Towards a Diagnostic Approach to Climate Adaptation for Fisheries

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Abstract

A diagnostic approach to climate change adaptation for fisheries is proposed to define potential climate adaptation pathways in well-managed fisheries. Traditional climate vulnerability and risk assessments tend to focus on biophysical threats and opportunities and thereby *what* needs to be done to adapt to climate change. Our diagnostic approach moves from such analysis to focus on *how* the processes of adaptation and development of adaptive capacity can be structured to achieve desired outcomes. Using a well-grounded framework, the diagnostic approach moves from system description to characterization of challenges and opportunities, through two stages of analysis and validation, to the definition and embedding of adaptation options and pathways. The framework can include all contextually relevant variables and accommodate evaluation of adaptation outcomes and comparisons across scales and contexts. Such an approach can serve as a basis for enabling stakeholders to identify challenges and opportunities, and to explore and prioritize options for development and implementation of legitimate adaptation pathways.

Keywords: collaborative management, adaptation, climate change, fisheries, diagnostic approach, governance

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1 Introduction

The gulf between knowledge and action is well recognized across many domains where science is funded to inform decision-making that affects public and private interests (Jasanoff and Wynne 1998; Leith et al. 2012; McNie 2007; Pohl 2008; Reyers et al. 2010). It is particularly problematic in fields where substantial uncertainties and inter-dependencies exist among biophysical, social, economic and political system drivers (Poteete et al. 2010). Developing strategies to adapt fisheries management to climate change is an example where long-term uncertainties associated with projected climate change impacts are just one of the many issues that limit uptake of climate adaptation.

While some examples of climate change adaptation within a particular fishery exist (Frusher et al. 2013), planned adaptation is still in its infancy. Resource-constrained public sector managers often already consider their processes to be adaptive (Frusher et al. 2013; Grafton 2010). Much adaptation as a result remains understandably incremental, progressing in response to seasonal and inter-annual variability (Frusher et al. 2013). This may not be adequate if climate change results in fundamental changes, such as a significant or abrupt shift in stock recruitment, or the carrying capacity of a stock (Brander 2010). There is rarely substantial social, economic or political incentives for planned adaptation to long-term climate change, except where obvious changes have occurred, such as major shifts in stock abundance or distribution of important commercial species (e.g. Astthorsson et al.2012). Challenges or barriers to planned adaptation are commonplace and represent a series of mostly sound reasons why knowledge about climate impacts and vulnerabilities does not usually translate into well-directed action to ameliorate them (Moser and Ekstrom 2010).

In this paper, we draw on lessons from climate change adaptation research in Australian fisheries to argue that adaptation in well-managed fisheries can build

on existing processes through the application of sound process coupled with a robust diagnostic framework. Although our experience is in Australian fisheries, we suspect that the approach described would be applicable to commercial fisheries in many developed country contexts, particularly where co-management is ascendant, and the fishery is at a scale to support such planning. Through work with larger fisheries it may be possible to refine the process to make it scalable for smaller and artisanal fisheries. We propose a structured approach to identifying barriers and opportunities to planned adaptation, expressly to prioritize options, and explore legitimate adaptation pathways. We focus on planned adaptation, defined as an ongoing, intentional process to contend with particular biophysical or socio-economic conditions, risks and/or uncertainties (Füssel 2007).

This framework- and process-based approach builds on contemporary management tools coupled with the understanding that many constraints on adaptation in fisheries are not scientific, but institutional and social (Brander 2010). Contemporary approaches, such as Management Strategy Evaluation (MSE) recognize the importance of formally accounting for risks and uncertainties in fisheries management. MSE also defines robust management strategies under a range of scenarios about alternative states of nature (e.g. de la Mare 1996; Punt and Smith 1999; Holland 2010) and can provide for detailed dialogue between industry, scientists and managers, thus allowing for ongoing adjustments in harvest rules (Bunnefeld et. al. 2011; Smith et al. 1999). MSE thus provides potential for incremental adaptation. However, MSE tends to focus on biological and biophysical variables (Plaganyi et al. 2012). In intentional adaptation, social and economic variables are often the key constraints to adaptation (Moser and Ekstrom 2010). These are often also phenomena that are most amenable to intervention. Additionally, MSE is usually based on single-species management and may limit long-term management of stocks under climate change, unless spatial structure, environmental forcing, and a broad ecosystem perspective are considered (Plaganyi et al. 2011). Moreover, MSE does not necessarily provide stakeholders with a clear or legitimate pathway to climate adaptation, at least on its own.

