# Case Study 1: Transforming Marine Conservation: Policy and Management Outcomes from AIMS Threatened Species Research

## 1. Summary of the Impact

Research by the Australian Institute of Marine Science (AIMS) on threatened marine species has had significant conservation impacts. This body of work has directly informed international policy for shark and ray conservation and driven new guidelines and management actions in Australia to protect marine turtle populations and pygmy blue whales. Consequently, global assessments and agreements have recognised the need for stronger shark protections, while Australian federal and state agencies have implemented measures, such as light pollution guidelines, marine park regulations, and environmental assessment requirements, that improve outcomes for threatened turtles and whales. These changes, spanning 2014 to 2024, demonstrate a clear link between AIMS research and on-the-ground conservation benefits for vulnerable marine species.

## 2. Underpinning Research

**Shark population and extinction risk research (2009–2014):** AIMS scientists led and contributed to pivotal studies on shark populations and their conservation statuses. This research conducted an extensive analysis of reef shark catch data from the Great Barrier Reef (GBR) between the late 1980s and 2006. Published in 2009, it found that no-take Marine Park zones had significantly higher catch-per-unit-effort of reef sharks than fished zones, indicating that fishing was depleting shark numbers in open areas and that protected areas were effective refuges. This study provided the first quantitative evidence that GBR no-fishing zones protected reef shark populations from overexploitation. Building on this foundation, AIMS researchers joined an international team to produce the first global assessment of extinction risk for sharks and rays. Published in 2014, this landmark study analysed 1041 species and revealed that over one-quarter of the world's sharks and rays are threatened with extinction, primarily due to overfishing. Large shallow-water species (e.g. reef sharks and sawfishes) were identified as particularly imperilled, and the analysis highlighted an urgent need for improved fisheries management and trade regulation globally. This global assessment, to which AIMS scientists contributed data and expertise, provided unprecedented insight into shark declines and underpinned subsequent conservation policy responses worldwide.

**Marine turtle hatchling behaviour and predation (2016–2019):** AIMS researchers investigated the effects of coastal lighting on baby sea turtles. In the 2016 study, the team experimentally demonstrated that artificial light on the water strongly attracts sea turtle hatchlings, causing them to linger in nearshore waters rather than dispersing quickly into the open sea. Hatchlings exposed to light (e.g. from coastal development) stay significantly longer near the shore, a behaviour predicted to increase their risk of predation. Following this, Wilson, Thums, Meekan and colleagues conducted field tracking of flatback turtle hatchlings near a Pilbara coastal jetty (2019). They found extremely high predation rates (~70% of hatchlings eaten) in the illuminated vicinity of the jetty, due to predatory fish congregating around artificial lights. This is one of the first studies to quantify how anthropogenic light *indirectly* increases turtle mortality by aiding predators. Together, the 2016 and 2019 studies provide clear scientific evidence that light pollution in nearshore marine areas poses a serious threat to the survival of turtle hatchlings. Another aspect of AIMS turtle research has focused on habitat use and movements. Fossette and collaborators tracked critically endangered hawksbill turtles from nesting beaches in Western Australia. Their 2021 study mapped the broad-scale distribution and migration routes of WA hawksbills for the first time, identifying a migratory corridor along the Pilbara coast used by over half (56%) of the tracked turtles. This study highlights previously underappreciated inter-nesting and foraging areas, emphasising the importance of WA coastal waters for hawksbill conservation.

**Pygmy blue whale movement and habitat use (2015–2022):** AIMS scientists also led groundbreaking research on this threatened subspecies. Thums and Ferreira (AIMS) and other collaborators undertook a multi-year study combining satellite tracking (2009–2021) and passive acoustic monitoring (2006–2019) to map pygmy blue whale migration and key habitats. Published in 2022, this research revealed that pygmy blue whales migrate from waters off southern Australia to Indonesia, with a significant portion of their route passing through offshore areas of northwestern Australia that overlap with oil and gas developments. The team identified critical "high-use" areas for foraging and migration, some of which had not been formally recognised in existing Biologically Important Areas. Notably, the tracking data showed that whales spent up to 124 days in Indonesian waters, likely on breeding grounds, underscoring the need for cross-jurisdictional management to safeguard this population. This comprehensive body of whale research provides robust new evidence to inform environmental impact

assessments and conservation planning for pygmy blue whales. All the above studies were published in high-quality peer-reviewed journals, reflecting their scientific rigour and significance.

Together, these research insights on reef shark fishery impacts, global shark extinction risk, turtle hatchling behaviour, and megafauna movement ecology form the foundation that underpins the real-world impacts described in this case study.

## 3. References to the Research


[3.1] Heupel, M.R.; Williams, A.J.; Welch, D.J.; Ballagh, A.; Mapstone, B.D.; Carlos, G.; Davies, C.; & Simpfendorfer, C.A. (2009). *Effects of fishing on tropical reef-associated shark populations on the Great Barrier Reef.* **Fisheries Research, 95**(2–3): 350–361. DOI: 10.1016/j.fishres.2008.10.005.

