

Practical insights for integrating social dimensions in fisheries management

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Carla Sbrocchi, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Arts and Social Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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2. Dedication

Praise the Lord, from whom all blessings flow.

And to Adam, Aurora, Leif, Wren (and Tavvie)

Thanks for sticking with me on this one.

Abstract

Social concerns are mostly absent in fisheries management practices. This causes legitimacy issues, based on the gap between the rhetoric of commitments for ecologically sustainable development, the social aspects of fisheries management and the actual actions of fisheries management bodies. Evidence supports that incorporating social dimensions into the design of management approaches can overcome legitimacy deficits which plague conventional management that is typically based on environmental or economic objectives alone. A systems approach considers the ecological, social and political components of a problem to be inter-related and dynamic. Functionally, it has many advantages because of its focus on learning and its ability to accommodate complexity and plurality, which is a feature of most conservation problems. However, designing, conducting, and mainstreaming integrated management has its own set of challenges, including accessing relevant research and conditioning managers to using interdisciplinary research in management decisions.

This thesis develops the field of fisheries management by demonstrating the ways that social scientific methods can be used for assessing fisheries as socioecological systems and evaluating different management options. These methods can help overcome system complexities and legitimacy constraints that to date have constrained management processes from being as equitable, efficient, and effective as they could be. The project employed various methods, including qualitative modelling, semi-structured interviews, surveys, and document analysis across two case studies: the southern king crab fishery in Chile, and the eastern rock lobster in New South Wales (NSW), Australia. This work provides practical insights and tools to integrate social dimensions in fisheries management, which turns research into something managers can use. The project also generates new insights into the key actions of management that typically fall short.

This thesis is empirically novel, providing an in-depth analysis of the complexity of the legitimacy deficits that influence the effectiveness of fisheries management in the two case studies. It does so through a systems lens and interdisciplinary techniques in the context of improving base information and decision support for fisheries managers and policymakers. It also provides a critical component to the adaptive management cycle by providing mechanisms for learning, such as reviewing management interventions' performance in achieving stated and emerging objectives. However, this research is not just for other researchers and policy makers.

Fisheries managers are at the front lines of implementing management, and without practical advice and support, mindsets related to management are unlikely to change.

An analysis of Australian legal frameworks demonstrates that social performance is not clearly articulated or measured in an appreciable way in Commonwealth or State fisheries. This limits understanding of how fisheries are operating and the confidence that fisheries are being managed in accordance with the principles of ecologically sustainable development (ESD). Further, the use of a social cost-benefit framework in the NSW lobster fishery shows inequalities in the distribution of benefits, and draws inferences on how private and public benefits may be affected as a consequence of current management approaches and interactions with climate change disturbances. In the Chilean cases, modifying a common preference study approach revealed values and motivations that are important considerations for reforming the management of a fishery so that it can continue to sustain the artisanal fishing sector as well as rebuild a depleted resource. This analysis contributed to the development of scenarios for modelling, which demonstrated consequences and impacts of different policy and management settings, climate disturbances, and the potential of different management options on critical system variables. The lessons learned from modelled system responses tests assumptions of status quo management and provides proof of concept for alternative management approaches.

Integrating social dimensions with fisheries management practices was demonstrated in several ways: improving current fisheries research methods to support an understanding of fisheries as socioecological systems, and generating new insights for researchers, policy makers and front-line fisheries managers, especially in relation to measurement, inequities and values and motivations. Incorporating social dimensions and genuinely integrating disciplines is a broader challenge still rife across the sciences and is critical across all natural resource management. This thesis offers a step in that direction.

3. Preface

This work is submitted as a Thesis by Compilation¹. The general structure of such a thesis includes an introduction outlining the background to the project and methods (this chapter), a series of individual research papers which are outlined below, and a conclusion (Paltridge, 2002). Each chapter is preceded by a short preamble that links the chapter to the main thesis.

I wrote this entire thesis with my supervisor K. Barclay providing primary guidance. E. Fulton, W. Gladstone and L. Nahuelhual provided additional supervisory support and guidance. I am the senior author on all chapters and led the design and implementation of the analyses. Copyediting services were financially supported by the Faculty of Arts and Social Sciences at UTS, and provided by Dr. Terry Royce, a Professional Member of the Institute of Professional Editors (IPEd.).

Background material contributing to Chapter 2 has been published as: Sbrocchi, C, Garcia Garcia, S, Barclay, K & Brooks, K 2021. 'Unlocking Legal and Policy Frameworks for Small-Scale Fisheries in Australia'. in V. Kerezi, J. Nakamura, M. El Halimi & R. Chuenpagdee (eds), *Unlocking Legal and Policy Frameworks for Small-Scale Fisheries: Global Illustrations*, TBTI Global Publication Series, St. John's, NL, Canada. Chapter 2 in its current state expands on the earlier work. I was responsible for leading and managing the project, data collection and analysis, manuscript preparation and editing. K. Barclay reviewed the manuscript and provided editorial support

Chapter 3 has been prepared for submission to a peer-reviewed journal. I developed the methods, collected the necessary data and wrote the manuscript with support from K. Barclay who is listed as a co-author on the paper based on this chapter.

Chapter 4 is being prepared for publication with co-authors K. Barclay and L. Nahuelhual. I developed the methods, collected the data, and wrote the core of the manuscript with assistance from K. Barclay and L. Nahuelhual. B. Fulton contributed to data analysis and manuscript preparation. G. Campos assisted with data collection. C. Panguipulli, M. Martinez, D. Farias and S. Martinez contributed to the data analysis (transcribing and translating interviews).

Chapter 5 is also being prepared for publication. I wrote the core of the manuscript with assistance from J. Dambacher and E. Fulton, who are co-authors. J.

¹ The UTS Graduate Research School states that a thesis by compilation is structured as a single manuscript that comprises a combination of chapters and published/publishable works (i.e., papers). Full details and criteria are outlined at the link < <https://www.uts.edu.au/sites/default/files/2019-11/graduate-research-candidature-management-thesis-preparation-submission-procedures.pdf>>

Dambacher and E. Fulton also assisted with developing the methods. L. Nahuelhual and G. Campos assisted with data collection. I performed the data analysis with support from J. Dambacher.

Author statements and signatures are provided as an Appendix ([Supplementary Materials 1](#)).

Ethics approval for this research was granted by University of Technology Sydney's Human Ethics Committee (Approval: ETH17-1518).

Note: I began working on the thesis as a full-time student, designing the research and collecting data between 2016 to 2018. I returned to full-time work in 2019 and took a leave of absence from the research. I later returned to full-time study, just prior to the COVID-19 pandemic in early 2020. I continued working on the thesis in a reduced capacity while sheltering in place. The impacts of COVID-19 included difficulty accessing study participants, reduced access to supervisory and other research support at the university and overseeing remote schooling for three children. For these reasons there is an extended delay between on-ground data collection and thesis submission.

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7. List of Abbreviations

AFMA	Australian Fisheries Management Authority
AMERB	Areas de Manejo y Explotacion de Recursos Bentónicos
CBA	Cost benefit analysis
CPUE	Catch per unit effort
DPI	Department of Primary Industries
EAF	Ecosystem Approach to Fisheries
EBM	Ecosystem Based Management
EBFM	Ecosystem Based Fisheries Management
EPBC	Environmental Protection and Biological Conservation
ESD	Ecologically Sustainable Development
FAO	Food and Agriculture Organisation of the United Nations
GVP	Gross Value of Production
IFOP	Instituto de Fomento Pesquero
ITQ	Individually transferrable quota
MEY	Maximum Economic Yield
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
NSW	New South Wales
OECD	Organisation for Economic Cooperation and Development
SERNAPESCA	Servicio Nacional de Pesca y Acuicultura
SSF	Small scale fisheries
SSS	Size-sex-season
SUBPESCA	Subsecretaria de Pesca y de Acuicultura
TSPZ	Torres Strait Protected Zone
TURF	Territorial User Rights for Fisheries

8. Glossary of terms

Academic Traditions (disciplines): Refers to the historical and typical approach of dividing fields of study into three main traditions (Humanities, Social Sciences and Natural Sciences). Disciplines within each tradition are more closely related to each other than to disciplines in other traditions, however, there are no material boundaries between disciplines or traditions and some disciplines straddle more than one tradition.

Humanities	Social Sciences	Natural Sciences
Art	Psychology	Biology
Music	Sociology	Chemistry
Philosophy	Political Science	Physics
Religion	Economics	Mathematics
Modern Languages	Geography	Geology
Ancient History	Modern History	Computer Science
Literature	Cultural Anthropology	Genetics
Journalism	Business studies –	Astronomy
Theatre/Drama	organisational management	Zoology
		Botany

Adaptive Management: Natural resource management conducted in a manner that purposely and explicitly aims at increasing knowledge and reducing uncertainty (Rist et al., 2013). A key component of adaptive management is learning and continuous improvement. Learning in the adaptive management cycle includes.....making adjustments to ensure actions are efficient and accountable (are we doing things right?, single loop), assessing performance and understanding effectiveness of business actions (are the things we are doing working?, double loop) and testing assumptions that underlay current business approaches (are these the right things?, triple loop) (Edmondson & Fanning, 2022).

The concept has been adapted to governance, in which Adaptive Governance refers to the dynamic structures and processes by which societies share power, and shape individual and collective actions regarding the management of natural resources (Ostrom, 1990; Folke, 2006; Armitage et al., 2020). Adaptive governance thus includes the political nature of decision-making which influences management, as well as the

steering and accountability mechanisms between a governing and management body (Rist et al., 2013; Gillson et al., 2019). For the purposes of this thesis, adaptive management is assumed to include the specifications related to adaptive governance.

Benefit: An advantage, something that produces good or helpful results or effects that promote wellbeing ((Merriam-Webster Online Dictionary, 2021). The antonym of benefit is a disadvantage, encumbrance, impediment.

Case Study: A research method that engages in the close, detailed examination of a single example or phenomenon (Calhoun, 2002). A case study uses many forms of data to provide an in-depth understanding (Creswell, 2013).

Conflict: Conflicts are broadly defined as a situation of non-cooperation between parties and contradictory objectives (FAO 1998). Conflicts in fisheries usually arise among stakeholders with differing economic and social motivations regarding the allocation and access rights to the limited natural resources. Why are there conflicts in fisheries? There is a set of three fisheries “world views” which reflect the philosophical basis of fisheries conflicts. This framework was specified by Charles (1992) to analyse the conflicts by introducing a trio of fishery paradigms, i.e. the conservation, rationalisation, and social/community paradigms. (Shao et al., 2013). While the majority of discussion in the academic field is about the conflicts between the conservation paradigm and the rationalisation paradigm, most conflicts occur between enhancing the community welfare while ensuring economic performance (Shao et al., 2013).

Cost-Benefit Analysis (CBA): An evidence-based method for systematically organising and presenting information to help government understand all the impacts of policies and projects, including economic, social and environmental impacts. CBA helps decision makers identify the best means to improve social welfare and assess competing proposals (NSW Government, 2017).

Economics: The study of incentives – how people get what they want, or need, especially when other people want or need the same thing (Levitt & Debrnev, 2005). Economics has long been the default ‘social science’ or ‘human dimension’ considered in fisheries policy and management. However, it has been less the domain of society and more the domain of individuals, particularly as it encourages individual wealth creation. The expression of economic development since the 1980s, of which Chile and Australia are part, highlights the conundrum of two parallel imperatives: an economic imperative to develop ‘wealth’ versus a human imperative for financial security, respect

and tenure (de Botton, 2004, pp. 107, 108). **See also *Academic Tradition, Social Sciences*.**

Ecosystem Approach (EA)/Ecosystem Based Management (EBM):

Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity, or concern; it considers the cumulative impacts of different sectors. The Conference of the Parties to the CBD defined the ecosystem approach as “a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way” (Engler, 2015). However, much like the concept of ESD, or Ecologically Sustainable Development (see the glossary entry following), the Ecosystem Approach to Fisheries or EAF has been interpreted and adopted in several ways within fisheries management globally. See also the following glossary entries for EAF, EBM, and EBSM.

Ecosystem Approach to Fisheries (EAF): The ecosystem approach to fisheries is perhaps the most prominent example of sectoral ecosystem-based management. Despite its name, the ecosystem approach is still sectoral (rather than integrated) management. A traditional fisheries management’s objective was to achieve maximum sustainable yield of the target stock based on population dynamics. The ecosystem approach to fisheries management also considers the status of the target stock in the broader context of a deeper understanding of its interactions with other ecosystem components (including primary productivity, predators, prey, habitat, or oceanographic conditions, among others) (FAO, 2007). In practice, it still largely relies on managing for a single species, but factoring in effects on/by predators or the environment.

Ecosystem Based Fisheries Management (EBFM): Ecosystem based fisheries management juggles the many ecosystem components that directly or indirectly interact with fisheries all at once – it puts emphasis on the dynamic and interconnected web of interactions between organisms and their environment. It differs from area-based management which entails an integrated or cross-sectoral management of all human activities within that particular area. Many authors consider that space-based implementation is of the essence of the ecosystem approach, but is perhaps less tractable and thus less evidenced in management implementation (Engler, 2015).

Ecosystem Based Management (EBM): De Young, Charles, and Hjort (2008, p. 4) assert that EAF takes place in the context of societal and/or community objectives, which inherently reflect human aspirations and values [requiring] management [to] induce outcomes in the fishery compatible with societal objectives. FAO defines EAF

as “an approach that strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecological meaningful boundaries” (cited in Engler, 2015). Therefore, the full expression of EAF is considered in EBM, where the explicit intent is to consider all human activities as well as ecosystem components when designing management strategies for target stocks.

Effectiveness: The extent to which a decision achieves its objectives (which for most environmental decisions is improving environmental quality) (Adger et al., 2003).

Efficiency: Generally described in economic terms, for example: the extent to which a course of action leads to an improvement in net social welfare (e.g., income, employment) (Adger et al., 2003).

Equality: In terms of fisheries situations, equality is often described as, given similar situations between fishers, opportunities and outcomes that should be distributed equally (modified from Finkel, Harre, & Lopez, 2001).

Equity: Distributional consequences of a decision (Adger et al., 2003).

Ecologically Sustainable Development (ESD): See also *sustainable (sustainability)* a guiding principle of international development, adopted into international agreements and multiple national legislative instruments, and applied as a condition of development activity. It is defined in Australia as “using, conserving and enhancing the community’s resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased” (Commonwealth of Australia, 1992). This concept has been applied to Australian legislation, such as in the *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999*: “the use, conservation, development and enhancement of ... resources in a way, and at a rate, that will enable people and communities to provide for their economic, social and physical well-being.”

Ethnography: The central aim of ethnography is to provide rich, holistic insights into people’s views and actions, as well as the nature (that is, sights, sounds) of the location they inhabit, through the collection of detailed observations and interviews. It is characterised by a strong emphasis on exploring the nature of a particular social phenomenon, rather than setting out to test hypotheses about it, a tendency to work primarily with “unstructured data” —that is, data that have not been coded at the point

of data collection as a closed set of analytical categories; and investigation of a small number of cases. (Reeves, Kuper, & Hodges, 2008).

Fairness: Fairness has multiple meanings, which are related to outcomes (distributional justice), processes (procedural justice), standing (human dignity and equal justice under law), and more. Equity and equality are often an underlying basis to many types of unfairness (Finkel, Harre, & Lopez, 2001), and are sometimes used interchangeably despite their different nuances (Lukasiewicz et al., 2017).

Fisheries Management: Typically understood as the process that creates and enforces the rules that are needed to prevent overfishing and help overfished stocks rebound (Smith & Sissenwine, 2001; Wilson & McCay, 2001). However, an increasing focus on ecosystem approaches and socioecological systems sees the scope of fisheries management as having a broader remit that considers the governance arrangements, administrative functions and objectives and societal forces that drive the implementation of fisheries policies (Jentoft, 2000; Mikalsen & Jentoft, 2001; Jentoft, 2006; Jentoft & Chuenpagdee, 2009; Kooiman & Jentoft, 2009; Fulton et al., 2011; Douglas & Wykowski, 2017; Bavinck, Jentoft, & Scholtens, 2018). Research to support fisheries management is therefore required to be interdisciplinary, focused on problem-solving and decision-making in organisations. These ‘management sciences’, ‘decision sciences’ and ‘fisheries management sciences’ use a combination of analytical models, data science, and behavioural sciences to address society’s most complex problems (Lane & Stephenson, 1995; Lane, 1999). Such approaches stem from the field of Operations Research.

Fishing Units (Fleet, Fishery, Métier): Three types of fishing units – fleet, fishery and métier – are currently used in fisheries science to classify the heterogeneity of fishing behaviour, of which fleet and métier are most frequently used. A fleet describes characteristics of distinct groups of fishing vessels (length, fishing gear used), while métier describes groups of vessels that share common fishing practices (such as gear use and species targeting) and behaviours (such as spatial location or depth of fishing, home port and vessels size). With the focus on practices, rather than on static characteristics of gear or vessels, métier tries to include the fishing intention – where to fish and for how long, which species to target and which gear to use – as part of the classification. Métier analysis is useful for explaining how different groups of fishers fish, but cannot effectively explain why differences exist (Boonstra & Hentati-Sundberg, 2016).

Grounded Theory: Grounded theory is appropriate when the study of social interactions or experiences aims to explain a process, not to test or verify an existing theory. Researchers approach the question with disciplinary interests, background assumptions and an acquaintance with the literature in the domain, but they neither develop nor test hypotheses. Rather, the theory emerges through a close and careful analysis of the data. (Lingard, Albert, & Levinson, 2008).

Harvest Strategy: Designed to set rules to achieve stipulated goals. A harvest strategy is a framework that specifies the pre-determined management actions in a fishery for defined species (at the stock or management unit level) necessary to achieve the agreed ecological, economic and/or social management objectives. In South Africa, harvest strategies are referred to as operational management procedures. (Sloan et al., 2014). Often, the process of selecting a harvest strategy involves testing alternative strategies to determine the ‘best’ for the fishery. (Dowling et al., 2016).

Human Dimensions: see *Social dimensions*.

Influence Diagrams: see *Qualitative models*.

Interdisciplinary (Interdisciplinarity): Interaction between the different disciplines. It can be described in terms of level of integration, or the type of interaction between the disciplines. For example, in terms of level of integration, ‘multidisciplinarity’ involves the use of two or more disciplines in parallel, ‘interdisciplinarity’ is where different disciplinary perspectives inform one another, and ‘transdisciplinarity’ goes beyond scientific knowledge to bring in other types of knowledge (Huutoniemi et al., 2010). Interactions may involve a temporary collaboration between researchers from different disciplines in order to address a specific practical problem, the temporary or permanent adoption of a specific method or concept from one discipline by another, a progressive convergence of different disciplines in terms of both subjects and methods, or the emergence of a new, fundamentally distinct ‘interdiscipline’ in its own right (Newing, 2010).

Legitimacy: A measure of the ‘rightness’ (or social acceptability) of a course of action (Adger et al., 2003). More specifically, legitimacy is the compatibility of the results of government (or management organisation) with the value patterns of those affected by these results, especially the value pattern of society, individuals, groups and other societies (Stillman, 1974). Legitimacy is therefore a matter of degree and can change with time, can be found at individual and collective levels, and depends upon inherent differences amongst constituents (Suddaby, Bitektine, & Haack, 2017). It is

therefore a complex phenomenon, constituted simultaneously as property, process and perception and constructed across multiple levels.

Legitimacy is a desirable property: a government benefits, for by being compatible with societal value patterns, it is able to exercise power with least cost, for few feel threatened and most agree. Costs of governing are therefore minimised for government, and for society. Governmental legitimacy assures society and its members that what they think is important and valuable, and will not be contracted or subverted by government. Further, “the assurance provides a framework within which the actors can plan and act with the expectation that the government will honour their commitments and will uphold rather than impinge upon their value pattern” (Stillman, 1974, p. 44). The view used in this thesis is that legitimacy is a process state: legitimacy must grow from a point where there is no legitimacy (a “zero” state) to pass a threshold or tipping point, at which legitimacy is established. Legitimacy is therefore a construct with continuous levels and comparative strengths, such as low/high, growing/declining. The authors acknowledge more work on how legitimacy is constructed would benefit its application to fisheries contexts.

Management Option/Management Approach/Management Intervention: A specific action performed by managing institutions.

Management Strategy/Management Procedure: The monitoring approaches, assessment methods and decision rules used to manage a fishery (Dowling et al., 2016). It forms an important component of the Harvest Strategy process.

Management Strategy Evaluation (MSE): Like many terms used in fisheries management circles, Management Strategy Evaluation can have multiple meanings. MSE is primarily known as a quantitative modelling tool that evaluates different management strategies through computer simulations. The MSE approach involves selecting operational management objectives [see ‘objectives’], specifying performance measures, specifying alternative management strategies, and evaluating these using simulation (Sainsbury, 2000). In other words, it replicates each part of the adaptive management cycle and looks to analyse the implications of the flow of that cycle, any potential bottlenecks, the efficiency and effectiveness of alternative components of that cycle and any unintended consequences. MSE allows analysts to explore diverse trade-offs and outcomes (Armitage et al., 2019) MSE stems from a field of Operations Research called Decision Analysis: “Decision analysis is a logical procedure for the balancing of the factors that influence a decision. The procedure incorporates

uncertainties, values, and preferences in a basic structure that models a decision. Typically it includes technical, marketing, competitive, and environmental factors. The essence of the procedure is the construction of a structural model of the decision in a form suitable for computation and manipulation; the realization of this model is often a set of computer programs (Matheson, 2013a).” However it is also important to note that MSE is a process as much as it is a tool (Butterworth et al., 2010; Schlueter et al., 2012; Bunnefeld, Nicholson, & Milner-Gulland, 2017; Dichmont & Fulton, 2017). The steps of an MSE is a useful approach for considering key drivers within a fishery, and developing a comprehensive set of management objectives to test through other (non-quantitative) approaches for simulation.

Maximum Yield: See also *Objectives*. Represents specific articulations of fisheries management objectives, which are often used as a single, or part of a reduced set of target objectives that become a primary focus of management. Explicit and implicit objectives can include:

- Maximum sustainable yield (MSY) – an explicit biological objective commonly found in fisheries legislation and international agreements which maximises biological production and operates as a measure of management effectiveness (Hilborn, 2007a). This objective is species-specific and does not consider protection of non-target species, protection of ecosystems and the broader social system (Rindorf et al., 2017a).
- Maximum economic yield (MEY) – an explicit economic objective in many fisheries settings which considers economic efficiency or “rent” as the desired outcome of fisheries management as a means of demonstrating economic efficiency
- Maximum social yield – currently a theoretical concept discussed in many fora. Various proposals include measures which encompass employment (Hilborn, 2007a), minimise conflict that results in political fall-out (Charles, 1992; Hilborn, 2007a; Rindorf et al., 2017a), address poverty and nutrient intake (Coulthard, Johnson, & McGregor, 2011; Robinson et al., 2022), and facilitate human flourishing (see Wellbeing) (Clay, Kitts, & Pinto da Silva, 2014)
- (Pretty good) multi-objective yield – a concept whereby the determination of the combined fishing mortality ranges of all fished stocks is restricted to

enhance stock, ecosystem, economic, and possibly social sustainability (Rindorf et al., 2017a; Rindorf et al., 2017b; Rindorf et al., 2017c)

Mixed Methods: Mixed methods research combines elements from both qualitative and quantitative paradigms to produce converging findings in the context of complex research questions. The mixing of methods may happen within one study or across several studies in a research programme. Central to the effectiveness of a mixed methods study is a clear and strategic relationship among the methods in order to ensure that the data converge or triangulate to produce greater insight than a single method could (Lingard, Albert, & Levinson, 2008). The process of research can be seen as a continuum between quantitative and qualitative approaches, with mixed methods the bridge between the two ends of the spectrum (Creswell, 2014). The approach taken can depend on the nature of the research problem, the personal experiences (including the disciplinary background) of the researcher, and the audience to which the researcher writes. To be clear, qualitative and quantitative approaches are not discrete - not polar opposites. They represent different ends on a continuum: A study tends to be more qualitative or quantitative. Mixed methods research resides in the middle of the continuum because it incorporates elements of both approaches.

Objectives: Objectives are specific articulations of desired goals of fishery management or governance quality, described in relation to efficiency, effectiveness, equity, and legitimacy, robustness, and responsiveness (Ostrom, 1990; Adger et al., 2003; Finkbeiner et al., 2017; Bennett & Satterfield, 2018). Objectives can be concerned with substantive, procedural, or distributive objectives (Ogier et al., 2020a):

- substantive objectives describe ecological, economic, social or cultural outcomes that management should achieve, e.g., *ensure catches are constrained to within maximum sustainable yield*.
- procedural objectives describe the processes that management should aim to follow, e.g., *management conducted in a transparent manner*; and
- distributive objectives describe how benefits should be shared among members of relevant communities, e.g., *management of fisheries should contribute to regional employment and economic development*.

Objectives should point to the purpose of management, such as clarifying how fish resources are to be used to benefit society (Cochrane, 2002), and a hierarchy of objectives is common in many fisheries management institutions which form the

directions, pathways and intermediate steps for achieving the higher-level goals established in legislation (e.g. *how* the goals will be achieved). Fisheries management institutions set objectives in line with their management priorities (Stephenson et al., 2017; Ogier et al., 2020a). These may include performance goals for the management body itself, such as the Australian Fisheries Management Agency (AFMA)’s corporate outcome, which is “to maximise net economic returns to the Australian community through the ecologically sustainable development of Commonwealth fisheries” and works towards four corporate goals (Commonwealth of Australia, 2019). Fishery-level performance targets, known also as operational objectives or harvest strategy objectives, describe specific performance targets and biological limits, and usually also outline triggers for management. The Torres Strait Prawn Fishery, for example, sets stability within the fishery as its primary operational objective, and monitors specific performance metrics such as total days fished at or near a specified number of days (AFMA, 2017). See *Maximum Yield* for examples of specific articulations of performance targets.

Operations Research (OR)/Operations Science/Management Sciences (MS):

A scientific approach to problem-solving and decision-making that is useful in the management of organisations (Wagner, 1975). OR traditionally attracted mathematical solutions, however, it has broadened to include a range of models, tools, techniques, and craft skills to understand the problems of people/machine/nature systems with a view toward ameliorating these problems, possibly by new understandings, new decisions, new procedures, new structures, or new policies (Miser, 2013). A particular stream of OR helps to address complex, unstructured and poorly developed problem statements so that appropriate management strategies can be developed and tested (Rosenhead, 1996; Rosenhead, 2013).

Outcomes: High-level statements of goals, e.g., the end result of fisheries management. Frequently confused with ‘objectives’. Typically, legislation articulates outcomes, but less frequently articulates objectives.

Outputs: The products of a scientific research program. Typically, this includes conference talks, posters, or scientific journal articles. Outputs can also refer to the results of a computational process, e.g., the output of the model was a matrix.

Perceptions: A belief or opinion, often held by many people and based on how things seem (Cambridge Dictionary, 2021); a mental image; a cognitive process that lets a person make sense of stimuli from the environment.

Performance: an assessment that tracks changes by comparing a current situation against specified reference points, which define progress against a management objective. Performance indicators and measures are used in combination with operational objectives to track achievement (Ogier 2020).

Qualitative Models: Also *influence diagrams, signed digraph models, loop analysis, qualitative mathematical models*. A type of model stemming from Operations Research (see *OR*) that addresses relationships between components of a system where there is uncertainty between the variables (Matheson, 2013b). Qualitative models work without measuring system parameters and instead rely on the general shape of functions that mediate relationships between variables: in sacrificing precision, they seek to maximize generality in a causal understanding of complex systems (Dambacher et al., 2007). This means they permit the inclusion of relevant but often immeasurable details to capture the structural aspects and essential dynamics of the whole system. In these models, components of a system (predator, prey, ecological variables, management interventions, etc) are drawn, and relationships to each other are described through arrows indicating the direct and indirect effects transmitted through these components. A mathematical conversion allows analysis of the impacts on different components of the system from various perturbations (disturbances or interventions).

Qualitative Research: See also *Mixed Methods*. Qualitative research is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. It typically involves data that are in the form of text or images rather than numbers. The process of research involves emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher drawing interpretation of meaning from the data. The final report has a flexible structure. Those who engage in this form of inquiry support a way of looking at research that honours an inductive style, a focus on individual meaning, and the importance of rendering the complexity of a situation (Creswell, 2014). Creswell also asserts that qualitative research is useful when the researcher does not know the important variables to examine. This might be because the topic is new, the subject has not been addressed with a certain sample or group of people, or existing theories do not apply to a particular sample. Qualitative research recognises that the researcher chooses methods often based on their own theoretical perspective (Crotty, 1998).

Quantitative Research: See also *Mixed Methods*. Quantitative research is an approach for testing objective theories by examining the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analysed using statistical procedures. The final written report has a set structure consisting of introduction, literature and theory, methods, results, and discussion. Like qualitative researchers, those who engage in this form of inquiry have assumptions about testing theories deductively, building in protections against bias, controlling for alternative explanations, and being able to generalise and replicate the findings.(Creswell, 2014). Creswell also asserts that certain types of problems suit the use of qualitative research approaches: a) identification of factors that influence an outcome; b) the utility of an intervention; c) understanding the best predictors of outcomes; d) testing a theory or explanation.

Reasons: A statement offered in explanation or justification, a rational ground or motive, an accounting (Mirriam-Webster Dictionary, 2021).

Scenario/Scenario Planning: A strategic, exploratory and deliberative planning process to find innovative and robust solutions to address complex and uncertain futures. It is a method that allows diverse stakeholder groups with different perspectives to make explicit mental models of the future through developing narratives or images in order to re-orient collective actions (Bennett, Kadfak, & Dearden, 2015).

Small Scale Fisheries/Artisanal Fishing: The FAO defines artisanal/small-scale fishing as ‘traditional fisheries involving fishing households, using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption.’ (FAO, 1999). In practice, however, definitions vary between countries and scholars, related to size, capacity or horsepower of boats, subsistence versus commercial, cultural traditions, type of gear, and domestic or export markets as but a few examples (Chuenpagdee et al., 2006; Smith & Basurto, 2019).

Social Sciences: The study of human society and social relationships (Oxford English Dictionary). Traditionally, multiple disciplines are categorised as social sciences, including psychology, sociology, political sciences, economics (see *Academic Traditions*).

Social Dimensions (of Fisheries): Comprises elements such as power and governance structures, economic push and pull mechanisms driving development activities (e.g. fishing), sociocultural values and norms associated with fishing, and

external contexts (such as markets, natural phenomena, emergencies, political changes) that impact both on the ability to manage fisheries and on the ability to maintain the needs of fishing communities (Jentoft, 2006; De Young, Charles, & Hjort, 2008; Thébaud et al., 2017). ‘Human dimensions’ as used in fisheries or conservation literature is often treated synonymously with social dimensions (see for example Fulton & Adelman, 2003; Jentoft, 2006; De Young, Charles, & Hjort, 2008; Hall-Arber, Pomeroy, & Conway, 2009; Loquine, 2010; Epstein et al., 2018). However, ‘human’ dimensions may also examine the roles of and effects on individuals through lenses such as medicine/health, theology and the arts. Social dimensions focus on humanity as operating within and influenced by groups.

Socioecological (Social Ecological; Socio-Ecological) System: Dynamic systems that span the natural world and human dimensions, which continuously change in response to internal or external pressures. (Schlüter et al., 2014).

Sociology: The structure of groups, organisations and societies, and how people interact within these contexts. It considers aspects of group dynamics, roles, rules, and institutions. It differs from Anthropology by the latter’s focus on cultural customs and rituals specifically. (American Sociological Association, 2021) . See also *Academic Traditions*.

Stewardship: The degree to which participants use a resource in a careful and responsible way and perceive that they are contributing to improving the quality of the resource base (Clay, Kitts, & Pinto da Silva, 2014). Clay also notes that although [the US government] is the official steward of the Nation’s fisheries, stewardship of fishermen is frequently mentioned as a by-product of catch share fisheries approaches. Compliance is the most frequent idea associated with stewardship, although the category includes any activity that contributes to the responsible use of the resource.

Sustainable (Sustainability): Refers to the ability of an activity to ‘meet the needs of the present without compromising the ability of future generations to meet their needs’ (World Commission on Environment and Development, 1987 para 49)[also called the *Brundtland Report*]. Sustainability is a contested concept with many meanings, understood and applied in a variety of ways (Carew & Mitchell, 2008). Historically, fisheries management has focused on biological sustainability - maintaining the stock(s) of fish such that the stock can continue to be harvested (Hilborn et al., 2015). Informally, sustainability principles have been distilled into three main categories: environmental, social, and economic sustainability. These three

categories are commonly termed the ‘three pillars’ of sustainable development (United Nations General Assembly, 2005) – or ‘triple bottom line’. This idea of integrating social, ecological and economic approaches for marine and coastal resource management is universally supported as a means to develop a relevant set of policy options, particularly for vulnerable and marginalized resource-dependent communities (Barclay, 2012; OECD, 2013; FAO, 2015; NSW Marine Estate Management Authority, 2015). Implementation of the concept has been challenging and contested for some time (Hilborn et al., 2015; Asche et al., 2018; Farmery et al., 2019; Wu et al., 2019; Ogier et al., 2020a).

Well-being (Wellbeing): Although there is no single definition, wellbeing is described as state of being with others, which arises where human needs are met, where one can act meaningfully to pursue one’s goals, and where one can enjoy a satisfactory quality of life (Coulthard, Johnson, & McGregor, 2011). This definition draws on important concepts originating in the seminal Brundtland report (World Commission on Environment and Development, 1987). It typically includes the satisfaction of material needs, the experience of freedom, health, personal security, good social relations, and a healthy natural environment (Weeratunge et al., 2014; Sangha et al., 2015; Breslow et al., 2016). Wellbeing can be discussed in fisheries literature in two ways: (1) a characteristic of human societies describing their physical, mental and psychological health, (2) a measurable outcome, which might provide a counterpart to other measures of fisheries management such as MSY and MEY (see *Maximum Yield*) (Coulthard, 2012; Clay, Kitts, & Pinto da Silva, 2014). Determining and measuring the wellbeing of fisheries-dependent communities is a case-specific activity, one which requires a high degree of engagement with the community and sensitivity in approach. Qualitative approaches are recommended for studying and assessing the needs of fishing communities, and multiple frameworks are available from social scientists in many countries (Jentoft, 1998; Allison & Ellis, 2001; Schirmer & Casey, 2005; Jentoft & Chuenpagdee, 2009; Brooks, 2011b; Clay & Olson, 2011; Levontin et al., 2011; Britton & Coulthard, 2013; Clay, 2014; Weeratunge et al., 2014; Breslow et al., 2016; Charnley et al., 2017).

9. Prologue

“Our curiosity was not limited, but was as wide and horizonless as that of Darwin or Agassiz or Linnaeus or Pliny. We wanted to see everything our eyes would accommodate, to think what we could, and, out of our seeing and thinking, to build some kind of structure in modelled imitation of the observed reality... We said, “Let’s go wide open. Let’s see what we see, record what we find, and not fool ourselves with conventional scientific strictures. We could not observe a completely objective Sea of Cortez anyway, for in that lonely and uninhabited Gulf our boat and ourselves would change it the moment we entered. We shall take something away from it, but we shall leave something too.” John Steinbeck, The Log from the Sea of Cortez

Nearing the end of what is now more than six years’ worth of dedication to graduate research and learning, I reflect on what it was that brought me to this area of study and what it means to me to continue to pursue it professionally.

I reflect on where I started. My graduate journey had finished, or so I had thought, on completion of a Masters by Research degree and the birth of my third daughter. Finishing that degree with a newborn and working full-time was not easy. I had always wanted to do a PhD “one day”, but it seemed to me at the time that I had enough on my plate, and I was satisfied with the professional career I was advancing. At the time I had the great fortune to work with some of Australia’s eminent scientists and businesspeople in developing, and responding to, environmental policies and practices that would see Australia maintain its valuable natural assets into the future. The work was invigorating – it was an acknowledgement that successful land, water and marine management is responsive and adaptive to emergent issues, not just recycling historical or current practices. But this work, and the minds behind it, felt like an anomaly. When I looked around, most Australian public policy was static and incapable of responding to changing socio-political and biophysical conditions. Legislation was often written before the language of complex systems and wicked problems became understood. And therefore, most management, as a direct regulatory instrument, was similarly unprepared to respond to the changing issues across coasts and marine environments and industries.

I didn't feel prepared. I was a marine scientist, working with local communities and varying levels of governments, to change the way we 'do' management in Australia. I had practical experiences in swathes, but it was challenging to find tools and research that could integrate the socio-political contexts with the biophysical body of knowledge to generate a more holistic set of management applications, capable of guiding management into the next century and beyond. How would you know which advice to apply? How do you use the literature to best advantage? What does a social science approach involve or imply?

In 2016, I responded to an advertisement for an interdisciplinary PhD project, focusing on integrating social and ecological knowledge to develop more accurate understandings of fisheries as social ecological systems. I jumped at the chance to work with a fisheries social scientist and ecological modeller. I truly was of the opinion an interdisciplinary approach was the way to address the issues managers face. Like the late, great Elinor Ostrom, "I presume(d) that individuals have very similar limited capabilities to reason and figure out the structure of complex environments. It is my responsibility as a scientist to ascertain what problems individuals are trying to solve and what factors help or hinder them in these efforts." (Ostrom, 1990, p. 25)

As I embarked on my PhD, four principles guided my enquiry:

- First: Interpret and make use of abstract thinking to discuss complex issues in a practical manner (Thouless, 1974). My goal was to bring together the depth of qualitative inquiry to the breadth of universal fisheries exploitation issues, in a way that would contribute to practical approaches to fisheries management.
- Second: Successful management takes its form in response to the infinite varieties of circumstance (Sun-tzu & Griffith, 1964). What is successful management in one place is not directly applicable to a situation elsewhere. Instead, to be successful, management must respond to contextual factors and receive legitimisation from its constituents.
- Third: Management is about how people respond to interventions and incentives. Actors within socioecological systems implicitly or explicitly utilise trial-and-error to gain a more accurate understanding of the physical world and what to expect from the behaviours of others (Ostrom, 1990). Learning should be a goal of management, as it is the way in which we adapt to changing societal and environmental values and conditions.
- The Fourth and final principle comes from a favourite author, John Steinbeck, penned during an exploratory voyage on the Sea of Cortez. Steinbeck encourages

the merging of scientific and relational approaches to enquiry, and concludes that “there is no reason why either approach should be inaccurate. Perhaps out of the two approaches...there might emerge a picture more complete and even more accurate than either alone could produce.” (Steinbeck, 1941)

These principles have been firm guides throughout a difficult and challenging research journey. In essence, I have juggled not just one project, but three, if one includes work and family commitments in addition to research. My journey has been punctuated with leaves of absence, fieldwork, training and networking abroad, flurries of analysis and writing, and periods of ‘sheltering in place’ due to the global pandemic known as COVID-19. I’ve had highs and lows (documented in a Spotify playlist), times of self-doubt as well as times of inspiration. John Steinbeck remarks that all biological collecting trips to fairly unknown regions should be made twice; once to make mistakes and once to correct them. Perhaps an interdisciplinary PhD is the same! However, what I reflect on now is this:

- What did I know before about social science and its value to marine management? I did not know much about the discipline of social science, its theories and frameworks and key scholars, but I had an appreciation for what it could bring to the table.
- What do I know now? I know to ask different questions when approaching a complex problem, like the management of marine resources or coasts. I’ve learned that the perspectives people bring to the decisions they make, the impact those perspectives have on decisions, and the consequences of making these decisions, is integral to understanding the system they operate within. I now know a little bit more about how to elicit and model these perspectives and I have some tools to work with.
- How has it been useful? Richard Branson once said that you don’t learn to walk by following the rules. You learn by doing, and by falling over. There has been plenty of doing and falling over in the past six years, and with that, I hope that I have also picked up a useful thing or two that I can share with you, my reader.

Chapter 1

Introduction

Understanding....cannot always prevent problems, but it can, at a minimum, teach us a host of useful things about the best ways to approach them, sharply diminishing a sense of persecution, passivity and confusion. More ambitiously, understanding may be the first step towards an attempt to shift, or tug at, a society's ideals." -Alain de Botton, Status Anxiety.

1. The Challenge – Integrating social dimensions with fisheries management

Fisheries management has been described as having an “implementation crisis” (Jentoft, 2000). This refers to a phenomenon described across the globe where, despite the presence of normative statements that encourage managing fisheries for both human and environmental outcomes, social concerns are mostly absent in fisheries management practices (OECD, 2017; Stephenson et al., 2017; Cottrell et al., 2019; Farmery et al., 2019; Lawless et al., 2020; OECD, 2020b). This disjoint causes legitimacy issues, based on the perceived difference between fisheries managers’ commitments to the social aspects of fisheries management and their actions (Jentoft, 2000; van Putten et al., 2018; Gammage & Jarre, 2020; Fudge et al., 2021).

Legitimacy is granted by fishery participants, communities, researchers, and consumers to accept the approach for working towards particular fishery goals (Suchman, 1995; Suddaby, Bitektine, & Haack, 2017). In contrast, fisheries management policies or decisions lacking legitimacy can lead to conflicts and erosion of trust in managing institutions and may lead to breaches in fisheries regulation compliance (Nielsen, 2003; Arias, 2015; Corciolani, Gistri, & Pace, 2019). The literature on this problem explains that integrated management approaches that consider social dimensions of fisheries in their design can overcome legitimacy deficits plaguing conventional management, which is typically based on environmental or economic objectives alone (Barclay, 2012; Barclay et al., 2016); and see review in Hoshino et al. (2020)). However, designing, conducting and mainstreaming integrated management that is perceived as legitimate has its own set of challenges, including accessing relevant research and conditioning managers to using interdisciplinary research in management decisions (Huutoniemi et al., 2010; Haapasaari, Kulmala, & Kuikka, 2012).

The true form and connected nature of the social dimensions of fisheries are not well understood in an integrated sense, having historically been scientifically separated from biological considerations, and under the remit of wholly separate scientific disciplines. Norms of integration between human and biophysical domains are part of legal frameworks (such as Ecologically Sustainable Development, see Table 1) and scientific frameworks (such as the Ecosystem Approach/Ecosystem-based Management, see review in Fulton (2021)). However, for a variety of reasons, legal norms do not always trickle down to implementation (Leslie et al., 2015a; Lawless et al., 2020), and there is still a disconnect in how important social dimensions of sustainable development, such as equity, justice and values, can be integrated at ecosystem-levels (Fulton et al., 2011; Begg et al., 2014; Guerrero et al., 2018; Fulton, 2021). Equally, research practice norms and training have to trickle down for ‘integrative’ research to be applied and accessed (Fulton & Adelman, 2003; Carew & Mitchell, 2008; Newing, 2010; Castree, 2017; Dayer & Mengak, 2020).

Governments are recognising each of these issues as becoming more important in achieving legitimacy, e.g. how industries regulated by governments are seen as operating in line with stakeholder and public expectations (also known as “social license to operate”), and in public perceptions of government accountability. Stakeholders and the public increasingly demand a demonstration of progress towards sustainable development agendas that support human dignity, opportunities, and the integrity of socioecological systems (van Putten et al., 2018; Lawless et al., 2020). This is increasingly important as the impact of climate change takes effect on fish stocks, the profitability of fishing businesses, and the provision of flow-on benefits to communities (Hare et al., 2016; Pecl et al., 2017; IPCC, 2022; Leiserowitz et al., 2022).

Table 1 Selected examples of legislation or international conventions featuring multiple outcomes for fisheries management including social aspects

Jurisdiction	Law/Agreement	Year enacted	Important wording of the act/agreement
Australia – NSW	NSW Environmental Planning and Assessment Act	1979	Meant to assess social costs of planning proposals. The definition of environment includes “all aspects of the surroundings of man, whether affecting him as an individual or in his social groupings.” Section 90 was amended in 1998 to require social impact assessment as part of environmental impact assessments.
USA	National Environmental Policy Act	1979	“utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making which may have an impact on man's environment”
Australia – National (Commonwealth)	Environmental Protection and Biodiversity Conservation (EPBC) Act	1992	“use, conservation, development and enhancement of ... resources in a way, and at a rate, that will enable people and communities to provide for their economic, social and physical well-being...”
Chile	Ley General De Pesca Y Acuicultura 1992	1992	Sustainable use: “the responsible use of hydrobiological resources, in accordance with local, national and international norms and regulations, as appropriate, so that the social and economic benefits derived from that use can be maintained over time without compromising the opportunities for growth and development of the future generations” (Ley 18,892, Article 2.61)
Australia - NSW	NSW Fisheries Management Act	1994	"provide social and economic benefits for the wider community of New South Wales"
UN	United Nations Convention on the Law of the Sea (UNCLOS)	1994	Key provisions: Limits of maritime zones, safe passage and navigation, peace and security of oceans and seas, conservation and management of marine living resources (Fish Stocks Agreement = legal regime for management of straddling and migratory stocks and establishment of regional fisheries management organisations and arrangements), protection and preservation of the marine environment, marine scientific research, dispute settlement procedures
FAO	Code of Conduct for Responsible Fisheries	1995	"balance diverse social objectives...and [apply] an integrated approach to fisheries within ecologically meaningful boundaries" (Paragraph 7.2.2) suggests that “the interests of fishers, including those engaged in subsistence, small-scale and artisanal fisheries are taken into account;” (Paragraph 7.1.2) “Within areas under national jurisdiction, States should seek to identify relevant domestic parties having a legitimate interest in the use and management of fisheries resources and establish arrangements for consulting them to gain their collaboration in achieving responsible fisheries”.
USA	Magnuson-Stevens Fishery Conservation and Management Act	1996	National Standard 8 – “meet social and economic needs; minimise economic impacts and sustain participation in fisheries in....communities”

EU	Council Regulation (EU) No 43/2014, 20 January 2014	2014	“on the basis of available scientific advice, taking into account biological and socio-economic aspects whilst ensuring fair treatment between fishing sectors, as well as in the light of the opinions expressed during the consultation of stakeholders”
UN	Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines)	2014	Draws on existing instruments and complements the Code of Conduct for Responsible Fisheries: Critical issues addressed in the SSF Guidelines include managing resources and allocating tenure rights responsibly; supporting social development and decent work; looking at fish workers along the entire value chain from catching through processing to trading fish; promoting gender equality; and taking into account climate change and disaster risk.
UN	Sustainable Development Goals	2016	SDG14 -“Conserve and sustainably use the oceans, seas and marine resources for sustainable development” where sustainable development, defined by the UN is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Fisheries managers typically do not know how to incorporate social features into standard fisheries decisions partially from a lack of understanding of what social dimensions of sustainable development might include (Adger et al., 2003; Symes & Phillipson, 2009; Brooks et al., 2015; Barclay et al., 2016). In 2014, Begg et al. (2014) interviewed fisheries managers, decision makers and other stakeholders across different Australian fisheries jurisdictions who raised important challenges about integrating social elements of sustainability with ecosystem-based management:

1. a lack of understanding in how to identify social and economic objectives and implementing performance monitoring programs
2. a lack of resources to implement explicit monitoring programs that include social and economic objectives
3. a lack of clarity or appreciation of the benefits of incorporating social and economic objectives
4. a belief that economic, social and environmental objectives should receive the same weight has been a barrier – how do you select priorities and trade-offs between competing objectives?
5. a belief that until the issue of 'rights' is sorted, managers can't move forward with social objectives
6. a need for expanding perspectives beyond commercial fishers
7. a lack of explicit objectives for social dimensions

Ironically, while the lack of explicit consideration of social and economic objectives in decision-making is not necessarily seen as a concern by industry, commercial fishers admitted that gaining and maintaining social license to operate is top of mind, as it has an impact on management and public perception (Begg et al., 2014). Further, commercial fishers also reported to Begg et al. (2014) that they considered total allowable catch (TAC) a proxy social objective in that the TAC was constructed based on multiple parties' needs, and it allowed a fisher flexibility and agency in determining when to fish to maximise price for catch. These findings highlight the disconnect between what fishers (and managers) conceive of as 'social objectives' and their perceived importance.

This disconnect affects more than fisheries managers, however: the problem can also be observed in fisheries research. Fisheries research should support improved fisheries decision-making, but, despite statements of intent since 1979 (Table 1), ESD agendas have struggled to make social dimensions research mainstream. A plethora of

studies in the environmental social sciences and other humanities (sometimes termed the ‘people disciplines’ see Castree (2016)) explore the phenomena, processes and individual attributes of justice, equity, power, and inclusion within fisheries settings (such as Nayak & Berkes, 2010; Clay & Olson, 2011; Fabinyi, Evans, & Foale, 2014; Weeratunge et al., 2014; Fabinyi, Foale, & Macintyre, 2015; Barclay et al., 2016; Bennett et al., 2017). However, social scientific studies often do not address the impact on the environment specifically (Epstein et al., 2013; Vogt et al., 2015; Rissman & Gillon, 2016). Equally, ecological science has been critiqued for its lack of social consideration, with causes including mistrust of the relevance of people disciplines to environmental matters, and a lack of understanding of how to connect different theoretical underpinnings and research approaches (Castree, 2017; Alexander et al., 2019). Steps are being made towards understanding gaps in this area (Bennett et al., 2017; Stephenson et al., 2017; Benson & Stephenson, 2018), but overall, operationalizing social dimensions is still a work in progress. That is, the rhetoric of ecologically sustainable development (ESD) in legal frameworks and the inclusion of social dimensions, present since 1979, has not been matched in fisheries management practice.

Successful ecosystem-based management of marine resources is inherently challenging given the complex socioecological systems in which they are embedded (Berkes, 2012). The resources systems, resources, users and decision-making bodies are intrinsically linked, and decisions made on one component inherently affects other components within the system (Ostrom & Cox, 2010; Alexander et al., 2019). Conventional approaches to management, which focus on a single aspect or discipline within the system, are therefore insufficient for responding to such complex situations. The incapacity of conventional approaches will only be compounded by the unpredictable and uncertain challenges posed by threats such as climate change or global health or economic crises (Pitcher, Hart, & Pauly, 1998; Berkes, 2003; Jones, 2006; Australian Public Service Commission; Ernst et al., 2013; Douglas & Wykowski, 2017). From an ecosystem perspective, integrating human dimensions ensures a consideration of feedback loops across scales which can produce regime shifts, to prevent undesirable ecosystem states, or poverty traps (Finkbeiner et al., 2017; Guerrero et al., 2018; Villasante et al., 2022). Socioecological systems approaches to management (and governance) can help address complex challenges where there is an intent to ensure long-term sustainability and provision of goods and services for human wellbeing (Garcia et al., 2008; Jentoft & Chuenpagdee, 2015b; Armitage et al., 2019).

1.1 The Opportunity – A systems lens

This thesis uses systems thinking to elucidate implementation problems. Such an approach considers the ecological, social, and political components of a problem to be inter-related and dynamic. These characteristics make systems thinking a more functional approach than others such as environmental impact assessment, which analyses interactions between the arbitrary distinctions of environment, economy and society (Gardner, 1989; Ostrom & Cox, 2010; Binder et al., 2013). This view increasingly applies the term ‘socioecological’ (including other variants, see **Glossary**) because it sees people and the environment as one inseparable, complex entity (Binder et al., 2013; Österblom et al., 2016). Policy-relevant socioecological systems research supports management of fisheries by moving away from isolated pressure-response actions, prevalent in much marine management, to integrated management that recognises complex interactions between people and environment (Linklater, 2003; Australian Public Service Commission, 2007; Jentoft & Chuenpagdee, 2009; Ostrom & Chang, 2012; DeFries & Nagendra, 2017; Bennett & Satterfield, 2018).

Within a socioecological systems framework, social dimensions exist in the interacting actions and resultant outcomes, as they are done by human groups or affect them and their environment (Figure 1). Using systems thinking to address implementation problems therefore works to understand how legal frameworks, organisations, rules, actors, resources and ecosystems together influence legitimate, equitable, efficient and effective outcomes (Ostrom, 1990; Adger et al., 2003; Binder et al., 2013).

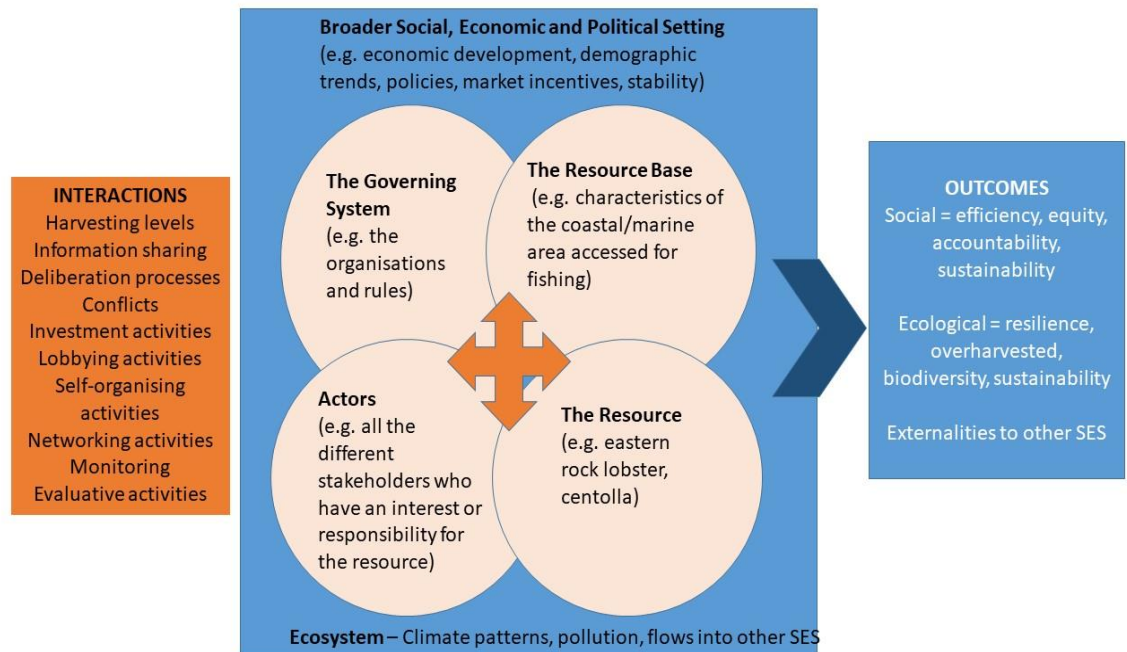


Figure 1 A depiction of the socioecological systems (SES) framework, modified from Ostrom (2011); McGinnis and Ostrom (2014). A SES comprises interactions (shown as orange arrows) between various components such as the governing system, the resource base, the resource itself, and actors, as well as interactions and feedbacks between these components, the broader ecosystem, and the social and political setting in which they operate. These interactions (examples listed in orange side bar) lead to various outcomes (examples listed in blue side bar). The components, and the interactions and outcomes, comprise the scope of the study of social dimensions in fisheries management.

1.1.1 Adaptive management

Adaptive management is posited as an ideal primary approach in natural resource management, as detailed in reviews by Williams (2011) and Rist et al. (2013). Fundamentally, adaptive management involves learning about a socioecological system to build understanding that can transform the problem, not merely ‘address it’. The concept of adaptive management has grown from a focus on reducing ecological uncertainty to reducing uncertainty in relation to improved institutional structures and governance processes, to dealing with stakeholder objectives, risk and productivity and short-term and long-term goals (Rist et al., 2013). It takes the form of a cycle whereby decisions are developed and implemented and then reviewed and modified as necessary (Figure 2).



Figure 2 Adaptive management cycle. Source: CSIRO, <https://www.cmar.csiro.au/research/mse/#fig1>

Based on Argyris and Schon (1974); Argyris (2004); Checkland and Poulter (2010), a key feature of adaptive management is 'triple loop learning', meaning that cycling through the process should enable managers to engage with learning at different levels to engage with, and update personal and institutional understandings of, the components and processes that make up the complexities of a socioecological system (Figure 2). For example, a single loop might focus on process improvements, e.g., are we doing things right? Cycling through the process (double loop) would lead to testing the assumptions of decisions, e.g., are these the right things? A third loop facilitates learning about the adaptive process itself, e.g., how do we know when things are right?

Adaptive management therefore includes a 'test' of objectives and the extent to which they contributed to outcomes, as well as an understanding of the effect of the process on the observed outcomes (Cundill et al., 2012). Cundill et al. (2012) developed five criteria for evaluating adaptive management, focused on learning about the process:

1. Situate the problem in its social and ecological context
2. Raise awareness about alternative views of the problem
3. Encourage enquiry and deconstruction of frames of reference
4. Undertake collaborative actions
5. Reflect on learning

Specific gaps with adopting adaptive management often relate to regularly reviewing key questions, paths of inquiry, and programmatic objectives to help participants maintain a focus on objectives and appropriate revisions to them (Flood,

2010; Cundill et al., 2012). It also involves co-creating a model of the system to be managed, which provides a foundation for learning, characterising the state of the system and its rates and directions of change (National Academies of Sciences Engineering and Medicine, 2004; Checkland & Poulter, 2010).

Adaptive management has many advantages over linear technical responses in terms of its focus on learning and its ability to accommodate complexity and plurality, which is a feature of most conservation problems. Adaptive management is also an approach already adopted in many fisheries management contexts and therefore becomes an important consideration for linking the advice from this thesis to fisheries management institutions. However, scholars criticise the effectiveness of the adaptive management concept, primarily due to practitioners poorly applying evaluation and learning, despite its cornerstone placement in an adaptive management framework (Walters, 2007; Westgate, Likens, & Lindenmayer, 2013; Gerlak et al., 2017). For adaptive management to lead to successful practical action, more emphasis has to be placed on the processes of enquiry that are involved in understanding social and ecological systems and on how learning might be promoted and acted upon within these processes (Cundill et al., 2012, p. 16; Douglas & Wykowski, 2017; Gerlak et al., 2017; McClory, Read, & Labib, 2017). As such, a systems approach is underpinned by adaptive management particularly in how reflection and learning allow management to respond to the dynamics of a complex system, and can overcome risks perpetuating past inequalities and instabilities, and subsequent legitimacy deficits (Cvitanovic, McDonald, & Hobday, 2016; Fulton, 2021). This raises the importance of accommodating learning as an outcome in and of itself, and developing appropriate objectives and indicators to promote learning within a monitoring, evaluation and learning program.

1.1.2 Navigating complexity

Systems research is by nature interdisciplinary (Alexander et al., 2019; Gurung, 2019), and as such, approaches for understanding socioecological systems must work to combine the best of all research traditions, mainly because assuming particular prescriptions and approaches run the risk of losing legitimacy if they are unable to acknowledge the complexity within the problem (Ernst et al., 2013; Gillson et al., 2019). Gillson et al. (2019) suggests that “methods are needed to explore different perspectives and to blend empirical data with subjective and experiential viewpoints, tacit knowledge, expert opinion, and other forms of knowledge” (p.39). Managers

already apply multiple lines of evidence to their decisions (Knight et al., 2004; Cook et al., 2012), but admit to difficulties in accessing or interpreting empirical evidence that deals with the broader socio-political context in which decisions are made (Linklater, 2003; Hall-Arber, Pomeroy, & Conway, 2009; Cook et al., 2012). To date, the fields of resource and conservation management, including that of fisheries, are littered with various approaches and frameworks, which is confusing at best and at worst, at cross-purposes to effective fisheries management. Granted, the field, while having originated several decades ago, is still relatively underdeveloped, so consolidation of approaches is yet to occur.

In much of western fisheries management, authorities and experts tend to search for solutions to complex problems from within their narrow bandwidth of experience (Australian Public Service Commission, 2007; Pascoe et al., 2014a; Syed et al., 2019). Most fisheries managers have biological training, some also have exposure to fisheries' bio-economic principles. However, if problem-solving is left only to experts in economics or biology then citizens can become further distanced or alienated from the important issues of their time. Natural sciences can't tell you about the social pressure points that lead to particular decisions: other forms of analysis, rooted in systems research, are needed to explain social aspects such as power relationships. Depending on the nature of the problem, the 'best available science' in fisheries management contexts supports the inclusion of the right experts and perspectives (Penney et al., 2016; Charnley et al., 2017; Dicks et al., 2018) to help inform the inclusion of critical social dimensions, and define social outcomes. Adoption of these best available science practices will help researchers and managers to support a systems-based approach to management.

1.1.3 Mindsets

Social-learning approaches build on adaptive management by exploring the mindsets that inform management interventions. This is critical because different stakeholder groups, as well as researchers and managers, perceive different problems, for different reasons, and solutions are value-dependent and context-specific. A concurrent adaptive management approach should also be informed by how the outcomes of tests of management interventions change mindsets on the problem-at-hand. There is no single solution for managing the effects of fisheries. However, understanding mindsets of all actors in the SES can help to inform a set of actions that

might have better outcomes for those involved, and testing potential actions might help to inform stakeholders about their role in the problem framing.

The adaptive management approach should raise important questions relating to the structuring of the problem (Rosenhead, 1996; Mingers, 2017; Elrick-Barr & Smith, 2022) to make known the possible views and values contributing to mindsets about a problem. Poor consideration of the plurality of views of a problem is a key source of legitimacy deficits in management decisions (Jentoft, 2000; Adger et al., 2003; Estévez, Jerez, & Gelcich, 2021; Fudge et al., 2021; Haas et al., 2022). However, views of management bodies are equal contributors to understanding the problem. For example, managing agencies typically take a view of their remit as limited to controlling fishing activities (see Troadec, 1992). However, Hobday et al. (2019b)'s review of fisheries management frameworks found that successful fisheries management was contingent on implementing a range of functions extending across setting policy and legislation, operational management, review and performance evaluation, communication and reporting, risk management, stakeholder engagement, and informing decision trade-offs. How fisheries managers view their role in successful fisheries management through these various functions can therefore be as helpful or problematic as individual stakeholder views. Of course, understanding whose mindsets frame fisheries problems in what ways introduces complexity, but must be done to understand the disjoint in perceptions of legitimacy of management.