We propose a practical participatory approach through which adaptation options or pathways can be collaboratively defined, tested and explored. Such participatory assessment can include multiple and cross-scale drivers of change: from international treaties and obligations, geo-politics and global markets, at the broadest scale, to familial and cultural institutions, and identities and relations at a local scale. This approach recognizes that, for adaptation, many policy, social, economic, human, political, cultural as well as environmental variables are at play (Eakin and Lemos 2006).

Fisheries governance around the world is moving away from top-down management (where scientists and public sector managers define regulatory controls) towards more collaborative approaches in which fishers and other stakeholders are involved in decision-making processes (Wilson et al., 2003). The diagnostic approach described in this paper is in line with this trend towards collaborative management and extends a partnership model between governments and fisheries sectors (FRDC, 2008, Smith et al., 1999) to include inter-disciplinary researchers as stakeholders.

In the following section we make the case for a diagnostic approach to fisheries adaptation. We then describe how Ostrom's (2009) diagnostic framework can be adapted to fisheries adaptation, and finally, we outline a collaborative process through which the diagnostic process could be applied to embed adaptation as an integral component of effective fisheries management.

2 Barriers and drivers of adaptation in fisheries

Marine-focused adaptation studies have made an important contribution to understanding the vulnerability, sensitivity and risks faced by Australian marine systems to climate change (Johnson et al. 2011; Hobday et al. 2008; Pecl et al. 2009). The development and evaluation of workable adaption pathways for associated fisheries has been far more limited. Following Moser and Ekstrom (2010), our experience in fisheries adaptation research (Davidson et al. 2013; Frusher et al. 2013; Haward et al. 2013; Leith and Haward 2010; Madin et al. 2012; Nursey-Bray et al. 2012; Pecl et al. 2009) has highlighted structural,

institutional, social and human challenges for adaptation within particular fisheries. These are briefly described below as a series of barriers under six generic headings, as follows:

2.1 Focus on reduction of uncertainty over decision-making under uncertainty

While climate change research provides a broad consensus about the direction of change for local and regional marine systems, we have little predictive capability regarding the degree of change, the timeframes of impacts, and whether impacts will be gradual or abrupt (Miller et al. 2010). Australian scientific and policy responses have generally prioritized reduction of such uncertainties rather than developing capacity for decision-making in the context of largely irreducible uncertainty (Nelson et al. 2008). Global climate models and their application in other biophysical and economic models (e.g. models which predict changes in abundance or recruitment of a target species) cannot 'predict' per se (Oreskes 1994). Through sensitivity analysis, such modeling can substantially improve understanding of system characteristics, and how they may respond to variability and shocks. However, they are rarely able to provide robust risk assessments that decision-makers can apply. There is a growing literature on processes and strategies for adaptive management and the development of approaches that are robust across diverse scenarios (Dessai et al. 2009). In such approaches, science provides scenarios to support processes and institutions that enable proactive and adaptive management (Nelson et al. 2008).

2.2 Lack of clear goals for adaptation research

Developing and evaluating adaptation pathways is complicated by the lack of well articulated or prioritized management objectives. Instruments such as management plans include some objectives for individual fisheries yet rarely specify the relative importance of these. Plans also commonly include objectives that may be countervailing such as achieving maximum economic benefit for industry and maximizing local employment opportunities. Generally, few effective mechanisms are applied to deal with divergent societal values that underpin such objectives, or to clarify how synergies and trade-offs between

competing objectives are dealt with when evaluating alternative adaptation strategies (Pascoe et al. 2009).

A common challenge encountered in the adaptation planning phase includes gaining the agreement of diverse stakeholders on the goals of adaptation (Moser and Ekstrom 2010). Definitions of adaptation continue to be contested (Adger et al. 2005) and, as a result, there is often little agreement as to what criteria should be applied to determine whether adaption actions have been (or would be) successful and sustainable (Doria et al. 2009). Assessing adaptation options against clearly defined goals for a system requires a transparent, systematic and broadly repeatable approach. Doria et al. (2009) note that adaption actions should be evaluated by those adapting or affected by adaptation.