[3.2] Dulvy, N.K.; Fowler, S.L.; Musick, J.A.; Cavanagh, R.D.; Kyne, P.M.; Harrison, L.R.; **... Heupel, M.R., ... White, W.T.** (2014). *Extinction risk and conservation of the world's sharks and rays.* **eLife, 3:** e00590. DOI: 10.7554/eLife.00590.

[3.3] Thums, M.; Whiting, S.D.; Reisser, J.; Pendoley, K.L.; Pattiaratchi, C.B.; Proietti, M.; Hetzel, Y.; Fisher, R.; & Meekan, M.G. (2016). *Artificial light on water attracts turtle hatchlings during nearshore transit.* **Royal Society Open Science, 3:** 160142. DOI: 10.1098/rsos.160142.

[3.4] Wilson, P.; Thums, M.; Pattiaratchi, C.; Whiting, S.; Pendoley, K.; Ferreira, L.C.; & Meekan, M. (2019). *High predation of marine turtle hatchlings near a coastal jetty.* **Biological Conservation, 236:** 571–579. DOI: 10.1016/j.biocon.2019.04.015.

[3.5] Fossette, S.; Ferreira, L.C.; Whiting, S.D.; King, J.; Loewenthal, G.; Pendoley, K.; Shimada, T.; Spiers, M.; Tucker, A.D.; Wilson, P.; & Thums, M. (2021). *Movements and distribution of hawksbill turtles in the Eastern Indian Ocean.* **Global Ecology and Conservation, 29:** e01713. DOI: 10.1016/j.gecco.2021.e01713.

[3.6] Thums, M.; Ferreira, L.C.; Jenner, C.; Jenner, M.; Harris, D.; Davenport, A.; Andrews-Goff, V.; Double, M.; Möller, L.; Attard, C.R.M.; Bilgmann, K.; Thomson, P.; & McCauley, R. (2022). Pygmy blue whale movement, distribution, and important areas in the Eastern Indian Ocean. *Global Ecology and Conservation,* 35*:* e02054. DOI: 10.1016/j.gecco.2022.e02054.


## 4. Details of the Impact

AIMS's threatened species research has made a distinct and material contribution to multiple conservation outcomes, from international agreements on shark protection to on-the-ground policy changes in Australia for turtles and for whales. The impact of this research is evident through its uptake and application by government agencies, management authorities and conservation bodies worldwide.

**Influencing global shark conservation policy:** The 2014 global shark/ray extinction risk study [3.2] directly informs international conservation agendas. Its findings underpin key discussions in the International Union for Conservation of Nature (IUCN) and the Convention on International Trade in Endangered Species (CITES). For example, the IUCN Shark Specialist Group's comprehensive *Global Status of Sharks, Rays, and Chimaeras* report (2024) cites [3.2] as a foundational source. This IUCN report concluded that many shark and ray families are in crisis, reinforcing the urgency highlighted by AIMS-supported research. The report has been disseminated worldwide, guiding NGOs and governments to update Red List assessments and conservation strategies [5.1]. Furthermore, AIMS research has influenced international fisheries policy through CITES.

Following new shark listings on CITES (e.g. various reef sharks, hammerheads, and rays between 2013 and 2019), Australia was required to demonstrate that any export of those species would not be detrimental to their survival. The Australian Government's official *CITES Non-Detriment Finding (NDF) for Sharks and Rays* (2023) drew on AIMS research to support its recommendations [5.2]. In particular, the NDF document explicitly references Heupel et al. (2009) [3.1] to demonstrate that marine park no-take zones on the GBR help sustain reef shark populations. This informed Australia's conclusion that certain reef shark harvests could be managed sustainably only with robust protected areas. By providing scientific evidence for international treaty processes, AIMS research has contributed to stricter trade regulations and improved management of threatened sharks. In summary, the research led by AIMS scientists has materially shaped the knowledge base that global and national authorities rely on to drive shark conservation policies. Beneficiaries include international conservation bodies (IUCN, CITES), fisheries regulators, and ultimately shark populations, which are now receiving greater protection owing to heightened awareness and policy action.

**Improving the management of marine turtle nesting sites:** AIMS research revealing the impacts of artificial light on turtle hatchlings has led to concrete changes in coastal lighting management and marine park policy in Australia [3.3], [3.4]. The evidence that nearshore lights disorient hatchlings and increase predation prompted action by environmental authorities. Notably, the Australian Government issued new National Light Pollution Guidelines for Wildlife in 2020, which directly

incorporate the findings of Thums et al. (2016) and Wilson et al. (2019). These guidelines, intended for use by developers, regulators, and park managers nationwide, cite AIMS studies to outline how coastal lighting should be managed to protect turtle hatchlings. For example, the guidelines recommend buffering turtle nesting beaches from artificial light and timing coastal works to avoid the hatching season, measures derived from the observed link between light and hatchling mortality.

