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EDITORIAL

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Advances in conservation science and practice in Oceania: Delivering on research priorities for the region

Oceania is a diverse region both biologically and culturally. Yet the region is also marked by high rates of biodiversity loss due to major threats such as habitat destruction, climate change and invasive species (Kingsford et al., 2009). Evidence-based strategies are needed for successful conservation in the region, and targeted research delivering on urgent practical questions can support this. In 2015, we set out to identify research questions that, if answered, would increase the effectiveness of conservation and natural resource management practice and policy within Oceania in the next 10 years (Weeks & Adams, 2017). The priority questions that we identified emphasized the need for research that addresses distinctive management challenges prevalent in Oceania, and which fits the sociocultural contexts of the region. Five years on, we reflect on some of the progress made in answering these priority questions, with the eight papers featured in this Special Section addressing 12 of the 38 priority questions (Table 1).

1 | MARINE ECOSYSTEMS AND FISHERIES

Relative to similar exercises undertaken elsewhere and globally, research priorities for Oceania placed a much greater emphasis on fisheries management (Weeks & Adams, 2017). Poor fisheries management practices present a critical threat to livelihoods, food security and biodiversity throughout Oceania. The challenge of managing multispecies, data-poor fisheries in a region with few resources for enforcement and sometimes complex systems of resource governance is substantial.

In this issue, Prince et al. (2020) describe a new approach to reef fish stock assessment and management in Fiji. Their approach exemplifies research that is tailored to the sociocultural context of Oceania's small island developing states: it is pragmatic and multidisciplinary, placing equal emphasis on generating the scientific knowledge required to underpin effective management and creating the social impetus for management reform. The paper addresses several of our research questions of importance. Their size-based approach to fisheries management provides an alternative or complement to marine protected areas (*Q7. What are the most effective fisheries management policies that contribute to sustainable coral reef fisheries?* in Table 1) using a methodology that empowers fishers to self-assess the vulnerability of their fish stocks (*Q15. Which fish species are especially vulnerable to fishing impacts and require strict management*. By bringing together fishing communities, traditional leaders and the National Government to conduct fisheries assessments, they also address questions 19 and 36, which relate to social context, policy and governance (see Table 1).

LaScala-Gruenewald et al. (2021) address another fisheries-related research question of importance to conservation practitioners in Oceania: *How can spatial management be designed to account for the ecology of commercially important macroinvertebrate species?* (Table 1). Empirical studies of spatial management for marine invertebrates are lacking, and critical knowledge gaps in their fisheries ecology has hindered effective management. LaScala-Gruenewald et al. (2021) examined long-term trends in rock lobster (*Jasus edwardsii*) populations within three small marine reserves in New Zealand. They found that these lobster populations are not fully protected from fishing due to seasonal foraging excursions beyond the offshore boundaries of the reserves where they are susceptible to fishing-related mortality, and conclude that reserves which encompass both a species' longshore and offshore movements are needed. While rock lobster is an important target species for commercial fisheries and cultural fishing in New Zealand and Australia, other macroinvertebrate species (e.g., sea cucumbers, giant clams, *Trochus*) have greater importance in the Pacific islands, and research into the dispersal and movement ecology of these species and implications for management remains a priority.

TABLE 1 Thirty-eight high-priority research questions for conservation and natural resource management in Oceania's small-island developing states identified by Weeks and Adams (2017), cross-referenced with the papers from this Special issue which address each question. Questions are grouped by their original research theme, and question numbers refer to their overall rank from the original prioritization exercise. An updated version of this table with additional references to research published elsewhere is available (and open to contributions) at http://scboceania.org/priorities