2.3 Divergent expectations of adaptation research

Across resource management contexts, managers, funders and researchers often have divergent expectations and perceptions of the possible role of researchers to influence management and achieve adaptation outcomes. Within fisheries management agencies, perspectives of adaptation research vary. Traditional fisheries management tends to maintain a purchaser-provider model as guiding the relationship between government and researchers. Reminiscent of Winston Churchill's notion that "scientists should be on tap not on top" (quoted in Churchill 1965) this approach can make application of science discretionary by maintaining decisions within a political sphere. In the purchaser-provider model, adaptation projects tend to occur as isolated research exercises that are not integrated with or embedded in broader fisheries research, monitoring, assessment and management processes (Miller et al. 2010). Contrastingly, research funding agencies often support adaptation research on the expectation that it will directly lead to changes in management.

2.4 Barriers to participation and collaboration

Climate variability and change are often seen as minor concerns among stakeholders with many competing demands on their time. Such issues tend to be of lower concern when compared to immediate economic viability and resource security or access (Nursey-Bray et al. 2012). Distrust between different

stakeholders involved in a fishery can inhibit collaboration (Glenn et al., 2012). For instance, in many countries, there has historically been little incentive for scientists and fishers to work together and develop a shared sense of purpose and language. Relationship building, collaboration and stakeholder participation are sometimes difficult to resource on an ongoing basis in both research or management, making inter- and trans-disciplinary assessment of risks and opportunities for adaptation challenging (Degnbol et al. 2006; Jacobsen et al. 2012; Miller et al. 2010).

2.5 Inadequate levels of support for monitoring of system states

Ongoing and appropriate data streams are necessary to ensure management can be flexible and adaptive, and success and failure can be properly evaluated. Trends in biological and socio-economic indicators need to be available, appropriate and integrated into decision-processes. Adaptive management is reliant on timely and relevant information (Moser and Ekstrom 2010), and so inadequate monitoring can and does stall adaptation. Too often monitoring and evaluation activities that could support adaptive management are focused on compliance rather than learning (e.g., Lockwood et al. 2009).

2.6 Resourcing and capacity constraints

A key barrier to adaptation action is resourcing within fisheries management agencies. In our experience, managers and researchers have often found it difficult to clearly articulate the specific risks and opportunities that need to be managed, resulting in adaptation being seen as a generic, amorphous or insubstantial concern, which in turn limits stakeholder or political interest. Making the case for 'soft' interventions through, for example, policy innovation and building improved social capital and adaptive capacity is usually a substantial challenge in such resource-constrained environments.

The barriers outlined above present substantial constraints to the practice of adaptation in Australian fisheries. Although these barriers are sometimes directly investigated in adaptation research, they are rarely systematically addressed within existing governance arrangements of a fishery. In the following sections,

we propose an approach which could embed adaption within effective marine governance systems through systematic diagnosis of barriers and opportunities.

3 Towards a diagnostic approach to climate adaptation

In this section, we draw on existing literature to detail why a diagnostic approach can be useful to overcome barriers to adaptation. Diagnosis is a useful metaphor to describe a process-driven and deliberative approach to identifying how the properties and dynamics of a system result in particular functions, structures and outcomes, and whether these are desirable or otherwise. A core challenge for diagnosis is integrating human values and science in the decision-making processes. For example, the resolution of 'desirability' of social-ecological system states is rightfully more democratic than scientific (Holling et al. 1998; Nelson 2011). Yet the processes which inform technical research, monitoring and evaluation of biophysical systems, policy instruments, models and management regimes tend to be more technocratic than explicitly driven by debates or deliberation over values.

In a complex system, such as a fishery, identification of cause and effect in precise terms is rare. Nevertheless, it is often possible to identify and, more importantly, agree on aspects of the broad system that constrain and enable strategic and/or tactical decision-making. These can range from biophysical to economic and social factors. For instance, lack of scientific certainty about the mechanisms that lead to seasonal variability in recruitment to industry may be perceived as a fundamental constraint. Such uncertainties may be less intractable than addressing factions within an industry that limit decision-making within the industry. Threats and solutions to the problems that beset fisheries can also stem from outside the domain of the fishery, and diagnostic approaches may facilitate intra-sectoral management in the developing world (Andrew et al. 2007).

