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Imagining reef futures after mass coral bleaching events

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ABSTRACT

Extreme climate events are dramatically changing social-ecological systems (SESs) and challenging long-standing environmental governance paradigms. How high level governance actors (e.g. decision-makers and those who advise them) imagine the future of SESs can shape what management approaches are pursued and how SESs change. Previous research on climate-induced shifts in governance suggests that: 1) crises can provide windows of opportunity to catalyze transitions, and 2) transitions require governance actors to revisit and reimagine possible management solutions and the underlying purposes and ultimate desired outcomes of resource management. Articulating the multiple visions of system futures that emerge in the wake of a crisis can encourage creative responses to change that can incorporate multiple perspectives and provide space for decision-makers to consider different options for management and potential conflicts therein. However, empirical research is needed to examine how governance actors actually envision future management in the context of a crisis. Here we explore governance actors' perspectives on future pathways for reef management in the wake of an extreme climate event, and what actions are underway to pursue these pathways. We specifically investigate perspectives after recurrent mass coral bleaching events impacted the Great Barrier Reef through 36 semi-structured interviews with governance actors across the region. Drawing on climate adaptation frameworks and narrative policy analysis, we demonstrate that crises trigger changes in governance actors' perspectives on the goals and approaches of reef management. However, rather than a single vision emerging in the wake of crisis, we find that multiple, and at times conflicting, visions for the role of management and plausible futures for the GBR are simultaneously shaping the trajectory of coral reef governance. Our findings suggest that transforming governance after crises involves negotiating multiple concurrent visions for social-ecological futures.

1. Introduction

Extreme climate events are changing social-ecological systems (SESs) and challenging resource management paradigms (Van Oppen et al., 2017; Bellwood et al., 2019; Morrison et al., 2020; Magness et al., 2022; Williams, 2022). Understanding how resource managers, decision-makers, and others with jurisdictional authority or advisory roles (henceforth "powerful governance actors" or "governance actors") shape governance after extreme climate events is critical for developing effective governance of SESs in the Anthropocene (Chaffin et al., 2016; Muiderman et al., 2022; Munera-Roldan et al., 2022; Schuurman et al., 2022). Many factors affect what decisions governance actors make in the wake of extreme climate events, including available resources, public opinion, and the political environment, but also the ways in which they interpret change (Adger et al., 2009; Chaffin et al., 2016; Louder and Wyborn, 2020; Muiderman et al., 2022; Munera-Roldan et al., 2022; Schuurman et al., 2022). Governance actors' interpretations of change are rooted in part in sociocultural factors such as how they understand a SES, the political coalitions they are a part of, and what values they hold for its future (Sabatier, 1998; Adger et al., 2009; Paschen and Ison, 2014; Munera-Roldan et al., 2022). Governance actors, like others, engage in cognitive processes of building 'narratives' or 'stories' about problems and possible solutions (Adger et al., 2009; Paschen and Ison, 2014; Munera-Roldan et al., 2022). This research examines what narratives

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emerge amongst governance actors after extreme climate events to illuminate how these actors understand recent change, imagine the future, and select relevant management solutions to steer SES governance through the challenges of climate change (Louder and Wyborn, 2020; Muiderman et al., 2022; Munera-Roldan et al., 2022; Schuurman et al., 2022).

Not all governance actors have equal power to influence resource management; thus, not all narratives have equal impact on governance. Narratives employed by governance actors in positions of power have a disproportionate influence on the trajectory of the system (Leach and Fairhead, 2000; Paschen and Ison, 2014; Muiderman et al., 2022). However, little attention is given to the competing narratives amongst these powerful governance actors, despite the effects different narratives may have on what solutions and ultimate system futures are prioritized or excluded, and which actors benefit as a result (Blythe et al., 2018, Muiderman et al., 2022). Examining the narratives powerful actors build around social-ecological challenges and possible solutions sheds light on the rationale behind emerging management approaches, identifies areas of tension, and encourages a pluralistic approach that embraces multiple narratives to encourage creative responses to change (Shanahan et al., 2011; Paschen and Ison, 2014; Louder and Wyborn, 2020).

As governance actors experience acute crises such as extreme climate events, they update their narratives about problems and solutions for future policy and management (Birkland, 1998; Pahl-Wostl, 2009; Chaffin and Gunderson, 2016). Some hypothesize that crisis events create opportunities for governance actors to transition towards more adaptive ways of governing SESs (Birkland, 1998; Olsson et al., 2006; Pahl-Wostl, 2009; Chaffin and Gunderson, 2016), but the extent to which this actually occurs depends on how actors conceive of the problem and imagine the future, among other factors (Pahl-Wostl, 2009; Chaffin et al., 2016; Muiderman et al., 2022). Adaptive governance and collaborative conservation research suggest that actors can use crises—both acute and slow-onset (e.g., climate change)—as opportunities to collectively re-envision shared management approaches (e.g. Armitage et al., 2009, Schultz et al., 2011, Schuurman et al., 2022). However, research also recognizes that change is messy and consensus is difficult; actors often contest proposed solutions and the nature of the problem itself (Leach and Mearns, 1996; Shanahan et al., 2011; Munera-Roldan et al., 2022). Some suggest that pursuing multiple visions simultaneously may be a more effective strategy for navigating climate-driven change (Paschen and Ison, 2014; Louder and Wyborn, 2020; Munera-Roldan et al., 2022). Further empirical investigation is needed to understand the different ways that governance actors interpret crises and re-imagine social-ecological futures, and what consequences this has for how SESs are governed.

One method for turning analytical attention to this issue is narrative policy analysis (e.g. Paschen and Ison, 2014; Warner, 2019). Narrative policy analysis exposes different problem and solution framings amongst actors who influence policy outcomes (Jones and McBeth, 2010; Shanahan et al., 2011). This approach can potentially broaden management and policy options by opening opportunities for dialogue between different ways of understanding SESs (Shanahan et al., 2011; Paschen and Ison, 2014; Warner, 2019; Louder and Wyborn, 2020). This can facilitate efforts to find consensus on a shared vision, or even encourage a pluralistic view in which multiple future pathways might be pursued simultaneously, rather than aiming for a shared vision (Paschen and Ison, 2014; Louder and Wyborn, 2020). Although useful in theory, this approach tends to be underutilized in research on governance responses to climate change, and empirical studies are needed to test its utility (Paschen and Ison, 2014; Shanahan et al., 2018; Louder and Wyborn, 2020).

Related research and practice on climate adaptation explores how environmental governance actors wrestle with tough decisions about how to react to climate change (Peterson St-Laurent et al., 2021; Schuurman et al., 2022; Williams, 2022). Researchers and resource managers are developing frameworks such as "Resist-Accept-Direct" (RAD) (Schuurman et al., 2022) and "Resistance-Resilience--Transformation" (RRT) (Peterson St-Laurent et al., 2021) to assist governance actors with decisions about how to respond to climate impacts. These frameworks are under development and are in tension with one another. Peterson St-Laurent et al. (2021) argue that the RAD framework gives inadequate attention to the desired outcomes of management, while Schuurman et al. (2022) contend that the RRT framework conflates outcomes and management approaches. Focusing on policy narratives in the context of these climate adaption frameworks can provide the perspective needed to untangle the multiple possible ways governance actors imagine future outcomes and management approaches.

We investigate how governance actors interpret crises and imagine social-ecological futures, and assess their perceptions of the role of management in influencing these futures. We leverage recent mass coral bleaching events on the Great Barrier Reef (GBR) as a case study of an extreme climate event. We draw on interviews with a subset of governance actors who are responsible for high-level decisions, or who provide advice or research to inform those decisions. Our findings illustrate areas of overlap and tension between different governance actors' perspectives on the future, and we demonstrate the utility of our "governance pathways" framework for addressing the limitations of the RRT and RAD climate adaptation frameworks. We conclude with a discussion of how this approach can be used to navigate shared or conflicting visions and enable a pluralist approach to pursue multiple pathways simultaneously.

2. Methodology and methods

2.1. Theoretical framework

Narrative policy analysis and climate adaptation decision frameworks can inform empirical assessments of how governance actors imagine the future of SESs after crisis. We do not analyze policy content, but rather verbal narratives provided governance actors with decision-making authority or advisory roles relative to managing the GBR. The narrative policy framework provides a structure for understanding how governance actors' perceive SES management challenges and what solutions they propose (Jones and McBeth, 2010; Shanahan et al., 2011; Paschen and Ison, 2014; Shanahan et al., 2018). This framework has emerged as an interpretivist method that is replicable across cases, allowing for the consideration of narratives within existing frameworks for studying policy processes such as the Advocacy Coalition Framework (Shanahan et al., 2011; Shanahan et al., 2018). Positivist approaches to studying policy processes assume individuals are rational actors and that an objective reality exists (Jones and McBeth, 2010). However, this has been rejected by those who take a more post-positivist approach because these approaches fail to give attention to actors' normative values, which lead them to understand reality differently and intentionally deploy stories that rally support around their subjective understanding of reality and their subsequent objectives for policy-making (Jones and McBeth, 2010; Shanahan et al., 2018).