Fisheries management is more than managing the use of resources, of course; it's about managing human behaviour (Hilborn, 2007b; Hall-Arber, Pomeroy, & Conway, 2009; Poteete, Janssen, & Ostrom, 2010; Fulton et al., 2011). The problem facing managers therefore, is one of motivating behaviour toward alignment with outcomes (Hilborn, Orensanz, & Parma, 2005; Grafton et al., 2006). The core of ecologically sustainable development is a win-win view of problem-solving (Australian Public Service Commission, 2007), where incentives reward innovative ideas and policies, and improve coordination and collaboration between fishers, regions and institutions (Harrison, 1998; Morrison & Termini, 2016). Scholars suggest that successful fisheries management is assessed by stakeholders based on the indivisible outcomes of (social) equity, (economic) efficiency, and (biological) effectiveness of the management approach or intervention (Adger et al., 2003; Pinkerton, 2013; Law et al., 2018). Complexity remains, however, in that stakeholders often have varied perspectives on what constitutes equity, efficiency and effectiveness, and motivating behaviour change comes in many forms (for a review of behavioural theories and research approaches, see

Davis et al., 2015). An adaptive management approach considers how experiences gained from taking action may lead to changes in how stakeholders view the problem, and their resultant behaviour. Behaviours and the contexts in which they occur can be informed by a range of social sciences (Figure 3), which can be used to understand the mindset drivers contributing to implementation deficits, and potential levers for motivating behaviour change.

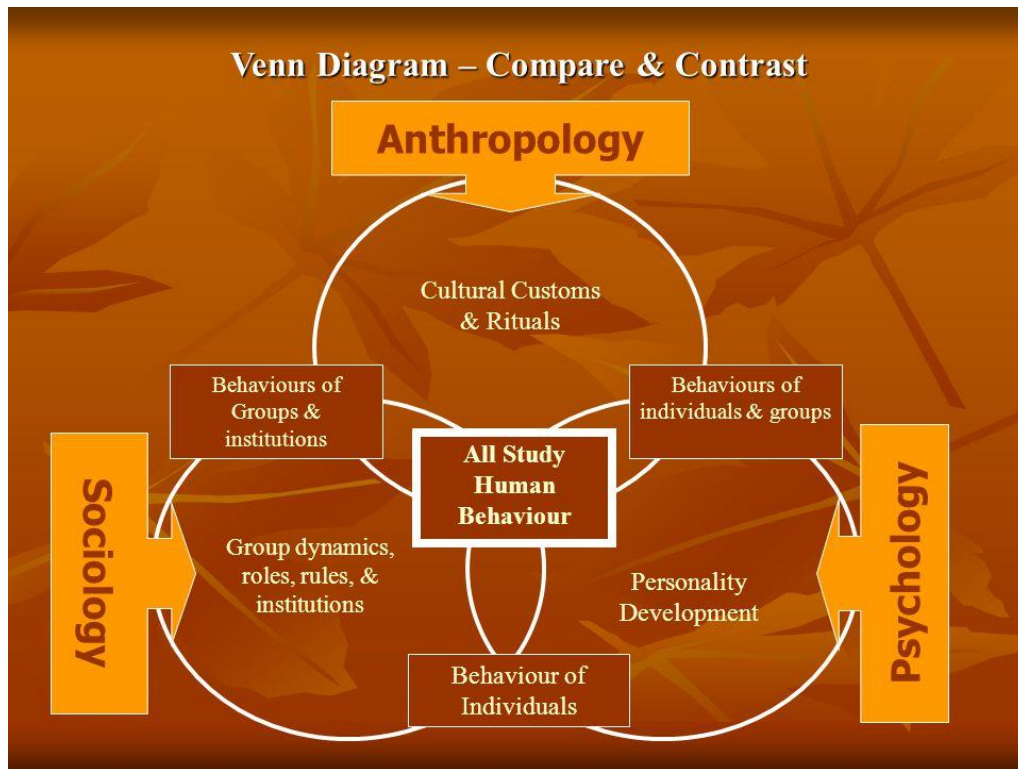


Figure 3 A selection of approaches used to study human behaviour. Source: Agatha Franklin, <https://slideplayer.com/user/5228970/>

1.2 The Response

Advice suggests that managers are more likely to implement different strategies (e.g., different to their typical approach) or avoid less effective strategies when they have evidence of the effectiveness of different options (Walsh, Dicks, & Sutherland, 2015). In response, this thesis aims to expand the reach of social scientific methods by presenting several techniques for assessing socioecological systems problems and evaluating different management options. In expanding the reach, systems research and the legal norm diffusion process can be expedited, overcoming system complexities and legitimacy constraints that to date have constrained management processes from being as equitable, efficient, and effective as they could be.

The thesis draws on theories and approaches of applied sciences across disciplines, including interactive governance, commons theory, ecosystem-based fisheries

management, socioecological systems, organisational theory, and adaptive management. Ideas from these many fields converged in the area of responsive management and integrating social and environmental concerns. I apply what has been called an ‘integrated approach’ and a ‘socioecological systems framework.’ Both approaches explicitly consider the social system connected with the biophysical system (Ostrom, 1990; Lane, 1999; Binder et al., 2013; Stephenson et al., 2017; Stephenson et al., 2019). This perspective reflects a more specific interpretation of what some consider Ecosystem-Based Management (Millennium Assessment and World Resources Institute, 2003; Berkes, 2012; Engler, 2015; Leslie et al., 2015b; Alexander et al., 2019).

I made methodological choices to ensure that integration of social dimensions with management practices could be facilitated. Aspers and Corte (2019, p. 154) argue that understanding “...*is accomplished when the elements are integrated in an iterative process.*” As such, I adopted a grounded theory approach to guide the research, which utilises an iterative process to allow explanations to emerge from the close study of social interactions or experiences (Crotty, 1998; Lingard, Albert, & Levinson, 2008; Creswell, 2014). Grounded theory is context-generated and constantly compares data against other data to generate insights. Such an approach is useful in particular for policy makers and managers because it provides a rich description of important surfeits or deficits that may limit the effectiveness of interventions (Simmons & Mehmet, 2018).

The approach used in this thesis draws from both quantitative and qualitative methods. Mixing of qualitative and quantitative paradigms (‘mixed methods’) is not yet a common feature of fisheries management studies, despite its advantages for complex research questions containing social and biophysical elements. Applying mixed methods to my cases uncovers practical aspects of addressing socioecological systems problems because it questions the assumed variables of quantitative studies and addresses the frequent and necessary qualitative elements within quantitative studies (van Putten et al., 2012; Pascoe et al., 2019). The use of mixed methods improves a researcher’s ability to identify patterns and associations in the data and understand processes, experiences, and the meanings people assign to things (Creswell, 2014; Boonstra & Hentati-Sundberg, 2016; Aspers & Corte, 2019).

The methods used in the thesis include qualitative modelling, semi-structured interviews, surveys, and document analysis across two case study contexts: the southern king crab fishery in Chile, and the eastern rock lobster in New South Wales, Australia.

The use of mixed methods and two case studies gives a rich response to the primary research question:

What insights from the application of a systems lens and adaptive management inform shifting mindsets on the inclusion of social dimensions in fishery management decisions?

This primary research question was explored through examination of cases and addressing the following sub-questions:

- How do legal frameworks, management approaches and fisheries research support or inhibit social dimensions in fisheries management?
- What aspects of social dimensions are supported or inhibited by fisheries management approaches?
- What are the consequences of ignoring social dimensions?
- How do interdisciplinary research techniques inform responsive and adaptive fishery management decisions?

1.3 The Contribution

Given that fisheries managers and researchers are looking for practical advice on how to incorporate social dimensions in fisheries management, this thesis will provide support for better decision making, measuring progress and dealing with trade-offs. It offers insights on many of the challenges documented by Begg et al. (2014), in what appears to be the primary gap in supporting fisheries management to be more responsive to social concerns.

The thesis will research two fisheries, centolla in southern Chile and rock lobster in New South Wales, Australia (for details, see Section 3, this Chapter). These fisheries have many similar aspects such as their legal setting (a statutory commitment to ESD), biological characteristics of the resource (migratory benthic crustacean), governance frameworks (government administration with stakeholder participation through advisory committees), economic conditions (regional economy, primarily global market), social conditions (fishers reside in and work out of distinct coastal communities), and fishery characteristics (historically inshore, small-scale fishery with increasing specialisation; prone to overexploitation). These cases, however, have two important distinctions: Chile has legislation expressly supporting the maintenance of artisanal fisheries in addition to their commitment to biological sustainability through ESD. Also, Chile is in the process of reform to recover a depleted centolla fishery. The NSW rock lobster

fishery was in this situation nearly 20 years ago and provides a useful contrast to Chile. What lessons on the incorporation of social objectives can be learned from these two cases?

Through applying grounded theory and a mixed methods question-based research approach, the thesis will advance fisheries management literature in two ways:

- First, it is empirically novel, providing an in-depth analysis of the complexity of legitimacy deficits that influence the fisheries management's effectiveness in the two case studies. It does so through a systems lens and interdisciplinary techniques, in the context of improving base information and decision support for fisheries managers and policymakers.
- Second, it provides a critical component to the adaptive management cycle in providing mechanisms for learning, such as reviewing the performance of management interventions in achieving stated and emerging objectives.

However, this research is not just for other researchers and policy makers. Fisheries managers are at the front lines of implementing management, and without practical advice and support, mindsets related to management are unlikely to change. Therefore, this work provides practical insights and tools to integrate social dimensions and fisheries management, which turns research into something managers can use. This work therefore shows that it is possible to integrate social dimensions with fisheries management practices, it improves upon current research fisheries methods to support an understanding of fisheries as a system, and derives insights for researchers, policy makers and front-line fisheries managers.

The scope of this study was limited to high-value, small scale commercial marine fisheries in particular contexts (Chile, NSW) and over a limited timeframe (2016-2019). Although the contexts are unique with different historical, cultural and socio-political traditions, the methods, approaches and frameworks developed in this thesis are general and comprehensive enough to be applicable to other fisheries contexts, and could be extended into broader marine and coastal management. The tools and techniques developed in this thesis were designed to support fisheries strategies and management reform processes which were at the planning stages during the course of my research. I invite further research into cooperative problem framing contexts in fisheries, to identify leverage points and drivers of change, and evaluating co-created management solutions intended to support critical social outcomes.

2. Thesis overview and scope of the study

This thesis contains four main research chapters, bookended by Chapter 1: Introduction and Chapter 6: Conclusions, which together address the objectives of my thesis. Each of the four research chapters provides a tangible case of adaptive management through a learning opportunity, and offers insights into how to address the practical challenges faced by fisheries managers and researchers in integrating social dimensions and fisheries management. Importantly, the research reveals insights into the role of management institutions (organisations and rules) in delivering on incorporating social dimensions as a commitment to ESD within a complex socioecological system.

Chapter 1 provides a literature review, establishing the research topic and situating the research within global fisheries management challenges. It also includes two sections covering the two primary case studies used in this research, the centolla (king crab) fishery in southern Chile, and the eastern rock lobster fishery in New South Wales (NSW), Australia (detailed in Section 3, this chapter).

In Chapter 2, I consider the legal frameworks that support ecologically sustainable development (ESD) objectives in fisheries management contexts in Australia to understand how legislation and associated policies enable or constrain the delivery of social outcomes. The key finding of this chapter is that legal frameworks encourage the inclusion of social dimensions. However, social performance is not clearly articulated or measured in an appreciable way in Commonwealth or State fisheries, which limits understanding of how fisheries are operating and the confidence that fisheries are being managed in accordance with the principles of ESD.

In Chapter 3, I turn my attention to assertions by management to do with meeting public benefit outcomes. This chapter continues the investigation of the Australian fishing contexts from Chapter 1, and uses the NSW eastern rock lobster as a case study to interrogate performance more closely. I assess the delivery of social benefits to fishery participants. Links to the main thesis are demonstrated through a critical evaluation of fishery performance, revealing important considerations for fisheries managers in enabling benefits to a range of fishery beneficiaries, beyond commercial fishers alone. As a result, these findings help to define potential focus areas for social objectives that address distributional inequities.

In Chapters 4 and 5, I use the Chilean centolla fishery as a case study to investigate and expose the underlying values and motivations of fishery participants that may not typically be revealed through conventional preference studies. The study of the centolla

fishery in the Magallanes region of Chile was part of a larger research project which included ethnographic studies and global supply chain analyses (Mellado et al., 2018; Morales, 2018; Nahuelhual et al., 2018; Nahuelhual et al., 2019). The contribution of my study, within the thesis and the other larger research project, reveals hidden objectives which contribute to developing management approaches that can both sustain the artisanal fishing sectors as well as rebuild a depleted resource. This analysis was used in the development of scenarios for testing in Chapter 5. The scenarios in Chapter 5 helpfully demonstrated the consequences and impacts of different policy and management settings, governance arrangements, and climate disturbances on critical system variables. The lessons learned from modelled system responses tests assumptions of status quo management and provides a proof of concept for alternative management approaches.

Finally, results reported in earlier chapters are discussed and conclusions drawn in Chapter 6. Furthermore, recommendations are made for the practical applications of integrating social dimensions with fisheries management. Management and research recommendations are aimed at contributing to the learning that advances a systems approach to managing fisheries. Practical application is a critical part of the learning loop, and important to ground the research in its context.

3. Case studies

Case studies are a useful inquiry strategy in qualitative and mixed methods research. They can be applied to a grounded theory approach, and by facilitating the combining of many different types of data within the bound of a specific case, lead to a greater depth of understanding. (Creswell, 2014).

Two small-scale fisheries were used as cases in this thesis: the eastern rock lobster fishery in NSW, Australia and the southern king crab fishery (*centolla*, in Spanish) in the Magallanes region of Chile. The two case studies are outlined in Table 2 and in text, below. As previously mentioned, the two cases share similar legislative arrangements, management philosophies, governance and technical arrangements, jurisdictional size, and biological features of the target species. Each has been subject to overfishing. Each also has a similar ecosystem context in that global climate changes are already influencing features of the fishery, and that the target fishery interacts with other coastal and marine socioecological systems, such other fisheries and aquaculture.

Where the cases differ is in their socio-political and cultural contexts, and their management decision journey. Chile has been developing management plans for specific species since 2014. The management plan for centolla is in a stage of development that enables research on social dimensions to contribute useful insights, particularly in relation to management arrangements and control measures being designed now for implementation in the future. In contrast, NSW has settled into catch shares and quota management for several decades but is now entering a stage of reviewing management practices through a new harvest strategy policy and process. These differences are useful launching points for showing how insights on social dimensions from the application of a systems lens and adaptive management can contribute to operational fisheries management at different stages of developing management interventions.

Table 2 Comparison of Case Studies. Data in table current as of 2018, and sourced from IFOP (2017), NSW Department of Primary Industries (2017), PROCHILE (2018), SUBPESCA (2019), Liggins (2018), ABARES (2021). SUBPESCA = Subsecretaria de Pesca y Acuicultura, SERNAPESCA = Servicio Nacional de Pesca y Acuicultura, IFOP = Instituto de Fomento Pesquero, DPI-Fisheries = New South Wales Department of Primary Industries (Fisheries)

	Southern King Crab (centolla), Magallanes, Chile	Eastern Rock Lobster NSW, Australia
Jurisdiction	Includes coastal waters to 5nm, including a special protection zone for artisanal fishers (1nm from coast). The stock is managed as one jurisdictional unit (Region XII, Magallanes).	Includes coastal waters to 3nm and waters within the jurisdiction of NSW under the Offshore Constitutional Settlement. The stock is managed as one jurisdictional unit (NSW coast).
Target species	<i>Lithodes santolla</i> (centolla), <i>Paralomis granulosa</i> (centollon)	<i>Sagmariasus verreauxi</i> (Eastern rock lobster)
Gear type	Trap	Trap (commercial) Hand-gathering (recreational)
Sectors (catch, t)	Artisanal (4000)	Commercial (155) Recreational (16) Aboriginal (no data)
Commercial catch value (\$ USD)	~\$65M (80% of national total value of king crab)	\$9.2M (0.01% of national total value of rock lobster)
Stock status	Fully Fished (SUBPESCA), Overexploited (IFOP)	Fully Fished
Number of registered fishers	~730 fishers	103 shareholders, who are assigned allocations of quota from the total allowable catch limit A minimum number of shares (55) is required for endorsement to fish. 85 fishers are currently endorsed.

Management Measures in Place	Restricted entry Controls on fishing gear type Seasonal closures Size limits Controls on sex	Limited entry Controls on fishing gear Spatial closures Size limits Total allowable commercial catch Individual transferable quota
Enforcement	Government Compliance and Enforcement Officers conduct compliance checks primarily at point of landing and ports, with occasional at-sea observation. Vessel monitoring for some of the fleet.	Government Compliance and Enforcement Officers conduct compliance checks at-sea and at point of landing. Logbooks/centralised and online record keeping. Real time quota checks Tags - 1 per lobster Labelling of vessels and traps
Management bodies	Joint Managers - SUBPESCA and Sernapesca;	DPI-Fisheries
Primary advisory body	Comité de manejo de centolla y centollón de la región de Magallanes y de la Antártica Chilena	NSW Lobster Fishery Working Group
Representation characteristics	Representatives are nominated by a fishing union within each of the four provinces of the Magallanes. The committee is chaired by the Secretary of SUBPESCA. Other members include representatives of various government agencies, conservation and research organisations.	Representatives are informally nominated by their peers and represent one of five fishing zones along the coast. The committee is chaired by DPI-F. Other members include representatives from the recreational sector, Aboriginal sector and a conservation group.
Resource Assessment body	IFOP Committee for Benthic Resources	DPI-Fisheries Total Allowable Fishing Committee

3.1 Management of the Eastern Rock Lobster fishery – NSW, Australia

The coastlines of NSW have been important fishing grounds for their traditional custodians for thousands of years, where fishing was important as a source of food and in social customs (Schnierer, 2011; Pepperell, n.d.). Fishing has continued to play an important role for NSW communities since European settlement in 1788, contributing to a range of social, economic, and environmental activities (Voyer et al., 2016), although its temporal and spatial influence has decreased with the expansion of other industries such as tourism, mining and other resources, and services (van Putten et al., 2014b; van Putten, Villanueva, & Cvitanovic, 2016).

The NSW Eastern Rock Lobster Fishery is a relatively small, but highly valuable fishery (Plagányi et al., 2017; Liggins, 2018). The primary species caught is eastern rock lobster (*Sagmaraisus verreauxi*) but southern rock lobster (*Jasus edwardsii*) and tropical rock lobster (*Panulirus longipes* and *P. ornatus*) are also occasionally caught. The fishery extends from Queensland to Victorian borders and includes all coastal waters, although some spatial closures apply as a result of a network of marine protected areas closed to commercial fishing (see Figure 4 below). Commercial fishery is undertaken both inshore (<10m depth) and offshore (<200m depth), using beehive, square or rectangular traps.

As for all NSW fisheries, the rock lobster fishery comprises three sectors: commercial, recreational and Aboriginal. Recreational comprises non-commercial fishing (subsistence and sport), while Aboriginal fishing may comprise commercial, recreational, and customary fishing. The commercial fishing sector may consist of smaller vessels with local distribution, but also includes offshore ships. Much of Australia's commercial fishing fleet in the coastal zone consists of household-operated, smaller vessels which means it can be considered 'small-scale' in practice if not in name (Sbrocchi et al., 2021).



Figure 4 Jurisdiction of NSW eastern rock lobster fishery

Together, the sectors have been managed through quota allocations for nearly 20 years (I&I NSW, 2009). An independent Total Allowable Fishing Committee develops annual lobster quota allocations for each of the three sectors, which are then approved by the NSW Minister for Primary Industries. Sectors are managed with different controls: Recreational fishers are subject to bag limits and catch methods (hand gathering only), and Aboriginal communities may apply for cultural fishing permits to meet their needs, which are offered free of charge. Commercial lobster fishing has been managed through size limits, gear type and catch-share arrangements since 2000, with lobster catch shares fully linked through individual transferrable quotas amongst the shareholders. The majority of management attention is focussed on the commercial sector, primarily due to a crash in the stock in the 1990s, and a subsequent imperative to rebuild (Liggins, 2018) (Figure 5). Management efforts have been reported as successful due to the steady recovery in stock, and the associated economic gains in market price and gross value of production (NSW Total Allowable Fishing Committee, 2018).

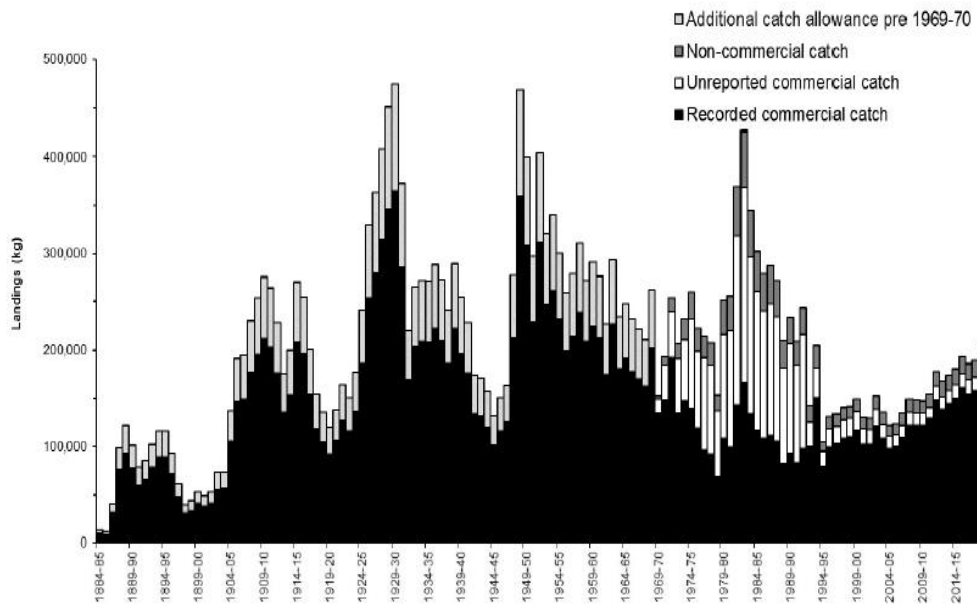


Figure 5 Landings of eastern rock lobster, 1884-2015. Source: DPI 2021. Notice historical periods of high landings followed by low. Since 2000 the fishery has been under total allowable catch limits to rebuild the stock.

The commercial allocation is managed through catch-shares, transferrable amongst individual shareholders. Commercial fishers must hold a minimum number of shares (55) for endorsement to fish, and may not hold more than 350. At the time of this study, and based on publicly available shareholding records, 85 of the 99 shareholders are endorsed to fish (hold the minimum number of shares) and at least 4 shareholders are at or near the maximum shareholding limit.

The NSW government provides for fisheries management in the *Fisheries Management Act 1994* and enshrined the rock lobster share management plan as regulation in 2000 (NSW Government, 2000). A non-statutory strategy was developed in 2007 (NSW Department of Primary Industries, 2007) which provided direction and objectives for the fishery. At the time of this study, a harvest strategy for the rock lobster fishery was in development, which as of 2021 has been adopted as a NSW-wide harvest strategy policy (NSW Department of Primary Industries, 2021). The management of fisheries must also concur with adjacent legislation at State level, such as the *Marine Estate Management Act 2016*, and the Australian Government's *Environmental Protection and Biodiversity Conservation Act 1999* as it relates to the export of native species.

Several consultative bodies from each of the sectors advise the Minister for Primary Industries on issues of concern (Figure 6). These include CommFish (Commercial Fisheries Representatives), the Aboriginal Fishing Advisory Council, the Recreational Fishing NSW Advisory Council, and the Ministerial Fisheries Advisory Council. The

NSW Lobster Fishery Working Group advises DPI-Fisheries, the NSW fisheries management agency. It comprises 11 members: five commercial fishers (one from each administrative zone), one recreational fisher, one member representing conservation/ecology, one Aboriginal representative, and three government employees of DPI-Fisheries (one officer each from its Management, Compliance and Science sections). The Conservation position on the NSW Lobster Fishery Working Group has been vacant since 2016, and the Aboriginal position has been vacant since early 2019. Although Aboriginal and Conservation interests have representation on other fisheries-related advisory committees within NSW, advice to DPI-Fisheries relating to the management of rock lobster has therefore been largely from commercial fishers.

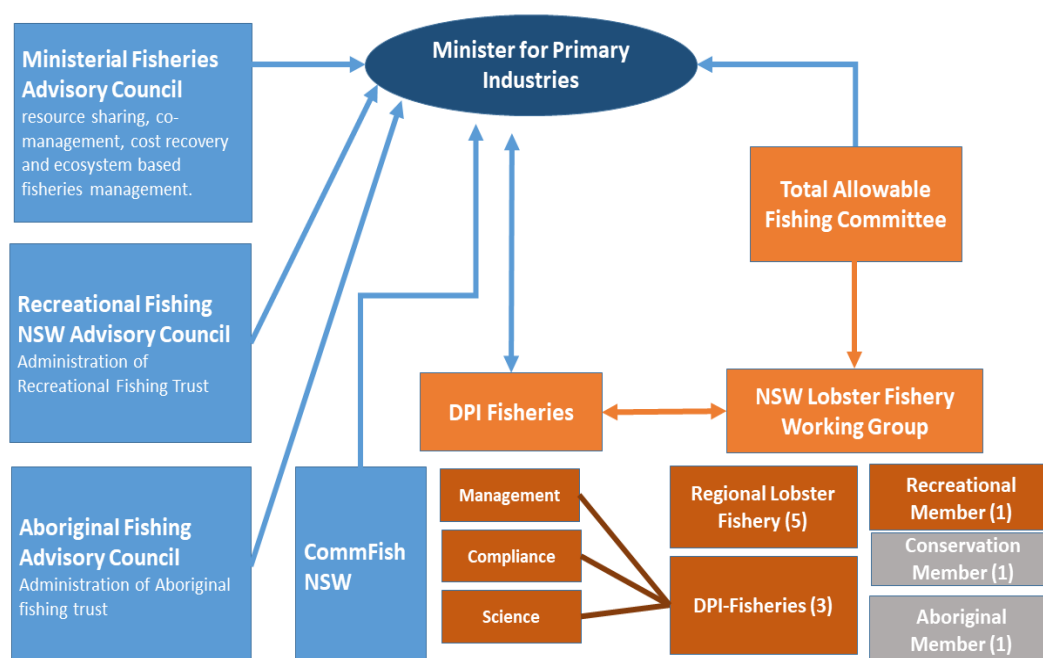


Figure 6 Management arrangements for the NSW Rock Lobster fishery, Australia. Management of the Lobster Fishery is indicated by orange arrows, with blue arrows showing the broader advisory functions within the NSW fisheries management context. The NSW Lobster Fishery Working Group comprises 11 members: five commercial fishers, one recreational fisher, one member representing conservation/ecology, one Aboriginal representative, and three government employees of Department of Primary Industries-Fisheries (DPI Fisheries), namely one officer each from Management, Compliance and Science sections of the agency. The Aboriginal and Conservation positions of the NSW Lobster Fishery Working Group, indicated in grey, are vacant.

3.2 Management of the Southern King Crab (*Centolla*) Fishery – Magallanes Region (Region XII), Chile

Settlers have been drawn to the rugged Southern Patagonian region for access to its rich natural resources, searching for opportunities to make a living (Mellado et al., 2018). Sheep and cattle farming, mining, and fishing have historically formed the basis of the region's economy, with a more recent increase in tourism and aquaculture (salmon and seaweed) activities (Giusti, 2008; FAO, 2010; Morales, 2018).

With a total population of roughly 163,000, the Magallanes region is comprised of four sparsely populated provinces (Instituto Nacional de Estadísticas Chile, 2017) (Figure 7), and shares borders with Argentina through the Beagle Channel and Tierra del Fuego.

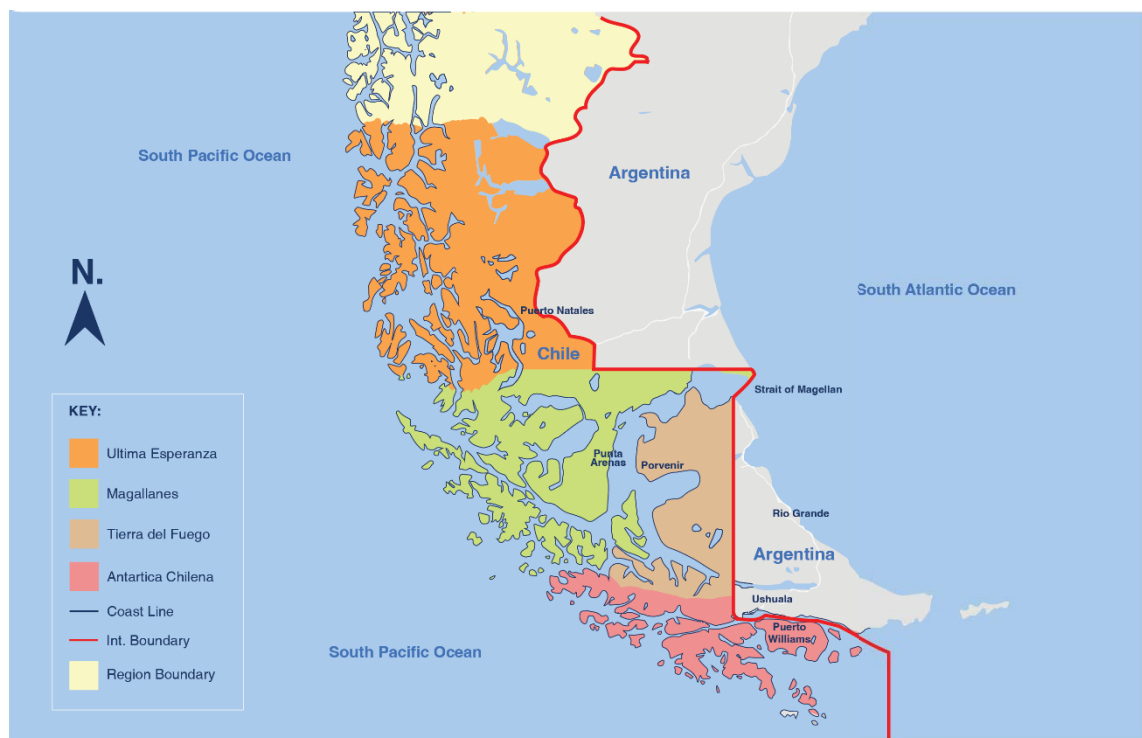


Figure 7 Map of the four provinces of the Magallanes region

The southern king crab fishery is the most important fishery in the region, and comprises nearly 80% of the total king crab landings for the country (IFOP, 2017; PROCHILE, 2018). It comprises two target species, *Lithodes santolla* and *Paralomis granulosa*, locally known as centolla and centollon, respectively. The fishery has been called one of the most productive in the world (Di Salvatore et al., 2019), but has been affected by periods of overharvesting. The government management agency, SUBPESCA, gives centolla a fully fished status, (SUBPESCA, 2019), while the resource assessment agency, IFOP, indicates the stock is over-exploited (IFOP, 2017).

Landings have been in decline for several years, while landings of centollon have increased (Figure 8). At the time of writing, there were no resource estimates for centollon.

Centolla and centollon are found throughout the Magallanes region, with centollon distributions more towards the higher latitudes (NMFS, 1986). Both species similarly migrate between deeper, cooler channels and shallower inshore areas to reproduce and moult. These migrations and physical vulnerabilities have resulted in discrete fishing seasons to protect breeding stocks and a permanent ban on harvesting females. (SUBPESCA, 2019). The centolla fishing season extends from 1 July to 31 November each year, while the centollon season occurs between 1 February and 30 November.

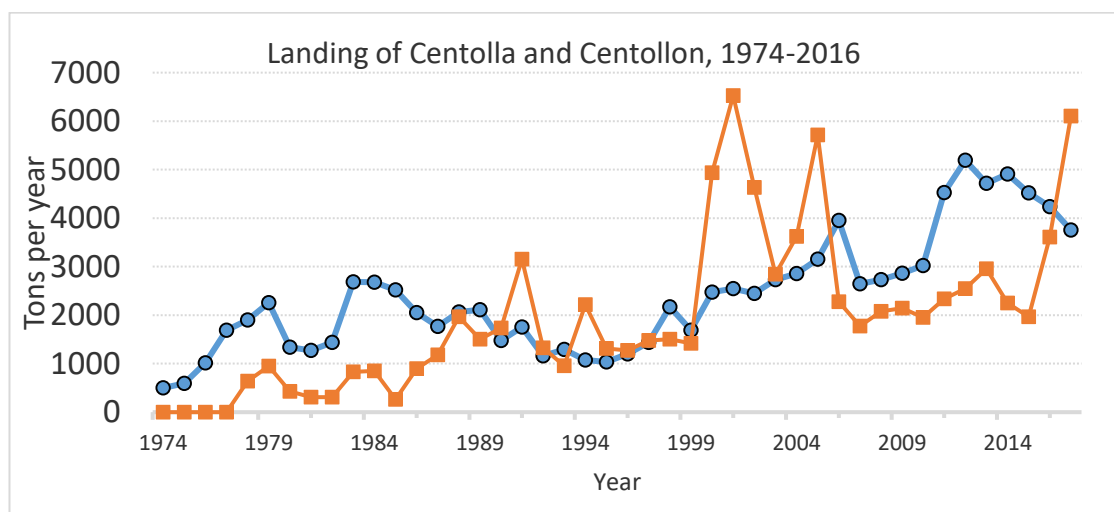


Figure 8 Landings of centolla (*Lithodes santolla*, in blue) and centollon (*Paralomis granulosa*, in orange), 1974-2016. Source: Sernapesca

Chile has legislated provisions for small-scale (artisanal fisheries) that restrict large-scale industrial fishing within 1nm of the coastline but allows artisanal fishers to access the various fjords and channels within 5nm of the coastline. The Magallanes experiences significant social and economic disadvantages compared to other regions of Chile (OECD, 2020a). The presence of special development legislation, enacted in the 1980s to attract investment and settlement into the region, also impacts on fishing activity, as it provides benefits to artisanal fishing businesses operating within the identified areas of the Magallanes region (Giusti, 2008; Mellado et al., 2018; Morales, 2018). The category of artisanal fishers comprises crew, skippers, and intermediaries, provided their vessel length is less than 15m and vessel capacity less than 50 GVM. There are approximately 730 fishers registered to the king crab fishery, and 591 registered vessels.

Fisheries in Chile operate according to the 2014 reform of the *Ley General de Pesca Y Acuicultura 1992* which provides important protections for the artisanal fishing sector as well as for biological sustainability (Ministry of Economy, 2013; Gelcich, 2014). Following legislative reform in 2014, the fishery has moved towards a co-governance arrangement, with the Comité de manejo de centolla y centollón de la región de Magallanes y de la Antártica Chilena (CMCC, the centolla and centollon management committee) having a mandate to develop a management plan for the fishery (Figure 9). The plan, when complete, will articulate management arrangements of the artisanal (small-scale) sector of the centolla fishery for the jurisdiction, including control measures.

Artisanal fishing representatives are nominated to the management committee from fishing unions within each of the four provincial jurisdictions (Magallanes, Tierra del Fuego, Última Esperanza and Antártica Chilena). The numbers of representatives for each jurisdiction are proportional to the regional population. The management committee also has representation from various government agencies (Figure 9): SUBPESCA and IFOP, who, as mentioned earlier are charged with fishery policy and resource assessments, respectively, the Servicio Nacional de Pesca y Acuicultura (SERNAPESCA), who oversee enforcement of fisheries regulations, and the Navy, who support SERNAPESCA with surveillance missions. IFOP also reports to the national Benthic Crustaceans Committee, as the Centolla and Centollon Scientific Technical Committee has not yet been established. The committee meets regularly during the fishing off-season. Progress on developing the management plan for the centolla fishery to date has been slow.

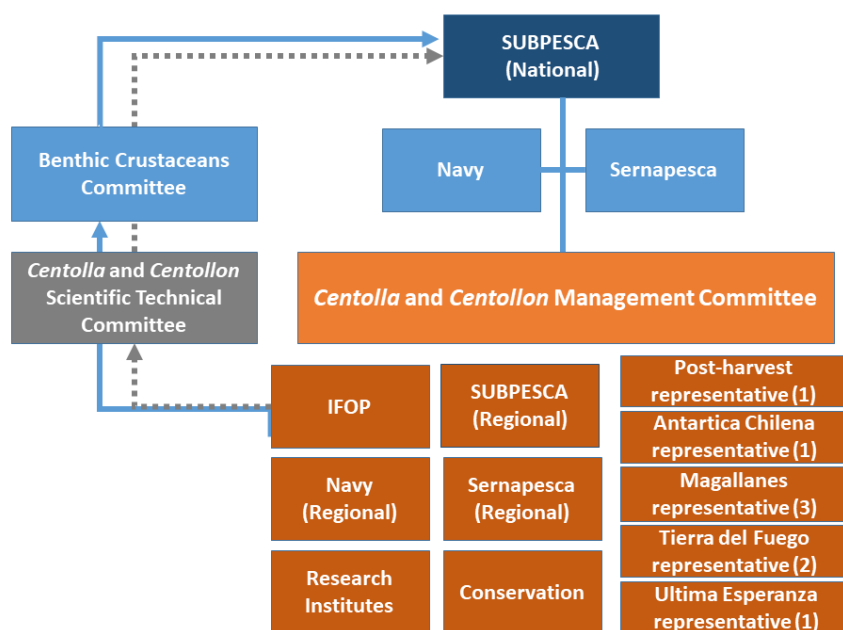


Figure 9 Management arrangements for the centolla fishery of Region XII (Magallanes), Chile. Artisanal fishing representatives are nominated to the centolla and centollon management committee from unions within each of the four provincial jurisdictions. Numbers of representatives for each jurisdiction are proportional to the Regional population. The committee is chaired by the Secretary of SUBPESCA, the fisheries policy agency. The committee allows for other representatives to sit as observers. In the absence of an established Centolla and Centollon Scientific Technical Committee, IFOP provides scientific advice to the Management Committee and the Benthic Crustaceans Committee, who advise SUBPESCA and Sernapesca, the joint managers of the resource.

Chapter 2

Ecologically Sustainable Development, Australian Fisheries and Social Performance – a review²

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Abstract

This chapter uses the case of Australian fisheries to explore legal frameworks, and to determine how these frameworks for fisheries management enable or constrain the integration of social dimensions in fisheries. The resulting analysis provides the scaffold for understanding the context in which fisher, manager and public interests are served by integrating social and environmental factors in Australian fisheries management. In particular, it offers insights to the researchers and managers into what kinds of social outcomes are being reported across Australian fisheries jurisdictions, and how social performance reporting is informing adaptive fisheries management decisions. The finding of this chapter is that, despite the strong presence of ESD principles across Australian fisheries legislation, social performance is not clearly articulated or measured in an appreciable way in national and sub-national fisheries, which limits understanding of how fisheries are operating and confidence that fisheries are being managed in accordance with the principles of ESD as per objectives in legislation. Fisheries under joint management have clearer objectives and social performance measures, for matters such as representation in decision-making, considerations of livelihoods and customary fishing opportunities. Emerging social concerns such as climate change and providing local seafood products to communities are not captured by existing performance frameworks in any jurisdiction, and it is unclear how learning about the system (e.g. changing social values, emerging ecosystem risks, market disruptions or opportunities) is accommodated through existing

² Parts of this chapter have been published in: Sbrocchi, C, Garcia Garcia, S, Barclay, K & Brooks, K 2021. 'Unlocking Legal and Policy Frameworks for Small-Scale Fisheries in Australia'. in V. Kerezi, J. Nakamura, M. El Halimi & R. Chuenpagdee (eds), *Unlocking Legal and Policy Frameworks for Small-Scale Fisheries: Global Illustrations*, TBTI Global Publication Series,, St. John's, NL, Canada

reporting and learning processes. Existing frameworks at all levels provide for, and encourage, regular review and updating of objectives and performance metrics in line with ESD objectives. Opportunities exist to reframe social objectives so they more closely reflect societal values, provide for a wider distribution of benefits, and incorporate considerations of climate change.

1. Introduction

Like many other countries of the world, Australian fisheries legislation has adopted ecologically sustainable development principles (ESD) that guide how fisheries are managed (Commonwealth of Australia, 1992), and ESD has a strong presence in national and sub-national fisheries management legislation. Social performance, meaning the degree to which fisheries management achieves its social objectives, is increasingly being recognised as crucial to the success of achieving overall ESD (Pascoe & al, 2009; Symes & Phillipson, 2009; Pascoe et al., 2014a; Pascoe et al., 2019). Social objectives include a range of criteria important to communities and consumers, such as economic and social wellbeing, maintenance of social, cultural and environmental values, and engagement with decision-making processes. How a fishery performs against these dimensions provides evidence to the public that fisheries are being ‘well managed’ in meeting ESD goals.

Ecologically sustainable development (ESD) refers to the ability of an activity to ‘meet the needs of the present without compromising the ability of future generations to meet their needs’ (World Commission on Environment and Development, 1987 para 49)[also called the *Bruntland Report*]. Informally, sustainability principles have been distilled into three main categories: environmental, social and economic sustainability. These three categories are commonly termed the ‘three pillars’ of sustainable development (United Nations General Assembly, 2005) – or the ‘triple bottom line’. However, sustainability is a contested concept with many meanings, and is consequently understood and applied in a variety of ways (Carew & Mitchell, 2008). For example, fisheries management has historically focused on biological sustainability – e.g. maintaining the stock(s) of fish such that the stock can continue to be harvested (Hilborn et al., 2015), with less priority placed on economic or social outcomes. Integrating social, ecological and economic objectives is recognised as the ideal approach for marine and coastal resource management (e.g. a ‘multi-objective’ approach), having the potential to fully describe how society should meet the needs of

people, informing decision-making processes related to fisheries and enabling a more relevant set of policy options, particularly for vulnerable and marginalised resource-dependent communities (Barclay, 2012; OECD, 2013; FAO, 2015; NSW Marine Estate Management Authority, 2015).

The concept of ESD, widely applied in fisheries legislation, provides for high-level aspirational goals to achieve environmental, economic and social outcomes in an integrated way. Making ESD operational (i.e. taking ESD from a concept to a practical management goal) relies on the development of management objectives that articulate a range of short and longer-term goals (Figure 10). Achievements against these objectives through management actions (such as those identified as ‘management measures’ in Figure 10) should incrementally progress the fishery towards the goals stated in legislation or fisheries policy, including any stated social goals.

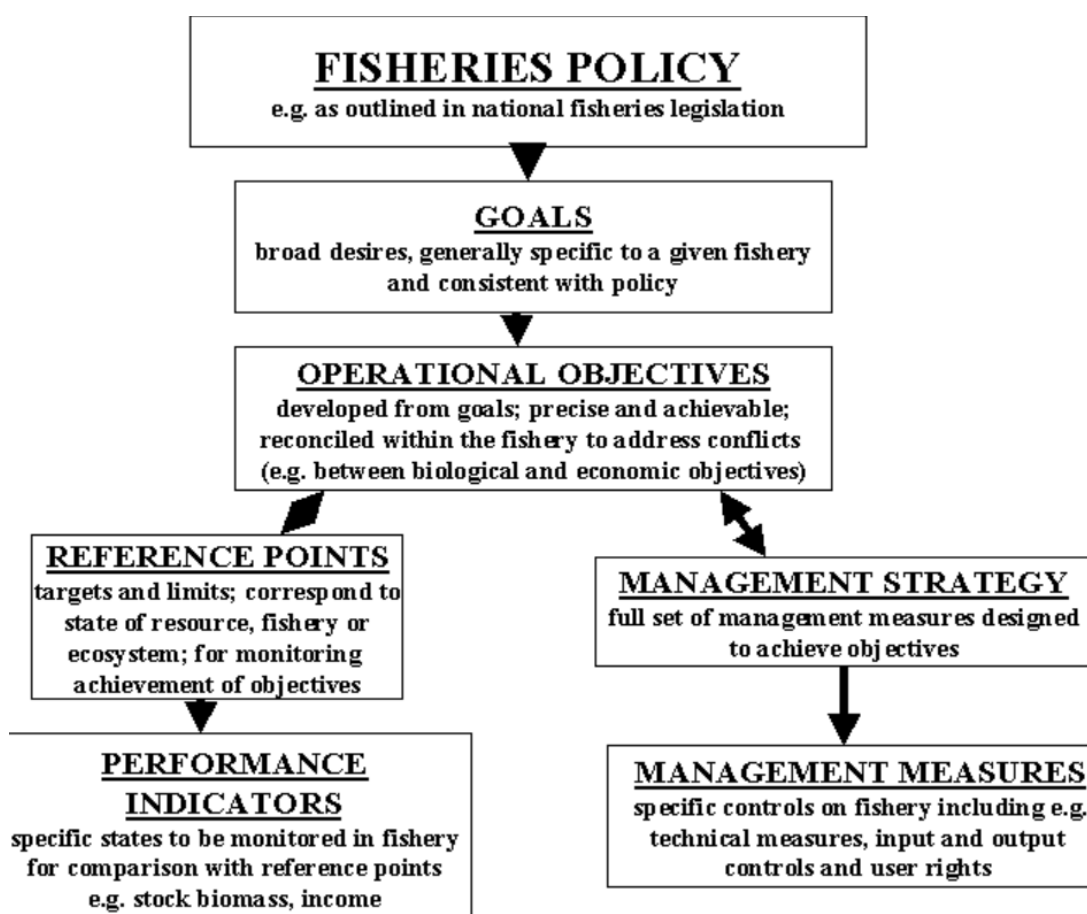


Figure 10 The links between legislation, fishery goals, objectives and performance indicators and management measures. Source: Cochrane (2002)

The term *objectives* is used frequently throughout the legal, policy, corporate, and other operational documents, as well as in studies related to fisheries management.

Objects or *objectives* are often one of the first articulated items of legislation and are used to specify the purpose and intended outcomes of the policy. Objectives clarify how fish resources are to be used to benefit society (Cochrane, 2002), and to more specifically describe the goal in relation to desired outcomes of management, such as efficiency, effectiveness, equity, legitimacy, robustness and responsiveness (Ostrom, 1990; Adger et al., 2003; Finkbeiner et al., 2017; Bennett & Satterfield, 2018). As such, fisheries management may be concerned with substantive, procedural, or distributive objectives (Ogier et al., 2020a):

- -substantive objectives describe ecological, economic, social or cultural outcomes that management should achieve, e.g. *ensure catches are constrained to within maximum sustainable yield*;
- -procedural objectives describe the processes that management should aim to follow, e.g. *management conducted in a transparent manner*; and
- -distributive objectives describe how benefits should be shared among members of relevant communities, e.g. *management of fisheries should contribute to regional employment and economic development*.

For example, the *Australian Fisheries Management Act 1991* (Australian Government, 1991) states its objectives as *the exploitation of fisheries resources in a manner consistent with the principles of ecologically sustainable development, and ensuring accountability to the fishing industry and Australian community*, which is both a substantive objective (“exploitation in a manner consistent with ecological sustainable development”) and procedural (“ensuring accountability”).

Governments and fishery managers will frequently set specific goals in line with their management priorities which function to guide the management of individual fisheries, consistent with the overarching legislation. These are often stated in aspirational ways, and when this occurs, they are known as *high-level objectives* because they provide a general direction for the management of a fishery. Intermediate objectives may form the pathways and intermediate steps for achieving higher-level goals (e.g., *how* the goals will be achieved) (Stephenson et al., 2017; Ogier et al., 2020a). Such management objectives might be found in regulations, strategies, or plans. Operational objectives should be clearly defined to enable direct implementation, and formulated with measurable outcomes, specified through several elements: a performance indicator, a performance measure and a management response (Bunnell & Dunsworth, 2004; Ogier et al., 2020a). Objectives may, therefore, be peppered through legislation and policies, as well as fisheries management plans, and corporate documents, and may not always be present in a unified location.

The Torres Strait Prawn Fishery states that a high-level objective is to *have regard.... for promoting economic development in the Torres Strait area and employment opportunities for traditional inhabitants* (Australian Government, 1984). It is further elaborated with an intermediate objective to *ensure cooperative, efficient and cost-effective management of the Fishery* (AFMA, 2017) which provides a pathway to the higher objective. A subsidiary operational objective is to *engage traditional inhabitant communities in consultation processes, specifically for issues regarding economic opportunities within the fishery* with performance criteria establishing a minimum number of meeting opportunities a year, requiring the presence of traditional inhabitants (AFMA, 2017). A management response indicator is not present in this example.

Thematically, social objectives span across the range of ESD categories of society, economy and governance (Ostrom, 1990), and, as a result, have been described as being ‘multidimensional’ (Pascoe et al., 2014a). This multidimensionality leads to social objectives overlapping with objectives in other nominal categories of economy and environment, and it is difficult to put hard boundaries around what a social objective is, or is not. This can be observed in the way fisheries scholars and managers take the same elements, but move them into different economic, social, management or governance objectives. For example, employment is sometimes identified as a social or economic objective, such as in the Torres Strait Fisheries legal framework (Australian Government, 1984; AFMA, 2017), but may also be implicit in environmental targets such as MSY (Hilborn, 2007a). Alternatively, minimising conflict is sometimes identified as social (Charles, 1992), but other times it is seen as a governance objective (Hart, 1998). Brooks et al. (2015) go some way to address this issue by offering a thematic analysis of social objectives according to the beneficiary (Figure 11), which contextualises the outcome of the objective: *to whom is the objective directed and why?* However, in the absence of such a contextualisation of objectives across fisheries management jurisdictions and studies in Australia, and because of the lack of distinction in the ESD literature, this chapter considers all social, economic, and governance-related objectives as part of the social performance category.

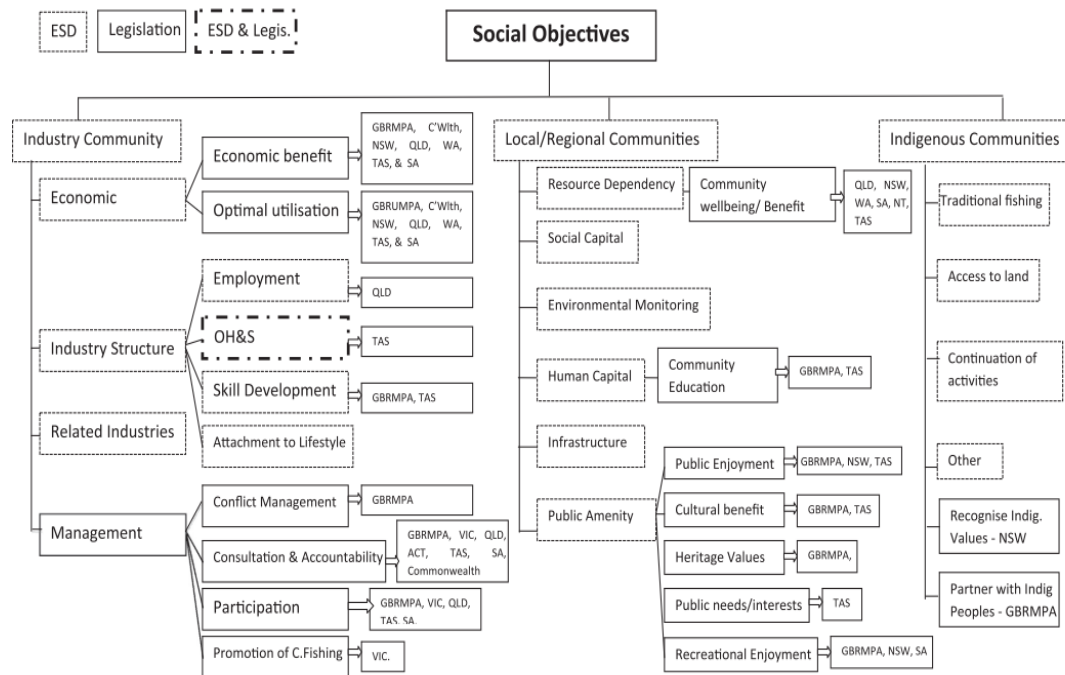


Figure 11 Expression of social objectives in Australian fisheries legislation, according to three broad categories of Industry (Commercial), Community (Public), and Indigenous (Cultural). Social objectives aligning with ESD principles are outlined in a close-dot border pattern, those in legislation are shown with a solid line outline, and those that are both ESD and legislation are in an open-dot border pattern. Note that not all ESD principles are represented in legislation, or in each jurisdiction. Abbreviations in boxes refer to the following jurisdictions: GBRMPA (Great Barrier Reef Marine Park Authority), C'With (Commonwealth), NSW (New South Wales), QLD (Queensland), WA (Western Australia), TAS (Tasmania), SA (South Australia), VIC (Victoria), NT (Northern Territory). Source: Brooks 2015

Monitoring and reporting is an important aspect of performance, and indeed, the adaptive management cycle is used extensively in natural resource management contexts such as fisheries (Williams & Hummelbrunner, 2010; Mascia et al., 2014). Monitoring the performance of fisheries interventions through monitoring and data collection is critical to informing which aspects of management to adjust in progressing towards particular goals (Lindenmayer & Likens, 2009). Reporting is a communication form that enables discussion of monitoring and performance data, and also provides accountability to the public that fisheries are meeting objectives and working towards expected outcomes. The scope over which a fishery operates, affects the nomination of objectives in fishery management, reporting on these objectives, and the learning that results from the process of monitoring progress (Figure 12). Integrating social dimensions in fisheries management therefore must consider the ways social aspects could intersect or interact with the drivers, processes and outcomes of management. However, observing that social goals are established in fisheries legislation within principles of ESD, an analysis of integration of social dimensions with fisheries

management must focus on (1) the presence and articulation of social objectives in policy, (2) tracking performance of social objectives, and (3) adoption of learning into practices.

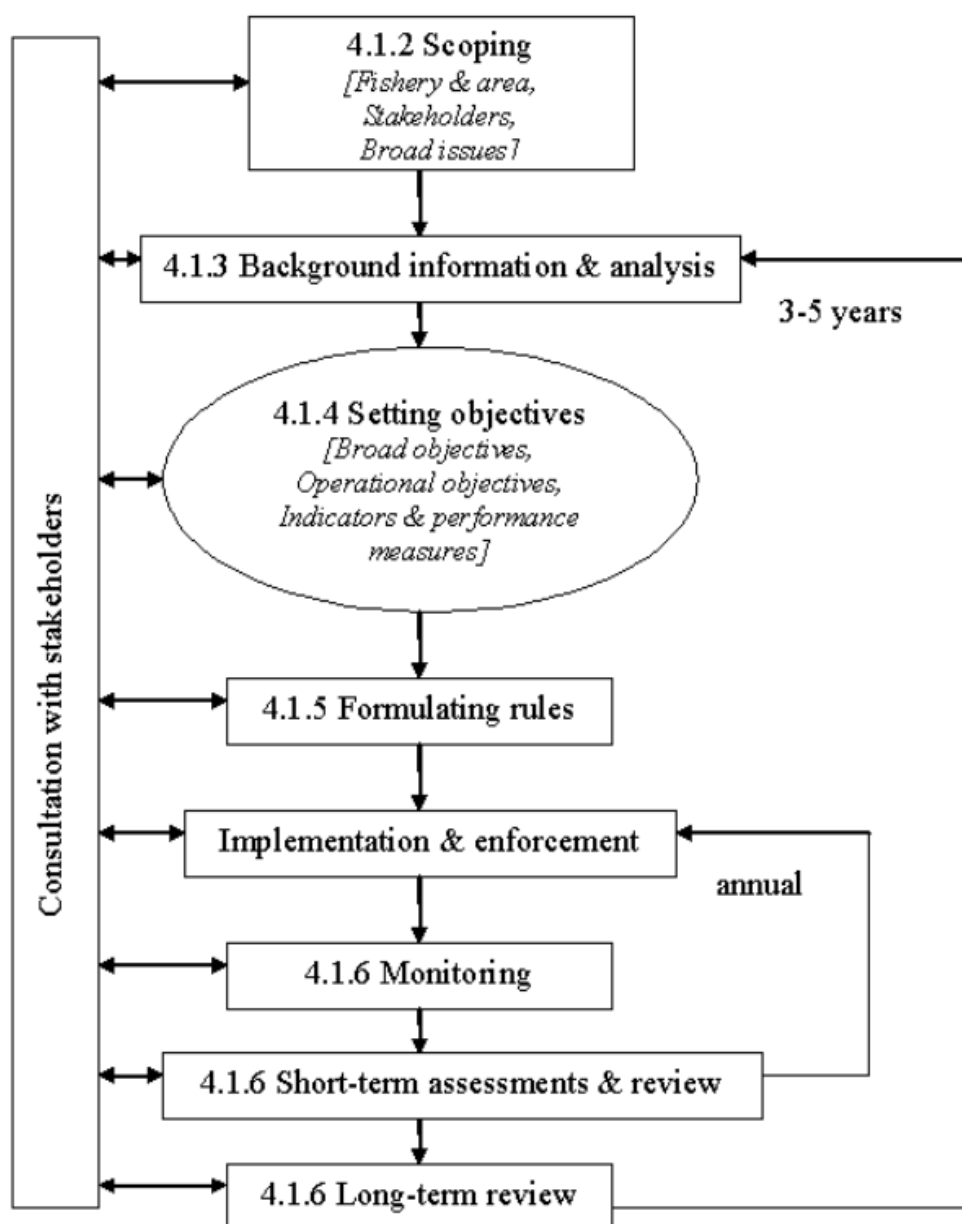


Figure 12 Social dimensions become part of fisheries management in considering the broader 'scope' of the fishery, the development of relevant objectives, the rules and their implementation and enforcement, and the consultative processes used to derive and evaluate these measures for their effectiveness, equity and efficiency. Source: (FAO, 2003)

The aim of this chapter is to review social performance frameworks to determine the extent to which social performance is enabled through legal frameworks and policies, including how social performance is reported and reviewed through appropriate monitoring, evaluation and learning programs, using examples from Australian fisheries management jurisdictions. This chapter begins with an outline of the approaches and metrics used to measure fishery performance in selected Australian

jurisdictions, and then reports findings on social performance. The use of New South Wales (NSW) specifically as an example of a sub-national fishery is used here as a prelude to the use of another NSW case in a subsequent chapter of the thesis. Finally, the chapter draws together the implications of these findings for Australians and others by identifying gaps in social performance assessments, and making recommendations on a way forward for incorporating routine social performance assessments as part of any fisheries performance and reporting process under an ESD framework. The resulting analysis provides the scaffolding on which to understand the context in which fisher, manager and public interests are served by the integration of social and environmental dimensions in Australian fisheries management.

2. Methods

2.1 Analytical framework

For this study, I compared the application of social objectives and the reporting of social performance in three Australian jurisdictions. However, the scope of management (e.g., enabling factors such as context and capacity) (refer to Figure 12) affects the nomination of objectives, the provision of performance assessment programs and the adoption of learning into strategies and plans. Therefore, this study also incorporates an assessment of the context and capacity of the fisheries management agencies, to understand what social dimensions influence the setting and delivery of social objectives.

The analytical frame I employed in this review analysed the documents for context and capacity as related to social objectives and performance in the relevant fishery jurisdictions. This borrows from the interactive governance framework of Jentoft and Chuenpagdee (2015a).

Context: The analysis focusses firstly on the overarching objectives for fishing in each of the selected jurisdictions, and secondly on the presence of social objectives, measures and performance measures in operational plans or policies. The process of setting objectives for fisheries management is influenced by the relevant policy and management community surrounding a fishery (Ogier et al., 2020a), which includes the managing body, and those who influence the development of legislation, conventions and agreements: these include international communities, users of the fisheries resource, traditional owners, interest groups, and the research community. The context allows an understanding of the degree to which fishery managers engage with the social dimension of fishing, and the potential effects of government policy and management

implementation on the fishing industry and the Australian public (Brooks et al., 2015). *Context* relates to the sphere of influence, or who decides what objectives, what performance measures to use, and when to report or review. In particular, how problems are framed determines solutions and in turn the outcomes of fisheries management (Elrick-Barr & Smith, 2022)

Capacity: The capacity of fisheries managers to implement their jurisdictions'' stated and implied objectives relies in part, if not the whole, on the levels of influence different communities have on setting objectives and performance measures. Depending on who has influence, the selection of objectives and performance measures may vary greatly between fisheries and affect how results are applied (Ostrom, 2009). Capacity is assessed by the ability of the managing body to apply performance measures, research and data to inform social outcomes of fisheries management. The provision (or lack) of reporting on social outcomes leads to identifying gaps in the social performance assessment in Australian fisheries.

Policy analysis is a process aimed at critically assessing information to understand and improve public policies (Simmons & Mehmet, 2018; Elrick-Barr & Smith, 2021). There is no universally recognised method for policy analysis. This study investigates policy content, and was based on a framework used by Australian fisheries scholars (Fletcher et al., 2005; Brooks et al., 2015; Farmery et al., 2019; Ogier et al., 2020a); Sbrocchi et al. (2021) and on other recent policy scholarship (Dupuis & Biesbroek, 2013). The works of these scholars form an important basis for the description of the policy context in which the management of Australian fisheries operates.

The choice of a prawn fishery as an example for the case study stems from their presence across multiple Australian jurisdictions. Data on prawn fishery objectives and social performance indicators were drawn from publically available management documents.

2.2 The case studies

Australia is a federation of eight states and territories, united by a Constitution that also grants powers to the Australian Government (also called the Commonwealth of Australia) (Parliamentary Education Office, 2022). As articulated by the Offshore Constitutional Settlement, fisheries powers are shared between the Commonwealth and states (*Attorney-General's Department, 2022*). The *Settlement* provides for the six Australian states and two territories to manage fisheries within the Exclusive Economic

Zone, extending from the coastline out to three nautical miles, and for the Australian Government to manage fisheries from three to 200 nm. In addition to domestic sharing arrangements, bi-lateral agreements establish resource sharing between Australia and its neighbouring nations: the *Torres Strait Treaty* occurs between Australia and Papua New Guinea, and the *Australia-Indonesia Memorandum of Understanding regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Fishing Zone and Continental Shelf* between Australia and the Republic of Indonesia (Department of Agriculture Fisheries and Forestry, 2020, 2021). Australian fisheries legislation, policy and practice differ for each state, at the Commonwealth level, and for the areas under bilateral agreements, and are under different managing regimes and agencies, however, each of the jurisdictions has signed up to the *National Strategy for Ecologically Sustainable Development*, which is non-binding, but provides common guiding principles, and commits them to high-level social objectives across all development activities, including fisheries (Commonwealth of Australia, 1992). Examples from each of the different fisheries management arrangements are extracted for this study to highlight social performance metrics and outcomes.