Moser and Ekstrom (2010) argue that barriers to adaptation can be addressed through normal problem management processes: identification and prioritization of options, monitoring and evaluation of successes and failures. Identifying barriers and drivers of change is a diagnostic task by which impediments to adaptation can be revealed, agreed upon and, where appropriate, acted upon. It should be noted that legitimate decisions may be to do nothing or 'wait and see', where such inaction is deliberate.

Diagnosis requires trans-disciplinary collaboration in order to ensure processes and decisions are legitimate (Cash et al. 2003); diverse, relevant knowledge is included (Pohl 2008); and workable policy options that balance multiple objectives at different scales can be evaluated (Nelson et al. 2008). These outcomes may require cultural change, new ways of thinking, and the ability to humbly, critically and openly reflect on failures as well as successes; practices that are currently not espoused in most public organizations (Jasanoff 2003). These personal and organizational traits are increasingly recognized as core elements of institutional adaptive capacity (Armitage 2005).

The medical analogy of diagnosis is useful in describing this process, but only to a point. Health in complex systems, such as fisheries, is more ambiguous and values-dependent than in humans (cf. Halpern et al. 2012). An essential task of any approach that seeks diagnosis in social-ecological systems is facilitating the articulation of goals agreed on by stakeholders. The recruitment and selection of appropriate stakeholders engaged in decision making is in itself vexed. Nevertheless, useful principles exist by which key questions (e.g. 'what is at stake and for whom?') can guide approaches (Innes and Booher 2003) and processes (Bryson 2004) for selecting and engaging participants.

The development of adaptation pathways can clarify strategic goals and review management and governance in relation to emerging knowledge of system drivers, and changes in these. This process is more akin to a review of fisheries governance than a side project about climate change. Defining adaptation pathways is thus not something to be undertaken lightly – it may precipitate desire for reorganization of fisheries management. However, our proposed diagnostic

approach is unlikely to rapidly impose new systems. Because it is oriented by deliberation, it is more likely to increase capacity for adaptive governance, build adaptive capacity and systematize a watching brief on potential risk factors and opportunities associated with system drivers (Nelson et al. 2008). .

4 A framework for diagnosis

The framework detailed below draws on Ostrom's (2009; 2007) scheme for analyzing social-ecological systems (SES), although we have unpacked some elements and make more explicit reference to fisheries systems. A central concern for diagnosis is disaggregation. Complex systems need to be made tractable to stakeholders, and a useful means of doing this is by identifying and agreeing on key elements that are vital to system function broadly and adaptation specifically. For fisheries systems, this process will require different forms of expertise to be applied to identifying and analyzing system characteristics and dynamics in relation to adaptation and strategic long-term planning (Ostrom and Cox 2010). Ultimately, key interactive elements will need to be considered together, but initially it is useful to identify the variables, processes and interactions that can be agreed upon as defining a system's structure and function. Such a process can also reveal points of tension and difference within and across a marine governance context, which themselves can be critical to defining adaptation options and possibilities.

Frameworks are a useful method of achieving these purposes because, as Ostrom (2011) observes, they help to establish the key variables and the relationships between them, and how these variables hold with or challenge existing theory. To adopt a framework that can assist in developing adaptation pathways we suggest that four essential criteria need to be met. The framework must: be clear and tractable to stakeholders; be open enough to include all relevant variables from social, economic and ecological components of a fishery; be consistent enough to enable comparison and meta-analysis across cases and systems; and be useful for defining goals and reflecting outcomes through monitoring and evaluation. Ostrom's (2009, 2007) ontological framework meets these requirements. Moreover, its foundations in management of common pool

10

resources (CPR) befit fisheries management, and especially collaborative management. As a nested framework, it does not predefine variables that are important in any particular fishery, yet still allows for comparison across contexts by providing a tiered approach to disaggregation. At the first level, only four subsystems are used to encompass all lower level system characteristics: resource systems, resource units, governance systems and users. These are contextualized by a fifth category – social, economic and political settings – which may drive decision-making within the system but are considered as external because they are not influenced substantially by action within the system (Urwin and Jordan 2008). For the purpose of working through the barriers and drivers of adaptation as a process, the sub-systems and context can be defined in general terms (Table 1). This approach allows for consistent use of a credible and legitimate framework without *a priori* imposition of a set of variables which can pre-ordain outcomes.