We agree that actors' subjective understanding of reality shapes policy processes and therefore responses to extreme climate events (e.g. multiple discourses around Victoria bushfires (Whittaker, Mercer, 2004)). We have therefore adopted key elements of Shanahan et al.'s (2018) interpretivist approach by assuming that a) policy realities are socially constructed, b) narratives have specific structures that are stable over time, and c) narratives are core to human cognition, leading people to think and speak in story form. Our analysis followed core elements of the narrative policy framework (Stone, Deborah, 2002; Jones and McBeth, 2010; and Shanahan et al., 2018), including: 1) context, i.e., who is speaking and what aspects of the GBR context do they highlight, i.e., bleaching, politics; 2) problem frame, i.e., problems and causes of problems; 3) solution frame, i.e., what outcomes are desirable and what actions are identified as solutions; 4) characters, i.e., who are the main

heroes, victims, and villains; and 5) plot, i.e., what general plotline ties these elements together (e.g. identifying a "story of decline" (Stone, Deborah, 2002)). Our analysis considered all these questions, however, our results center on problems, solutions, and the overall plot to identify several governance pathways emerging after bleaching events.

When analyzing the solutions portion of narratives, we drew on the RAD (Thompson et al., 2021; Schuurman et al., 2022) and RRT frameworks (Peterson St-Laurent et al., 2021), because these are recently developed and used by practitioners to navigate responses to climate change. This allowed us to generate results in a format familiar to practitioners and thus contribute insights on how a narrative approach can build on these frameworks. Schuurman's RAD framework has three options for action (resist, accept, direct) based on how much change in a system is deemed acceptable, and how intensively management should intervene. Peterson St-Laurent et al. (2021) propose the resist-resilience-transformation (RRT) framework, which similarly considers how much change is acceptable but places greater attention on desired outcomes and integrating varying levels of management intensity into a single spectrum. Both frameworks consider actions ranging from "resist" as attempts to stop change, to "direct" (RAD) or "transformation" (RRT) as seeking to assist change (see Peterson St-Laurent et al., 2021 and Schuurman et al., 2022). To analyze the solutions component of the narratives, we drew on these frameworks by explicitly considering participants' level of acceptance of change, views on the ideal intentions for management actions (e.g. address drivers or address impacts), and desired ultimate outcomes for an SES. This allows for more a nuanced picture of actors' views than provided for in RAD and RRT frameworks, making it easier to articulate differences and similarities amongst actors.

2.2. Case study: Great Barrier Reef

The GBR is an internationally significant Australian icon that stretches 344,000 km^2 and generates $6.4 billion of economic revenue each year (GBRMPA, 2022). The GBR is composed of a myriad of reefs, islands, seagrass, mangroves, and other habitats—which we refer to as the "reef system." Once viewed as "too big to fail", climate change is now fundamentally shifting the composition and functions of the GBR (Hughes et al., 2018; Bellwood et al., 2019; Dietzel et al., 2021). Mass coral bleaching events in 1998, 2002, 2016, 2017, 2020, and 2022 have collectively impacted the north, central, and south regions of the reef, leading to changes in coral species composition across the reef system (Hughes et al., 2018; Dietzel et al., 2021; Australian Institute of Marine Science, 2022). Although disturbances have always shaped reef ecology, the scale and frequency of these events presents an unprecedented challenge that is causing researchers and practitioners to re-evaluate strategies for reef management and governance (Bellwood et al., 2019; Morrison et al., 2020; Dietzel et al., 2021; Kleypas et al., 2021; Barnes et al., 2022).

The GBR is a World Heritage site and a national marine park governed jointly by the Australian Commonwealth and Queensland (State) governments (Fig. 1). The Reef 2050 Long-Term Sustainability Plan (henceforth "Reef 2050") provides the overarching framework driving management efforts of both governments. The Great Barrier Reef Marine Park Authority (GBRMPA) is the Commonwealth agency that works with the Queensland Parks and Wildlife Service and other agencies to manage the reef. There are two panels to provide advice from researchers and actor group representatives to government described in Fig. 1. In 2018, the Commonwealth awarded $443 million to the Great Barrier Reef Foundation, a Queensland-based NGO, to implement a range of management strategies (restoration, water quality, etc.), making this organization another central player (GBRF, 2022). Diverse reef-dependent industries (e.g. fisheries, tourism), industries in the GBR catchment (e.g. mining, agriculture), NGOs, Traditional Owners, and researchers also regularly engage in reef governance. Government agencies and reef actor groups have differing values for the reef and varying perceptions of its current status (Thiault et al., 2021), making conflicts of use commonplace (Day, 2016; Vella and Baresi, 2017). This research focused on individuals within these government organizations and those advising these organizations.

2.3. Methods

The lead author conducted 36 confidential semi-structured interviews identified through a purposive sample to represent the views of individuals within organizations with authority over, or an advisory role

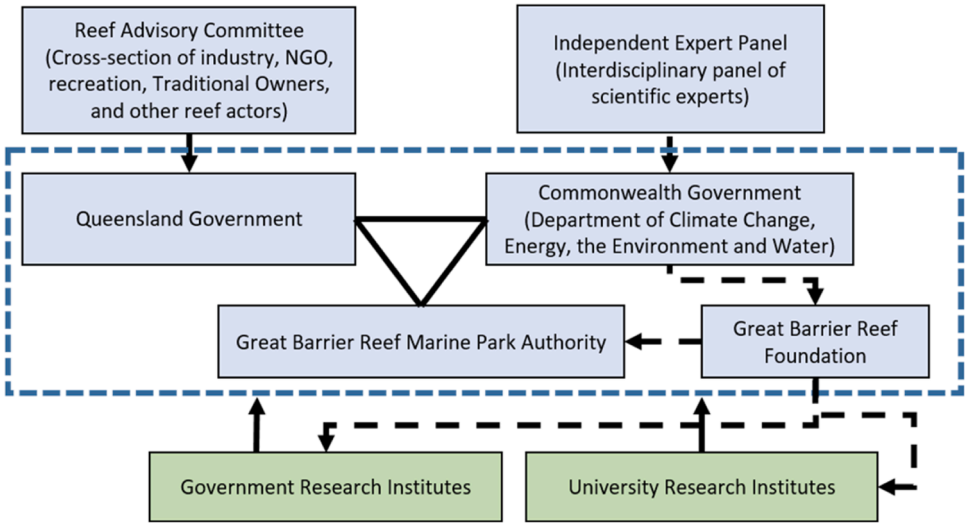

Fig. 1. Governance of the Great Barrier Reef. Decision-making organizations encompassed by the blue dashed line. The Commonwealth and Queensland government share responsibility for the Great Barrier Reef Marine Park (solid black lines). The Great Barrier Reef Foundation distributes Commonwealth funding through the Reef Trust Partnership for research and management activities (dashed black arrows). The Reef Advisory Committee, administered by the Queensland Government, is the highest level platform at which these actors engage in advising decision-makers. The Independent Expert Panel, administered by the Commonwealth, is the highest level platform at which researchers advise on reef management. Both advisory bodies are under the umbrella of Reef 2050. Government and university research institutions (indicated in green) regularly provide data and advice to these entities. Participants from each of these organizations and advisory groups are included in this study.

in, decision-making for the entire GBR (Fig. 1). Organizations were identified through a review of literature and documentation of reef governance, and key informants from government agencies (e.g. Great Barrier Reef Marine Park Authority) and high level reef advisory bodies (e.g. Reef Advisory Committee) helped to identify potential participants (Fig. 1). Additional participants were identified through snowball sampling or referral. Final participants included State and Commonwealth government resource managers, researchers who regularly engage with management and participate in advisory panels, elected officials, professionals at NGOs, consultants to NGOs and government, Traditional Owners, one recreational fisher, and tourism, agriculture, and mining industry representatives in Queensland. This represents all actor groups in the region except commercial fishers, who did not respond to interview requests.

Interviews were recorded and lasted 40–90 min, with most averaging an hour. Participants were invited to share their personal views and speak to their roles as governance professionals, but were not asked to speak formally on behalf of their organization. Participants were asked about the reef's condition after mass bleaching events in 2016 and 2017 (the first recorded recurrent mass bleaching events in the region (Hughes et al., 2018)), and what they expect the reef to look like in the future. Participants were then invited to discuss their views on high and low priority solutions for the reef, the role of resource management in achieving solutions, and what solutions are already underway. We cross-referenced and augmented this information with publicly available material from participants' organizations. Interviews were professionally transcribed and the lead author conducted, edited, and coded all interviews using Nvivo 12 qualitative analysis software. See Appendix A for additional information on deductive and inductive coding methods and analysis.