The impact is evident in policy uptake: in Queensland, the Great Sandy Marine Park Zoning Plan (2024) explicitly includes new provisions to minimise light pollution near critical turtle nesting sites (e.g., around Mon Repos, a major loggerhead rookery) [5.4]. The Decision Regulatory Impact Statement for that zoning plan cites Thums et al. (2016) [3.3] as key scientific evidence of light disturbance to turtles, justifying rules such as seasonal dimming of lights and restrictions on coastal development during the nesting season. Similarly, in Western Australia, the AIMS turtle research has been applied to environmental management plans. The Ningaloo Lighthouse Resort Development's *Artificial Light Management Plan* (2023), mandated by WA's Environmental Protection Authority, references both the 2016 and 2019 AIMS-led studies to identify acceptable lighting designs and predator mitigation strategies at the site [5.5]. As a direct consequence, the resort was required to implement turtle-friendly lighting (e.g. low-intensity, downward-pointing amber lights) and predator monitoring, thereby reducing harm to hatchlings [5.5]. These interventions were not standard practice prior to the AIMS study.

The Great Barrier Reef Marine Park Authority has recognised this issue in its latest outlook, the *GBR Outlook Report 2024* [5.7], which highlights artificial light as an emerging threat to marine turtles and cites the work of Wilson et al. (2019) [3.4] in its assessment of turtle vulnerabilities. The breadth of these changes, from national guidelines to state park regulations and site-specific management plans, demonstrates the reach of AIMS's research. The primary beneficiaries are marine turtle populations (e.g. flatback and loggerhead turtles), which are now experiencing improved protection of hatchlings, as well as government agencies that are better equipped to mitigate anthropogenic threats. Early indicators suggest that these measures will increase hatchling survival rates, thereby boosting juvenile recruitment and bolstering the recovery of these threatened turtle species in Australia.

**Informing the protection of pygmy blue whale habitats:** New knowledge on pygmy blue whale movements and important areas [3.6] has rapidly been taken up by environmental regulators to avoid or mitigate impacts on this endangered cetacean. The research revealed previously unrecognised whale "hotspots" and the timing of migrations, which have been used to refine impact assessments for coastal and offshore developments. For example, the 2024 Environmental Impact Statement for the Marinus Link (Tasmania), a proposed interconnector cable, incorporated the findings of Thums et al. (2022) to evaluate the risks to pygmy blue whales in Tasmanian waters [5.8]. The EIS's marine fauna assessment cites the AIMS-led study to identify sensitive times and routes of whale migration, leading the proponent to adjust the project schedule. In response, undersea cables are now planned to be laid near migratory corridors outside the peak whale migration months to prevent disturbance [5.8]. In Western Australia, a 2024 referral to the EPA for coastal development in the Kimberley region likewise drew upon pygmy blue whale tracking data [5.9]. The referral's supporting document and marine fauna review (prepared by environmental consultants for EPA WA) reference the 2022 study to acknowledge that pygmy blue whales traverse offshore Kimberley waters en route to Indonesia [5.9]. This knowledge has prompted the proposal of specific mitigation measures, such as requiring vessel speed restrictions and acoustic monitoring during April–June when whales are present, to reduce the risk of ship strikes and noise impacts on whales [5.9]. Although these projects are ongoing, the early integration of AIMS research into their planning indicates a clear pathway to impact: decision-makers are using the best available science to safeguard whale populations.

Internationally, the findings have been shared through the International Whaling Commission's Scientific Committee (IWC SC) and Southern Ocean Research Partnership reports, contributing to a broader understanding that protection is needed not only in Australian waters but also across the whales' migratory range (e.g. in Indonesian seas).

The pygmy blue whales themselves are the beneficiaries of this impact, as they are now better shielded from anthropogenic threats along their migratory route, as well as regulatory agencies (EPA Tasmania, EPA WA, Australian Department of Climate Change, Energy, Environment, and Water), which have stronger evidence to base their conservation decisions on. The nature and extent of this impact include new project-level conditions to minimise harm to whales and a push for inter-jurisdictional conservation efforts (Australia-Indonesia) to ensure the species' full protection. These outcomes, emerging in 2023–2025, exemplify how AIMS research made a material contribution to environmental management, directly linking scientific outputs to policy and operational changes that benefit threatened marine megafauna.

## 5. Sources to corroborate the impact

[5.1] **IUCN Shark Specialist Group (2024).** The global status of sharks, rays, and chimaeras: a report for the IUCN Species Survival Commission. Gland, Switzerland: IUCN. (Cites research [3.2] as basis for global shark extinction risk assessments and calls for enhanced protections.)

[5.2] **Department of Climate Change, Energy, Environment, and Water, Australia (2023).** *Non-detriment findings for CITES-listed shark and ray species harvested in Australian export fisheries*. (Report by Australia's CITES Scientific Authority, referencing [3.1] to support management measures for reef sharks.)