Theme	Question	Relevant special section paper
Ecosystem management and restoration	*Q1. What are the highest priority areas for conservation (and sustainable development efforts) in the face of increasing resource demand and climate change?*	*Adams et al.*
	Q54. How can surveillance be better targeted to mitigate the risk of movement of invasive species?	*Baker and Bode; Emery et al.*
Protected areas	*Q2. How should marine protected areas be networked to account for connectivity and climate change?*	*Adams et al.*
	Q16. What is the true cost of implementing effective protected areas in Oceania, and who will pay that cost?	
Fisheries	Q3. What minimum level of protection is needed to ensure the long-term sustainability of coastal fisheries stocks under future projected changes to coastal habitats and species?	
	Q7. What are the most effective fisheries management policies that contribute to sustainable coral reef fisheries?	*Prince et al.*
	Q15. Which fish species are especially vulnerable to fishing impacts and require strict management?	*Prince et al.; LaScala-Gruenewald et al.*
	Q20. What are the key economic, policy, and management changes that need to be implemented to better sustain tuna stocks in the region?	
	Q23. How can we measure total fisheries catch of Pacific Islands, given that fish landings are often dispersed and unreported?	
	Q24. Which fisheries need to be protected most for future generations after coral reefs collapse from climate change and ocean acidification?	
	Q33. How should periodically harvested closures be designed and managed to maximize their ability to conserve fish stocks and provide for short term needs?	
Marine ecosystems	*Q4. How can spatial management be designed to account for the ecology of commercially important macroinvertebrate species (e.g., sea cucumbers, giant clams, Trochus, etc.)?*	*LaScala-Gruenewald et al.*
	Q11. Where are areas of critical importance (breeding, feeding) to oceanic, pelagic and migratory species within Pacific Island nations, and are there areas of overlap for multiple species?	
	Q22. Which characteristics of oceanic coral reefs confer resilience to natural and human disturbances?	
	Q47. How do larval dispersal patterns vary among species and how spatially or temporally consistent are these patterns for a given species?	
Impacts of conservation interventions	*Q5. What is the comparative feasibility and cost-effectiveness of different land- and marine-based conservation actions to mitigate key threats to coastal-marine ecosystems?*	*Adams et al.*
	Q12. What conservation strategies are most successful in engaging isolated communities in the Pacific?	
	Q27. What conservation intervention has the largest impact on restoring native species and indigenous cultures?	*Kingsford et al. Irwin et al.*

TABLE 1 (Continued)

Theme	Question	Relevant special section paper
Climate change	Q6. How will the anticipated loss of biodiversity associated with climate change, sea level rise and ocean acidification impact local economies and human health throughout the Pacific?	
	Q14. How can protected areas be designed to address impacts of future climate change?	*Adams et al.*
	Q43. How do we build long term climate change planning into an environment focused on short-term disaster risk reduction?	
	Q67. How will ongoing climate change impact the ability of coral reefs to recover from routine disturbances (e.g., cyclones) or anthropogenic disturbances (e.g., overfishing)?	
Terrestrial and freshwater ecosystems	Q8. What are the minimum areas needed to sustain populations of terrestrial island species?	
	Q18. How can we manage water resources to preserve and yet utilize?	
Policy and governance	Q9. How do we move from a donor dependent conservation ethic to a self-sustaining approach to incentivizing or funding protected areas?	
	Q36. How can scientific information be communicated effectively to Pacific Island politicians to influence decision-making?	*Prince et al.*
	Q44. How do we align policies, laws, rules, and regulations across levels of government to have a holistic approach to conservation and management of natural resources?	
Species management	*Q10. How can invasive species be most effectively controlled with the few resources available?*	*Butt et al.; Baker and Bode*
	Q41. What are the specific local- and landscape-scale habitat requirements of Pacific at-risk endemics?	
	Q64. Can we develop novel molecular or genetic approaches to small mammal pest control (including lethal viruses) that will be socially acceptable?	
Societal context and change	Q13. What incentives can be provided to local resource owners to contribute towards national conservation and management of natural resources?	
	Q19. How can governments work effectively with communities to help them take ownership of managing their own resources in a more sustainable way?	*Prince et al.*
Ecosystem function and services	Q30. How much habitat loss, fragmentation, and degradation is occurring on Pacific islands and what impact is it having on native wildlife?	
	Q39. What are the stress points at which ecosystems flip from a desirable state to an undesirable one and how can this be avoided?	
	Q34. How can we combine the best modern science with the best indigenous and local knowledge as a basis for biodiversity conservation and sustainable use in Oceania?	
	Q17. How can conservation oriented natural resource management interventions contribute to livelihood improvement in the Pacific Islands?	
	Q28. What alternative livelihoods from fishing can sustainably provide economic gains and food security to island communities?	
	Q49. How can we determine ecological carrying capacity for tourism in small island developing states?	