3. Results

Participants expressed a shared understanding of the current state of the GBR and related drivers. However, their perspectives on possible and probable futures varied, as did their views on the role of management. We first describe the mostly shared understanding of the current state of the reef. We then examine where actors' perspectives split in envisioning reef futures and what pathways are available (or not) for management. Finally, we discuss which pathways and associated solutions are being implemented and how this shapes the programs and policies that govern the GBR.

3.1. Converging on climate: areas of shared understanding of the current and future state of the reef

From across all sectors, participants' views on the current state of the reef agreed on four key points:

- *The reef system is degraded after mass coral bleaching events and its future is highly uncertain.* Participants expressed that the reef is "in the worst condition it's ever been in", and used terms like "flipping states" or "crossing a threshold" to express fear that the reef system is already (or at risk of) changing dramatically. All agreed that the exact future state of the reef is now highly uncertain.
- *Climate change is the number one driver of decline.* Participants were shocked by the bleaching recurring in both 2016 *and* 2017, and affecting the far North region previously thought to be "pristine". That this occurred now was "terrifying," and a "major signal to virtually everybody" that climate is the leading driver of reef change.
- *Different localities face different issues.* Participants frequently identified stressors like water quality, crown-of-thorns starfish (a coral-eating starfish), and fishing pressure. Nearly all participants emphasized that the reef is "complex" and "patchy", with stressors differing across localities.
- *The reef is in a recovery period (2017–2021).* Many participants mentioned that the reef partially recovered after the recurrent events in 2016 and 2017, with most citing the regularly released long-term monitoring report from the Australian Institute of Marine Science (Australian Institute of Marine Science, 2021).

These points indicate that most participants' views are aligned on the current state of the reef and the issues it faces. There were some areas of debate, including participants' degree of optimism about recovery, discussed further in Section 3.2. Discussion of possible reasons for observed agreement on reef problems, along with some additional areas of disagreement related to water quality, are discussed in Appendix B.

3.2. Four pathways for GBR management

Participants imagined at least four possible future states for the GBR, which we refer to as "historic state" (i.e. pre-bleaching state), "key sites", "ongoing patchiness", and "undesirable state" (Fig. 2). These four states are generalized to illustrate differences in how participants envision future reef states and the role of resource management in pursuing that state (Fig. 2), and were associated with four possible pathways for reef management after mass coral bleaching events that emerged from our research: "natural return", "assisted return", "retain key sites", and "direct transitions" (Fig. 3). We generalized these pathways from an amalgamation of participant responses, and leverage them to illustrate differences and similarities in the way governance actors are responding to change.

The pathways do not fully represent any one individual's perspective. An individual may pursue different pathways at different times, or pursue multiple pathways simultaneously. Across all pathways, participants emphasized that the future state of the reef is highly uncertain and contingent on the following factors: the frequency of disturbance events (particularly bleaching and cyclones); the global emissions trajectory (e.g. IPCC 1.5 C vs 2 C); and the extent to which local and regional drivers are addressed. Below, we describe the four pathways for future reef management, highlighting the following: 1) desirable and undesirable outcomes for the reef system; 2) the role of management; 3) relevant management solutions; and 4) how bleaching events are interpreted within the pathway. The suites of solutions chosen by managers are considered along a spectrum from primarily focusing on mitigating drivers of change (e.g. spatial planning to manage user impacts, described as "passive" in other frameworks (Peterson St-Laurent et al., 2021)) to focusing on mitigating impacts (e.g. site restoration, aligns with "active" in other frameworks). The first pathway was generally agreed to be infeasible after bleaching events, but provides a point of contrast for the other pathways.

3.2.1. Natural return to historic state

Here the desirable state is a reef system that naturally returns to historic diversity and structure of the GBR. Participants had different "historic" baselines, but generally imagined reefs in pre-bleaching condition or earlier. Here the reef is considered capable of "bouncing back" on its own, resonating with the idea of "return" (Schuurman et al., 2021). The undesirable state is the GBR losing its natural resilience and degrading into a patchy and/or eventually algae-dominated state.

Management's role focuses on removing drivers of change rather than actively intervening via restoration efforts. The goal is to allow natural resilience to rebuild the historic state, rather than trying to direct a transition to a different state (see 3.2.3). Several participants described that prior to bleaching, the GBR management was primarily "hands off"; the reef was expected to naturally recover once stressors were removed. Relevant solutions in this pathway have included reef use zoning, banning gillnets, and regulating and promoting best practices to improve water quality.

After mass coral bleaching, most participants no longer considered a full return to a historic state feasible. One participant, a university

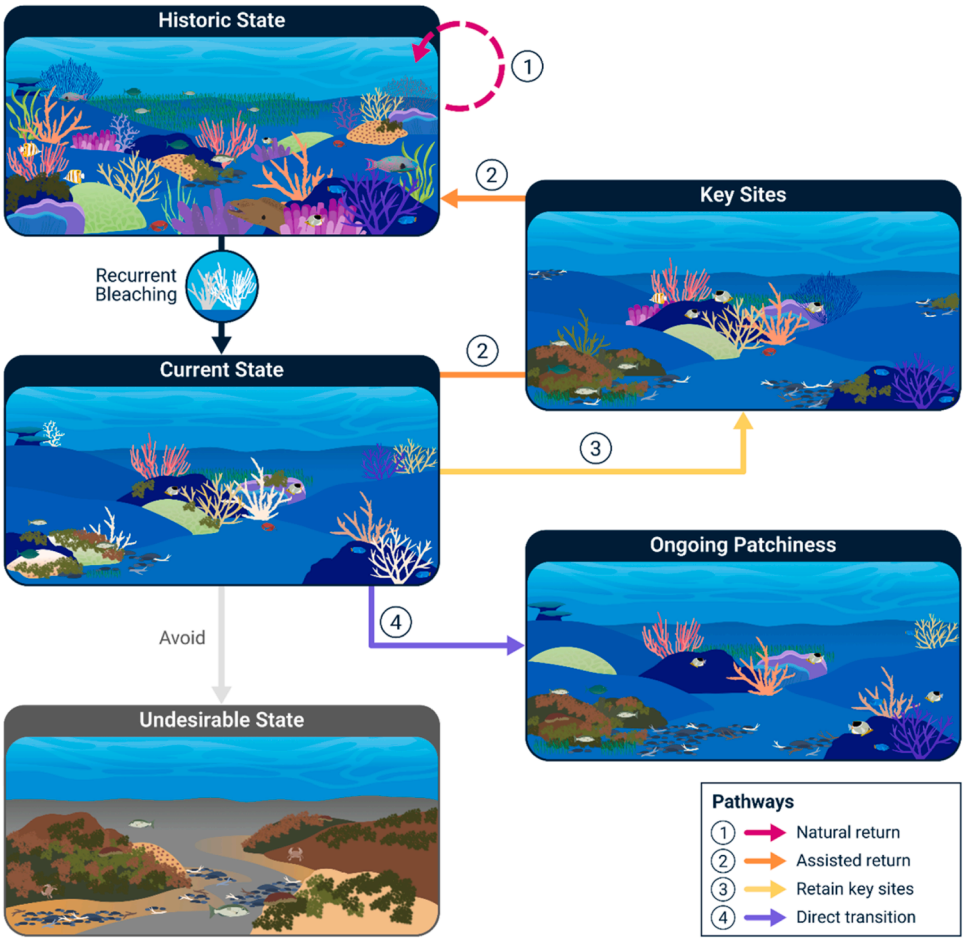

Fig. 2. Four possible future states for the GBR were generalized from participants' perspectives. A) Historic state: the GBR returns to a composition and structure at least as vibrant as prior to mass coral bleaching events. B) Undesirable state: a bleak, algae-dominated system, with a few heat tolerant corals. C) Key sites: specific patches of reef are restored and maintained while the rest degrades. D) Ongoing patchiness: state involved some reefs remaining structurally and functionally diverse and others flipping into states dominated by algae or fast-growing coral species with little structural diversity. These reef states were associated with four different pathways for responding to change, as described in Fig. 3.

researcher previously employed at a government agency, reflected, "I'd like to see the reef back to how it appeared when I first started diving in the 80 s. But…maybe that's being unrealistic" (Participant 1). A mineral resources professional similarly suggested that a return to old reefs would be nice, "but realistically.it's never going to be like it was, it just can't be…not within 100 years" (Participant 21). Another explained:

> *"…most of the conventional wisdom was remove the pressures from the park and then leave it well alone and it'll recover. Equilibrium management. And it's solid as a strategy. However, as…we get more and more mounting impacts and serious decline in the underlying habitats. Then you need to intervene more, which is where we're at." (Participant 4 Government professional)*

Participants sometimes argued for management solutions similar to those previously used within this pathway, such as improving water quality or expanding "green zones" (no fishing) in the GBR marine park. However, they now incorporated these solutions into other pathways.,m n Though this pathway was considered unviable, a few suggested it may become viable again in the future (see 3.2.2 and 3.2.3), but that other pathways (e.g. "Assisted return") are necessary for now.