3. Results

3.1 Social objectives

Legal frameworks across all Australian fishery management jurisdictions support social outcomes and require social outcomes to achieve the intent of the legislation. Although Australian governments demonstrate a strong commitment to maintaining ecological values and biological stocks (Ogier et al., 2020a), when it comes to other dimensions of ESD, such as economic and social benefits and good governance, jurisdictions varied substantially in what objectives were expressed or whether they were expressed at all (Brooks et al., 2015; Farmery et al., 2019; Ogier et al., 2020a) (Table 3, see also [Supplementary Materials 2](#)). An especially important finding from Ogier et al. (2020a) was that many jurisdictions expressed countervailing objectives such as to increase social benefits from employment, but also to increase economic yields by fleet consolidation, which are difficult, if not impossible, to mutually achieve.

The Commonwealth government has argued that their primary fisheries objective, "maximising the economic benefit to the Australian community" is a social objective in that greater economic wealth is correlated with social outcomes and delivers a positive community (social) benefit. This appears to be the only reference to social objectives at the Commonwealth level. Despite this, social objectives are present in state-level

policies (Brooks et al., 2015), and governance objectives are particularly well represented in the joint management policies of the Torres Strait Protected Zone (TSPZ), who oversee the bi-lateral agreement between Australia's Torres Strait Islands and Papua New Guinea.

Interestingly, the concerns of objectives in each jurisdiction's legislation and policies also varied greatly. For example, procedural objectives were prominent in Commonwealth fisheries (e.g. *accountability, taking account of corresponding law*), but not in the other jurisdictional examples. Distributional objectives were present in policies of the TSPZ and NSW (e.g., *Appropriate access and allocation, regional development for traditional owners, broader community benefits*) but less represented in Commonwealth fisheries. Possible reasons for these two observations are further elaborated in the next section.

Table 3 Presence of objectives corresponding to generalised ESD outcomes. Dark fill = present, grey fill = inferred, white cell = absent. Reproduced from Ogier 2020. NSW = NSW fisheries Where objectives within legislation or policy simply referred to a conceptual goal (i.e. ecologically sustainable development), it was inferred that the objective referred to all of the first level of sub-themes on the basis of the value terms specified in the National Strategy for Ecologically Sustainable Development 1992, to which all Australian jurisdictions are signatories.

Generalised objective themes		Primary Fisheries Management Acts		
	Objective Sub-theme	Commonwealth (national)	NSW (sub-national)	Torres Strait (Bi-lateral)
Sustainable Resource Use	Target Species stocks			
	Non-target species stocks			
Ecosystem maintenance and protection	Aquatic ecosystem function, structure and diversity			
	Aquatic habitats and communities			
	Protected species, habitats and communities			
	Non-retained species			
Economic benefits	Viability and efficiency of commercial fishers			
	Net economic returns			
	Broader community benefits			
	Regional development for traditional owners			
Social benefits	Benefits for commercial fishing communities			
	Broader community benefits			
	Opportunity for recreational users			
	Indigenous cultural fishing community benefits			
Fisheries administration	Sufficient information for decision making			
	Cost-effective and efficient management			
	Cost recovery			

	Accountability			
	Compliance			
	Take account of the corresponding law			
Good governance	Appropriate access and allocation			
	Resource stewardship			
	Public consultation			
	Stakeholder participation			

3.2 Performance reporting and learning

In their review, Farmery et al. (2019) found a lack of an operational-level of objectives for most ESD categories, including economic and biological objectives. The translation of social objectives into operational-level goals and metrics is generally not done at a jurisdictional level (e.g. for each state, for example), and therefore a closer inspection of fishery-level plans and policies was required to determine trends in performance metrics and reporting (Figure 13).



Figure 13 Representation of the presence of objectives in Australian fisheries policies and plans. H = High Level Objectives, I=Intermediate Level Objectives, O = Operational Level Objectives, P=Performance measures

A detailed examination of fishery plans, strategies and policies revealed firstly that ‘social objectives’ spanned a range of fishery management areas, including economic aspects, fishery administration, fishery governance and social aspects as summarised in Table 4 (see Table 19, [Supplementary Materials 3](#) for detail). Economic objectives were most consistently carried through from high-level, aspirational statements in legislation through to performance metrics and reporting for each of the jurisdictions. Equally, those objectives associated with Good Governance were generally carried through, although the indicators that were most often presented in reports were related to fishery administration objectives such as cost-effectiveness, risk management, and the provision of compliance and enforcement services (this was noted as ‘partial presence’ in the summary of objectives in Table 4). Objectives for social aspects of the fishery diffused the least from high level to performance level. Even where objectives were present at different levels, they were not fully represented with

relevant performance metrics. Examples of this include Commonwealth fisheries that use the performance indicator *net economic return* of the commercial fishery to represent flow-on benefits from the fishery to Australian communities, and in NSW, where some metrics were presented in the Fishery Management Strategy but not in the Share Management Plan, and vice versa. Confusion arises, therefore, over which metrics are appropriately being applied. As NSW does not regularly report on social objectives, an explanation for this discrepancy is not offered.

Explorations of individual jurisdictions' practices in providing measures of social performance and reporting are provided in detail in the next section.

Table 4 Presence of social objectives in Australian fisheries management acts, management plans and other forms of policies and guidelines for prawn fisheries in three jurisdictions Shading indicates the presence in relevant documents: dark fill = present, hatched= partially, white = absent.. H = High level objective, I = intermediate (management) objective, O = operational objective, P=performance measures provided, Reporting=evidence of reporting on objectives publically available.

	Level of policy	Northern Prawn Fishery	Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
Economic benefits	H			
	I			
	O			
	P			
	Reporting			
Social benefits	H			
	I			
	O			
	P			
	Reporting			
Good governance/ Fisheries Administration	H			
	I			
	O			
	P			
	Reporting			

3.3 Context and capacity of Australian fisheries jurisdictions

3.3.1 National (Commonwealth fisheries), northern prawn fishery

Social performance has not been a priority for Commonwealth fisheries managers, with no specific targets for social outcomes expressed in operational level strategies (Table 4; see also descriptions of performance measures in [Supplementary Materials 2](#)).

As previously mentioned, the Commonwealth government has argued that “maximising the economic benefit to the Australian community” is a social objective. This assumes that the owners of a public resource are the public themselves, and, according to this logic, community economic impact becomes a reasonable proxy, in that greater wealth within society is generally correlated with other social outcomes. However, this has been interpreted in management as a target setting for maximum economic yield to the shareholders of the fishery, which does not meet the condition of returning wealth to wider society.

Overall, Commonwealth fisheries’ performance measures include only economic, administrative and biological sustainability objectives (Pascoe et al., 2013) and, as shown in [Supplementary Materials 2](#), they fall under the direction of the Commonwealth Fisheries Harvest Strategy Policy, its Bycatch Policy or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC). These policies define biological and economic objectives for Commonwealth fisheries and identify reference points to be used in harvest strategies to achieve these objectives, but do not offer specific performance measures or triggers related to social aspects of the fishery. Given this, fishery participants in 2012 rejected a performance metric based on fleet profitability (a measure that encourages competition) and instead applied an alternative metric based on the total allowable effort to align more closely with community visions for social equity³. Ironically, this metric is reported as a biological performance measure as effort controls are used to manage the biological stock of prawns. As for other social objectives, their lack was raised in 2019 at a meeting of the advisory committee⁴ and may be addressed through an update to one or more of the

3 Northern prawn fishery Management Advisory Committee (NORMAC) November 2012 <https://www.afma.gov.au/fisheries/committees/northern-prawn-management-advisory-committee/normac-past-meetings>

⁴ https://www.afma.gov.au/sites/default/files/normac_82_minutes_-_20_february_2019_-_final.pdf

Management Plan, the Fishery Management Strategy and the Industry Performance Monitoring Report and Framework⁵, all of which is anticipated for release in 2022.

Although social objectives are expressed at a high level, other matters have significantly influenced how social objectives have been pursued in the management of Commonwealth fisheries. For example, in 1997, a legal matter ruled that AFMA, the Commonwealth fishery managing agency, would contravene its primary statutory requirements to ensure the biological sustainability of fish stocks and the protection of the marine environment if it also pursued social, cultural and other matters (Harden-Jones, 2000). As a result, during the 2000s and much of the 2010s, AFMA focused its management exclusively on ecological and administrative objectives. In 2012, however, the recommendations of an independent review of Commonwealth fisheries' legislation, policy and management recommended that management arrangements should be modified to ensure equal weighting between objectives, rather than a hierarchical approach to ecological objectives only (Stevens, Cartwright, & Neville, 2012). AFMA, as a result, addressed this gap by releasing a statement detailing its social performance requirements towards meeting ESD principles (AFMA, 2019a), but it appears that the 1997 ruling has continued to limit how the 2012 Review's recommendations might be applied. AFMA's 2019 position statement on how it considers the social aspects of ESD principles does include procedural and distributive objectives related to decision-making and a commitment to intergenerational equity, but no additional substantive objectives are included in relation to social outcomes whereby social performance metrics can be assessed through time.

An array of Commonwealth strategies and reporting arrangements contributes to general confusion over expectations on social performance metrics and assessment for fisheries⁶. For example, the interaction of fisheries with the *Environmental Protection and Biodiversity Conservation Act 1999 (EPBC)* requires the Australian Government to assess the environmental performance of Commonwealth fisheries and state-export fisheries, as set out in the *Guidelines for the Ecologically Sustainable Management of Fisheries* (Australian Government Department of Environment and Water Resources, 2007). The purpose of Assessments under these protocols is to demonstrate that fisheries are 'managed in an ecologically sustainable way.' Also, under EPBC,

⁵ https://www.afma.gov.au/sites/default/files/normac_83_minutes_-_01_october_2020_-_final_-_signed.pdf

⁶ For example, see submitted comments on AFMA's position statement on ESD in Harvest Strategies, regarding expected scope of the position statement versus AFMA commitment to social outcomes <https://www.afma.gov.au/social-aspects-esd>

Commonwealth agencies and authorities are required to report on environmental matters related to EPBC in their annual reports. In 2003, a sophisticated evaluation package for reporting on ESD principles was developed and included a suite of performance measures and indicators to assist Commonwealth agencies in their reporting, relating to social outcomes, representation and decision-making and conflict management (Environment Australia, 2003). However, despite the potential, the statutory reporting requirements for ESD under *EPBC* declared the *National Strategy for ESD* definition invalid, did not refer to the ESD evaluation package, nor did it require Commonwealth agencies to articulate or report on specific performance metrics (Department of Environment, 2010). The *Australian National Strategy for Ecologically Sustainable Development 1992* provides a definition of sustainable development that clearly states an outcome for Australians of the present generation and the future, of drawing a range of benefits from the management of a resource. Using this definition would enable a broader range of social benefits to be measured and reported to the public. Consequently, a potential opportunity for drawing together a more holistic interpretation of ESD for fisheries, in the end, was not facilitated by the interaction with *EPBC*.

Despite the limited scope of social objectives in Commonwealth fisheries such as the Northern Prawn Fishery, the commitment to Good Governance has resulted in a cooperative management arrangement between AFMA and an industry partner, NPF Industry Pty Ltd (NPMI). This co-management arrangement contributes to AFMA's objective of cost-effectiveness and reduction in administration, by enabling the NPMI to undertake some administrative functions including managing data collection and liaising with fishers. AFMA also has objectives and performance metrics related to its engagement with a number of consultative bodies such as the Northern Prawn Fishery Management Advisory Committee (NPMAC) and the Northern Prawn Fishery Resource Assessment Group, who provide advice on management approaches. Furthermore, its commitment to transparency and accountability means that performance on its objectives in these arenas can be tracked annually through AFMA's corporate report.

3.3.2 Bi-laterally agreed fisheries management (Torres Strait Protected Zone) – Torres Strait Prawn Fishery

The Torres Strait Treaty of 1985 between Australia and Papua New Guinea established boundaries between the two nations and provided for joint management of the shared marine resource. The primary tenets of the treaty are to acknowledge and

protect the way of life, and livelihood of the traditional inhabitants of the area. This includes protecting traditional fishing methods and the rights of fishers to move freely through the area. In contrast to national and sub-national fishery examples, objectives in primary legislation and subsidiary management plans of the Torres Strait Prawn Fishery are aligned with the primary goals articulated in high-level legal instruments.

Intermediate objectives within the management strategies and plans that guide the Torres Strait Prawn Fishery management focus on stability, e.g. consistency in effort and allocation from year to year. These intermediate and subsequent operational objectives were developed through input from traditional inhabitants of both parties to the Treaty, as specified by concurrent governance-related objectives which specific performance metrics for representation and participation in decision-making. In fact, it was the engagement with the representative process that facilitated a modification to the standard Commonwealth fishery performance metrics used in bi-lateral fishing agreements (e.g. MEY) to include aspects of stability, and which resulted in agreed units of effort over a period of time as a staged approach to MEY. It also resulted in an agreement amongst the parties to increase the traditional inhabitant share of the fishery, through the transfer of fishing licenses from non-traditional inhabitants. Together, these provide assurance to traditional inhabitants within the community of an expected level of income, meeting the statutory requirement to maintain traditional livelihoods.

Since 2005, the Protected Zone Joint Authority (PZJA) who oversees the management of fisheries in the Torres Strait Protected Zone, has publically and regularly reported key metrics such as effort-based units (total allowable effort) and numbers of licenses for traditional inhabitants, numbers of consultative meetings with traditional inhabitants, and efforts to improve general understanding of the management of the fishery in the community in annual reports. Since arrangements for sharing the resource relate to the social objectives of the Treaty (Commonwealth of Australia, 2011), effort allocations and effort days are reported as social performance, rather than as biological performance, as in the case of the Northern Prawn Fishery. Annual reports report on this indicator, as well as a range of other fishery objectives such as catches, Gross Value of Production, effort in fishing days, the condition of the fishery and the number of licenses for traditional inhabitants⁷. In addition, reporting costs and their recovery provides scrutiny and accountability on how fees are used towards management activities. Annual reporting, regular field-based stakeholder meetings and

⁷ <https://www.pzja.gov.au/resources/publications/annual-reports>

regular (5-yearly) reviews provide transparency to fishery participants and the community that measures of stability and fishery participation are meeting their expectations.

3.3.3 Sub-national (State fisheries)

Like the Commonwealth, NSW has interacting policies in the marine environment that influence the social performance of fisheries. At the highest level, two Acts of Parliament provide overarching direction to fishing activities. The *Fisheries Management Act 1994 (FMA)* provides for the state's conservation, development and sharing of fishery resources for the benefit of present and future generations. The *Marine Estate Management Act 2016 (MEM)* concurrently has the mandate to provide for the management of the marine estate of New South Wales that, amongst other environmental aspects, facilitates economic opportunities for all people of New South Wales, and provides for the cultural, social and recreational use of the coastal zone. The FMA provides for the creation of comprehensive Fishery Management Strategies, which offer a long-term vision for the management of a fishery, clearly outlining the strategies that are in place to achieve that vision. In particular, the Strategies allow the public to scrutinise the management arrangements for each fishery and ensure they provide for sustainable fishing activities into the future. Fishing Management Strategies typically outline intermediate and operational objectives including trigger points and management measures. Additional operational objectives for share-managed fisheries, such as the Estuary Prawn Trawl Fishery, are outlined in Share Management Plans (NSW Fisheries, 2003).

Despite the logical framework, it is not clear how the performance measures in the Estuary Prawn Trawl Share Management Plan (SMP) align with the vision statements and comprehensive performance metrics in the Fishery Management Strategy (the Strategy). For example, the Strategy outlines a vision statement, four goals and eleven performance measures specific to social, economic and governance objectives, developed in response to community consultation (NSW Fisheries, 2002). On the other hand, the SMP provides only two measures of performance in total, which aim to minimise environmental impact and ensure net returns to the fishery. Neither of these describes social outcomes directly.

At face value, the introduction of the MEM in 2016 should have influenced the shape and direction of fisheries management, particularly in how objectives for ensuring

the wellbeing of communities of NSW are incorporated into fishing management practices. Fishery Management Strategies have provisions to encourage managers to update goals, objectives and performance metrics as new information emerges. There is no evidence that the Estuary Prawn Travel Fishery Management Strategy has been updated in response to the introduction of the MEM, nor to any other influence.

The Department of Primary Industries (Fisheries) (DPI-Fisheries) which manages NSW fisheries does not regularly report on social objectives. Since 2003 when the Fishery Management Strategies were first developed, DPI-Fisheries has produced regular ecological reports, annual economic reports (2016-2021)⁸ and key conservation statistics (NSW Department of Primary Industries, 2016), which report primarily on biological and some economic objectives of the fishery. Intermittently produced reports on the progress of fishery management strategies (NSW Department of Primary Industries, 2004) have been insufficient to track identified social and governance performance metrics.

Multiple resources on social performance indicators relevant to NSW fisheries have been developed through the years, either on behalf of DPI-Fisheries or with input from DPI researchers and managers, including the 2005 Social Assessment Handbook, the 2015 Guide to Social Performance Metrics, the 2017 Social and Economic Impact Monitoring Framework, the 2020 Economic analysis & Social and Economic monitoring following the NSW Commercial Fisheries Business Adjustment Program (Schirmer & Casey, 2005; Brooks et al., 2015; Schirmer, Yabsley, & Clayton, 2017; Barclay, 2020). In 2017, DPI-Fisheries committed to improving its social and economic performance reporting and has since produced an economic and social indicator report from 2019-2020, with a limited range of indicators relevant only to the commercial fishery. Wider social performance, as identified in multiple levels throughout NSW fisheries management legislation and policy, is as yet operational

4. Discussion

4.1 Presence and articulation of social objectives

Despite international and Australian legislation purporting to state that the goal of fisheries management is to produce outcomes across multiple domains, evidence from this study and elsewhere demonstrates that conventional fisheries management primarily focusses on biological or economic objectives as the means to achieving these

⁸ <https://www.dpi.nsw.gov.au/about-us/publications/pdi>

higher goals (Pascoe et al., 2013; Marre et al., 2016; Pascoe et al., 2019). As such, performance assessments report on biological sustainability and sometimes also on economic efficiency, mostly to the exclusion of all other considerations (Christensen, 2010; Hey, 2012; Costello et al., 2016; Melnychuk et al., 2017).

A key finding of the 2017 Audit of the Status of the Australian Fish Stocks Report was that issues important to the wider community were not being captured because of the way in which ‘public benefit’ is currently interpreted and applied in Commonwealth fisheries (Neville, 2017). AFMA rationalises its use of net economic returns as a proxy social performance indicator in relation to AFMA’s responsibility to the ‘community of economic resource users’ (AFMA, 2019a), not to the people of Australia. Communities are consistently telegraphing that managing fisheries for public benefit should include flow-on benefits to Australian communities through provision of seafood, employment or use of services by fishing industry, and the integration of diverse perspectives in management decisions⁹ rather than solely to the economic community of resources sharers. In fact, these concerns rate above sustainability concerns across most of the Australian community (Neville, 2017; Wu et al., 2019).

Trade-offs, such as those between economic efficiency, which generates benefits for commercial participants, and other community benefits - like regional employment, local consumer surplus, and economic rent capture (Farmery et al., 2019; Wu et al., 2019) - are inevitable. The Commonwealth has been clear on the trade-offs they are making (e.g. prioritising economic yield over regional development), however, the under-articulation of social objectives for many Australian fisheries has resulted in managing trade-offs in an ad-hoc manner. Because of a lack of information on social outcomes, managers have relied on subjective opinions on the best way to balance trade-offs. As evidenced by the findings of Neville (2017), Wu et al. (2019) and other scholars throughout this chapter, choices have to be made, but currently, these choices appear to be inconsistent with the value patterns of society, reducing their legitimacy.

In evidence from other countries, under-articulation of social objectives also masks how policies for subsidies and taxes affect actions of the firms and returns on community benefit (Sumaila, 2004; Sumaila & Hannesson, 2010; Shao et al., 2013). The description of objectives as being multidimensional goes some way to explaining how social objectives may be captured in some ways by existing economic, biological

⁹ Submissions on the Draft Social aspects of ESD Harvest Strategy Policy
https://www.afma.gov.au/sites/default/files/submissions_agreed_to_be_made_public_for_the_draft_state_ment_on_the_social_aspects_of_esd.pdf

and governance objectives, but doesn't fully capture all the ways that social dimensions interact with the fishery. Like any type of indicator, if social indicators are poorly designed and lack ground-truthing, they could give an inaccurate picture of the social situation, leading to policy based on erroneous assumptions and potentially contradictory outcomes. The approach taken in this study, considering the context and capacity in which the fishery operates, helps to understand the external drivers and influences on the wording of goals and objectives, the importance placed on them, and resourcing allocated to measuring and monitoring them. It could be that social dimensions may play more of a nuanced role in the description of all management objectives, in addition to an explicit imperative to do better on managing for social objectives.

Objectives provide specific articulations of desired outcomes of fishery management or governance quality, such as efficiency, effectiveness, equity, legitimacy, robustness, and responsiveness (Ostrom, 1990; Adger et al., 2003; Finkbeiner et al., 2017; Bennett & Satterfield, 2018). Given that the derivation of an objective, and the importance placed on it, is subjective and relative to social, cultural, historical or personal circumstances (Bennett, 2005; Law et al.), different participants, managers, or policy makers may maximise or minimise the importance of different objectives. Therefore, the mindsets of the authors of the objectives matter (Chesson, Clayton, & Whitworth, 1999; Adger et al., 2003; Bennett, 2005; Minter & Collins, 2005; Jentoft, 2006; Hilborn, 2007a; Vieira, Schirmer, & Loxton, 2009; Murphy, 2017).

Those whose interests are represented in fishery decisions are a strong determinant of what objectives and performance metrics are selected, and whether reporting is a priority. Improved representation of non-commercial interests, or expanding management to include industry partnerships like that in the Northern Prawn Fishery may yield improved articulation and adoption of social objectives that are directly relevant to the stakeholders.

Representation is an important aspect of social performance reporting, but it was not a specific focus of this study. Some inferences from the Torres Strait Prawn Fishery can be drawn in that a diversity of views in representational bodies has been carried through from a legislated requirement, and there is a marked difference in social performance metrics and reporting compared to other jurisdictions of Australia. For studies on the importance of representation and how it can impact management decisions we refer readers to work by Ostrom (1990); Mikalsen and Jentoft (2001); Fudge (2018); Armitage et al. (2019); Fudge et al. (2021).

4.2 Evidence of performance monitoring

It's important to note that the long-running failure to report on social objectives by fisheries managers or fishing industry stakeholders may be influenced by a range of factors, such as a lack of experience with social concepts generally (Symes & Phillipson, 2009; Brooks et al., 2015; Rindorf et al., 2017c; Alexander, 2020) or a lack of history with social performance indicators and methods (Pascoe et al., 2014a; Rindorf et al., 2017c). These factors also influence how managers and stakeholders might prioritise social objectives or 'balance' against the other ESD domains (Pascoe & al, 2009; Dichmont et al., 2013; Pascoe et al., 2013; Begg et al., 2014; Pascoe et al., 2014a; Alexander, 2020). It is unlikely that Australian fisheries managers are unaware of the need for social performance metrics given the focus on them from a range of national research and development programs¹⁰. However, Begg et al. (2014) found that managers lack relevant examples that demonstrate the 'case' for social objectives. The challenge for social researchers is to engage managers in conversations highlighting the value of social objectives using examples and experiences from relevant fisheries elsewhere.

A further difficulty in social performance monitoring can be inferred from the type of performance metrics reported. There appears to be a preference or unstated requirement for quantitative measures, which poses a problem for reporting social performance that relies on qualitative data, which can't be meaningfully quantified in this way. Examples of this include the protection of cultural heritage values, motivations behind fishing livelihood choices, and changes to management resulting from public consultation. Addressing the lack of social performance reporting in fisheries management means admitting that not all performance metrics can be quantified, and reversing the tendency to ignore qualitative data in monitoring.

4.3 How is learning incorporated?

In the current Australian context, fishery objectives have largely not included a diversity of views and values, nor reflected changing societal ideas. They may not incorporate learning as an objective, despite how learning can help to interpret, derive or review objectives (Minteer & Collins, 2005; May, 2015; Ogier et al., 2016; Fudge, 2018; Farmery et al., 2019; Hakkarainen et al., 2020). Learning assists fisheries managers in engaging with social dimensions and adapting to changing values and

¹⁰ <https://www.frdc.com.au/hdr-coordination-program>

conditions of the fishery and its stakeholders. Given that a lack of social consideration in the management system is due to poor understanding about how to “do” it, or even why it is necessary, this study recommends enhancing learning opportunities, both in theory and practices, and promote opportunities for co-learning with fishers (Fujitani et al., 2017; Gerlak et al., 2017). With the already low trust in public institutions (BMT WBM, 2016; Next25, 2021), fishery managers and researchers must act now if they wish to maintain public support for their management activities.

Research undertaken in the past two decades demonstrates that societal values have changed, and new issues have emerged, since fisheries legislation, fishery management and harvest strategies and share management plans were first adopted. First, the people of Australia are concerned about the impact of management and regulations on the benefits provided to communities and fisheries (Schirmer & Pickworth, 2005; BMT WBM, 2016; Voyer et al., 2016; Neville, 2017; Gollan et al., 2019; Ogier et al., 2020a; Voyer, Goodall, & Gladstone, n.d.). Second, climate change is now of wide societal concern (Leiserowitz et al., 2022). Climate change will impact fish stocks, the profitability of fishing businesses, and the provision of flow-on benefits and seafood to communities (Fleming et al., 2014; van Putten et al., 2014b; Creighton et al., 2015; Hobday et al., 2016b; Ogier et al., 2016; Phillips & Welch, 2017; Fogarty et al., 2019; Ogier et al., 2020b).

Adaptation scholars and practitioners increasingly note that climate change may require transformative adaptation that can respond to, or produce, non-linear shifts in societal or ecological subsystems (Siders, Ajibade, & Casgrande, 2021) particularly as ‘communities’ change in response to climate impacts. Adapting to climate change can be framed as social transformation, which benefits and empowers people and protects ecosystems (Siders, Ajibade, & Casgrande, 2021), and is a concept that should be carried through to management in Australian fisheries. However, most fisheries legislation, including Australia, is not primed to adapt to climate change impacts (Fleming et al., 2014; Bryndum-Buchholz, Tittensor, & Lotze, 2021).

Fishery plans and policies should ensure objectives and metrics are meeting the needs of the NSW public both now and into the future, rather than perpetuating an existing ‘set and forget’ mentality. Annual reports provide accountability on primarily administrative aspects of management, whereas adaptive management requires periodic review of processes and examination of assumptions about objectives in achieving stated goals. This type of reporting is not routinely done in Australian fisheries and is not a statutory requirement beyond the requirement to review newly-ascended legal

instruments. Based on this, reporting is predominantly an exercise in accountability and is backwards-looking; it shows what was. Paired with good time-series data, applied research that can provide insights on potential impacts to inform future decisions will become increasingly important as fishery participants adapt to changing societal, geopolitical, and climatic situations. The management designs of 1994 no longer suit the fishery socioecological system in 2022, and there is a great opportunity to modify policies and management practices to fit with the situation governments, management agencies, and communities now find themselves in.

The Commonwealth has committed to updating its management frameworks and developing a national fisheries plan (Australia, 2022). Care will be required to ensure any new objectives and performance metrics are developed in line with community expectations (Schirmer & Casey, 2005; Clay, Kitts, & Pinto da Silva, 2014; Brooks et al., 2015; Asche et al., 2018; Orlove et al., 2020) and with emergent evidence and advice that addresses impacts and opportunities of climate change on social outcomes and transformations (Ojea et al., 2017; Asche et al., 2018; Weber, Borit, & Aschan, 2019; Free et al., 2020; Siders & Pierce, 2021).

There is no ‘best’ reporting cycle, but examples from other jurisdictions in Australia may be useful to consider. Commonwealth fisheries apply a 5-10 year review cycle, and in NSW, the practice in state and local government more broadly, is to review strategic plans every 10 years, often with broad community involvement¹¹. Such a program has been successful for local government for some time, and modelling the approach could provide a practical way forward for fisheries strategies in the future.

Reporting cycles aim to review policies and objectives within an adaptive management framework, and typically focus on process improvements. However, it may be that a strategic review would include an evaluation of the policy itself and determine whether ESD is a relevant approach for managing social expectations of Australian fisheries today, given the difficulty in integrating social dimensions with its predominant economic and environmental concerns. Other frameworks offer an improved focus on social concerns, including human wellbeing approaches (Breslow et al., 2016; Voyer et al., 2016), threat and risk assessments focused on social risks and benefits (Gollan et al., 2019) and community-based conservation (Armitage et al., 2020). Given the dominance of ESD and its position in management legislation and practice, these frameworks are unlikely to replace the need for objective-based

¹¹ <https://www.olg.nsw.gov.au/councils/integrated-planning-and-reporting/framework/community-strategic-plan>

performance assessments in Australia. They do, however, offer an opportunity to couple social performance assessment to existing ESD Frameworks. This is certainly an area for future research.

Resourcing performance assessments are both financial and time intensive, and may contribute to a perception that current levels of resourcing are insufficient to accommodate additional indicators beyond current monitoring and reporting commitments. Advances in modelling, artificial intelligence and decision science could improve the overall direction and volume of investment in fisheries management by, for example, helping to select critical objectives and indicators driving fishing behaviour and which drive a successful outcome (Field et al., 2007; Price & Daust, 2009; Canessa et al., 2015; Chadès et al., 2017). Such approaches could be applied in many of the fisheries research programs across Australian jurisdictions.

5. Conclusion and recommendations

The key finding of this chapter is that social performance is not clearly articulated or measured in an appreciable way in Australian Commonwealth or State fisheries, which limits understanding of how fisheries are operating, and confidence that fisheries are being managed in accordance with the principles of ESD as per objectives in legislation. Despite the strong presence of ESD principles across Australian fisheries jurisdictional legislation, social objectives and performance metrics are less widely specified or monitored in fisheries management practices than other biological or ecological objectives. The under-articulation of social objectives for many Australian fisheries has resulted in ad-hoc trade-offs between economic efficiency, which generates benefits for commercial participants, and other returns on community benefit. Furthermore, the absence of articulated, defined social objectives has made tracking the consequences of these trade-offs more challenging.

Fisheries management primarily relies on regulations, plans and performance assessments designed in the late 1990s, which developed in response to an imperative to curb overcapacity and the risk of overfishing. Emerging social concerns such as climate change and local seafood products are not captured by existing performance frameworks in any jurisdiction, and it is unclear how learning about the system (e.g. changing social values, emerging ecosystem risks, market disruptions or opportunities) is accommodated through existing reporting and learning processes. Existing frameworks at all levels provide for, and encourage, regular review and updating of objectives and performance metrics in line with ESD objectives. Managers could take

advantage of these opportunities such that objectives better reflect changing societal values to provide for a wider distribution of benefits, and which incorporate and respond to impacts of climate change.

Despite these gaps, evidence from the case studies presented here through the use of policy analysis and capacity assessments, shows that solutions are available that facilitate routine social performance assessments as part of a continual improvement process of adaptive management under an ESD framework. The Northern Prawn Fishery and Torres Strait Fisheries, for example, have addressed environmental, economic and social trade-offs by designing performance metrics that align with their social objectives for stability in the fishery, and have incorporated regular data collection and relevant social metrics to inform adjustments to management based on ecological and social factors. NSW is making strides in this direction with an increased focus on monitoring social and economic measures, however, it will be important that this work also contributes to an understanding of greater social welfare beyond commercial industry participants.

In light of the findings of this study, the following recommendations are made, first for fisheries researchers, then for fisheries managers and their management agencies.

Recommendations for fisheries researchers:

1. To understand the potential social impacts of any recommended changes to environmental performance metrics, make an effort to appreciate the political, economic, and cultural context of the fishery. Explore any findings about fisher behaviour that may affect the application of fishery performance metrics.
2. Consider applying decision science techniques across the research, monitor portfolios to optimise resourcing in monitoring programs, and determine key indicators driving fishery behaviour.
3. Engage the expertise of social scientists to develop a range of simple performance metrics aligned with known social outcome frameworks that track key social outcomes which can be readily added to other reporting formats (e.g. organisational annual reports). Evaluate (ground-truth) these indicators and metrics to ensure they provide the relevant information for management decisions.
4. Include climate issues in all fisheries reports, providing analyses of observed and potential impacts on catch or allocation decisions, e.g. on size or bag limits, geographic areas, or specific fishery participants.

Recommendations for fishery managers and management agencies:

5. Review Fishery Management Strategies every 10 years, in collaboration with a diverse set of fishery participants (communities, fishers and Aboriginal people). Review goals and objectives, and update the delivery program to ensure nominated actions reflect societal values and contribute to achieving the stated goals. These Strategies should also indicate how trade-offs will be managed when target levels for social indicators are triggered.
6. Update objectives and performance metrics to reflect more realistic performance indicators, which track ecological, economic, social and governance areas, including relevant climate-related metrics.
7. Continue to provide regular reports, but also consider that incorporating social performance metrics doesn't have to be onerous. Incremental modifications to include social performance metrics are as equal a commitment to change as those which are more expansive.

Chapter 3

NSW Eastern Rock Lobster Fishery: Who Benefits?

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Abstract

This Chapter looks at the flows of benefits provided by the management of NSW eastern rock lobster, a mature share-managed fishery, as an approach to assessing social performance. It assesses how the fishery delivers a comprehensive set of benefits for the range of beneficiaries specified in legal frameworks, such as commercial and recreational fishers, Aboriginal communities, and the people of NSW. Qualitative thematic coding of key informant interviews and public documents compiled evidence on benefits different groups were receiving, and qualitative analysis teased apart the connections between benefits and beneficiaries, and the impact of fisheries management in their delivery. Based on informant responses, benefits were considered for the present and the future. Results demonstrate that, to date, management approaches have yielded net benefits to commercial fishers, with a limited flow to other beneficiaries. When considering intergenerational equity, benefits may diminish even to commercial fishers if critical drivers of change, such as climate and social values around the domestic provision of seafood, are not addressed. These results have significant implications for assertions by management of meeting public benefit outcomes. Recommendations to address gaps in social performance include more regular performance reporting that includes how management uses costs recovered from the fishery, and tracking initiatives to deliver Aboriginal cultural fishing benefits. This case contributes to the thesis by providing a practical example of iterative inquiry and social learning in a complex context, teasing apart the connections between dimensions of ecologically sustainable development (ESD). This case demonstrates how a fisheries researcher can understand the outcomes of management (e.g., the benefits produced) including the range and distribution of benefits for beneficiaries now and into the future. A fisheries manager can use the output of the research (knowledge about the benefits from fisheries and their social distribution) to realign program delivery to address gaps in how benefits

are delivered for specific groups to meet societal obligations related to the objectives of the *Fisheries Management Act*.

1. Introduction

Management of fisheries resources ought also to be accountable to the public interest: ‘managing well’ will assure the public that the benefits or costs associated with the fishery are delivered or minimised appropriately. The tools that managers use to ‘manage well’ include policy settings, management objectives and performance measurement and reporting (Ogier et al. 2020). Despite widespread acknowledgement by NSW and Australian governments that fisheries should be, and are being, managed for public benefit in accordance with principles of intergenerational equity, there is limited evidence that supports this assertion (see examples from this thesis, chapter 2). The lack of evidence has wide-ranging implications for the government, including the potential for reduced public confidence in its fisheries management (BMT WBM, 2016; Voyer et al., 2016), and inappropriate management of the system it is intended to protect (Australian Public Service Commission, 2007).

Globally, concerns have been raised on the ability of share-managed fisheries to deliver social and economic outcomes (Beddington, Agnew, & Clark, 2007; Grafton & McIlgorm, 2009; Allison et al., 2012; Pinkerton, 2013; van Putten et al., 2014a; Productivity Commission, 2016; Hoshino et al., 2020). This may partially be an outcome of management approaches that typically rationalise a set of fishery objectives to optimise for one or two primary objectives, such as Maximum Sustainable Yield (MSY) or Maximum Economic Yield (MEY). However, experience has shown that the components of a system cannot be optimised in isolation from the other elements interacting with it, or affecting it (Brooks et al., 2015). Consequently, managing through single objective approaches provide no insights into a community’s ability to derive non-market benefit (advantages provided by the management of the fishery) from interactions with the fishery, or how they engage with stewardship of the resource (van Putten et al., 2013b; van Putten et al., 2014a; Brooks et al., 2015). Ultimately, single-objective management approaches mask an understanding of the breadth of benefits, and costs, of fisheries (Begg et al., 2014; Wu et al., 2019).

How this phenomenon plays out in Individual Transferable Quota (ITQ) fisheries is specifically of interest given the application of ITQ in many Australian fisheries and throughout developing and developed economies of the world (Grafton & McIlgorm, 2009; Melnychuk et al., 2016). In fact, seven of nine commercial fishing

sectors in NSW are managed with ITQ, a result of a business adjustment program implemented in 2018. The eastern rock lobster fishery in NSW has been managed with ITQ for over 20 years, and evidence suggests that it has successfully achieved biological sustainability targets (Liggins, 2018; NSW Total Allowable Fishing Committee, 2018). Rock lobster is the most mature of the NSW share-managed fisheries and provides an ideal opportunity to evaluate the outcomes of the management approach for the full range of intended benefits implied by the Act.

Voyer et al. (2016)'s work examining wild-caught fisheries in NSW found that without a full understanding of benefits, it would be difficult to determine whether proposed or existing management changes might inadvertently impact benefits to other resource users. A similar sentiment is found in the 2016 report on Australian fisheries, with the Productivity Commission (2016) noting that better performance reporting would foster greater accountability for fisheries managers. They suggest that reporting performance against all objectives would also help inform decision-making and management actions. Because of a premise that fishing is no longer just about catching fish - it is about a sustainable industry and management of a broader range of factors (Anderson et al., 2015; Brooks et al., 2015; Hobday et al., 2016a) - it is important to assess measures of performance related to the management of the fishery alongside the performance of fishing objectives. Several indicator-based frameworks are available that integrate social outcomes with other areas of performance, such as Health Check (Hobday et al., 2016a; Hobday et al., 2019a), the Fisheries Performance Indicators (Anderson et al., 2015; Smith et al., 2019); and Rapfish (Pitcher & Preikshot, 2001; Pitcher et al., 2013). Still, others concentrate specifically on social aspects of performance (Clay, Kitts, & Pinto da Silva, 2014; Triantafillos et al., 2014). However, data to populate these frameworks are not routinely collected, or indicators and data have limited application as they are not linked to management decisions (Brooks et al., 2015). Instead, a simple social performance framework was developed for this study based on benefits, which is a concept embedded in many Australian government contexts, and applied to a range of development situations (NSW Government, 2017; Australian Government, 2020)

The aim of this Chapter is to assess how the eastern rock lobster fishery delivers on a comprehensive set of benefits for the range of beneficiaries specified in legal frameworks, by compiling evidence on benefits different groups receive. A qualitative analysis teased apart the connections between benefits and beneficiaries, and the impact of fisheries management in their delivery. This Chapter is an empirical study showing

how the benefits stack up with what NSW fisheries legislation says it should provide. It complements and adds to Chapter 2 by offering an in-depth look at a particular fishery's social performance and the factors that enable or constrain the operational delivery of social objectives.

2. Overview of the case

2.1 About the NSW eastern rock lobster fishery

The Rock Lobster Fishery of NSW primarily harvests eastern rock lobster (*Sagmariasus verreauxi*), but southern rock lobster (*Jasus edwardsii*) and tropical (i.e. painted) rock lobster (*Panulirus longipes* and *Panulirus ornatus*) are also caught (I&I NSW, 2009; Liggins, 2018). The Fishery extends from the Queensland border to the Victorian border and includes all waters under the jurisdiction of NSW (0-3nm from the coast). Eastern rock lobster are relatively long-lived, living up to 30 years, and are known to be the world's largest species of rock lobster, reaching 7kg at full maturity (25 cm carapace length). Eastern rock lobster occur on rocky inshore reefs (<10m depth) through to offshore reefs at about 200m. The fishery has been commercially harvested since the late 1800s, but a concern about the sustainability of the fishery in the 1980s led to management restrictions. These restrictions were implemented in the 1990s and included a range of measures such as reducing the number of fishers endorsed to take lobster, introducing a maximum legal length and individually numbered tags for harvested lobster, and introducing a total allowable commercial catch and an individual transferrable quota system. A formal Share Management Plan and Fishery Management Strategy were established in 2000 and 2007 respectively, which established biological performance indicators and trigger points for the lobster fishery (NSW Government, 2000; NSW Department of Primary Industries, 2007). Annual total allowable catch limits are assessed by an independent committee based on data from the commercial fishery, and approved by the Minister responsible for the Fisheries Act. Allowable catch limits take allocations to the Aboriginal and recreational sectors into account and consider the impacts of illegal catch on the resource. Data on the use of allocations by recreational and Aboriginal sectors is not collected. Therefore allocation assessments made by the independent committee are currently based on anecdotal evidence and best estimates against the data collected by fisheries scientists through financial contributions from the commercial fishing industry.

Catch rates and biomass have increased over the past twenty-five years since the management measures were put in place (NSW Total Allowable Fishing Committee,

2018). Lobster shares and catch are fully linked through individual transferrable quotas, and use effort (minimum shareholdings) as a secondary control. As of 2019, the total allowable commercial catch was 170t, valued at \$11.7M AUD. The domestic consignment was trending downwards in 2019, with about 70% sold at domestic markets, and 30% of the catch exported, primarily to China. Rock lobster prices are prone to some fluctuation throughout the year but have reached \$80/kg (AUD) for domestic markets and up to \$100/kg (AUD) for exports (NSW Total Allowable Fishing Committee, 2018). The situation changed dramatically in 2020 with COVID-19 and Chinese bans on imports of some commodities, including lobster from Australia. Chinese and domestic markets appear to be recovering from the effects of the pandemic, although access to transport, and the high cost of available transport, continue to be problematic. NSW's Total Allowable Fishing Committee reports that prices might remain depressed for at least part of the 2020–21 fishing period (NSW Total Allowable Fishing Committee, 2020).

The eastern rock lobster fishery is managed under the *NSW Fisheries Management Act 1994 (FM Act)*, whose primary objectives are to conserve, develop and share the fishery resources for the benefit of present and future generations (NSW Government, 1994). In principle, the management of fisheries should also be coherent with the *Marine Estate Management Act 2014*, which provides for the management of the marine estate of New South Wales to facilitate economic opportunities for the people of NSW and the cultural, social and recreational use of the marine estate, amongst other goals (Refer to Legislation listed in [Supplementary Materials 2](#)).

2.2 Analytical methods

The nomination of benefits and beneficiaries draws upon a review of the deep scholarship of ESD in Australian fisheries contexts, and is based on information drawn from key informant interviews. A grounded theory approach was used for the nomination of benefits and beneficiaries. Literature searches were initially exploratory to provide background. Additional literature was sourced in response to stakeholder and co-collaborator responses and suggestions, pulling the relevant literature together as the process emerged. This literature review was supplemented with policy analysis, using frameworks offered by Ogier et al. (2020a) and Farmery et al. (2019).

NSW Fisheries legislation, like many ESD-based legal frameworks, states that the management of fisheries must provide for social, economic and environmental benefits, and supports the provision of benefits for current as well as future generations.

For this study, a list of beneficiaries was drawn from NSW fishing legislation, from interviews with fishery actors, and from the work of several Australian scholars, who collaborated with fisheries managers across multiple Australian jurisdictions (Fletcher et al., 2002; Begg et al., 2014; Triantafillos et al., 2014; Brooks et al., 2015; Hobday et al., 2016a; Farmery et al., 2019; Ogier et al., 2020a). Beneficiary categories included in this study are commercial fishers, recreational (subsistence) fishers, Aboriginal communities and the NSW public. Some scholars have provided two categories of society, such as fishing-dependent communities and civil society, or the wider community of NSW and Australia. Although fishing-dependent communities are distinct from the wider NSW and Australian public, for purposes of this study, we have incorporated the two into a category called “NSW Public”.

Further, for purposes of this study, the focus is on Aboriginal people who have had traditional custodianship of sea country and how to maintain connections to coastal areas. They may also rely on the sea for cultural, economic, and social reasons. NSW was also in a unique position in that in 2009, an Amendment to the FM Act was made to allow for Aboriginal cultural fishing as an exercise of native title (NSW Government, 2010), but this has not yet been implemented. As a result, the legal status of Aboriginal fishing is still unclear in practice in NSW and is a subject of a Parliamentary Inquiry¹². Ogier et al. (2020a) note that beneficiaries are, by default, the State which has jurisdiction over the resources under the law unless other beneficiaries are specifically stated. Because the law in NSW does refer to specific beneficiaries, the authors are confident in applying the categories above. Further, the authors are confident that the expansion of these beneficiary categories by other scholars through consultation with fisheries managers accurately reflects the law's intent.

Benefits were firstly drawn from the FM Act, and supplemented by interviews and a review of publicly available documentation relevant to NSW marine environments, as shown in [Supplementary Materials 3](#). The coding process used to identify benefits was iterative in that literature searches first helped identify preliminary benefits, which were then compiled with legislation to derive the list found in Table 5. This list was then used to go back into the interviews and apply the codes in Table 5 to benefits, which resulted in the framework shown in Figure 14. Benefits are the

¹² Commencement of the Fisheries Management Amendment Act 2009
<https://www.parliament.nsw.gov.au/committees/inquiries/Pages/inquiry-details.aspx?pk=2850#tab-hearingsandtranscripts>

advantages provided by the management of the fishery, not just the activity of fishing. Six benefit categories resulted (Table 5, Figure 14).

Table 5 Benefits from the NSW Eastern Rock Lobster fishery and its management

Benefit name	Explanation
Economic and Social Wellbeing	Management provides for the economic and social wellbeing of the beneficiary.
Cohesion	Management (with a focus on resource sharing and collaborative decision-making) produces cohesion amongst beneficiaries.
Quality experience	Management ensures a quality fishing opportunity and promotes the enjoyment of experiences related to fishing by the beneficiaries.
Conservation of the Resource	Management supports appropriate conservation of the resource and the persistence of culturally and ecologically important biodiversity that meets beneficiary expectations.
Assurance	Management produces information through cost-recovery practices that inform management decisions and assures beneficiaries that objectives are being achieved.
Local seafood	Management produces conditions that provide seafood for beneficiary consumption through local access points, provenance and economies.

Between June 2018 and April 2019, twenty key informants were interviewed using open-ended, semi-structured questionnaires. Questions asked related to experiences in the fishing industry, reported benefits from the management of the ITQ fishery, and negative impacts. Informants represented a range of interests, including commercial, recreational, industry representation, the wider community, and other fisheries (Table 6). Requests to participate in the study were distributed through the NSW Professional Fishermen's Association, NSW Government Lobster Working Group members, and by direct contact with fishing co-operatives and fishing-related businesses. Those who were interested in participating were invited to contact the lead author to arrange an interview. Interviews of 30-60 minutes were conducted via telephone and in person. Due to problems of survey fatigue associated with other unrelated projects, interviews with Aboriginal community representatives could not be secured. As a result, this study draws from secondary sources to report on this area of performance.

Table 6 Sample of interviewees for the current study. Informants were drawn from a range of beneficiary types.

Type of key informant		Number of informants
Post-harvest (community economies)		8
Harvest - commercial (8)	new entrants	2
	ongoing	4
	exited	3
Harvest - recreational (1)	Recreational	1
Other (peak body, science, fisheries management*)		2
		20

Commercial fishers comprised the highest number of informants (9/20). To fully understand the context and conditions of the fishery, current fishers as well as those who had exited the fishery in recent years were also interviewed. New entrants (within five years) were also represented in the sample. Each of the commercial fishers interviewed were owner-operators (i.e. active fishers as well as shareholders), although not all held the minimum shareholding to qualify as an endorsed fisher¹³. At the time of the study 9727 shares were held by 99 shareholders in the fishery. Some shareholders also held endorsements in other NSW commercial fisheries. Based on publicly available shareholding records, the commercial fishers interviewed (new + ongoing categories in Table 6) represented 8% of the shareholders and 21% of total shareholdings.

Several of the informants held roles in various state government-established advisory committees. The community economy representative category included owners and business staff in towns where lobster fishing is based. Other categories included recreational fishers, peak body representatives and fisheries scientists. At the time of the study, the fisheries manager responsible for the lobster fishery was unavailable for an interview.

Interviews were transcribed from audio recordings. Source material (policies, literature and interview transcripts) was compiled into themes and analysed for patterns using a combination of the qualitative software NVIVO and spreadsheet packages in Microsoft Excel.

¹³ A fisher must hold a minimum of 55 shares in the NSW Lobster Fishery to be 'endorsed' to catch lobster. A fisher without endorsement may work as a crew member for a licensed fisher.

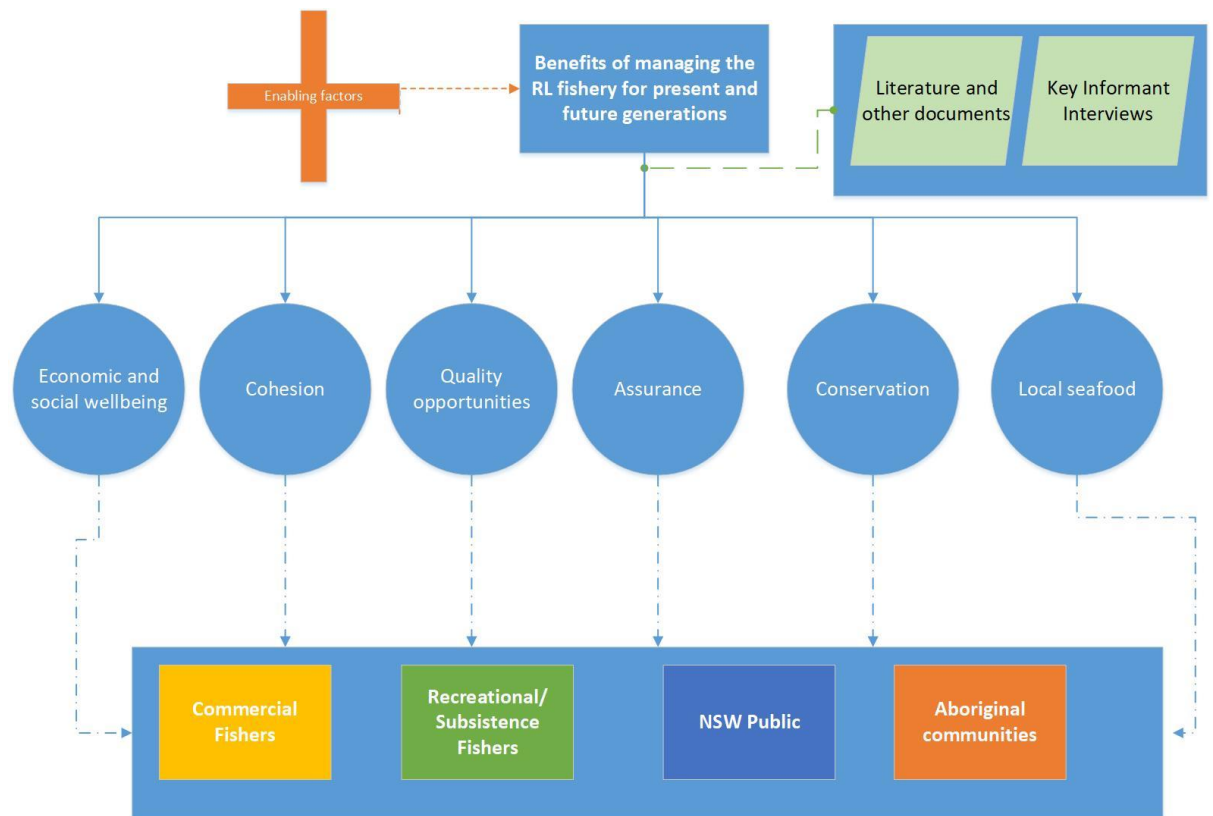


Figure 14 Benefits and Beneficiaries of the NSW Eastern Rock Lobster Fishery

An Excel spreadsheet was used to compile representative statements from each source that demonstrated either a benefit or its opposite (disadvantage) for each beneficiary group, and each of the six benefit categories. An example is shown in Table 7 below. Note that a benefit is an advantage produced by the fishery and its management, but its quality and quantity vary across groups, and through time (NSW Government, 2017).

Coding related to distributional equity reflects the persistence of a benefit within a beneficiary grouping (e.g., do all commercial fishers receive the same or equivalent benefit?) or across a range of beneficiaries (e.g., do all beneficiary groups receive the same or equivalent benefit?). Consequently, intergenerational equity can be considered as the persistence of a benefit through time, i.e., all commercial fishers receive the same or equivalent benefit both now and into the future. After coding for all participants and reviewing documentation for each benefit category, an iterative and subsequent analysis used the frequency of responses to develop a summary of the reported benefits provided by respondents. The summary of benefits was formulated based on the frequency and distribution of responses related to reported positive or negative experiences, described for the present and future. Using the example in Table 7 below, advantages related to

providing social and wellbeing benefits to commercial fishers were broadly positive. The impact of the consolidation of the fishery (fewer quota-owners due to the high cost of quota) on future beneficiaries modulated the overall positive benefit. Thus, on balance, the benefit was determined as neutral and colour-coded yellow.

Summaries of findings for each benefit category, each beneficiary within the category, and an overall statement of benefit were compiled in a colour-coded matrix so that patterns could be more easily seen (Table 8). Green colours indicate a summary of benefits as overwhelmingly positive, red indicates a summary of benefits as overwhelmingly negative, and yellow indicates neutral (provides both positive and negative benefits). These findings are described in the next section, followed by a discussion (see the detailed table results in **Error! Reference source not found.**, [Supplementary Materials 3](#)).

Table 7 Example - Coding used to identify benefits from source statements (interviews, and other documentation). Example shows coding related to Economic and Social Wellbeing benefits for commercial fishing beneficiaries. The reason for the yellow colour in the final row is that the overall (net) benefit was judged to be neutral.

	Commercial Fishing – Economic and Social Wellbeing
Statement of benefit	Economic wellbeing has increased substantially over the last 20 years, with many fisher respondents (primarily owner-operators) expressing satisfaction with the industry and their position in it. Social networks are also strong and contribute to the sense of wellbeing.
Indicative quote	"Everyone's seeing stability in prices, fellows that own their shares have come from something worth \$600 a share, now to \$15,000 a share. They've realized that they've got a strong, valuable fishery and they've got something that's saleable and worthwhile as an exit strategy for retirement and all those things. So now there's a lot of happiness with it all. " "Then if you know somebody ... fishermen tend to look after each other a bit, you know, if you've got a problem, so and so will come around and will help you do a refit or something like that." "The lobster fishery, has become a lot more close-knit, particularly the bigger blokes" "We were catching lobsters back at \$28, \$30/kilo. Now, start of the season, finish of the season and even now we're looking between \$80 and a \$100, we got over \$100. But the thing that's different is that we were leasing quota at \$4/kilo, now we're leasing at \$40/kilo. Now that's got to benefit somebody." "Now I guess the lobster are more, as you go up the coast, there are more of them and more big ones, so it's definitely focussed from Sydney north are the main areas."
Disadvantage	Real shareholdings to individuals are increasing above the nominated cap, as shares can be purchased by spouses, business partners, businesses and under the auspices of superannuation funds. As shares are limited, shares exchange hands primarily within existing shareholders, concentrating the distribution of benefits.
Indicative quote	"Husbands and wives have 350 shares, and the wives nominate the husbands to go to work for them. And we have one big buyer, a restaurateur - he might be the maximum shareholder in the whole fishery now - He bought a lot of shares, and he nominates 2-3 fishers to catch for him. That has caused a tiny bit of dissatisfaction, some dislike. But there is nothing you can do. It's a free trade. You can own shares. It's a free trade."

Summary of reported benefits and their distribution across beneficiary group	Owner-operator fishers' (i.e. those who are active fishers and also shareholders) economic wellbeing appears to be increasing, but the distribution of beneficiaries has decreased since shares were first allocated and may continue to decrease without intervention (i.e., the benefit distribution will contract). Short-term economic viability was high in 2019 and had increased substantially through share management and reform process because of the efficiencies and innovations that occur through output-controlled systems. However, longer term viability may be impacted for some owner-operators as they age out of working as fishers, and modify their business operations. Fishers typically have diversified business interests which may buffer market volatility, such as that caused by the COVID-19 pandemic. Social wellbeing is high, with strong networks amongst fishers that enable economic and social transactions; however, if consolidation of the industry continues and entry continues to be limited, networks will be impacted as fishers begin to exit active fishing. Skill transfer will also diminish with fewer fishers in the industry. The impact of consolidation on a sense of place and identity and maintaining connections to the community cannot be predicted but is likely to have an effect. Likewise, if quota ends up in the hands of investors more than owner-operators, and fishers' profits are reduced by leasing arrangements, as seems a likely scenario, reports of economic benefits to commercial fishers may change.

3. Results and discussion

The analysis results are first summarised below, then described in detail for each of the six benefit categories. As for many qualitative studies, results and discussion will be presented together as it helps the reader to make sense of the data (Guetterman, Fetters, & Creswell, 2015).

Each identified benefit is present and enabled through the management of the Eastern Rock Lobster Fishery. However, many benefits are discounted through effects of distributional or intergenerational equity concerns (Table 8). Positive benefits are most strongly associated with Conservation (received by two out of the four beneficiary groups), attributed to the presence of strong management controls and share management. Quality opportunities are the least well-received benefit (no positive net benefits for any beneficiary), with substantial distributional equity concerns.

Benefits from the Eastern Rock Lobster Fishery primarily accrue to commercial (owner-operator) fishers, with recreational fishers also receiving substantial benefit.

Benefits from lobster fishing to the NSW public and Aboriginal communities are less apparent. Advantages are not demonstrated for the NSW public in three of six benefit categories, and none of the six benefits are realised for Aboriginal communities

Table 8 Summary of benefits from the NSW Eastern Rock Lobster fishery. Reported benefits were summarised to describe net benefits, indicated by positive (green), neutral (yellow) and negative (red) cells. Summaries are also provided for each category (right hand column) and for each beneficiary group (bottom row). Summarised net benefits incorporate a judgement based on the effect of distributional equity (d) or intergenerational equity (i) which has reduced its net positive benefit.

	<i>Beneficiary</i>				
<i>Benefit</i>	Commercial	Recreational	NSW Public	Aboriginal Communities	<i>Net Category Benefit</i>
Economic and social wellbeing	(i)		(i)	(d)	
Cohesion	(i)			(d)	
Quality opportunities	(i)	(d)	(d)	(d)	
Assurance		(d)	(d)	(d)	
Conservation			(d)		
Local seafood		(d)	(d, i)	(d)	
<i>Net Beneficiary Benefit</i>					

3.1 Economic and social wellbeing

Benefits from the Eastern Rock Lobster Fishery primarily accrue to commercial fishers (i.e. owner-operators), with recreational fishers also receiving substantial benefit, particularly as both groups directly benefit from current management practices that focus on the restoration and conservation of the resource. Output controls such as ITQ promote efficiency, innovation and investment in the fishery, but have also led to consolidation. There are fewer commercial fishers receiving these benefits. From a business point of view, consolidation ensures greater economic return from a limiting resource. As a result, economic benefits have been consistently returned to a select group of shareholders who maintain fishing operations, but the distribution of economic benefits has contracted over time. Contraction of the fishery with share consolidation is likely to continue, leaving benefits to be accrued by a minority of fishers and/or shareholders. Such a narrow focus on current benefits without adequate consideration of future beneficiaries could impact intergenerational equity concerns.

The focus of management to date has been on stock recovery. International evidence suggests that stock rebuilding may take as little as ten years (Neubauer et al., 2013). The rock lobster fishery first moved to stock recovery more than 20 years ago and management (the application of the TAC to restore biomass) has been successfully demonstrated in this area (Liggins, 2018; NSW Total Allowable Fishing Committee, 2018).

The intent of a decision to couple a TAC with tradeable, private shares was to achieve certain social and economic elements of ESD. Trade-offs amongst these elements is inevitable: tradeable shares favour economic rent, but they reduce employment. Shares may be traded and held by non-fishers to allow share prices to rise, but a focus on share prices subsequently de-prioritises regional economic development. The interpretation that ITQ has been successfully implemented in the NSW Rock Lobster Fishery rests primarily on the successful application of TAC to restore biomass. Respondents, however, have revealed a number of social issues emerging from the application of ITQ, such as an aging industry with minimal opportunities for new entrants due to the cost of quota, perceptions of inappropriate representation in decision-making, poor returns to other beneficiaries and a shift away from owner-operators to leasing. Lobster fishers used the interviews as an opportunity to reflect on what this shift could mean for the future of the fishery: “I mean, theoretically, could somebody come in and buy it up? Yes. And then the fishery would still contribute lobster to the world and the economy, but it doesn't meet that criteria that we were talking about - having people on the water, local people on the water.” Management approaches may need to be redirected from an objective of stock recovery, and its direct link to tradable shares, to a broader set of management objectives to ensure benefits continue for commercial fishers into the future.

The mechanism of ITQ manages primarily for the benefit of commercial fishers who are shareholders/quota owners with potential public benefits received as shareholders pay the government to access the fishery through quota. Without further information, however, it is not possible to determine whether these payments are collected, and how they are applied to meet a public benefit outcome. It's worth drawing specific attention to the discrepancy between the reported benefits for commercial fishers and NSW Public, as there is a common belief in fisheries management that if the commercial fishery is doing well, the wider community will also benefit. This stems from an assumption that as the fishery business becomes more profitable, it will spend money in local communities, employ local people in their

business, provide outputs to consumers and contribute fees to the government to access the resource (AFMA, 2019a; Wu et al., 2019). However, the downstream effects of the reduction in fishing capacity due to the introduction of ITQ on community social and economic wellbeing have been further exacerbated with increasing vertical integration of fishing businesses, whereby commercial fishers package and export product directly to foreign markets, bypassing local service providers.

“You used to have the lobster industry that spanned across many communities along the coast. Gradually over time those fishers sell out of those communities. So you no longer have that fishery in that community, supporting that community. It all goes to the bigger ports. It hasn't happened completely in NSW yet, but it is on the way. It's very much on the way. The shares are slowly but surely getting consolidated. So, again, from one point of view, it's fantastic. But from the other point of view, is it? From the community's point of view, it's a horrifying thing,” says a community member.