Table 1: Definitions of first order variables to be used for eliciting higher order variables in fisheries cases (adapted from Ostrom 2009; 2007).

First Order Variables	Description
Social, Economic and Political Setting (S)	The external variables which structure action within a fishery but are not easy to change from within the system
Resource system (RS)	The physical and biological aspects and processes of the system that constrain or enable adaptation
Resource units (RU)	Characteristics of the resource itself (e.g. of the particular fish species) that affect how adaptable the fishery is to change
Governance system (GS)	The formal and informal organizations, institutions, relationships, networks and rules that govern action within the system and thus affect adaptation and adaptive capacity
Users (U)	The traits of the resource users and other stakeholders, and interactions among them, including their use of technology, information and knowledge

At the second tier, many more variables potentially come into play. Decades of detailed empirical analysis of CPR management and collective action have

identified 52 second tier variables that recurrently underpin system structure and function (Table 1 in supplementary material, adapted from Ostrom 2009). Ten of these variables consistently underpin the ability to self organize to manage CPR problems (see supplementary material, Ostrom 2007) and are likely to be influential in developing adaptation pathways within marine governance and management.

Drawing on our experience in adaptation research in fisheries and the adaptation literature, we suggest that Ostrom's second order variables pertain to adaptive capacity and the definition of adaptation options (Supplementary material). These are not meant to pre-empt or prioritize the actual identification of second or higher order variables, but provide a heuristic for the way the variables are related to adaptation in fisheries systems.

Analytically and diagnostically, second and higher order variables could be used in an action research context to pose questions about efficacy and equity of adaptation options or pathways for a given fishery. Such questioning is derived through imaginatively interrogating the status, trends, variability and interactions across key variables once they are defined. For instance, a highly productive system (RS5) of high value fish (RU4) within a smaller geographical area (RU7) may be associated with better-organized resource users than a similarly productive system that is more distributed. Highly distributed systems with low productivity/value may be more vulnerable to generic or specific change, unless other livelihood options (a higher order variable under U2) are present or possible. Where there are relatively high numbers of users (U1) over broad geographical area (RU7), opportunities for face-to-face meetings are reduced. Consequently, a higher proportion of users will be unknown to each other (U6), may be less able to cooperate (see Ebenhöh and Pahl-Wostl 2010) and have less consistent mental models of the fishery system (U7).

These sorts of interactions appear to underlie fundamental aspects of adaptive capacity (Armitage 2005), yet need to be tested in specific contexts in order to identify barriers and opportunities for adaptation and thereby the pathways that best fit within a specific fisheries context. We have argued that Ostrom's

12

framework provides a robust and tractable foundation for facilitating such deliberation. In the following section we briefly outline a process that could be employed to embed climate adaptation within a collaborative fisheries governance context while building capacity for ongoing adaptation.

The six stage process (see overview in Figure 1 and described in the supplementary material) is instigated by an inter-disciplinary research team via analyses of secondary socio-economic data, biophysical data and publications. A series of key-informant interviews provides preliminary contextual variables. The framework is used as a lens to analyse and organize variables continually throughout the process. For instance, the first order variables (Table 1) would be applied to organize discussion in collaborative workshops (stages 2, 5 and 6, Figure 1). In stage 5 of the process, adaptation pathways are developed drawing on the earlier diagnostic work to understand and evaluate constraining and enabling elements of the fisheries system. Throughout this, and subsequent processes, attention would be needed to build capacity and trust within the team and to actively and reflexively expand a network across industry bodies, management agencies, relevant NGOs, and among fishers.