3.2.2. Assisted return to historic state

Similar to the previous pathway, the desirable state is for the reef to return to pre-bleaching diversity and structure. Again, continued to decline towards an algae-dominated state, or increasing patchiness (i.e. a mix of coral, rubble, algae, etc.) is undesirable. However, two key features differentiate this pathway: intensive human intervention is considered critical for recovery, and a patchy reef is considered marginally acceptable in the short term. For example, one government researcher emphasized short term action to support eventual long term recovery:

> *"The aim…is to…do what we can over the next few years so that we maintain some in-built resilience or the capacity of the reef to respond once those broader climate drivers hopefully start coming under control. So it's about leaving some gas in the tank so the reef has a capacity to recover in 20 years' time." (Participant 11)*

Here reef "patchiness" is central to the idea of "building back" and is viewed as a temporary, intermediate step towards an ultimate return to the diversity of the pre-bleaching reef. Participants conceived of patches of healthy reefs as "bright spots" or "ecologically and culturally important sites" that could serve as "seed reefs" to help other reefs "bounce back" with time.

In this pathway, management's role focuses on interventions aimed at mitigating impacts to the reef by a) restoring the reef (e.g., genetically engineering corals for heat resistance), and b) reducing exposure to stressors (e.g., cloud-seeding to shade reefs during heat waves). Most participants whose views aligned with this pathway were NGO or government professionals, along with some researchers. Participants emphasized that "business as usual" will not facilitate the desired return

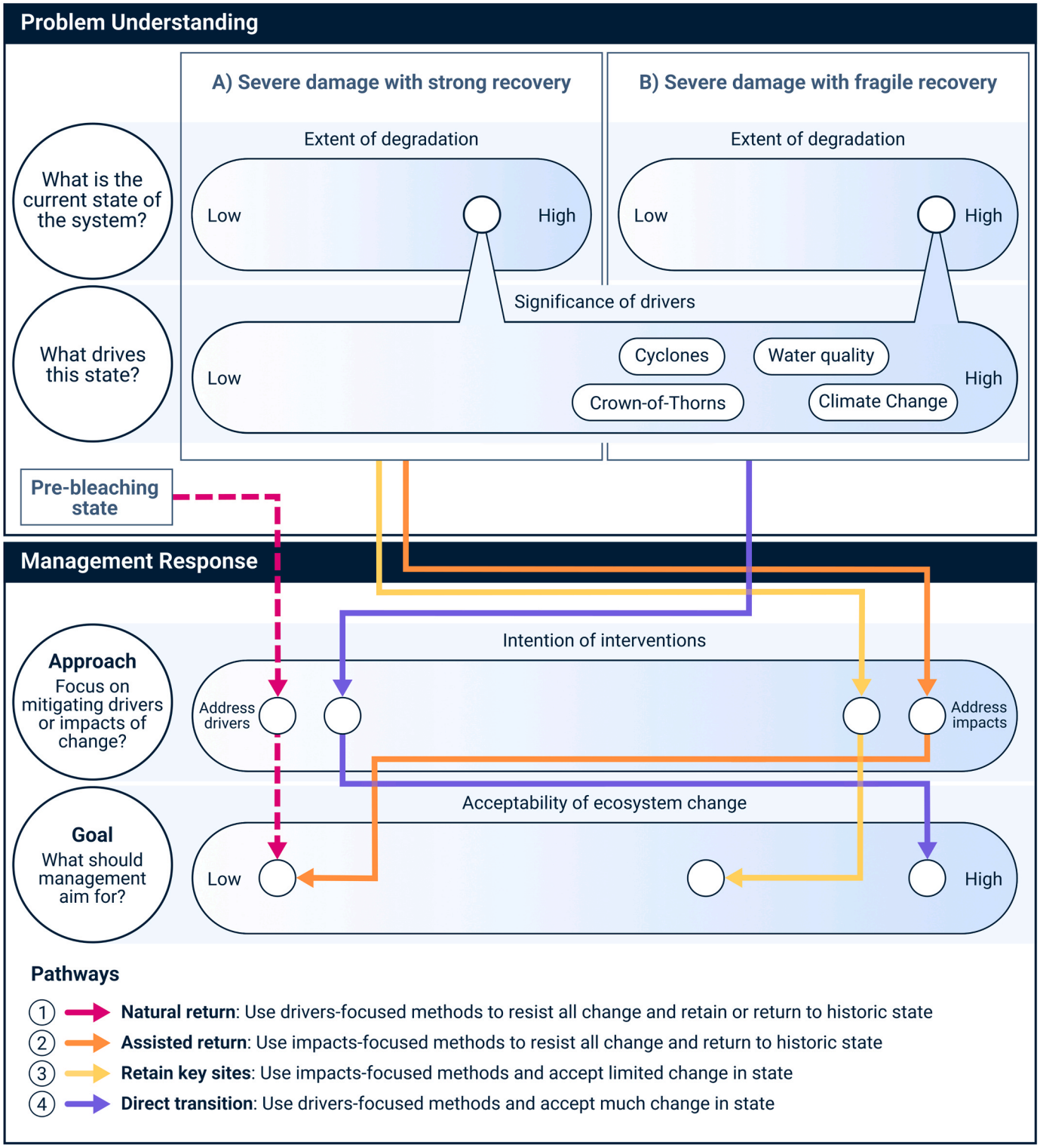

Fig. 3. Four pathways for the Great Barrier Reef (GBR) amalgamated from interviews: 1) natural return (dotted line indicates this pathway is no longer considered viable), 2) assisted return, 3) retain key sites, and 4) direct transitions. All four pathways rank the drivers of change similarly, but there were differences in views on current recovery. Box A shows respondents' view that the reef showed strong recovery whereas box B reflects the view that the reef shows fragile recovery; the pathways further diverge from there. White dots indicate governance actors' generalized responses to each of the four questions on the left side of the chart.

to a pre-bleaching state. Here this implied a rejection of "hands-off" management and a dire need to embrace intensive interventions focused on mitigating impacts on reefs. One NGO professional described that the aim is "just providing those interventions at the minimum level necessary to keep… [reefs] self-sustaining" because "there's…a clear tipping point that we can't get past" (Participant 26). This participant suggested that it is important to gauge when interventions are feasible, as they require constant input unless the system quickly gets to a point where it can "bounce back". Most participants articulated that these types of interventions should be undertaken alongside a broader focus on

reducing drivers of change because a full return to pre-bleaching state is not possible without a rapid move onto a < 1.5 C emissions trajectory. At the same time, participants here considered post-bleaching recovery to be strong at the time of interviews (late 2021, early 2022), with some framing recovery as a demonstration that an eventual return to a pre-bleaching state is plausible. Resource managers, politicians, NGO professionals, and tour operators emphasized that recovery is "strong" and going "very well," and some suggested that reefs could "u-turn" as demonstrated by the recent "massive bounce back." One tour operator emphasized:

"[Climate change] is not a battle that can't be won, and that's…really important…reef health, what we're seeing at the moment, it's on a strong recovery, and from a tourism perspective, the reef [has] not looked as good as it does now in a number of years." (Participant 24)

Participants' whose views aligned with this pathway emphasized that there is still hope for a near full recovery of the reef. Others shared some of the optimism of this pathway but expected more limited results, as discussed further in the next section on the "retain key sites" pathway.

3.2.3. Retain key patches

Here a reef system-wide return to historic conditions is considered impossible–the desired outcome is the recovery of key sites. As with the first two pathways, a reef system-wide shift to an algae-dominated state is undesirable, but here some degree of patchiness is viewed as unfortunate but necessary to accept. Most participants whose views aligned with this pathway were professionals at NGOs or government agencies, as well as a few researchers.

"I think our goal has got to be that some parts of the reef as good as we can possibly get them, which might mean that some parts of the reef look like they did yesterday…[but] I don't think that we'll have the reef as it was… no matter where you went, you would see beautiful life…" (Participant 30 University researcher and government advisor).

