fishers experiencing bycatch interactions should have the same understanding of what bycatch is and what species are considered bycatch.

As seen in Figure 7, fishers still consider some bycatch to be beneficial if the species is economically viable. This is important to note as new markets for bycatch species have started to develop due to the increased demand and consumption of seafood, leading to the establishment of new markets for formally considered "non-target species" which were not exported earlier (Lobo, 2012). Some fishers in Chilika explained, "we get income opportunity when we find sharks in our nets". This is especially interesting because sharks were not always considered to be economically viable species in Chilika, with fishers traditionally leaving the sharks intact or killing them for safety. This shows how a "bycatch" species can eventually turn into an economic species targeted as a source of income depending on the interlinked local conditions.

Many fishers are aware of the ecological importance of cetaceans. However, in areas like Chilika Lagoon since bycatch of Irrawaddy dolphins is so rare many fishers do not consider it to be a problem. This contradicts the views of key bycatch experts who explained how even if one dolphin is killed in a year and it is a small population, it can still negatively impact the overall population (see Figure 10). Small-scale fishers must be informed on how bycatch incidents are very traumatic for individual dolphins to experience even if it is rare, and they are freed from the nets (Wilson et al. 2014; Raby et al. 2011). Fishers must also be made aware of the use of potential biological removal (PBR) to estimate the "sustainable annual rate of human-caused mortality based on a minimum population estimate, an estimate of the net productivity rate of the population, and a 'recovery factor'" which has been used by key bycatch experts to help inform fisheries management and policies (Whitty 2020; Wade 1998). Since the Irrawaddy dolphin subpopulation in Chilika is endangered (Minton et al. 2018) and the CDA dolphin count for 2022 stated a range of 155-165 individuals (Figure 11), even using 165 as the "minimum population estimate" the Chilika Irrawaddy dolphins' PBR would be around 0.33 (Figure 12). This means that even less than one bycatch event a year can be

detrimental to the Irrawaddy dolphin population in Chilika Lagoon (Whitty 2020), even using the higher population estimate provided by the CDA for 2022. If fishers in Chilika Lagoon knew about this and understood how detrimental rare bycatch events are, they may take bycatch events more seriously and be more open to active involvement in bycatch mitigation strategies.

Year	Dolphin Population in Chilika lake
2013	152
2014	158
2015	160
2016	145
2017	121
2018	155
2019	150
2020	156
2021	162
2022	155 – 165 (156 were directly sighted during the monitoring and the range inferred from the yearlong monitoring by CDA)

Figure 11. Numbers of Irrawaddy dolphin population in Chilika Lagoon in India from 2013-2022. Information collected from Flora and Fauna surveys completed by the Chilika Development Authority (CDA). (Source: news article https://kalingatv.com/features/latest-flora-and-fauna-survey-in-odishas-chilika-lake-out-check-details/)

$$PBR = N_{MIN}\frac{1}{2}R_{MAX}F_R$$

Figure 12. PBR equation where N_{min} represents the minimum population estimate of the stock, $1/2R_{max}$ represents one half the maximum estimated net productivity rate of the stock with a small population size (0.04 is the default for cetaceans), and F_R representing the recovery factor between 0.1 and 1 (0.1 is used for endangered populations) (Wade 1998, pg.5). **Chilika Irrawaddy dolphin PBR = (165)x(0.5)(0.04)x(0.1) = 0.33**

There is a common misconception that fishers do not care about cetaceans and bycatch events. However, many fishers are upset if a cetacean dies due to a bycatch interaction (Whitty, 2014). As previously explained, in areas like Chilika Lagoon, cetaceans have a cultural and religious importance to the local community. Some fishers in Chilika stated how “dolphins are our Laxmi and fishers’ friend”. They also explained how dolphins are their livelihood and they have a traditional relationship with the Irrawaddy dolphins. “Since our father and grandfather’s time, they are our friends” stated another fisher in Chilika. The livelihoods and food security of small-scale fishers are especially vulnerable to bycatch as it depletes their food source for local

consumption (Lobo, 2012). Therefore, any bycatch solution is directly linked to fisheries management and must consider social-ecological linkages that shape fishing practices including economic need, food security, cultural significance, as well as SSF fisher wellbeing and livelihoods (Whitty, 2018).

4.4.2 Is catching a seabird the same as catching a dolphin?

When fishers in Chilika were asked the question of whether they considered accidentally catching a seabird to be the same as catching an Irrawaddy dolphin the answers were surprising and very insightful. This question was asked anticipating fishers to say no, since the damages to their gear would be very different depending on the species due to their size differences. However, many fishers surveyed in Chilika (72%) said they consider catching seabirds and dolphins to be the same as seen in Table 3. Fishers explained how this is because "we are heartedly connected with dolphins and have traditional relationships. We are sympathetic towards birds also. We let them free, hurting none of them". Another fisher stated, "both lives are equally important". The perspectives of fishers are very insightful showing a value for life that's separate from economic value. Adopting this type of point of view could completely change the way fisheries are managed, providing a truly holistic approach to managing fisheries interactions with oceanic species. This would go hand in hand with the precautionary principle by not allowing the lack of scientific data or economic value to delay acts of conservation (Kriebel et al. 2001).

4.4.3 Critical linkages between bycatch impacts on both natural and social subsystems

Both the natural and social subsystems in SSF are impacted by the way bycatch is managed. This is because bycatch management is influenced by both economics and access to power. Traditionally, bycatch has been managed from a top-down perspective without considering fishers who face the upfront costs of bycatch interactions. In addition to this, many environmental issues in our natural world lack the financial support they need to be successfully solved (Galdas 2017). In a lot of cases bycatch management expects fishers to deal with bycatch on their own and yet are not given proper access rights or access to decision making processes to be able to do so (Nayak et al. 2016). Small-scale fishers are more

vulnerable to dramatic changes in livelihoods usually associated with cetacean conservation measures and bycatch mitigation strategies as they do not have the proper resources to manage bycatch on their own. As seen in Table 11, fishers in Chilika cannot even afford good fishing gear and are forced to work with damaged gear. Considering the financial strains faced by small-scale fishers, how can we expect fishers to be able to avoid bycatch interactions on their own? One fisher stated, "in case a dolphin dies, that impacts our own livelihood." Unfortunately, small-scale fishers are set up for failure when it comes to being able to manage bycatch due to their economic needs not being met as well as unfair power dynamics involved in top-down management.

The mistreatment of fishers through inappropriate top-down bycatch management explains the mixed answers fishers in Chilika Lagoon gave for the question regarding whether or not they felt as though Irrawaddy dolphin bycatch has become a threat to fishing operations. As seen in Table 4, 40% of fishers agreed that dolphin bycatch has become a threat to fishing operations while 60% said no. Some fishers explained how they face losses when bycatch occurs which threatens their ability to fish, while the other fishers kept stressing how dolphins are their friends and bycatch does not occur. The controversy here is clear: fishers face threatening losses when dolphin bycatch occurs, however due to fear of punishment fishers cannot be truthful on the occurrence of dolphin bycatch. With fishers being unfairly punished for unintentional capturing of dolphins through bycatch, it is not surprising that bycatch can be linked to the occurrence of IUU as fishers are being pushed towards illegal forms of fishing since they may be punished for bycatch no matter their true intentions.

In most SSF there is open, unrestricted, and usually unregulated access to fish resources (Drammeh, 2000). In many cases, a lack of resources and capacity limits the ability of local fisher organizations to manage fisheries sustainably with monitoring, controlling, and surveying being almost non-existent or very ineffective (Drammeh, 2000). As seen in Table 14, interviewed key experts were asked on their opinion of the connection between bycatch and IUU in SSF. Key bycatch experts point out the issues of top-down management involving banning and forbidding actions, usually not involving fishers and local communities in decision making. IUU fishing practices are usually caused by economic, institutional, and social problems

which have profound natural consequences (Drammeh, 2000). Unfair power dynamics and not considering fisher livelihoods when making decisions on bycatch management drastically impacts both the natural and social subsystem because fishers are being pushed towards more invasive and illegal methods of fishing which can have more drastic impacts on the local environment and potentially its productivity.

The productivity of the local aquatic system impacts the wellbeing and livelihoods of fishers since they depend on fish resources. As seen in Table 12, there were a mix of answers from fishers on how Irrawaddy dolphin bycatch impacts their mental wellbeing. Once again, we can see mixed responses where Chilika fishers are happy to see the dolphins but are also saddened if a dolphin dies due to bycatch as well as frustrated with having the fix/buy new gear. One fisher stated, “we feel sad if dolphins get injured and our heart is in pain.” Another fisher explained, “we are worried to keep dolphins safe”. As seen in Table 13, majority of fishers surveyed in Chilika believe their livelihoods are impacted by dolphin bycatch. Specifically, they explain how there is low fishing productivity, and they are now needing to increase their fishing effort with less fish being caught. This means fishers are spending more time out in the water and expanding their range of fishing. This increased effort will most likely increase their chances of interacting with cetaceans and the occurrence of stressful unavoidable bycatch interactions which they have no power in managing.

4.4.4 How can we adapt current bycatch policies to capture the complexity of bycatch?

The disconnect between fishers in Chilika and the key bycatch experts interviewed on the definition of bycatch highlights the importance for fisheries and conservation management addressing bycatch to make sure fishers understand the information used to inform policies. This is especially important as bycatch policies can impact fisher livelihoods and daily fishing operations. Since fishers in Chilika consider economic species (e.g., sharks) to be bycatch while key experts interviewed do not, it would be important to distinguish between commercial bycatch and true bycatch which is caught unintentionally and discarded (Borges et al. 2002).