According to the data in this study, the sum of positive and negative benefits across all categories (i.e. the distributional equity), is more negative than positive despite the broadly positive benefits reported for the commercial fishers group. The emerging issues appear also to have an impact on the presence and flows of quality experiences and economic and social wellbeing across a range of beneficiaries, and the provision of local seafood through interactions with climate change. Voyer et al. (2016) report that seventy-two per cent of the NSW public support the continuation of the fishing industry primarily as respondents of that study valued the role of the industry in local economies. In fact, an audit of fisheries reports found that the provision of seafood and its impacts on communities rated more highly than sustainability concerns for most public respondents (Neville, 2017). There appear to be major gaps, therefore, in how social and economic wellbeing, assurance and local seafood are delivered to these beneficiary groups, now and into the future.

3.2 Cohesion

The method of representation and participation in decision-making served an important purpose in recovering the fishery from collapse. It was also described by a respondent as being a pivotal contributor to ongoing management. “I think it's good for the New South Wales community to see and to realize that it is possible [to recover a depleted fishery]. And that with the appropriate management, consultation, and

cooperation with the main stakeholders, this can be achieved, which is clearly a good thing for anyone involved with rock lobsters, but potentially also a very important thing for improvements, in many of our other spaces. So that's what I'd say is probably the most important current benefit and potential future benefit that might apply to other spaces.”

However, although promoted in principle, resource sharing has not been adequately supported with evidence or consultation, particularly in the case of Aboriginal communities. ITQs inhibit commercial access to the fishery because of the cost to enter. Shares must be purchased at a price negotiated with a current shareholder, who benefited from an initial free entitlement and a history of decisions that have prioritised the commercial sector over other sectors. Secondly, Aboriginal access is limited by permit conditions that ensure the impact from this sector is negligible and the catch cannot be traded. Thirdly, because ITQs are designed to target maximum economic yield, the target reference point defaults to Maximum Economic Yield (Bmey) for commercial fishers. In essence, this depletes the stock below a point where traditional cultural fishing methods are possible because a TAC based on Bmey would be allocated predominantly to the commercial sector. Taken together, it's clear that although the government provides cultural permits as an access point for Aboriginal communities to the resource, the current practices and policies on ITQs implicitly eliminate traditional cultural fishing opportunities (and, to a lesser extent, diminishes recreational fishing opportunities).

The lack of understanding on how ITQs have directly affected Aboriginal access to the resource has resulted in unnecessary tension over an emerging issue of native land and sea title claims. Native title claims are perceived by some commercial fishers to have the potential to alter the flow of benefits away from commercial fishers:

“One of the big contentious issues, which is becoming more and more current is with the Native Title and land claims and the claims for part of the sea as well. And that throws the whole Quotas up in the air because if they win claims then it's going to be outside that quota, and how is the fishery going to be managed properly then? It opens up a massive can of worms, it's a big challenge for the future.”

Although the respondent quite rightly acknowledges that resource sharing is a challenge, the challenge they identify is not in the future and not a result of potential Native Title Claims. The challenge is now, and is entirely comprised of the decisions

and determinations related to sectoral allocations of the TAC. To share the resource as intended by the FM Act, greater attention must be paid to understanding the needs of the different sectors and setting appropriate targets and limits that facilitate, rather than preclude, sharing. There is great potential to improve cohesion through a range of options presented by Aboriginal communities, such as culturally suitable bag limits for key species, the selling of species taken in a cultural catch, and enforcing compliance through community rangers or more culturally sensitive fisheries officers. (Schnierer, 2011).

Given that the resource has recovered (NSW Total Allowable Catch Setting and Review Committee, 2017) the focus of management on stock-rebuilding and the system of representation that supported stock-building decisions may not serve long-term decisions for the future of the industry. Despite the past successes that industry involvement has had in stock recovery, inertia and familiarity can be powerful inhibitors of change. A seafood retailer noted, “We're just stuck, we're doing the same with fisheries as what we were doing in the 60s, as if it's still relevant. Which is a shame, as everything is so changed in our marketing area, that we really need to be moving on and looking about commercial fishing today and not from 40 or 50 years ago.” A mechanism to address these challenges may be to change the way decision-making is undertaken to bring more voices into the discussion about whose interests and which benefits are prioritised. According to well-known engagement models such as the IAP2 Public Participation Spectrum, the current method is primarily an “inform” approach with limited opportunities for most beneficiaries to be involved (IAP2, 2014). Moving to a collaborative model would require more resources to establish and facilitate decision-making but could address emerging social issues more effectively. Expanding membership of the Working Group to include a member of the wider community would ensure a voice for the NSW public in these decision making forums. Additionally, moving to an ‘empower’ model would give those who stand to benefit or lose the authority to make decisions (Ostrom, 1990), but admittedly is a marked change in decision-making models and may not be immediately possible.

3.3 Quality opportunities

Quality fishing opportunities have been experienced by a range of beneficiaries, and the opportunity to catch is likely to remain. However, the quality of the experience appears to be absent or diminishing in the commercial sector, particularly for younger fishers, Aboriginal people, new entrants, or those associated with fishing-related

services in the wider community. The community's enjoyment may diminish as fishing businesses engage less with local communities through a reduction in services and disassociations with local economies.

Evidence indicates that there are limited benefits to Aboriginal communities from the rock lobster fishery. Cultural licenses are supposed to be available under NSW legislation for Aboriginal communities to consume and access rock lobster, which is used in community and cultural practices (Schnierer, 2011). Cultural licenses, however, have not been taken up as intended (Australian Government Department of Sustainability, 2012; NSW Total Allowable Catch Setting and Review Committee, 2017). It would be worth pursuing why this is the case, given that evidence shows rock lobster has traditionally been used for cultural practices, as a source of revenue or barter (Schnierer, 2011; Schnierer & Egan, 2016). It could be that regulations associated with the cultural practices licenses make it difficult to implement the cultural practice, particularly if lobster are used as a form of exchange. The sale of lobsters outside of shares associated with ITQ is prohibited under current management arrangements, but could be an area to explore for cultural purposes. There is also the opportunity to explore aquaculture opportunities to enhance and supplement cultural fishing practices, in the form of hatchery-raised, or storage of wild-caught lobsters in reticulated systems. Aboriginal people have put several ideas forward in various fora that go some way to addressing the gap to improve quality opportunities, cohesion and economic and social wellbeing (Schnierer, 2011; Schnierer & Egan, 2012; Schnierer & Egan, 2016), but it appears that the lack of adequate representation plays a major part in advancing progress in these areas.

3.4 Assurance

Research and data on stock recruitment and commercial catch has provided critical information on which to restore the fishery. Commercial fishers authorised and partially paid for such data which has to been to their benefit and also for the other sectors who benefit from TAC allocation decisions based on such data. A fisher from the northern parts of NSW explained, "We have been paying for research ever since day one. We have our own research....We even had to pay for our own EIS¹⁴. That [took] 6 years. The government loaned us the money, we had to pay it back - \$600,000." Another commercial fisher recognised the benefits to other beneficiaries from their

¹⁴ An "EIS" is an Environmental Impact Statement, a requirement of state and Commonwealth government on industries to describe the environmental impact of industry activities.

investment in data but was also conflicted in how other sectors might disproportionately gain. "We see our fees as going to a good thing but we don't want these other fisheries getting it gratis, you know. So that's the grey area in between all that."

The concern over reporting of costs of management, how costs are recovered, and where recovered fees are used is not a purely academic point, as it has practical implications for where management can best invest limited financial and human resources into improving the management of the fishery and assuring the public that management is appropriate for the system. Management costs include acquiring, analysing, writing up and distributing information about the fishery, establishing processes to achieve particular outcomes, the operational costs of the fishers in management-related tasks as well as those incurred by the government associated with observing fishing and enforcing the regulations, and must also consider the resources and capacity of managers to determine an appropriate implementation program. The financial costs of management are fairly well understood (Dowling et al., 2016), but costs associated with resourcing and capacity, and collecting relevant data on social objectives are not as well described. However, learning is a goal of adaptive management and ESD: good experimental design should produce reliable new information for decisions. Therefore, performance reporting helps address some of these gaps by allowing stakeholders to reach a view on whether the costs of interventions are sufficiently outweighed by the benefits (Productivity Commission, 2016). Improving assurance to stakeholders will firstly require managers to formally acknowledge the importance of assessing social benefits and costs at different spatial and temporal scales, and in relation to existing management arrangements. Advocates for increased transparency and reporting drew attention to Cost Recovery Implementation Statements in Commonwealth fisheries (AFMA, 2019b), supported a measured approach to recovering costs from recreational fishers, and cautioned against using cost recovery to Aboriginal cultural fishing. How these suggestions could apply to the NSW rock lobster fishery would be worthy of consideration by relevant decision-makers.

Commercial fishers overall were satisfied with the level of reporting to continue their fishing activities. Most respondents do concur that research and data on stock recruitment and commercial catch have provided critical information on which to restore the fishery. Despite this, the lack of transparency related to performance reporting, including reporting on the use of management fees and community contributions, does not provide beneficiaries with the assurance that management is effective and efficient in delivering benefits as stated in the Act to all beneficiaries. The

ongoing lack of data collection on other sectors, or data provision beyond basic biological and economic data, is seen as a significant disadvantage to future beneficiaries. Research related to climate change impacts is beginning. However, it has not yet been incorporated into decisions.

In particular, the ongoing lack of data collection on recreational and Aboriginal cultural lobster fisheries and the absence of data provision beyond basic biological and economic data, combined with a perception of inability or unwillingness to review management practices, is seen by many respondents as a significant disadvantage to current as well as future beneficiaries. For example, the lack of information on Aboriginal cultural fishing has contributed, in part, to the development of fisheries management measures that have been inadequate in addressing the special nature and place of Aboriginal fisheries as the first fishery in NSW (Schnierer, 2011). In particular, assuring the public of how climate change is being considered in managing the lobster fishery will be an important aspect of climate adaptation broadly (Brown Weiss, 2008; Creighton et al., 2015; Hobday et al., 2016b; Ojea et al., 2017; Fogarty et al., 2019; Holsman et al., 2019; Free et al., 2020).

3.5 Conservation

Managing the fishery through total allowable catch benefits the public through stock rebuilding and increased distribution and availability to all sectors (recreational, commercial, and Aboriginal). One commercial fisher proudly stated, “It's come back, that's a benefit for everyone.” The management of the fishery is also reported to have increased the size and availability of rock lobster across the coastline of NSW, and has reduced bycatch and interactions with other marine species, primarily in response to the reduction in overall fishery effort. Fishers may well continue to harvest a well-maintained stock into the future, but the distribution of benefits may contract depending on changes in the patterns of rock lobster presence along the coast. Rock Lobster are increasingly abundant, but their local presence, size and regional distribution may be changing due to warming ocean temperatures associated with climate change (Phillips & Welch, 2017; Plagányi et al., 2017), which may impact the distribution of benefits to the future generations. The cultural and intrinsic values of rock lobster and the broader ecosystem are supported in principle through statutory arrangements. However, more work needs to be done to understand how to conserve and maintain the cultural significance of lobster for Aboriginal people.

The concept of stewardship arose in interview responses, and it related to compliance, and to pro-environmental behaviour beyond fisheries. Compliance is an issue because of such a high-value resource, but compliance practices (tagging) and regulations are strongly supported despite the occasional bad experiences with compliance personnel. With respect to other forms of stewardship, commercial fishers are using innovation to minimise interactions with threatened species such as sea turtles and whales as they target rock lobster.

The issue of stewardship will have increasing importance and interest as shareholdings consolidate. It will be interesting to note whether stewardship continues to be a prominent value of fishers as they become more reliant on short term income as lease fishers, and how environmental knowledge is transferred amongst them. The impact of consolidation of shareholdings on stewardship values is not limited to commercial fishers: how shareholders who are not active fishers understand their role in conservation of the marine environment, and how the wider community perceives the commitment of the fishing industry to conservation will also be important to track.

3.6 Local seafood

The NSW RL fishery provides a reliable local (NSW-based) luxury product to consumers. Benefits accrue to commercial and recreational fishers, with a limited flow to some members of the wider community (d). With a strong international market, commercial fishers are likely to continue to realise benefits from a range of consumers. However, with the increasing direct-to-export market, benefits to local consumers are unlikely to increase under existing policy and management arrangements (d,i). A fisher admitted, "The price of lobster is staggering. 80 to 100, 100 plus dollars per kilo around Christmas. Yeah. Because the demand in China is so great."

The issue of local seafood, as a wider cultural experience, and its contribution to a healthy diet is becoming more prominent (Voyer et al., 2016; Gollan et al., 2019; Hicks et al., 2019). Although the eastern rock lobster fishery does supply a food consumption benefit, the relatively low yield across NSW (TAC for non-commercial sectors: 10% of 180t = 18t) means that it does not contribute greatly to the supply of seafood to the community. Despite this, community members are able to source their own lobster if motivated enough to fish recreationally, however, allocations to recreational fishers have not grown proportionally to the allocation to commercial fishers. The delays associated with decisions on the proportional allocation of the annual catch (and determinations around bag limits and sizes) indicate a diminishing

benefit to recreational fishers, and raise concerns about the benefits of fresh, local, sustainable seafood returning to local people. Once determined, greater availability to recreational fishers may partially offset the reduced benefit to local consumers due to price. It is unlikely that average households will purchase rock lobster at market rates. In fact, even during COVID-19, when the export market was depressed and domestic market prices were reduced to roughly \$50/kg, there is no evidence to suggest that the NSW public took advantage of these lower, but still premium prices (NSW Total Allowable Fishing Committee, 2020). Hoshino et al. (2020) note a negative consequence of high prices is the potential for black market sales. Indeed, this is something that requires further exploration.

Eastern rock lobster will never be a daily consumer product – it is an example of a high price, luxury fishery. Managing it for a wider community benefit is therefore is not necessarily about the provision of seafood, but the distribution of economic rents (the returns from use of a public resource). Despite the success of TAC in recovering the stock, the privatisation of the resource through ITQ has resulted in the drift of economic rents outside the jurisdiction (ownership outside of NSW). Further, assurance to the public that the management of the fishery is delivering on its ESD commitment is hampered by a lack of an explicit objective to return economic rents to the community, and inadequate reporting on costs of management and use of funds. In the absence of such objectives, ad-hoc decisions were made to privatise the fishery which were popular at the time, but are already demonstrating limited benefits into the future.

The observed impacts on benefits from managing this fishery through ITQ are not unique to NSW. Hoshino et al. (2020) reported many similar experiences across fisheries internationally, highlighting a serious and urgent problem. Several countries such as Canada and New Zealand are reviewing ITQ policies in an effort to mitigate the effects of unrestricted quota trading and return benefits to coastal and Indigenous communities (<https://www.dfo-mpo.gc.ca/reports-rapports/regs/piifcaf-policy-politique-pifpcca-eng.htm>; (Day, 2004). Advocacy is also occurring to encourage governments to buy-back fishing quotas, returning control of fishing resources to the government and the public. In fact, returning quota to government and leasing quota to fishers (or requiring some other access fee) ensures that rents could be returned to the public domain and re-invested into management of the fishery (National Academy Press, 1999). The application of a benefits framework such as that used in this study can be widely applied to any fishery and may help to inform urgent and necessary

modifications to fishery systems to ensure benefits for all fishing beneficiaries, now and into the future.

4. Conclusions and recommendations

The purpose of this research was to assess the social performance of the NSW Eastern Rock Lobster, an ITQ fishery, to understand how benefits are being provisioned by the management of the fishery, under the objectives of the NSW Fisheries Management Act. This study finds that the full intent of the Fisheries Management Act and its objectives is not currently being achieved through ITQ management. On the whole, current management arrangements – for the conservation, the development and the sharing of resources, as prescribed by the *NSW Fisheries Management Act* – produce net neutral benefits, tending towards negative net benefits. Positive benefits are most strongly associated with conservation; however, it must be noted that the benefits of conservation are primarily provided through the application of a total allowable catch determination rather than the provision of tradable shares. In addition, the conservation benefits of the current approach to the long-term viability of the commercial fishing sector, as the primary beneficiary, are less certain.

The implementation of ITQ as the preferred management approach set in motion a series of impacts including fewer fishers in the industry, reducing downstream flow of benefits to communities, and an orientation towards export which means that the catch is not available as a source of food. Based on current trajectories, it is likely that quota ownership will move from fishers to investors as current owner-operators move to retirement. This has implications for the NSW public in several ways:

- (1) Consolidation of shares prevents equitable and just access to the resource by community members or future generations of commercial fishers
- (2) Lack of controls on ownership of shares results in flows outside of the jurisdiction
- (3) Because of the lack of an explicit objective to ensure economic benefit to the community from use of a public resource, economic rents flow exclusively to shareholders.

Management of the fishery provides marginal benefits to current generations of some beneficiaries, but given the current set of climatic, market, technological and social conditions which vastly differ from when catch shares for rock lobster first came to be, management will have to consider how to adapt its approach to addressing significant distributional and intergenerational equity issues.

Most importantly, although Aboriginal people were not available for interviews and the study relied on secondary sources, the research demonstrates that benefits are not being provided to Aboriginal communities, which is a significant shortcoming of the current management approach.

The wider implication of this work is that without a systematic look at social benefits, fisheries managers may assume good social performance of the fishery, because it is profitable and the stocks have recovered well. However, with a benefits framework, such as that provided in this study, it becomes evident that there are many limitations in the benefits that should be flowing from the fishery. The findings of the study provide an opportunity for fisheries researchers and managers to reflect on what elements of social performance should be pursued through fisheries management, what indicators can be used to evaluate performance, and how current management practices can be adapted to address identified gaps. Making efforts to implement the Amendment to the FM Act section 21aa to enable cultural fishing should be the first priority. Facilitating flows of advantages to Aboriginal communities is likely to have a concomitant positive effect on other benefit categories, meaning that it could be an opportunity to gain a return on investment. Regular performance reporting, including reporting on the use of funds recovered from the fishery, will also help to provide assurance to the NSW public that management is targeting critical areas that support the industry into the future. The use of scenario analysis and management strategy evaluation may be helpful extensions to the benefits approach to improving understanding on the sensitivity of benefits to different management measures.

Chapter4

Integrating qualitative assessments of preference to inform options for management: a case study of the southern king crab fishery, *Lithodes santolla*, Chile

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Abstract

Fisheries management approaches vary according to the characteristics of the fisheries, the resources available for management, the efforts which their value justifies, and the legal framework in which they operate. A reform process in the king crab (centolla) fishery of Chile provided an opportunity to explore stakeholder views related to different management approaches, contributing to a revised implementation program. In this study, preferences for different objectives were assessed. A typical research process is first to elicit stakeholders' preferences related to fishery objectives and then propose a management approach that aligns with those preferences. This conventional approach was expanded with a qualitative component to address a known gap in interpreting preference study results. A semi-structured and semi-quantitative questionnaire survey asked 22 stakeholders of the centolla fishery to rank management options for their ability to achieve different objectives such as social and economic wellbeing or reduction in conflict. Stakeholder results were compared based on a number of characteristics such as industry participation, geographic region, boat ownership and point of landing. Our results show that only reporting preferences gives a shallow understanding of stakeholder preferences regarding fishery objectives. Results of preference rankings, disaggregated by stakeholder group and reasons show that respondents have a complex set of reasons underpinning preferences related to reducing social and economic vulnerabilities, improving fairness, addressing implementation

concerns and supporting long-term biological outcomes for the king crab fishery. The study demonstrates that many management options could be viable, provided they could be designed to address social and economic vulnerabilities, based on vessel size, geography, interactions between economic development policies and artisanal fishing, and social contracts. Addressing the biological sustainability of the resources is paramount to most stakeholders, but how this is done must address fairness concerns, and have a reasonable chance of implementation success. The method in this study advances a deeper understanding of preferences to inform adaptive management in a way that achieves multiple objectives rather than trading off benefits.

1. Introduction

Gaining support from stakeholders is an important driver of management and policy: Policy will never please all, but decision-makers need to be able to justify their decisions to their constituents such that decisions are seen to be legitimate by most stakeholders and gain ‘buy in’ (Pascoe et al., 2017; Simmons & Mehmet, 2018). Understanding preferences for management strategies may assist managers in making their decisions, or at least understanding the weight and impact of the decision on different constituents. Preference studies are an important tool to gauge the importance of fishery objectives to people, such that management interventions and incentives can be designed appropriately (Holland, 2010; Sloan et al., 2014).

Preference studies provide decision-makers with sets of statements, which participants sequentially rank in order of preferred importance to them. Ranking, or sorting, gives subjective meaning to the statements, allowing respondents’ subjective viewpoints to be analysed (Van Exel & de Graaf, 2005). Differing stakeholder views and values are inevitable (Charles, 1992; Shao et al., 2013), but knowing preference structures can make working through compromises much easier (Bennett, 2005). Fisheries management, and in fact most conservation management, has become more of a focus on trade-offs, e.g. identifying what overarching societal values “win” or “lose” in a final policy decision (Tetlock, 2003; Leader-Williams, Adams, & Smith, 2010; Daw et al., 2015; Bunnefeld, Nicholson, & Milner-Gulland, 2017; Law et al., 2018). This approach carries through to research, where stakeholders can be asked to rank their preferences amongst high-level economic, social or environmental objectives, and for a range of reasons, results in social objectives being poorly preferred (Begg et al., 2014; Pascoe et al., 2014a; Castree, 2017; Punt & Anderson, 2017; Pascoe et al., 2019). People are concerned about social system interactions with conservation and

management interventions, as demonstrated in the results of multiple evaluations of fisheries management and development programs in recent years (for a few examples, see Hiruy & Wallo, 2018; Teh et al., 2019; Barclay, 2020). Therefore, designing and evaluating management interventions needs to consider how to derive more comprehensive insights about preferences and impacts across fishery participants.

A review of some fisheries preferences studies would lead one to believe that social outcomes are less of a concern than economic or biological concerns (see, for example, Dichmont et al., 2013; Marre et al., 2016; Pascoe et al., 2017). However, scholars also admit that preference weightings are highly subjective, and inconsistency is a common problem, particularly when decision-makers are confronted with many sets of comparisons (Pascoe et al., 2014b). There is also acknowledgement in the field that social objectives are frequently vaguely specified, which makes it difficult to contrast them with well-articulated and measurable economic and environmental objective statements (Pascoe et al., 2014a; Brooks et al., 2015). Further, many preference elicitation approaches rely on aggregating responses from many respondents to determine final, optimal solutions, and, despite their increased usage, proponents admit that the weakness of such an approach is a lack of granularity of responses and forcing trade-offs between user groups (Dichmont & Fulton, 2017; Pascoe et al., 2019). Those who make decisions on fishery objectives and management options would benefit from insight into perceptions of negative consequences of certain options, something which is often not captured by preference alone (Simmons & Mehmet, 2018).

Qualitative methods are useful to policymakers because they shed light on the context and reasoning behind conflict rather than just preferences for policy choices (Simmons & Mehmet, 2018). For example, asking “why” encourages participants to state their reasons for their preference decisions, providing critical information for management interventions (Arias, 2015). Knowing reasons helps reduce the granularity present in quantitative preference data to resolve perspectives, by understanding not only more and less preferred options, but also preferred and rejected, and reasons for these determinations across the various decision-makers. Since reasons – and the interconnections between reasons for preferences, objectives, and norms and beliefs – about feasibility are complex (Maxwell, 2019), eliciting these is best done through qualitative, open-ended questions. This approach can help to address concerns related to how ranking does not always reflect what people really think. Therefore mixing qualitative components about interrelationships between elements and reasons adds a more comprehensive understanding of the problem than aggregative preferences alone.

This study adds qualitative results to a more standard quantitative ranking approach typical of preference studies. When combined, the two should be capable of providing broad patterns in responses and a more nuanced picture of preferences and perceived likely consequences of certain management options amongst stakeholders. This study focusses on the Southern King Crab Fishery in the Patagonian region of Chile, which is in a state of reform to address overfishing. In a state of reform, there is an opportunity to (re) develop the fisheries management plan to improve the relevance of objectives and design appropriate management approaches. The paper contributes an understanding of fishery participants' preferences concerning the management of the southern king crab fishery in Chile. Importantly for policymakers, it explains reasons for preferences, and different preferences among stakeholder groups, which may help managers better understand the complexity of preferences, and enable decisions to be accepted as legitimate by stakeholders.

The following sections outline the methods used to gather and interpret preferences, followed by the findings and discussion.

2. Methods

2.1 Study location and context

Chile is a developing economy, with a strong focus on artisanal (small-scale) fishing and aquaculture. Artisanal fishing in Chile is defined by a maximum vessel length and capacity (<15m, <50 GVM) and fishing activities occurring within 5 nm of the coastline. Simultaneous economic and political incentives have driven the artisanal fishing sector to increasing industrialisation (Eisman, 2016; Mellado et al., 2018; Morales, 2018), with fishing vessels increasing in size and capacity (Cerdeira D'Amico, 2014). This has resulted in overcapacity and is impacting fishing stocks, including in the southern king crab fishery. Catches of king crab have been declining for several years (SUBPESCA, 2018, 2019). The fishery comprises a mix of two species, *Lithodes santolla* and *Paralomis granulosa*, known locally as centolla and centollon, respectively, and has a joint export value of \$80M USD (PROCHILE, 2018). Eighty per cent of Chile's centolla and one hundred per cent of centollon exports are derived from the most southern region of Chile, the Magallanes (Figure 15).

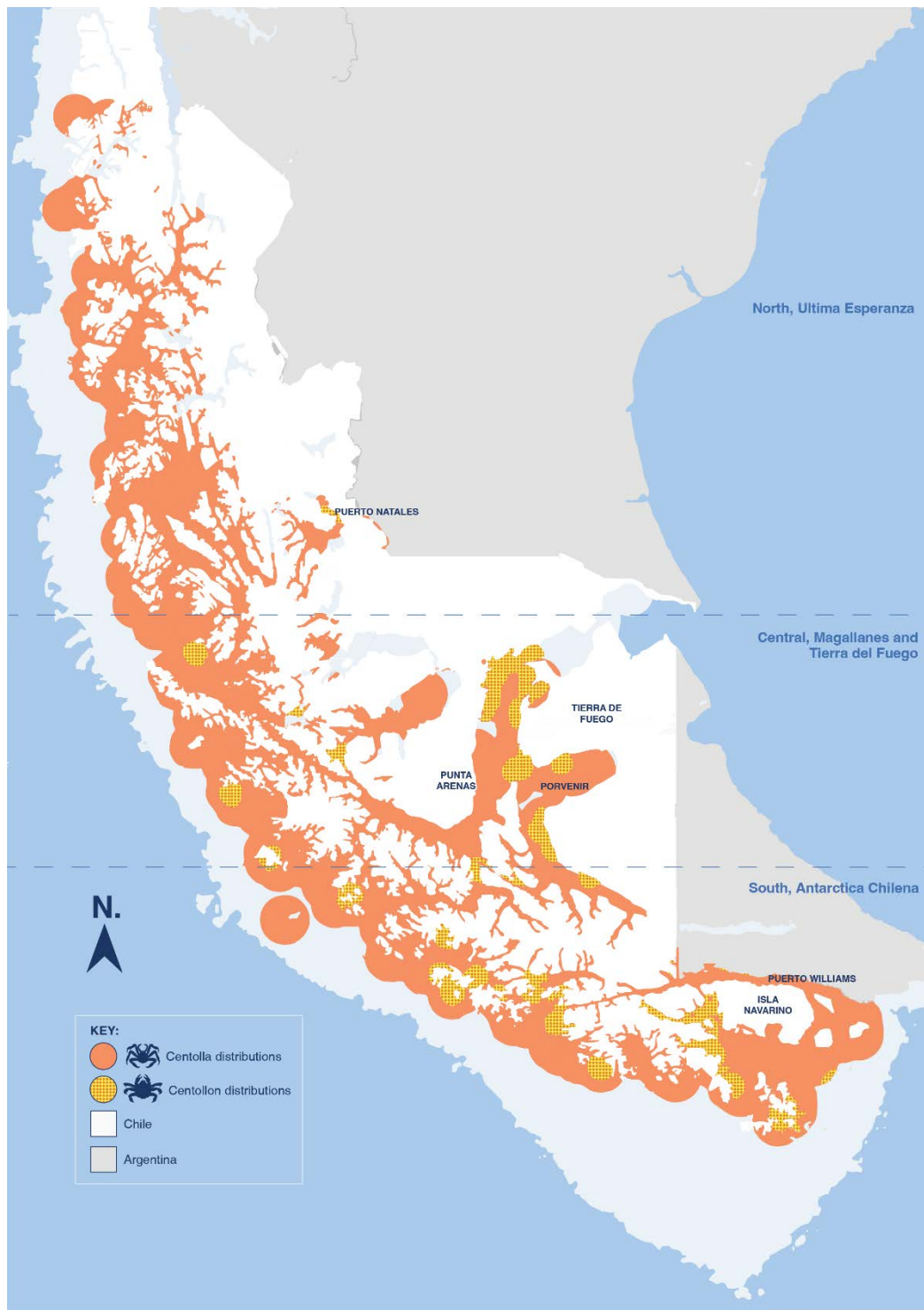


Figure 15 Location of centolla and centollon fishing grounds in Magallanes. Fishing zones are typically divided into north, central and south. North is primarily comprised of the province of Ultima Esperanza, Central comprises the provinces of Tierra del Fuego and Magallanes, including the Strait of Magellan, and South extends across the Beagle Channel (shared with Argentina) into the province of Antarctica Chilena. Orange areas indicate the distribution of centolla fishing grounds, light orange hatching indicates known centollon fishing areas, which are concentrated in the central to southern fishing zones. Source: Subpesca, IFOP, Comité de Manejo Meeting June 2017

Geographically, centolla are accessible in shallower locations in the northern parts of the region and occur in deeper channels in the southern parts of the region. Centollon occur only in the central to southern parts of the region (see *Figure 15*). The various fleets that target centolla and centollon aggregations use different gears and fishing

behaviours: fishers on the smallest boats (<12m) target the shallower aggregations, closer to shore. Fishers on larger boats (12-15m) target the deeper aggregations, and may spend several days, weeks or months out at sea during the fishing season.

King crab is culturally significant for many Chileans, but is also increasing in economic importance (Pollack, Berghöfer, & Berghöfer, 2008; Mellado et al., 2018; Morales, 2018). The economic importance has resulted in high levels of illegal commercial fishing and underreporting of catches (Nahuelhual et al., 2018). Moreover, declining legal commercial catches precipitated a reform process in 2014 to address the sustainability of the fishery in this region.

The Magallanes is socially complex. Crews, skippers, vessel owners, intermediaries and transport vessel operators are all considered artisanal fishers under the law (Ministry of Economy, 2013), with categories entrenched through a variety of social and economic contracts. For example, vessel owners have agreements with particular processing plants that are often negotiated via intermediaries who may transport the product from the fishing grounds to the landing port. Many fishers are trapped in debt through complex interrelating economic, social and political factors (Nahuelhual et al., 2019), exacerbating a race to fish, and the resultant underreporting of catches. Therefore, proposing different management options should address or help to understand the trade-offs experienced by fishers given these geographical and contextual complexities within the fishery.

Understanding the current legal context for the fishery is an important launch point when looking at future policy options. Economic development in remote parts of the country (the Zonas Extremas, ZEs, such as the Magallanes region), has been enhanced with special policies that provide fiscal incentives for private enterprises and public programs that establish enterprises and settlement of people in the ZEs. In the Magallanes, although fishers may access king crab anywhere throughout the region, various instruments of the ZE policy influence where and how some fishers operate, as special benefits are provided to businesses and communities in the southern part of the Magallanes region. This equates roughly to the area from Porvenir southwards to Isla Navarino. ZE policies have a strong influence on other public policy programs (World Bank, 2005).

2.2 Research design and sample

Mixed methods, an approach combining qualitative and quantitative analysis and data, is based on the assumption that collecting diverse types of data provides a more complete understanding of a research problem than qualitative or quantitative data alone (Creswell, 2014). In this instance, qualitative semi-structured interviews and semi-quantitative questionnaires were used. The semi-quantitative questionnaires included closed and open-ranking questions as part of the interview.

Interviews are well-recognised as a way of discussing attitudes and behaviours that are socially sensitive, that is, topics that participants may not feel comfortable discussing in front of others, and which may have a bearing on the expression of preferences (Fudge, 2018; Simmons & Mehmet, 2018). Interviews can also elicit contextual information that is not possible with closed-question questionnaire surveys (Pascoe et al., 2019). Twenty-two interviews were conducted in May-June 2018 in each of the four provinces of the Magallanes region. Study participants were recruited through three concurrent approaches: invitations were issued to past participants of studies conducted by one of this study's authors (LN); fishing union representatives were contacted with requests to pass invitations on to their members; and direct invitations were given to fishers at landing points called *caletas*. Interviews with processing plant representatives were requested but not accepted.

Interviews were conducted by a Chilean research assistant in Spanish, with the lead author (CS) present. Interviews were typically 1-1.5h in length and were conducted in homes, public libraries, offices and port facilities. Interviews covered a range of discussion topics, with some sections specific to different stakeholders (Sections B, C, D, E, F, [Supplementary Materials 4](#)). Three sections were common to each participant (A, G, H), covering general demographics, experience with fishing, objectives, and preferences for management options. The ranking exercise was the final topic of the interview, and used a modified version of q-sorts (Newing, 2011) to engage participants physically in the ranking exercise: index cards were prepared with images representing each of the seven management options. Respondents were presented with hypothetical objectives and management approaches drawn from relevant legislation and literature. Participants were asked to arrange these cards in order of preference with the lead interviewer probing their responses and the lead author recording the preferences. Respondents were then asked to give reasons for their preferences. This provided insight into respondents' beliefs about how the management approaches might affect achieving these stated objectives.

The twenty-two participants constituted a cross-sectional sample of the general population willing to participate in conversations about fishery management, and whose responses provide a manager with a range of issues to consider (Table 9). A single case study using a small purposive sample is a well-established method for exploring under-researched topics (Fudge, 2018). Despite the small sample size, our sampling strategy allowed for a cross-section of views; however, in some cases, we received only one response for a given category. For the analysis, respondents were categorised firstly into two main interest groups: (1) those directly involved in the fishing industry – such as fishers and traders, noted as Fishery Industry Group, and (2) those conducting or advocating for fisheries management, noted as Fishery Management Group. The categories of each indicator and the number of responses for each category are supplied in Table 9. Categories are exclusive, e.g. levels of boat ownership do not correspond with particular fishing zones or landing ports. Note that under Artisanal fisheries legislation, artisanal fishers can register up to 2 boats; however, where the ZE applies, a fisher can register as a limited liability company (known as EIRL), exempting them from the 2-boat limit. We call such fishers (>2 vessels) entrepreneur fishers. Entrepreneur fishers are involved in multiple aspects of the fishing supply chain, and typically receive corporate benefits from being established as a company under ZE (World Bank, 2005).

Table 9 Differentiation of participants (n=22) into groupings for analysis purposes. Firstly, participants are divided into those directly involved in the fishing industry – such as fishers and traders, noted as Fishery Industry Group, and (2) those conducting or advocating for fisheries management, noted as Fishery Management Group. The fishing industry group is further elaborated into categories such as boat ownership, usual fishing grounds and point of landing. The fishery management group is differentiated into specific occupational types.

Interest Group	Indicators and Categories (no. of respondents)
Fishing Industry Group (13)	Boat Ownership: 0 boats (crew) (1) 1 boat (6) 2 boats (3) >2 boats (3)
	Usual Fishing Grounds: North (5) Central (4) South (4)
	Point of Landing: Magallanes (1) Tierra del Fuego (4) Ultima Esperanza (1) Antarctica Chilena (0) Fishing Zone (7)

Fishery Management Group (9)	Government (5) Conservation NGO (1) Fisheries researcher (3)

2.3 Analytical framework for management preferences study

Two primary questions guide this study: what are the management preferences of centolla fishery stakeholders, and what are the reasons for those preferences? Respondents' preferences for different management options are therefore expressed as a ranking (order of preference), and discursively through the reasons given for their preferences. While the centolla fishery is under reform, no agreement on the way forward for management had yet been reached at the time of this study. Understanding stakeholder responses would help to inform management interventions, which consider respondents' preferences related to access to the fishery, biological limits and monitoring and enforcement practices. Therefore, this study proposes several hypothetical options for management to gain insight into the aspects of management that are most important (preferred) by fishery stakeholders. The options are based on other Chilean fisheries experiences, recommendations from the scientific literature for fisheries managed through size-sex-season restrictions, recommendations from the scientific literature for fisheries subject to illegal fishing (also known as 'IUU' fishing), property-rights based approaches, and ecosystem-based approaches, which are briefly outlined below. Each management option differs in the access rights given to fishers, the monitoring and enforcement requirements to support the system, and the level of biological limits enforced (see Table 22, [Supplementary Materials 4](#)).

1. Seafood certification programs: Certification by third-party programs, such as the Marine Stewardship Council, may help to position the centolla fishery to ensure consistency in price and demand in a highly volatile market, despite the species having high biological fluctuations (Otto, 2006). Third-party certification requires meeting accreditation criteria on a fishery basis (Marine Stewardship Council (MSC), 2014). Linked consumer marketing and education programs can effectively combat illegal catch and trade of king crab (WWF, 2014; Petrossian, Weis, & Pires, 2015). Although not the intended meaning of the management option, some interviewees included European Union and US anti-IUU measures in their ranking exercises related to certification. Both systems include fishers following management rules and traceability to ensure only fish caught within

the rules proceeds to the designated market, they can be considered part of the same management option category.

2. *Territorial User Rights Framework, Marine Management Areas, Community-based Management*: Territorial User Rights Frameworks supply exclusive access rights to a resource. In Chile, the concept is applied not just for traditional custodians, but to groups of artisanal fishers under the legislated Marine Management Area (*AMERB*, in Spanish) framework. Marine Management Areas (MMAs) have been successfully deployed in Chile (Gelcich et al., 2010; Basurto, Gelcich, & Ostrom, 2013a; Gelcich, 2014), although none exist in the Magallanes region to date. A fishing portfolio for the MMA can consist of a range of benthic species outlined in a community management and monitoring plan. The plan must address how community managers plan to meet sustainability objectives outlined in legislation, and is audited by government officials. Nominated areas are self-monitored to exclude outsiders. The underlying idea of the Marine Management Area concept is to reconcile marine protected areas with marine tenure. It addresses many of the limitations of artisanal fisheries, aligns with human-rights approaches for small-scale fisheries and accommodates the principles of ecosystem-based management (Orensanz et al., 2005; Allison et al., 2012; Berkes, 2012; FAO, 2015).
3. *Opening the fishing register (the Registro Pesca Artisanal, RPA)*: The primary function of the RPA is as an effort restriction measure, which limits the number of vessels in the fleet. The centolla fishery is capped at 573 vessels. Opening access to the fishery can address concerns of an aging fishery sector, encourage renewal in the industry and is perceived by the Management Committee as a genuine option for reducing illegal commercial fishing (IUU)¹⁵.
4. *Closures*: Spatial management in the form of marine protected areas has been used in different conservation contexts to protect important spawning or feeding grounds (Cinner et al., 2016). Spatial restrictions could be employed to replenish depleted local populations by protecting females or juveniles in known aggregation areas. They could be utilised on a moratorium or a rotating basis. A broader spatial management approach allows for multiple uses, and protections

¹⁵ Centolla and Centollon Management Committee Meeting, 17 March 2017, <https://www.subpesca.cl/portal/616/w3-propertyvalue-61300.html#collapse03>

across the entire region, such as implementing multi-use protected areas (Rozzi et al., 2007; Pollack, Berghöfer, & Berghöfer, 2008; Porobic et al., 2018).

5. *Total allowable catch (global quota)*: Total allowable catch (TAC) is specifically mentioned as a management strategy in Chilean fisheries legislation (Ministry of Economy, 2013) with a defined set of arrangements presented. Global quota, such as TAC, has been applied to several fisheries in Chile (SUBPESCA, 2019). TAC has been used extensively in fisheries worldwide to curb overharvesting, setting limits in response to population dynamics measures to ensure biological sustainability (Cochrane, 2002; Pascoe et al., 2022).
6. *Individual quota*: Prominently featured in Chilean fisheries legislation, harvest control measures such as individual quota under a TAC are also a common approach in fisheries across the world, promoted for their ability to produce incentives to reduce fishing pressure and ensure access and income stability through property rights, and can promote co-management governance structures (Orensanz et al., 2005; Gutierrez, Hilborn, & Defeo, 2011).
7. *Community quota*: The historical presence and relevance of fishing unions and cooperatives in promoting artisanal fishing are significant in Chile (Gutierrez, Hilborn, & Defeo, 2011). This proposed option borrows from experiences in France, in which a syndicate could be allocated quota from the TAC which could be shared amongst its members under its own allocation rules (Bellanger, Macher, & Guyader, 2016). Self-monitoring would occur within the group to comply with the group limit. It addresses the limitations of small-scale fisheries addressed by Orensanz et al. (2005).

In addition to the proposed management options, preference studies also require information on management objectives (Pascoe & al, 2009; Pascoe et al., 2013; Plaganyi et al., 2013; Pascoe et al., 2014a; van Putten et al., 2015). Formal fisheries management objectives are not yet present in Chilean fisheries management, so potential objectives were derived based on Chilean legislation and generic “triple bottom line” objectives reflecting social, economic, and ecological outcomes from the fisheries management literature. These were adopted by the Centolla and Centollon Management Committee¹⁶. A fourth objective related to implementation was added,

¹⁶ During the meeting of the Management Committee on 17 March 2017, the members agreed to the following general objective: To promote the conservation and sustainable use of the Centolla and

recognising that institutions frequently hold administrative management objectives in addition to sustainability criteria. As such the four hypothetical objectives assessed were:

- *Provide for effective and cost-efficient implementation (Implementation)*
- *Improve social and economic wellbeing of artisanal fishers (Social and economic wellbeing)*
- *Provide for sharing of the resource and reduce conflict amongst artisanal fishers (Reduce conflict)*
- *Ensure biological sustainability of the stock¹⁷. (Biological sustainability)*

Although ranking objectives and management approaches are typically undertaken as separate steps within preference studies (Pascoe et al., 2014a; Pascoe et al., 2019), the two were combined to understand better the connected relationships amongst objectives, management options and preferences. In the first step of the ranking exercise, respondents were asked to rank seven management options for their performance against the four high-level objectives and to explain their ranking. An example of the question is provided below (Table 10). To reduce the chance that respondents would select the first-named management option as the first choice, options were presented in different orders to each respondent.

Centollón resources of the Magallanes and Chilean Antarctica Region, enhancing the social, cultural and economic value.

¹⁷ The original objective areas posed to participants were ‘viabilidad para la implementación, buenos resultados para los Pescadores, buenas relaciones entre los actores de la pesca, buenos resultados para recuperar el stock’ however, respondents frequently asked for further clarification prior to giving their rankings. We modified the explanation of ‘relaciones entre los actores’ as reducing conflict; ‘buenos resultados para los Pescadores’ as improving personal/business; and ‘recuperar el stock’ as biological sustainability of the stock.

Table 10 Ranking template. Participants were asked to rank each of the management options (left-hand column) in order of preference for each of the four hypothetical objectives (Headings used to describe objectives have applied a shortened title). A rank of 1 is the highest preference and 7 is the lowest.

Management options	Implementation	Social and economic wellbeing	Reduce conflict	Biological sustainability
Opening the RPA	[1-7]	[1-7]	[1-7]	[1-7]
Closures	[1-7]	[1-7]	[1-7]	[1-7]
Marine Management Areas	[1-7]	[1-7]	[1-7]	[1-7]
Certification	[1-7]	[1-7]	[1-7]	[1-7]
Total Allowable Catch (Global Quota)	[1-7]	[1-7]	[1-7]	[1-7]
Community Quota	[1-7]	[1-7]	[1-7]	[1-7]
Individual Quota	[1-7]	[1-7]	[1-7]	[1-7]
Reason Given for Ranking Order	[text]	[text]	[text]	[text]

2.4 Coding and analysis

Rank data on preferences were tallied and median scores were calculated for each management option and each objective. Using medians is an effective comparative measure, particularly where outlier data points are likely, and provides a relational point of context to compare and contrast management approaches (D'Ambrosio et al., 2019; Finch, 2022). Rank data are inherently subjective; therefore, median scores provide the most stability in situations when personal biases may contribute to rank assignments (Garcin, Faltings, & Jurca, 2009). The original study included a question that requested participants assign weightings to preferences, in an effort to gauge the magnitude of difference in preferences for management options and not just the order. Respondents were inconsistent in their weightings, reducing the usability of the data and the power of interpretation (Dichmont & Fulton, 2017; Pascoe et al., 2017). Weightings data were therefore removed from the final analysis.

The reasons given for rankings were drawn from the Spanish language audio recordings of the interviews, transcribed by a Chilean research assistant and then translated into English by professional translators in Australia. Themes and salient quotes were compiled in the NVIVO software program (QSR International Pty Ltd., 2018) by a single coder (CS). Responses were first coded deductively (according to the response category such as the four objective areas), and then with an inductive coding

approach to identify themes emerging from the qualitative preference data (see example in Table 11).

A semi-quantitative analysis of inferred reasons based on stakeholder differentiation was used to triangulate the analysis of expressed reasons for preferences.

Table 11 Example of coding Chilean interviews, using the Management Strategy "Closures" as an example.

Implementation		Social and Economic Wellbeing		Reduce Conflict		Biological Sustainability	
quote/reason	Inductive theme	quote/reason	Inductive theme	quote/reason	Inductive theme	quote/reason	Inductive theme
"Who can allocate the catch zones? Do the authorities really know the fishing zones? No studies indicate how many fishers should fit in a zone. The distribution could be done if the zones were understood, with studies" Interview D	Implementation	"because the person with a large vessel can go wherever they want and those of us who have small boats, with an outboard motor, where are we going to go?" Interview H	Fairness	"however, [the level of disadvantage from restricted access] is not that bad because it affects everyone equally. If you prohibit this zone no one will go there, so I as a fisher will lose the opportunity to fish here, the same as the rest. " Interview T	Fairness	"The catch would be concentrated in the more accessible areas. " Interview D "If we can determine which are the recruitment areas, where the females are, I would protect those places; I'd place a territory restriction" Interview I	Biological Sustainability

3. Results

Findings from the analysis are presented against each of the two research questions (what are the management preferences, and what are the reasons for those preferences). The analysis of the management preferences based on the ranking exercises is first presented based on objectives, and then by the management option. Management option preferences are then broken down by stakeholder groups. The approach taken here presents the qualitative and quantitative findings jointly and discusses the findings alongside the results. The joint presentation of results and findings, while unorthodox in the biophysical and quantitative social sciences, is encouraged in mixed methods research to assist both researchers and readers in making meaning of the data and generating new insights (Guetterman, Fetters, & Creswell, 2015).

3.1 What are the management preferences?

Respondents highly support the use of certification in the centolla fishery (Figure 16). Conversely, community quota is nearly universally rejected as a management approach by most respondents. Results for most of the other management approaches tend to be poorly supported, however results are mixed (note wider distributions of scores, see Figure 17) and appear to be connected to different cohorts of respondents (Table 12). For example, the least preferred options within the different categories of the Fishing Industry Group vary greatly, and this occurs across each of the different category groupings.

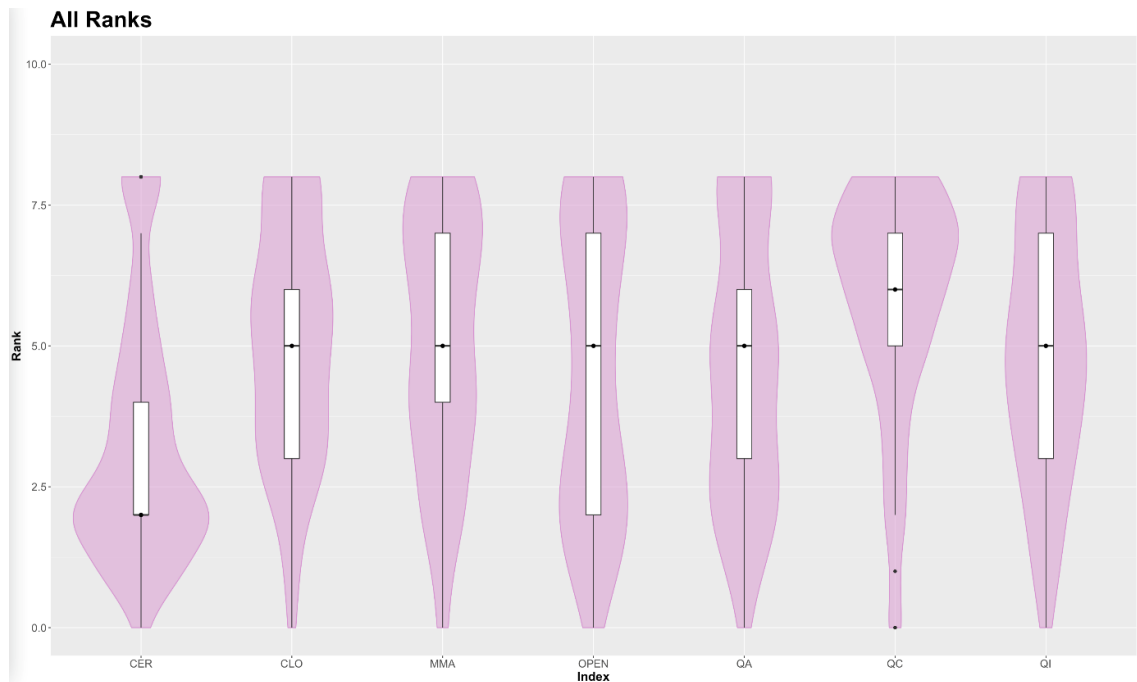


Figure 16 Overall ranks for each of the seven management options. A lower score (rank of 1) indicates the management option is more preferred. CER = certification, CLO = spatial or temporal closures, MMA = marine management areas (community managed), OPEN = open the fishery registry, QA = Total Allowable Catch (global quota), QC = Total Allowable Catch, allocated to community groups, QI = Total Allowable Catch, allocated to individual fishers

Table 12 Summary of responses by each stakeholder category. The number of respondents for each category is indicated in parentheses. Management options listed as more preferred scored between 1-3, and Least preferred scored between 6-8. Weak preference/support (scores between 3-6) indicated with *. MMA = Marine Management Areas (community managed), Open RPA = Open the fishing registry

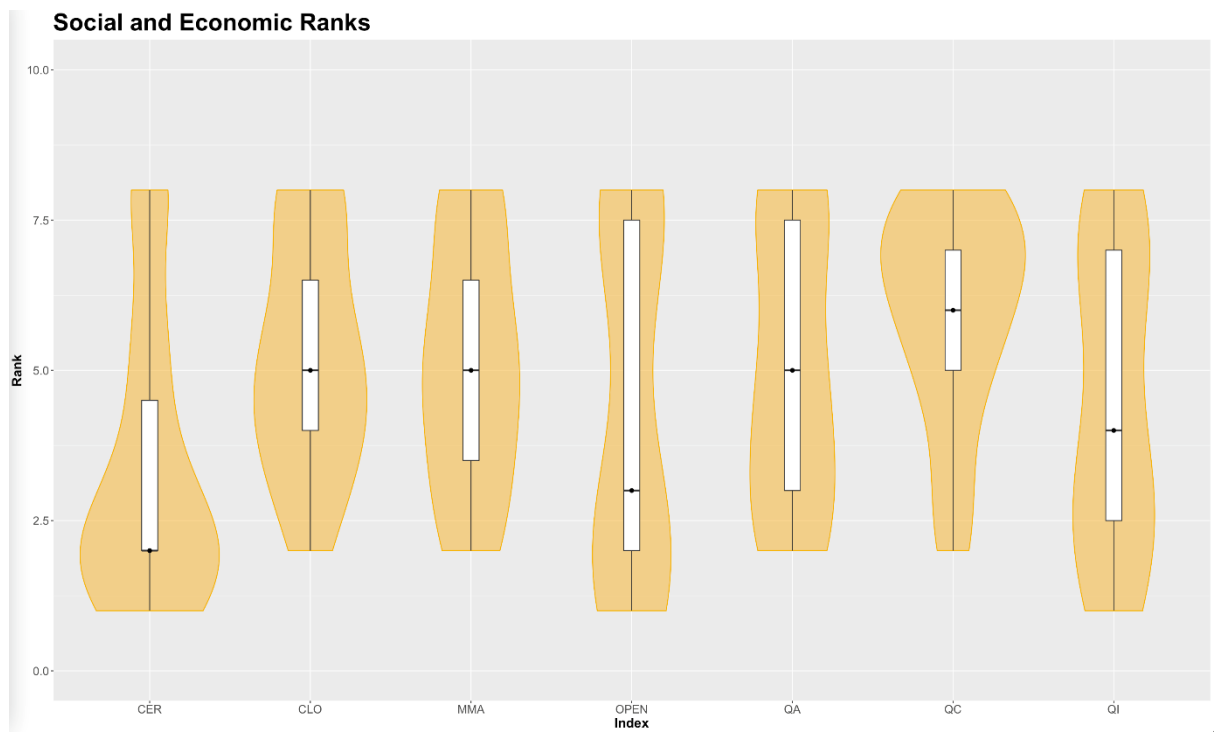
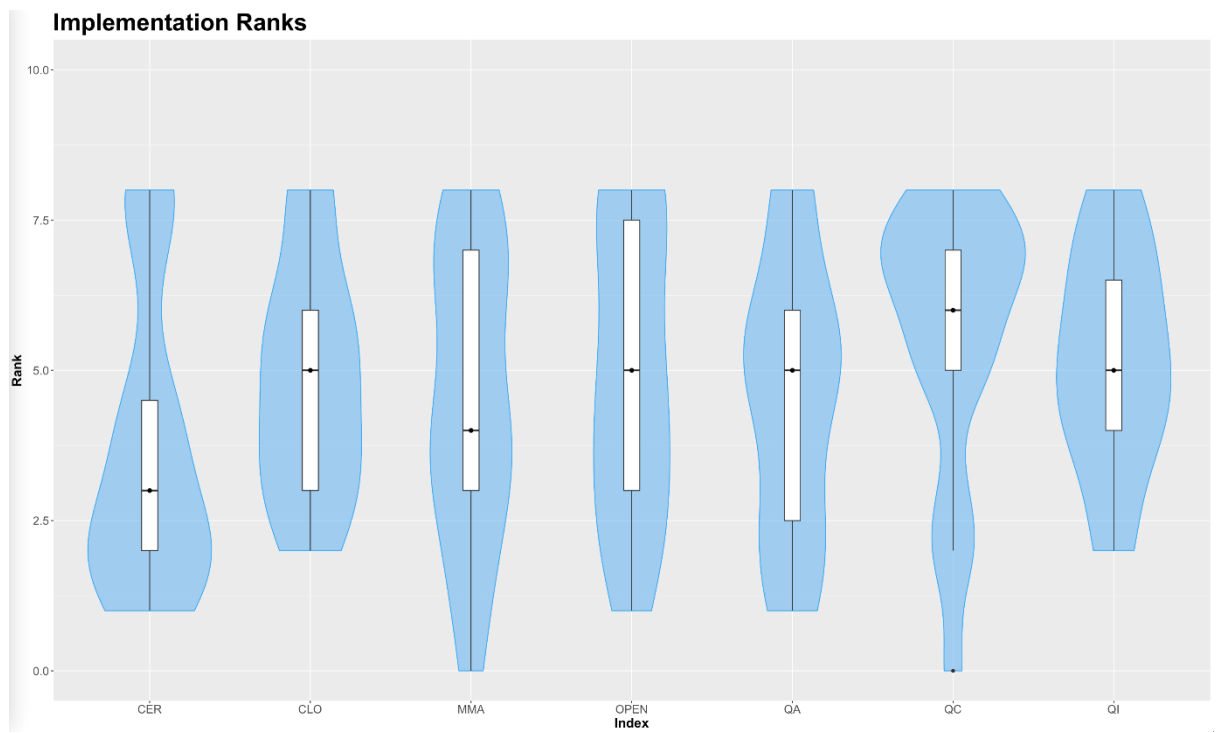
	Stakeholder types (number of responses)	Overall Preference	More preferred options	Less preferred options
Usual Fishing Grounds	Northern zone (5)	Certification	Certification, Open RPA	MMA
	Central zone (4)	Certification	Certification, MMA	Closures, Community Quota
	Southern zone (4)	Certification, Open RPA	Certification, Open RPA	Individual Quota, Community Quota
Boat Ownership	>2 boats (3)	Opening RPA	Open RPA, Certification, Global quota	MMA
	2 boats (3)	Certification, Individual Quota	Certification, Individual Quota	Global quota
	1 boat (6)	Certification	Certification, *MMA	Community Quota
	0 boats (crew) (1)	Open RPA	Open RPA, Global quota	MMA, Community Quota
Point of Landing	At sea (to a transport vessel) (7)	Open RPA	Open RPA, Certification	Community Quota
	Tierra del Fuego (4)	Certification	Certification	Opening RPA*
	Ultima Esperanza (1)	Open RPA	Open RPA, Global quota	MMA
	Magallanes (1)	Certification	Certification, MMA	Open RPA, Global quota, Community Quota, Individual Quota
	Antarctica Chilena (0)	n/a	n/a	n/a
Interest Group - Broad Grouping	Government/researchers (9)	Certification	Certification, Closures	Opening RPA
	Fishers Group (13)	Certification	Certification, Open RPA	Community Quota, *MMA
Interest Group - Narrow Grouping	Artisanal Fisher (11)	Certification	Certification, Open RPA	Community Quota
	Trader (2)	Certification	Certification, Open RPA	Community Quota
	Conservation (1)	Certification	Certification, Open RPA	MMA

	Stakeholder types (number of responses)	Overall Preference	More preferred options	Less preferred options
	Government (5)	Certification	Certification, Closures	Open RPA
	Researcher (3)	Certification	Certification, *MMA, *Closures	Community Quota

A purely quantitative and superficial view of this data would generate a policy recommendation that certification is the overwhelming preference, with opening the RPA as another possible option in line with preferences. However, stopping at this step fails to consider the potential drawbacks of these options, and unintended consequences. We advance our understanding of the data on preferences by going deeper into the reasons for those preferences, with the intent to understand the factors contributing to them. In doing this, reasons will be inferred based on the rankings as expressed through the four objectives, and then reasons for stated preferences from interviews will be presented, disaggregated by stakeholder group.

3.2 Reasons for expressed preferences

Emergent properties of preferences were first revealed through the rankings given for each of the four objective areas. Deconstructing preferences into their component objective areas reveals each management option's perceived strengths and weaknesses (Figure 17, Table 13). Opening the RPA, for example, is perceived by respondents to improve social and economic wellbeing and reduce conflict, but it is weak in ensuring biological sustainability. The majority of the hypothetical management options resulted in poor performance in conflict management, apart from Certification and Opening the RPA, which performed strongly in reducing conflict, and ultimately were ranked highest overall.