Here retaining key patches is recognized as a long term goal, rather than as a means to the eventual ends of restoring the whole reef system (e.g. "assisted return"). Participants described these patches as "ecologically and culturally important sites" or "pockets in reasonable condition" maintained so that some parts of the reef "look like they did yesterday".

The solutions here are similar to the "assisted return" pathway, for example, planting heat-resistant coral or shading the reef. Yet participants adopted a pragmatic tone and expressed that given mass bleaching events, they had no expectations that a full return to historic reefs is possible. One NGO consultant was blatant: "the prognosis [after bleaching] really, was that our best endeavours…could well just end up with two or three pockets of fairly defined coral reef systems in reasonable condition. And everything else…in bad condition" (Participant 23). Another NGO professional pointed out "[the reef] management approach probably needs to be…different than how we viewed it a decade or two ago… this focus on interventions [e.g. restoration], while we do, hopefully…lift our game on climate action, is going to have to be part of the equation" (Participant 13). Similar to the previous two pathways, reducing major stressors like climate change and water quality was considered important, but even with these actions participants expected spatially limited outcomes in the long term.

Many participants interested in interventions focused on addressing impacts (i.e. reef restoration) raised the prospect of triage (i.e. picking a few priorities due to limited resources). Participants across the study were hesitant to identify lower priority solutions, but when contemplating the realities of limited funding they suggested that choices would need to be made in the future to retain key patches. For example, a university researcher and government advisor suggested:

"…Ultimately, a political decision will end…up being made to say … we can only do so many [reefs] and we will do everything we can about global warming…But the ones we can go ahead and actively protect…for whatever reason, probably commercial… none of [the ministers] would like it…that'd be a truly tough call." (Participant 30)

The idea of triage, either picking certain reefs or certain issues over others (e.g. restoration over water quality), was raised by several participants despite their finding it noticeably uncomfortable to discuss due to the highly political nature of such decisions.

In comparison to the previous two pathways, the perceived role for management after bleaching events mostly aligns with the "assisted return" pathway, but the desired outcome is different as a full "return" is no longer considered feasible. In the language of the RAD framework, this pathway allows some change at large scales but resists it at localized scales.

3.2.4. Directing transitions to future states

Here the desired future is not a specific reef state but rather the ability to navigate ongoing changes in the reef system. The reef is expected to continuously shift in structure and function as the effects of climate change and other stressors are realized. Returning to pre-bleaching structures and functions is considered unlikely or impossible, and reef patchiness is assumed as a future reality that must be accepted and actively directed when feasible. Contrary to other pathways, the exact reef state (e.g. structure and composition) is less relevant than key ecosystem functions and processes (e.g. nutrient cycling or fish stock reproduction). There were few participants whose views resonated with this pathway, and all were university researchers.

As elsewhere, a full regime shift to an algae-dominated state is undesirable; however, because participants expected patchy reefs in the future they did not view system-wide algae-dominated state as likely. One researcher instead suggested that "certain reefs… regions and… habitat are going to degrade more so than others" (Participant 5). Another researcher echoed:

"…depending on the species and location, there's going to be boom and bust and there's going to be beautiful places and…not so nice places, and it's going to be patchy. It's going to be changeable. But my overall feeling is reefs are amazingly resilient. They've been around for a long time and we overestimate humans' abilities to destroy reefs." (Participant 20)

Here patchiness is not considered equivalent to losing resilience, but is instead considered part of reef resilience. This researcher articulated that patchiness may be desirable because it creates diverse structures that facilitate reef processes. Consequently, an algae-dominated state is not the only undesirable outcome in this pathway—a monoculture of a single coral species is also something to avoid because it lacks diverse resources for fish and therefore has limited fish species diversity. Thus, short-term recovery after bleaching events was regarded as unimportant because it involved a limited number of "weedy", fast-growing corals that did not provide structural diversity. Where recent recovery was cited as a hope in other pathways, here it was merely a temporary change of little long-term significance. Recovery is considered "fragile" and "easily wiped out" by another bleaching event.

This pathway stands in direct contrast to the "natural return" pathway in regard to both its desired state and the role of resource management. As with the previous two pathways, participants suggested that "business as usual" is no longer sufficient after mass bleaching events. However, here this was interpreted to mean that managing for a stable desirable state is not feasible; rather than seeking to switch to intensive, impacts-focused management, this pathway is about addressing drivers of change and also changing desired management outcomes. University researchers articulated a paradigm for reef management that embraces extensive change, with one researcher suggesting that management approaches must recognize that "further change is inevitable and maintaining the status quo is no longer possible" (Participant 35). Another emphasized that managers are currently "change avoiders" but need to be "change copers" and that

"we're trying to resurrect the reefs of our childhood and dreams…[but] what we should be looking at for society is to cope with what we've got" (Participant 20).

Participants aligned with this pathway suggested that priority solutions should focus on reducing large-scale drivers of change (e.g. water quality). One university researcher elaborated:

> *"…The number one priority has to be to address…the causes of coral loss before you even think about restoring reef or habitats. It's the old adage that prevention is better than cure. It's going to be much more effective to stop the loss of corals out there on the reef than to try and replace them once they're lost." (Participant 5)*

The focus on reducing drivers of change resulted in less interest in or downright rejection of smaller scale interventions aimed at mitigating impact (e.g. coral restoration). There was a clear focus on identifying important reef functions, but also a recognition that this requires a subjective value judgement by management agencies and reef actor groups. Several participants expressed that decisions about what is valued, and why, are needed and that managers, local communities, and others should be involved in these decisions.

3.3. On-the-ground solutions: footsteps towards multiple reef futures

Here we briefly highlight how governance actors take steps down three of the four pathways simultaneously ("natural return" was not actively pursued by participants) (Fig. 4). Despite some disagreement about what specific solutions should be pursued, participants agreed that pursuing any solution should involve advocating for greater community engagement and a stronger role for Traditional Owners in research, management, and decision-making.

Activities related to all pathways included adopting best practices and enforcing regulations to improve water quality, typically implemented by state government, NGOs, and the agriculture industry. Addressing climate change and making water quality improvements are seen as key to restoring the historic reef state, or directing the degree of change in future reefs. Some larger NGOs and prominent researchers actively advocated for emission reduction and campaigned for renewable energy and stopping coal mining. Efforts to address water quality and climate change aligned most strongly with "natural return" and "direct transitions" pathway.

Restoration activities related primarily to "assisted return" and "retain key sites" include government-funded programs (e.g. Reef Restoration and Adaptation Program), NGO research and management (e.g. Crown of Thorns Starfish control program) and private sector research and development (e.g. Reef Ecologic coral gardening project). Other activities involve developing policies and regulations for these new approaches, such as the GBRMPA "Policy on GBR Interventions." Some activities were initiated prior to mass bleaching events, but the events heightened their importance. For example, removing crown of thorns starfish was part of the "natural return" pathway prior to bleaching, but became part of the "assisted return" and "retain key sites" pathways.

There is clear overlap in solutions included across the four pathways, but also some tensions (Fig. 4). For example, actors whose views most closely aligned with the "assisted return" or "retain key sites" pathway usually focused on restoration and reducing stressors, whereas most actors aligned with the "direct transitions" pathway favored reducing drivers of change. In addition, actors interested in the "assisted return" and "retain key sites" pathway discussed triage, with a few tentatively suggested reallocating funding from water quality efforts towards restoration and adaptation interventions, whereas those in the "direct transitions" pathway opposed this.

4. Discussion

Climate-driven change in SESs poses difficult, sometimes existential questions for governance actors about the purpose of resource management. The perspectives of this subset of governance actors are particularly important to understand because they influence decisions about the future of these systems. In exploring these perspectives, our narrative policy analysis brings attention to the notion that problems and solutions are framed in different ways by different actors (Sabatier, 1998; Stone, Deborah, 2002; Jones and McBeth, 2010; Wyborn et al., 2021; Munera-Roldan et al., 2022). The four pathways that emerged illustrate that these actors imagine multiple futures for the GBR, and provide a starting point for negotiating which future(s) become a focal point for management efforts. Participants' responses tended to align with the second or third pathway, and a minority supported the fourth pathway.