“Bycatch” could be defined as the unintentional capture or injury of a non-target species which has no commercial value and is discarded. Whereas “commercial bycatch” would be the

capture or injury of a non-target species which is not discarded and is intentionally used for economic gain by being sold in markets. There could also be "consumed bycatch" to account for areas where the animal is consumed local without being sold in markets. This way we can distinguish between fishers who truly discard non-target species from those who use the species for economic gain, as well as fishers who consume the animal. This is especially important with bycatch occurring in legal nets (Kelkar & Dey, 2020). Therefore, if the fisher sells the bycaught species instead of discarding it, it would be easier to prove their intent. By having different categories of bycatch, it can help countries have a more concrete system for setting policies for both bycatch and commercial bycatch species (Banzon et al. 2019). Distinguishing between types of bycatch species will help create more applicable and representative policies to address the overexploitation of fisheries and create a greater availability of food and resources for both marine and human life as bycatch generates immense waste and costs (Banzon et al. 2019). However, it is important for small-scale fishers to have more access to decision making and be given the opportunity to work directly with key bycatch experts who help to inform fisheries policies.

Another potential option for policies investigated through this research was whether it would be beneficial for bycatch policies to distinguish between different species. This bycatch policy adaptation was explored as it did not seem to make sense to group large mammals like cetaceans with comparably smaller animals like seabirds, invertebrates, and other smaller sized bycatch species within bycatch guidelines. A study by Banzon et al. (2019) found that having different categories for bycatch species helped create a more concrete system for valuing oceanic resources. As seen in Table 5, majority of fishers surveyed in Chilika supported the idea of fisheries policies addressing different scales of bycatch and distinguishing between bycatch of large mammals and smaller species. "By this, people will be aware themselves and be optimistic towards these living creatures and their lives" said one fisher. Some key bycatch experts that were interviewed also agreed that distinguishing between different species for bycatch would be beneficial for management as more context specific policies could be created based on the species involved. However, other experts explained that since bycatch is so context specific distinguishing between bycatch species in policies may not work for fishers on

the ground. However, fishers may be more open to bycatch policy changes than some interviewed key experts assume. This was evident in the Chilika Lagoon case study with fishers being open to creating appropriate bycatch policies for their local environment due to current issues in how bycatch is ineffectively managed.

A management approach for bycatch that focuses on harsh punishments like fines or, jailtime for fishers is ineffective and possibly unfair. The death or injury to a Schedule 1 animal like an Irrawaddy dolphin involves 3 to 7 years imprisonment along with a penalty of Rs.25000 in India (Willems et al.2021; Pattnaik et al. 2007). However, if it was unintentional how can a fisher be punished? As previously explained, unintentional means the issue was unavoidable. For fishers in Chilika to be going to jail for something that is considered unavoidable does not make sense. These types of ineffective conservation management approaches add to the lack of reliable bycatch data explained in Figure 9. This lack of reliable bycatch data also plays a role in how governments view the urgency of bycatch.

Since many governments do not want to try and actively manage bycatch, they depend directly on fishers to deal with this complex issue. As seen in Table 7, bycatch experts interviewed explain how bycatch is recognized to be a problem by governments but is not being effectively dealt with by many countries. As explained by one of the key experts, “fisheries are a major economic resource and are managed as agriculture with no ecosystem-based thinking”. For bycatch policies to work fishers need to have access to power and deserve to be respected when it comes to dealing with bycatch interactions. Without small-scale fishers, economies around the world would greatly suffer (Lobo, 2012). Minimizing the wastage and costs of fisheries through appropriate bycatch policies could create a greater availability of food, increase resources for future use, and create a healthier living environment for both cetaceans and coastal communities (Banzon et al. 2019). Bycatch management power dynamics must shift for SSF to be viable for the long-term, with fishers having access to power for environmental decision making and having a say in how bycatch is being managed, not only bycatch experts and other stakeholders.

4.5 Conclusion and Chapter Summary

The societal linkages of cetacean bycatch management and conservation are very clear in this study, showing how cetacean value highly impacts its conservation (Bashir, 2010). Cetacean value is evident through their religious and cultural importance in some SSF areas (Schuhbauer et al. 2019). However, culture and religion alone do not guarantee cetacean protection with many other societal factors in play such as social wellbeing. This is especially true since this research has brought to light how cetacean bycatch and its' management impacts both material and mental wellbeing for many small-scale fishers in Chilika involved in bycatch events. Understanding the economic viability of a SSF is essential to better understanding their long-term viability as well as helps to provide fishers and policy makers with important information to inform effective bycatch policies (Schuhbauer et al. 2019). The results and discussions in this chapter have also highlighted how bycatch policies must consider SSF fisher livelihoods and perspectives on bycatch as fisher perspectives do not always align with stakeholders who inform policies.

The ecological components of bycatch are also important and must be considered since cetaceans are an important part of the natural subsystem in many coastal communities (Tynan, 2004). However, the results and discussions in this chapter reveal how too much time and resources have been spent on trying to quantify the natural system impacts of bycatch to justify acting against bycatch. It is known that the specific ecological linkages of bycatch impacts are hard to identify due to many external drivers like overfishing and climate change, therefore solutions to bycatch must focus on its' management as well as the societal context and vulnerabilities faced by small-scale fishers which are clearer and more easily understood.

The societal value of cetaceans seems to have more weight in terms of pushing for more effective fisheries management of bycatch. This is especially true with ineffective fisheries management linkages between areas with higher levels of IUU and areas with higher levels of bycatch as learned through interviews with key bycatch experts. This chapter also brought to light the fact that bycatch species can shift to economically viable species depending on the local context. Therefore, it makes sense for pathways for viable and effective bycatch

management to focus on the social and political obstacles and vulnerabilities currently in the way of effective cetacean bycatch governance.

Chapter 5

Cetacean Bycatch Governance: Strategies for Social-ecological Viability

5.1 Introduction

The objective investigated in this section of the thesis is to determine a set of mitigative and adaptive strategies which are most likely to increase social-ecological viability through appropriate cetacean bycatch governance. As previously explained in Chapter 4, bycatch policies must be adapted to play an effective role in bycatch management. However, bycatch policies need to be supported by both fishers and the institutions involved (Whitty 2015; Senko et al. 2014). Enforcement as well as compliance are considered crucial to the success of any bycatch mitigation or adaptation measure (Leaper & Calderan, 2018). In most developing country contexts, where resources for external enforcement are limited, management policies depend on local implementation and compliance (Cisneros-Montemayor & Vincent, 2016). This requires local support of such policies, which requires collaborative efforts and knowledge sharing from all stakeholders which serve to protect both fishers and cetaceans from external vulnerabilities. Cetacean bycatch governance, along with policies that support community engagement in cetacean conservation, may help to promote community stewardship for cetaceans beyond just controlling fishing practices. By having strong cetacean governance with supportive fisheries and conservation policies, it may be possible to increase the viability of fisher-cetacean relationships and hopefully increase the occurrence of positive long-term relationships between both fishers and cetaceans.

When trying to manage cetacean bycatch the social-ecological linkages must all be considered (Whitty, 2018). By incorporating awareness of the social-ecological linkages, it may be possible to adapt current bycatch management and allow for the exploration of new innovative ideas which support more effective cetacean bycatch governance (Whitty, 2015). This includes taking an ecosystem-based approach to bycatch, by which specific biodiversity conservation issues can be managed as part of a broader social-ecological system using diverse policy instruments (Squires & Garcia, 2013).

Mitigative strategies for bycatch management involve trying to reduce interactions between fishing gear and cetaceans. Bycatch reduction strategies tend to focus on command-and-control methods (ex. Time-and-area closures, reducing fishing effort) or technological advances with associated legislative changes (ex. Mesh sizes, bycatch excluding devices) (Squires & Garcia, 2013). Time-area closures are a mitigative approach to bycatch, however they can also be adaptive by being extremely flexible to cetacean movements (Senko et al. 2014), especially since some cetaceans are highly migratory species and are shifting migration patterns to adapt to climate change (Williamson et al. 2021). Even cetacean species that are not migratory can shift their range depending on seasonality and other conditions (Weelden et al. 2021).

Many approaches for mitigating bycatch also include limiting fishing effort, and the modification of fishing practices (Cox et al. 2007). Modifying fishing practices usually involve new technologies for bycatch exclusion including devices such as pingers and lights on both nets and boats which have become widely used as bycatch mitigation strategies (Berninsone et al. 2020). Pingers produce sound waves which are meant to deter cetaceans from fishing operations, with lights being used in the same way (Omeyer et al. 2020). Incentive-based bycatch mitigation measures have also been used such as Dolphin Mortality Limits (DMLs), taxes, as well as insurance to cost-effectively reduce bycatch (Squires & Garcia, 2013). For incentive-based approaches to be adaptive they must be flexible and interchangeable to be able to keep up with climate change (Lent & Squires, 2017). However, these strategies have yet to become effective enough to have a global impact on reducing bycatch interactions (Senko et al. 2014). Such strategies usually rely heavily on implementation, monitoring, and enforcement by authorities, as well as gear modifications which increase gear costs (Temple et al. 2018), this makes applying these strategies to developing countries particularly difficult.

Fisher behaviour and whether they are willing to accept certain management plans must also be considered to compare potential outcomes for different bycatch management strategies (Senko et al. 2014). Bycatch mitigative measures assume fishers are a homogenous group that is supposed to apply new technologies or act according to the most up-to-date ecological insights (Barz et al. 2020). However, as seen in Chapter 4, there is a clear disconnect

between what Chilika fishers and interviewed key bycatch experts perceive to be bycatch. So how can fishers be expected to act according to the most up-to-date ecological insights when these insights are not shared with them? Many fishers also do not have the financial means to apply new technologies as learned in Chapter 4, with Chilika fishers not being able to afford good fishing gear and being forced to work with damaged gear. Adaptive measures to bycatch on the other hand incorporate the heterogeneity of fisher actions and drivers as they are important for effective fisheries management (Barz et al. 2020). The only way we can understand the heterogeneity of fisher actions and drivers is by directly working with fishers and respecting their insights on how they believe bycatch should be managed. As learned in Chapter 4, many fishers in Chilika really care for the dolphins and are open to trying new adaptive strategies to help protect cetaceans from fishery interactions.