It should be noted that the process outlined above is analytically partial. A complete and impartial analysis of a resource system's characteristics that underpin its vulnerability, sustainability, resilience or the capacity to govern the system is not possible (Ostrom 2005). The numerous variables that potentially affect adaptation mean that millions of potential combinations exist, especially if each variable is described through numerous nominal categories. For similar reasons, setting 'optimal' policy and institutional arrangements is neither possible nor the aim of such work. Rather, the ideal of diagnosis is to build more adaptive governance systems, capable of learning driven by biophysical, socio-political and/or cultural processes (Nelson et al. 2008).
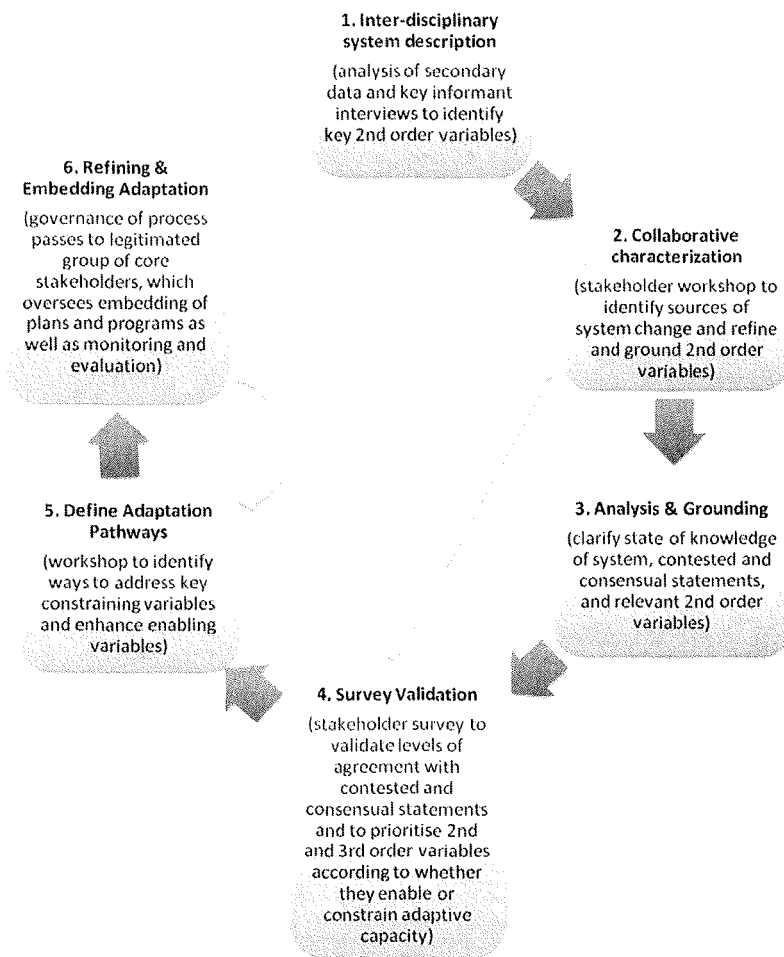
1. Inter-disciplinary system description

(analysis of secondary data and key informant interviews to identify key 2nd order variables)

6. Refining & Embedding Adaptation

(governance of process passes to legitimated group of core stakeholders, which oversees embedding of plans and programs as well as monitoring and evaluation)

2. Collaborative characterization

(stakeholder workshop to identify sources of system change and refine and ground 2nd order variables)

5. Define Adaptation Pathways

(workshop to identify ways to address key constraining variables and enhance enabling variables)

3. Analysis & Grounding

(clarify state of knowledge of system, contested and consensual statements, and relevant 2nd order variables)

4. Survey Validation

(stakeholder survey to validate levels of agreement with contested and consensual statements and to prioritise 2nd and 3rd order variables according to whether they enable or constrain adaptive capacity)

Figure 1. Schematic of the diagnostic process for developing adaptation pathways for a fishery

6 Concluding comment

Emerging collaborative arrangements in fisheries governance offer a substantial opportunity to build pathways for climate adaptation using a diagnostic approach. Such work will require strong commitment from and collaboration between fishers, public sector managers, scientists and other stakeholders to develop and embed adaptation within fisheries governance. The trans-disciplinary approach developed in this paper is designed to integrate our best science with knowledge of managers and fishers, and ultimately passes ownership of adaptation to the key players in fisheries governance. At the same time, it aims to build capacity within fisheries governance to deal more effectively and proactively with uncertainty and

14

indeterminacy. Through the disaggregation of the system into key second and higher order variables, and the clarification of the barriers and opportunities for adaptation associated with these variables, adaptation options and their implementation can be monitored at a systems level and comparable across contexts. The process suggested enables legitimate approaches to adaptation to be developed, but also effectively evaluated in relation to objectives and measures of success agreed on through the latter stages of the diagnostic process. This diagnostic approach enables collaborative evaluation of policy options, programs and plans for adaptation which can then be credibly and legitimately embedded in the governance of the fishery and potentially compared across fisheries.

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