Our primary contribution was to bring a focus to how governance actors understand problems, and to connect different problem frames to solutions. The RAD and RRT framework skip over the question of how actors conceive of problems and move immediately to a focus on management approaches (Peterson St-Laurent et al., 2021; Schuurman et al., 2022), but drawing on a narrative approach introduces attention to how actors frame problems (Stone, Deborah, 2002; Jones and McBeth, 2010; Shanahan et al., 2018). By first asking governance actors about the current state of the GBR and what drives this, we were able to empirically demonstrate a relatively shared view of drivers of change, but also detect differences. The strong agreement on drivers was somewhat

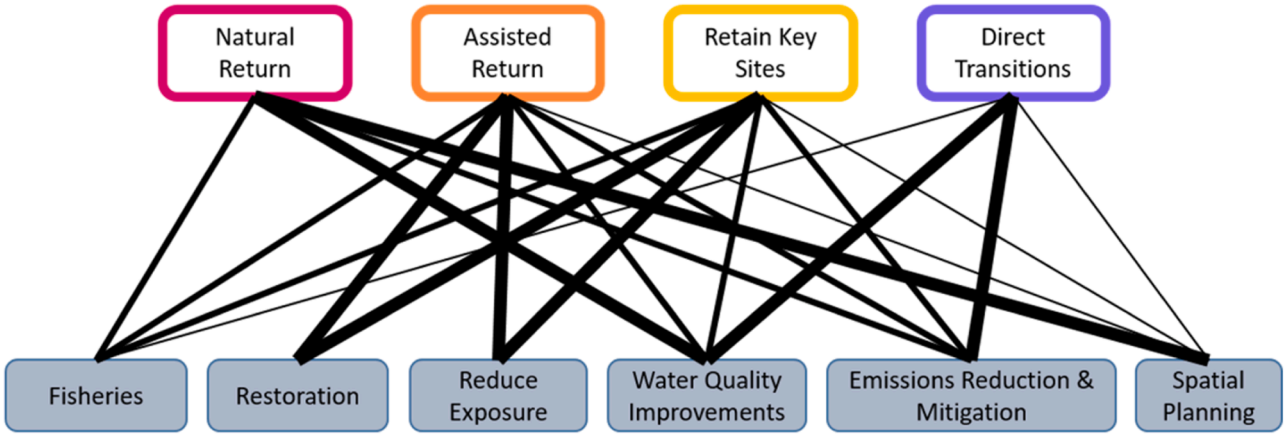

Fig. 4. The four pathways relate to a range of different reef management solutions. Solutions are generalized from interviews into six general categories (grey boxes). The black lines are weighted based on a qualitative assessment of how much a given solution was emphasized in relation to the desired outcome of a given pathway—thicker lines reflect greater emphasis.

unexpected given the frequent conflicts between actors' perspectives within the GBR region (Vella and Baresi, 2017), though this resonates with research showing that bleaching events brought commercial fishers, tour operators, and coastal residents into greater alignment on perceptions of GBR threats (Thiault et al., 2021). Differences in interpretations of coral recovery marked the first major point of departure between pathways, with those ascribing significance to recovery tending toward impact-oriented management more so than those who considered recovery insignificant in the long term. Our framework contributes to practical efforts to negotiate between governance actors'

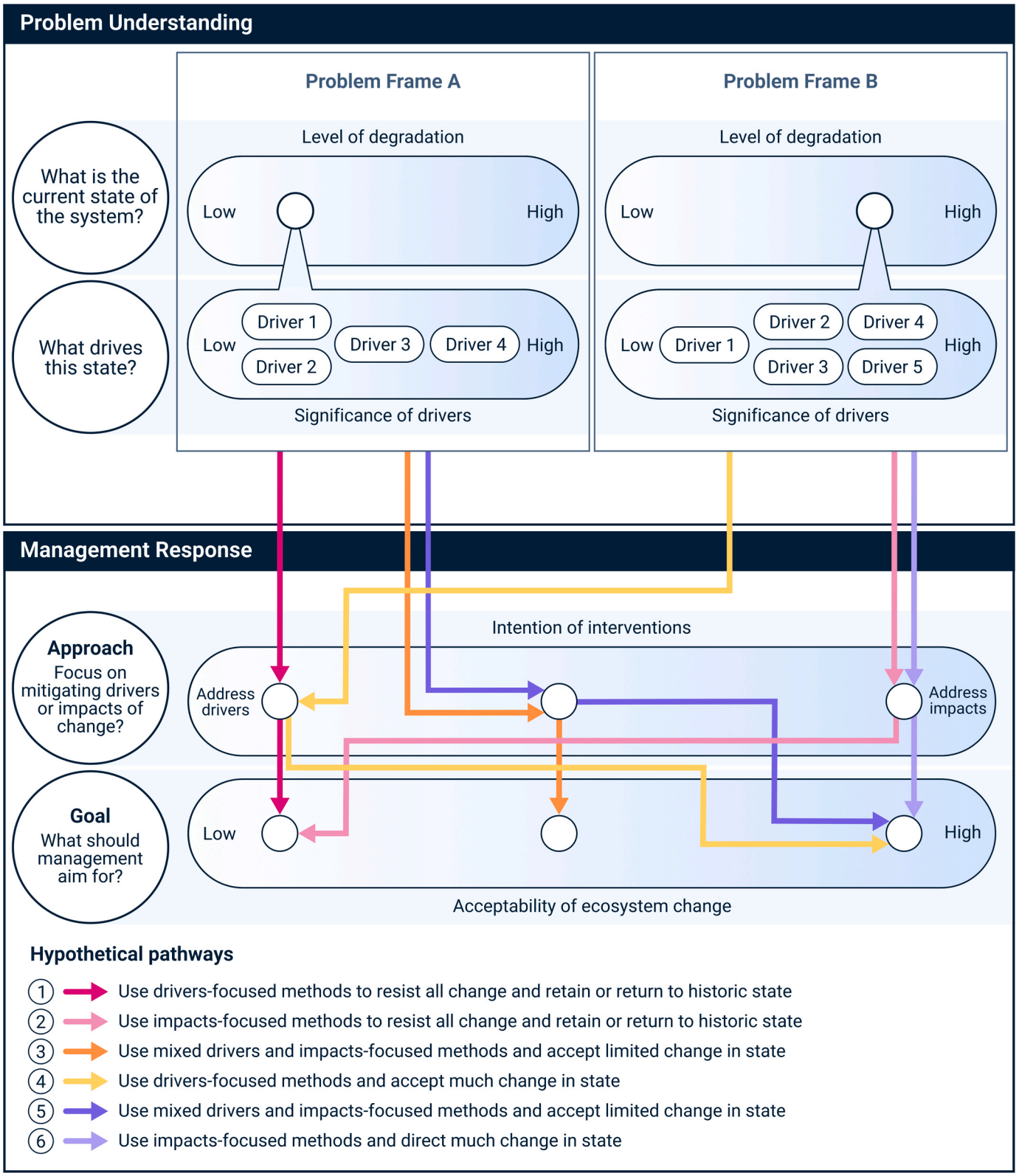

Fig. 5. Governance Pathways Framework: Pathways are indicated by colored arrows that begin from specific problem frames, consider management approach, and end with management goals. White dots indicate governance actors' hypothetical responses to each of the four questions on the left side of the chart.

by revealing unrecognized areas of overlap that could become the basis for building consensus on some issues.

Our second contribution was to consider, but not conflate, actors' views on solutions, management approaches, and desired outcomes. The RAD framework (Thompson et al., 2021; Schuurman et al., 2022) focuses on management approach and attends to actors' level of change acceptance, but is critiqued for not being specific about desired outcomes (Peterson St-Laurent et al., 2021). The RRT framework (Peterson St-Laurent et al., 2021) is criticized for conflating management approach and outcomes (Schuurman et al., 2022). Our framework addresses these limitations by incorporating spectrums for management aim and level of acceptable change from the RAD framework, but keeps them clearly differentiated (Fig. 2 'Management Response' box). Both the RAD and RRT frameworks imply that management solutions (e.g. restoration) can be sorted into discrete outcome categories (e.g. "resist" for RAD or "passive resistance" for RRT), but this did not align with our findings. Our framework illustrates that different solutions are used to realize the same outcome simultaneously, or the same solution may be implemented in pursuit of entirely different outcomes. For example, the "natural return" and "assisted return" pathways share a desired outcome of an eventual return to historic reef composition, but differ in approach, with "assisted return" involving interventions focused on mitigating impacts to reefs. This illustrates that our framework can be used by actors to find overlap in their management solutions even when their desired outcomes are different, creating potential grounds for collaboration.

Lastly, the RAD and RRT frameworks posit that the biggest challenge to deciding on how to respond to change is a lack of clear frameworks, and that a clear framework will make it possible to decide on a single shared path forward (Peterson St-Laurent et al., 2021; Schuurman et al., 2022). This follows a broader trend in adaptive governance and climate adaptation literature that assumes that convergence on a single shared vision is essential (Olsson et al., 2004; Schultz et al., 2011; Schuurman et al., 2022); this perspective was also prevalent amongst participants. However, depending on a shared vision negates the possibility that actors may not ever decide on a shared path forward and could instead take multiple paths simultaneously (Paschen and Ison, 2014; Louder and Wyborn, 2020; Wyborn et al., 2021). The diversity of pathways evident in the wake of bleaching events suggests that reaching consensus across problem conception, solutions, *and* desired outcomes may be unrealistic. While our framework can be used to uncover unrecognized areas of consensus across some elements of management pathways, it may also be used by governance actors to foster a more pluralistic approach to reef management As a first step, we present a generalized version of our framework, referred to as the "Governance Pathways Framework", which can be used to engage directly with governance actors in diverse settings (Fig. 5). We also identify future research directions to develop the utility of the framework for supporting governance of SES futures.