The following subsections will focus on the 3rd objective of this research which was to determine a set of mitigative and adaptive strategies which are most likely to increase social-ecological viability through appropriate cetacean bycatch governance. Mitigative and adaptive strategies for cetacean bycatch were discussed with both the fishers from Chilika Lagoon and key bycatch experts interviewed. As in the previous section, insights from both research groups will be compared below in order to see whether fishers in Chilika Lagoon and key bycatch experts interviewed have common perspectives on how to manage cetacean bycatch through governance actions. As previously explained, since key bycatch experts and their research help inform bycatch policies as well as how they are implemented, their recommendations should coincide with the perspectives of small-scale fishers to be effective for the long-term.

5.2 Results: Strategies Most Likely to Increase SSF Viability through Cetacean Bycatch Governance

Both mitigative and adaptive strategies for cetacean bycatch used to date in SSF have yet to be widely effective in protecting cetaceans against bycatch interactions (Barz et al. 2020). For fishers and cetaceans to remain viable for the long-term, bycatch management must take a social-ecological systems perspective to the problem (Whitty, 2018). The social-ecological systems perspective of bycatch focuses on the social-ecological context in which fishers and

cetaceans exist and how social-ecological drivers impact the fisher-cetacean relationship. As explained in Chapter 4, cetacean bycatch does not involve the natural subsystem alone but also the social subsystem. Since we have little control over what happens in the natural world, it makes sense to focus bycatch efforts on both social and political solutions. Especially since without social-political considerations, management will not work.

The following section will go through governance and management survey questions which were completed with fishers in Chilika Lagoon (see Appendix A). This section will also include insights from key bycatch experts on questions regarding bycatch governance (see Appendix B). Both responses will be compared to explore new insights on potential mitigative and adaptive approaches to cetacean bycatch management. Comparing such a wide range of perspectives on bycatch and what solutions fishers and interviewed key experts consider to be possible, allows for this research to provide new innovative insights on the potential of cetacean bycatch governance and it's focus.

5.2.1 Who manages bycatch and how?

Government organizations are usually responsible for bycatch management, either on the national or local level; however, it is very dependent on the country and how it is governed (Bering et al. 2022; Lobo 2012). Whether fishers are directly involved in bycatch-related decision making also varies greatly between countries (Bering et al. 2022). However, some countries have attempted to take more action on managing bycatch (Bering et al. 2022, Moore et al. 2009). The following subsection will distinguish between who manages bycatch and how in more westernized countries with more robust fisheries and marine mammal data (Canada, US, and AUS) verses Global South countries with less information available on marine mammal populations (India, Brazil, and Bangladesh) (Bering et al. 2022). This information was analysed using insights from key bycatch expert interviews. As previously explained, the opinions of the key bycatch experts interviewed do not represent the views of all key bycatch experts as there are many perspectives on how bycatch should be managed. This subsection will also go into further detail on who manages bycatch and how in the Chilika Lagoon case study, using

information collected from fisher surveys as well as key experts interviewed who have done extensive research in the Indian context.

5.2.1.1 Global North verses Global South Countries

As seen in Table 15, there are differences in how cetacean bycatch is managed in Global North (Canada, US, & AUS) verses Global South countries (India, Brazil, & Bangladesh). However, it is consistent between these countries that national governments and agencies are mainly responsible for managing bycatch (Table 15). Key bycatch experts were asked: who manages bycatch in the areas you've studied and how - are there bycatch policies? Key experts interviewed explained how in Global North countries (Canada, US, & AUS) bycatch policies have been established and fishers are directly involved in the decision making (Table 15). In countries like India with less information available on marine mammal populations, there are fisheries management systems in place which address bycatch generally (mesh sizes and economic species focus), however there are no specific bycatch policies being implemented or enforced by fisheries (Bering et al. 2022). Mesh size regulations are not always effective. Kelkar and Dey (2020) found that over two-thirds of reported bycatch mortality of South Asian River dolphins (*Platanista*) occur in legal nets. Incidental capture in legal nets makes enforcement of wildlife laws even more complicated (Kelkar and Dey, 2020). Fishers in these areas have historically been penalized through conservation protection laws with fines and jailtime if a dolphin is killed through any means – not specifically through bycatch (Table 15). However, in 2021 India adopted Marine Megafauna Stranding Management Guidelines which depend on fishers reporting all stranding incidents, including bycatch, and provide voluntary guidelines for reducing marine mammal bycatch (Bering et al. 2022). Although it is unknown whether these guidelines are effective in bycatch management, it is a promising first step for fisheries in India.

Table 15. Chart comparing who manages bycatch and how in both Global North countries (Canada, US, & AUS) verses Global South countries (India, Brazil, & Bangladesh). The information included here was analyzed from key bycatch expert interviews (n=10).

Canada, US, & AUS	India, Brazil, & Bangladesh
WHO? - National governments and agencies ex. Canada – Department of Fisheries and Oceans **HOW?** - Bycatch policies established and implemented within fisheries - Directly include fishers in decision making - US providing economic incentives for other countries (ex. Canada) to conserve marine mammals to their standards or else will impact trade between countries	**WHO?** - National governments and agencies ex. India - Forestry Department **HOW?** - No specific bycatch policies established and implemented by *fisheries management* - Focus on mesh sizes and economic species as general guidelines - Mainly harsh punishments such as fines and jailtime through *conservation laws*

5.2.1.2 India Case Study – Chilika Lagoon

Fishers in Chilika Lagoon were asked about what relevant organization(s) or individual(s) are legally responsible and empowered for bycatch governance of fishers at local, regional, and national levels. As seen in Table 16, 46% of fishers explained how a government agency (Forest Department) is managing bycatch at a national level. While 48% of fishers stated that the Chilika Development Authority (CDA) is responsible for managing bycatch (Table 16). Therefore, both the Forest Department and CDA are legally responsible and empowered for bycatch governance of fisheries in Chilika Lagoon.

Table 16. **What are the relevant organization(s) or individual(s) legally responsible and empowered for bycatch governance of fisheries at local, regional, and national levels? (Fisher surveys, n=50)**	
	% Of respondents
Primary Fishermen Society at local level	6
Government agency managing bycatch at national level	46
Scientists and NGOs at the local level	0
There is currently no bycatch governance of fisheries	0
Other…(Chilika Development Authority)	48

As seen in Table 17, fishers were also asked if the on-ground management of bycatch was done on a local or national scale. Majority of fishers (92%) stated that if bycatch of a

dolphin occurs, local organizations or groups are the ones dealing with the issue (Table 17). Local groups would include fisher associations and fisher cooperatives. Only 8% of fishers consider bycatch to be actively managed on a national scale (Table 17). These fishers explained how if dolphin bycatch occurs, it must be reported to a high authority and is not dealt with by the local community (Table 17). As seen in Appendix C, the Marine Megafauna Stranding Management Guidelines in India explains the process fishers need to follow for reporting bycatch incidents and dealing with entanglements, however these are voluntary and not enforced. It is also unknown if fishers in Chilika are aware of these management guidelines.

Table 17. **Is the management of bycatch done on a local or national scale? (Fisher surveys, n=50)**	
	% Of respondents
Local – if dolphin bycatch occurs local organizations or groups deal with the issue	92
National – if dolphin bycatch occurs it must be reported to a high authority and is not dealt with by the local community	8

Fishers in Chilika Lagoon were then asked about what key rules, regulations, and measures are being employed to achieve bycatch management objectives. Over half of the fishers (68%) stated that dolphins are known to be protected and therefore are not illegally caught (Table 18). Some other fishers (20%) explained how they need to pay a fine if dolphin bycatch occurs. No fishers in Chilika are compensated for damaged gear if bycatch occurs as there are no specific bycatch policies implemented in India and fishers are expected to follow voluntary guidelines for disentanglement (Table 18). Many fishers explain how, “government rules are implemented in paper and pen only, practically these are not being implemented”.

Table 18. **What are the *key* rules, regulations, and measures employed to achieve bycatch management objectives? (Fisher surveys, n=50)**	
	% Of respondents
Need to pay a fine if dolphin bycatch occurs	20
Dolphins are known to be protected and are not illegally caught	68
We are compensated for damaged gear if bycatch occurs	0
There are no rules or regulations employed against bycatch	0

Fishers in Chilika were also asked about any informal rules, regulations, or measures that play important roles in managing Irrawaddy dolphin bycatch. As seen in Table 19, fishers in Chilika value Irrawaddy dolphins and because of this do not purposely seek to harm them (70%). This strong value of the dolphin's life is considered an informal rule among fishers. One fisher explained, "dolphins help us to fish more, dolphins get the fishes together, and that helps us fish easily." Other fishers (20%) explained how they also voluntarily try to stay farther away from the dolphins during fishing operations (Table 19). This is voluntary as there are no policies enforcing fishers to keep specific distances from dolphins during fishing operations in Chilika. No fishers surveyed in Chilika mentioned the use of sound devices and/or adapting fishing gear to deter dolphins from boats (Table 19).

Table 19. **Are there any *informal* rules, regulations, or measures that play important roles in managing Irrawaddy dolphin bycatch? (Fisher surveys, n=50)**

	% Of respondents
We as fishers value Irrawaddy dolphins and do not harm them	70
Try to stay farther away from dolphins during fishing operations	30
Use of sound devices and/or adapting fishing gear to deter dolphins from boats	0

As seen in Table 20, fishers were asked about any current enforcement or monitoring for cetacean bycatch or illegal fishing in Chilika Lagoon. Majority of fishers (94%) explained how the CDA is responsible for monitoring the lagoon once a year (Table 20). While some fishers (6%) were not aware of any current enforcement or monitoring for bycatch or illegal fishing (Table 20). Some of these fishers (6%) also explained how enforcement was not actually implemented on the ground (Table 20). Although the CDA has been completing a Flora and Fauna survey once a year as well as an annual dolphin census of Chilika Lagoon, fishers do not believe it is enough for effective enforcement or monitoring. Fishers explain how restrictions are being made by the villagers and the CDA does not take active steps to implement their guidelines.