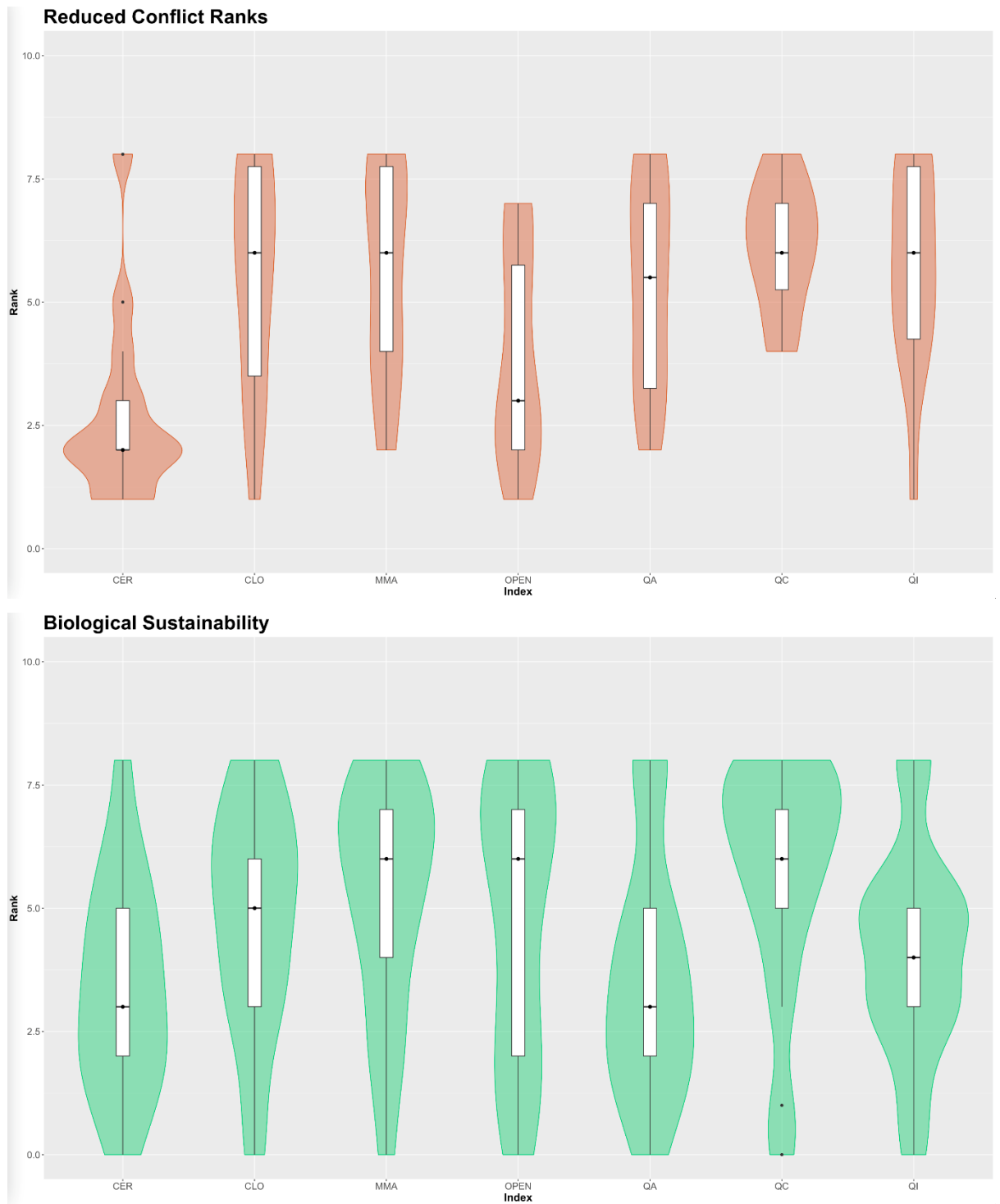


Figure 17 a,b,c,d (top to bottom) Rankings given for the seven management options against each of the four objectives. A lower score (rank of 1) indicates the management option is more preferred. CER = certification, CLO = spatial or temporal closures, MMA = marine management areas (community managed), OPEN = open the fishery registry, QA = Total Allowable Catch (global quota), QC = Total Allowable Catch, allocated to community groups, QI = Total Allowable Catch, allocated to individual fishers

Table 13 Perceived performance of management systems against objectives. Median rank scores across 22 participants are shown in parentheses. Scores of 1 are the highest/most preferred, and indicate the perceived strengths of the given management options. Scores of 7 (the lowest/least preferred) represent perceived weaknesses of the management option. Open RPA = open the fishing registry

Objective	Best option/most preferred	Worst option/least preferred
Social and economic wellbeing	Certification (2) , Open RPA (2)	Community quota (6)
Reduce conflict	Certification (3), Open RPA (3)	Individual quota, Marine Management Area, Community quota (6)
Implementation	Certification (3)	Community quota (6)
Biological sustainability	Individual quota (4)	Marine Management Area, Community quota, Open RPA (6)

Disaggregating rankings by various categories revealed, on the whole, that certification remained the most preferred option and community quota the least preferred (Table 13Table 12). It was surprising that stakeholders were mostly ambivalent to individual and global quotas, given the widespread application of these management approaches in other areas of Chile, and across the globe. The presence of wide distributions of rankings for Marine Management Areas, Time-Area Closures and opening the RPA flags that there are important perspectives that are also not visible through ranking alone (Figure 17). The qualitative analysis of reasons revealed that the most frequently reported reasons for preferring certain management options over others included ideas about 1) fairness to fishers and equity between fishers; 2) environmental sustainability; and 3) decision-making and implementation (Table 14):

*Table 14 Reasons related to different management measures, according to interest groupings.
Management strategies are listed in descending order of overall (aggregated) preference rankings.*

Management Strategies	Characteristics of respondents who support this measure	Reasons for Preference	Reasons for Non-preference
Certification Traceability	All respondents	Fairness: Increased transparency benefits all in accessing international markets Biological sustainability: certification discourages illegal fishing	Unequal accrual of benefits between producers and sellers
open RPA	Fishers with 0 boats (i.e. crew), fishers with more than 2 boats Those who fish in the north and southern zones Fishers who land at sea and at Ultima Esperanza	Fairness: No one should be excluded from working in the fishery Implementation: Easy to implement	Fairness: More fishers results in dividing a limited resource further. Allowing a new entrant reduces the catch of those already registered in the system and contributes to job insecurity. (is the new entrant more deserving than the one already in?) Biological sustainability: resource would be affected by an increase in effort
Individual quota	Fishers with 2 boats Those who fish in the north zone Weakly supported by fishers who land in Ultima Esperanza and Tierra del Fuego	Fairness: Everyone receives the same quota/opportunity to fish	Fairness: Concerns regarding allocation method (by vessel or by an individual, according to typical remuneration practices between owner and crew) and allocation volume (equal division, proportion to historic catch, etc.)
Closures	Managers group Weakly supported by fishers with 2 boats	Fairness: Everyone is excluded from a given area. Biological Sustainability: Provides refuges for king crab, protecting them from fishing	Fairness: the capacity constraints of smaller fishers prevent them from fishing or accessing alternative fishing grounds within their zone; it impinges on access rights to the resource.
Total Allowable Catch	Fishers with 0 boats (i.e. crew), fishers with more than 2 boats Weak support from southern zone fishers Fishers who land in Ultima Esperanza	Fairness: Everyone has access to the resource until the quota is filled; when the quota is filled, everyone is excluded from the resource.	Fairness: many fishers are disadvantaged by geographic location and capacity to catch, unfairly benefiting the largest, most mobile vessels in a race to fish. The efficiency of larger vessels is due in part to

		Biological Sustainability: limits catch to ensure long-term sustainability of the resource	subsidies and other financial support not available to everyone. Therefore the starting point is not the same.
MMA	Managers group Weakly supported by fishers with 1 boat Those who fish in the central zone Fishers who land in Magallanes province	Implementation: legislation already provides for MMAs and coastal exclusion zone for artisanal fishers Fairness: Enables smaller fishers with a proportional advantage to larger fishers who may have access to special development policies.	Fairness: the capacity constraints of smaller fishers prevent them from fishing or accessing alternative fishing grounds within their zone; it impinges on access rights to the resource.
Community quota	Mostly not supported, with some mixed results for and Managers group and those who land in Tierra del Fuego	Implementation: Unions (syndicados) and caletas exist under existing fishery policies, providing the mechanism for common quota	Implementation: Membership of a group "community" is determined by power relationships rather than the location of residency – some fishers may be excluded and disadvantaged by allocation of quota within a "community"

Fairness is a prominent feature in many developing small-scale fishing contexts, such that it forms a key component of the FAO's small-scale fisheries guidelines (FAO, 2015). Perceived deficits in equity or fairness are a common cause of conflict in fisheries (Finkel, Harre, & Lopez, 2001; Fabinyi, Foale, & Macintyre, 2015). The concept of fairness was frequently raised in reasons given for the rankings of management options and was expressed in a variety of ways. Perceptions of fairness related to inequalities of access between larger and smaller-scale fishers affected the management option preference. M, a fisher from Punta Arenas describes how "...the sea, it should not be given to [only] some people, [and] neither [should] the resources." Fairness as a value in accessing the sea and a right to work is evident in the interviews of the majority of respondents, and the management measures that restrict or impede access are often described as unfair. To a lesser degree, biological sustainability and feasibility of implementation were also frequently given as reasons behind preferences.

Respondents across different groups stated that biological sustainability was an important consideration that was lacking in current management, and felt that more could be done to strengthen biological outcomes. Amongst respondents, achieving

biological outcomes was more linked to spatial and output measures like closures and quotas than input measures like effort or gear restrictions. For the most part respondents were not strongly opposed to closures to support biological conservation, possibly because exclusion would apply to all fishery actors. Closures thus align with two of the four objectives by supporting artisanal fishing and sharing the resource. Reasoning behind preferring to 'share the resource' thus seems to be connected to the values of fairness and equality. A spatial management approach which closes and protects a strategic location "isn't that bad because it affects everyone equally. If you prohibit this zone no one will go there, so I as a fisher will lose the opportunity to fish here the same as the rest," says T, a Management respondent. In contrast, despite protecting the stock, catch-share-based solutions such as community and individual quotas were seen to affect fishers unequally, and therefore were less preferred.

Reasons given for particularly low scores were often influenced by respondents' perceptions that particular management options would be difficult to implement. Q, Management respondent explained that "the question of how to implement management, well, that is different from the fact that I think it is a potentially good tool for the resource." In fact, in most cases, the ranking exercise was followed with an extended response related to how none of the measures would be feasible to implement given current capacity constraints and a lack of will to implement effectively on the part of fishery managers. Respondents' primary concern was the monitoring and enforcement required under certain management approaches, and the lack of information available to support the design of certain management options such as total allowable catch. These statements highlight how the objectives, as desired outcomes of the fishery, are closely related to the reasons people give for preferring certain management approaches, including administrative management objectives such as surveillance, enforcement and other forms of monitoring and compliance.

3.2.1 Certification

The reason certification was so overwhelmingly supported is because it had few perceived fairness problems and in fact, was seen to increase fairness. It was also perceived to have benefits in protecting the biological resource and in the product's marketability by promoting the point of origin or highlighting how the fishery might meet biological and social sustainability standards. Vessels over 12m in length are already required to weigh their catch and be issued with a formal landing certificate that is traceable through to the processing plant and export, tracking landings of the larger

vessels and providing important data on the resource. In fact, respondents suggested that extending this standard to all vessels – making smaller vessels do this paperwork as well as the large ones - would increase fairness. This action would also position the fishery to meet international trade requirements to eliminate illegal commercial fishing and protect stocks. The fishery would also benefit from improved access to certain markets. Extending the traceability scheme to smaller vessels was not reported by respondents as an inequitable impost on those vessels.

While respondents mostly agreed that certification seemed fair horizontally across different segments of the fishery, some respondents said certification raised significant fairness concerns vertically along the supply chain. T, a government official, notes "the thing is... what we've studied of MSC type [systems], the party who wins significantly is from the intermediary onwards....the one who generally benefits is the seller of the product. And that's what we need to change. That is, we want to transfer the benefit of the certification to the artisanal fisher." The concern about the distribution of benefits between producer and seller is discussed in other studies related to Chile and the Magallanes region (Giusti, 2008; Mellado et al., 2018; Morales, 2018; Nahuelhual et al., 2019). Another concern, raised by F, a fisher from Tierra del Fuego, is the cost of meeting additional requirements of the certification program. Care is required to minimise any unnecessary administrative burden and reduce the price premium's impact on producers. Evidence from recent research suggests that the concern expressed by Chilean respondents may be premature as MSC certification appears to add value down the market chain, at least in the early days of establishing certification programs (Anderson et al., 2021)

3.2.2 Community quota

Fishers do not fish alone – they require a crew of 3-5 members to set and bring up the traps. Remuneration is via a catch share method, with each participant allocated a portion of the value of the trip's catch according to their role (owner, skipper, crew, etc.) (Morales, 2018). In some ways an active fishing vessel is a small collective, pooling resources and receiving benefits from the collective activity over the 5-month fishing period. Despite this, participants in this study universally rejected the option of community quota – the idea that a collective of some kind would pool an allocation of quota and distribute it amongst themselves. The rejection of this option conflicted with an expectation of the authors that, given the history of union membership combined with the seemingly collective nature of fishing, the situation lends itself strongly to a

community quota. However, contract abuse amongst owners and crew and low trust in unions, as reported by participants in this study, has resulted in low union membership in the region, and perhaps indicates that the collective norm does not prevail in the current situation.

Equally, respondents' answers for community quota revealed that the measure was poorly understood by most participants. During interviews, significant time was required to explain the concept. Ultimately, there was little consensus in their responses on what a likely definition of "community" would be for purposes of a common quota arrangement, and because of the seeming confusion on this, it is not surprising that it was given the last rank in the majority of cases. If quota in some form were to be pursued for this fishery in the future, it might be worth revisiting this idea with fishery participants, as in theory, the idea fits with their current practices, but perhaps the explanation and details around what constitutes a community could be further explored with participants. Community and collective (e.g. producer organisation) quota has been successfully applied across Europe and in Alaskan fisheries. Specifically of note is the development of a range of collaborative options such as cooperatives, community quota funds and risk pools in the West Coast Groundfish Trawl fishery (Russell, Oostenburg, & Vizek, 2018). Key lessons from these collective quota experiences could inform further discussions in the Magallanes, include minimising high start-up costs and facilitating a heterogeneity of views contributing to decisions (National Research Council, 1999; Fanning, 2007)

3.2.3 Marine Management Areas (MMAs), Closures

Because rankings for Marine Management Areas and Time-Area Closures varied substantially among respondents, elucidating the reasons behind the preferences is an important exercise towards informing any future management interventions.

The entire Magallanes region is vast, and king crab occur primarily in remote locations, with limited direct access from settlements. Smaller fishers, like H, a Fisher from Tierra del Fuego, are less able to access the deeper, more productive aggregations located further away, compared to larger vessels. Local management arrangements such as MMAs could overcome existing inequalities in the fishery by providing a benefit to small-medium fishers proportional to that gained by larger enterprises through ZE policies, for example. MMA was seen to be advantageous to fishers in the central region as controlling access to their local area would ensure exclusive access to a productive and reliable resource and reduce competition with fishers from elsewhere.

Time or Area Closures or exclusion from local community MMAs could disadvantage certain fishers in that "the person with a large vessel can go wherever they want and those of us who have small boats, with an outboard motor, where are we going to go?" (M, Punta Arenas). MMAs and Closures by definition restrict access to specified geographic areas. This was seen by some fishers to be unfair in that "a person [should not be] prevented from fishing in x location, you can fish in the whole region. To say that x vessel can only work in [x] sector...I think that's unfair. That wouldn't be good, it would create conflicts amongst fishers." (B, Fisher from Ultima Esperanza). The perceived unfairness of the measure by some cohorts contrasts with the establishment of the concept in legislation, as well as the 1 nm exclusion zone which prohibits non-artisanal fishers from accessing coastal resources. These measures were established expressly to protect artisanal fishers.

Small to medium enterprises (1-2 boats) may also be disadvantaged by virtue of the ZE instruments, which provide tax and business incentives, but only for certain fishers who are fortunate enough to reside within the area where the Navarino Law is in effect (Poblete, 2013). Injustices occur when management measures are seen to exacerbate these inherent inequities, or favour larger enterprises over smaller ones. F, an entrepreneur fisher from Tierra del Fuego, observes "the problem [for fisheries managers] is that some people have small boats, so you need to fight for the people that don't have the same possibilities [the larger operators] have. It's complicated."

Northern and southern fishers dismissed MMAs as an option for them, not because of unfairness but because of implementation issues. Their particular concern was the difficulty in patrolling and keeping others out of MMAs in their zones, which comprise remote islands, fjords and channels (this study; Rozzi et al., 2007). B, a fisher in Ultima Esperanza asks, "For me, it would be good and for the fishery it would also be good, but how do we monitor it? How is implemented?" SERNAPESCA, the country's fisheries regulator, has committed to improved monitoring, surveillance and compliance across the country through electronic surveillance of vessels. If this technology becomes mainstream, it may assist those fishers interested in MMAs to overcome the difficulties of monitoring the areas under their responsibility.

In contrast to the Fishing Industry Group, exclusive measures such as MMA and Closures were more preferred by Manager respondents. The Managers stated that such measures "not only conserve the stock but also conserve the long-term socio-economic system with the king crab." (U, a university-based researcher). Managers did recognise that conservation efforts may impact perceptions of fairness related to access to the

resource and offered suggestions for how closures could be implemented to reduce the impact on fishers. Suggestions included rotational access to areas where king crab occur in high concentrations such as through lotteries, reducing the fishing season, or establishing permanent reserves where the conservation benefit was highest. Issues with implementation (firstly negotiating the locations, then enforcing them) were seen to be currently prohibitive.

3.2.4 Total allowable catch and quota allocations

Total Allowable Catch and associated quota allocations are a common form of harvest control. Views on the total allowable catch (i.e. global quota) and the various iterations for allocating quota varied amongst respondents. Explanations for preferences are therefore illuminating of perceived positive and negative impacts of implementing quota arrangements for the centolla fishery.

Catches of king crab are diminishing from year to year (SUBPESCA, 2018, 2019) and fishers are concerned about reduced catches and how the available stocks can be maximised to their benefit. Because of the societal norm of borrowing capital from money lenders, indebtedness levels are high, and with decreasing catch, repayments are difficult. Therefore, those with two boats are often caught in a trap to race to fish to pay back their loans (Nahuelhual et al., 2019), with diminishing returns and prospects with an ever-diminishing catch. Two-vessel owners' preferences for individual quota speak to a desire for stability and a form of certainty through an individual allocation of a total allowable catch that can provide assurance of catch from year to year.

Individual quotas were not broadly supported, with reasons given related to the perception of its failure in other Chilean fisheries such as hake and Patagonian toothfish, where the sale of shares between artisanal fishers and the industrial sector resulted in the eventual exclusion of artisanal fishers from these fisheries. A, owner of a small vessel in the Punta Arenas area, wanted allocation of quota for "each fisherman, not per vessel. Sometimes there are arrangements on the boat and the agreements [contracts] are abusive, it must be equitable for everyone alike." F, a fisher from Tierra del Fuego, agrees: "[Equal allocation] is good for me, because it's [equitable]...the same for everyone. The fact that someone's smaller doesn't mean they should get less [of an allocation]." However, fishers from the southern zone were not as supportive. Fishers from this area have access to the deepest, most reliable aggregations of larger king crab specimens. S, from Antarctica Chilena, says, "[W]ith a total allowable catch obviously you will have a lower proportion of the catch [compared to the way it is

now], and that means that those who are fishing well or have greater effort, with good boats, good fishing equipment, they will be harmed for the [sake of sharing with the] little ones.”

Entrepreneurial fishers (e.g. those with >3 boats) showed some support for a global quota as means to both curb overfishing and provided a fair means to do so. “The total allowable catch gives everyone the option of catching,” says D, from Ultima Esperanza. In practice, however, the entrepreneur fishers have an advantage over other fishers as larger vessels, enabled by a range of technological advancements, can harvest at a greater rate. Temporal differences in the catchability of king crab across the region mean entrepreneurial fishers could catch all of the quotas at the start of the season, even before some fishers are able to access their local stocks.

Quota allocations such as ITQ are unlikely to provide an assurance of resource protection as exacerbating financial stress with tradeable quota shares makes people less willing to forego catch now for future stock rebuilding. Having said that, biological sustainability is important to many respondents in maintaining their livelihoods (11 of 20 respondents) and they have confidence that this is achievable through some form of restricting catch. In fact, a further option may be available to fishery participants that was not originally presented in the questionnaire. Respondent T indicated that regulating effort could be viable. T suggested that limiting the number of traps per vessel might be favourable because “it generates, upfront, equitable starting conditions.” Allocations of total allowable effort are in use in many fisheries internationally including in co-managed fisheries of Australia, such as the Northern Prawn and Torres Strait Fisheries (AFMA, 2017). It very well may warrant investigating these options further.

3.2.5 Opening RPA

The fishing registry for king crab has been closed for several years, and this impact featured strongly in many respondents’ explanations of their perceptions of this option. King crab are available to fishers according to environmental conditions that vary over the fishing season and across the region's geography. Fishing in different parts of the region exposes fishers to different risks and vulnerabilities related to hazards and fishing conditions, gaps in human resources, and the availability of king crab and its commercial marketability. Those who primarily fish in the more remote northern and southern fishing zones are exposed to rough at-sea conditions, traverse a wide territory and require more technical equipment to harvest. Due to the remoteness of these locations and the cap on the fishing registry, finding qualified local crew is difficult.

Fishers in northern and southern zones supported opening the RPA, opening the registry to allow new entrants, and offering the potential for local and transient workers to participate in the king crab fishery. The crew who do not own vessels, also expressed preferences for opening RPA. The crew are typically transient workers; they are not dependent on the king crab fishery, but because of a current lack of deckhands, are in high demand and gain favourable remuneration. Their preference for opening RPA is no surprise, as allowing more vessels to enter the registry offers more opportunities for crew to participate in the king crab fishery. Opening the RPA is seen to be a fair response to the observed deficit of qualified crewmembers, removing the barriers for younger fishers or migrants to enter fishing, and reducing the number of illegal fishers by making them 'legal'.

Several respondents queried how opening the RPA would interact with any management strategies to curb the current overcapacity in the fishery (IFOP, 2017), citing a perception that the fishery could not sustainably support an increase in fishing pressure. J, a fisheries manager, said they have "mixed feelings about that, because in some way I feel resistance to the closure of access [to new entrants], but... opening it would decrease job security [overall]. And it's also violating, I feel, the [existing] fisher's right to work, who has a historical right because they're registered." Another manager, T, further explains: "[By allowing a new entrant] I'm going to take away from everyone in order to give more to one person. That is, reopening the RPA will obviously be a benefit for the person who comes in, but it will take away from the one who's already inside." For this reason opening the RPA was not preferred by the Management Group of respondents.

Several respondents related their preference for opening RPA to the presence of local landing ports, called caletas. One of the ways Chile supports artisanal fishing is the provision for caletas throughout the region, where fishers can bring their catch and have it transferred to a processing plant. Each province has several caletas, and provisionally, it also has at least one processing plant. As noted earlier, fishing vessels are increasing in size and capacity, capable of travelling further before having to land their catch at local ports. This, together with the consolidation of business in areas under the Navarino Law, has been difficult for many processing plants to remain competitive, and several have closed, resulting in the further consolidation of product coming to a few select locations. This affects the resilience of fishers in remote locations of the region, as it forces them to land or sell product outside of their own province. Most fishers (7 out of 13 respondents) transfer their catch to a registered transport vessel

which eventually transfers to a processing plant. These fishers and those who land directly to a caleta in the northern zone supported opening the RPA, whereas those fishers who land directly to a caleta in the central zone did not. This contrast deserves further investigation by the decision-makers in the fishery as they consider the management options, particularly in how the ZE policies can be addressed if fishery management is to achieve an objective for supporting geographic regions.

4. Discussion

This study contributes insights into stakeholder perceptions about different management interventions for the Chilean centolla fishery. These insights include beliefs about the feasibility and likely impacts of measures, as well as normative perceptions about what kinds of impacts would be (un)fair, and a breakdown of which perceptions are held by which groups among stakeholders. Results of rankings, disaggregated by stakeholder group and reasons show that respondents have a complex set of reasons that underpin preferences related to reducing social and economic vulnerabilities, improving fairness, addressing implementation concerns, and supporting long-term biological outcomes for the king crab fishery.

Stakeholder analysis is an important first step in improving typical approaches to preference studies. Eliciting explanations as reasons reveals the motivations and values behind observed behaviours (Simmons & Mehmet, 2018). Knowing these reasons for preferences helps policymakers and fisheries managers to anticipate stakeholder reactions to proposed interventions, and assist in the design of the management options such that they will be accepted by the fishery participants. It is important to note that this study included representation from some of the stakeholders in this fishery, but did not include other important voices, such as members of the local community, Indigenous communities, and the post-harvest sector. Despite this limitation, the study still yields important understandings of the value of qualitative enquiry alongside typical preference studies. Including this line of enquiry enables researchers and decision makers to interrogate mental models and assumptions that stakeholders have about various management approaches which can be brought to wider discussions and considerations of alternate designs that might provide more equitable outcomes. In particular, the stakeholder analysis, coupled with the qualitative analysis, yields important information on the power imbalances amongst the “smaller” and “larger” fishers and those from the nominated economic development zones, and lack of

equitable representation in decision making fora. Applying principles outlined in the FAO's Voluntary Guidelines for Sustainable Small-scale Fisheries (FAO, 2015), the State should facilitate, train and support small-scale fishing communities to participate in the design, planning and, as appropriate, the implementation of management measures affecting livelihood options. Participatory options, such as co-management should be pursued where possible.

Rankings indicated that Certification was the preferred management strategy, with Opening the RPA (e.g. opening the fishing registry to allow new fishers) a close second preference. However, when interrogating the reasons given for the various management strategy rankings, respondents gave many reasons in opposition to opening the RPA, particularly for its inability to deliver on biological outcomes. It is possible that it rose to the top by virtue of its ability to be enacted easily and quickly. Ultimately, the reasons provided by respondents across each of the management strategies provide evidence that many of the management options could be viable options, provided they could be designed to address social and economic vulnerabilities, based on characteristics related to vessel size, geography, interactions between economic development policies and artisanal fishing, and social contracts. The stated reasons given for preferences show that addressing the biological sustainability of the resources is paramount to most fishers, which shows that accepting Opening the RPA as a highly preferred option could be flawed. The reasons given for preferences also show that the way in which addressing the biological sustainability of the fishery is done must address fairness concerns, and have a reasonable chance of implementation success.

The analysis makes clear that biological objectives cannot be traded off with social concerns, as preference studies are wont to do. In contrast to studies in Australia, Chilean fishery participants' rankings in this study showed a preference for social objectives over biological goals (Pascoe et al., 2013; Pascoe, Plaganyi, & Dichmont, 2017)(Table 13). The definition of success, therefore, should not be how one or the other of these is achieved, but how to make progress in each to achieve win-win situations (Adger et al., 2003; Daw et al., 2015; Bunnefeld, Nicholson, & Milner-Gulland, 2017; Asche et al., 2018). For example, a spatial management approach might be used to protect key breeding areas ensuring ongoing harvests in future seasons. Mitigating the impact on regionally vulnerable fishers might include rotating fishing grounds or access to them via lotteries, or modifying the frequency and duration of the fishing seasons in line with the lifecycle and geographic differences in king crab population dynamics. In some Alaskan fisheries, a quota is allocated by vessel size as

well as geographic location (Pinkerton, 2013). Allocations of total allowable effort are in use in many fisheries internationally including in co-managed fisheries of Australia, such as the Northern Prawn and Torres Strait Fisheries (AFMA, 2017). Further consideration of these examples might be relevant to managers in the southern king crab fishery.

Conceptual and computation models may be helpful to managers as they apply these results and develop bespoke management strategies (Dambacher, Rothlisberg, & Loneragan, 2015; Fulton et al., 2015; Lane, 2020). Models can help to compare results for key concerns across different management scenarios. For this fishery, it would be useful to assess how different management options reduce the impacts of socio-ecological traps linked to a dependence on king crab fisheries (Cinner, 2011; Steneck et al., 2011; Nahuelhual et al., 2019; Eriksson et al., 2021) and how alternative livelihood options might mitigate the effect of the management, which will reduce overcapacity in the fishery (Gelcich et al., 2010; Pomeroy, 2013). It is also important to note that preferences and reasons for them are not static and fishers' behaviour will respond to any newly implemented measures. It may be necessary to review extant arrangements and create new scenarios to determine whether the 'mix' of outcomes is being, or could be, achieved (Bunnefeld, Nicholson, & Milner-Gulland, 2017).

The method used to assess preferences in this study offered depth to a typical quantitative approach, particularly in how it explained more and less preferred options, preferred and rejected options, and differentiated reasons for these determinations across the various decision-makers. The method had some limitations, related to the strength of the respondent's preference and their understanding of the proposed management approach. Our observation was that without clarity around the implementation of a given strategy, respondents did not have enough information to favour nor strongly oppose, resulting in a middle to lower ranking for both global quota and individual quota options. This is not a problem unique to this particular elicitation method (pers comm, Ingrid van Putten, regarding van Putten et al., 2013a; van Putten et al., 2015). In fact, the reasons given against these options help to prompt further discussion on how future iterations of proposed options might better address concerns. Future studies may find it valuable to consider using hypothetical but realistic scenarios to explain the different management options including implementation considerations (costs, allocations, etc) and reduce the ambiguity of the management option and stabilise preferences. Despite this, one of the utilities of preference ranking is to provide a starting point for discussion amongst stakeholders in order to arrive at some consensus

about future options. This step was not taken in this study, but would be an important contribution to developing feasible, bespoke management options that address some of the limitations of the hypothetical examples presented here.

It is also possible that respondents did not give the ranking activity their full attention or were subject to survey fatigue, which may have affected responses. We did attempt to change the order of questions in some of the interviews to compensate for this effect, and it is possible we did not reduce the effect sufficiently. In addition, the ranking exercise appeared much more difficult for participants to complete as we required all seven management options to be ranked sequentially for each criterion. At times, respondents were unable to completely enumerate the options, which may have affected the calculation of results. Further, the scaling method used to produce the rankings may not have been able to capture all the nuances about the scenarios. Other methods, such as paired comparisons or multivariate analysis may yield improved presentation of results. Future research that refines this method and results in improvements for the user would be beneficial for the field.

5. Conclusion and recommendations

This study contributes insights into stakeholder perceptions about the different management interventions for the Chilean centolla fishery, based on a method that combined qualitative responses on reasons to a typical quantitative preference study approach. These insights include beliefs about the feasibility and likely impacts of measures, as well as normative perceptions about what kinds of impacts would be (un)fair, and a breakdown of which perceptions are held by which groups among stakeholders. Results of rankings, disaggregated by stakeholder group and reasons, show that respondents have a complex set of reasons that underpin preferences related to reducing social and economic vulnerabilities, improving fairness, addressing implementation concerns and supporting long-term biological outcomes for the king crab fishery.

Ultimately, the reasons behind the preferences given generate powerful insights that could be applied in reformed management approaches, even reforming some of the management options suggested in this paper. Fishery participants invited managers to consider recognising categories of fishing power and facilitating policies that enable the smaller artisanal fishers opportunities and fishing potential across the region in relation to over-exploitation, climate change and market share, broadening employment patterns across aquaculture, production, and tourism sectors, and the influence of the oligopsony

of buyers on fishing pressure. Future research could revisit preference studies to explore these options in relation to each other, or could expand the scope of work to engage stakeholders in scenarios and modelling to understand trade-offs and compromises. The methods in this study provide a bridge towards improving the consideration of social aspects of fisheries in fisheries management options assessments and preference studies.

Chapter 5

Preliminary insights into reform options for the centolla fishery, Chile: assessing the effectiveness of management options to deliver multiple objectives.

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Abstract

Fisheries managers are learning how to manage fisheries as complex sociological systems, particularly in the case of fisheries reform, where there is opportunity to consider multiple factors in developing new management measures. This chapter presents a second analysis to help stakeholders of the centolla fishery decide among management options, to address overfishing and illegal commercial fishing that threatens the ability to meet legislated objectives for biological stocks and protecting artisanal fisheries.

Qualitative models provide some direction on the relative merit, benefits and disadvantages of the different management options for the centolla-centollon fishery. This approach is particularly appropriate in the early stages of fisheries reform planning when a rapid assessment of the system might reveal the consequences of current or planned management interventions and drivers that may lead to undesirable behavioural responses in the system. The analyses demonstrate that qualitative models can be usefully applied to assist managers in determining courses of action for managing exploited resources such as king crabs. The study reveals inequity deficits amongst artisanal fishers across multiple modelled scenarios, which economic and climate drivers exacerbate. Spatial management, increasing enforcement and initiating a stock enhancement (stocking) program produce desirable results across multiple response domains, i.e. recovering centolla stocks, supporting the artisanal fishing fleet, and reducing illegal fishing. When combined with longer-term disturbances such as climate change, the benefits from initial interventions are not observed. Management may need to consider a broader suite of interventions that are typically outside the remit of technical management levers, such as ecosystem and livelihood approaches, to address the effects of a rapidly depleting resource and maintain legislated objectives that

support artisanal fishers. These models are useful constructs to visualise the likely impacts of certain system arrangements, including subsidies, markets and actors, on achieving sustainability outcomes for subfleets and biological stocks. Managers are encouraged to further elaborate on our heuristics and design alternate models for their responses to climate change and inequity amongst artisanal fishers. Reflecting on these consequences can help inform decisions, particularly as communicating on a set of scenarios can provide opportunities to discuss and develop more options that may suit the situation better.

1. Introduction

Research on the importance of socioecological-based management is growing, particularly in its appreciation for how social and political contexts influence human behaviour and outcomes for management (Adger et al., 2003; Australian Public Service Commission, 2007; Fulton et al., 2011; Cenek & Franklin, 2017; Schlüter, 2017; Stephenson et al., 2018; Gammage & Jarre, 2020; Fulton, 2021; Haas et al., 2022). Taking a systems approach means moving resource-based research beyond the daily, technical levers of management and considering the broader institutions and power structures and behaviour of actors (van Putten et al., 2012; Ernst et al., 2013; Kittinger et al., 2013; McGinnis & Ostrom, 2014; Chuenpagdee & Jentoft, 2015). The challenge for socioecological researchers is in finding tools that sufficiently incorporate data from natural and social systems and in selecting relevant and representative information for decision-making that doesn't overly convolute or complicate the decision and can reflect the connections and knowledge in rigorously structured ways that allow for repeatability (Hall-Arber, Pomeroy, & Conway, 2009; Levin et al., 2009; Cvitanovic, McDonald, & Hobday, 2016; Alexander et al., 2019). Evidence demonstrates that attempts to integrate social dimensions into fisheries management research and practice are still lagging (Weber, Borit, & Aschan, 2019; Estévez & Gelcich, 2021; Fulton, 2021; Stephenson et al., 2021).

Qualitative mathematical models (or qualitative models) provide useful analytical frameworks for drawing together information from multiple sources. These approaches are increasingly being applied to complex socioecological questions (Puccia & Levins, 1985; Levins, 1998; McCann, Marcot, & Ellis, 2006; Dambacher et al., 2007; Aguilera et al., 2011; Vasslides & Jensen, 2017; Raoux et al., 2018; Lane, 2020; Reum et al., 2020; Szymkowiak, Rhodes-Reese, & Kraak, 2021). This is particularly because they elaborate critical information for managers, such as causal connections between the

source of disturbance to a socioecological system and important variables, and which relevant indicator should be monitored (Dambacher et al., 2009; Lane, 2020).

Qualitative models are visual depictions of relationships within a system, allowing for a structured representation of how the system functions. These approaches are accompanied by a mathematical interpretation, providing a rigorous analysis that is readily understandable by scientists and easily translated into a form managers and stakeholders can also engage with. In these models, attention is focused on describing general relationships and trends, which, as Dambacher et al. (2009) note, “fall within the realm of what is practical and achievable in the modelling and monitoring of a complex ecosystem”. (p. 3).

We examined how qualitative models can help support decision-making in complex fishery systems, specifically in how the models compare possible outcomes of management interventions to support the recovery of the centolla (*Lithodes santolla*) and centollon (*Paralomis granulosa*) fishery in Chile. Together, centolla and centollon is a high-value fishery in Chile and is a major contributor to the Magellanes regional economy and Chilean exports (Soza Amigo, 2008; Guerrero, 2016; PROCHILE, 2018). Centolla is an iconic species and a focal point of cultural festivities and gastronomic offerings for tourists. However, it has also been subject to overexploitation and is showing signs of collapse (IFOP, 2017; SUBPESCA, 2019). The pressure for reform in the centolla fishery is situated in a context of high global demand for king crab, accompanied by high market value, high incidence of illegal fishing pressure, and volatility and collapses in other polar and sub-polar king crab populations globally (WWF, 2014; Petrossian, Weis, & Pires, 2015; Molinet et al., 2020; Reum et al., 2020). King crabs, like many austral species, are at risk from thermal and acidification stresses associated with climate change (Yanez et al., 2018b; Molinet et al., 2020) affecting centolla distributions and abundance. Since 2014, centolla and centollon have become the focus of an invigorated species recovery process to find management solutions that will ensure biological sustainability of the stock of both species while also maintaining benefits to artisanal fishers (Ministry of Economy, 2013; Gelcich, 2014). See also the Management Committee determination (Session 4, March 2017, http://comitesdemanejo.cl/wp-content/uploads/2016/01/articles-97379_documento.pdf.)

Literature supporting management interventions for species recovery spans a number of issues relevant to the centolla-centollon fishery, such as size-sex-season fisheries (Orensanz et al., 2005), small-scale fisheries (Chuenpagdee & Jentoft, 2015; FAO, 2015), high-value fisheries subject to illegal fishing (Petrossian, Weis, & Pires,

2015), and local management arrangements in Chile (Bernal et al., 1999; Aburto et al., 2013). So far, solutions for recovering the stock have been limited in how they address sociocultural feedbacks, or climate change-related stresses.

This paper uses qualitative models to provide some direction on the relative merit, benefits and disadvantages of the different management options for the centolla-centollon fishery. This approach is particularly appropriate in the early stages of fisheries reform planning when a rapid assessment of the system might reveal consequences of current or planned management interventions and drivers that may lead to undesirable behavioural responses in the system (Lane, 2020; Reum et al., 2020; Szymkowiak, Rhodes-Reese, & Kraak, 2021). This work expands the research by Reum et al. (2020) on Alaskan king crabs by including the social system and sociocultural perturbations, and extends the work on human dimensions and qualitative models by Szymkowiak, Rhodes-Reese, and Kraak (2021) to compare different interventions on the system. Specifically, this work asks: What are the most effective interventions for achieving multiple outcomes of protecting the stock and preserving small-scale fisheries, and reducing illegal fishing activities? The results are intended to engage managers and others looking for guidance on options for the fishery with possible outcomes of different interventions, in the specific context of this socioecological system¹⁸.

2. Methods

2.1 Representations of the centolla-centollon fishery

We interviewed 22 key informants with fishing experience in the centolla fishery, and from fishery science, conservation and government, to understand the ecological, institutional, social and economic connections in the fishery system, and possible intervention points. We synthesised the diverse understandings of these informants following the interviews with a literature review and created a basic representation of the socioecological system (Figure 18). Details of the recruitment and interview process and literature review are provided in Chapter 4 of this thesis.

¹⁸ Centolla and Centollon Management Committee Meeting, Session 12, September 2018: committee members discuss development of management scenarios.

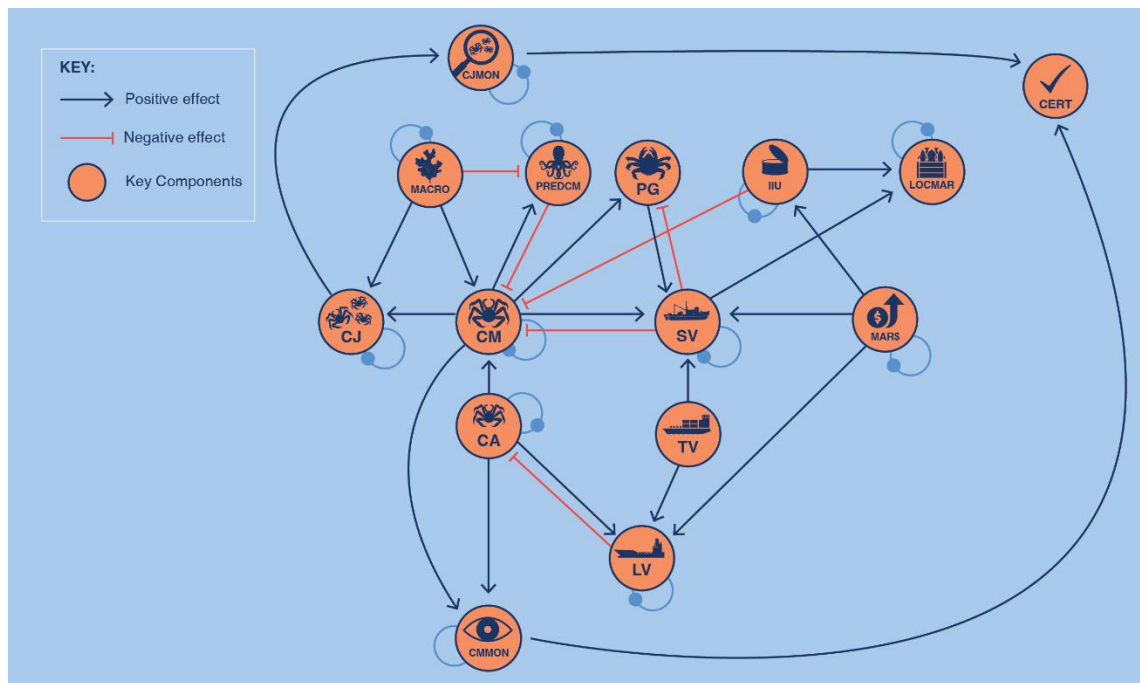


Figure 18 The depiction of the centolla socioecological system, in the form of a signed digraph. CA, CJ, CM refer to Adult, Juvenile and Moulting forms of centolla (*Lithodes santolla*). PG is centollon, *Paralomis granulosa*. SV, LV, and TV refer to small, large and transport vessels, all of which are artisanal fishers. MACRO is *Macrozooids*, PREDCM are predators of centolla. Other aspects of the model include illegal fishing (IIU), market prices (MARS) and certification as authorisation to fish (CERT).

The model represents a basic understanding of the centolla-centollon fishery: seasonal, ambient sea surface temperatures encourage the growth of *Macrozooids* beds (MACRO), which provides protection from predators (PREDCM) in shallow, inshore areas in the summer months for moulting adult centolla (CM), as well as juvenile centolla (CJ) who pod around the holdfasts. Sexually mature centolla (CA) migrate to these shallow areas and return to deep channels after the moulting and mating period. Very little is known about centolla and centollon life histories in the Magallanes region, such as larval settlement patterns, predator-prey relationships during early life stages, migration patterns or site fidelity and ecological relationships between centolla and centollon. Some of these issues came to light during interviews with stakeholders, and some inferences are drawn from research on king crabs elsewhere and information provided through interviews. As such, the models presented are indicative of the current understanding of the system, subject to the provision of more information.

The social components of the system are built around the behaviour (actual and predicted) of fishing actors of the centolla and centollon artisanal fishery, which we divided into three subfleets. The subfleets follow the classification of the sector by Gelcich et al. (2010) and Nahuelhual et al. (2018): (i) smaller extractive vessels

(generally open vessels, < 10 m in length) denoted as SV who primarily target shallow centolla (CM) and centollon (PG); (ii) larger extractive vessels (larger than 12m, with closed cabin and often with hydraulic lift) denoted as LV who primarily target deeper centolla (CA); and (iii) transportation vessels with on-board cold water circulation facilities which are the intermediaries between extractive fishers and landing ports and processing plants, denoted as TV. Available information indicates that centolla are preferentially harvested over centollon, possibly due to distributional differences (see map, *Figure 15*, Chapter 4 of this thesis).

After identifying the core social interactions, the model was expanded further to represent social, political, and institutional interactions. Management actions (MANAG) primarily comprise pre-determined enforcement missions to act upon illegal practices (IUU), including ensuring compliance with season-sex-size fishing regulations. No restriction on effort or catch is imposed. Monitoring (CJMON, CMCAMON), although present, is not connected to management interventions. Economic development policies (INCENT) support artisanal fishers through funding programs to enhance catching capacity and subsidies to TV operators allowing LV to offload more catch. Most catch is exported due to international demand and high market prices (INTDEM, MAR\$, respectively). Local markets (LOCMAR: retail, restaurants, domestic market to other parts of the country) is primarily supplied by illegal fishing activity, which may include unregulated supply by and to registered fishers (Nahuelhual et al., 2018; Nahuelhual et al., 2019).

A qualitative mathematical model represents relationships between actors and their environment through diagrams, called *signed directed graphs*, or signed digraphs (Dambacher et al., 2009). In the digraphs, the different components of the socioecological system are shown as nodes and the direct effects of one component on another are represented by links, which indicate either unidirectional or pairwise effects. The ‘sign’ associated with the link indicates the direction of the effect, which can either be positive (enhancing) or negative (limiting). Full details of the rationale supporting the development of the interactions in the signed digraphs are provided in [Supplementary Materials 5](#) and we direct interested readers to more detailed technical presentations in the literature, such as (Dambacher, Li, & Rossignol, 2002); Dambacher, Li, and Rossignol (2003); (Ortiz & Levins, 2017; Lane, 2020; Reum et al., 2020), Dambacher, Li, and Rossignol (2002), and Dambacher, Rothlisberg, and Loneragan (2015). Our practical goal with the model was not to account for all known variables and interactions within a system but to identify the essential dynamics tailored to the problem at hand (Dambacher

et al., 2009). The approach taken in this study is in line with the structural aspects of minimal realistic modelling (Plagányi, 2007; Plagányi et al., 2011), as the model was constructed with an intermediate level of complexity (Fulton, Smith, & Johnson, 2003).

In the context of fishery reform, various options are available to fishery administrators to meet their objectives. Considerations may include modifying policies and practices, implementing education or incentive programs, or changing the governance arrangements. We developed five additional system models that reflect plausible alternatives for the centolla-centollon system, and reflect different incentives and policies, effort or output restrictions, and differing governance approaches such as central and local management (Table 15, Figure 19-Figure 23). These different system arrangements are compared for their responses to various interventions or disturbances (for details of this analysis, see next section). In particular, we were interested in the responses of particular variables in these scenarios: stocks of centolla and centollon (CM, CA, PG), artisanal fishers (SV and LV) and illegal fishing (IUU). We specifically looked for interventions that could yield positive results simultaneously in at least two of the three variables, indicating the achievement of the multiple objectives articulated in Chilean fisheries law.

Table 15 Rationale for model arrangements.

Alternate Model Number and Short Description	Rationale
5 – Supporting Local Markets	Respondents of a previous study (this thesis, Chapter 4) suggested that the local market is currently unable to supply sufficient product for festivals and local/domestic consumption – as most product is exported and the price is too high. This model represents economic development within the region by strengthening opportunities to supply local markets (restauranters, residents, ex-region but domestic), rather than exclusively supporting an export market. Supporting the local market may also include local cooperatives to improve their business models/diversification/value-add (Giusti, 2008; Valle, Romano, & Kataishi, 2017). Illegal fishing remains a “temptation” but no longer supplies artisanal fishers. The model also represents an incentive structure that reduces illegal fishing operations and illegal products entering the local market.
6 - Certification	Fisheries such as centolla experience high biological fluctuations and can result in a volatile market. Certification, such as programs offered by Marine Stewardship Council, may help to position the centolla fishery to ensure consistency in price and demand, addressing the biological constraints associated with this species (Otto, 2006). To combat some of the problems identified with MSC for Chilean fishers and in Argentine crab fisheries (Pérez-Ramírez, Lluch-Cota, & Lasta, 2012; Pérez-Ramírez et al., 2012; Plotnek et al., 2016) this scenario will combine certification with enforcement settings. This is particularly important in terms of implementing advice from Petrossian, Weis, and Pires (2015) and the WWF (2014) regarding consumer education on catch sustainability to combat illegal catch and trade of king crab. Consumer education exists for southern king crabs through Monterey Bay Aquarium’s Seafood Watch program (Monterey Bay Aquarium, 2017). However, it pertains only to Argentine centolla. In this model, a fishery is certified as ‘sustainable’ based on levels of stock provided by the monitoring program(s). A certified fishery increases international demand for a sustainable product, and promotes high market prices for those artisanal fishers participating in the program. Discerning consumers (tourists, locals and international consumers) are assured the product is sustainable through a certification process ensuring appropriate management and enforcement. Consumers are assured that king crab from southern Chile is ‘sustainably fished’.
7 – Effort or Output Control	Prominently featured in the Chilean Fisheries legislation, catch- or effort-shares are also a common approach in SSF across the world, promoted for their ability to produce incentives to curbing harvesting effort through property rights, and can promote co-management governance structures (Orensanz et al., 2005; Gutierrez, Hilborn, & Defeo, 2011). A quota arrangement aims to reach equilibrium in the fishery, and severs the link between the stock abundance and fishing fleet nodes (Dambacher, Rothlisberg, & Loneragan, 2015). Effort-share has been successful in other fast-growing crustacean fisheries (e.g. Australia’s Northern Prawn Trawl Fisheries) and maintains the Chilean government’s commitment to artisanal access to the resource. Participants in a previous study proposed a cap on the number of traps per vessel (this thesis, Chapter 4), and initial work by IFOP has explored this (June 2017 Committee meeting), with a proposal to hard-cap 300 traps per vessel. We explore the hard-cap as part of this structure and arrangement.

Alternate Model Number and Short Description	Rationale
	In this model, management is continuously informed on stock levels to set relevant controls (either effort or output/quota). When the market price is high, additional enforcement activity occurs to ensure compliance with regulations (limiting artisanal fishing). Illegal fishing remains a temptation but is not significantly attached to the model.
8 – Effort or Output Control with redirected incentives to improve management	The “Zonas Extremas” (ZE) policy provides specific incentives to businesses that establish themselves in particular areas of the Magallanes to encourage regional development, and primarily benefits higher-capacity artisanal fishers. The detrimental effects of the policy have been noted by the World Bank and others (World Bank, 2005; Giusti, 2008). This model however explores the possibility of extinguishing the ZE policy altogether, where it redirects policies to increase the capacity and strength of fishery managers to suppress effort, i.e. Management restricts fishers when monitoring gives information on low stock. Management actively targets illegal fishing activities. This policy change is combined with the effort/output controls described in Model 7.
9 – Community managed fisheries	It is believed that rights-based management strategies, such as customary marine tenure systems, community-based resource management approaches, territorial use rights, and other similar models that assign rights to fishermen or fishing associations are more successful in sustainably managing resources (Ruddle, Hviding, & Johannes, 1992; Govan, Tawake, & Tabunakawai, 2006; Allison et al., 2012). Castilla and Defeo in Gelcich et al. (2010) define co-management as the “formal participation of fishers in the formulation, planning and surveillance of management measures”. Within this context, co-management is considered to be key in mitigating the conflicts that lead to overexploitation, and has proven to be a successful management strategy for coastal fisheries in some countries.” Territorial User Rights Frameworks supply exclusive access rights to a resource. In Chile, the concept is applied not just to traditional custodians, but to groups of artisanal fishers under an instrument enacted under the Fisheries and Aquaculture legislation, called Áreas de Manejo y Explotación de Recursos Bentónicos (AMERB). AMERBs have been successfully deployed in Chile (Gelcich et al., 2010; Basurto, Gelcich, & Ostrom, 2013b; Gelcich, 2014), although none exist in the Magallanes region to date. The underlying idea of the AMERB concept is to conciliate marine protected areas with marine tenure. Managing an AMERB in a profitable way implies that the generated turnover, subtracting all involved costs, leaves enough to provide sufficient income for all participating fishers over time. The costs fishers must bear comprise the annual charges for the marine concession. These depend on the size of the area and cost of monitoring, which is part of annual reporting requirements, enforcement costs, transaction costs incurred by the internal decision-making process, and finally opportunity costs due to harvest restrictions and restrictions on other uses (Pollack, Berghöfer, & Berghöfer, 2008; Gelcich, 2014). It relies on groups self-organising and nominating a particular area for management, and typically involves sedentary benthic resources. It addresses many of the limitations of season-sex-size fisheries, and aligns with human-rights approaches for small-scale fisheries (Orensanz et al., 2005; Allison et al., 2012; FAO, 2015). In this approach, illegal fishing becomes socially unacceptable. This model presumes there are some parts of the region under local management. Local managers control access to the stock and the level of fishing effort within their inshore area. We assume that fishing reserves and local management areas do not co-occur.

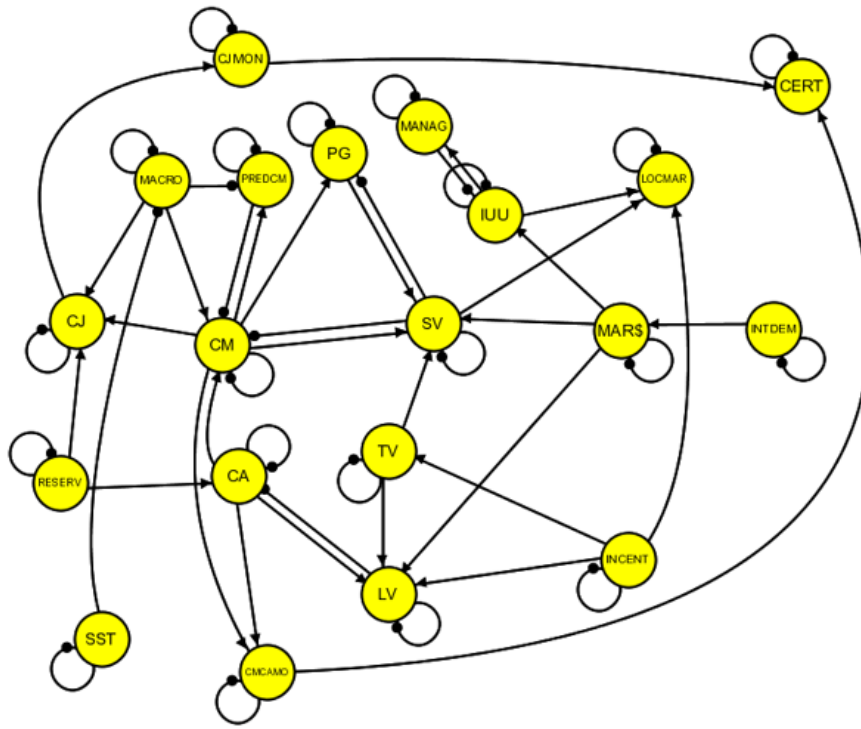


Figure 19 Model 5 Represents an opportunity to 'open' the fishing registry so that illegal fishers become legal; provides incentives to encourage local markets.

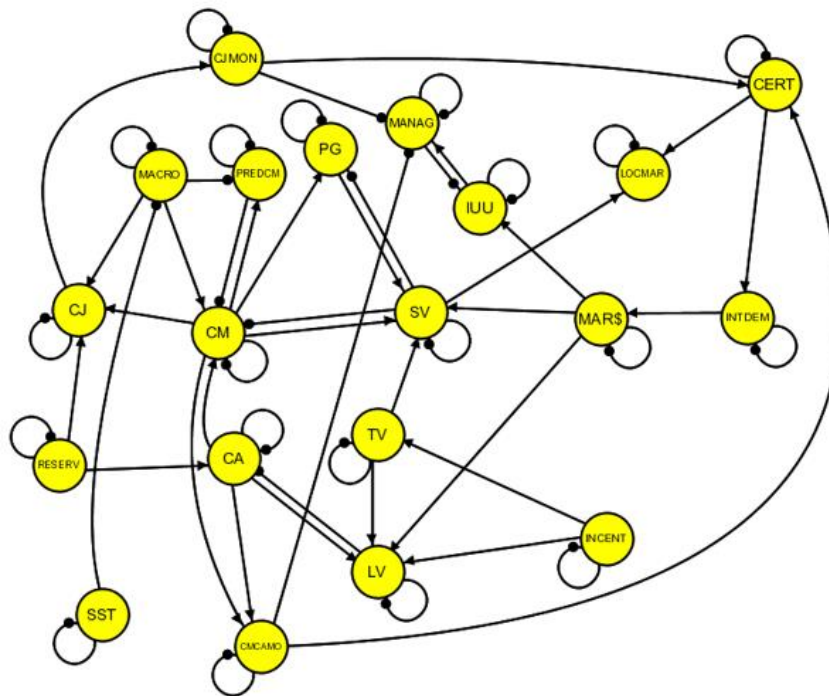


Figure 20 Model 6 Assumes an external certification program is used to monitor and certify the fishery, and inform discerning consumers who only purchase a certified product.

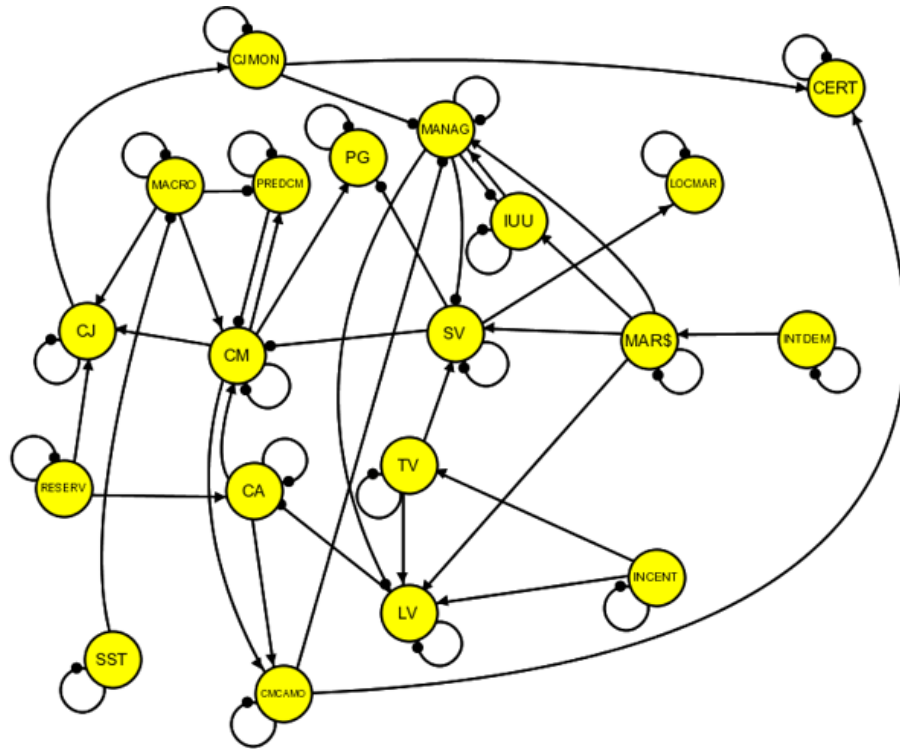


Figure 21 Model 7 Effort or Output Control measures, where strict harvest limits are imposed and enforced.

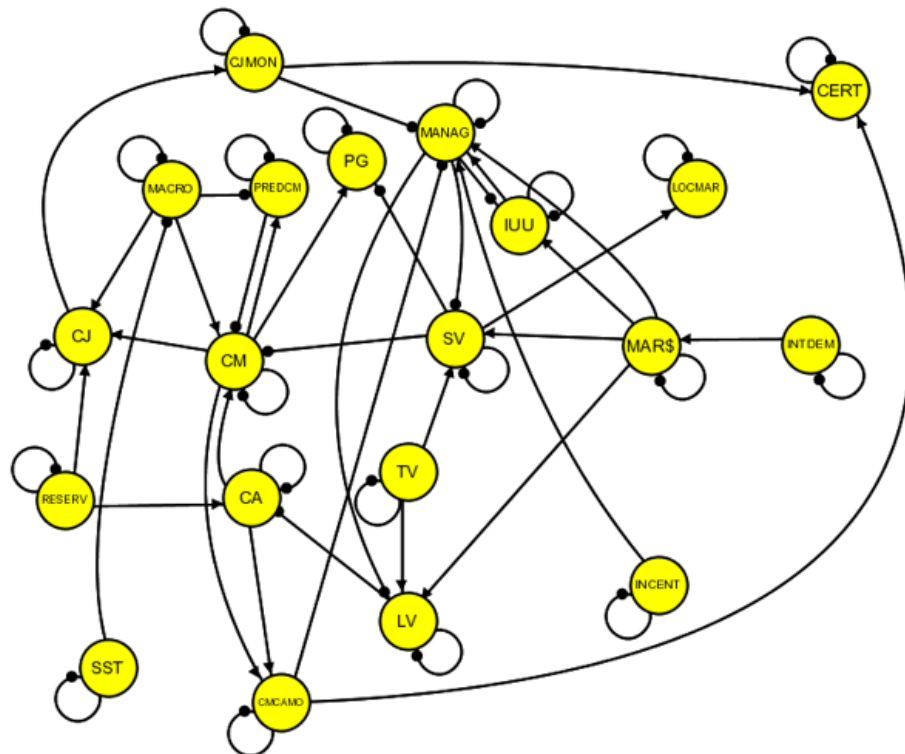


Figure 22 Model 8 Effort or Output Control with a modified incentive structure to rebuild and maintain the stock and enable improved management.

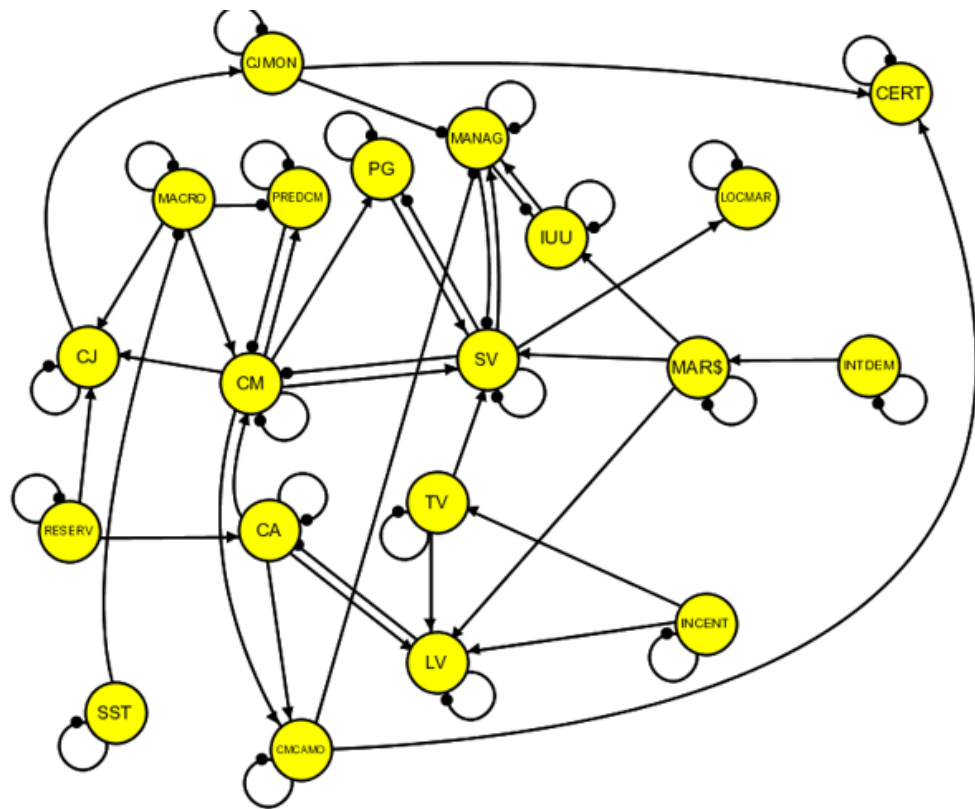


Figure 23 Model 9 Local Management where illegal fishing is not socially acceptable.

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2.2 Perturbation scenarios

We compared the responses of the centolla-centollon system to individual and combinations of short, medium and long-term disturbances across environmental, management and policy categories (*Figure 24*).