[5.3] **Great Barrier Reef Marine Park Authority (2014).** Great Barrier Reef Outlook Report 2014. GBRMPA, Townsville. (GBR-wide assessment report, acknowledges [3.1] findings on reef shark status and efficacy of no-take zones.)

[5.4] **Queensland Dept. of Environment and Science (2024).** Great Sandy Marine Park Zoning Plan – Decision Regulatory Impact Statement. Brisbane: QLD Government. (Policy document for marine park rezoning, cites [3.3] on artificial light impacts to justify new turtle protection measures.)

[5.5] **Department of Biodiversity, Conservation and Attractions, WA (2023).** Ningaloo Lighthouse Resort Project – Artificial Light Management Plan. Perth: WA EPA. (Environmental management plan for a coastal development, incorporating recommendations based on [3.3] and [3.4] to reduce turtle hatchling mortality.)

[5.6] **Department of Agriculture, Water and Environment, Australia (2020).** National Light Pollution Guidelines for Wildlife (Marine Turtles, Seabirds and Migratory Shorebirds). Canberra: Commonwealth of Australia. (National guidelines citing AIMS research [3.3][3.4]; provides best-practice measures to manage lighting near turtle nesting beaches.)

[5.7] **Great Barrier Reef Marine Park Authority (2024).** Great Barrier Reef Outlook Report 2024. GBRMPA, Townsville. (Most recent GBR outlook report, uses [3.4] to highlight artificial lighting as a threat to turtle recruitment.)

[5.8] **EPA Tasmania (2024).** Marinus Link – Heybridge Shore Crossing EIS (Volume 3, Appendix D: Marine Ecology). Hobart: TAS EPA. (Environmental Impact Statement for an infrastructure project, cites [3.6] data on pygmy blue whale migration to inform impact mitigation and timing of activities.)

[5.9] **EPA Western Australia (2024).** Referral Supporting Document and Marine Fauna Review for [Kimberley Coastal Development] (Report No. 24ENV322). Perth: WA Environmental Protection Authority. (Proposal referral documents that reference [3.6], demonstrating consideration of pygmy blue whale migratory routes in project planning.)

## 6. Additional Contextual Information (High level/indicative)

- ☐ **Funder(s):** CRC Reef Research Centre (for early reef shark studies); Australian Institute of Marine Science (core funding); IUCN Shark Specialist Group (through Simon Fraser University - Global Marine Species Assessment); WA State Government and industry partners (turtle research through WAMSI); Australian Department of Environment/NESP Marine Biodiversity Hub (whale research via Australian Marine Mammal Centre and IWC-SORP).

- ☐ **Funding Programs and Grants:** *e.g.* CRC Reef Effects of Line Fishing Project (1995–2004); NESP Marine Biodiversity Hub Project 1.2 (2015–2021) "Improving Blue Whale Conservation" (AMMC Grants #14/15 & #16/17); Shell-EMC Turtle Conservation Project (2015–2018). *(Total funding across projects exceeds AUD $5 million.)*

- ☐ **ORCIDs of Some Key Researchers:** M. Heupel – 0000-0002-9853-6439; M. Meekan – 0000-0003-3167-3042; M. Thums – 0000-0001-8223-6339; S. Fossette – 0000-0001-7493-4934.

- ☐ **Partner Organisations include**: James Cook University; WA Department of Biodiversity, Conservation. Attractions, UWA Oceans Institute, Australian Antarctic Division, IUCN SSC Shark Specialist Group, and Pendoley Environmental.

- ☐ **Countries where impact occurred:** International (global shark conservation status and U.S. policy discourse); Australia (Commonwealth and states: Queensland, Western Australia, Tasmania); and Indonesia (as critical habitat identified for pygmy blue whales, prompting bilateral conservation considerations).

# Case Study 2: Impact of AIMS Adaptive Management Research on the Great Barrier Reef

## 1. Summary of the Impact

This case study describes how the Australian Institute of Marine Science's Long-Term Monitoring Program (LTMP) has produced the authoritative evidence base that underpins government assessment, management, and long-term planning for the Great Barrier Reef. Through more than 36 years of standardised ecological monitoring, the LTMP has enabled policymakers to track reef condition, detect disturbance and recovery cycles, and evaluate the effectiveness of management interventions such as crown-of-thorns starfish control. LTMP outputs, including the 2021-22 Coral Reef Condition Report, which documented 36-year highs in hard coral cover across much of the Reef, have helped shape national and state decision-making, informed statutory reporting, and influenced the strategic direction of reef conservation programs. Together, the research derived from the LTMP has made a distinct and material contribution to evidence-based reef management, improving governments' capacity to respond effectively to rapidly evolving climate-driven bleaching events, cumulative disturbances, and long-term ecosystem change.