2 | INVASIVE SPECIES

Invasive mammals, particularly rodents, cats, stoats, mongoose and possums, have contributed to the decline and extinction of many birds, mammals and reptiles in Oceania (Doherty, Glen, Nimmo, Ritchie, & Dickman, 2016). Invasive plants have also transformed ecosystems and altered fire regimes (Meyer, 2014). Management of invasive species is crucial to island conservation globally, and especially in Oceania's island states (Kingsford et al., 2009). Reflecting this key threat to Oceania's biodiversity, a number of research priorities identified in Weeks and Adams (2017) emphasized the need to control invasive species, with key issues being the prevention of further invasions and controlling and eradicating established species (Questions 10, 54, 64 in Table 1).

Baker and Bode (2020) in this issue review recent advances in the use of quantitative modeling for island eradications. They highlight how prioritization, return-on-investment, value-of-information, multi-objective decision analysis, and other tools can help identify and improve where, how and when island eradications should take place. Key limitations and challenges in quantitative modeling for island eradications include the use of flawed methods, the omission or inappropriate treatment of costs, and insufficient treatment of uncertainty in parameter estimates.

Butt et al. (2020) provide an application of best practice theory, as highlighted by Baker and Bode, of how to prioritize invasive species control and eradication activities in an island system. Their novel Bayesian belief network model supports prioritization of quarantine, surveillance and control, and eradication across large numbers of locations and species. In their case study, they explored three possible scenarios for prioritizing management actions across 550 islands along the Pilbara coast, Western Australia. The flexibility of their model supports adaptation to different objectives and regions that could support explicit decision-making in the Small Island Developing States of Oceania, and helps to address the priority questions: *Q10. How can invasive species be most effectively controlled with the few resources available?* and *Q54. How can surveillance be better targeted to mitigate the risk of movement of invasive species?* We expect such quantitative approaches to become increasingly important as the risk of new invasions and the scale of eradications increases into the future.

The need for effective quarantine, surveillance and control is also highlighted by Emery et al. (2021), who undertake a retrospective expert elicitation of the patterns and drivers of reptile extinctions on Christmas Island, Australia. Their collaborative approach involved researchers, local environmental managers and people involved in the captive breeding programs. Predation by the introduced wolf snake emerged as the most likely causal agent for lizard declines and extinctions on the island. Worryingly though, several unheeded warnings were made about the consequences of allowing the snake to establish and spread across the island. The broader lesson for Oceania from this case study is that acting swiftly is critical for non-native species incursions on islands; the longer you wait, the harder it becomes to stem the damage, which in the case of extinctions, is irreversible.

3 | ECOSYSTEM MANAGEMENT AND RESTORATION AND IMPACTS OF CONSERVATION INTERVENTIONS

Given the constrained funds available to support conservation interventions, and the need to meet multiple objectives, prioritization of cost effective, impactful actions is critical (Questions 1, 2, 5, 14, and 27 in Table 1). Oceania identified more research priorities related to protected areas than similar exercises undertaken elsewhere (Weeks & Adams, 2017). We speculated this might be due to the need to adapt approaches to protected area design and implementation to fit the diverse sociocultural contexts of Oceania's small island developing states. Here, protected area network implementation typically proceeds incrementally, as resources and opportunities allow.

In this Special Section Adams et al. (2021) demonstrate how a national scale protected area system can be designed and scheduled for implementation to maximize conservation impact. They engaged policy makers and other experts in Papua New Guinea to identify areas they felt were most in need of conservation action or most likely to support feasible implementation, based on a range of locally relevant factors. These Areas of Interest formed a set of immediate priorities for action. This work helps address priority questions 1, 2, 5, and 14 (Table 1), which focus on protected areas, spatial prioritization and conservation of coastal marine ecosystems.