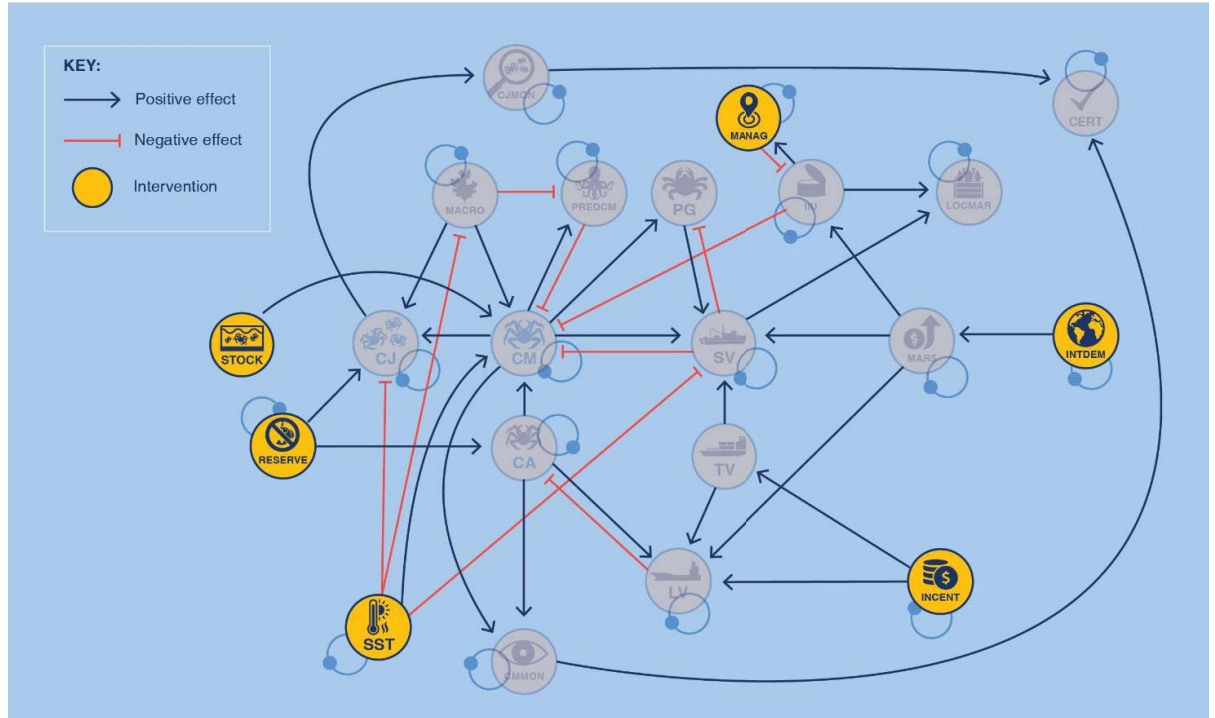


Figure 24 Six individual perturbations (interventions) were tested: Stocking (STOCK in the diagram, noted as CM in the models), Reserves (RESERV), Ocean warming (SST), Increased incentives (INCENT), Increased demand (INTDEM) and Improved Management (MANAG). Three additional perturbations combined these interventions in different ways.

Nine perturbation scenarios were developed through responses from interviews and supplemented with relevant literature (Table 16). The first three perturbations focus on stock recovery:

1. initiate a stocking program of mature centolla, releasing into the shallow inshore areas.
2. implement a reserve or system of time-area closures where fishing for mature centolla is prohibited. The node RESERV was added to the model to represent this scenario and linked positively to juvenile centolla and deeper centolla (CA).
3. enhance surveillance, control and enforcement (MANAG) such that illegal and regulated fishing activity is more closely monitored, and management activities are responsive to information gained from biological monitoring.

We assumed that monitoring centolla combined with direct control measures of fishery subfleets (SV, LV, TV) and illegal fishing (IUU) would reduce exploitation pressure. We have not explicitly linked MANAG to larger fishing vessels. However, the presence of the transponder policy confirms compliance with an

existing boundary condition disallowing a link between large vessels and shallow centolla, according to legislation that prevents large vessels from fishing within the coastal edge (1nm from the coastline).

Climate effects from ocean warming were considered as an individual perturbation and combined with other interventions. We assumed that adverse effects of ocean warming indirectly affect centolla and centollon by reducing the presence and quality of *Macrocystis* sp, a known habitat for juvenile and adult centolla who have migrated to the shallows to mate or moult. To represent this scenario, the node SST was added to the model. The impacts of ocean warming are not certain either in the literature or amongst interview participants – we therefore tested a variety of alternate links and effects (see the Sensitivity Tests section below).

The fifth and sixth perturbations focus on policy and market drivers: redirecting economic subsidies and incentives, and sustained international demand. Perturbations seven through nine combine climate, management control measures and various other interventions to understand the impacts of synchronous interventions.

Table 16 Descriptions of perturbations on the centolla socioecological system. Note perturbations are listed in the order presented in the analysis/results.

Perturbation Category	Timeframe for perturbation to take effect	Perturbation (node pressed)	Description/Rationale
Management and Enhancement	Medium to Long term	Initiating a stocking program (+CM)	Advances in stock enhancement via the release of hatchery-reared juveniles and at-sea stocking have the potential for centolla (Lovrich & Tapella, 2006; Stevens, 2006; Sotelano et al., 2018; Sacristán et al., 2019; Sacristan et al., 2020).
	Medium to Long term	Increased coverage of reserves or frequency/patterns of closures (+RESERVE)	Reserves are demonstrated to positively protect vulnerable life stages of stocks. Establishing permanent reserves or specific time-area closures may benefit the stock of centolla and also contribute to a wider ecosystem-based management approach (Rozzi et al., 2007; Pollack, Berghöfer, & Berghöfer, 2008; Vila et al., 2015; Porobic et al., 2018; Bozzeda, Marín, & Nahuelhual, 2019).
	Short term	Enhanced fishery management, e.g. monitoring, control and surveillance	Monitoring the system for illegal fishing (e.g. at sea or via technology) detects and controls both illegal and regulated harvesting activity.

		(+MANAG)	
Environmental	Medium to Long term	Climate change, specifically increasing sea surface temperature (+SST)	The coastal waters of Chile are already experiencing the effects of climate change, such as increasing sea surface temperature, on the presence and quality of <i>Macrocystis</i> sp. (Yanez et al., 2018a; Iriarte et al., 2019). Climate change will likely alter biophysical and socioecological systems, such as the centolla fishery.
Policy	Short to Medium term	The direction of incentive structures (+INCENT)	Incentive structures under the Zonas Extremas policies encourage overcapacity and increase effort, affecting the sustainability of the king crab stock. These incentive structures are only available to businesses in particular areas of the region and require the product to be exported internationally. Demand could be redirected with incentives for other markets.
Market	Medium term	Sustained international demand (+INTDEM)	International demand drives centolla market prices. Demand can change as a result of international trade requirements (such as requirements by the European Union for traceability) and consumer-based sustainable seafood programs. However, demand can also diminish due to international disruptions such as the recent COVID-19 pandemic, or changes in incentives for other markets.
Combined Scenarios	Medium - Longer term	SP1- A simultaneous combination of drivers and interventions that includes SST, MANAGE, INTERNATIONAL DEMAND	A suite of mid-to-longer term perturbations including increased sea surface temperature due to climate change, increased monitoring, control and surveillance, and sustained international demand controlling harvest decisions.
	Medium - Longer term	SP2 – A simultaneous combination of drivers and interventions that includes SST, MANAGE, RESERVES	A suite of mid-to-longer term perturbations including increased sea surface temperature due to climate change, increased monitoring, control and surveillance, and reserves protecting

			breeding stock, genetic pools and/or mature individuals.
	Medium - Longer term	SP3 – A simultaneous combination of drivers and interventions that includes SST, MANAGE, STOCKING	A suite of mid-to-longer term perturbations including increased sea surface temperature due to climate change, increased monitoring, control and surveillance, and enhancement through stocking.

Signed digraphs (e.g. the systems models) correspond to a community matrix, which encapsulates all the pairwise interactions between variables in the system through a set of numerals (Dambacher, Li, & Rossignol, 2002). Analysis of the perturbation consists of checking how the effect of an input or change in a variable impacts the state of another variable. For each press perturbation scenario, the predicted sign or direction of response for system variables was assessed for its probability of sign determinacy (Table 17). Based on the number of positive or negatively signed pathways that connect the source of perturbation to another variable through the pairwise comparisons, a qualitative response prediction is made: where all pathways (links) leading to a response variable have the same sign then the response prediction is completely determined as a positive or negative effect. Outcomes with 60-80% and >80% signed agreements were considered possible (weak) and high signed agreements, respectively. Positive predictions are shown in blue and negative are shown in red. The response sign is ambiguous where there are both positive and negative signed pathways (Dambacher, Li, & Rossignol, 2003; Dambacher et al., 2003). Outcomes <60% were considered ambiguous (shown in yellow). Alternatively, when there are no pathways leading to a variable from the source of input then there is a completely determined response prediction of no change or zero (responses coloured in white).

As per Dambacher, Li, and Rossignol (2002) we used Maple program commands for qualitative and symbolic analysis of the community matrix and the use of PowerPlay greatly facilitated the creation and manipulation of community matrices, especially for large and complex systems, thus reducing transcription errors common to matrix editing. Following the basic protocol (Dambacher, Rothlisberg, & Loneragan, 2015; Reum et al., 2020) the community matrix resulting from the digraph was checked against system stability criteria (Dambacher et al., 2003) and as the models were stable no more modification was necessary and the press perturbation was calculated.

2.3 Sensitivity tests

Some interviewees differed in their understanding of interactions amongst model components (e.g. uncertain effects between system variables). This was dealt with by exploring and comparing a number of alternative model arrangements (e.g. different links between nodes), which focused on the responsiveness of illegal fishing to compliance, interactions between vessels and enforcement and surveillance management activities, the effects of increased sea surface temperature due to climate change on different system components, the stability of the fishery, effects of biological monitoring, and differences in governance arrangements (see Table 24, [Supplementary Materials 5](#)). The results of the sensitivity tests are integrated as relevant into the Results and Discussion section below.

3. Results and Discussion

Overall, none of the various system arrangements produced simultaneous positive outcomes in the response variables under any of the scenarios (see Table 17). However, the scenarios that consistently predicted positive outcomes in at least two of the target response variables comprise enhanced management control measures, establishing reserves and introducing stocking programs. That is, these three management interventions “guarantee” a positive response in centolla and artisanal fishers even under different system arrangements, despite each reflecting disparate biophysical and sociopolitical realities. Nonetheless, when climate change is considered, the only scenario which produced mutual benefits for biological and social components of the system was SP2 (Reserves), which predicted positive effects in deep centolla and large vessels but only when combined with certain system arrangements that support local markets and management.

The overall results highlight the consequences for the continuation of smaller artisanal fleets in the fishery. Most predictions show a reduction in centolla and a decrease in small vessels. This is likely a result of several concurrent drivers:

- i. Over-exploitation of centolla in the shallower, more accessible parts of the ecosystem, with a significant reduction in abundance. Lower catch rates reduce the efficacy of smaller vessels and increase costs, which may cause artisanal fishers with smaller vessels to exit the fishery.
- ii. Small illegal vessels compete with registered artisanal fishers for diminishing resources.

iii. Incentives to industrialise the fishery promote investing in larger vessels to access remaining aggregations of centolla (resulting in fishing deeper, and further away).

iv. Ocean warming due to climate change produces thermal stress in centolla, causing a reduction in fecundity, death, or migration to deeper water which is less accessible to artisanal fishers with smaller vessels.

Results of the scenarios are explored in more detail below, first for business-as-usual, and then for the alternative scenarios. We then discuss the results related to various sensitivity analyses, including governance arrangements. Note that discussion will be presented alongside the results, as is the custom for qualitative and mixed-methods studies, because it improves the reader's ability to make sense of the findings (Burnard, 2004; Burnard et al., 2008; Guetterman, Fetters, & Creswell, 2015).

Table 17 Predictions for selected response variables to perturbation scenarios. Blue indicates a positive response, red/pink indicates negative response, yellow is ambiguous and white is no response.

Model 1	Status Normal								
Response variables	Input variables								
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto
Shallow Centolla	Blue	Red	Red	Red	Blue	Blue	Pink	Yellow	Yellow
Small Vessel	Blue	Red	Yellow	Yellow	Blue	Yellow	Pink	Pink	Pink
Deep Centolla			Red	Red	Blue		Red	Blue	
Large Vessel			Blue	Blue	Blue		Blue	Blue	
Transport Vessel			Blue						
Illegal Fishing				Blue		Red	Yellow	Red	Red
Centollon	Yellow		Pink	Pink	Yellow	Blue	Pink	Blue	Blue
Model 2'	Business as usual								
Response variables	Input variables								
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto
Shallow Centolla	Blue	Red	Red	Red	Blue	Blue	Pink	Pink	Yellow
Small Vessel	Blue	Red	Yellow	Yellow	Blue		Pink	Pink	Yellow
Deep Centolla			Red	Red	Blue		Red	Blue	
Large Vessel			Blue	Blue	Blue		Blue	Blue	
Transport Vessel			Blue						
Illegal Fishing				Blue		Red	Yellow	Red	Red
Centollon	Yellow		Pink	Pink	Yellow	Yellow	Pink	Yellow	Yellow
Model 3	Uncertain SST effects								
Response variables	Input variables								
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto
Shallow Centolla	Blue	Yellow	Red	Red	Blue	Blue	Pink	Yellow	Blue
Small Vessel	Blue	Pink	Yellow	Yellow	Blue	Blue	Pink	Pink	Yellow
Deep Centolla			Red	Red	Blue		Red	Blue	
Large Vessel			Blue	Blue	Blue		Blue	Blue	
Transport Vessel			Blue						
Illegal Fishing				Blue		Red	Yellow	Red	Red
Centollon	Yellow	Blue	Pink	Pink	Yellow	Yellow	Yellow	Blue	Blue
Model 4	Hyperstable fishery								
Response variables	Input variables								
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto
Shallow Centolla	Blue	Red	Red	Red	Blue	Blue	Pink	Pink	Yellow
Small Vessel	Blue	Red	Pink	Pink	Blue	Blue	Pink	Pink	Yellow
Deep Centolla			Pink	Pink	Blue		Pink	Blue	
Large Vessel			Blue	Blue	Blue		Blue	Blue	
Transport Vessel			Blue						
Illegal Fishing				Blue		Pink	Yellow	Pink	Pink
Centollon	Yellow		Pink	Pink	Yellow	Yellow	Yellow	Yellow	Yellow

Model 5	Supporting local markets									
Response variables	Input variables									
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto	
Shallow Centolla										
Small Vessel										
Deep Centolla										
Large Vessel										
Transport Vessel										
Illegal Fishing										
Centollon										

Model 6	Certification									
Response variables	Input variables									
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto	
Shallow Centolla										
Small Vessel										
Deep Centolla										
Large Vessel										
Transport Vessel										
Illegal Fishing										
Centollon										

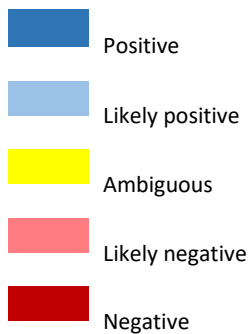
Model 7	Effort or Output Control									
Response variables	Input variables									
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto	
Shallow Centolla										
Small Vessel										
Deep Centolla										
Large Vessel										
Transport Vessel										
Illegal Fishing										
Centollon										

Model 8	Effort or Output Control + Modified incentives									
Response variables	Input variables									
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto	
Shallow Centolla										
Small Vessel										
Deep Centolla										
Large Vessel										
Transport Vessel										
Illegal Fishing										
Centollon										

Model 9	Local (community) management								
Response variables	Input variables								
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto
Shallow Centolla	Positive	Likely negative	Likely negative	Likely negative	Likely positive	Positive	Likely negative	Likely negative	Likely negative
Small Vessel	Positive	Negative	Likely negative	Likely negative	Positive	Negative	Likely negative	Likely negative	Likely negative
Deep Centolla			Negative	Negative	Positive		Negative	Positive	
Large Vessel			Positive	Positive	Positive		Positive	Positive	
Transport Vessel			Positive						
Illegal Fishing	Likely positive	Likely negative	Likely negative	Ambiguous	Likely positive	Negative	Likely negative	Likely negative	Likely negative
Centollon	Ambiguous	Likely positive	Ambiguous	Ambiguous	Likely negative	Positive	Likely positive	Ambiguous	Likely positive

Model 10	Effort or Output Control + Biological Monitoring								
Response variables	Input variables								
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto
Shallow Centolla	Positive	Negative	Likely negative	Ambiguous	Likely positive	Positive	Likely negative	Likely negative	Ambiguous
Small Vessel	Positive	Negative	Ambiguous	Ambiguous	Positive	Negative	Likely negative	Ambiguous	Likely negative
Deep Centolla	Negative	Positive	Likely negative		Positive	Positive	Likely positive	Positive	Likely positive
Large Vessel	Positive	Negative	Likely positive	Ambiguous	Positive	Negative	Likely negative	Ambiguous	Likely negative
Transport Vessel			Positive						
Illegal Fishing	Positive	Negative	Negative	Ambiguous	Positive	Negative	Likely negative	Ambiguous	Likely negative
Centollon	Likely positive	Likely negative	Likely negative	Ambiguous	Likely negative	Positive	Ambiguous	Ambiguous	Ambiguous

Model 11	Effort or Output Control + Modified Incentives + Biological Monitoring								
Response variables	Input variables								
	Stocking	SST	Incentive	Int Demand	Reserves	Mgmt	SP1-Dem	SP2-Res	SP3-Sto
Shallow Centolla	Positive	Negative	Positive	Ambiguous	Likely positive	Positive	Likely negative	Likely negative	Ambiguous
Small Vessel	Positive	Negative	Negative	Ambiguous	Positive	Negative	Likely negative	Ambiguous	Likely negative
Deep Centolla	Negative	Positive	Positive	Ambiguous	Positive	Positive	Likely positive	Positive	Likely positive
Large Vessel	Positive	Negative	Negative	Ambiguous	Positive	Negative	Likely negative	Ambiguous	Likely negative
Transport Vessel									
Illegal Fishing	Positive	Negative	Negative	Ambiguous	Positive	Negative	Likely negative	Ambiguous	Likely negative
Centollon	Likely positive	Likely negative	Positive	Ambiguous	Likely negative	Positive	Ambiguous	Ambiguous	Ambiguous



3.1 Business-as-usual

Business-as-usual reflects a management approach whereby system arrangements are minimally altered, and management focusses on ‘tweaking’ existing programs. For this study, business-as-usual represents a current (circa 2018) understanding of the socioecological interactions in the centolla and centollon fishery, including incentive structures and levels of international demand. Under a business-as-usual system arrangement, improving management control measures such as surveillance and enforcement was the best-performing scenario (Table 17, Model 2). This intervention predicted benefits for shallow centolla and small vessels, and reduced illegal fishing pressures. Reserves and Stocking also performed well, but did not predict a decrease in illegal fishing, which is a primary objective of the fishery.

Current management practice requires the largest artisanal fishing vessels (>12m) to be fitted with electronic monitoring systems. An improved management control approach might require all artisanal fishing vessels to be so fitted, and may also consider implementing a standardised electronic log book system to track landing transactions, as has been initiated in other geographically dispersed, small-scale fisheries in the Pacific using mobile phones or tablet applications¹⁹ (Andrew et al., 2020). Blockchain is an emerging practice that has promise, particularly as it prevents illegal catches from getting to markets (Blaha & Katafono, 2020).

Enhanced management practices clearly would have benefits for the fishery, and yet may struggle to compensate for the combined effects of climate change (specifically, ocean warming) and strong demand that promotes overfishing. For example, in most scenarios, large vessels are able to maintain positive effects. However, caution should be applied: the stability in the results for large vessels may be a consequence of fishers targeting known centolla-centollon aggregations to ensure a high catch-per-unit effort (CPUE) (see Figure 28, [Supplementary Materials 5](#)). As a result of their aggregating tendency, the CPUE for centolla could remain stable while the abundance and range of the stock shrinks (Erisman, 2011; Eisman, 2016; IFOP, 2017). This may be further exacerbated as thermal stress from ocean warming affects the availability and catchability of centolla and centollon across the region (Yanez et al., 2018a; Iriarte et al., 2019; Pretterebner, Pardo, & Paschke, 2019). As such, benefits for

¹⁹ Tails is a tablet application which facilitates the collection of tuna, deep bottom snapper and reef fish catch data from small scale fishers and allows for the data to be uploaded to a central database for analysis: <https://fisheries.gov.vu/index.php/what-we-do/projects/tails-projects-sites.html>; <https://oceanfish.spc.int/en/ofpsection/data-management/spc-members/dd/505-tails-application>

large vessels may be only temporary, particularly as centolla are predicted to be negatively affected across a range of scenarios, and the effects of climate change are not yet fully appreciated. Moreover, when taking a longer-term view, the results are less certain, but reserves combined with greater surveillance are the only viable candidate under the current model structure to maintain populations of centolla, even those at depth. However, these results are contingent on that model structure holding as climate changes the system.

3.2 Best options for stock recovery, artisanal fishers and reducing illegal fishing

We explored potential alternative socioecological system arrangements related to the centolla fishery, reflecting varying levels of adjustment from business-as-usual, and tested their responses to various drivers through perturbation scenarios. No scenario produced desirable outcomes across the full range of response variables (artisanal fleets, stocks of centolla-centollon and illegal fishing). However, three scenarios, Stocking, Reserves and Management Controls, combined with specific system arrangements, were capable of producing predicted desired effects in at least two of the response variables.

Initiating a stocking program has strong potential in the centolla fishery, given that the scenario consistently predicted positive effects for shallow centolla and small vessels, irrespective of the alternative management structure. Positive outcomes for deep centolla and centollon were also predicted in some models, possibly as fishing pressure on them was reduced after the hatchery centolla were released into the shallows. Despite the cost and effort of establishing a stocking program, aquaculture in the form of hatcheries may provide other benefits to fishers and their communities in promoting alternative livelihoods and stewardship of the resource, providing training opportunities, access to different markets, and sharing the costs of maintaining stocks of king crab (Poblete, 2013). Such a venture might also enhance the ability of local cooperatives to improve their business models, add value to their fishing activities, and deter illegal fishing activities (Giusti, 2008; Valle, Romano, & Kataishi, 2017; Nahuelhual et al., 2019). A business case would need to weigh up start-up costs and financial models (i.e. government or beneficiary contributions) to know whether the return on investment to the community is sufficient to proceed. A further benefit of a stocking program is that it is expected to counteract some of the impacts of ocean warming in that rearing centolla to

maturity in controlled environments could compensate effects of thermal stress on reproduction and geographic distributions. However, when we consider stocking in a long-term climate change scenario (multiple perturbation scenario SP3) we find that the stocking programs would not yield the same positive outcomes.

In addition to stocking, we found that a scenario which created fishing exclusion areas in the form of permanent reserves or time-area closures also performed well, showing benefits for all cohorts of centolla and artisanal fishing fleets. Spatial management approaches have the potential to improve outcomes for the stock and the fleet, as they could be situated to maximise biological productivity and minimise disturbance to small-scale fishers. In fact, Bozzeda, Marín, and Nahuelhual (2019) highlights locations where fishing effort on centolla could be transferred: they identified overharvested ‘hot spots’ in the north and south which could be replaced with temporary reserves to protect genetic diversity (Barrera García, 2016). Spatially explicit reserves in different fishing zones might also be useful, by ensuring breeding stocks are protected as fishing pressure shifts southward (Guzmán M. et al., 2004; Rozzi et al., 2007; Pollack, Berghöfer, & Berghöfer, 2008; Bozzeda, Marín, & Nahuelhual, 2019; Pretterebner, Pardo, & Paschke, 2019).

Comparatively, the scenario which focused on enhancing management controls through improved surveillance and reporting (as described in business-as-usual, above) predicts benefits for centolla and centollon and controls illegal fishing but does not always benefit artisanal fishers. Consequently, a much narrower set of interventions are likely to be successful within the centolla fishery when considering the medium to long-term effects of climate change. Although SP2, the scenario which combined Reserves and Climate Change, produced mutual benefits for stocks of deep centolla and large vessels, it did not result in the same benefits for smaller vessels and stocks of shallow centolla. The perpetuation of positive outcomes for deep centolla and large vessels over shallow centolla and small vessels in most scenarios demonstrates that the positive effects perhaps need to be viewed as short to medium-term rather than medium to long-term benefits. For if the stock is depleted to a level that is not commercially viable, at some point even the deep centolla and large vessels will be affected.

3.3 Counterproductive options for stock recovery, artisanal fishers and reducing illegal fishing

Scenarios which did not yield positive outcomes for our three target response variables included economic development incentive schemes, increasing market

demand, and ocean warming due to climate change. These scenarios resulted in consistently negative outcomes for centolla and centollon across models, albeit with varying effects on smaller and larger vessels.

Across nearly all model alternatives, maintaining incentives that promote the development of the fishery, in the face of consistent or increasing international demand, produces strong negative effects on the stock of centolla with few positive effects on the fleet. The negative effects of strong international demand on all stocks of centolla are poorly addressed by the models here. This happens even in models where seafood certification standards are imposed on the fishery, and with increased delivery of the certified product to local markets, which aim to smooth problems of demand because they provide a niche product to discerning customers (see Model 6, and also the discussion in [Supplementary Materials 5](#)). We find, however, there is too much uncertainty in the responses produced from most models to determine whether market-based instruments improve the sustainability of the stock more or less than other management alternatives.

On the other hand, it is possible to interpret the effect of incentives through the perturbation scenarios. Because several leading organisations have suggested the regional economic incentive policy should be removed (World Bank, 2005), this study developed an alternate SES structure that removed the policy's effects (Model 8) or modified it to support local markets (Model 5,9). Unfortunately, these modifications as imagined in this study do not appear to sufficiently protect small vessels from cumulative pressures even with local market modifications. The presence of the economic development structure as currently enacted provides perverse outcomes on stock and small artisanal fishers, although it does allow for short-term benefits to larger vessels. We can infer that as the stock depletes, the opportunities for fishing are weighted against small vessels and towards large vessels, which receive increased subsidies to continue their operations. Management decisions focused on fleet efficiency as a mechanism for reducing fishing pressure may, by default, preference larger vessels over the smaller ones, resulting in legitimacy problems for managers (Panayotou, 1982; Branch et al., 2006; Murray & Ings, 2015; Pascoe et al., 2015; Nahuelhual et al., 2019). Symes and Phillipson (2009) note that the artisanal sector can be provided without resorting to financial subsidy, and may well be better provisioned through actions such as preferential access, limiting the transfer of fishing rights away from inshore fisheries, and relaxing regulations around licensing and quotas. For these

reasons, continuing the current incentive structure must be reconsidered to ensure artisanal fishing, as intended by the law, can continue.

Model 8, on the other hand, saw strong positive effects on centolla and centollon under an incentives perturbation, which were not observed in the sensitivity comparison with Model 7. This suggests that changing the incentive structure to remove harmful subsidies is a necessary structural change if maintaining biological sustainability is an objective of fishery management. Further, the literature demonstrates that many countries who utilise subsidies are not maximising potential net economic gains and instead would gain higher potential returns from investing instead in education, infrastructure and health, which in turn reduces economic overfishing and increases the catch value from the resource into the future (Sumaila & Hannesson, 2010). Several studies have discussed the unsuccessful and perverse outcomes of Chile's regional economic development policies, such as the Navarino Law (World Bank, 2005; Giusti, 2008) and, instead, promote increasing marketing power of small-scale artisanal fishers and improving local markets through cooperative clusters (Enright, 2000; Delgado, Porter, & Stern, 2010; Valle, Romano, & Kataishi, 2017)

Ocean warming is an important driver within the centolla socioecological system, and radically affects the expected success of management interventions. These findings are similar for northern king crab fisheries (Reum et al., 2020) and other global fisheries under climate change scenarios (Free et al., 2020). On its own, and combined with the sets of perturbations, warming waters and associated effects such as thermal stress, oxygen depletion and food availability, could have significant impacts on viable livelihoods and the reliability of centolla as a regional economic activity and export product. Evidence is mounting already on the thermal stress of northern latitude (41°) populations, and range extension of king crab species in latitudes south of 60° (Belchier, Peatman, & Brown, 2012; Aronson et al., 2015; Iriarte et al., 2019; Pretterebner, Pardo, & Paschke, 2019). This comes when demand for centolla is high due to king crab collapsing elsewhere (e.g. Alaska). An ongoing market is, however, predicated on the availability of product. This is a motivation for a binding management plan for the fishery, to arrest declines. Such a management plan, rather than focussing specifically on centolla, might be better situated within a broader plan for economic opportunities for regional residents, and in consideration of impacts of climate change on fishers, producers and international relations (Poblete, 2013; Mellado et al., 2018; Porobic et al., 2018).

3.4 Sensitivity tests

3.4.1 Governance

Given the importance placed on governance and policy instruments on the success of biologically sustainable fisheries, we explored (through different system arrangements) whether particular governance structures or policy instruments result in better outcomes for the whole socioecological system. Scholars differ in their advice on governance structures, with some advocating for “strong” top-down authoritative, regulatory control (Hilborn, Orensanz, & Parma, 2005), and others suggesting market-based solutions can regulate (Petrossian, Weis, & Pires, 2015; Jaffry et al., 2016). Conversely many small-scale fisheries scholars promote local, area-based fishing rights with local institutions as the key to successfully managed fisheries, although scholars also note the challenges of it in Chile (Bernal et al., 1999; Hilborn, Orensanz, & Parma, 2005; Orensanz et al., 2005; Gelcich, Edwards-Jones, & Kaiser, 2007; Gutierrez, Hilborn, & Defeo, 2011; Allison et al., 2012; Gelcich, 2014; Grafton & Kompas, 2016). Four different fishery control mechanisms were explored in these models: government regulatory environment (Model 5), market-based/seafood certification standards (Model 6), harvest control (Model 7) and community-based/local management (Model 9).

Different scenarios revealed positive outcomes for stock and others for fleet, but no model performed strongly across all response variables (Table 17). This result demonstrates that the form of governance or mechanism of harvest control is not the main driver in this system, at least in the way we have drawn it. As such, managers have the opportunity to choose the system that best suits fishery actors and consumers in the future, and do not have to be locked into historical or pre-existing conceptual models. This is not an insignificant finding, and one that I hope will help overcome the biases many managers and researchers perpetuate in their system arrangement preferences (Fulton, 2021). Consequently, managers may need to consider a more nuanced version of response variables, considering aspects of power and agency of artisanal fishers, livelihood diversification, ecosystem effects, and financial, social, political and operational costs. For example, Models 5 and 9 yield similar results, telling us that a top-down approach or a local-management approach provides similar outcomes for our response variables. However, a local management approach provides fishers with the agency to make their own decisions regarding harvest, monitoring and enforcement, and places the cost of management on their shoulders, having significant flow-on benefits for the

government, industry and fishers alike (Weeratunge et al., 2014; Jentoft & Chuenpagdee, 2015b).

Several complicating factors may limit the feasibility of various approaches. A choice for one management approach over another may be, and should be, motivated by a number of factors. These include cost, the administrative burden to establish, political will, the characteristics of the fishery, and the legal framework in which they operate (Troade, 1992). For one, centolla is a mobile resource, and there are concerns that a local management approach based on mostly-sedentary benthic resources may not suit in the same way it has been approached elsewhere in Chile (Plotnek et al., 2016). This is perhaps why the concept has not yet been established in the Magallanes region. Equally, consumer-led seafood certification programs like that of the Marine Stewardship Council (such as our Model 6), have been attempted before in Chile but have not generally been successful, primarily due to the ongoing costs of monitoring and problems with enforcement (Poblete, 2013; Plotnek et al., 2016). Our study is unable to elaborate on this issue specifically. However, it suggests that an appetite for this arrangement might increase where monitoring and accreditation costs are shared amongst a greater number of people, or partially provided by the government, making the certification option practical. Thirdly, although MSY limits and quotas are components of Chilean legislation, their application to management has suffered from implementation problems at the local scale, including enforcement levels, cost sharing, and allocation issues (Bernal et al., 1999; Chávez, González, & Salgado, 2008; Salgado et al., 2015; Eisman, 2016; Plotnek et al., 2016). Given the legislated objective to maintain the artisanal fishing fleet, the scenario of harvest control (such as our Model 7), without substantial consideration for how harvest controls and allocation would affect smaller vessels, may not achieve the holistic set of desired outcomes for the fishery.

The literature cites typical effects of harvest control as shifting benefits to larger vessels within the fleet (Panayotou, 1982; Branch et al., 2006; Christensen, 2010; Ernst et al., 2013; Melnychuk et al., 2016; Brown et al., 2017), which dishonours the intent of the artisanal fishing policy. Working with stakeholders to better understand which trade-offs are 'taboo,' i.e. non-negotiable, and then elaborating system models to find solutions for taboo trade-offs is an area of work that can address the legitimacy of management interventions (Daw et al., 2015; Asche et al., 2018).

3.4.2 Monitoring – how important is it?

Our sensitivity analysis also assessed the importance of biological monitoring to understanding the outcomes of the scenarios. Stock monitoring is a costly exercise, and signals a commitment to applying the information to adjust or limit harvesting activities. Therefore, managers may want to know whether the effort is worth the cost and political struggle to implement. In our study, models with biological monitoring node interactions predict outcomes in key response variables more accurately than those without node interactions. That is, monitoring can inform where expectations of mental models might differ from reality: without monitoring, the models show stronger responses than what may actually be “true” of the system. Monitoring can therefore improve the certainty of system responses. Monitoring also provides (in its own right) confidence to managers and researchers as they track fishery events and that the models (conceptual, mental, qualitative, stock assessment etc.) remain relevant with the correct connections and assumptions, particularly around the intended outcomes of management interventions. Globally, climate change is creating novel conditions where the past is not necessarily a good indicator of the future, so vigilance in the form of monitoring is necessary to update our understanding of interactions between system components. Given the certainty of uncertainty, models may not conform to the system as we’ve drawn it, highlighting the importance of monitoring to managing the system. It may also be useful to further the analysis with Bayesian Belief Networks to help identify the key variables in the system to monitor (Gammage & Jarre, 2020).

3.5 Limitations and opportunities

3.5.1 Limited representation of the centollon ecosystem

Our models focused primarily on centolla, given its focus on the fishery reform process. King crab species are highly substitutable in international markets (WWF, 2014), and, although centolla are currently preferred, harvest efforts may quite easily transfer onto centollon should stocks of centolla continue to decline. However, without additional life history or ecological information, our model incompletely describes how fishing centolla affects centollon. Some negative effects are observed on centollon in the Reserves scenario (possibly as exclusion from fishing centolla may transfer effort on to centollon) and positive effects from stocking programs and additional management control efforts. However, these effects are not consistent across models. Given its slower growth and maturity rate compared to centolla (Lovrich & Vinuesa, 1999; Lovrich & Vinuesa, 2016;

Wyngaard, Iorio, & Firpo, 2016), and the exploitation of harvest of larger, older, more productive individuals (Guzmán M. et al., 2004), centollon may be more sensitive to fishing than currently recognised. Since centolla and centollon co-occur in the central and southern fishing zones (see *Figure 15*, Chapter 4), centollon are a frequent bycatch. The impacts of keeping or returning centollon bycatch by centolla fishers need further study as evidenced by similar studies elsewhere (Varisco et al., 2017; Di Salvatore et al., 2019). This means an explicit consideration of centollon in the centolla reform process will be important for ensuring the recruitment of centollon into the future.

3.5.2 Limited representation of markets

The negative effects of strong international demand on centolla are poorly addressed by any of the alternative ‘futures’ models, even where seafood certification standards were imposed on the fishery (Model 6), controls on harvesting were initiated (Model 7,8) and we increased delivery of the certified product to local markets (Model 5,6,9). Our model of international demand modulating catch levels was simple. Future models may wish to focus on refining the understanding of possible avenues for expanding, or modulating, catch levels through international demand or market-based instruments. There was too much uncertainty in responses from most models to determine whether demand-based instruments could be predicted to improve the sustainability of the stock more or less effectively than other management interventions. Equally, we have not applied economic instruments like taxes (Ortiz & Levins, 2017) which may result in other effects within the system, nor have we captured subsidies for fuel that may affect how profits are made (Sumaila et al., 2008). The global pandemic COVID-19 imposed significant constraints on trade in recent years and the effects of this on centolla stocks would be a valuable learning outcome to add to subsequent models.

3.5.3 Opportunities to expand this work

Despite positive indications of the potential power of management interventions, given evidence of fishery impacts on the stock from current fishing practices (Bozzeda, Marín, & Nahuelhual, 2019; Di Salvatore et al., 2019) and a possibility of hyperstability in the CPUE that masks the observed level of stock depletion (IFOP, 2017), short-term interventions are unlikely to compensate for cumulative impacts on the fishery. This study importantly highlighted the social system interactions with the centolla fishery and the impact of different system arrangements on linked social and environmental objectives.

Achieving outcomes for stocks of centolla and artisanal fishers will require a radical shift in how management is conceived. Managers and regional officials will have to consider a more holistic set of interventions across the region and industries to support achieving legislated social and environmental objectives. This study moved some way towards expanding the breadth of resource management measures to include social performance. Further extensions could take an ecosystems approach and incorporate livelihood and regional economic diversification options for artisanal fishers: future work could expand the scope of the models and interventions from this study to explore how different system arrangements or interventions move beyond climate adaptation, and proactively encourage community transformation that empowers people and ecosystems (Orlove et al., 2020; Siders, Ajibade, & Casgrande, 2021; Siders & Pierce, 2021). Doing so can help to highlight perceived conflicts between objectives, ensuring that management reforms create opportunities to consider the potential for long-run increases in fishery stocks and social outcomes for artisanal fishers.

4. Conclusion

This study assessed the relative merits of potential control mechanisms and policies for the centolla fishery in the Magallanes region of Chile. It fulfilled one part of the overall thesis' goal to build an understanding of fisheries as socioecological systems, to improve fisheries management. We examined how qualitative models can help support decision-making in complex fishery systems, specifically, how the models provided an understanding of the social and ecological performance of different management approaches, supporting artisanal fishers and recovery of the centolla fishery. Such models are useful for visualising different outcomes of management approaches and contribute to continuous learning associated with adaptive management approaches.

The overall results highlight the consequences for the continuation of smaller artisanal fleets in the fishery. Most predictions show a reduction in centolla and a decrease in small vessels. Choices will have to be made regarding whose preferences will be privileged. For example, the analysis makes clear that managers will have to choose whether the management system should continue to advantage larger vessels, possibly leading to medium and small-scale demise, or try to even up the advantages. Avoiding the issue is a de facto choice to advantage larger scale fishers, as evidenced by this study and other studies in the region. Managers can

either be intentional in a choice to address the inequalities, or they can just allow the choice to happen through no change at all.

Short-term management control interventions such as improved surveillance and enforcement are a practical first step in reform, and are predicted to yield positive outcomes for artisanal fishers and stocks of centolla. However, given the evidence of fishery impacts on the stock from current fishing practices and a possibility of hyperstability in the CPUE that masks the observed level of stock depletion, short-term management control interventions are unlikely to compensate for cumulative impacts on the fishery. In our models, initiating a stocking program and implementing some form of spatial management (e.g. permanent or time-area closures) shows promise; however, impacts of climate change could have significant impacts on viable livelihoods and the reliability of centolla as a regional economic activity and export product. Our study demonstrates that a reform process that genuinely seeks positive social and environmental outcomes may need to extend management beyond the typical domain of management control and consider other economic opportunities for fishers, and make decisions that enable adaptation and transformation with climate change.

Chapter 6

Synthesis and conclusions

1. Introduction: an overview of the thesis and summary of findings

The true form and connected nature of social dimensions of fisheries are not well understood in an integrated sense, and there is a disconnect in how important social dimensions of sustainable development, such as equity, fairness, and opportunities, can be integrated at ecosystem levels. Research programs associated with fisheries management agencies and day-to-day fisheries management are lacking in social dimensions, resulting in significant legitimacy deficits and inadequate and improper renderings of trade-offs across social and environmental dimensions. This reduces the effectiveness, equity, and efficiency of fisheries management. Institutions are increasingly being held accountable for demonstrating progress towards sustainable development agendas that support human dignity and the integrity of socioecological systems, as well as for how they address impacts of climate change on communities and societies.

This thesis offers an important step in addressing this challenge by offering a range of practical solutions to management and the potential to address through a socioecological systems approach that was first explored in Chapter 1. The literature reviewed showed that the challenges fisheries managers face in integrating social dimensions include a lack of understanding of how to identify social objectives and performance metrics, a need to expand perspectives beyond commercial fishers, a lack of clarity or appreciation of the benefits of incorporating social and environmental objectives, and a belief that trade-offs are necessary despite a rhetoric that environmental, social and economic objectives should have equal weight in decision-making. While fishers and managers are not typically concerned by the lack of inclusion of social objectives in decision-making, they do admit the importance of demonstrating social accountability to stakeholders. There is therefore a disconnect between the low priority for ‘social objectives’ by fishers and managers in strategic decision-making and their actual importance in day-to-day management and performance assessments, which warrants a closer look to determine what is driving this mindset. Evidence suggests that managers are more likely to adopt new approaches based on examples of similar decisions. There is therefore an urgency to provide relevant examples of fisheries management where social dimensions form a primary aspect of the decision. Together,

the consideration of fishery manager challenges and needs guided the direction of the research in this thesis.

The aim of the thesis was to therefore draw lessons on the incorporation of social dimensions in fisheries management that could provide examples to fisheries managers. It drew lessons from two cases – the eastern rock lobster in NSW, Australia, and centolla in southern Chile, by applying a systems lens and adaptive management to develop approaches that would help to shift mindsets on the inclusion of social dimensions in fishery management decisions. To honour the intent of adaptive management and ‘learning by doing’, the thesis provided four studies, outlined in preceding chapters, each presenting a practical alternative approach to a fisheries management problem and an evaluation of the approach in offering insights towards operationalising social dimensions. To do so, I drew from a range of disciplinary methods and frameworks, applying mixed methods, as mixed methods improve a researcher’s ability to identify patterns and associations in the data. I was guided by a grounded theory approach, which utilises an iterative process to draw out explanations. The work provides practical insights and tools to integrate social dimensions with fisheries management which turns research into something managers can use.

In the first Australian case study, the analysis of legal frameworks demonstrated that social performance is not clearly articulated or measured in an appreciable way in Commonwealth or State fisheries, which limits understanding of how fisheries are operating and confidence that fisheries are being managed in accordance with the principles of ecologically sustainable development (ESD). Further, the use of a social cost-benefit framework in the NSW lobster fishery showed inequalities in the distribution of benefits, and drew inferences on how private and public benefits may be affected as a consequence of current management approaches and interactions with climate change disturbances. In the Chilean cases, modifying a common preference study approach revealed values and motivations that are important considerations for reforming management of a fishery so that it can continue to sustain the artisanal fishing sector as well as rebuild a depleted resource. This analysis contributed to the development of scenarios, which, when modelled, demonstrated consequences and impacts of different policy and management settings, climate disturbances, and the potential of different management options on critical system variables. These included social dimensions that to date have not been considered alongside ecological variables. The important lessons learned from modelled system responses tests assumptions of

status quo management and provides proof of concept for alternative management approaches.

1.1 Adaptive management and shifting mindsets

Achieving outcomes in fisheries that meet the needs of present and future generations as per the 2030 Agenda for Sustainable Development (UN, 2015) and other international commitments requires a shift in how management is conceived. Using adaptive management, and the social learning processes embedded within, previous management actions should be reviewed and evaluated, and new actions introduced, which reduce the gap between fisheries management commitments for Ecologically Sustainable Development (ESD) and the implementation of actions.

Each of the cases in this study clarified the nature of the socioecological problem, showing that social objectives are not, in fact, precluded from legal frameworks, or outside of the scope of ESD. In reality, both Australia and Chile have positive social outcomes as goals within legislation. It is therefore not the legal framework that poses a challenge to integrating social dimensions in fisheries management, but rather it is their interpretation, implementation, and assessment. To clarify, the legal frameworks themselves do not prohibit fisheries managers from integrating social objectives into management, but it does require a change in mindset amongst those in management institutions to change status quo management approaches.

The absence of a mechanism or process for incorporating lessons learned - or an objective for learning - substantially affects the ability of management to have the necessary platforms to adapt as needed as conditions of the system change, including social aspects. In both Chile and NSW (Chapters 3 and 4) learning is indirectly an objective of management in the sense that research activity is promoted in each fishery; however, to date, most of the research conducted by and for fisheries management decisions has been focussed on environmental aspects, and has contributed limited knowledge on economic or social outcomes. Work is being done to improve information streams in the case locations, as in the various studies undertaken by the Human Dimensions stream of the research institute, CentroIdeal, in Chile (see <https://centroideal.cl/en/20050-2/>, and the Economic and Social Indicator Monitoring on behalf of the NSW Department of Primary Industries (Fisheries), <https://www.dpi.nsw.gov.au/fishing/commercial/bdo-economic-and-social-indicator-framework>), as well as support from the Fisheries Research and Development Corporation Human Dimensions Research Coordination Program

(<https://www.frdc.com.au/hdr-coordination-program>). It will be important to watch how this information leads to improved economic and social decisions for communities and fishery participants.

Without promoting learning as a valuable outcome in and of itself, it will continue to be difficult for fisheries managers to access examples of work that might help to shift their understanding of the problem, and possible alternative ways of seeing solutions. The value of learning to shifting mindsets was observed in Chapter 3, where learning about the benefits of fishery management to a range of stakeholders highlighted significant gaps in how benefits of the rock lobster fishery are provided to stakeholders outside of the commercial fishery. Further, the learning exercise showed that participation in decision-making and information provision are important benefits that are poorly enabled by management, which inhibits benefits for other stakeholders. Particular social objectives therefore become more evident as primary drivers of socioecological inertia, or change.

The use of catch-share systems, particularly individual transferable quota (ITQ) provides a pertinent example to observe the importance of social objectives, particularly as a growing body of literature raises concerns on the legitimacy of ITQ due to conflicts with achieving biological and profitability objectives at the expense of social outcomes (van Putten et al., 2013a; van Putten et al., 2014a; Acheson, Apollonio, & Wilson, 2015; Garrity, 2020; Hoshino et al., 2020). The conventional approach which is focused on managing stocks for biological sustainability is losing legitimacy with stakeholders as it does not provide outcomes consistent with other stakeholder values, nor with the ESD commitments made in line with normative statements for multi-objective fisheries management. From the evidence in Chapter 3 and the scenarios in Chapter 5, this is particularly apparent when the focus on biological stocks or profitability affects social cohesion, fishing opportunities -both now and into the future - and provision of seafood to local communities: identified conventional management approaches resulted in net benefits to certain commercial and artisanal fishers with limited flow to other beneficiaries.

When considering intergenerational equity, benefits may diminish even to these fishers if critical drivers of change such as climate, and social values around domestic provision of seafood, are not addressed. These results have significant implications for assertions by management agencies of meeting public benefit outcomes. If such research were applied during fisheries reform processes and when fisheries move from stock-building to maintenance, policy makers may be able to make more informed

decisions which are more acceptable to the full range of beneficiaries – small-scale commercial and recreational fishers, Aboriginal communities, consumers, and the wider public alike. Without a marked improvement in accountability and reporting on social objectives, the fishery may experience further reductions in public confidence (e.g. a loss of legitimacy).

A first step in adopting an enquiry or learning-based management approach is to set management targets to improve social outcomes for the full range of beneficiaries identified in legislation. Objectives and targets can be informed through the analysis of benefits and beneficiaries (as in the eastern rock lobster case), through preferences for management (as in the centolla case), and by comparing likely outcomes from different management schemes (also for centolla), which are provided as examples in this thesis. In the case of the NSW eastern rock lobster fishery, managers may apply the lessons learned from the benefits analysis to set a target for increasing the number of customary fishery permits for Aboriginal communities. For Chile, this may mean setting specific objectives for smaller and larger artisanal fishers, or for fishers from different parts of the region. Such actions are perceived to produce positive effects on other benefit categories, meaning that it could be an important opportunity to quickly gain return on investment, as well as improve legitimacy deficits associated with current approaches. Based on the tools developed for the NSW and Chilean case fisheries, I recommend to managers to take the additional step to include social benefits (and social costs) to management decisions and to formally acknowledge the importance of assessing social costs at different spatial and temporal scales. Such considerations already are part of Australian Government policy (NSW Government, 2017; Australian Government, 2020), but not yet in practice across most jurisdictions.

An additional step in a learning-based management approach is to explicitly make learning a management objective (Cundill et al., 2012; McKenzie et al., 2017; McKenzie, 2021; Edmondson & Fanning, 2022). The triple loop approach to adaptive management (e.g. how do we know these are the right things to study and implement?) tests assumptions about the system that may help reduce path dependencies that lead to consequences that are seen as illegitimate by stakeholders (Chuenpagdee & Jentoft, 2015; Fulton, 2021). Learning is a fundamental part of any monitoring, evaluation and learning program, and much can be learned from practices in the learning and evaluation field, such as theories of change and logic models (Argyris, 2004; Funnell & Rogers, 2011). Future research should examine the extent to which learning has occurred and been integrated into the adaptive management process, which will

contribute to an understanding of how mindsets have been shifted in response to the approach.

1.2 Co-creating a foundation for learning – creating models of the system that better reflect inherent complexity

From a research perspective, a key learning from this thesis was that progress with integrating social dimensions in fisheries management is a result of mindsets and existing toolkits which preference single objective-management approaches and optimise present over future benefits, and profitability over stability of income. This masks a range of social consequences: in the NSW rock lobster fishery (Chapter 3), a mindset of stock-rebuilding which has prevented managers and participants from addressing emerging issues which impact on the presence and flows of economic and social wellbeing across a range of beneficiaries, and the provision of local seafood. Instead, an approach that mixed typical quantitative studies with qualitative information showed that stakeholders concurrently hold a complex set of preferences for management that reduce social and economic vulnerabilities, improve fairness, address implementation concerns, and support long-term biological outcomes for the fishery. Management models therefore need to match real-world complexity to bridge legitimacy gaps between what managers ought to consider in their decisions, and typical models applied in conventional fisheries management.

Across each of the thesis chapters, bringing in 'people disciplines' helps to understand connected risks and complexity across the socioecological system (Wassénus & Crona, 2022). The thesis introduced a range of simple models, such as tracking the types and flows of benefits in Chapter 3, and preferences for management in Chapter 4, which highlighted important gaps in enabling factors – the regulations, the policies and practices of management – that could be improved to increase flows of benefits of small-scale fisheries to present and future generations. Chapter 5 (centolla fishery) empirically demonstrated that management cannot limit itself to control activities alone if it is to enable legislative goals for artisanal fishers and biological sustainability, particularly as the effects of climate change will exacerbate existing issues amongst fishers. Learning about the system in this way cannot be underestimated, as it forms a critical opportunity to reflect on the impact of management options on identified social and environmental objectives, which can contribute to the development of bespoke solutions that reduce or remove inequalities amongst fishers with social, economic, and geographic limitations.

Importantly, the analyses throughout this thesis demonstrate that there is no ‘single best outcome’ and various combinations of behavioural, technical, legal and economic levers could theoretically achieve similar desired social objectives (see also Brooks et al., 2015; Bunnefeld, Nicholson, & Milner-Gulland, 2017; Asche et al., 2018). It is highly recommended, therefore, for fisheries researchers to engage managers and fishery participants in scenario development. Such an approach has been shown to be useful for improving trust between managers and participants, and for demonstrating how diverse values and personal objectives can be accommodated in management decision-making (Plaganyi et al., 2013; Bennett, Kadfak, & Dearden, 2015; Fulton et al., 2015; Le Heron et al., 2016; Teh, Cheung, & Sumaila, 2016). Qualitative network models in particular facilitate an understanding of drivers and feedback on interventions, gaining insight into the likelihood of intended and unintended consequences of management on fishery participants and the resource (Syme, Dzidic, & Dambacher, 2012; Fulton et al., 2015; Lane, 2020). Applying scenarios (including the analysis of benefits and preferences) may help institutions to understand the importance of making changes to existing arrangements and the implications of not adapting (Free et al., 2020; Ogier et al., 2020b). Supplementing this work with legitimacy research, such as lab experiments, multiple (large-n) case studies, deliberation and genealogical analysis will help to inform the suitability of various management designs (Ostrom, 1990; Poteete, Janssen, & Ostrom, 2010; Suddaby, Bitektine, & Haack, 2017; Fudge et al., 2021).

Fundamentally, fisheries managers and researchers have to stop thinking about fishery systems as ‘joined up’ between the social and environmental dimensions, and consider them as one complex socioecological system. The developments in this thesis may go some way to help address the problem by making a better case for the value of the ‘people disciplines,’ and the inclusion of practical examples that apply self-reflection, a willingness to challenge assumed practices, and a capacity for collective reinvention such as co-produced alternative futures (Castree, 2017; Nash et al., 2022). Future work could more closely examine how adaptive interventions (i.e. operational management actions) enable broader positive outcomes like resilience, capacity building, empowerment and human and social potential and promote positive transformations in fishery stakeholders (Becker & Vanclay, 2003; Siders, Ajibade, & Casgrande, 2021; Siders & Pierce, 2021).

2. Applications

Although not directly a focus of this study, I draw inferences as to the relevance of the study findings to the development of harvest strategies, particularly as fisheries management practices internationally moves towards their adoption (Beddington, Agnew, & Clark, 2007; Sloan et al., 2014; Dowling et al., 2016; Pascoe et al., 2019). Decision support tools, such as harvest strategies, are used by fisheries managers to determine an appropriate set of management actions for achieving desired objectives. However, harvest control rules may not address access or allocation problems that underlie harvest strategies, which may result in deficits in legitimacy, particularly when the wellbeing of fishers and communities has not been considered adequately (Ostrom, 1990; Dowling et al., 2016; Rindorf et al., 2017b). Problems therefore arise in selecting and implementing harvest strategies as they are utterly dependent on the articulation of stakeholders' objectives, and the sociopolitical context, which can't be revealed by biophysical science alone. In Australia, the harvest strategy framework divorces allocation arrangements, management arrangements, compliance and surveillance strategies and control mechanisms from the process (See Sloan et al. (2014) for a review of the framework and global experiences in developing harvest strategies).

My research supports an assertion that fisheries management will require more than stock assessments and autocratic decision-making (Troade, 1992; Finkbeiner et al., 2017). It will require assessment and evaluation of additional relevant local drivers, facilitated by the integration of social science data on fishing communities and cultures, as well as local stakeholders' knowledge, needs and beliefs. How harvest strategies more closely integrate social considerations into the development of alternate management strategies that address compliance, cooperation, risk spreading, and participant wellbeing is a critical area of growth. This study demonstrates that managing institutions, at least in Chile and Australia, are not approaching fisheries management from an adaptive, systems-view. The implications of my research demonstrate that perpetuating the existing approach, albeit with more sophisticated and elaborate coverage, risks further stakeholder alienation and legitimacy gaps in the harvest strategy process. This is a significant moment in time for fisheries management, and adaptation is urgently required.

3. Conclusions and Recommendations

The challenge raised by this study was to investigate practical research methods for integrating social dimensions into day-to-day fisheries management operations,

resulting in important insights that can drive better fisheries policy and management. This project generated new insights into the key actions of management that typically fall short, such as legitimacy deficits and inertia, poor measurement and reporting on the effectiveness of the institutions governing the resource, as well as inequalities and a failure to account for values and motivations. The examples herein demonstrated that not only is it possible to incorporate social dimensions with fisheries management, but that there are practical feasible ways of making it happen right now. In particular, examining the legal context in which the fishery operates, understanding the types of benefits and social objectives and their distribution across the fishery, and applying management intervention scenarios, can help to evaluate the efficacy of management in achieving social, environmental and learning objectives. Into the future, fisheries management mechanisms should be evaluated not only for how they simultaneously regulate fishing rates, reduce production costs, facilitate compliance, but also address distributional inequities and promote learning and participation in management of the fishery. Most importantly, the process of raising awareness of alternative views of a problem and the testing of different options can help researchers and managers 'unlearn' what they think they know about a system (e.g., deconstruct frame of reference). It can help to shift their mindsets, to open up to the needs for social objectives, and how to begin to look out for them and incorporate them with environmental data into fisheries management. Future research exploring the extent to which learning has occurred and been integrated with the adaptive management process would help understand the role of learning frameworks in shifting mindsets and improved integration of social dimensions. By applying these methods, researchers and managers can ensure management of fisheries is responsive to needs of beneficiaries of the fishery and adaptive to conditions that enable or constrain the delivery of social and environmental outcomes. Genuinely applying adaptive management and a systems lens is especially critical across all natural resource management, and yet it is a broader challenge still rife across the sciences.

Supplementary Materials 1

Author Statements

Chapter 3: NSW Eastern Rock Lobster Fishery: Who Benefits?

Abstract:

This chapter looks at the flows of benefits provided by management of NSW eastern rock lobster, a mature share-managed fishery, as an approach to assessing social performance. It assesses how the fishery delivers on a comprehensive set of benefits for the range of beneficiaries specified in legal frameworks, such as commercial and recreational fishers, Aboriginal communities, and the people of NSW. Qualitative thematic coding of key informant interviews and public documents compiled evidence on benefits different groups were receiving, and qualitative analysis teased apart the connections between benefits and beneficiaries, and the impact of fisheries management in their delivery. Benefits were considered for the present and for the future, based on informant responses. Results demonstrate that, to date, management approaches have yielded net benefits to commercial fishers, with limited flow to other beneficiaries. When considering intergenerational equity, benefits may diminish even to commercial fishers if critical drivers of change such as climate, and social values around domestic provision of seafood, are not addressed. These results have significant implications for assertions by management of meeting public benefit outcomes. Recommendations to address gaps in social performance include more regular performance reporting that includes how management uses costs recovered from the fishery, and tracking initiatives for delivering on Aboriginal cultural fishing benefits. This case contributes to the thesis theme by providing a practical example of iterative inquiry and social learning in a complex context, and teasing apart the connections between dimensions of ecologically sustainable development (ESD). This case demonstrates how a fisheries researcher can gain an understanding of the outcomes of management (e.g. the benefits produced) including the range and distribution of benefits for beneficiaries now and into the future. A fisheries manager can use the output of the research (knowledge about the benefits from fisheries and their social distribution) to realign program delivery to address gaps in how benefits are delivered for specific groups to meet societal obligations related to the objects of the *Fisheries Management Act*.

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Chapter 4: Integrating qualitative assessments of preference to inform options for management

Abstract:

Fisheries management approaches vary according to the characteristics of the fisheries, the resources available for management, the efforts which their value justifies, and the legal framework in which they operate. A reform process in the king crab (centolla) fishery of Chile provided an opportunity to explore stakeholder views related to different management approaches, as a contribution towards a revised implementation program. In this study, preferences for different objectives were assessed. A typical research process is to first elicit the preferences of stakeholders related to fishery objectives and then to propose a management approach that aligns with those preferences. The conventional approach was expanded with a qualitative component to address a known gap in interpreting preference study results. A semi-structured and semi-quantitative questionnaire survey with 22 stakeholders of the centolla fishery to rank management options for their ability to achieve different objectives such as social and economic wellbeing or reduction in conflict. Stakeholder results were compared based a number of characteristics such as industry participation, geographic region, boat ownership and point of landing. Our results show that only reporting preferences gives a shallow understanding of stakeholder preferences regarding fishery objectives. Results of preference rankings, disaggregated by stakeholder group and reasons shows that respondents have a complex set of reasons underpinning preferences related to reducing social and economic vulnerabilities, improving fairness, addressing implementation concerns and supporting long-term biological outcomes for the king crab fishery. The study demonstrates that many of the management options could be viable, provided they could be designed to address social and economic vulnerabilities, based on characteristics related to vessel size, geography, interactions between economic development policies and artisanal fishing, and social contracts. Addressing the biological sustainability of the resources is paramount to most fishers, but the way in which this is done must address fairness concerns, and have a reasonable chance of implementation success. The method in this study advances a deeper understanding of preferences to inform adaptive management in a way that achieves multiple objectives rather than trading off benefits.

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Chapter 5: Preliminary insights into reform options for the centolla fishery, Chile: assessing effectiveness of management options to deliver multiple objectives.

Abstract:

Fisheries managers are learning how to manage fisheries as complex sociological systems, particularly in the case of fisheries reform, where there is opportunity to consider multiple factors in developing new management measures. This chapter presents a second analysis to help stakeholders of the centolla fishery decide among management options, to address overfishing and illegal commercial fishing that threatens the ability to meet legislated objectives for biological stocks and protecting artisanal fisheries.

Qualitative models provide some direction on the relative merit, benefits and disadvantages of the different management options for the centolla-centollon fishery. This approach is particularly appropriate in the early stages of fisheries reform planning when a rapid assessment of the system might reveal the consequences of current or planned management interventions and drivers that may lead to undesirable behavioural responses in the system. The analyses demonstrate that qualitative models can be usefully applied to assist managers in determining courses of action for managing exploited resources such as king crabs. The study reveals inequity deficits amongst artisanal fishers across multiple modelled scenarios, which economic and climate drivers exacerbate. Spatial management, increasing enforcement and initiating a stock enhancement (stocking) program produce desirable results across multiple response domains, i.e. recovering centolla stocks, supporting the artisanal fishing fleet, and reducing illegal fishing. When combined with longer-term disturbances such as climate change, the benefits from initial interventions are not observed. Management may need to consider a broader suite of interventions that are typically outside the remit of technical management levers, such as ecosystem and livelihood approaches, to address the effects of a rapidly depleting resource and maintain legislated objectives that support artisanal fishers. These models are useful constructs to visualise the likely impacts of certain system arrangements, including subsidies, markets and actors, on achieving sustainability outcomes for subfleets and biological stocks. Managers are encouraged to further elaborate on our heuristics and design alternate models for their responses to climate change and inequity amongst artisanal fishers. Reflecting on these consequences can help inform decisions, particularly as communicating on a set of scenarios can provide opportunities to discuss and develop more options that may suit the situation better.