## 2. Underpinning Research

**Impact of no-take marine reserves:** AIMS and collaborators produced a body of research from the mid-2000s to the late-2010s that underpins the above impact. One major insight was that networks of no-take marine reserves can yield rapid and substantial benefits for reef fish populations and ecosystem resilience. A comprehensive study led by McCook *et al.* (2010) reviewed data after the GBR's 2004 rezoning and found marked increases in the abundance of target fish (and some sharks) on no-take reefs, along with indications that reserves reduced the frequency of COTS outbreaks and supported higher coral cover. This demonstrates that a large-scale reserve network can be a powerful tool for the integrated and adaptive management of coral reef systems. The research highlighted that effective reserves require strong compliance (as even no-take zones showed poaching impacts) and should be designed using best-practice principles, even in data-poor contexts. These findings provide empirical validation for the GBR Marine Park's zoning plan and offer a globally significant case study on MPA effectiveness.

**Long-term decline of coral cover:** Another pivotal research outcome was the documentation of a long-term decline in coral cover on the GBR and its cause. De'ath *et al.* (2012) analysed 27 years of monitoring data (2,258 surveys of 214 reefs from 1985–2012) and revealed that mean live coral cover had dropped from 28% to 13.8%, a loss of ~50%. The study quantified that tropical cyclones (48% of the loss), crown-of-thorns starfish outbreaks (42%), and mass bleaching (10%) were the primary drivers of this decline. Notably, the northern GBR (with fewer human impacts) showed no overall decline, and in the absence of these disturbances, coral cover could recover at ~2.85% per year. This study identified COTS outbreaks as a major controllable source of coral mortality. Conducted by AIMS scientists (De'ath, Fabricius, Sweatman, and Puotinen) around 2010–2012, this research leveraged the AIMS Long-Term Monitoring Program and provided a clear, quantitative rationale for targeting COTS and cyclone impacts in management.

**Reef resilience, phase shifts, and recovery dynamics:** Cheal *et al.* (2010) investigated why some disturbed reefs shift to macroalgal dominance while others recover, focusing on the role of herbivorous fishes. Over 11 years of data on reefs impacted by bleaching and storms, they observed the GBR's most persistent coral–algal phase shift (7+ years) on a reef with a low diversity of herbivores (particularly a deficit of algal browsers like rabbitfish and grazers like surgeonfish) despite high parrotfish abundance. Two comparable reefs with similar initial damage but intact herbivore diversity recovered their coral cover relatively quickly. This indicates that herbivore functional diversity is critical to reef resilience and that even unfished herbivore populations cannot ensure recovery if key functional groups are missing.

**Summary Report of Coral Reef Condition 2021/22:** AIMS researchers regularly present findings from the Long-Term Monitoring Program (LTMP), which surveys GBR coral communities (and has done for more than 36 years) using standardised manta tow and fixed-site methods. In this study, which drew on surveys of 87 reefs between August 2021 and May 2022, the report documents a significant period of coral recovery, with hard coral cover reaching the highest levels recorded in the Northern (36%) and Central (33%) GBR since monitoring began. This recovery was largely driven by the rapid expansion of Acropora corals, following a lull in acute disturbances such as cyclones and crown-of-thorns starfish outbreaks. The report also provides a detailed analysis of the 2022 mass bleaching event, the first to occur during a La Niña year, showing widespread

bleaching but limited mortality, as most reefs experienced heat stress below the threshold for mass coral death. Through its long-term ecological record, the LTMP contextualises these results within decadal disturbance and recovery cycles, highlighting both the resilience of GBR reefs and their increasing exposure to frequent marine heatwaves and other climate-driven pressures. This body of work underpins national reef management by providing authoritative, policy-relevant assessments of the GBR's condition.

**Post-disturbance recovery of coral and fish communities:** Emslie *et al.* (2008) analysed long-term data on reefs following different disturbance types (cyclones, COTS, bleaching). They found that reef recovery rates varied by disturbance; for instance, recovery was slower after crown-of-thorns starfish (COTS) outbreaks than after storms. Importantly, their results suggested that while the GBR had no net coral decline from 1995 to 2009 due to asynchronous regional impacts, there were dramatic sub-regional differences, with some areas declining and others increasing, largely driven by localised disturbances. This underscores the GBR's resilience in parts but also warns that increased disturbance frequency could undermine long-term stability. Such insights reinforced the need for ongoing monitoring and adaptive responses tailored to disturbance regimes.

**Resistance and recovery of reef communities:** Mellin *et al.* (2016) demonstrated that marine protected areas increase the resistance and recovery of reef communities in the face of disturbances. Using AIMS monitoring data (1993–2013), this study compared 20 no-take reefs to 26 fished reefs, including some that changed their protection status during the period. It was found that within no-take MPAs, reef fish and benthic community composition were 21–38% more stable, disturbance impacts (from bleaching, disease, COTS, storms) were 30% less severe, and post-disturbance recovery was 20% faster than on unprotected reefs. Notably, sites that gained protection showed clear community stabilisation after rezoning. This provided direct evidence that MPAs on the GBR have enhanced both the resistance and recovery (resilience) of coral reef communities, likely via mechanisms such as improved herbivory, trophic cascades, and the "portfolio effects" of biodiversity.