Table 20. **Is there any current enforcement or monitoring for cetacean bycatch or illegal fishing in the area? (Fisher surveys, n=50)**	
	% Of respondents
Yes – Chilika Development Authority monitors the lagoon once a year	94
No	6

5.2.2 Are fishers supported to better deal with bycatch, and if so, how?

Interviewed key bycatch experts were asked if there are any organizations/groups for fishers to join on a local level to have discussions on bycatch and have their opinions on bycatch issues be heard and respected. Bycatch experts interviewed brought to light how whether fishers receive support for bycatch and exactly how they receive support depends on the country. Mitigating against bycatch has been considered mainly a fisheries management issue, however research into cetacean bycatch and fisheries governance is severely limited, with the impacts of management implementations falling on the fishers themselves (Whitty, 2015). As seen in Table 21, countries like Canada and the US are able to establish local scale fishery cooperatives which have regular meetings with all stakeholders addressing bycatch. Annual meetings also take place with the implementation of "Take Reduction Teams" which work to mitigate bycatch (Table 21).

Table 21. Chart comparing the status of organizations and groups fishers can join to talk about bycatch in westernized (Canada, US, & AUS) countries verses Global South (India, Brazil, & Bangladesh) countries. The information included here was analyzed from key bycatch expert interviews (n=10).

Canada, US, & AUS	**India, Brazil, & Bangladesh**
- Local scale fisheries and cooperatives - Have regular meetings with all key players/stakeholders - Have annual meetings for updates on the status of bycatch issues Ex. Canada – Take Reduction Teams	- Weak/poor/absent organizations of fishers – do not talk about bycatch - Instead: research stations - Need for democratic, deliberative, and participatory forums involving both fishers and other stakeholders - "Awareness" workshops to "teach" (do not collaborate with fishers) - Research conferences but no fishers included
Depends on population size and resources	

Key expert insights revealed that whether a country can provide bycatch management support can depend on both population size and quality of life (Table 21). Population size is important to consider because the more people in an area, the more they impact the environment and cause economic constraints (Washington & Twomey, 2016). With increased economic constraints and overcrowding of people it is not surprising the quality of life in these areas lowers and therefore so does the ability to address conservation issues. Some developing countries have weak organizations of fishers which do not discuss bycatch issues or do not have any well-established fisher organizations (Table 21). Local fisheries organizations often lack the resources and capability to manage SSF on a sustainable basis (Drammeh, 2002). Instead, research stations often play a bigger role in countries like India to provide small-scale fishers with a platform to discuss bycatch issues (Table 21). Key bycatch experts interviewed stressed how there lacks proper fisher representation and collaboration on bycatch issues in most developing countries (Table 21). The lack of fisher involvement in bycatch management in countries like India can be explained by the scarcity of information available on cetacean populations and the absence of specific policies for cetacean bycatch (Bering et al. 2022).

Fishers in Chilika were asked about who dominates the most social power in the area to deal with bycatch. As seen in Table 22, majority of fishers (74%) stated how governments have the most social power to deal with bycatch. This could be since government organizations seem to have more access to power and enforcement compared to local communities (Drammeh, 2002). For Chilika Lagoon specifically, this would include the CDA and Forest Department. However, other fishers explained how fishermen's cooperative societies and fishers' associations also have the social power to deal with bycatch in the area (Table 22). This is especially true as fishers explain the lack of active implementation of guidelines from the CDA, forcing fishermen's cooperative societies and fisher associations to take action. As explained by Whitty (2015), due to the lack of cetacean bycatch governance, the impacts of management implementations fall on the fishers themselves.

Table 22. **Who dominates the most social power in the area to deal with bycatch? (Fisher surveys, n=50)**	
	% Of respondents
Fishermen's cooperative society	10
Fishers' associations	16
Unions	0
Corporations	0
Governments	74
Business owners	0

Chilika fishers were also asked about whether there have been any recent changes to key rules, regulations, and measures, or new rules introduced to deal with cetacean bycatch. It was brought to light by most fishers (88%) that a new rule has been implemented by local governments in Chilika where if bycatch occurs and is reported, fishers no longer need to pay a fine (Table 23). One fisher explained, "Though the fishers don't fish dolphin, in case, we see injured dolphin in Chilika area, villagers or we, fishers inform the concerned officers of Forest Department and CDA immediately. They take its corpse and villagers or we, fishers are not punished or penalised." Local governments in Chilika include institutions such as fisher cooperatives and fisher associations. Since the CDA has been lacking in their implementation of bycatch guidelines it is promising to see fisher level institutions adapting their management of bycatch and starting to better support fishers. However, some fishers in Chilika (12%) were still unaware of any new bycatch rules or regulations being introduced to the area (Table 23). This is concerning as all fishers in the local area should be made aware of such changes.

Table 23. **Have there been any *recent changes* to key rules, regulations, and measures, or have any new ones been introduced to deal with cetacean bycatch? (Fisher surveys, n=50)**	
	% Of respondents
Yes – a new rules that has been implemented by local governments is that if bycatch occurs and we report the incident we no longer must pay a fine	88
No – no new rules or regulations have been introduced to help deal with bycatch	6
Can't say/no idea	6

5.2.3 What should be the focus of bycatch management?

Interviewed key bycatch experts were asked their opinions on what they believe effective cetacean bycatch management would involve in the context of managing SSF fisheries to be more viable. As seen in Table 24, key experts interviewed explained how there must be bottom-up management which incorporates the human dimensions of bycatch. This is especially important as most wildlife policies focus on only the biological information to inform policy strategy, leaving out the human dimensions of marine mammal management (Meek et al. 2011). They also explained how any agencies responsible for managing bycatch must talk with local communities and fishers to determine what exactly their bycatch issues are and how they would address them (Table 24). Examining the local fisher-cetacean social-ecological system is extremely important as human relationships and modes of governance play a huge role in conservation success (Meek et al. 2011). Key bycatch experts interviewed further explained how there must be direct on-the-groundwork with fishers on prevention technologies and methods before they are implemented, such as marine spatial planning and pingers/deterrence devices (Table 24). However, they also stated how all the strategies explained above must be supported by policies which give fishers more access to power and decision making, as well as provide better representation for both fishers and cetaceans (Table 24). Effective adaptive policies require new ways of understanding and governing human interactions with cetaceans (Meek et al. 2011).

Table 24. **What would *effective* cetacean bycatch management involve in the context of managing SSF fisheries to be more viable? (Key bycatch expert interviews, n=10)**

- Bottom-up management which incorporates human dimensions of bycatch
- Need to talk with locals and determine what exactly the problem is and how they would address it
- Prevention work with fishers involving their participation in marine spatial planning
- Working with fishers on the ground to test technologies and prevention methods BEFORE they are implemented

All the above needs to be backed up with policies to support these actions and give fishers access to power = need policy shift with better representation of small-scale fishers and cetaceans

Fishers in Chilika were asked their opinions on what measures they think are necessary to better prevent unwanted bycatch related issues. As seen in Table 25, majority of fishers (80%) stated that they believe sensitization and training for fishers is necessary to better prevent bycatch incidents. Governments must help sensitize fishers on the need for responsible and sustainable fishing practices (Drammeh, 2000). Although the CDA and Forest Department provide training at the village level every year, fishers still have ideas on bycatch management which need to be discussed. For example, one fisher stated, "The unwanted accident can be stopped, if the dolphins are kept in reserved areas." Some fishers (16%) still support the notion that restrictions and penalties are needed to better prevent unwanted bycatch related issues (Table 25). When asked who should implement these measures, most fishers (88%) agreed that the CDA should be responsible for implementing bycatch prevention measures as well as provide training (Table 25.1). However, some fishers (4%) think that fisher societies and associations should be the ones implementing these bycatch measures, while others (8%) believe it should be all the organizations working together to tackle bycatch issues (Table 25.1). Governments need to make a genuine effort to help bring together small-scale fishers for sensitization as well as to help empower them and have fishers actively participate in bycatch decision-making processes at the local level (Drammeh, 2000).

Table 25. **What measures do you think are necessary to better prevent the unwanted bycatch related issues? (Fisher surveys, n=50)**	
	% Of respondents
Sensitization and training	80
Restrictions and penalty	16
No measures necessary as bycatch incidents occur but rarely	2
Other…(dolphins should be kept in reserved areas)	2
Table 25.1 **Who should implement these measures?**	
	% Of respondents
Chilika Development Authority	88
Fishermen's Society	2
Fishermen's Association	2
Other…(all of the above)	8

Voluntary Guidelines for Securing Sustainable SSF in the context of food security and poverty eradication have started to be implemented in SSF around the world. However, this document fails to address or mention bycatch and its' related issues. Interviewed key bycatch experts were asked about these SSF guidelines implemented by the Food and Agriculture Organization (FAO) of the United Nations, and if they agree with there being no mention of bycatch since bycatch species are not considered to be "commonly harvested aquatic living resources". As seen in Table 26, key bycatch experts interviewed agree that bycatch should at least be recognized in the document and included as a problem being faced by SSF. This is especially true since the widely used definition of bycatch still includes the catch of economic species (Table 26). Interviewed key experts also brought to light how bycatch species can shift to becoming economic species (Table 26). This is especially true with the development of new markets for bycatch species and products which were never exported earlier due to the increased demand and consumption of seafood (Lobo, 2012). However, one key expert interviewed explained how since the purpose of the document was on reclaiming rights and food security and fails to address increased fisheries intensities, it is not surprising they would not address bycatch (Table 26).