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Supplementary Materials 2

Chapter 2 Materials

Relevant fisheries legislation and policies referred in this study

Table 18 Relevant legislation and policies referred in this study

Name of Act, Regulation or Policy (and URL)	Jurisdiction	Statement
Fisheries Management Act 1991 https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/fisheries/domestic/hsp.pdf	Commonwealth	An objective of the Fisheries Management Act 1991 is exploitation of fisheries resources in a manner consistent with the principles of ecological sustainable development, ensuring accountability to the fishing industry and Australian community in AFMA's management, achieve government targets in relation to cost recovery of AFMA, and implement efficient and cost-effective Commonwealth fisheries management.. A further objective of the Fisheries Management Act 1991 is to pursue maximisation of net economic returns to the Australian community from the management of fisheries. The interests of the commercial, recreational and Indigenous fishing sectors may all be relevant to the pursuit of this objective and the development of harvest strategies. Principles of ESD are defined in part 3A. The following principles are principles of ecologically sustainable development: a) (a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations; b) (b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation; c) (c) the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; d) (d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making; e) (e) improved valuation, pricing and incentive mechanisms should be promoted.
Fisheries Administration Act 1991 https://www.legislation.gov.au/Details/C2017C00373	Commonwealth	The Fisheries Administration Act establishes the Australian Fisheries Management Authority with functions and responsibilities for the management of Commonwealth fisheries. AFMA must pursue efficient and cost-effective fisheries management, ensure that exploitation is carried out within the principles of ecologically sustainable development, maximise net economic returns to the Australian community, ensure accountability to fishing industry and Australian community in AFMA's management, and achieve government targets in relation to the recovery of the Authority's costs. In addition, the Authority is to have regard for ensuring the interests of commercial, recreational and Indigenous fishers are taken into account. Principles of ESD are defined in part 6A. The following principles are principles of ecologically sustainable development: a) (a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations; b) (b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;

		c) (c) the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; d) (d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making; e) (e) improved valuation, pricing and incentive mechanisms should be promoted.
<i>Environment Protection and Biodiversity Conservation Act 1999</i> (EPBC Act) Fisheries Assessments - Guidelines for the Ecologically Sustainable Management of Fisheries https://www.environment.gov.au/marine/publications/guidelines-ecologically-sustainable-management-fisheries - Overview of status of fishery assessments (CMWTH) https://www.environment.gov.au/marine/fisheries/commonwealth-managed-fisheries - Overview of status of fishery assessments (EXPORT fisheries from other jurisdictions) https://www.environment.gov.au/marine/fisheries ESD Reporting - Generic ESD and environmental performance indicators for Commonwealth Organisations 2003 https://webarchive.nla.gov.au/awa/20191110183155/https://www.environment.gov.au/resource/generic-ecologically-sustainable-development-esd-and-environmental-performance-indicators - Example of ESD reporting by AFMA, annual report 2018-2019 Appendix 6 https://www.afma.gov.au/sites/default/files/afma_annual_report_201819_full_fa_tagged_final.pdf	Commonwealth/export fisheries from other jurisdictions	The objectives of the EPBC Act are to: - provide for the protection of the environment, especially matters of national environmental significance - conserve Australian biodiversity - provide a streamlined national environmental assessment and approvals process - enhance the protection and management of important natural and cultural places - control the international movement of plants and animals (wildlife), wildlife specimens and products made or derived from wildlife - promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources - recognise the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity - promote the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge The EPBC Act 1999 requires the Australian Government to assess the environmental performance of fisheries and promote ecologically sustainable fisheries management. The Sustainable Fisheries Section (of the Environment Dept) is responsible for the assessment of fisheries management under Commonwealth legislation and state-export fisheries in accordance with the Act. The primary role is to evaluate environmental performance of fisheries including the strategic assessment of fisheries under Part 10 of the EPBC Act, assessment relating to impact on protected marine species under Part 13 and assessments for the purpose of export approval under Part 13A. An independent assessment of all export and Australian Government managed fisheries is required (<i>roughly every 4 years</i>) and are conducted against the 2nd edition of the Guidelines for the Ecologically Sustainable Management of Fisheries which outline principles and objectives to ensure strategic and transparent evaluation of ecological sustainability of fishery management arrangements. Commonwealth and Export Fisheries in other jurisdictions must satisfy only ecological criteria to ensure Export approval under the EPBC Act. Commonwealth organisations have a statutory requirement to report on their environmental performance and how they accord with and advance the principles of ecologically sustainable development (ESD). The annual reports of Commonwealth departments, Parliamentary departments, Commonwealth authorities, Commonwealth companies and other Commonwealth agencies must under Section 516A of the <i>Environment</i>

		<i>Protection and Biodiversity Conservation Act 1999</i>, all now include a report on environmental matters in their annual reports. • Section 516a of the EPBC Act The annual reports must: • report how the agency's activities have accorded with the principles of Ecologically Sustainable Development (ESD) • identify how their departmental outcomes contributed to ESD • document the agency's impacts upon the environment and measures taken to minimise those impacts • identify the review mechanisms in place to review and increase the measures the agency takes to minimise its impact upon the environment (https://www.environment.gov.au/epbc/about/reports-and-statistics#annualcwth) Note: It is important to be clear that the principles identified in the EPBC Act are the only ones that are relevant for the purposes of Section 516A reporting (which may differ from other expressions of ESD), and these principles have a very strong environmental emphasis. Notably, only the first and last of the ESD principles under the EPBC Act relate to the integration of social, economic and environmental issues. The middle three principles relate specifically to ensuring that environmental consequences are considered in decision-making. Note2: Having said that, the Performance Indicators document has a sophisticated evaluation framework for assessing performance against high-level ESD objectives, including an assessment of how conflicts and trade-offs between ESD objectives has been dealt with. Evidence of ESD consideration includes answering: • In how many/what proportion of decisions during the year is there documentary evidence that ESD, or its principles, were considered? • In how many/what proportion of decisions during the year was an assessment of the potential social, environmental and economic effects of an activity conducted? • In how many/what proportion of decisions during the year was a consultative mechanism invoked to resolve an ESD related conflict? • In how many/what proportion of decisions during the year was any other mechanism used to resolve such a conflict? And evidence that processes are contributing to overarching ESD outcomes should answer: • In how many/what proportion of decisions during the year is there documentary evidence that decisions have been modified on the basis of this consideration? • In how many/what proportion of decisions during the year is there documentary evidence that decisions have been modified on the basis of an assessment of the potential social, environmental and economic effects of an activity?

		• In how many/what proportion of decisions during the year is there documentary evidence that decisions have been modified on the basis of reference to a consultative mechanism ? • In how many/what proportion of decisions during the year is there documentary evidence that decisions have been modified on the basis of reference to some other mechanism for resolving conflicts? Indicators have been developed in line with these Key Evaluation Questions.
<i>Commonwealth Fisheries Policy Statement 2017</i> https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/fisheries/domestic/cwlth-fisheries-policy-statement.pdf	Commonwealth	The Commonwealth Fisheries Policy Statement sets out the Australian Government's objectives for the fisheries and aquaculture sectors. The statement outlines the government's approach to managing fisheries and the marine environment. The statement establishes a set of guiding principles which will help inform the Australian Government's approach to fisheries management, policy and program design. The government's position is guided by these principles: • Sustainability—our fisheries are managed in a manner consistent with the principles of Ecologically Sustainable Development, with no overfishing and the recovery of overfished stocks. • Science-based decision-making—fisheries management decisions are based on the best available science. • Resource sharing—equitable access among professional, recreational and Indigenous fishers to our shared marine resources. • Rights-based fisheries management—through the use of statutory fishing rights, with a preference for individual transferable quotas, and fisheries managed using output controls. • Maximising utilisation and productivity—we develop our fisheries and aquaculture to maximise the net economic return to the Australian community. • Regulatory effectiveness and cost recovery—regulatory and cost recovery requirements that are fit for purpose. • Transparency in decision-making—decisions are made in consultation with all relevant stakeholders. • Meeting our international obligations—our fisheries are managed in a manner that is consistent with Australia's international obligations, emphasising cooperation in the management of highly migratory and shared fish stocks. • Stamping out illegal, unreported and unregulated fishing—we will continue to fight and prosecute illegal, unreported and unregulated fishing and implement international agreements that help close loopholes exploited by those who threaten our fish stocks
<i>AFMA Performance reporting (annual reporting)</i> https://www.transparency.gov.au/annual-reports/australian-fisheries-management-authority/reporting-year/2018-2019-12 <i>Note: performance indicators drawn from AFMA's chapter in the Agriculture and Water Resources 2018-2019 Portfolio Budget Statements p.248 and AFMA's Corporate Plan for 2018-2019 p.7</i>	Commonwealth	(1) Management of commonwealth fisheries consistent with principles of ESD; complete an ERA and Fisheries Management Strategy for each fishery every five years, number of high-risk species in ERA declines, number of fisheries reporting bycatch (general and volume), number of fisheries with decreasing interaction with Threatened and Endangered Species (2) Maximum net economic returns to the Australian Community from the management of Commonwealth Fisheries; For economically significant stocks maximise the number of key commercial stocks with harvest strategy targets based on MEY or the best available proxy, number of stocks assessed as being on economic target or heading towards target reference point, number of fisheries that meet the Harvest Strategy Policy 2018 or that meet within 4 years. (3) Compliance with Commonwealth fisheries laws and policies and international obligations and standards; % treatment targets for all priority domestic risks met (number of compliance and

		enforcement activities documented), % of apprehended illegal, unreported and unregulated vessels and suspected illegal entry vessels delivered to AFMA were disposed of (4) Deliver effective, cost efficient and accountable management of Commonwealth fisheries resources; industry cost recovery charges do not exceed the levels derived by increasing the 2005 level (CPI per year), number of news subscribers via afma.gov.au, number of AFMA Facebook likes and followers, number of followers and retweets on AFMA Twitter Note: AFMA reports on their accountability in the annual report as including engagement with scientists, industry, and recreational and Aboriginal stakeholders and representative groups (MACs and RAGs) and the production of videos to explain the role and activities of AFMA. It explains that it uses several avenues to ensure activities are visible to clients and stakeholders, such as the Client Service Charter, the GoFish licensing system and the number of complaints as other explanatory data to support accountability, but these items are not listed in the performance criteria. (5*ESD) Note: AFMA reports that it meets ESD by managing and reporting on the ecological components relating to target and by-product species, bycatch, TSPHECs, and provides a narrative on that. It does not conform to the ESD performance indicators framework.
<i>National Strategy for Ecologically Sustainable Development (1992)</i> (https://webarchive.nla.gov.au/awa/20130905024205/http://www.environment.gov.au/about/esd/publications/strategy/index.html)	Commonwealth, other Australian governments	defines ecologically sustainable development as: 'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased'.
Commonwealth Fisheries Harvest Strategy Policy and Guidelines 2018 https://www.agriculture.gov.au/fisheries/domestic/harvest_strategy_policy	Commonwealth	The harvest strategy policy and associated implementation guidelines aim to ensure key commercial fish species are managed for long-term biological sustainability and to maximise the net economic returns to the Australian community. The policy also seeks to provide the fishing industry with a more certain operating environment. The harvest strategy policy provides a framework that allows a precautionary, evidence-based approach to setting total allowable catch levels in all Commonwealth fisheries on a fishery by fishery basis, to ensure that fisheries provide maximum economic returns while maintaining stocks at sustainable levels. The implementation guidelines provide practical advice on how to interpret and apply the harvest strategy policy to Australia's fisheries and contain details of the science behind the fisheries management decisions. To pursue this objective the Australian Government will implement harvest strategies that: • ensure exploitation of fisheries resources and related activities are conducted in a manner consistent with the principles of ecologically sustainable development, including the exercise of the precautionary principle; While the Harvest Strategy Policy does not outline the government's policy on resource sharing, where it is clear there is a significant non-commercial (recreational or Indigenous) interest in a fishery, the need to share the resources appropriately will be considered (HSP Policy 2018). However, consistent with the role of these guidelines, the interest to be considered is confined to the economic benefit to the Australian community, e.g. allocation and of share in the fishery to different sectors, i.e. allocate shares in an optimal way (HSP Guidelines 2018). A number of less formalised and non-optimised approaches to allocation are also likely. However, because allocation is out of scope for the Harvest Strategy Policy, it is also out of scope for these guidelines.(Guidelines 2018) • maximise net economic returns to the Australian community from management of Australian fisheries—always in the context of maintaining commercial fish stocks at sustainable levels; Maximising the net economic return from a fishery to the Australian community will in most cases be consistent with maximising the net economic returns from the commercial fishery. E.g. the welfare of the total 'economic community of Australia' (e.g. those who are returned an economic benefit from fishing)

		• maintain key commercial fish stocks, on average, at the required target biomass to produce maximum economic yield from the fishery • maintain all commercial fish stocks, including byproduct, above a biomass limit where the risk to the stock is regarded as unacceptable (BLIM), at least 90 per cent of the time • ensure fishing is conducted in a manner that does not lead to overfishing—where overfishing of a stock is identified, action will be taken immediately to cease overfishing • minimise discarding of commercial species as much as possible • are consistent with the <i>Environment Protection and Biodiversity Conservation Act 1999</i> and the <i>Guidelines for the Ecologically Sustainable Management of Fisheries (2nd edition)</i>. -harvest strategies will be reviewed every 5 years. Ongoing performance of each harvest strategy against its objectives must be assessed and publicly reported. Note1: The HSP defines Net Economic Return as A fishery's NER over a particular period is equal to fishing revenue less fishing costs. Fishing costs include the usual accounting costs of fuel, labour, and repairs and maintenance, as well as various economic costs such as the opportunity cost of owner labour and capital (see 'Opportunity cost'). The concept of NER is very closely related to economic efficiency, a necessary condition for NER to be maximised. Note2: The Harvest Strategy Policy indicates spatial and temporal management can complement other management measures and indicates the effect of closures on fishery objectives must be evaluated and reflected in the harvest strategy. However, as social objectives are not stated, there is an implicit trade-off between economic objectives and social impacts that would be captured by following this policy and its interpretation of fishery objectives. Note3: The HSP Guidelines recommend having a Fishery Management Strategy in place that document: • high-level objectives for the fishery, as required under the Harvest Strategy Policy • shorter-term operational objectives adopted in support of achieving the high-level objectives—such as objectives relating to improving some aspect of monitoring or data collection to either improve current assessments or allow a more reliable assessment method to be applied • methodology used and results of categorisation for the fishery • specification of the indicators to be used for each stock (such as B estimates, F estimates or available and appropriate proxies for these) and the target and limit reference points for each stock expressed in terms of the specified indicators • details of the harvest strategy, including HCRs for the fishery • assessment methods to be applied to each stock, including the stocks that will only be subject to risk assessment • overview of monitoring and data collection requirements to support the chosen assessment methods • the extent of discarding of commercial species and the actions taken to both monitor and reduce discarding • where a fishery contains an overfished stock that is subject to a rebuilding strategy, provide an overview of the objectives and requirements of that strategy
Commonwealth Resource Sharing Framework 2020 https://www.agriculture.gov.au/fisheries/domestic/resource-sharing	Commonwealth	The Commonwealth fisheries resource sharing framework outlines the government's approach to sharing fisheries resources across commercial, recreational, and Indigenous fishing sectors and between the Commonwealth and the states and the Northern Territory.

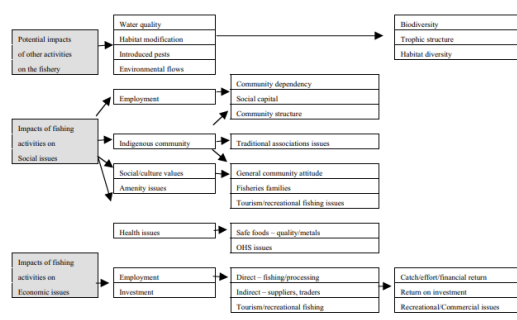
		The framework provides a principles-based approach to creating resource sharing arrangements to manage access and allocation issues in Commonwealth fisheries.
Northern Prawn Fishery Management Plan 1995 https://www.legislation.gov.au/Details/F2012C00160 <i>Report: AFMA Annual Report 2018-2019</i> https://www.transparency.gov.au/annual-reports/australian-fisheries-management-authority/reporting-year/2018-2019-25 <i>Note: Sources of data are: economic data taken from ABARES' gross value of production data for Commonwealth fisheries and AFMA stock assessments, and fishing mortality and biomass data taken from ABARES Fishery Status Reports 2019</i>	Commonwealth	The objectives of the plan are to ensure that the objectives pursued by the Minister and by AFMA are met in relation to the Northern Prawn Fishery, and that incidental catch is reduced to a minimum. Measures by which the objectives are to be attained include: (a) developing and implementing appropriate management measures (including directions referred to in subsection 17 (5A) of the Act) in relation to the Northern Prawn Fishery; and (b) implementing an effective program of surveillance for the Northern Prawn Fishery to ensure compliance with this plan; and (c) promoting research that is relevant to the Northern Prawn Fishery; and (d) preparing an annual budget of costs associated with managing the Northern Prawn Fishery; and (e) setting and collecting levies and fees in relation to the Northern Prawn Fishery; and (f) collecting data that can be used to assess the status of the Northern Prawn Fishery; and (g) monitoring the impact of catching operations in the fishery on ecologically related species and implementing any practical strategies that are necessary to minimise the impact of those operations on those species; and (h) developing and implementing a by-catch action plan. Performance criteria against which the measures are assessed include: (a) the status of economic efficiency of the Northern Prawn Fishery; and (b) the status of the biological resources and environmental conditions in the Northern Prawn Fishery area; and (c) the cost effectiveness of the management arrangements for the Northern Prawn Fishery. These performance criteria are reported on in the AFMA Annual report
Harvest Strategy for the Northern Prawn Fishery under input controls 2014 (amended 2019) https://www.afma.gov.au/sites/default/files/harvest_strategy_-_npf_-_october_2019.pdf	Commonwealth	5.1 Operational Objective – Tiger Prawn The operational objective of this Harvest Strategy is to attain long term MEY from the tiger prawn fishery. For operational purposes, the objective of MEY can be considered equivalent to the objective of maximising the net present value of the flow of profits in the fishery over an indefinite period. For the NPF, MEY is assumed to be achieved over a seven-year period. The dynamic path to MEY is calculated as the effort level and associated catch in each year over a seven year projection period that leads to a long run sustainable yield that maximises profits over time 5.4.3. Closures • Spatial and temporal closures will be used for biological/ecological protection (e.g. seagrass, habitat protection), for prawn size protection (e.g. juveniles, prespawning adults) and to maximise prawn growth/increase economic return. • Closures will be introduced and/or amended by NORMAC according to the protocols in the NPF Closures Review 2005 report, "Documenting the history of and providing protocols and criteria for changing existing or establishing new closures in the NPF". • A daylight trawl ban will be used to protect spawning tiger prawns in the second (tiger prawn) season. Performance indicators: Stock size: >0.5Smsy (less is overfished) Effort: Ey/Emey = 1 (greater is overfished)
Fisheries Management Act 1994 No 38 https://legislation.nsw.gov.au/view/html/inforce/current/act-1994-038	NSW	The objects of the act are to conserve, develop and share the fishery resources of the state for the benefit of present and future generations. Specific objects of the act are to conserve fish stocks, promote ESD, including the conservation of biological diversity, promote viable commercial fishing and aquaculture industries, promote quality recreational fishing

Protection of the Environment Administration Act 1991 https://legislation.nsw.gov.au/view/html/inforce/current/act-1991-060	opportunities, appropriately share fisheries resources between users, provide social and economic benefits for the wider community of NSW, and recognise the spiritual, social and customary significance to Aboriginal persons and to protect and promote the continuation of Aboriginal cultural fishing. Section 7C-F Instructs the Minister to arrange for the preparation of a draft fishery management strategy for each designated fishing activity, and outlines the purpose and content of a fishery management strategy. The Minister may revise the existing strategy from time to time. A fishery management strategy is the strategy for achieving the objectives of this Act with respect to the designated fishing activity for which it is prepared (e.g. Those in Schedule 1A which are share managed fisheries). A fishery management strategy is to— (a) describe the designated fishing activity for which it is prepared, and (b) incorporate any management plan or draft management plan for the fishery concerned, and (c) outline the fishing regulatory controls or proposed fishing regulatory controls applicable to the designated fishing activity, and (d) outline the likely interaction of the designated fishing activity with other fishing activities, and (e) include performance indicators to monitor whether the objectives of the strategy (and the management plan) and ecologically sustainable development are being attained, and (f) describe how the designated fishing activity is to be monitored, and (g) specify at what point a review of the strategy is required when a performance indicator is not being satisfied. Note—see section 57 for content of a management plan for a share management fishery. Division 5 Management Plans 56 The Minister is to arrange for the preparation of a draft management plan for a share management fisher and may arrange for the preparation of a new draft management plan following a fishery review. 57 The management plan for a share management fishery may make provision for or with respect to the following— (a) the objectives of the plan, (b) the classes of shares in the fishery and the provisions of the plan applicable to each such class, (c) the rights of shareholders to take fish or nominate others to take fish in the fishery, (d) the fish that may be taken in the fishery, (e) the area for taking fish in the fishery, (f) the times or periods for taking fish in the fishery, (g) the use of boats and fishing gear in the fishery, (h) the conduct of fishery reviews for the purposes of the preparation of a new plan, (i) the species or group of species of fish taken in the fishery that are to be subject to a total allowable catch for the commercial fishing sector, (j) the protection of the habitats of the species of fish that may be taken in the fishery (including habitats at all stages of the life history of any such species), (k) the taking of bait for use in the fishery, (l) the matters expressly authorised by this Act to be included in the plan, (m) any other matters relating to the management of the fishery that are consistent with this Act and its objects. (2) A management plan must— (a) include performance indicators to monitor whether the objectives of the plan and ecologically sustainable development are being attained, and (b) specify at what point a review of the management plan is required when a performance indicator is not being satisfied. 60 A management plan for a fishery is to be made by regulation.

		62 Plan prevails over other regulations (1) If a provision of the management plan for a fishery (or a provision of a supporting plan adopted by the management plan) is inconsistent with any other regulation under this Act, the management plan prevails. (2) However, the management plan does not prevail over a provision of a regulation which is expressed to have effect despite the management plan. 63 Fisheries reviews – new plan (2) The Secretary is to arrange a review into each share management fishery at such times as the management plan for the fishery provides and, subject to that plan, at such other times as the Minister determines. A review must be held before the term of the shares in the fishery is due to expire. (3) The Secretary is to constitute a representative group of persons to assist in the conduct of the review. The group is to include representatives of any relevant advisory group and any other relevant commercial or recreational fishing industry bodies, as appropriate. (4) The Secretary is to report to the Minister on the review. (5) The Minister is to consider the report of the review and take such action (including the preparation of a new management plan) under this Act with respect to the fishery the subject of the review as the Minister considers appropriate. Section 76-77 outline charges determined by the Minister: 76: management charges to meet the costs of managing a fishery, attributed to industry by the management plan. 77: community contribution for access to share management fishery for their right of access to the fishery, payable in accordance with the management plan. ESD has the same meaning as under section 6(2) of the Protection of the Environment Administration Act 1991: ecologically sustainable development requires the effective integration of social, economic and environmental considerations in decision-making processes. Ecologically sustainable development can be achieved through the implementation of the following principles and programs— (a) the precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by— (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and (ii) an assessment of the risk-weighted consequences of various options, (b) inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations, (c) conservation of biological diversity and ecological integrity—namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration, (d) improved valuation, pricing and incentive mechanisms—namely, that environmental factors should be included in the valuation of assets and services, such as— (i) polluter pays—that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement, (ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste, (iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

		The review of the Act must be undertaken within 5 years of the Threatened Species Legislation Amendment Act 2004, to determine whether the policy objectives of the Act are being fulfilled and whether the terms of the Act, and any environmental planning instruments granted biodiversity certification under Division 11 of Part 7A, remain appropriate for securing those objectives.
Marine Estate Management Act 2014 No 72 https://legislation.nsw.gov.au/view/html/inforce/current/act-2014-072#sec.26	NSW	Objects of the act: (a) to provide for the management of the marine estate of New South Wales consistent with the principles of ecologically sustainable development in a manner that— (i) promotes a biologically diverse, healthy and productive marine estate, and (ii) facilitates— • economic opportunities for the people of New South Wales, including opportunities for regional communities, and • the cultural, social and recreational use of the marine estate, and • the maintenance of ecosystem integrity, and • the use of the marine estate for scientific research and education, (b) to promote the co-ordination of the exercise, by public authorities, of functions in relation to the marine estate, (c) to provide for the declaration and management of a comprehensive system of marine parks and aquatic reserves. (2) For the purposes of this Act, the principles of ecologically sustainable development require the effective integration of economic, social and environmental considerations in decision-making processes. Ecologically sustainable development can be achieved through the implementation of the following— (a) the precautionary principle, (b) inter-generational equity, (c) conservation of biological diversity and ecological integrity, (d) improved valuation, pricing and incentive mechanisms. 6 Meaning of the marine estate: In this Act, the marine estate means the following— (a) the coastal waters of the State within the meaning of Part 10 of the Interpretation Act 1987, (b) estuaries (being any part of a river whose level is periodically or intermittently affected by coastal tides) up to the highest astronomical tide, (c) lakes, lagoons and other partially enclosed bodies of water that are permanently, periodically or intermittently open to the sea, (d) coastal wetlands (including saltmarsh, mangroves and seagrass), (e) lands immediately adjacent to, or in the immediate proximity of, the coastal waters of the State that are subject to oceanic processes (including beaches, dunes, headlands and rock platforms), (f) any other place or thing declared by the regulations to be the marine estate, but does not include any place or thing declared by the regulations not to be the marine estate. The act also provides for the establishment of a Marine Estate Management Authority (the Authority), and a Marine Estate Knowledge Panel. 2) In particular, the Authority has the following functions— (a) to advise the relevant Ministers on the management of the marine estate and in relation to any matter referred to it by the relevant Ministers, (b) to undertake assessments of threats and risks to the marine estate, (c) to prepare a draft marine estate management strategy for submission to the relevant Ministers in consultation with the relevant public service agencies,

		(d) without limiting paragraph (a), to advise the relevant Ministers on the implementation of the marine estate management strategy by public authorities, (e) to promote collaboration and co-ordination between public authorities in their exercise of functions relating to the management of the marine estate, (f) to foster consultation with the community in relation to the management of the marine estate and the preparation of the marine estate management strategy. The assessments of threat and risk must be undertaken every 10 years. The Marine Estate Strategy must be undertaken every 10 years. The Review of the Act must be undertaken within 5 years of commencement, to determine whether the policy objectives of the Act remain valid and whether the terms of the Act remain appropriate for securing those objectives
Fisheries Management (Estuary Prawn Trawl Share Management Plan) Regulation 2006 https://legislation.nsw.gov.au/view/whole/html/inforce/2014-06-13/sl-2006-0735	NSW	Objectives and performance indicators: (5) Contribute, in conjunction with other fishing regulatory controls (as defined in section 7A of the Act), to managing the impacts of the fishery on the environment and to ensuring ecologically sustainable development: reduction in discards, new classifications of 'overfished' or 'recruitment overfished', total landings of target species and by-product are within specified limits, no interactions between the fishery and threatened species, no interactions between the fishery and protected fish that are likely to threaten the survival of threatened and protected fish (6) Contribute, in conjunction with other fishing regulatory controls (as defined in section 7A of the Act), to promoting viable commercial fishing: there are net returns to the fishery
Fisheries Management (Lobster Share Management Plan) Regulation 2000 https://legislation.nsw.gov.au/view/whole/html/inforce/current/sl-2000-0048	NSW	<i>rock lobster</i> means fish of the species <i>Sagmariasus verreauxi</i>, <i>Jasus edwardsii</i>, <i>Panulirus longipes</i> and <i>Panulirus ornatus</i>. Objectives and performance indicators: (1) Increase the biomass of eastern rock lobster (<i>S. verreauxi</i>): Levels of stock increase or remain stable relative to 1998-99 levels (but trigger is in relation to CPUE levels, not stock....) (2) Promote commercial fishing practices that do not have an adverse environmental impact: research indicates fishing practices do not have an adverse impact (3) Ensure management arrangements do not have a significant impact on costs of taking eastern rock lobster for sale: Management charge does not increase significantly (4) Promote cost efficient management: independent review of arrangement, conducted periodically at request of Minister, determine arrangements are appropriate (5) Ensure appropriate research and monitoring in relation to the fishery: sufficient data is available for rock lobster stocks (6) Minimise the number of offences committed by fishers: number of offences indications compliance with the act, this plan and regulations of the Act Management charge payable under section 76 of the FMA is not to exceed \$98 per share Community contribution payable under section 77 of the FMA is payable by each shareholder for each fishing period, at \$115.

Fishery Management Strategy https://www.dpi.nsw.gov.au/fishing/commercial/ea • Estuary Prawn Trawl 2003 • Eastern Rock Lobster 2007 Environmental Impact Statements https://www.dpi.nsw.gov.au/fishing/commercial/ea • Estuary Prawn Trawl 2002 (with additional social impacts assessment in 2001) • Eastern Rock Lobster 2004	NSW	A fishery management strategy is a document outlining the management goals, objectives, strategies for achieving the objectives (including the fishing or activity controls), performance indicators and the monitoring programs that apply to a fishery or activity. Environmental impact statements and fishery management strategies have been prepared for each of the major fisheries and activities managed by NSW DPI. This will help to ensure they are managed in a sustainable way. EIS are to be prepared to ensure all impacts of commercial fishing (e.g. on biological, economic and social) are considered and to consider all available alternate management regimes for impact on env/soc/ec/administrative areas.  <pre> graph LR PI[Potential impacts of other activities on the fishery] --> WQ[Water quality] PI --> HM[Habitat modification] PI --> IP[Introduced pests] PI --> EF[Environmental flows] WQ --> B[Biodiversity] HM --> B IP --> B EF --> B B --> TS[Trophic structure] B --> HD[Habitat diversity] IF[Impacts of fishing activities on Social issues] --> E[Employment] IF --> IC[Indigenous community] IF --> SCV[Social/culture values] IF --> AM[Amenity issues] E --> CD[Community dependency] E --> SC[Social capital] E --> CS[Community structure] IC --> TA[Traditional associations issues] SCV --> GCA[General community attitude] AM --> FF[Fisheries families] AM --> TRF[Tourism/recreational fishing issues] IF2[Impacts of fishing activities on Economic issues] --> EMP[Employment] IF2 --> INV[Investment] EMP --> DFP[Direct - fishing/processing] EMP --> ISL[Indirect - suppliers, traders] EMP --> TRF2[Tourism/recreational fishing] INV --> DFP INV --> ISL INV --> TRF2 DFP --> CEF[Catch/effort/financial return] ISL --> CEF TRF2 --> CEF CEF --> ROI[Return on investment] CEF --> RCI[Recreational/Commercial issues] </pre> Comprehensive Fishery Management Strategies, which include a description of the fishery and its management arrangements, have been prepared and approved by the Minister for Primary Industries. Before each Strategy was finalised, a draft strategy was subject to a comprehensive environmental impact assessment process under the NSW Environmental Planning and Assessment Act 1979. Fishery management strategies are valuable because they: • provide a long term vision for management of a fishery or activity, • clearly outline the strategies that are in place to achieve that vision, • provide stakeholders with greater certainty by knowing the management programs that apply in the fishery or activity, and provide useful background information. The strategies allow the community to scrutinise the management arrangements for each fishery or activity and seek to ensure that the management arrangements in place provide sustainable fisheries and activities into the future. As outlined in the Act, fishery management strategies provide performance metrics and schedules. In addition to the performance monitoring process outlined below, a share management plan will be prepared for the fishery and include goals and performance indicators consistent with those specified in this management strategy. The Fisheries Management Act 1994 provides that the share management plan must specify at what point a review of the management plan is required when a performance indicator is not being satisfied. Accordingly, when the share management plan for the fishery is prepared the plan will need to provide for a review process that is complementary to the review process described in this management strategy. An annual performance report assessing the performance of the fishery will be submitted to the Minister for Fisheries each year following the review of trigger points by the MAC. This is to

		commence in 2004 and the report is to be submitted to the Minister for Fisheries within six months of the Estuary Prawn Trawl MAC being consulted over the development of the report. The annual performance report is the formal mechanism for reporting on performance indicators and trigger points, and will be made publicly available. To note: The EIS specifically outlines the steps following on from approval of the EIS. (see, for example, the Estuary Prawn Trawl Fishery EIS, Appendix A2): Step 3- - Once the Commonwealth Minister makes a determination under Commonwealth legislation, the NSW Minister for Fisheries makes a determination under Part 5 of the EP&A Act and an approval of the finalised FMS under the Fisheries Management Act. - NSW Fisheries prepares relevant management plans and amends any existing management tools (e.g. regulations which are not consistent with the Strategy) necessary to give effect to the approved strategy. NSW Fisheries consults with FRCAC, relevant Advisory Councils, MACs and other stakeholders and if relevant the general community in finalising the management plans. Minister for Fisheries approves management plans. Step 4- - NSW Fisheries monitors the implementation of the Strategy and reports to FRCAC, relevant Advisory Councils, MACs and - stakeholders on the resource and environmental management performance. - NSW Fisheries reviews the Strategy or aspects of the strategy (based on triggers in the FMS). Estuary Prawn Fishery Vision and Goals A fishery that under the principles of ecological sustainable development is economically viable, using environmentally friendly fishing gear to provide fresh, high quality seafood and bait to the community. The goals that have been set for the fishery to assist in achieving this vision are: 1. To manage the Estuary Prawn Trawl Fishery in a manner that promotes the conservation of biological diversity in the estuarine environment 2. To maintain target and by-product species harvested by the Estuary Prawn Trawl Fishery at sustainable levels 3. To promote the conservation of threatened species, populations and ecological communities associated with the operation of the Estuary Prawn Trawl Fishery 4. To appropriately share the resource and carry out fishing in a sustainable manner that minimises social impacts 5. To promote a viable commercial fishery (consistent with ecological sustainability) 6. To ensure cost-effective and efficient management and compliance in the Estuary Prawn Trawl Fishery 7. To improve the knowledge of the community about the operations and management of the Estuary Prawn Trawl Fishery 8. To improve the knowledge about the Estuary Prawn Trawl Fishery and the resources upon which the fishery relies. Performance indicators specific to economic/social: Goal 4-

		1) Estimates by NSW Fisheries of the catch of target species for all sectors (including recreational and Indigenous/estimates available within 3 years from commencement of management strategy) 2) Annual reported landings from the commercial sector compared to estimates of unreported annual catch by the recreational and Indigenous sectors (excluding catches attributable to Recreational Fishing Havens)/the shift in relative landings and catch levels between sectors is on average 25% or less over five years 3) Annual reported landings of target species taken in the estuary prawn trawl fishery relative to those from the same estuary by other commercial fisheries/Relative landings levels between commercial fisheries shifts on average by 25% or less over five years *NB. The comments state explicitly that these indicators relate primarily to the objective of evaluating and managing equitable allocations between commercial fisheries Goal 5- 1) Coded counts (number of individuals per half kilogram) for eastern king or school prawns/Coded counts have been implemented to the satisfaction of the Director, NSW Fisheries.*Note. This is used as a proxy for a size restriction. 2) Median fishery wide gross return to estuary prawn trawl fishers derived from commercial fishing in NSW/no KPI set to date 3) Average market value of estuary prawn trawl shares/No KPI set to date 4) Viability of the estuary prawn trawl fishery and its contribution to businesses of fishers therein/no KPI set to date Goal 6- 1) Rate of compliance of the estuary prawn trawl fishery in respect to (i) overall and (ii) "share forfeiture offences" under the share management plan/overall compliance is more than 85% 2) Number of Estuary Prawn Trawl MAC meetings held each Year/More than 2 per calendar year 3) Occasions when this management strategy is in direct conflict with other approved Commonwealth or State programs/Any occasion when the Director, NSW Fisheries determines that the MS is consistent with other programs 4) [Cost of managing the fishery]/TBD Goal 7 1) Dissemination of information to the public/More than 2 pieces of information published every three years 2) Level of community awareness/more than 50% of those surveyed are aware of operation and management of estuary prawn trawl NSW Rock Lobster Fishery Vision and Goals A lobster fishery that is ecologically sustainable and profitable and that works to improve the understanding and management of this valuable species through a high standard of research and compliance and pro-active co-operation amongst stakeholders. The goals of the NSW Lobster Fishery are: 1. Manage the Lobster Fishery in a manner that promotes the conservation of biological diversity in the marine environment; 2. Maintain the stock of eastern rock lobster at a biologically sustainable level and manage by-product taken in the Lobster Fishery; 3. Promote the conservation of threatened species, populations and ecological communities and protected species likely to be impacted by the operation of the Lobster Fishery; 4. Appropriately share the resource and carry out fishing in a manner that minimises negative social impacts; 5. Promote a viable commercial fishery, consistent with ecological sustainability; 6. Facilitate effective and efficient compliance, research and management of the Lobster Fishery; 7. Improve knowledge of the Lobster Fishery and the resources upon which the fishery relies.

		Performance indicators specific to economic/social: A performance assessment examining each performance indicator will be undertaken annually and a report on the performance indicators will be submitted to the Minister for Primary Industries within two years of the commencement of the FMS, and biennially thereafter. The report is the formal mechanism for reporting on performance indicators and triggers points and will be made publicly available. It will also include a review of progress made in implementing each of the management responses. The performance report may be submitted to the Minister for Primary Industries in conjunction with performance reports for other relevant fishery management strategies. The vast majority of management responses in the FMS are linked to specified implementation timeframes. If the performance report identifies that any specified target timeframe has not been met, a review will be undertaken and any necessary remedial measures recommended to the Minister for Primary Industries.
DPI and Fishery Performance Reports - Fishery Management Strategies Performance Report 2004 https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0010/639973/FMS-Performance-Report.pdf -avail for prawn but not for lobster - DPI Fisheries, Aquaculture and Aquatic Conservation Key Highlights and Statistics 2014-15 https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0003/599421/Fisheries-statistics-report-2014-15.pdf - DPI Performance, Data and Insights 2018, 2019 https://www.dpi.nsw.gov.au/about-us/publications/pdi/2018 - Status of Fisheries Resources NSW (now the Status of Australian Fish Stocks Reports) 2012-2020 https://www.fish.gov.au/jurisdiction/new-south-wales 2011-2015 https://www.dpi.nsw.gov.au/content/research/fishing-aquaculture/sustainable-fish-harvest-program 2008-2009 https://www.dpi.nsw.gov.au/content/research/areas/fisheries-and-ecosystems/wild-fisheries/outputs/2010/1797 (DPI Strategic Plan 2015-18//2017-2019) https://www.dpi.nsw.gov.au/about-us/publications/nsw-dpi-strategic-plan-2017-2019 Stock Status Summary Reports – avail for specific species	NSW	In 2004, as required under the performance reporting framework developed with the Fishery Management Strategies, a first set of indicators were reported on. They are reported by “theme,” and by implementation of management actions: 1) Trigger points related to commercial landings For estuary trawl (p. 13) indicators and trigger points are reported to identify short-term shifts in catch rates of the target species. It presents each target species/estuary against catch triggers (kg/day) and the previous year’s CPUE data (2002/03) and provides an indication of status performance. 2) Trigger points related to compliance and administrative matters 3) Implementation of management – a table of management actions across several fisheries and DPI administrative functions documents progress, but does not directly relate management to KPIs of individual fishery strategies In 2008/09 DPI Fisheries provided a “Status of Fisheries Resources” Report that “meets the public reporting requirements associated with resource assessment of key species as indicated in the Fishery Management Strategies and Share Management Plans of the Estuary General, Estuary Prawn Trawl, Ocean Hauling, Ocean Trawl and Ocean Trap and Line Fisheries. I&I NSW will update the status reports on a regular basis (approximately every two years).” These reports have gone through several iterations and produced by different organisations, but are still reported roughly every 2 years. -School prawns declared sustainable using catch, CPUE and environmental models indicators As for Organisational reporting on other aspects of the fisheries management, DPI Fisheries provides annual reports on their operations. DPI Fisheries contributes to 3 key programs in the new DPI Strategic Plan 2015-18: • Increase economic contribution from fishing & aquaculture (commercial fisheries, recreational fisheries and aquaculture) • Maintain sustainable access and use of aquatic resources (resource assessment, Aboriginal fisheries, marine estate, aquatic ecosystems, and fisheries compliance) • Mitigate and manage risks from use of land and water (the shark (bather protection) program). Each of the following two parts of the 2014-15 Highlights and Statistics report is divided into chapters which reflect these DPI programs. The first part describes – for each program area – the outcomes that DPI Fisheries is seeking to achieve on behalf of the NSW Government, industry and the community, as well as key measures to indicate success in achieving these outcomes and selected achievements from 2014-15. The second part provides statistical tables, maps and figures which provide detailed information on industry performance, resource status and DPI Fisheries activities, outputs and efficiency.

https://www.dpi.nsw.gov.au/fishing/commercial/open-for-comment/stock-status-summary-reports -not avail for lobster or prawn in 2018/2019 or any year previous	The 2014-2015 Highlights and Statistics reports on • “increased viability and profitability of the commercial fishing industry” through total tonnes caught, total GVP, total businesses with shares/entitlements, and average GVP per reporting fishing business. The report refers to the ongoing Business Adjust Program and economic analyses performed showing that most businesses to date were not “viable” (e.g. showing negative Return on Investment). This provided impetus to pursue the BAP to improve productivity of the sector. • “increased economic contribution from recreational fishing” through revenue from fishing fee -note: revenue is placed in trusts and funds are used to improve recreational fishing in NSW, including fishing enhancement, fishing education, habitat protection, research, fishing access and facilities, enforcement and repayment of loans to create recreational fishing havens. • “improved knowledge and understanding to support evidence-based management of fisheries resources” through assessment of stock status/overfishing • “sustainable access and use for Aboriginal fishers” through discussions with the Aboriginal Fishing Advisory Council • Marine estate: “healthy coast and sea, managed for the greatest well-being of the community, now and into the future” through assessment of community confidence in marine estate management. And “improved status of aquatic ecosystems, habitats and species” through fish assemblage condition metrics. • Compliance “an optimal level of compliance to maintain sustainable use and access of natural resources” through compliance levels for commercial and recreational fishing. • Mitigate and manage risks from use of land and water “shark management strategy” – n/a for fisheries • “Increase economic contribution from fishing and aquaculture” by comparing #fishing businesses and participation type/proportion across years, landings and GVP by fishery and by species • Also reports on number of trigger points met or exceeded, and not measurable. Not sure how this is useful without descriptions/context. • *There is no link between the performance report and adaptive management implications Information about DPI and its performance goals is only available at the departmental level. Specific divisional goals and metrics (e.g. for Fisheries) is not publicly available. DPI plays a key role in driving economic growth and increasing the value of primary industries in NSW. DPI will achieve this through a focus on two key strategic outcomes: • Economic growth through research and innovation to improve resilience, productivity and sustainability; and • Risks to community and industry managed and reduced. These will be supported by two key enablers:

		- Engage and collaborate, facilitating mutually beneficial relationships; and - Foster and innovative, commercially focused and collaborative department. By 2020, DPI programs and projects will have delivered on these three key measures: - Total Primary Industries output of \$20 billion by 2020; - Increased our stakeholder satisfaction score by 5%; and - Achieved 69% on our employee engagement score. Annual reports focus on high-level generic reporting for fisheries, with out of date data. The 2019 performance report reported on each of the 10 geographical/latitudinal areas of NSW with landings (tonnes), return average (\$) per tonne, and GVP aggregated across fishery types.
Assessment of NSW Fisheries – Prawn Trawl Fishery (2011) https://www.environment.gov.au/system/files/pages/37d1e9f6-cae3-4233-a1f7-0e6386a33224/files/estuary-prawn-trawl-assessment-2011.pdf	NSW	Assesses fisheries against the Australian Government’s Guidelines for the Ecologically Sustainable Management of Fisheries - 2nd Edition. -assesses every 5 years against EPBC Act conditions. Focusses exclusively on biological aspects, except where management arrangements for resource sharing may impact on stocks. For example,
Torres Strait Fisheries Act 1994 https://www.legislation.gov.au/Details/C2016C00677	TSPZ	The objectives to be pursued include acknowledging and protecting the traditional way of life and livelihood of traditional inhabitants, protect and preserve the marine environment, manage commercial fisheries for optimum utilisation, share the allowable catch with PNG in accordance with the Treaty, and have regard to promoting economic development in the TS area and employment opportunities for traditional inhabitants. <i>Note: no reference to ESD, but the objects embrace the dimensions of ESD in a more specified form.</i> <i>15A outlines that the Minister may determine a plan of management for a fishery, which must set out:</i> <i>(a) the objectives of the plan of management; and</i> <i>(b) measures by which the objectives are to be attained; and</i> <i>(c) performance criteria against which, and time frames within which, the measures taken under the plan of management may be assessed.</i>
Torres Strait Prawn Fisheries Management Plan 2009 https://www.pzja.gov.au/sites/default/files/tspf_management_plan_2009_with_amendments.pdf Torres Strait Prawn Fishery Handbook and Data Summary https://www.pzja.gov.au/resources/publications/torres-strait-prawn-fishery-handbook	TSPZ	Objectives of the Plan Objective 1 Ensure the optimum utilisation of the fishery resources within the TSPF is consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle. Objective 2 Promote economic efficiency in the utilisation of the fisheries resources within the TSPF. Objective 3 Ensure cooperative, efficient and cost effective management of the Fishery. Objective 4 Manage the fishery’s interaction with the marine environment including the incidental capture of non-target species and impacts on demersal habitats. Measures and performance indicators against numbered objectives. (1) Preservation of traditional fishing opportunities; develop an EMS limited to an ERA and bycatch reduction strategy; develop a research program; maintain a unit-based effort management system to control the sustainable level of effort in the fishery; maintain target stocks (Develop harvest strategy); continue a monitoring and surveillance

		(2) Develop indicators to assess the fishery (published in annual report); movement of licenses and effort units between operators (measured and included in annual report) (3) Effective consultation on issues that could affect traditional fishers (representation, min. two meetings); prepare annual budget and fees (budget in consultation with reps, and meet Gov cost recovery targets); maintain accuracy of records; monitor cost-effectiveness and compliance with TSPF arrangements; Increasing industry understanding of TSPF management, research and environmental matters (comms strategy, extension program to communicate achievements) (4) Monitor the impact of fishing practices on species and ecosystems (develop ERA, biological ref points, data collection); exclusion regimes that ensure critical habitat are protected (identified critical habitats are protected); ensure bycatch levels are sustainable, develop fishing gear to minimise impacts, support research on bycatch reduction PZJA and TSPMAC will, at least once every 5 years, assess the effectiveness of the Plan including the measures, and performance criteria. Each year TSPMAC will assess the extent to which the performance criteria have been met each year. PZJA will include in its annual report the extent to which the performance criteria were met in the year. PZJA will develop a timeframe and process for implementing appropriate management measures within specified timeframes for addresses failed performance criteria. The prawn fishery is the only cost-recovered fishery in the Torres Strait to cover certain costs of management, outlined in the Handbook and reported in the Annual Report.
Harvest Strategy for the Torres Strait Prawn Fishery 2011	TSPZ	The development of the Torres Strait Prawn Fishery Harvest Strategy 2010 was guided by the Commonwealth Fisheries Harvest Strategy Policy (2007). The objective of the Harvest Strategy Policy is the sustainable and profitable utilisation of Australia's Commonwealth fisheries in perpetuity through the implementation of harvest strategies that maintain key commercial stocks at ecologically sustainable levels and within this context, maximise the economic returns to the Australian community. The PZJA's priority for this harvest strategy is facilitate stability within the fishery. This will be facilitated through setting a short term harvest strategy target of BMSY and a TAE in line with this, with a long term target of BMEY which will be pursued when effort in the fishery increases (see section 6.1). This progression will be done within a flexible timeframe to help minimise financial pressures on the fishery and maximise stability. Measures and performance criteria for Tiger Prawn: Stocks: maintained or above Bmsy = B28 Economic: short-term Bmsy (see Social below), long-term Bmey, Social: TAE based on Bmsy = 9200 days (as long as it doesn't put pressure on stocks) *Note: annual effort has been set at 9,200 fishing days in the Australian jurisdiction of the Protected Zone. This is shared with Papua New Guinea through catch sharing arrangements under the Torres Strait Treaty: 75 per cent of the effort is allocated to Australian licence holders (6,867 fishing days) and 25 per cent is reserved for use by Papua New Guinea (2,333 fishing days).
Performance Reports PZJA Annual reports – PZJA activities including condition of fisheries https://www.pzja.gov.au/resources/publications/annual-reports Annual Data Summaries	TSPZ	PZJA Annual report documents catches (t), GVP (\$), fishing days (effort), condition of the fishery, licenses held by traditional inhabitants. Cost recovery is reported for the Prawn fishery, according to AFMA's modified CRIS model (reported in the the PZJA Annual report). Costs are partially recovered for data collection, facilitating consultation, engagement and governance forums, licensing administration, research and policy support.

Torres Strait Prawn Fishery Data Summary 2018 https://www.pzja.gov.au/sites/default/files/prawn_data_summary_with_cover_sheet_2018.pdf		

Table 19 Objectives, performance measures, and reporting practices for three Australian fisheries jurisdictions. The level of policy relates to L (Legislative), M (Management) and O (Operational)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
Jurisdiction		Commonwealth (national), managed by the Australian Fisheries Management Authority (AFMA)	New South Wales (state), managed by the Department of Primary Industries (Fisheries)	Torres Strait Protected Zone (joint management with Papua New Guinea), managed by the Protected Zone Joint Authority (PZJA)
The theme associated with Social objectives	Level of policy			
Economic benefits	H	Maximising the net economic returns to the Australian community from the management of Australian fisheries (Fisheries Management Act 1991)	(i) to promote viable commercial fishing and aquaculture industries; and (ii) to provide social and economic benefits for the wider community of New South Wales (Fisheries Management Act 1994); (ii) facilitates • economic opportunities for the people of New South Wales, including opportunities for regional communities (Marine Estate Management Act 2016)	(e) to manage commercial fisheries for optimum utilisation; (g) to have regard, in developing and implementing licensing policy, to the desirability of promoting economic development in the Torres Strait area and employment opportunities for traditional inhabitants (Torres Strait Fishery Act 1984)
	I	Maximising utilisation and productivity (To maximise the net economic returns to the Australian community from the management of the fishery, Commonwealth Fishery Policy Statement 2017); The status of economic efficiency of the Northern Prawn Fishery (Northern Prawn Fishery Management Plan 1995)	Contribute, in conjunction with other fishing regulatory controls, to promoting viable commercial fishing - there are net returns to the fishery (FM (Estuary Prawn Trawl Share Management Plan) Regulation 2006);	Promote economic efficiency in the utilisation of the fisheries resources within the Torres Strait Prawn Fishery (Objective 2: Torres Strait Prawn Fisheries Management Plan 2009)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	O	Maximising the net economic return from a fishery to the Australian community will in most cases be consistent with maximising the net economic returns from the commercial fishery. E.g. the welfare of the total 'economic community of Australia' (e.g. those who are returned an economic benefit from fishing) (Harvest Strategy Policy and Guidelines 2018); the operational objective of this Harvest Strategy is to attain long-term MEY from the tiger prawn fishery. For operational purposes, the objective of MEY can be considered equivalent to the objective of maximising the net present value of the flow of profits in the fishery over an indefinite period. For the NPF, MEY is assumed to be achieved over a seven-year period. The dynamic path to MEY is calculated as the effort level and associated catch in each year over a seven-year projection period that leads to a long-run sustainable yield that maximises profits over time (Harvest Strategy for the Northern Prawn Fishery 2014/2019).	1) Codend counts (number of individuals per half a kilogram) for eastern king or school prawns/Codend counts have been implemented to the satisfaction of the Director, NSW Fisheries.*Note. This is used as a proxy for a size restriction. 2) Median fishery-wide gross return to estuary prawn trawl fishers derived from commercial fishing in NSW/no KPI set to date 3) Average market value of estuary prawn trawl shares/No KPI set to date 4) Viability of the estuary prawn trawl fishery and its contribution to businesses of fishers therein/no KPI set to date (Estuary Prawn Trawl Fishery Management Strategy)	movement of licenses and effort units between operators (Torres Strait Prawn Fisheries Management Plan 2009); The PZJA's priority for this harvest strategy is facilitate stability within the fishery (Harvest Strategy for the Torres Strait Prawn Fishery 2011).

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	performance measure	1) The status of economic efficiency - currently based on Fishing effort (Ey/Emsy=1). The fishery is considered to be experiencing overfishing if Ey/Emsy is >1, meaning effort is exceeding what could be expected to maintain a sustainable stock size. (Harvest Strategy for the Northern Prawn Fishery 2014/2019)	Gross value of product (GVP) for commercial fisheries (trend). A review is triggered if the gross value of production of the fishery has not exceeded the sum of indicative industry operational costs and government management costs relevant to the fishery for three consecutive years (e.g. if GVP is less than total costs); net returns to the fishery (FM (Estuary Prawn Trawl Share Management Plan Regulation 2006)	This will be facilitated through setting a short-term harvest strategy target of BMSY and a TAE in line with this, with a long-term target of BMEY which will be pursued when effort in the fishery increases. (Harvest Strategy for the Torres Strait Prawn Fishery 2011). Number of allocated fishing days vs usage; GVP. Published in the annual report.(Torres Strait Prawn Fisheries Management Plan 2009)
	Performance reporting	#of statutory rights used; GVP; Fishing effort as proxy for MEY; net economic returns with commentary on effect of GVP and fuel prices on net economic return (AFMA annual report 2018-2019)	aggregated across fishery types by geographic region - not by individual fishery - with tonnes, return average of tonnes (\$) and GVP, without commentary on whether KPI is being met (DPI performance report 2019)	catches (t), GVP (\$), effort(fishing days) as proxy for MEY (PZJA Annual report)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
Social benefits	H	(c) the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; ensuring that the interests of commercial, recreational and Indigenous fishers are taken into account (Fisheries Management Act 1991); Resource sharing—equitable access among professional, recreational and Indigenous fishers to our shared marine resources; Rights-based fisheries management—through the use of statutory fishing rights, with a preference for individual transferable quotas, and fisheries managed using output controls; Maximising utilisation and productivity—we develop our fisheries and aquaculture to maximise the net economic return to the Australian community. (Commonwealth Fisheries Policy statement 2017) The ESD principles in AFMA’s legislation² that relate to social aspects in particular are: “decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations;” and “the principle of intergenerational equity – that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.” (AFMA Position Statement on social aspects of ESD 2019)	(i) to promote quality recreational fishing opportunities; (ii) to provide social and economic benefits for the wider community of New South Wales; and (iii) to recognise the spiritual, social and customary significance to Aboriginal persons of fisheries resources and to protect, and promote the continuation of, Aboriginal cultural fishing (FMA); (ii) facilitates • economic opportunities for the people of New South Wales, including opportunities for regional communities, and • the cultural, social and recreational use of the marine estate (MEMA)	(i) to acknowledge and protect the traditional way of life and livelihood of traditional inhabitants, including their rights in relation to traditional fishing, (ii) to administer the provisions of Part 5 of the Torres Strait Treaty (relating to commercial fisheries) so as not to prejudice the achievement of the purposes of Part 4 of the Torres Strait Treaty in regard to traditional fishing; (iii) to adopt conservation measures necessary for the conservation of a species in such a way as to minimise any restrictive effects of the measures on traditional fishing; (iv) to have regard, in developing and implementing licensing policy, to the desirability of promoting economic development in the Torres Strait area and employment opportunities for traditional inhabitants (Torres Strait Fisheries Act)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	I	Ensure equitable ensure equitable access to Commonwealth fisheries resources among commercial, recreational and Indigenous fishers, for the benefit of the Australian community (Commonwealth Fisheries Resource Sharing Framework 2020) None articulated by the management plan. Default position arises from the Harvest Strategy Policy and Guidelines: While the Harvest Strategy Policy does not outline the government's policy on resource sharing, where it is clear there is a significant non-commercial (recreational or Indigenous) interest in a fishery, the need to share the resources appropriately will be considered (Harvest Strategy Policy 2018). However, consistent with the role of these guidelines, the interest to be considered is confined to the economic benefit to the Australian community, e.g. allocation and of share in the fishery to different sectors, i.e. allocate shares in an optimal way (Harvest Strategy Policy Guidelines 2018, AFMA Position Statement on social aspects of ESD 2019). A number of less formalised and non-optimised approaches to allocation are also likely. However, because allocation is out of scope for the Harvest Strategy Policy, it is also out of scope for these guidelines. (Harvest Strategy Policy Guidelines 2018)	A fishery under the principles of ecological sustainable development is economically viable, using environmentally friendly fishing gear to provide fresh, high-quality seafood and bait to the community: 4. To appropriately share the resource and carry out fishing in a sustainable manner minimises social impacts 7. To improve the knowledge of the community about the operations and management of the Estuary Prawn Trawl Fishery 8. To improve the knowledge about the Estuary Prawn Trawl Fishery and the resources upon which the fishery relies. (Estuary Prawn Trawl Fishery Management Strategy);	To acknowledge and protect the traditional way of life and livelihood of Traditional Inhabitants, including their rights in relation to traditional fishing; Preservation of traditional fishing opportunities; movement of licenses and effort units between operators, Effective consultation on issues that could affect traditional fishers, Increasing industry understanding of TSPF management (Torres Strait Prawn Fisheries Management Plan 2009)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	O	None articulated in Resource Sharing Framework (although lists 'principles and processes') None articulated in Operational plan/Harvest strategy; The default position arises from the Harvest Strategy Policy and Guidelines 2018: Maximising the net economic return from a fishery to the Australian community will in most cases be consistent with maximising the net economic returns from the commercial fishery. E.g. the welfare of the total 'economic community of Australia' (e.g. those who are returned an economic benefit from fishing) (Harvest Strategy Policy and Guidelines 2018) Provide a secure supply of seafood now and into the future; Provide flow-on benefits to communities; takes interests of commercial, recreational and Indigenous fishers into account; provide for partnerships in managing the fishery, maintaining stakeholder trust, documenting and making information available about AFMA decisions (AFMA Position Statement on social aspects of ESD 2019)	1) Estimates by NSW Fisheries of the catch of target species for all sectors (including recreational and Indigenous/estimates available within three years from the commencement of management strategy 2) Annual reported landings from the commercial sector compared to estimates of unreported annual catch by the recreational and Indigenous sectors (excluding catches attributable to Recreational Fishing Havens)/the shift in relative landings and catch levels between sectors is on average 25% or less over five years 3) Annual reported landings of target species taken in the estuary prawn trawl fishery relative to those from the same estuary by other commercial fisheries/Relative landings levels between commercial fisheries shifts on average by 25% or less over five years *NB. The comments state explicitly that these indicators relates primarily to the objective of evaluating and managing equitable allocations between commercial fisheries (EPT Fishery Management Strategy); none articulated in Share Management Plan	PZJA's priority is to facilitate stability within the fishery. This will be facilitated through setting a short-term harvest strategy target of BMSY and a TAE in line with this, with a long-term target of BMEY which will be pursued when effort in the fishery increases. (Harvest Strategy for the Torres Strait Prawn Fishery 2011); Maintain a unit-based effort management system to control the sustainable level of effort in the fishery (Torres Strait Prawn Fishery Management Plan 2009)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	performance measures	none articulated in the fishery management plan; Provide a secure supply of seafood now and into the future/management systems in place such as AFMA's ecological risk management framework, bycatch strategies and harvest strategies; Provide flow-on benefits to communities/ maximising net economic return from fishery; takes interests of commercial, recreational and Indigenous fishers into account/via partnerships (see below) provide for partnerships in managing the fishery/maintain key engagement forums such as management advisory committees, resource assessment groups, expert working groups, public consultation, and meetings, developing co-management arrangements, maintaining stakeholder trust/engaging appropriately with stakeholders, delivering impartial and responsive management, ensuring advice is accurate and timely, and decisions are made with integrity (AFMA's Client Service Charter) documenting and making information available about AFMA decisions/Copy of decisions available on AFMA website, published data on fisheries catch at data.gov.au; The statement will be reviewed at least every five years and more frequently as	none articulated in the share management plan	Social: TAE based on Bmsy = 9200 days (as long as it doesn't put pressure on stocks) Annual effort has been set at 9,200 fishing days in the Australian jurisdiction of the Protected Zone. This is shared with Papua New Guinea through catch-sharing arrangements under the Torres Strait Treaty: 75 per cent of the effort is allocated to Australian licence holders (6,867 fishing days) and 25 per cent is reserved for use by Papua New Guinea (2,333 fishing days). (Harvest Strategy for the Torres Strait Prawn Fishery 2011); Effectiveness of the effort-based management and evaluation of alternative management strategies if required, Effort in the fishery successfully manipulated as a result of stock assessment and other scientific advice (including levels of interactions with traditional fishery species and bycatch species) via variations in the unit system (Torres Strait Prawn Fishery Management Plan 2009)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
		required (AFMA Position Statement on social aspects of ESD 2019)		

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	Performance reporting	Innovations section of the report outlines joint economic/social and administrative benefits to the co-management arrangement of the NPF: "These co-management measures add value to the management of the fishery and are cost-effective for industry and AFMA. They increase stewardship outcomes in the fishery and provide valuable information which will enhance future management decisions" but are not a performance criteria per se. (AFMA annual report 2018-2019) AFMA Annual reports	measures not reported in DPI Fisheries status of fish stocks reports, annual reports or other forms of reporting	fishing days (effort), licenses held by traditional inhabitants (PZJA Annual report 2018-2019)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
Good governance	H	(i) implementing efficient and cost-effective fisheries management on behalf of the Commonwealth, (ii) ensuring accountability to the fishing industry and to the Australian community in AFMA's management of fisheries resources, (iii) achieving government targets in relation to the recovery of the costs of AFMA (Fisheries Administration Act, Fisheries Management Act 1991)	to conserve, develop and share the fishery resources of the state for the benefit of present and future generations (Fisheries Management Act 1994); environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems (Protection of the Environment Administration Act 1991).	To share the allowable catch of relevant Protected Zone commercial fisheries with Papua New Guinea in accordance with the Torres Strait Treaty (Article 22 and 23, Torres Strait Treaty)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	I	That the objectives pursued by the Minister in the administration of the Act, and by AFMA in the performance of its functions, are met in relation to the Northern Prawn Fishery To implement efficient and cost-effective fisheries management of the fishery on behalf of the Commonwealth. To ensure AFMA's accountability to the fishing industry and to the Australian community in the management of the resources of the fishery To reach Government targets for the recovery of the costs of AFMA in relation to the fishery To ensure the best use of the living resources of the fishery To ensure that conservation and management measures in the fishery implement Australia's obligations under international agreements that deal with fish stocks, and other relevant international agreements To ensure, as far as practicable, that measures adopted in pursuit of these objectives are not inconsistent with the preservation, conservation and protection of all whale species (Northern Prawn Fishery Management Plan 1995)	To appropriately share fisheries resources between the users of those resources, To ensure cost-effective and efficient management and compliance in the Estuary Prawn Trawl Fishery (Estuary Prawn Trawl Fishery Management Strategy 2003);	Ensure cooperative, efficient and cost-effective management of the Fishery (Torres Strait Fisheries Management Plan 2009)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	O	the cost-effectiveness of the management arrangements for the Northern Prawn Fishery (Northern Prawn Fishery Management Plan) encourage regulators to undertake their functions with the minimum impact necessary to achieve regulatory objectives and to effect positive ongoing and lasting cultural change within regulators (Australian Government Regulator Performance Framework)	1) Rate of compliance of the estuary prawn trawl fishery in respect to (i) overall and (ii) "share forfeiture offences" under the share management plan/overall compliance is more than 85% 2) Number of Estuary Prawn Trawl MAC meetings held each Year/More than 2 per calendar year 3) Occasions when this management strategy is in direct conflict with other approved Commonwealth or State programs/Any occasion when the Director, NSW Fisheries determines that the MS is consistent with other programs 4) [Cost of managing the fishery]/TBD (EPT Fishery Management Strategy); none articulated in share management plan.	Effective consultation on issues that could affect traditional fishers (representation, min. two meetings); prepare the annual budget and fees (budget in consultation with reps, and meet Gov cost recovery targets); maintain the accuracy of records; monitor cost-effectiveness and compliance with TSPF arrangements; Increasing industry understanding of TSPF management, research and environmental matters (communications strategy, extension program to communicate achievements (Torres Strait Prawn Fisheries Management Plan 2009)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	performance measure*	Research plan (cost-effective and high-quality research contributing to TAC, management measures and stock assessments) Data collection (data collected and verified to enable management measures) Statutory fishing rights (granted to eligible persons) Fishing concessions (access to fishery limited through #concessions) Management measures (consistent with international agreements; comm fishing activity monitored and responses implemented as appropriate) Total Allowable Catch (setting of TAC) Catch (concession holders do not fish in excess of entitlements) Cost recovery (levies and fees) Communication and accountability (stakeholder satisfaction with the management of fishery, including information availability and timely communication; develop comms strategy) Consultation (advisory committees consulted in development of the budget) Fishery budget (budgetary objectives achieved) Cost-effectiveness (periodically assessed) (indicators drawn from AFMA's chapter in the Agriculture and Water Resources 2018-2019 Portfolio Budget Statements p.248 and AFMA's Corporate Plan for	1) Estimates of catch of target species for all sectors (including recreational and Indigenous)/estimates must be available within 3 years of commencement of the management strategy 2) Reported landings for all sectors/shift in relative landings and catch levels between sectors must be on average less than 25% over five years (EPT Fishery Management Strategy); none articulated in share management plan. For the purposes of section 57 (2) (b) of the Act, a review of this Plan is required in the circumstances provided for in Column 3 of the Table to this clause next to the objective and performance indicator concerned (EPT Share Management Plan Regulation); A comprehensive review of the appropriateness of all performance indicators and trigger points will be carried out not more than two and a half years from the commencement of the management strategy, in consultation with the Estuary Prawn Trawl MAC. This will occur in addition to the preparation of the annual performance report that reports on whether performance indicators have breached corresponding trigger points. If the performance report identifies an inappropriate performance indicator prior to the two and half year review it can be addressed accordingly at	Consultation with traditional inhabitant communities Number of meetings and member composition (minimum two TSPMAC meetings/yr) Fishery budget Review of logbooks Review of recommendations in compliance risk assessment Development of a communications strategy Development of extension program (Torres Strait Prawn Fisheries Management Plan 2009) PZJA and TSPMAC will, at least once every 5 years, assess the effectiveness of this Plan, including the measures taken to achieve these objectives, by reference to the performance criteria set out in subsection (1); (3) Each year, TSPMAC will assess the extent to which the performance criteria have been met in that year.; (4) PZJA will include in its annual report for a financial year a statement of the extent to which the performance criteria were met in the year; (5) PZJA will develop a clear process and timeframe for determining the reason for failing to meet a performance criterion and implement appropriate management measures within specified timeframes. (Torres Strait Prawn Fisheries Management Plan 2009)

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
		2018-2019 p.7 and reported in the AFMA Annual Report) The RPF contains six indicators against which regulators are to measure their performance: regulators do not unnecessarily impede the efficient operation of regulated entities, communication with regulated entities is clear, targeted and effective, actions undertaken by regulators are proportionate to the regulatory risk being managed, compliance and monitoring approaches are streamlined and coordinated, regulators are open and transparent in dealing with regulated entities, regulators actively contribute to the continuous improvement of regulatory frameworks. (Australian Government Regulator Performance Framework)	this stage. (EPT Fishery Management Strategy)	

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
	performance reporting	Research plan (cost-effective and high-quality research contributing to TAC, management measures and stock assessments) Data collection (data collected and verified to enable management measures) Statutory fishing rights (granted to eligible persons) Fishing concessions (access to fishery limited through #concessions) Management measures (consistent with international agreements; commercial fishing activity monitored and responses implemented as appropriate) Total Allowable Catch (setting of TAC) Catch (concession holders do not fish in excess of entitlements) Cost recovery (levies and fees) Communication and accountability (stakeholder satisfaction with the management of the fishery, including information availability and timely communication; develop comms strategy) Consultation (advisory committees consulted in the development of the budget) Fishery budget (budgetary objectives achieved) Cost-effectiveness (periodically assessed) (AFMA Annual Report) Self-assessment of performance indicators related to the Australian	shifts in catch rates of target species between commercial and other sectors, trigger points related to compliance and administrative matters, progress with implementation of management (Fishery Management Strategies Performance Report 2004); revenue contributions from commercial and recreational fees, access by all sectors including Aboriginal fishing, assessments of community confidence, condition of fishing stocks, compliance, participation rates in fishing sectors, reports on triggers met or exceeded (2014-2015 Highlights and Statistics report); landings (t), return average per tonne (\$/t) and GVP (\$) aggregated across fishery types by geographical area (DPI Performance, Data and Insights Report 2018, 2019); sustainability of stock, measured via CPUE, landings and environmental models (Status of Australian Fish Stocks Reports).	Consultation with traditional inhabitant communities, Number of meetings and member composition, Fishery budget Review of logbooks, Review of recommendations in compliance risk assessment, Development of a communications strategy, Development of extension program, cost recovery (PZJA Annual report).