## Section 3: References to the Research (Underpinning Research Outputs)


[3.1] McCook, L. J., Ayling, T., Cappo, M., Choat, J. H., Evans, R. D., et al. (2010). Adaptive management of the Great Barrier Reef: A globally significant demonstration of the benefits of networks of marine reserves. **Proceedings of the National Academy of Sciences,** 107(43), 18278–18285. DOI: 10.1073/pnas.0909335107.

[3.2] De'ath, G., Fabricius, K. E., Sweatman, H., & Puotinen, M. (2012). *The 27–year decline of coral cover on the Great Barrier Reef and its causes*. **Proceedings of the National Academy of Sciences**, 109(44), 17995–17999. DOI: 10.1073/pnas.1208909109.

[3.3] Emslie, M. J., Cheal, A. J., Sweatman, H., & Delean, S. (2008). *Recovery from disturbance of coral and reef fish communities on the Great Barrier Reef in Australia*. **Marine Ecology Progress Series,** 371, 177–190. DOI: 10.3354/meps07657.

[3.4] Australian Institute of Marine Science (2022). ***Annual Summary Report of Coral Reef Condition 2021/22.*** AIMS Technical Report.

[3.5] Mellin, C., MacNeil, M. A., Cheal, A. J., Emslie, M. J., & Caley, M. J. (2016). *Marine protected areas increase the resilience of coral reef communities*. **Ecology Letters,** 19(6), 629–637. DOI: 10.1111/ele.12598.

[3.6] Cheal, A. J., MacNeil, M. A., Cripps, E., Emslie, M. J., Jonker, M., Schaffelke, B., & Sweatman, H. (2010). Coral–macroalgal phase shifts or reef resilience: links with diversity and functional roles of herbivorous fishes on the Great Barrier Reef. **Coral Reefs,** 29(4), 1005–1015. DOI: 10.1007/s00338-010-0661-y.


## Section 4: Details of the Impact

**Broad scale impact:** The Great Barrier Reef Marine Park Authority (GBRMPA) and Australian government agencies has (and continue to) incorporated these research insights into their planning documents and management actions, as evidenced by citations of the research in official reports and strategies. For example, the *GBR Outlook Report 2014* explicitly cited De'ath *et al.* (2012) to highlight the severity and causes of coral decline, and subsequent Outlook Reports (including 2019 and 2024) continued to reference these AIMS findings as a key benchmark of reef health and threats. By quantifying the impacts of disturbances and the benefits of protection, AIMS research provides a scientific rationale for adaptive management interventions on the GBR [5.1], [5.2], [5.3].

**COTS control:** One clear pathway from research to impact was the development and expansion of the Crown-of-Thorns Starfish Control Program. The identification of crown-of-thorns starfish (COTS) outbreaks as a major driver of coral loss in a 27-year decline study [3.2] prompted urgent management. In direct response, the GBRMPA launched a broad-scale COTS control program in 2012. The program's design and evolution have been underpinned by ongoing AIMS research and

monitoring. AIMS scientists have demonstrated that without COTS outbreaks, coral cover could increase on many reefs, underscoring that controlling this predator is one of the most feasible and critical actions for reef resilience. Consequently, COTS management has become a national priority for GBR conservation. The Reef 2050 Long-Term Sustainability Plan (2018) [5.4], Australia's overarching roadmap for the GBR, explicitly references the need to reduce COTS impacts, citing evidence of COTS-driven coral decline.

Further, an official COTS Strategic Management Framework (GBRMPA 2020) was developed, which cites the best available science and adopts an adaptive management approach to COTS outbreaks. This framework describes how the control program, in partnership with research organisations, uses thresholds informed by research to "ensure COTS are controlled to levels that allow for coral growth and recovery". The program has continuously improved (e.g., through more efficient culling methods and decision-support tools) in collaboration with AIMS researchers. Beneficiaries of this impact include the GBR ecosystem itself (through reduced coral predation), the tourism industry (which depends on coral health at key sites protected by COTS control), and reef managers, who now have an effective mechanism to intervene during outbreaks. As an indicator of extent, by 2019, over 771,000 COTS had been culled, and outbreak frequencies on many reefs had been significantly reduced, helping to stabilise coral cover on high-value reefs. This sustained management effort, directly underpinned by AIMS research on COTS [3.2], is credited with mitigating one of the top two causes of coral loss on the GBR [5.6].

Marine Reserve Networks: Another major impact area is the establishment and validation of marine reserve networks as core conservation strategies. AIMS's 2010 demonstration of reserve benefits [3.1], along with follow-up studies [3.5], provided GBR managers and policymakers with robust evidence that no-take zones were working and yielding ecosystem-wide gains. This evidence base was vital in justifying the maintenance of a large no-take area (over 33% of the GBR) despite socio-economic pressures. The research was cited in the GBR Outlook Report 2014 to assert the positive effects of the 2004 rezoning, and in the Outlook Report 2019, which noted that reefs in no-take areas had higher coral cover and greater biodiversity resilience, citing Mellin *et al.* (2016). Thus, AIMS research has made a material contribution to adaptive management by reinforcing the need to preserve and optimise current marine park zoning.