Table 26. **The voluntary FAO SSF guidelines do not consider bycatch species to be "commonly harvested aquatic living resources" and because of this do not address bycatch in any way. Do you agree with this? Why or why not? (Key bycatch expert interviews, n=10)**
- Should include bycatch or at least recognize it happens in SSF and is a problem - This is especially true as the definition of bycatch still includes the catch of economic species - Bycatch species can shift to being economic species (ex. Sharks in Chilika Lagoon) - Purpose of the document is to focus on reclaiming rights and food security, do not talk about increased fisheries intensity therefore do not address bycatch

5.2.4 What role should fishers play in bycatch management and governance?

Fishers in Chilika were asked their thoughts on what they think their role should be in preventing unwanted bycatch issues. A majority of fishers (90%) believe that they should be responsible for sensitization and orientation of the community on the issues of bycatch (Table 27). Sensitization of the community would involve increasing the quality of fisher responses to bycatch, making sure everyone involved is aware of the traumas associated with bycatch and

are trained properly to deal with entanglements. Orientation of the community depends on fishers sharing their insights on the struggles of bycatch without the fear of persecution. Some fishers (10%) still believe reporting bycatch incidents to concerned authorities should be their role in preventing unwanted bycatch related issues (Table 27). All fishers surveyed in Chilika Lagoon believe they have a role to play in the prevention of bycatch incidents, with no fishers stating they had no idea as to how they could contribute to bycatch prevention (Table 27).

Table 27. **What should be your role or the contribution of other fishers in preventing unwanted bycatch related issues? (Fisher surveys, n=50)**

	% Of respondents
No idea	0
Sensitization and orientation of the community of this issue	90
Reporting bycatch incidents to concerned authorities	10

Key bycatch experts interviewed were asked about what they thought would be a feasible and realistic support to help fishers better handle interactions with dolphins. As seen in Table 28, interview participants believe there is a drastic need for including fishers in decision making as well as actively participating and collaborating with fishers on prevention technologies and methods. The fisher's role in bycatch management is extremely important as they are the driving force in addressing bycatch conflicts (Borges et al. 2002). Key bycatch experts explained how by working directly on-the-ground with fishers on ways to help protect dolphins, it allows them to be proud of their efforts instead of feeling shame when bycatch does occur (Table 28). It was also brought to light how the definition of bycatch needs to be updated, specifically the differentiation between unintentional bycatch and targeted "bycatch" that is not discarded (Table 28). However, as previously explained, these strategies must still be supported through strong bycatch policies (Table 28). This is especially important as good fishing practices in the marketplace must be recognized and rewarded (Lobo, 2012).

Table 28. **What would be a feasible and realistic support to help fishers better handle interactions with dolphins? (Key bycatch expert interviews, n=10)**
- Including fishers in decision making - Testing technologies with fishers on the ground - Active participation and collaboration - So fishers can be proud instead of shamed - Talking with fishers and sharing ideas - Definition of bycatch needs to be updated – need to differentiate between unintentional "bycatch" and targeted "bycatch" *would need supportive policies*

5.3 Discussion

This section will discuss the above results and explain their significance as well as common themes discussed by both fishers and key experts while completing surveys and interviews.

5.3.1 Defining bycatch: Why top-down management of bycatch does not work

The way bycatch is defined has significant implications for bycatch management because this definition determines which species are bycatch and therefore cannot be intentionally caught by fishers. The widely used definition of bycatch is very broad and does not account for the human dimensions of bycatch, failing to encompass its' economic linkages (Banzon et al. 2019). The perspectives of local fishers must be incorporated in how bycatch is defined as they are the ones directly interacting with bycatch species. Fisher-cetacean interactions are extremely complicated; therefore, the definition of bycatch must become more diverse and representative of bycatch interactions with fishers.

As learned in Chapter 4, there is a disconnect between what fishers in Chilika and interviewed key experts believe to be bycatch which can influence how effectively it is managed due to fishers being directly responsible for dealing with bycatch interactions. Having a clearer definition of bycatch and understanding how certain countries view certain bycatch species can lead to more effective management plans, mitigation efforts, and bycatch quantification (Banzon et al. 2019). Effective bycatch management that works to support fishers may help small-scale fishers be more resilient to the material and mental wellbeing impacts of bycatch.

For effective bycatch management to be possible, fishers must be given the resources and services they need to be made aware of the most up-to-date ecological insights used by management to inform bycatch policies.

Top-down management of bycatch has been directly impacted by the way bycatch is defined since fishers are expected to deal with the consequences of bycatch on their own. As seen in Table 16, fishers in Chilika explain how the Forest Department and CDA are legally responsible and empowered for bycatch governance of fisheries in Chilika Lagoon. Meanwhile, when fishers were asked about on-ground management of bycatch, majority of fishers (92%) stated that if bycatch of a dolphin occurs local organizations or groups are the ones dealing with the issue (Table 17). One fisher stated, "No one follows the rules that are made at local level in support of the CDA." These results show that although government organizations are the ones legally responsible to deal with bycatch issues, fishers and their local communities are the ones actively dealing with cetacean bycatch once it happens on-ground. Therefore, it only makes sense that fishers and their perspectives on bycatch be incorporated in how bycatch is defined as they are the ones directly dealing with the problem.

Key rules and regulations employed to achieve bycatch management objectives are also directly impacted by the way bycatch is defined in policies. Depending on how bycatch is defined and which species it encompasses, this can influence what kinds of key rules and regulations are implemented in the local area. Although fishers in Chilika know dolphins are protected and are therefore not illegally caught, some fishers (20%) still claim they need to pay a fine if dolphin bycatch occurs (Table 18). However, when later asked about recent changes to key rules and regulations 88% of fishers explained how a new rule has been implemented by local governments in Chilika where if bycatch occurs and is reported, fishers no longer need to pay a fine (Table 23). Local governments changing whether fishers receive a fine for dolphin bycatch is extremely important as removing this harsh punishment could impact bycatch reporting (Figure 10). The fact that not all fishers are aware of this new rule brings to light the miscommunication between management and fishers. Many fishers in Chilika explain how, "government rules are implemented in paper and pen only, practically these are not being implemented". Other fishers explained, "the system is implemented only in government's file,

in fact it is the opposite." If fishers currently lack the support they need from active participation by governments, then they need to be given more power through appropriate cetacean bycatch governance to have a say in bycatch management decisions and directly influence the implementation of strong and supportive bycatch policies.

5.3.2 Why do some countries have bycatch policies while others do not?

Bycatch is considered a leading global conservation threat to cetaceans and other marine mammals with more than 600,000 marine mammals being killed each year in our world's fisheries (Bering et al. 2022). Since bycatch is considered such a global threat, it would make sense for all countries engaging in fisheries to have bycatch policies in place to try and manage this threat. However, this is not the case as learned through key bycatch expert interviews with countries like India, Brazil, and Bangladesh not having any specific bycatch policies (Table 15). Bering at al (2022) completed the first analysis of the U.S Marine Mammal Protection Act's Import Provisions Rule and found that countries like India need to take significant additional steps to build more comprehensive policies on marine mammal protection and bycatch, as well as increase data collection, reporting, and monitoring of marine mammal bycatch. Although India has relatively strong fisheries management programs, they still lack in effectively addressing bycatch and do not have marine mammal mortality data for any of their fisheries (Bering et al. 2022). The lack of quality information to inform management and policies is a main threat to the successful survival of cetaceans in India (Kumarran, 2012). As explained by key bycatch experts, there is a strong need for democratic, deliberative, and participatory forums involving both small-scale fishers and other stakeholders which could be established through appropriate cetacean bycatch governance (Table 21). Cetacean bycatch governance must work to provide small-scale fishers with access to power and decision making in order to give them a voice in influencing bycatch policies which adequately address the human dimensions of bycatch.

5.3.3 Conflicts between fisheries and conservation management objectives

Fisheries management goals have yet to coincide with conservation management objectives. In India, although the Forest Department and Ministry of Environment and Forests

focus on restricting and banning the harvest of cetaceans, the Fisheries Department and Ministry of Agriculture aim to maximize fisheries production (Lobo, 2012). As explained by one of the key bycatch experts, “fisheries are a major economic resource and are managed as agriculture with no ecosystem-based thinking.” Fishery laws often contradict conservation laws and therefore affect bycatch mitigation and management (Kelkar & Dey, 2020). This is because conflicting objectives confuse management strategies, especially for bycatch, with ongoing industrialization of fisheries and declining fish catches (Lobo, 2012). This becomes especially difficult when bycatch occurs in legal nets/gear (Kelkar & Dey, 2020). Small-scale fishers in areas like Chilika are forced to apply their own informal rules for managing dolphin bycatch (Table 5). Informal rules involve fishers voluntarily keeping safe distances from cetaceans and not purposely harming cetaceans as they recognize their value (Table 19). Since fishers are the ones participating in informal rules for bycatch management it makes sense to involve small-scale fishers in developing supportive bycatch policies.

Although bycatch reporting is considered mandatory for fishers there is still significant under-reporting, making fisher logbooks unreliable (Basran & Sigurosson, 2021). In Chilika Lagoon, the CDA itself completes a Flora and Fauna survey once a year using a “Transact Survey Method”. However, they fail to provide further details as to which type of transect survey method they use as there are line transect methods as well as photo transect methods (Jackson et al. 2015, Lyons et al. 2015). Fishers tend to have difficulties accurately identifying species with no widely used monitoring system in place (Basran & Sigurosson, 2021). Therefore, it would make sense to include small-scale fishers in the CDA surveys for them to learn how to properly identify dolphin species to help with bycatch reporting and monitoring, however only Officials of the CDA and Government were involved. This example illustrates unfair power dynamics faced by fishers in how bycatch management decisions are informed.