		Northern Prawn Fishery	NSW Estuary Prawn Trawl Fishery	Torres Strait Prawn Fishery
		Government's Regulators Performance Framework (AFMA's regulatory Performance Framework 2019-2020)		

Supplementary Materials 3

Chapter 3 Materials

Public benefits identified in literature, public policy and by informants

Table 20 Public benefits identified in Australian public policy and domestic literature

Identified Benefit/Beneficiary	Source
○ Maintenance of supporting marine ecosystem function and integrity (Fletcher et al 2012; ○ Indigenous Peoples' cultural rights and interests (Schnierer and Hagan 2015; Lee 2019); ○ Defined benefits to society (community 'net' benefits) due to the public nature of the resource (Andersen et al. 2015; Bromley 2009; Squires, Weber et al. 2018); ○ Defined benefits to resource users, including: livelihood opportunity for commercial fishers (Brooks et al. 2015); economic returns to commercial fishers (Grafton, Kompas et al 2012; Ridge Partners 2009); quality of recreational experience (Arlinghaus 2004; Hunt and Sutton 2013); and ○ local consumer benefits from provision of locally-produced seafood (McClanahan, Allison et al. 2015). – including health benefits from seafood consumption and quality ○ *distributed benefits ○ *intergenerational equity ○ *existence values	Ogier et al. (2020a)
economic benefits: ○ indirect (intrinsic and bequest values) ○ viability of businesses ○ direct economic values social benefits: ○ participation (safety, health and wellbeing) ○ community enjoyment (relaxation, socialising) ○ enjoying biodiversity and beauty ○ consumptive use	NSW Threat and Risk Assessment (BMT WBM, 2016)
○ Community economic benefits: ○ Employment, supply of seafood and economic benefits	Environmental Impact Statements ("Lobster environmental impact statements (eis) ", 2004)
○ Marine ecosystem function and integrity is maintained ○ Threatened, populations and ecological communities are protected ○ Target stocks are maintained or enhanced ○ Long-term viability of commercial fishing businesses ○ Social cohesion (Resources are shared in a way that minimises negative social impact) ○ Effective and efficient compliance, research and compliance (transparency, appropriateness) ○ Improved knowledge	Fishery Management Strategy (NSW Department of Primary Industries, 2007)
○ Marine ecosystem function and integrity is maintained ○ Target stocks are maintained or enhanced	Share management plan (NSW Government, 2000)

○ Relevant information is used to make decisions on the stock ○ Cost-efficient management is used to administer the fishery (beneficiary: fishers, community)	
○ to conserve fish stocks and key fish habitats, and ○ (b) to conserve threatened species, populations and ecological communities of fish and marine vegetation, and ○ (c) to promote ecologically sustainable development, including the conservation of biological diversity, and, consistently with those objects— ○ (d) to promote viable commercial fishing and aquaculture industries, and ○ (e) to promote quality recreational fishing opportunities, and ○ (f) to appropriately share fisheries resources between the users of those resources, and ○ (g) to provide social and economic benefits for the wider community of New South Wales, and ○ (h) to recognise the spiritual, social and customary significance to Aboriginal persons of fisheries resources and to protect, and promote the continuation of, Aboriginal cultural fishing.	NSW Fisheries Management Act (NSW Government, 1994)
○ Supports community economies (revenue, employment, relationships) ○ Provision of seafood ○ Provision of safety services (search and rescue) ○ Maintaining and providing skills training ○ Transfer of environmental knowledge ○ Environmental stewardship ○ Participation in management of the resource and decisions ○ Contributing to community life – provisioning culturally important events, other contributions ○ Continuing sense of place and identity, including historical identity ○ Maintaining infrastructure and supplies for public (bait, jetties)	Voyer et al. (2016)
○ Positive community perceptions	Brooks (2011a)
○ Effective and efficient compliance, research and compliance (transparency, appropriateness)	(Productivity Commission, 2016)
○ Social licence ○ Marine ecosystem function and integrity is maintained ○ Threatened, populations and ecological communities are protected ○ Target stocks are maintained or enhanced ○ Long-term viability of commercial fishing businesses ○ Social cohesion (Resources are shared in a way that minimises negative social impact) ○ Effective and efficient compliance, research and compliance (transparency, appropriateness) ○ Improved knowledge	(Hobday et al., 2019a)

Summary of benefits and flows of the NSW eastern rock lobster fishery

Table 21 Summary of benefits and flows of the NSW eastern rock lobster fishery

	Beneficiary				Net benefit
<i>Benefits</i>	Commercial	Recreational	NSW Public	Aboriginal Communities	
Economic and social wellbeing	Fishers' economic wellbeing appears to be increasing, but the distribution of beneficiaries has decreased since shares were first allocated, and likely will continue to decrease without intervention (i.e. the distribution of the benefit will contract). Short term economic viability is high and has increased substantially through share management and reform process because of the efficiencies and innovations that occur through output controlled systems. However, longer term viability may be impacted for some fishers as they age out of working as fishers, and have to modify their business operations. Fishers typically have diversified business interests which may buffer market volatility, such as that experience more recently in the COVID-19 pandemic. Social wellbeing is high, with strong networks amongst fishers that enable economic and social transactions, however, if consolidation of the industry and entry continues to be limited, networks will be impacted as fishers begin to exit active fishing. Skill transfer will also diminish with less fishers in the industry. How sense of place and identity, and connection to community, is maintained can't be predicted but is likely to have an effect.	Social wellbeing is a benefit received through recreational fishing activities and is likely to remain steady as long as recreational fishers continue to be granted access to the resource. Recreational fishers appear to have a strong sense of place and identity with specific locations.	A dominant narrative across respondents was that the RL support local community wellbeing through provision of services such as search and rescue and materials for community events, employing locals, and contributing to local economies as a business. However evidence also shows that as fishing businesses become more integrated, less of the downstream social and economic benefits flow into the local community. Less employees, less use of other services like mechanics, gear makers, ice, freight, boat sales, less retail presence. Therefore, the benefit may decrease through time as less fishers interact with local economies.	Other sources indicate that cultural fishing is still as relevant today as it has always been. The cultural catch remains an important source of food and is a means for the barter of goods and services. Cultural fishing is also seen as a potential source of revenue, as well as a mechanism for maintaining connections within and between families and the rest of the community. Cultural fishing plays an important role in the maintenance of traditional fishing knowledge (TFK)." Schnierer 2011. The RL fishery could potentially contribute to both social and economic wellbeing, however, information is currently insufficient to support this statement. First people have difficult accessing RL for cultural practices, or, are penalised for taking RL for cultural practices without appropriate permits.	Output controls (ITQ) promote efficiency, innovation and investment in the fishery, which generate maximum economic returns. Consolidation, from a business point of view, ensures greater economic return in a limiting resource. Economic benefits are consistently returned to a select group of commercial fishers, but few other beneficiaries benefit economically from the rock lobster fishery (d). In fact, the distribution of economic benefits has contracted through time and is likely to continue, leaving benefits to be accrued by a minority of fishers (i). Social benefits are enjoyed more widely across a range of beneficiary groups than economic benefits, and have potential for a wider distribution.

Cohesion	The experience of ITQ in the RL fishery, including the method of representation and advocacy for reform, benefits the public through stock rebuilding and increased availability to all sectors (rec, commercial, Aboriginal). Cohesion amongst commercial fishers was maximised through the reform process (ie. since the collapse in the 1980s/1990s) and also the relationships between fishers, management agencies and political persona has benefited commercial RL fishers through time. But now that the fishery has recovered, the representation may not serve long-term decisions for the future of the industry.	Representation and advocacy processes have enabled positive benefits with the rec sector. However, delay of decisions related to the proportional allocation of the annual catch (and determinations around bag limits and sizes) indicate a diminishing benefit to recreational fishers.	Public policy supports sharing of the resource amongst various sectors, and the objects of the FM Act specify a range of beneficiaries and types of benefits. Through the policies and procedures in place, the wider community are given opportunity to contribute to decisions on the RL fishery. The benefit is not large, but it has a large distribution, and the benefit is likely to be maintained into the future due to its statutory requirement.	The targeted Aboriginal role on the RL Working Group has been vacant for some time. It appears that the representative process has not worked well and that the benefit is not adequately being delivered to this beneficiary. There are also some concerns from other users regarding how native land title claims may interact with quota and allocations. This has not yet been discussed in Lobster working group forums. However, there are many opportunities to improve cohesion and reduce negative social by exploring some of the potential solutions such as... (see above).	The method of representation and participation in decision making served an important purpose in recovering the fishery from collapse. It encouraged collaboration and agreement on resource sharing to all sectors. However, resource sharing, although promoted in principle, has not been adequately supported with evidence or consultation, particularly in the case of Aboriginal communities (d). Given that the decision making focus of fisheries policies has been on stock-rebuilding, now that the resource has recovered, the representation may not serve long-term decisions for the future of the industry (i). Additionally, newer issues such as native land and sea title claims may affect cohesion if not adequately addressed. There is great potential to improve cohesion through a range of options presented by Aboriginal communities that could provide additional community benefits to recreational and wider community (d).
Quality opportunities	The lifestyle of RL is flexible and enjoyable, but entry to this lifestyle is limited (opportunity and cost). The opportunity to catch will remain, but the quality of opportunity may diminish, as may the distribution of benefits to commercial fishers into the future.	The fishing experience is enjoyable, yielding a perceived large benefit to rec fishers. Rec fishers perceive some of the benefit has been traded-off between size and taste, diminishing the benefit to some.	Evidence in supporting documentation demonstrates that NSW residents expect to have a connection to fishing industries when they visit, such as watching fishers work, or working in a local fishing industry. Benefits are diminishing to the wider community as RL fishing businesses move to more integrated models, with less fishers fishing from 'local ports' or employing locals in their businesses, reducing the opportunity for community to engage and get enjoyment.	Evidence in supporting documentation indicates that there are limited benefits to First People from the RL fishery. In 2010 there were 7 cultural permits issued with an unknown take, and in 2017-2018 a permit was issued for 150 lobsters. No other permits have been recorded. There is opportunity to explore aquaculture opportunities to enhance and supplement cultural fishing practices.	Quality fishing opportunities are or have been experienced by a range of beneficiaries, and the opportunity to catch is likely to remain. However, the quality of the experience appears to be absent or diminishing in the commercial sector particularly for younger fishers, Aboriginal people, new entrants or those associated with fishing-related services in the wider community (d). The community's enjoyment may diminish as fishing businesses engage less with local communities through services or

					through local economies (i). There are limited opportunities for Aboriginal people to engage in commercial fishing due to the cost of entry, and cultural fishing opportunities are not easily accessible to local communities, or, policies and practices are directly harming cultural practices. Opportunities exist to expand aquaculture opportunities to supplement and enhance cultural fishing opportunities.
Assurance	The research on the recruitment and harvestable biomass of lobster has been important for establishing quotas and the biological sustainability limits of the fishery. This research is funded by way of commercial fishers' management fees, and with the new harvest strategy will allow fishers to self-regulate/self-determine increases in line with Harvest Strategy Rules. How management fees are specifically allocated is not currently provided, which limits an understanding of management cost to benefit and appropriateness of management fees/cost-recovery processes.	Rec fishers acknowledge that information collected and used for the commercial fishery has a benefit for allocating a portion of the resource to rec fishers. Rec fishers are calling for more precise information on rec fishing effort to inform any TAC adjustments, potentially increasing the benefit to rec fishers. However, this information also incurs a cost which would need to be balanced with the potential benefit. Additionally, the delay of decisions related to the proportional allocation of the annual catch (and determinations around bag limits and sizes) indicate a diminishing benefit to recreational fishers.	Information available to the community is limited. As a result certain communities have negative or positive impressions of RL fishing rooted in perceptions rather than evidence. Reports such as the annual allowable catch determination don't reflect the types of benefits the community is interested in, only the benefits to commercial fishers. Further, regular performance reports on the broader objectives of the fishery are lacking (the last full report was in 2014-15). "The public was keen to support and 'see' the Australian industry and overall did not feel like the resource is in jeopardy". Voyer 2016 Commercial fishers contribute an annual levy towards the management of the resource (a community contribution) however it is not clear how this levy is used to support community benefits.	Other sources comment that the dearth of published information on the species harvested and habitats used by Aboriginal fishers to date has contributed to a general lack of awareness of the Aboriginal harvest as a distinct fishery, with important similarities and dissimilarities to the other sectors. The lack of information has also contributed, in part, to the development of fisheries management measures that have been inadequate in addressing the special nature and place of Aboriginal fisheries as the first fishery in NSW (Schnierer and Egan 2011).	Research and data on stock recruitment and commercial catch has provided critical information on which to restore the fishery. Such data was authorised and paid for by commercial fishers for their benefit, and for the benefit of the other sectors who share in the resource. Despite this, the lack of transparency related to regular performance reporting, including reporting on the use of management fees and community contributions, does not provide beneficiaries with assurance that management is effective and efficient in delivering benefits as stated in the Act to all beneficiaries (d). The ongoing lack of data collection on other sectors, or data provision beyond basic biological and economic data, is seen as a significant disbenefit to future beneficiaries (i). Research related to climate change impacts is beginning, however, not yet incorporated into decisions.
Conservation	The experience of ITQ in the RL fishery benefits the public through stock rebuilding and increased availability. RL are increasingly abundant, but their local	Rec Fishers are positively benefiting from the management regime, and the presence and abundance of the stock of RL. Recreational fishers have a strong sense of place, resulting in a sense of	The community benefits from the stewardship of the resource by fishers that protects ecosystems and maintains the presence of RL, however, there are varied	Policies and practices of the fishery are insufficient to address RL as a culturally significant species, and support rules for its harvest.	Managing the fishery through catch shares benefits the public through stock rebuilding and increased availability to all sectors (rec, commercial,

	presence/regional distribution may be changing due to climate change. Fishers will be able to continue to harvest a well-maintained stock, but benefits are not uniformly distributed to beneficiaries in various areas of the NSW coast because of natural conditions of where stock are more prevalent and where their sizes are more economically valuable. Compliance is an issue because of such a high value resource, but compliance practices (tagging) and regulations are strongly supported despite the occasional bad experiences with compliance personnel. Commercial fishers are using innovation to minimise interactions with threatened species such as sea turtles and whales ensure the maintenance of ecosystems in targetting rock lobster. Consolidation of businesses and reduction in employed fishers may affect how environmental knowledge is transferred to other fishers and whether stewardship continues to be a prominent value amongst commercial fishers (e.g. as owners are further removed from day to day operations of fishing and the local area results in a lower perception of environmental value of the area). Some commercial fishers are concerned about water quality impacts, but don't see that they have a role in that.	maintaining the ecosystem. Compliance with bag limits may be affected into the near future, resulting from a conflict between rec fisher advocacy to increase bag limits due to RL population expansion.	perceptions amongst the wider public on whether compliance and stewardship are sufficient to protect RL and its ecosystem. Some studies demonstrate that the community perceives the industry to be sufficiently protecting the resource, but, overall, there is low confidence in NSW marine management.		Aboriginal)(d). Fishers will be able to continue to harvest a well-maintained stock, but the distribution of benefits may contract depending on changes in the patterns of RL presence along the coast (i). The cultural and intrinsic values of RL and the broader ecosystem are supported in principle through statutory arrangements, however more work needs to be done understand how to maintain the cultural significance of lobster for Aboriginal people.
Local seafood	The NSW RL fishery provides a reliable local (NSW-based) luxury product to consumers. Product is sold live so food safety is less of an issue, however, quality (size and intactness) is something that fishers consider important aspects of their product. Fishers harvest and market their product to maximise availability for important Australian	Rock Lobster provides a reliable and enjoyable source of seafood for local recreational fishers. However, delay of decisions related to the proportional allocation of the annual catch (and determinations around bag limits and sizes) indicate a diminishing benefit to recreational fishers.	RL is a desirable but not affordable seafood product. Benefits accrue to more affluent members of communities, potentially across the state, but more likely in larger cities such as Sydney.	Benefits are limited to First People: First people have difficult accessing RL for cultural practices, or, are penalised for taking RL for cultural practices without appropriate permits.	The NSW RL fishery provides a reliable local (NSW-based) luxury product to consumers. Benefits accrue to commercial and recreational fishers, with limited flow to some members of the wider community (d). With a strong international market, commercial fishers are likely to continue to realise benefits from

	cultural events such as Christmas and Chinese New Year.				a range of consumers, however, with increasing direct-to-export market, benefits to local consumers and Aboriginal communities and are unlikely to increase under existing policy and management arrangements (d,i).

Supplementary Materials 4

Chapter 4 Materials

Characteristics of each hypothetical management option

Table 22 Descriptions of hypothetical management options proposed in the study, differentiated by the different access, monitoring/surveillance and biological limits. SSS = size-sex-season regulations for the fishery which prohibit the harvesting of the species

	Access	Monitoring	Biological Limits
Status Quo/ Baseline	Free License for each fisher and/or boat; allocated per individual fishery and per province; registry closed since 2014. New licenses are released after retirement.	Vessels >15m fitted with GPS; Vessels >12m have landings weighed/checked at accredited stations; Landings checked at port or at sea for complying with SSS regulations	Nominal biological limit which is not enforced.
Certification (market-based, like MSC), including increased transparency measures	Voluntary participation. Must meet third-party accreditation criteria. Requires financial contribution to participate/become accredited. Due to biological limits criteria, accreditation is undertaken on the whole-fishery level rather than by individual operators.	Initial accreditation criteria must be met. Ongoing accreditation is required. All vessels within the fishery are fitted with GPS and required to weigh in at accredited stations.	MSC accreditation relies on restricting fishing within biological limits. Accreditation is therefore done on a fishery basis
Marine Management Areas	Access is granted to groups of fishers (self-defined) for a particular region; the fishing portfolio can consist of agreed species	Self-monitoring to exclude outsiders; Auditing of activity by government officials	Catch restricted to those within the management area and any other limits the managers impose on themselves
Quota – individually allocated catch shares	Access is granted to those with an allocation. The allocation could be granted by individual fishers or by vessel.	Increased monitoring is required to ensure SSS and individual limits are enforced	Catch restricted
Opening RPA	Increased access to the fishery by individual fishers and/or by vessels in addition to the retirement allocation process.		

Closures	Closure of particular areas restricts fishing to those with site fidelity.		Catch restricted in certain areas or during periods important in centolla life history.
Total Allowable Catch (global quota)		Increased monitoring is required to ensure SSS and total limits are maintained.	Catch restricted
Quota – Community-allocated Catch Shares	Access is granted to groups of fishers (self-defined) with an allocation.	Self-monitoring within the group to comply with group limits. Auditing is required to ensure SSS and group limits are maintained.	Catch restricted

Survey instrument

Instrumento de la encuesta

Opciones De Manejo Para La Pesquería Centolla

Mi nombre es Carla Sbrocchi. Soy un estudiante en la Universidad de Tecnología de Sydney, en colaboración con el Centro de Investigación Dinamica de Ecosistemas Marinos de Altas Latitudes (IDEAL) de la Universidad Austral de Chile . Estoy investigando el impacto de los cambios propuestos en el manejo de las pesquerías de centollas en la región de Magallanes para los pescadores, las comunidades costeras, la industria pesquera y los consumidores, y agradecería su ayuda. La investigación incluirá una entrevista individual y no debería tomar más de una hora de su tiempo. Le he pedido que participe debido a su participación en la industria , su rol en la administración o porque ha publicado trabajos relacionados con este tema. Esta investigación contribuye a mis estudios en ciencia pesquera. No tiene ninguna obligación de participar en esta investigación.

☐ Opciones De Manejo Para La Pesquería Centolla

☐ Información de la entrevista

FECHA	
HORA	
UBICACION	

☐ Invitación enviada	☐ Permiso recibido para tomar fotos (s)
☐ Hoja de información dada	☐ Foto (s) tomada (s)
☐ Consentimiento recibido	

☐ **Información del participante**

Nombre	
Género (M / F)	
Años	
Dirección actual / lugar de residencia	
Categoría de Ocupación A. Administración pesquera B. Fiscalizador (Cumplimiento) C. Intermediario D. Investigador académico E. ONG, conservación F. Pescador artesanal G. Procesador H. Representante de sindicato	
Título del puesto	
Número de teléfono	
Correo electrónico	

☐ **Sección B: Solo para pescadores**

1. Describe tu relación con la pesca artesanal en la región?
2. ¿Por qué estás involucrado en la industria pesquera?
3. ¿Eres de aquí?
4. ¿Dónde vives cuando no estás pescando?
5. En la pesquería de centolla ¿Trabajas de manera permanente o temporal? ¿Tiempo completo medio Tiempo?
6. ¿En qué pesquería has trabajado?
7. ¿Tienes trabajo fuera de la pesca? ¿Participas en otra actividad fuera de la pesca?
 - i) (0) NO (1) SÍ
 - ii) Si la respuesta es SÍ, ¿cuántas otras posiciones tiene (no pesque)?
8. _____ (número)
9. _____ (sector de trabajo)
10. _____ (permanente o temporal)
11. ¿Crees que tu trabajo en la pesca es estable?
 - a) ¿Por qué?
 - b) Si no es estable, ¿qué te haría sentir estable?

c) ¿Por qué?

12. Estimación de los ingresos

d) Pesca _____

e) Si no conoce el monto exacto, calcule cuánto paga normalmente de un día o trabajo promedio o de un viaje de pesca (cantidad de pago y cantidad de días o semanas)

f) De otras fuentes no relacionadas con la pesca, si corresponde _____

g) Si no conoce el monto exacto, calcule cuánto paga normalmente por un día laboral promedio (cantidad de pago y cantidad de días que trabaja en este trabajo)

h) ¿Su trabajo (s) cubre los gastos del hogar? i) (0) NO (1) SÍ

i) Cantidad de tiempo dedicado a la pesca en centolla por año (normalmente)

13. Información laboral

14. ¿Qué tipo de bote trabajas? (transporte o extracción)

15. ¿Eres el dueño del barco en el que trabajas? (0) NO (1) SÍ

16. ¿Es dueño del equipo de pesca con el que trabaja? (0) NO (1) SÍ

17. ¿Cómo se paga el uso del barco?

18. ¿Cómo se paga el mantenimiento del barco y el equipo?

19. ¿Dónde está el equipo almacenado en la temporada baja?

20. Nombre del puerto de partida principal _____

21. Nombre del puerto de aterrizaje principal _____

22. ¿Cuánto cuesta la licencia de RPA?

23. ¿Cómo y cuándo se paga?

24. Percepciones de las condiciones de trabajo: califica en la escala a continuación

a) de los pescadores (salud y seguridad) _____

b) De los empleados de las plantas de procesamiento (salud y seguridad)

-2 (muy mal) -1 (algo malo) 0 (neutral) +1 (bien) +2 (muy bien)

c) ¿Por qué le das esta calificación?

25. Describe cómo ha cambiado la captura de centolla en los últimos tres años.

(disminución continua, variación, aumento continuo, etc.)

26. Describe la zona de pesca donde pescas centolla.

27. Describe cualquier cambio en el lugar donde tomas centolla, en los últimos 3 años.

28. ¿De qué otras maneras te ha afectado el cambio en la captura?

29. Califica el impacto de los cambios en la captura sobre ti _____

-2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bueno)

30. Si tienes otro trabajo, ¿te afectarán los cambios en la pesquería de centolla?

31. Por favor describe cómo te sientes acerca de lo siguiente

TARJETA

32. Operaciones

Numero de embarcaciones que tiene _____

Numero de personas que tiene a su cargo _____

33. Costo por viaje _____

34. Utiliza Adelanto o “habilitación” para iniciar la faena

(0) NO (1) SI

35. ¿Con quien realiza la transacción?

36. ¿Mantiene algún registro de sus capturas y desembarques?

(0) NO (1) SI

En qué forma si responde que si

☐ **Sección C: Para los sindicatos de pesca**

1. ¿Cómo funciona el sindicato de pesca?
 2. ¿Cómo ganas miembros?
 3. ¿Cuánto cuesta la cuota sindical?
 4. ¿Cómo se financia la unión?
 5. ¿Cuál es la relación entre la unión y la administración (gobierno)?
 6. ¿Qué ofrece el sindicato a sus miembros?
-

☐ **Sección D: Para ONG y organizaciones de investigación**

1. Describa cómo su organización está involucrada en la pesca artesanal de centolla
 2. Describa su experiencia personal o participación con la pesquería de centolla
 3. ¿Cuáles son sus percepciones sobre los cambios en el stock de centolla en los últimos tres años?
 4. La tendencia en los cambios aumenta, no cambia, disminuye
 5. La causa de los cambios
 6. En su opinión, ¿qué investigación se necesita para administrar mejor las existencias de centolla?
 7. En su opinión, ¿qué acciones se requieren para administrar stock de centolla?
 8. ¿Cuáles son las interacciones entre los actores de la pesquería? ¿Cómo crees que se está implementando tu consejo con los actores presentados en la tarjeta?
-

☐ **Sección E: Preguntas para Sernapesca**

1. ¿Cuáles son los desafíos actuales para la aplicación en la pesca de centolla?
 2. Bajo las reglas actuales de fiscalisation, ¿qué acciones están permitidas para tratar infracciones?
 - Multas
 - Exclusión
 - Confiscación del barco
 - Otro
 3. ¿Qué estrategias usas para abordar el cumplimiento?
 4. ¿Qué mejoraría tu habilidad para hacer cumplir?
 5. ¿De dónde provienen los fondos para sus actividades?
 6. ¿Qué otro apoyo recibes?
-

☐ **Sección F: Preguntas para Subpesca**

1. ¿Cuáles son los desafíos actuales para la administración en la pesca de centolla?
 2. ¿Qué estrategias usas para regular la pesquería?
 3. ¿Qué mejoraría tu habilidad para administrar la pesquería?
 4. ¿De dónde provienen los fondos para sus actividades? ¿recupera los costos de la pesquería en sí, o los fondos provienen exclusivamente de las asignaciones presupuestarias del gobierno?)
 5. Subsidios
 - a. ¿Cómo se asignan los subsidios a los pescadores?
 - b. ¿Para qué son los subsidios?
 6. ¿Hay un límite de cuántas veces se pueden recibir subsidios?
 7. ¿Hay alguna condición del programa de subsidio? el propietario del pescador / barco debe cumplir con ciertos criterios
 8. ¿Existe un proceso de consulta previo a las decisiones sobre cambios de gestión? Si es así, por favor describe.
 9. ¿Tiene Subpesca un papel en la regulación de los intermediarios? Si es así, por favor describe.
 10. ¿Tiene Subpesca un papel en la regulación de la habilitación? Si es así, por favor describe.
 11. Describa el proceso de implementación de cuota para merluza. ¿Cuándo llegó, cómo se implementó la cuota (cómo se gestiona la asignación) y qué rol desempeñas en la configuración de la cuota? ¿La cuota se ajusta anualmente o sigue siendo la misma?
-

☐ **Sección G: [para todos] Metas (objetivos) de la pesquería**

Esta sección pregunta sobre los diferentes objetivos para la industria pesquera, que usted o los demás actores de la pesquería tienen. Lo que queremos decir con "objetivos" son las razones para pescar, o lo que quiere lograr con la actividad pesquera.

1. ¿Qué esperas lograr de la pesca (objetivos)?

TARJETA, las preguntas más bajas también se responden en la tarjeta

2. ¿Qué crees que otros quieren como objetivos de la pesquería? [prompt if required: e.g. high yield, continued family fishing business, etc]
3. ¿Cómo calificaría su capacidad actual para lograr su objetivo de pesca?
4. ¿Cuáles son sus preocupaciones sobre la capacidad de lograr sus objetivos de pesca?



Sección H: [para todos] Gestión de la industria Pesquera

1. Eficacia percibida de la gestión actual para apoyar a la industria pesquera en curso / futura - en la industria de stock y pesca?
2. Aquí hacemos una pregunta: ¿Qué pasaría si la pesquería de centolla se manejara de manera diferente? Le mostraremos varios posibles enfoques de gestión utilizados en otras pesquerías. Por favor haga preguntas si desea saber más sobre ellos. Luego le pediremos que haga un comentario sobre cuál prefiere.
3. ¿Qué piensas sobre abrir el RPA?
4. Nivel esperado de impacto personal (escala de uso) - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
5. Nivel esperado de impacto en la pesquería centolla - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
6. ¿Qué piensas sobre las restricciones espaciales?
 - a) Nivel esperado de impacto personal (escala de uso) - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
 - b) Nivel esperado de impacto en la pesquería centolla - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
7. ¿Qué piensas sobre los derechos territoriales de uso?
 - a) Nivel esperado de impacto personal (escala de uso) - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
 - b) Nivel esperado de impacto en la pesquería centolla - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
8. ¿Qué piensas de los sistemas de cuota global?
 - a) Nivel esperado de impacto personal (escala de uso) - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
 - b) Nivel esperado de impacto en la pesquería centolla - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
9. ¿Qué piensas de los sistemas de cuota comunidad?
 - a) Nivel esperado de impacto personal (escala de uso) - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
 - b) Nivel esperado de impacto en la pesquería centolla - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
10. ¿Qué piensas de los sistemas de cuota individual?
 - a) Nivel esperado de impacto personal (escala de uso) - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
 - b) Nivel esperado de impacto en la pesquería centolla - -2 (muy mal) -1 (algo malo) 0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
11. ¿Qué opinas sobre los sistemas de certificación para la industria pesquera?

- a) Nivel esperado de impacto personal (escala de uso) - -2 (muy mal) -1 (algo malo)
0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____
- b) Nivel esperado de impacto en la pesquería centolla - -2 (muy mal) -1 (algo malo)
0 (sin efecto) +1 (algo bueno) +2 (muy bien) _____

TARJETA

12. Indique los motivos de la orden dada

13. Si desea combinar opciones o tiene otra idea, díganos qué es.

☐ **Gracias por su asistencia. ¿Es muy apreciado?**

□ **TARJETAS**

Interacciones con otros

Interacciones con otros	Describir
relaciones o interacciones con (otros) pescadores (socialmente, durante la actividad pesquera)	
interacciones con (otros) sindicatos / organizaciones pesqueras	
interacciones con (otros) intermediarios o procesadores	
interacciones con (otros) administradores de pesca u oficiales de cumplimiento	
interacciones con (otros) científicos que estudian la pesquería	
sentimientos de agencia para hacer cambios dentro de la industria	
Otro (describa)	



Metas (objetivos) de la pesquería

ACTORES	OBJETIVOS (estado)	HABILIDAD PARA LOGRAR (1-5)	PREOCUPACIONES sobre la capacidad de lograr
YO			
LEGISLADORES			
CUERPO DE CONTROL			
OTROS PESCADORES			
PROCESADORES			
ONG			

1 (muy bajo), 2 (bajo), 3 (medio), 4 (alto), 5 (muy alto)

Cambio del sistema de gestión	Criterios: viabilidad para la implementación		Criterios: buenos resultados para los pescadores		Criterios: buenas relaciones entre los actores de la pesca		Criterios: buenos resultados para recuperar el stock	
	Orden de preferencia (1-8)	Ponderación de preferencia	Orden de preferencia (1-8)	Ponderación de preferencia	Orden de preferencia (1-8)	Ponderación de preferencia	Orden de preferencia (1-8)	Ponderación de preferencia
Sin cambio de la corriente								
Reabrir RPA								
Gestión espacial								
Derechos de uso territorial (TURFs)								
Certificación								
Cuota, global								
Cuota, administrada por la comunidad								
Cuota, individual								
POR QUE la ordenar								

Supplementary Materials 5

Chapter 5 Materials

Rationale for components of the signed digraph and drawn effects

Table 23 Connections between nodes of the socioecological system. Node name identified in parentheses.

* indicates predator-prey links between indicated nodes.

^indicates uncertain link explored in sensitivity tests

CORE SYSTEM COMPONENTS (MODEL 2)			
From	To +effect	To -effect	Description of logic used in model creation
Moulting and/or mating adult centolla (CM), found in shallows. Hereafter referred to as “shallow centolla”	Juvenile centolla (CJ)		Mating crabs provide zoea larva (puerulus). In the model context, we have noted this life stage as juvenile centolla. Settlement is 19-129 days, with a median of 70 (Lovrich & Vinuesa, 1999; Calcagno et al., 2005). The retention level in any one location will depend on the coastal geography and flushing time versus the puerulus behaviour in the water column. It is possible for retention in some fjords, especially if the puerulus intentionally swim in a way that minimizes being flushed out. Alternatively, if an individual puerulus is in a major channel or current flow it could go longer distances. Given the prevailing flow is often toward Argentina in the largest waterways, some form of puerulus retention must occur (via the use of eddies, coastal counterflow, or trapping in fjords), or there is intentional movement in later life history stages, otherwise Chile would not have a persistent stock. Consequently, it was assumed that some puerulus, but not all, are returned relatively locally (at least with respect to the extent of the model domain).
<i>Macrocystis porifera</i> (MACRO)	Juvenile centolla (CJ); Shallow centolla (CM)	Predators of shallow centolla (PREDCM)	<i>Macrocystis</i> beds enhance recruitment of juvenile Centolla as they provide refugia for juvenile crabs, and mating and moulting adults. (Cárdenas et al., 2007; Palomares & Pauly, 2019). The presence of <i>Macrocystis</i> reduces predation on crabs, as it provides a protective cover. Juveniles pod around <i>Macrocystis</i> holdfasts (Cárdenas et al., 2007), which concurs with information from other king crab fisheries (e.g. Alaska, Russia, Argentina) indicating that both juvenile and adult crabs seasonally migrate and congregate in shallower, coastal waters for protection from predation, to inhabit preferred habitat, and to mate (WWF, 2014; Firpo et al., 2016; Lovrich & Vinuesa, 2016). <u>Note:</u> Although it is likely that Macro is also a habitat for centollon (PG), the connection was not included due to a lack of literature to support it.

Centolla, Adults at depth (CA), hereafter referred to as “deep centolla.”	Shallow centolla (CM)		Adult crabs migrate from deeper, cooler areas to the shallows to mate and moult. This occurs 1-2x per year (Lovrich, Vinuesa, & Smith, 2002; Lovrich & Vinuesa, 2016). Some monitoring in the form of fishery-dependent observations occurs in the region (IFOP, 2017).
Predators of mating and moulting centolla (PREDCM)		Shallow centolla (CM)*	Predators of Centolla are not numerous; however, moulting Centolla is more vulnerable.
Shallow centolla (CM)	Centollon (PG)		Centolla is the preferred target species, however, as Centolla diminishes in the catch, the effort is transferred to Centollon. <u>Note:</u> A small negative effect from Centollon to shallow Centolla is ignored and accepted as it is less than the benefit back to the fleet (From Centollon to small vessels). Interactions between Centolla and other commercial or benthic species have not been explored, primarily as these interactions remain largely undocumented. However, occurrences of bycatch or interactions related to fishing practices could be included in the future (such as Varisco et al. (2017); Di Salvatore et al. (2019)).
Centolla, Juvenile (CJ)	Monitoring of juvenile centolla (CJMON)		Larval detection is a component of stock monitoring. Some larval monitoring occurs in the region (IFOP, 2017).
Monitoring of juvenile centolla (CJMON)	Sustainability certification or assurance (CERT)		Information on larvae informs whether the stock is certified or assured as sustainable.
Monitoring of adult centolla (CAMON)	Sustainability certification or assurance (CERT)		Information on stock informs whether the stock is certified as sustainable.
Large vessels (LV)		Deep Centolla (CA)*	Deeper, adult crabs are accessed by larger vessels with hydraulic winches. <u>Note:</u> Multiple catch-and-release on individual females affects juvenile centolla (Di Salvatore et al., 2019); however, we have not included this effect in the model.
Transport Vessels (TV)	Small vessels (SV); Large vessels (LV)		Transport vessels help other vessels gain market access by bringing the product to the port/ processor.
Small vessels (SV)		Centollon (PG)* Shallow centolla (CM)*	Shallow centolla supply inshore fishers (smaller vessels) (Wyngaard, Iorio, & Firpo, 2016).
Illegal, unreported and unregulated catch (IUU)	Small vessels (SV)	Shallow centolla (CM)	Illegal activities supply inshore vessels, allowing them to gain additional market access and subtract from shallow centolla stocks (Guerrero, 2016; Nahuelhual et al., 2018). Unintended consequences may occur due to different management interventions, such as catch of undersize crabs, catch of females, catch outside of season, and use of nets which affect both the biomass and the catchable component of centolla and centollon. We’ve considered

			these impacts within the category of IUU. However, this could be more specifically articulated in future iterations of the model.
Market Price (MAR\$)	Illegal, unreported and unregulated catch (IUU); Small vessels (SV); Large vessels (LV)		High market price signals catch. <u>Note:</u> We followed the advice of Dambacher, Rothlisberg, and Loneragan (2015) and represented the fishery subsystem with multiple variables in order to depict interactions between catch, effort and market price. The system is regulated by market price, which, in turn is determined by a global market, whose demand is insensitive to the regional supply of catch.
Illegal, unreported and unregulated catch (IUU)	Local Market (LOCMAR)		Provides Local Market through illegal processes, e.g. unregistered fishers, or noncompliant product (e.g. crabs that do not comply with Sex-Size-Season restrictions). <u>Note:</u> High market price encourages the export market and limits the domestic market, which is why the local market is typically supplied by illegal fishing activities.
Reserves, e.g. protected areas and seasonal closures (RESERVE)	Centolla, Juvenile (CJ); Shallow centolla (CM)		Reserves prevent offshore exploitation from occurring. In the case of FAGA, SSF is not permitted offshore, and many forms of fishing are restricted within 1 NM of the coastline. <u>Note:</u> “reserves” can also include seasonal fishing closures to protect breeding stocks. This occurs in the centolla fishery, where the season is closed between DEC and JUNE.
Rising sea surface temperature (SST)	Shallow centolla (CM)^	<i>Macrocystis</i> (MACRO); Centolla, Juvenile (CJ)^; Small vessels (SV)^	Ambient sea surface temperatures regulate the abundance and distribution of <i>Macrocystis</i> habitats.
Management: Surveillance and Enforcement (MANAG)		Illegal, unreported and unregulated catch (IUU)*^	The management policy of fitting larger and transport vessels with transponders reduces but does not eliminate illegal fishing activity. Management operates independently of IUU, i.e. activities of Management in the form of enforcement are pre-determined and not necessarily responsive. <u>Note:</u> We have not explicitly linked MANAG to larger fishing vessels, but the presence of the transponder policy confirms compliance with an existing boundary condition disallowing a link between large vessels and shallow centolla, according to legislation that prevents large vessels from fishing within the coastal edge (1nm from the coastline).
International Demand (INTDEM)	Market Price (MAR\$)		The primary global market creates high value (increases prices for product).

Incentive structures (INCENT)	Large vessels (LV); Transport Vessels (TV)		Incentive structures increase the activity of larger and transport vessels through economic development policies and subsidies. These policies support companies that export product internationally. Small vessels do not meet the criteria for these incentives.

Description and rationale for sensitivity tests

Table 24 Description of sensitivity tests used in the scenario analysis

Sensitivity test	Description
Uncertain effects of management (surveillance and control) arrangements on illegal fishing Models compared: 1, 2	Compares whether increased surveillance and control arrangements affect illegal fishing offloading to artisanal fishers. This model represents the present context of the southern king crab fishery; a world where management uses pre-determined enforcement missions to act upon illegal fishing, including ensuring compliance with current season-size-sex fishing regulations, a fishing registry, and fishing gear. No restriction on effort or catch is imposed. Development policies indirectly support higher-capacity artisanal fishers (LV and TV) allowing LV to offload more catch (World Bank, 2005; Giusti, 2008). Most catch is exported as a result of international demand and high market prices. Local market (retail, restaurants, domestic market to other parts of the country) is primarily supplied by illegal fishing (Guerrero, 2016; Morales, 2018; Nahuelhual et al., 2018; Nahuelhual et al., 2019). A weak interaction of artisanal fishers on local markets is present, but it is negligible and not included compared to illegal fishing. Model 2 represents a responsive management situation, where all vessels are fitted with geo-locating transponders. Management can track and respond to IUU activity, including vessels entering protected areas (permanent no-take zones, the coastal nearshore environment reserved for the smallest SV, or an additional seasonal/geographic restricted area). This enforcement removes the ability of illegal fishers to offload to artisanal fishers. Responding to illegal fishing strengthens the previously weak link between SV and LOCMAR. This reflects standard MCS (monitoring, control and surveillance) practices in many fisheries worldwide, particularly where at-sea surveillance is difficult. It extends the current requirement for artisanal VMS to all vessels registered to the fleet.
Fishery effect – hyperstability in fishery (CPUE of centolla) Models compared: 2, 4	Compares the outcomes of presuming a hyperstable catch (measured as CPUE) of centolla (i.e., fishing occurs on the last remaining aggregations of centolla). Strong evidence supports this is likely the case in the southern king crab fishery (Eisman, 2016; IFOP, 2017). Note: Links drawn as per (Dambacher, Rothlisberg, & Loneragan, 2015), e.g. CM is drawn with a positive self-effect.
Uncertain links regarding impacts of ocean warming due to climate change on model components Models compared: 2, 3	This model tests a set of uncertain links regarding the impacts of rising sea surface temperatures (SST) due to climate change. We have included five different uncertain links in the one model. Some are less certain than others, but do not have strong evidence to support levels of uncertainty and thus we consider them together as a set. We based this model on inferences of climate change increasing sea surface temperature, indirectly affecting centolla and centollon by reducing the presence and quality of <i>Macrocyctis</i> sp., a known habitat for juveniles. SST reduces the abundance and distribution of <i>Macrocyctis</i> habitat, by reducing propagation (Yanez et al., 2018b; Iriarte et al., 2019). In addition, increased SST can reduce the catchability of crabs in warming coastal waters (Guerrero, 2016; Hobday et al., 2016b; Pecl et al., 2017; Yanez et al., 2018b; Palomares & Pauly, 2019; Pretterebner, Pardo, & Paschke, 2019). There is evidence to suggest that SST may reduce the reproductive capacity of adults in some parts of its distribution due to thermal stress (Pretterebner, Pardo, & Paschke, 2019), therefore there is a weak negative link from SST to CM. SST affects the fecundity of crabs, reducing the number of juvenile Centolla (Pretterebner, Pardo, & Paschke, 2019). The positive effect of SST on shallow Centolla is based on SST suppressing the effect of the fishery on Centolla. This is because as SST increases, the physiology of Centolla is affected, yielding a smaller, thinner, less commercially viable product (according to

	interviewees). As shallow Centolla are commercially less viable, pressure on Centolla is reduced, positively affecting smaller vessels. Note: We assume the thermal stress is not strong enough to kill the stock of Centolla.
Effects of Governance Structures Models compared: 2, 6 and 9	Scholars differ in their advice on governance structures, with some advocating for “strong” top-down authoritative, regulatory control (Hilborn, Orensanz & Parma 2005), and others suggesting market-based solutions can regulate (Petrossian, Weis & Pires 2015; Jaffry et al. 2016). Conversely many small-scale fisheries scholars promote local, area-based fishing rights with local institutions as the key to successfully managed fisheries, although scholars also note the challenges of it in Chile (Bernal et al. 1999; Hilborn, Orensanz & Parma 2005; Orensanz et al. 2005; Gelcich, Edwards-Jones & Kaiser 2007; Gutierrez, Hilborn & Defeo 2011; Allison et al. 2012; Grafton & Kompas 2013; Gelcich 2014). Four different fishery control mechanisms were explored in these models: government regulatory environment (Model 5), market-based/seafood certification standards (Model 6), harvest control (Model 7) and community-based/local management (Model 9).
Effects of Biological Monitoring Models compared: 7, 10, and 8,11	These models remove the links from CJ to CJMON to test the importance of stock (puerulus) monitoring.

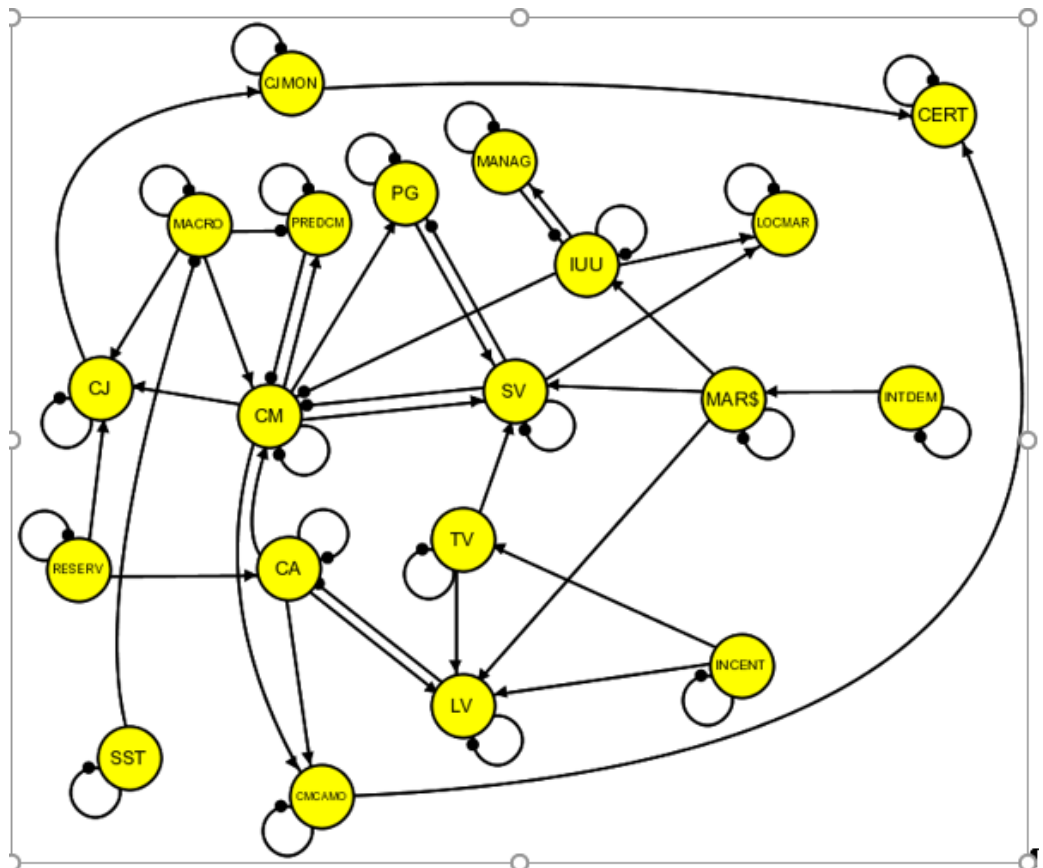


Figure 26 Model 2 Enhanced Business as Usual

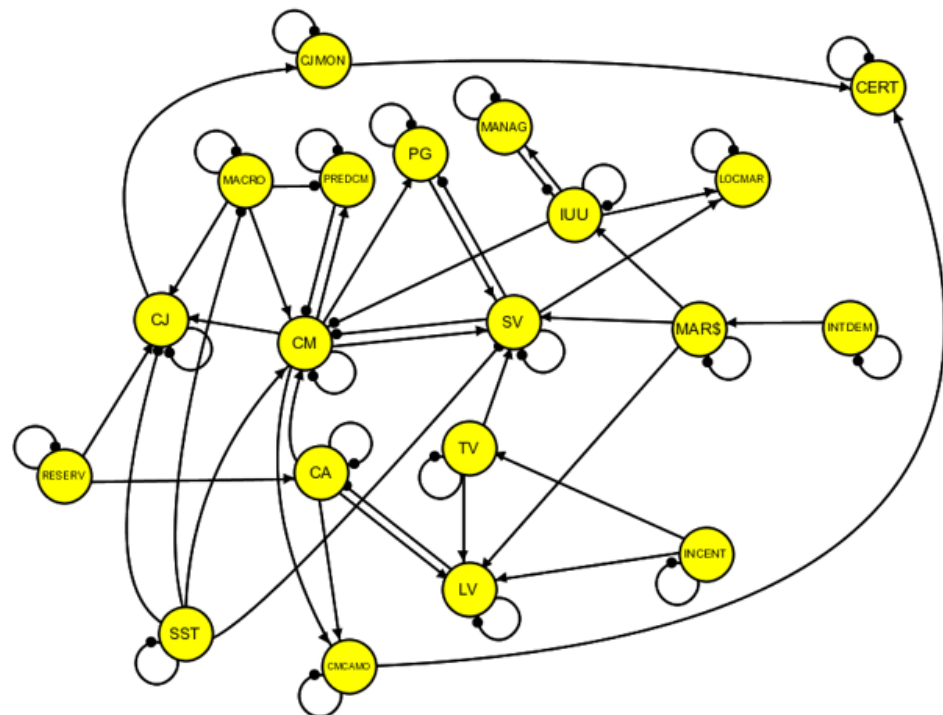


Figure 27 Model 3 Ocean warming effects

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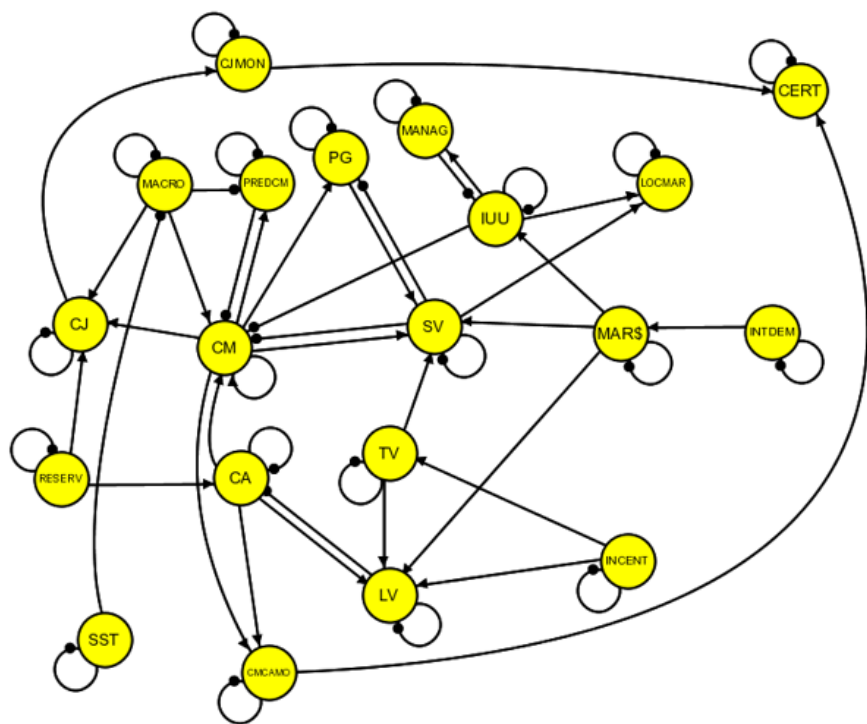


Figure 28 Model 4 Hyperstability of centolla catch per unit effort (CPUE)

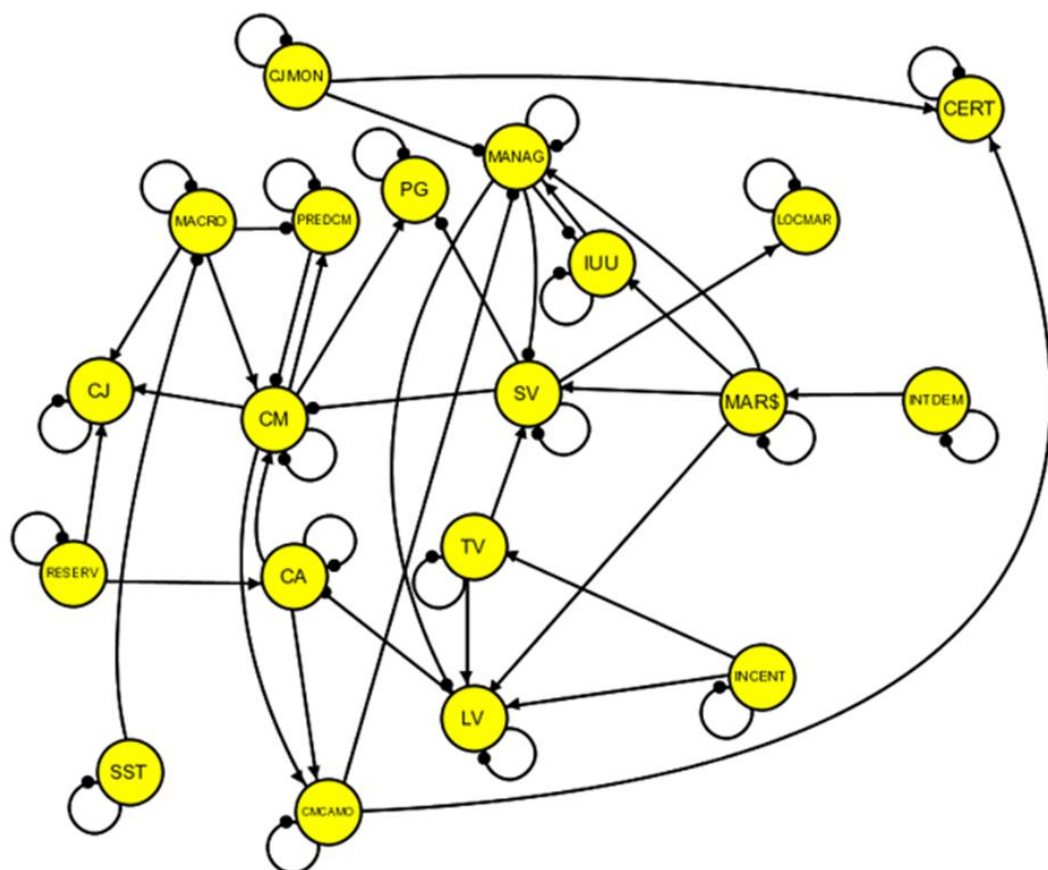


Figure 29 Model 10 Based on Model 7, with the monitoring link removed between CJ and CJMON

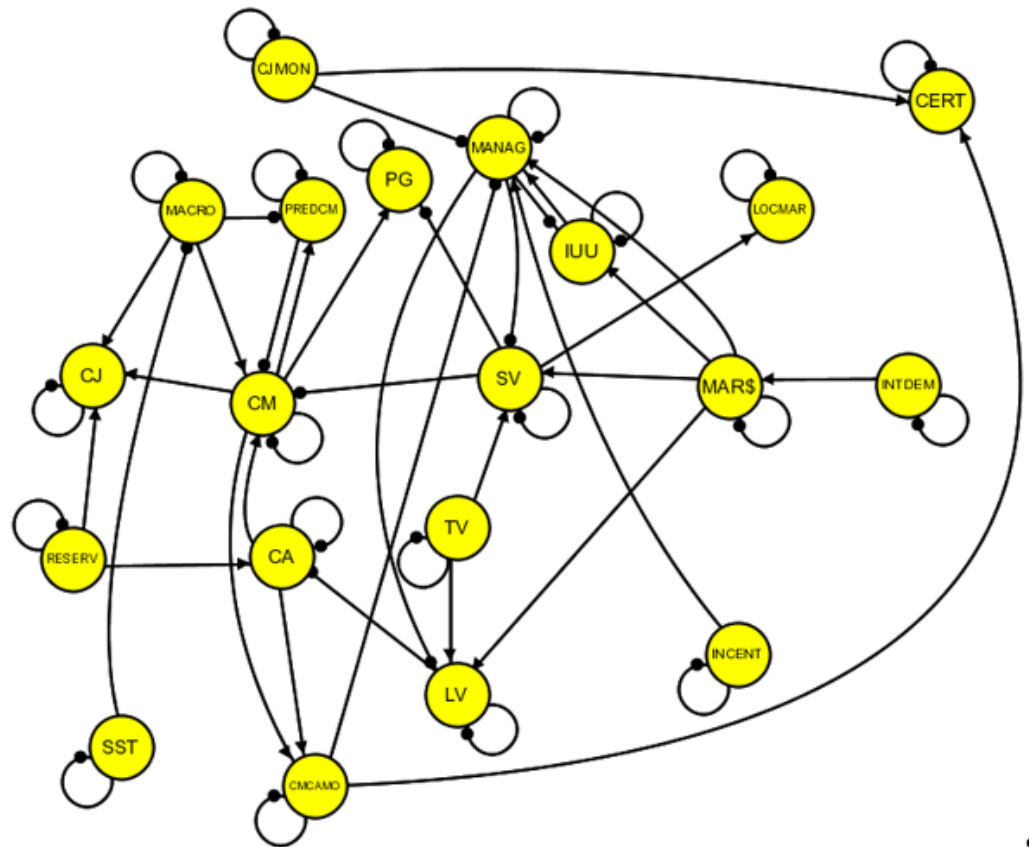


Figure 30 Model 11 Based on Model 8, with the monitoring link between CJ and CJMON removed

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