Our generalized "Governance Pathways Framework" does not duplicate but rather builds on the RAD and RRT. Our pathways approach integrates easily with the six categories of the RRT, which could be incorporated as pathways in the "management response" section. For example, the "active resistance" category of RRT would map similarly to "assisted return" in our GBR case. However, we do not limit our framework to a set number of pathways but instead use spectrums to emphasize that a plurality of other pathways are possible. This framework can be applied in different SES settings to encourage creativity and enable governance actors to clearly articulate points of overlap and difference in their visions for the future, as demonstrated in this study. While areas of overlap may offer limited grounds for consensus, areas of departure between pathways indicate places where the coordination of multiple approaches may be needed (i.e. pluralist approach).

In releasing attachment to a consensus vision, a pluralistic approach requires turning attention to coordinating the simultaneous pursuit of multiple pathways such that they mutually reinforce, or at least do not detract from, one another. This calls first for engagement with a broader range of actors (e.g. beyond those at the decision-making table) to identify all possible pathways for management, as well as explicit attention to the spatial scale at which actors hope to realize different outcomes. Because different actors have different levels of influence in a given SES (Blythe et al., 2018; Morrison et al., 2019), it is also necessary to attend to who has authority and resources to implement which pathways, and what factors drive actors' preference for some pathways over others (e.g. perceptions of risk, uncertainty, and potential benefits (Axelrod and Lehman, 1993, Dewulf and Biesbroek, 2018, Bradley et al., 2020)). Attending to these factors while engaging diverse actors directly with the Governance Pathways Framework could provide the information necessary to coordinate between pathways. For example, it may be that certain pathways are most relevant at different scales involving actors with different jurisdictions and capacities. In the GBR case, the "Retain Key Sites" pathway focuses on localized areas potentially small enough for industry actors and reef managers implement, while the "Direct Transitions" pathway appeared much broader, requiring action by government and reef managers. It may even be that pathways can nest inside one another; this is suggested by previous research utilizing the RRT, which found that the implications of a solution are scale dependent (e.g. an action to "resist" at a local level can simultaneously realize a "resilience" outcome at the regional level) (Clifford et al., 2020). In other cases, the framework may identify points where zero-sum tradeoffs between pathways cannot be avoided, for example choosing to allocate funds for solutions relevant to one pathway but not another. By articulating diverse pathways and the ways in which they interact, the Governance Pathways Framework could enable governance actors to better understand each other's positions, and use this understanding to better navigate change even in the absence of consensus.

In addition to applying our framework for practical negotiations between actors, further empirical research could also shed light on how governance shifts after crises by examining whether multiple pathways are maintained or lost over time in a given SES, why this occurs, who benefits or loses as different pathways are pursued, and how power dynamics between actors are maintained or shift through the crises. Future research could also consider how to apply the Pathways Framework consistently to allow comparison across sites but prioritize relevance to specific contexts. The spectrums in our framework allow actors to sort problem frames and solutions relative to one another within a specific location. Future research could investigate the benefits and downsides of creating more standardized spectrums to enable cross-case comparison.

5. Conclusion

Governance actors are faced with the daunting task of navigating climate-driven change in SESs. We investigated the various ways that a subset of governance actors responsible for making or advising on decisions about the globally iconic Great Barrier Reef are grappling with devastating recurrent mass coral bleaching events (Dietzel et al., 2021). We found that the experience of bleaching events has upended the dominant "natural return" paradigm for reef management and left actors seeking new pathways. Three pathways for future reef management emerged simultaneously—"assisted return", "retain key sites", and "direct transitions". Many participants seemed to expect to eventually settle on a single pathway, but the myriad of pathways being pursued suggests that this may not occur in the foreseeable future, and perhaps should not be the goal. Though this lack of consensus was a source of disappointment amongst participants, understanding multiple perspectives may prove more useful for navigating change through experimenting with a plurality of approaches rather than struggling for consensus. A clearer sense of where, how, and why governance actors agree and disagree is a critical starting point for developing coherent approaches to governing the GBR – and other SES – through future crises. We developed the Pathways Framework to enable this understanding by bringing attention to how actors frame problems, and

clearly articulating desired outcomes. Our framework makes it easier to articulate nuanced but consequential differences in actors' views and expose the great diversity of perspectives at play even amongst this subset of governance actors. This opens up opportunities for pluralist ways of thinking about change in contentious democratic settings with diverse actors. We present this pathways framework with the hope that it will enable researchers and managers to creatively navigate future climate change impacts.

CRediT authorship contribution statement

Amber Datta: Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Resources, Writing-Original Draft, Writing-Review & Editing, Visualization, Funding acquisition, Project administration. **Carina Wyborn:** Conceptualization, Methodology, Formal Analysis, Writing-Review & Editing, Supervision. **Brian Chaffin:** Conceptualization, Methodology, Writing-Review & Editing, Supervision. **Michele Barnes:** Conceptualization, Writing-Review & Editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

The data that has been used is confidential.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2023.103625.

References

Adger, W.N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D.R., Wreford, A., 2009. Are there social limits to adaptation to climate change? Clim. Change 93 (3), 335–354. https://doi.org/10.1007/s10584-008-9520-z.

Australian Institute of Marine Science. (2021). Annual summary report of coral reef condition 2020/2021. Australian Government. https://www.aims.gov.au/sites/default/files/2021–07/AIMS%20Long%20Term%20Monitoring%20Program%20Annual%20Summary%20Report%20on%20Coral%20Reef%20Condition%20%28GBR%29%202020–2021_July2021.pdf.

Australian Institute of Marine Science. (2022). Annual summary report of coral reef condition 2021/2022. Australian Government. https://www.aims.gov.au/sites/default/files/2022–08/AIMS_LTMP_Report_on%20GBR_coral_status_2021_2022_040822F3.pdf.

Axelrod, L.J., Lehman, D.R., 1993. Responding to environmental concerns: What factors guide individual action? J. Environ. Psychol. 13 (2), 149–159. https://doi.org/10.1016/S0272-4944(05)80147-1.

Barnes, M.L., Datta, A., Morris, S., Zethoven, I., 2022. Navigating climate crises in the Great Barrier Reef. Glob. Environ. Change, 102494. https://doi.org/10.1016/j.gloenvcha.2022.102494.

Bellwood, D.R., Pratchett, M.S., Morrison, T.H., Gurney, G.G., Hughes, T.P., Álvarez-Romero, J.G., Cumming, G.S., 2019. Coral reef conservation in the Anthropocene: confronting spatial mismatches and prioritizing functions. Biol. Conserv. 236, 604–615. https://doi.org/10.1016/j.biocon.2019.05.056.

Birkland, T.A., 1998. Focusing events, mobilization, and agenda setting. J. Public Policy 18 (1), 53–74. https://doi.org/10.1017/S0143814X98000038.

Blythe, J., Silver, J., Evans, L., Armitage, D., Bennett, N.J., Moore, M.L., Brown, K., 2018. The dark side of transformation: latent risks in contemporary sustainability discourse. Antipode 50 (5), 1206–1223. https://doi.org/10.1111/anti.12405.

Bradley, G.L., Babutsidze, Z., Chai, A., Reser, J.P., 2020. The role of climate change risk perception, response efficacy, and psychological adaptation in pro-environmental behavior: A two nation study. J. Environ. Psychol. 68, 101410 https://doi.org/10.1016/j.jenvp.2020.101410.

Chaffin, B.C., Gunderson, L.H., 2016. Emergence, institutionalization and renewal: rhythms of adaptive governance in complex social-ecological systems. J. Environ. Manag. 165, 81–87. https://doi.org/10.1016/j.jenvman.2015.09.003.

Chaffin, B.C., Garmestani, A.S., Gunderson, L.H., Benson, M.H., Angeler, D.G., Arnold, C. A., Allen, C.R., 2016. Transformative environmental governance. Annu. Rev. Environ. Resour. 41, 399–423. https://doi.org/10.1146/annurev-environ-110615-085817.