Fishers in Chilika should be actively involved in the CDA surveys since fishers currently have little incentive to report bycatch events due to concerns over negative repercussions (Basran & Sigurosson, 2021). Fishers in Chilika described the CDA surveys as “useless talking.” This is evident as the true status of the Irrawaddy dolphin in Chilika Lagoon is unclear with the CDA report stating there were 156 Irrawaddy dolphins sighted in 2022 (Figure 11), inferring a

range of 155-165, as well as stating that the dolphin population is increasing. However, no information on the sex ratios were provided and as discussed previously, whether there are adult and/or female dolphins is extremely important for monitoring and understanding the true status of the population (Figure 10). With the CDA claiming there to be a steady population of Irrawaddy dolphins in Chilika Lagoon, it contradicts the findings in the Concerted Action Plan for the Irrawaddy dolphin which states the species is in danger of extinction and populations are showing decreasing trends (UNEP, 2019). Therefore, involving small-scale fishers in surveys who regularly interact with the Irrawaddy dolphins and have knowledge on past populations would be extremely beneficial in understanding the true status of the Irrawaddy dolphin population in Chilika Lagoon.

Government organizations are considered by fishers in Chilika to have the most social power to deal with bycatch (Table 22). However, fisher associations and fisher cooperative societies also have social power to deal with bycatch (Table 22). It must be taken into account that the objectives of government organizations may not coincide with the objectives of fisher associations and fisher cooperative societies, especially in terms of addressing the industrialization of fisheries and bycatch (Lobo, 2012). Fishers in Chilika explained how, “some people don’t follow the government’s rules.” With fishers not seeing the value in current bycatch management methods, there is an urgent need for more comprehensive fisheries management policies in countries like India. More holistic bycatch management strategies must emphasize the need for well-considered and context-specific approaches to devising legal definitions, realistic incentives, and disincentives for minimizing negative social, ethical, and ecological impacts of bycatch (Lobo, 2012).

An example of conflicting goals of fisheries management and conservation is evident with the Voluntary FAO Guidelines for SSF not mentioning bycatch or bycatch related issues as they do not consider bycatch species to be “commonly harvested aquatic living resources” (Table 26). However, as previously discussed, the current definition of bycatch includes economically viable species. It must also be considered that discarded portions of fishery catches (ex. protected species, and unknown mortalities of oceanic species not caught) represent an intolerable waste of aquatic living resources (Borges et al. 2002). One key expert

stated how the Voluntary FAO Guidelines for SSF not mentioning bycatch in any way "is a prime example of when an organization wears a fisheries hat and considers everything to be fine from a natural perspective" (Table 26). Issues of how bycatch is not fully understood and how this impacts the way it is defined, as well as whether it is addressed through fisheries management, is evident in this example.

5.3.4 How can cetacean bycatch governance help both fishers and cetaceans be viable?

When key bycatch experts were asked about what is needed for effective cetacean bycatch management, the main insight was the need for fishers to be directly involved (Table 24). Therefore, it is important to talk with fishers to figure out how they want to be involved and what they consider to be needed in terms of bycatch management. Fishers (80%) in Chilika feel as though sensitization and training are necessary to better prevent bycatch events (Table 25). Key bycatch experts also agree that training fishers directly on the ground and testing technologies and prevention methods with them would be extremely beneficial for managing SSF to be more viable for the long-term (Table 24). It is necessary for governments to help sensitize fishers and make genuine efforts to strengthen fisher organizations by empowerment and encourage fisher involvement in policy adaptations (Drammeh, 2000). Fishers (88%) also believe that the CDA should be mainly responsible for implementing sensitization and training (Table 25.1). However, the CDA would still "need the support of the public" as explained by a fisher in Chilika. Therefore, it is imperative that the CDA works directly with small-scale fishers in trying to reduce unwanted bycatch events. For bycatch implementations like sensitization and training to remain viable and effective for the long-term, they must be supported by strong bycatch policies (Table 24).

The fisher's role in bycatch management is extremely important as they are the driving force in addressing bycatch conflicts, can provide scientists with unique practical knowledge of relevant fishing technologies, and are the ones made responsible for implementing solutions into their daily fishing operations (Borges et al. 2002). However, fishers need access to power and institutional supports to implement bycatch management strategies which can only be provided through appropriate cetacean bycatch governance. Cetacean bycatch governance

would involve bringing together bycatch stakeholders with fishers to actively collaborate with one another. Fishers in Chilika explained how, “we would all benefit if bycatch is managed through some committees.” Cetacean bycatch governance must work together with bycatch management to help organize fishers and connect them with other bycatch stakeholders in order to actively collaborate with one another on potential bycatch management implementations for their local SSF environment.

Along with fishers, scientists are also important for bycatch management, however their role should focus on the organization, analysis, and dissemination of work, as well as to ensure scientific experiments are done effectively (Borges et al. 2002). Therefore, scientists play an important role in cetacean bycatch governance by helping organize fishers and ensure bycatch management strategies decided on by small-scale fishers and their community are being implemented properly. When key bycatch experts were asked their opinions on feasible and realistic supports for fishers, they explained the need for active participation and collaboration with fishers (Table 28). Key experts explained how by directly involving fishers in testing technologies and mitigation strategies, fishers can be proud of their efforts instead of being shamed when bycatch events occur (Table 28). However, as previously explained, any efforts for managing bycatch must be supported with strong bycatch policies as well as appropriate cetacean bycatch governance.

5.4 Conclusion and Chapter Summary

Mitigative measures are not enough to effectively increase social-ecological viability through cetacean bycatch governance because fishers cannot completely avoid cetaceans while out on fishing operations, especially with increased fishing effort and the expansion of SSF. External drivers like overfishing and climate change add additional pressure to SSF dealing with bycatch as well as inappropriate bycatch mitigation. Strategies used to manage bycatch must be able to adapt to societal changes and values, or else they may add to the vulnerabilities already faced by SSF such as overfishing. Therefore, adaptive strategies for bycatch management are more complimentary to cetacean bycatch governance as adaptive approaches are more likely

to effectively increase social-ecological viability by directly involving fishers and incorporating their perspectives within bycatch policies.

This is especially true in terms of adapting the definition of bycatch within fisheries policies to better represent both fishers and cetaceans, as well as the economic linkages of bycatch. The current widely used definition of bycatch (the incidental capture of non-target species) has influenced the way bycatch has been managed as the definition of bycatch represents which species are bycatch species and therefore cannot be targeted by fishers. However, since "incidental" capture means the action was unavoidable it makes distinguishing between true bycatch species more difficult since a fisher may incidentally catch a bycatch species but then still use the species for economic gain. Therefore, it is extremely important to actively involve fishers in creating new bycatch definitions and policies which are clearer and easily understood by fishers involved in bycatch events, allowing for the bycatch policies to be supportive of cetacean bycatch governance.

There is a strong need for cetacean bycatch governance, especially in coastal SSF communities. Small-scale fishers need to be provided with the institutional support they need to manage bycatch according to their local context and values. Guidelines created for SSF like the Voluntary Guidelines for Securing Sustainable SSF in the Context of Food Security and Poverty Eradication made by the FAO need to address bycatch and its interactions with SSF vulnerability and viability. Small-scale fishers need to be provided with better platforms to organize discussions on bycatch issues and potential pathways for viability. Through cetacean bycatch governance small-scale fishers would be given the access to power they need to better protect themselves, cetaceans, and their local resources from bycatch and inappropriate bycatch mitigation implementations.

Chapter 6

Conclusions

6.1 Thesis Summary

The question guiding this research was focused on identifying vulnerabilities faced by both cetaceans and small-scale fishers to help develop common strategies for their viability. As learned through the comparative analysis of surveys with fishers in Chilika and interviews with key bycatch experts, small-scale fishers themselves potentially play the biggest role in protecting both themselves and cetaceans against vulnerabilities of ineffective bycatch management. However, small-scale fishers in some countries like India are not given the institutional support they need to have the power to manage bycatch themselves. Unfair power dynamics in how bycatch is managed in SSF was brought to light by the disconnect between the opinions of Chilika fishers and interviewed key experts on bycatch and its related social-ecological linkages, as key bycatch experts and their research help to inform policies and fisheries management. Therefore, it is clear that common strategies to help both small-scale fishers and cetaceans must have a broader social-ecological focus involving cetacean bycatch governance as strategies used to address bycatch can align with strategies to empower SSF and small-scale fishers.

6.2 Key Insights

This section of the report will explain in further detail what was learned from each research objective and what implications the results have on increasing the viability of both small-scale fishers and cetaceans for the long-term. This section will also discuss the contributions and recommendations of this research, as well as potential directions for future research.

6.2.1 Objective 1

The first objective of this research was to understand the nature and extent of cetacean bycatch within the Chilika Lagoon SSF social-ecological system. The Chilika Lagoon case study

provided vast insights from fishers explaining the nature and extent of cetacean bycatch in their social-ecological system to be extremely rare and therefore not considered to be an urgent problem by fishers in the case study area. However, as learned from the PBR of Irrawaddy dolphins in Chilika, even 1 bycatch event a year can be a big threat to this small subpopulation. Therefore, even with fishers in Chilika having unique positive relationships with the dolphins, bycatch events could still be having an impact on the social-ecological system. These results also brought to light the disconnect between what fishers in Chilika and key experts interviewed believe to be bycatch: pointing out the need for SSF fisher perspectives to be incorporated in how bycatch is defined. The results of this study highlight the context specific nature of bycatch and the need to directly talk with fishers about bycatch, instead of grouping all SSF together and making assumptions on SSF fisher involvement in bycatch events.

6.2.2 Objective 2

The second objective of this research was to examine how cetacean bycatch and its mitigation add to the vulnerabilities of the social-ecological system by focusing on cetacean bycatch impacts on both the natural and social subsystem in the Chilika Lagoon case study. The results of this research highlighted the uncertainty of how cetacean bycatch impacts the natural subsystem (both in a global and case study context) due to various external drivers (e.g., overfishing) impacting the vulnerability of SSF natural subsystems. This research highlighted the importance of focusing on the social context of bycatch and how ineffective cetacean bycatch management impacts both small-scale fishers and their livelihoods as well as fisher-cetacean relationships. These results also highlight how areas with higher levels of cetacean bycatch could be linked to higher levels of IUU fishing as these areas greatly lack in enforcement as well as monitoring – making both small-scale fishers and cetaceans more vulnerable to the impacts of overfishing and IUU. Therefore, although cetacean bycatch impacts are context specific, fisher-cetacean relationships can play an important role in how cetacean bycatch and its' mitigation impact the vulnerabilities of SSF. This is especially true in the Chilika Lagoon case study where fishers have positive relationships with cetaceans and therefore are open to adapting current cetacean bycatch management as they have many new innovative insights on how Irrawaddy dolphin bycatch impacts their wellbeing and livelihoods.