Kingsford et al. (2020) present an adaptive management framework for restoration of the functionality and composition of the desert ecosystem in the Sturt National Park, Australia. Their paper details the design and implementation of different management approaches to achieve the ultimate project goals of eradicating and controlling introduced animals, managing native herbivores, removing artificial waters and reintroducing seven regionally extinct mammal species. The approach was developed in partnership with a wide range of

stakeholders including traditional owners and addresses the priority question *Q27. What conservation intervention has the largest impact on restoring native species and indigenous cultures?* Similarities between Kingsford et al. (2020) and Adams et al. (2021) are that adaptive planning and management is critical for successful conservation, and approaches must be tailored to local context. Both papers feature strong stakeholder engagement in the design of plan objectives, processes, and implementation to ensure that the plans are locally relevant and there is strong support for the approaches to ensure successful implementation.

The final paper in this Special Section is Irwin et al. (2021), who studied a population of kākāriki (*Cyanoramphus novaezelandiae*), or red-fronted parakeets, that were translocated to a predator-proof sanctuary in Wellington, New Zealand in 2010–11. This work also falls under the priority question *Q27. What conservation intervention has the largest impact on restoring native species and indigenous cultures?* and similar to Kingsford et al. (2020) explores fenced sanctuaries for protecting and restoring native wildlife populations. Fenced sanctuaries have been shown to be a highly effective conservation tool in Oceania, particularly in New Zealand (Tanentzap & Lloyd, 2017), Hawaii (Young et al., 2013) and Australia (Legge et al., 2018), but establishing threatened species' populations "beyond the fence" is a persistent challenge. Although previous monitoring had shown that the population had established, it was not known what happens to the birds when they disperse outside the fenced area. Radio-tracking of 22 fledgling parakeets showed that half of them appeared to permanently leave the sanctuary, of which three (but possibly five) succumbed to predators during the study period (Irwin et al., 2021). In contrast, all birds remaining in the sanctuary survived during the study period. This highlights the effectiveness of the fenced sanctuary for kākāriki conservation. Importantly, data on dispersal behavior and behavior outside of the sanctuary could help inform future "beyond the fence" strategies.

4 | CONCLUSIONS

The papers in this Special Section are representative of the current state of conservation science in Oceania. They comprise diverse approaches, from community-led science to complex quantitative modeling, but all are responsive to a local management need. Importantly, many of the contributions demonstrate approaches that are readily applicable throughout the region and transferable to other regions globally. A key message emerging from these papers resonates with our knowledge of the region—research specific to the region that takes local context into account is critical to successful conservation.

These papers demonstrate progress made towards answering some of the priority questions for conservation in Oceania identified in Weeks and Adams (2017). Other questions have been tackled elsewhere. For example, Cheok, Weeks, Morrison, and Pressey's (2020) analysis of multiscale conservation governance in Melanesia addresses the question: *Q44. How do we align policies, laws, rules, and regulations across levels of government to have a holistic approach to conservation and management of natural resources?* NGOs including One People One Reef (https://onepeopleonereef.org) and others are working with remote Micronesian communities to develop conservation strategies which integrate local knowledge and traditional practices with modern science and technology, making inroads into identifying *Q12. Which conservation strategies are most successful in engaging isolated communities in the Pacific?* There is also a growing body of work addressing the question *Q64. Can we develop novel molecular or genetic approaches to small mammal pest control (including lethal viruses) that will be socially acceptable?*, including indigenous perspectives on novel biotechnologies (e.g., Palmer, Ripeka Mercier, & King-Hunt, 2020).

A comprehensive review of contemporary conservation science and practice in Oceania is beyond the scope of this editorial, and there is undoubtedly further relevant research (published and forthcoming) and practice ongoing in Oceania of which we are unaware. In an effort to support a research agenda that is responsive to practitioners' information needs, we have begun to document research that answers or addresses these priority questions for conservation and natural resource management in Oceania at www.scboceania.org/priorities. We invite all conservation scientists and practitioners to contribute to this living repository of research which we hope will support evidence-based conservation action in Oceania and elsewhere.

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