Beyond the GBR, these findings have influenced broader marine policies. For instance, the Reef 2050 Plan (2018) [5.4] emphasises the role of marine protected areas and cites McCook *et al.* (2010) when discussing the importance of no-take zones for reef health and resilience. International beneficiaries include other coral reef regions and global conservation organisations. The GBR reserve network has become a global exemplar, and the IPBES Nexus Assessment (2024) on biodiversity solutions highlights the GBR's network as a successful case, referencing the McCook et al. study as evidence of "major, rapid benefits" from no-take areas. Likewise, countries such as the Maldives have looked to GBR science; the World Bank's 2024 Maldives Climate and Development Report specifically cited McCook et al. (2010) to support recommendations for expanding marine reserves in Maldives reefs. In Western Australia, the state government's marine park design guidelines (2023) drew upon the findings of Mellin et al. (2016), adopting similar design principles to boost ecosystem resilience via no-take zones. These examples show the wider impact: AIMS adaptive management research not only informs local GBR policy but also shapes best-practice guidance internationally, benefiting global coral reef governance and communities dependent on reef services.

Nature and Extent of the Impact: The impact can be characterised as both instrumental (directly guiding policy/management changes) and conceptual (shaping understanding and priorities). Instrumentally, the research led to concrete measures: the GBRMPA implemented an adaptive management cycle via its five-yearly Outlook Reports that heavily use AIMS data and research to evaluate reef conditions and adjust policies. The Great Barrier Reef Outlook Report 2019, for instance, cites five of the six Section 3 outputs, demonstrating that AIMS research underpins assessments of ecosystem condition, threat levels, and management effectiveness in that report. These Outlook assessments feed into decisions made by the Australian Government and UNESCO. Notably, the knowledge that local actions (such as COTS control and water quality improvement) could substantially slow coral loss gave policymakers a tangible sense of agency despite global climate threats. This helped justify increased funding and efforts for water quality programs and COTS control under the Reef 2050 Plan [5.4][5.5]. Conceptually, AIMS research reframed how reef resilience is understood by introducing the notion of managing for resilience through the protection of functional diversity and critical processes (e.g., herbivory), an idea now embedded in GBR policy. Beneficiaries of this shift include conservation NGOs and Indigenous Sea Country managers, who now collaborate in resilience-based management initiatives, supported by the evidence that such approaches work.

The extent of the impact covers the entire 344,000 $km^2$ GBR Marine Park and influences policies in other countries and is deeply integrated into policy (from high-level international assessments to on-ground action plans). The impact has been ongoing since 2012 and continues to the present (2025). The GBR's Outlook Report 2024 again uses AIMS long-term data to report slight increases in coral cover in some regions due to reduced acute disturbances, attributing this, in part, to effective local management measures [5.1]. Meanwhile, the latest GBRMPA COTS control reports show that the program, guided by research-based thresholds, has protected dozens of critical reefs from outbreak destruction [5.6]. The Reef 2050 Plan – Implementation Report (2017) confirms that key actions (such as crown-of-thorns culling and expanded no-take areas) were executed and notes improvements in reef health metrics where these interventions occurred. On the global stage, the

incorporation of GBR research into UN Environment Programme reports (for instance, a 2020 UNEP report on coral reef pollution references Cheal et al. 2010 to discuss phase shifts) indicates the worldwide uptake of these findings in guiding reef management and policy [5.9]. In summary, AIMS's adaptive management research on the GBR has led to tangible policy outcomes (new or enhanced management programs), informed strategic plans, and improved on-reef conditions. These claims are corroborated by external sources listed in Section 5, which document the use and influence of research in policy and management contexts.

## Section 5: Sources to Corroborate the Impact

**[5.1] Great Barrier Reef Outlook Report 2019 (GBRMPA, 2019)** Chapter *3: Habitat and Biodiversity*. This official report evaluates reef conditions and explicitly references AIMS research (including [3.2], [3.5], and [3.6]) in assessing the causes of coral decline and the benefits of no-take zones. (Corroborates the use of AIMS data in GBR ecosystem assessments and influence on management effectiveness evaluations.)

**[5.2] Great Barrier Reef Outlook Report 2014 (GBRMPA, 2014)** *Technical Volume*. It contains multiple citations of AIMS studies (e.g., [3.1], [3.2], [3.6]) when discussing trends in coral cover and the positive effects of rezoning in 2004. (Corroborates that since 2014, GBRMPA has relied on these research outputs to underpin management decisions and highlights the early integration of AIMS findings into policy documents.)