6.2.3 Objective 3

The third objective of this research was to determine a set of mitigative and adaptive strategies that are most likely to increase social-ecological viability through appropriate cetacean bycatch governance. Adaptive bycatch management strategies are needed as they consider the human-dimensions of bycatch and are flexible to environmental changes unlike mitigative approaches to bycatch management. I found that fishers in Chilika Lagoon are open to bycatch management adaptations and recognize the role they play in preventing bycatch events. Bycatch management adaptations would include creating a more representative definition of bycatch, as well as testing technologies and collaborating on marine spatial planning ideas with fishers before implementation. Cetacean bycatch governance would need local and national government organizations as well as fisheries stakeholders to directly collaborate with small-scale fishers and provide them with the institutional supports they need to be able to test potential bycatch adaptation management strategies and see what works best for their community. Small-scale fishers need to be respected and have access to power to inform bycatch policies as fisher perspectives do not always align with the most up-to-date ecological knowledge as seen through this study. Therefore, for cetacean bycatch governance to be effective for the long-term and increase social-ecological viability it must work together with adaptive bycatch management and provide small-scale fishers with a seat at the table, incorporating their perspectives into all bycatch adaptation strategies.

6.3 Contribution and Recommendations

By approaching cetacean bycatch research from a transdisciplinary perspective and recognizing complex fisher-cetacean interactions this research may be more effective at providing solutions to both bycatch and cetacean conservation. Focusing on both cetaceans and small-scale fishers who face similar vulnerabilities and share the same space and resources has helped to bring more innovative perspectives to dealing with bycatch – potentially creating a viable future. External pressures that might lead to increased frequency and urgency of bycatch events have been exacerbated due to overfishing and unsustainable management of fisheries (Whitty, 2015). By effectively investigating bycatch adaptations from a transdisciplinary

perspective with emphasis on the definition of bycatch within policies, the results can be applicable to overall fisheries management and governance. Fisheries management is currently unsustainable with fisheries expanding operations and increasing fishing effort in response to overfishing (Zhou et al. 2015). This cycle of unsustainable fisheries management will only continue if it is not dealt with.

6.4 Directions for Future Research

Bycatch is context specific and depends on various social-ecological factors. Therefore, it is important to further investigate fisher-cetacean relationships around the world and small-scale fisher perspectives on potential cetacean bycatch governance. Further case studies which involve fisher perspectives on how they would like to manage bycatch are extremely important. However, it is important to not only 'extract' information from the fishers, but to actively involve them in adaptations of bycatch management. With the definition of bycatch playing such a significant role in management, it is especially important to actively change how bycatch is being defined and start incorporating fishers and the human-dimensions of bycatch into its definition. Future research must also work to analyze the effectiveness of adapting the bycatch definition and making sure it works to benefit both fishers and cetaceans in the long-term. Any type of bycatch adaptation implemented will need to include ongoing monitoring and analysis of its effectiveness. The reality of bycatch research is that we are still far from understanding the best potential solutions and ongoing research on bycatch and its social and governance potential is required.

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APPENDIX A: SURVEY QUESTIONNAIRE

General Questions

Village/town: Block: District:

Code number: [for researcher to keep track of participants for data analysis ex.F01]

Gender:

Age:

Occupation:

Annual household income:

Role/Membership in primary fishermen cooperative society:

Role/Membership in fishermen federation (matsyajivi mahasangha):

Social-Ecological

1. What does the word "bycatch" imply to you?
   a) Accidental/unavoidable capture of an unwanted species
   b) Loss of money/business
   c) Unnecessary trouble
   d) Some source of income
   e) Do not know what it means
   f) Does not mean anything
   g) Other

2. What fisheries interactions would you consider to be bycatch?
   a) Getting water snakes, dolphins, stingray('sankucha'), jellyfish, or other aquatic animals of considerable size
   b) Getting commercially valuable species of secondary preference (fish or shellfish) while targeting the primary preference (like, getting small fish species while targeting shrimps)
   c) Getting unwanted(and apparently useless) juveniles of other valuable fish species while catching prawn juveniles
   d) Other

3. Of the above responses (selected by the respondent), how frequently you face it?
   a) Rarely
   b) Frequently

c)During certain seasons only (please specify the season)
d)Never
e) Other

4. What has been your relationship with the Irrawaddy dolphins?
   a) Positive/good(friendly)
   b) Negative/bad(hostile)
   c) Neutral/do not like or dislike the dolphins
   d) Other

5. How often do you interact with Irrawaddy dolphins while fishing?
   a) Every time you go fishing
   b) Only during certain seasons
   c) Once every week
   d) Never directly interact with the dolphins
   e) Other

6. Do you consider accidentally catching a seabird/migratory bird/water bird to be the same as catching an Irrawaddy dolphin during the fishing operations?
   a) Yes
   b) No
   c) Other

7. Do you think it would be beneficial for fisheries policies to address different scales of bycatch in policies and distinguish between bycatch of large mammals like Irrawaddy dolphins and smaller species like turtles and seabirds?
   a) Yes
   b) No
   c) Other

8. Do you feel as though Irrawaddy dolphin bycatch has become a threat to fishing operations?
   a) Yes, and why (ex. costs a lot of money to replace fishing gear)
   b) No and why not (ex. bycatch of Irrawaddy dolphins does not happen/very rare)
   c) Other

9. When did you start to notice less Irrawaddy dolphins in the lagoon?
   a) I did not know there were less dolphins in Chilika Lagoon
   b) A couple of months ago
   c) A year ago
   d) A couple of years ago
   e) Other

10. Have changes occurred in the Lagoon ecosystem due to Irrawaddy dolphin bycatch?

a) Although rare, bycatch incidents with dolphins have increased
b) With less dolphins there is less biodiversity and fish
c) No changes have occurred
d) Dolphin bycatch is not an issue for the Lagoon ecosystem
e) Other

Social-economic

11. Have changes occurred involving your material wellbeing due to Irrawaddy dolphin bycatch?
    a) Can still afford good fishing gear
    b) Cannot afford good fishing gear, forced to work with damaged gear
    c) Can afford fishing gear but not other material goods (ex.clothes,cellphone…)
    d) Cannot afford good fishing gear or other material goods
    e) Dolphin bycatch does not impact my material wellbeing
    f) Other

12. Has Irrawaddy dolphin bycatch interactions impacted your mental wellbeing in any way?
    a) Yes, and in a negative way (ex. Frustrated with having to fix and buy fishing gear)
    b) Yes, and in a positive way (ex. Happy to see the dolphins, do not have bad interactions)
    c) No, do not care for the dolphins/unbothered by them
    d) Other

13. What have been the impacts on the environmental/natural system of Irrawaddy dolphin bycatch?
    a) Negative, less fish and biodiversity
    b) Positive, more fish and other species
    c) Dolphin bycatch does not occur
    d) Dolphin bycatch extremely rare, having little impact on the natural system
    e) Other

14. What have been the livelihood impacts of Irrawaddy dolphin bycatch?
    a) Low fishing productivity – more effort spent on fishing operations with less fish being caught
    b) Change of occupation/loss of job
    c) Loss of access rights due to dolphin “protection”
    d) Loss of rights to decision making on dolphin bycatch events
    e) No impact on livelihoods
    f) Other

15. Was there ever a time in Chilika Lagoon with no bycatch of Irrawaddy dolphins?
    a) Yes
    b) No
    c) I don’t know

d) Other

16. What was the productivity of the system ex. fish stocks (low, medium or high) prior to Irrawaddy dolphin bycatch events/when they were lower?
    a) Low fish stocks
    b) Medium/Average fish stocks
    c) High fish stocks
    d) Dolphin bycatch does not impact fish stocks/productivity
    e) Other

17. What other livelihood opportunities are possible/available in the area not affected by Irrawaddy dolphin bycatch?
    a) Farming/agriculture
    b) Construction
    c) Education
    d) Other

18. If Irrawaddy dolphin bycatch occurs, what % of total catch from daily fishing operations is used for own household consumption (not sold)?
    a) More than half of the total catch
    b) Half the total catch
    c) Less than half of the total catch
    d) Less than a quarter of the total catch
    e) Other

Governance and Management

19. What are the relevant organization(s) or individual(s) legal responsible and empowered for bycatch governance of fisheries at local, regional, and national levels?
    a) Fisher Association at the local level
    b) Government agency managing bycatch at the national level
    c) Scientists and NGOs at the local level
    d) There is currently no bycatch governance of fisheries
    e) Other

20. Is the management of bycatch done on alocal or national scale?
    a) Local – if dolphin bycatch occurs local organizations or groups deal with the issue
    b) National – if dolphin bycatch occurs it must be reported to a high authority and is not deal with by the local community
    c) Other

21. Are there any other institutions or other community groups trying to manage bycatch voluntarily?

a) Yes (please specify the name)
b) No
c) Other

22. What are the key rules, regulations, and measures employed to achieve bycatch management objectives?
    a) Need to pay a fine if dolphin bycatch occurs
    b) Dolphins are known to be protected and are not illegally caught
    c) We are compensated for damaged gear if bycatch occurs
    d) There are no rules or regulations employed against bycatch
    e) Other

23. Are there any **informal** rules, regulations, or measures that play important roles in managing Irrawaddy dolphin bycatch?
    a) We as fishers value Irrawaddy dolphins and do not harm them
    b) Try to stay farther away from dolphins during fishing operations
    c) Use of sound devices and/or adapting fishing gear to deter dolphins from boats
    d) Other