Clifford, K.R., Yung, L., Travis, W.R., Rondeau, R., Neely, B., Rangwala, I., Wyborn, C., 2020. Navigating climate adaptation on public lands: How views on ecosystem change and scale interact with management approaches. Environ. Manag. 66, 614–628. https://doi.org/10.1007/s00267-020-01336-y.

Day, J., 2016. The Great Barrier Reef Marine Park—the grandfather of modern MPAs. Big, bold blue: Lessons Australia's Mar. Prot. Areas 65–97.

Dewulf, A., Biesbroek, R., 2018. Nine lives of uncertainty in decision-making: strategies for dealing with uncertainty in environmental governance. Policy Soc. 37 (4), 441–458. https://doi.org/10.1080/14494035.2018.1504484.

Dietzel, A., Connolly, S.R., Hughes, T.P., Bode, M., 2021. The spatial footprint and patchiness of large-scale disturbances on coral reefs. Glob. Change Biol. 27 (19), 4825–4838. https://doi.org/10.1111/gcb.15805.

GBRF). 2022. Reef Trust Partnership. https://www.scribbr.com/apa-examples/website/.

GBRMPA). 2022. Reef Facts. https://www2.gbrmpa.gov.au/learn/reef-facts.

Hughes, T.P., Kerry, J.T., Baird, A.H., Connolly, S.R., Dietzel, A., Eakin, C.M., Torda, G., 2018. Global warming transforms coral reef assemblages. Nature 556 (7702), 492–496. https://doi.org/10.1038/s41586-018-0041-2.

Jones, M.D., McBeth, M.K., 2010. A narrative policy framework: clear enough to be wrong? Policy Stud. J. 38 (2), 329–353. https://doi.org/10.1111/j.1541-0072.2010.00364.x.

Kleypas, J., Allemand, D., Anthony, K., Baker, A.C., Beck, M.W., Hale, L.Z., Gattuso, J.P., 2021. Designing a blueprint for coral reef survival. Biol. Conserv. 257, 109107 https://doi.org/10.1016/j.biocon.2021.109107.

Leach, M., Fairhead, J., 2000. Fashioned forest pasts, occluded histories? International environmental analysis in West African locales. Dev. Change 31 (1), 35–59. https://doi.org/10.1111/1467-7660.00146.

Leach, M., Mearns, R., 1996. Environmental change and policy. lie Land.: Challenging Receiv. Wisdom Afr. Environ. 1–33. https://www.researchgate.net/profile/Robin-Mearns/publication/253318163_Environmental_Change_and_Policy/links/54b818860cf28faced620360/Environmental-Change-and-Policy.pdf.

Louder, E., Wyborn, C., 2020. Biodiversity narratives: stories of the evolving conservation landscape. Environ. Conserv. 47 (4), 251–259. https://doi.org/10.1017/S0376892920000387.

Magness, D.R., Hoang, L., Belote, R.T., Brennan, J., Carr, W., Stuart Chapin III, F., Sofaer, H.R., 2022. Management foundations for navigating ecological transformation by resisting, accepting, or directing social–ecological change. BioScience 72 (1), 30–44. https://doi.org/10.1093/biosci/biab083.

Morrison, T.H., Adger, W.N., Brown, K., Lemos, M.C., Huitema, D., Phelps, J., Hughes, T. P., 2019. The black box of power in polycentric environmental governance. Glob. Environ. Change 57, 101934. https://doi.org/10.1016/j.gloenvcha.2019.101934.

Morrison, T.H., Adger, N., Barnett, J., Brown, K., Possingham, H., Hughes, T., 2020. Advancing coral reef governance into the Anthropocene. One Earth 2 (1), 64–74. https://doi.org/10.1016/j.oneear.2019.12.014.

Muiderman, K., Zurek, M., Vervoort, J., Gupta, A., Hasnain, S., Driessen, P., 2022. The anticipatory governance of sustainability transformations: Hybrid approaches and dominant perspectives. Glob. Environ. Change 73, 102452. https://doi.org/10.1016/j.gloenvcha.2021.102452.

Munera-Roldan, C., Colloff, M.J., Locatelli, B., Wyborn, C., 2022. Engaging with the future: framings of adaptation to climate change in conservation. Ecosyst. People 18 (1), 174–188. https://doi.org/10.1080/26395916.2022.2043940.

Olsson, P., Folke, C., Hahn, T., 2004. Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. Ecol. Soc. 9 (4). https://www.jstor.org/stable/26267691.

Olsson, P., Gunderson, L.H., Carpenter, S.R., Ryan, P., Lebel, L., Folke, C., Holling, C.S., 2006. Shooting the rapids: navigating transitions to adaptive governance of social-ecological systems. Ecol. Soc. 11 (1). https://www.jstor.org/stable/26267806.

Pahl-Wostl, C., 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Glob. Environ. Change 19 (3), 354–365. https://doi.org/10.1016/j.gloenvcha.2009.06.001.

Paschen, J.A., Ison, R., 2014. Narrative research in climate change adaptation—exploring a complementary paradigm for research and governance. Res. Policy 43 (6), 1083–1092. https://doi.org/10.1016/j.respol.2013.12.006.

Peterson St-Laurent, G., Oakes, L.E., Cross, M., Hagerman, S., 2021. R–R–T (resistance–resilience–transformation) typology reveals differential conservation approaches across ecosystems and time. Commun. Biol. 4 (1), 1–9. https://doi.org/10.1038/s42003-020-01556-2.

Sabatier, P.A., 1998. The advocacy coalition framework: revisions and relevance for Europe. J. Eur. Public Policy 5 (1), 98–130. https://doi.org/10.1080/13501768880000051.

Schultz, L., Duit, A., Folke, C., 2011. Participation, adaptive co-management, and management performance in the world network of biosphere reserves. World Dev. 39 (4), 662–671. https://doi.org/10.1016/j.worlddev.2010.09.014.

Schuurman, G.W., Cole, D.N., Cravens, A.E., Covington, S., Crausbay, S.D., Hoffman, C. H., O'Malley, R., 2022. Navigating ecological transformation: Resist–accept–direct as a path to a new resource management paradigm. BioScience 72 (1), 16–29. https://doi.org/10.1093/biosci/biab067.

Shanahan, E.A., Jones, M.D., McBeth, M.K., 2011. Policy narratives and policy processes. Policy Stud. J. 39 (3), 535–561. https://doi.org/10.1111/j.1541-0072.2011.00420.x.

Shanahan, E.A., Jones, M.D., McBeth, M.K., 2018. How to conduct a Narrative Policy Framework study. Soc. Sci. J. 55 (3), 332–345. https://doi.org/10.1016/j.soscij.2017.12.002.

Stone, Deborah, 2002. Policy Paradox: The Art of Political Decision Making. Revised Edition, 3rd ed. W. W. Norton, New York.

Thiault, L., Curnock, M.I., Gurney, G.G., Heron, S.F., Marshall, N.A., Bohensky, E., Claudet, J., 2021. Convergence of stakeholders' environmental threat perceptions following mass coral bleaching of the Great Barrier Reef. Conserv. Biol. 35 (2), 598–609. https://doi.org/10.1111/cobi.13591.

Thompson, L.M., Lynch, A.J., Beever, E.A., Engman, A.C., Falke, J.A., Jackson, S.T., Wilkening, J.L., 2021. Responding to ecosystem transformation: resist, accept, or direct? Fisheries 46 (1), 8–21. https://doi.org/10.1002/fsh.10506.

Van Oppen, M.J., Gates, R.D., Blackall, L.L., Cantin, N., Chakravarti, L.J., Chan, W.Y., Putnam, H.M., 2017. Shifting paradigms in restoration of the world's coral reefs. Glob. Change Biol. 23 (9), 3437–3448. https://doi.org/10.1111/gcb.13647.

Vella, K., Baresi, U., 2017. Understanding how policy actors improvise and collaborate in the Great Barrier Reef. Coast. Manag. 45 (6), 487–504. https://doi.org/10.1080/08920753.2017.1373453.

Warner, B.P., 2019. Explaining political polarization in environmental governance using narrative analysis. Ecol. Soc. 24 (3). https://www.jstor.org/stable/26796972.

Whittaker, J., Mercer, D., 2004. The Victorian bushfires of 2002–03 and the politics of blame: a discourse analysis. Aust. Geogr. 35 (3), 259–287. https://doi.org/10.1080/0004918042000311313.

Williams, J.W., 2022. RAD: A paradigm, shifting. BioScience 72 (1), 13–15. https://doi.org/10.1093/biosci/biab123.

Wyborn, C., Montana, J., Kalas, N., Clement, S., Davila, F., Knowles, N., Ryan, M., 2021. An agenda for research and action toward diverse and just futures for life on Earth. Conserv. Biol. 35 (4), 1086–1097. https://doi.org/10.1111/cobi.13671.