**[5.3] Great Barrier Reef Outlook Report 2024 (GBRMPA, 2024)** *In Brief and Assessment chapters*. The latest Outlook (as referenced in GBRMPA's summary) continues to cite long-term AIMS datasets and publications on coral condition and resilience. It notes slight regional coral recovery and attributes this to reduced disturbances and ongoing management, citing earlier research (e.g. De'ath et al. 2012) as a baseline.

**[5.4] Reef 2050 Long-Term Sustainability Plan – July 2018 (Australian Government, GBRMPA)** . This comprehensive policy plan for protecting the GBR explicitly references McCook et al. (2010) and De'ath et al. (2012) in the bibliography. The plan's narrative highlights the need to expand no-take zones and control COTS, directly reflecting the science in these studies. (Corroborates that national policy drew on AIMS research findings to set reef management targets and actions.)

**[5.5] Reef 2050 Plan – Progress on Implementation Report (Australian Government, 2017)** reviews the progress of reef protection actions and, on p. 42, cites De'ath et al. (2012) to reaffirm the need to address COTS outbreaks. Following the research, expanded COTS culling efforts were undertaken, and water quality improvements accelerated. (Corroborates that the research prompted implementation of specific management interventions and that those actions were tracked by the government.)

**[5.6] GBRMPA Crown-of-Thorns Starfish Strategic Management Framework (GBRMPA, 2020)** . An official strategy document outlining the COTS control program. It describes the phases of outbreak management and cites scientific sources (including AIMS/CSIRO research) for threshold-based culling to protect coral. This confirms that since 2012, a dedicated COTS Control Program has been in place and has evolved using an adaptive, science-based approach.

**[5.7] IPBES Nexus Assessment Report – Chapter 5: Options for Sustainable Management (2024)** . A global assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Page 150 cites McCook et al. (2010) as an example of successful, large-scale marine reserve networks contributing to sustainability.

**[5.8] World Bank. Maldives Climate and Development Report (2024).** This report (pg. 21) cites McCook et al. (2010) to discuss how marine protected areas can enhance reef resilience in the Maldives. It uses GBR evidence to support policy recommendations for expanding MPAs under climate adaptation strategies.

**[5.9] Design Principles Guiding Western Australia's Marine Park Network** (WA Dept. of Biodiversity, Conservation and Attractions, 2023). This state government guideline (p. 25) references Mellin et al. (2016) to underscore that no-take areas increase ecological resilience. It credits science (such as the AIMS study) for shaping the design of WA's newer marine parks.

**[5.10] UNEP – "Wastewater Pollution on Coral Reefs: Science for Policy" (2020)** . A UN Environment Programme report (pg. ( 49) citing Cheal et al. (2010) in a discussion on coral-macroalgal phase shifts. It uses this reference to explain how nutrient pollution and the loss of herbivores can drive algal dominance, informing policies on land-based runoff management.

## Section 6: Additional Contextual Information (High-level/indicative)

- ☐ **Funder(s):** Australian Institute of Marine Science (AIMS, Australian government funding), Australian Research Council (ARC), and Australian Government Department of Environment (e.g., National Environmental Research Program).

- ☐ **Funding program(s):** AIMS Long-Term Monitoring Program (ongoing since 1985, core government-funded program); National Environmental Research Program (NERP) Marine Biodiversity Hub (2011–2014); ARC Discovery Projects and Fellowships (for example, ARC Centre of Excellence for Coral Reef Studies, ARC DECRA to C. Mellin).

- ☐ **Grant number(s):** NERP Marine Biodiversity Hub Project 1.3 (no formal number, collaborative funding to AIMS and partners); multiple internal AIMS project codes for Long-Term Monitoring (e.g. AIMS Project #Data-REEF). *(Note: Additional grant details available on request, as some AIMS research was internally funded.)*

- ☐ **Amount of grant:** NERP Marine Biodiversity Hub (Theme 1) ~AUD $20 million across all projects (AIMS portion supported several sub-studies); AIMS Long-Term Monitoring Program ~AUD $3–5 million annually (estimated through institutional funding).

- ☐ **ORCID iDs of some key researchers:** Katharina E. Fabricius – 0000-0001-7671-4358; Hugh Sweatman – 0000-0002-1200-9606; Marji Puotinen – 0000-0002-1383-697X; M. Aaron MacNeil – 0000-0001-8406-325X; Alistair J. Cheal – 0000-0002-1564-3207; Camille Mellin – 0000-0002-7369-2349.

- ☐ **Partner institutions:** Great Barrier Reef Marine Park Authority (GBRMPA); James Cook University (ARC Centre of Excellence for Coral Reef Studies); University of Queensland and University of Adelaide (collaborators on specific studies); CSIRO (co-funded COTS research); Queensland Parks & Wildlife Service (management partner for COTS program); and the Great Barrier Reef Foundation (supporting the implementation of research-informed programs).

- ☐ **Countries where impact occurred: Australia** (primary impact on GBR management in Queensland, national policy in Canberra); **Global** (secondary impact via international organisations and other coral reef nations adopting insights, e.g. policy influence in the Maldives, guidance through IPBES/UNEP to various countries).