24. Is there any current enforcement or monitoring for cetacean bycatch or illegal fishing in the area?
    a) Yes – if so by who (ex. Government agency monitors the lagoon once a year)
    b) No
    c) Other

25. Is there a support or conflict between SSF fishers and current bycatch policies/implementation measures?
    a) Support – fishers abide by and support current bycatch policies
    b) Conflict – fishers do not abide by current bycatch policies and are not supportive of implementation measures
    c) There are currently no bycatch policies being implemented
    d) Other

26. Who dominates the most social power in the area to deal with bycatch?
    a) Fishermen's cooperative society
    b) Fishers' associations(mahasangha)
    c) Unions
    d) Corporations
    e) Governments
    f) Business owners
    g) Other
27. Have there been any recent changes to key rules, regulations, and measures, or have any new ones been introduced to deal with cetacean bycatch?

a) Yes – a new rule that has been implemented by local governments is that if bycatch occurs and we report the incident we will no longer have to pay a fine
b) No – no new rules or regulations have been introduced to help deal with bycatch
c) Other

28. What measures do you think are necessary so as to better prevent the unwanted bycatch related issues?
    a) Sensitization and training
    b) Restrictions & penalty
    c) No measures necessary as bycatch incidents occur but rarely
    d) Other

29. Who should implement these measures?
    a) Chilika Development Authority
    b) Fishermen's Society
    c) Fishermen's association(mahasangha)
    d) Other

30. What should be your role or the contribution of other fishers in effecting the same?
    a) No idea
    b) Sensitization and orientation of the community on this issue
    c) Reporting the incidents to the concerned authorities
    d) Other

APPENDIX B: SEMI-STRUCTURED INTERVIEW QUESTIONNAIRE

Objective 1: Understanding the nature and extent of cetacean bycatch within the social-ecological system:

1. What does the word "bycatch", specifically of marine mammals, represent to you?
2. Do you think it would be beneficial for the definition of bycatch in fisheries policies to distinguish between different species?
3. How do you think bycatch species should be distinguished from one another within bycatch policies, specifically for reporting and monitoring? (ex. size, reproductive rates etc.)
4. Can you describe the relationship fishers have with dolphins? (ex. do they benefit each other in any way? Is it mutual or does one benefit while the other does not?)
5. How do you think fishers view dolphin bycatch?
6. How are dolphins (individual level and population level) impacted by bycatch interactions with fishers? (ex. can't catch enough food, becoming injured, needing to migrate to a new area…)
7. How is dolphin bycatch represented/explained by governments in a local vs national context? Is it considered to be an urgent problem on either scale?

Objective 2: How cetacean bycatch adds to vulnerabilities of the social-ecological system:

8. Have the monitoring efforts and records of bycatch levels for dolphins changed in any way *(in the case study area in question*) within the last 10 years? If yes, how have they changed?
9. How often do dolphins and fishers interact while fishing operations are taking place? (ex. once a day, twice – maybe only during certain seasons etc.)
10. How close do dolphins come to boats while fish are being hauled into the boat during fishing operations vs when there are no fish?
11. If the rate of current cetacean bycatch were to continue without effective interventions, how do you see this impacting SSF productivity and ability to provide enough fish for global food security?
12. How are SSF with higher levels of cetacean bycatch and the occurrence of Illegal, Unreported and Unregulated (IUU) within local fishing communities connected?

Objective 3: Determining set of mitigative and adaptive strategies most likely to increase social-ecological viability through appropriate cetacean bycatch governance:

13. Who manages the bycatch in the areas you've studied and how - are there bycatch policies?
14. What would be a feasible and realistic support to help fishers better handle interactions with dolphins?
15. How well are cetaceans protected against tourism operations compared to fishing? Should the same rules apply?

16. The voluntary FAO SSF guidelines do not consider bycatch species to be “commonly harvested aquatic living resources” and because of this do not address bycatch in any way. Do you agree bycatch species are not “commonly harvested”? Why or why not?
17. Are there any organizations/groups for fishers to join on a local level to have discussions on bycatch and have their opinions on bycatch issues be heard and respected?
18. What would *effective* cetacean bycatch management involve in the context of managing SSF fisheries to be more viable? (ex. reporting, monitoring, prevention, mitigation, etc.)

APPENDIX C: Ethics Clearance

UNIVERSITY OF WATERLOO

Notification of Ethics Clearance to Conduct Research with Human Participants

Principal Investigator: Prateep Nayak (School of Environment, Resources and Sustainability)
Student investigator: Emily Filinska (School of Environment, Resources and Sustainability)
File #: 43532
Title: Cetacean-fisher Interactions in a Coastal Social-ecological system: Bycatch impacts on vulnerability and adaptation strategies for viability
The Human Research Ethics Board is pleased to inform you this study has been reviewed and given ethics clearance.
Initial Approval Date: 08/24/21 (m/d/y)
University of Waterloo Research Ethics Boards are composed in accordance with, and carry out their functions and operate in a manner consistent with, the institution's guidelines for research with human participants, the Tri-Council Policy Statement for the Ethical Conduct for Research Involving Humans (TCPS, 2nd edition), International Conference on Harmonization: Good Clinical Practice (ICH-GCP), the Ontario Personal Health Information Protection Act (PHIPA), the applicable laws and regulations of the province of Ontario. Both Boards are registered with the U.S. Department of Health and Human Services under the Federal Wide Assurance, FWA00021410, and IRB registration number IRB00002419 (HREB) and IRB00007409 (CREB).
This study is to be conducted in accordance with the submitted application and the most recently approved versions of all supporting materials.
Expiry Date: 08/25/22 (m/d/y)
Multi-year research must be renewed at least once every 12 months unless a more frequent review has otherwise been specified. Studies will only be renewed if the renewal report is received and approved before the expiry date. Failure to submit renewal reports will result in the investigators being notified ethics clearance has been suspended and Research Finance being notified the ethics clearance is no longer valid.
Level of review: Delegated Review
Signed on behalf of the Human Research Ethics Board
Karen Pieters, Manager, Research Ethics, karen.pieters@uwaterloo.ca, 519-888-4567, ext. 30495
This above named study is to be conducted in accordance with the submitted application and the most recently approved versions of all supporting materials.
Documents reviewed and received ethics clearance for use in the study and/or received for information:
file: Multi-stakeholder Household Telephone Surveys.pdf
file: Semi-structured interview guide with Key Informants.pdf

file: Global Cetacean Bycatch Survey Questions.pdf
file: Telephone Recruitment Script for Multi-stakeholder Household Surveys.pdf
file: Telephone Recruitment Script for Key Informant Interviews.pdf
file: Email Recruitment Script for Online Global Cetacean Bycatch Surveys.pdf
file: Information Letter for Household Telephone Surveys.pdf
file: Information Letter for Key Informant Interviews.pdf
file: Information Letter for Online Global Cetacean Bycatch Surveys .pdf
file: Verbal Consent Script for Household Telephone Surveys.pdf
file: Verbal Consent Script for Key Informant Interviews.pdf
file: Online Consent Script for Online Global Cetacean Bycatch Surveys.pdf
file: Email Participant Appreciation Letter for Key Informants.pdf
file: Verbal Appreciation Script for Household Telephone Surveys.pdf
file: Global Cetacean Bycatch Survey Web Appreciation closing page Script.pdf
Approved Protocol Version 3 in Research Ethics System
This is an official document. Retain for your files.
You are responsible for obtaining any additional institutional approvals that might be required to complete this study.

APPENDIX D: Protocols for handling of stranded/entangled animals in India

Key steps for handling of stranded/ entangled animals on the board of vessel/boat

STEP 1: Ideally, the bycaught/entangled animal should remain in the water and be released there. Crew members attempting to release an animal should try to avoid entering the water to do so.

STEP 2: On the board of a vessel or boat, handle the stranded/ entangled animal in a way that avoids pushing, pulling or twisting its appendages, as this may cause painful injuries that can decrease the chances of survival.

STEP 3: Stay clear of the tail fluke and rostrum to avoid injury to crew/fishermen.

STEP 4: Whenever possible, use lifting 'stretchers', which are safer for the animals and the crew

STEP 5: Do not cover or block the blowhole, or spray water in or near it, to allow uninterrupted breathing.

STEP 6: Make all efforts to keep the animal in the upright position at all times, including when moving, or when returning to the water

STEP 7: Use props, such as sand bags or rolled towels placed on either side of the animal, to gently hold it upright and in a 'natural' position.

STEP 8: If the animal is held aboard a vessel for an extended period, apply Vaseline around the exterior surface of the blowhole to maintain skin condition (using gloves), although this should be done carefully to ensure none comes into contact with the interior surfaces of the nasal passage.

STEP 9: Avoid placing the animal downwind of exhaust fumes and where possible, the crew should avoid being downwind of the blowhole.

STEP 10: Under no circumstances should the jaw be used to move or hold the animal, despite looking robust.

STEP 11: Crew should avoid placing their hands or feet inside the mouth, as they may be easily injured. 14

STEP 12: For animals being held aboard the vessel for extended periods, wet towels should be carefully placed over the animal to ensure they are kept moist, using water collected from overboard that is of ambient temperature.

STEP 13: Due to limited or complete lack of support, the crew are not to provide more than basic first aid care to the bycaught animal.

STEP 14: If the animal is already injured then keep the animal in a physically stable position aboard, cover with wet towels, carefully and humanely remove net or embedded objects, stop bleeding by applying pressure over the wound site, and make sure the blowhole and mouth are free from obstructions. If possible, seek advice from a pre-arranged source, such as a vet, or a

stranding network. Informed advice may improve the survival prospects of the bycaught animal. After first aid, the animal should be released back to the sea safely.

STEP 15: In case the stranded or entangled animal is found dead then the carcass should be photographed for record and identification. The animal should be freed from entangled materials and be left in the sea where it was found dead.