Solitary Islands Marine Park: Safeguarding a Unique Marine Protected Area

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Methodology

This review was undertaken largely as a desk study supported by numerous phone conversations with engaged parties. The bibliography was compiled as part of the literature review process and is reasonably comprehensive addressing the key areas of investigation.

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Acronyms and Abbreviations

Abbreviation	Definition
BRUVs	Baited Remote Underwater Video Systems
CAR	Comprehensive, Adequate, Representative
CSIMP	Commonwealth Solitary Islands Marine Park
CCWS	Coffs Coast Wildlife Sanctuary
DCCEEW	NSW Department of Climate Change, Energy, the Environment and Water
DPRID	Department of Primary Industries and Regional Development
EAC	East Australian Current
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FM Act	Fisheries Management Act 1994
GBR	Great Barrier Reef
GBR MP	Great Barrier Reef Marine Park
GKNP	Great Koala National Park
ICOLLs	Intermittent Closed and Open Lagoons or Lakes
IPA	Indigenous Protected Area
IUCN	International Union for Conservation of Nature
Marine Park	Marine Park
MEMA	Marine Estate Management Act 2014
MES	Marine Estate Strategy
MPA	Marine Protected Area
NRSMPA	National Representative System of Marine Protected Areas
NHL	National Heritage List
NSIMP	New South Wales Solitary Islands Marine Park
SCU	Southern Cross University
TEMR	Temperate East Marine Region
TMB	Tweed–Moreton Bioregion
WHP	World Heritage Property

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1 Introduction and Context

1.1 Purpose of the Report

The Solitary Islands Marine Park (NSIMP), declared in 1998, sits within the Tweed-Morton Bioregion, stretching along the New South Wales's (NSW) coastline between Muttonbird Island, Coffs Harbour, to the south and the Sandon River mouth to the north. Renowned for its exceptional diversity of coral species and rare overlap of tropical and temperate marine life, the park is a regionally significant conservation asset. It lies adjacent to the Commonwealth-managed Solitary Islands Marine Park (CSIMP), extending protections into deeper offshore waters. Further offshore, the Central Eastern Marine Park provides complementary protection for deep-ocean ecosystems.

The report independently evaluates NSIMP's ecological integrity to help aid community engagement and understanding of the park's values, threats to values, identification of knowledge gaps, and further proposes nature positive solutions[1] within the context of the forthcoming NSW Government marine park review and the Federal Government's review of the Temperate East Network of offshore marine parks.

This review has been commissioned by the Coffs Harbour Branch of the National Parks Association of NSW (NPA), with the aim of sharing the report's findings with the community to increase awareness, education and participation in marine park management; the ultimate goal is to engage a broad range of stakeholders.

The review processes are an opportunity for the first comprehensive reassessment in over a decade and the most significant opportunity since 1998 to strengthen the effectiveness of conservation management for the benefit of not just marine life, but for local livelihoods and wellbeing. Findings and recommendations are intended to support stakeholder engagement, adaptive management, and evidence-based policy reform. The report explores how improved protection and management of the park can enhance the Coffs Coast's marine values as a known centre of research, tourism and higher education which parallels the Great Barrier Reef Marine Park (GBR MP), Queensland.

From a local perspective, a review of NSIMP is important to the Coffs Coast because it is NSW's first recognised ECO Certified Destination; an accreditation assessed at a whole-of-destination level, not limited to land that council directly controls. The condition of NSIMP is relevant to certification in that it considers how the region protects and manages its natural assets, supports sustainable tourism, and demonstrates continuous environmental improvement across the destination.

1.2 Description of the Study Area

The State-managed inshore Park (NSIMP) extends approximately 75 kilometres along the Mid North Coast reaching out to the NSW State Boundary of 3 Nautical Miles and covering more than 72,000 hectares of marine waters. The Commonwealth-managed offshore park (CSIMP) adds a further 15,200 hectares of protected waters on the seaward side, out to the 50-metre depth contour. There is a gap in the reserve network between the two SIMPs and the large Central Eastern MP which protects 70,054 square kilometres, beginning 30 kilometres east of Coffs Harbour.

[1] NSW's Plan for Nature interprets 'nature positive' to mean the environment being repaired and regenerated in contrast with traditional sustainability approaches, which have sought to minimise negative impacts by slowing or stabilising the rate of biodiversity loss. To clarify this definition further, the report defines 'nature positive' as an 'environmental management approach' that aims to halt and reverse biodiversity decline through actions that protect and regenerate ecosystems, leading to an overall improvement in nature.

NSIMP straddles the 30-degree latitude parallel where the warm water of the East Australian Current (EAC) converges with the cooler Tasman Sea waters, producing a confluence of tropical and temperate marine life. This overlap means many species are at or near the northern or southern limits of their range, giving NSIMP an exceptional and nationally significant level of biodiversity.

NSIMP's habitats are diverse, encompassing intertidal and subtidal reefs, soft sediments, beaches, seagrass beds, mangroves, saltmarsh, and open waters. The offshore island group forms the ecological centrepiece, supporting well-developed coral communities of 100 species, 550 reef fish species (temperate and tropical), including species of high conservation significance; the critically endangered Grey Nurse Shark, Black Rock Cod, and marine turtles, humpback whales, and migratory seabirds are among its high value biodiversity.

NSIMP is under the jurisdiction of NSW Department of Primary Industries and Regional Development (DPIRD, Fisheries), within the broader strategic oversight of the Marine Estate Management Authority (MEMA). Fisheries are subject to the statutory SIMP Operational Plan. The adjoining CSIMP is managed by Parks Australia in partnership with DPIRD.

The Yaegl and Gumbaynggirr Nations are the Traditional Owners of the land and sea country and have cared for this land and waters for thousands of years, imbuing the NSIMP region with deep cultural, spiritual, and resource connections.

1.3 Brief History of Marine Protection in NSW

Formal marine conservation and protection in NSW finds its roots in fisheries regulation, with the *Fisheries and Oyster Farms Act 1935* (FOF Act 1935) providing early, but limited controls over aquatic resources. The FOF Act 1935, amended in 1979, enabled the Minister to declare aquatic reserves, the first of which was declared 1980 (Long Reef, Sydney). From 1980-2002, 12 Aquatic Reserves were established: ten are located in the Hawkesbury Shelf Bioregion, one in the Batemans Shelf Bioregion, and one in the Tweed-Moreton Bioregion. This model of small, localised reserves offered patchy protection with no overarching strategic framework.

At the time, other jurisdictions internationally were beginning to plan at a bioregional or ecosystem-based scale. For example, the Watamu Marine National Park and Watamu Marine National Reserve in Kenya was designated a marine protected area (MPA), 5 January 1968, and designated a UNESCO Biosphere Reserve, as a site of natural excellence, in 1979. This twin reserve network was more ambitious and strategic in its efforts to protect representative ecosystems, conserve biodiversity, support fisheries sustainability and support local tourism, with coordinated management.

It was not until towards the end of the 90s, that NSW began to take a more strategic approach to marine conservation planning, with a focus on bioregional conservation and ecosystem-based management. The *Marine Parks Act 1997* (MP 1997) was the tool used to deliver a more comprehensive network, with the original Solitary Islands Marine Reserve (established 1991) reclassified as a Marine Park, and five further marine parks; Jervis Bay, Lord Howe Island, Cape Byron, Port Stephens–Great Lakes and Batemans.

1.4 History of the Solitary Islands Marine Park

NSIMP has its origins in community action. Since the late 1960s, local divers, underwater photographers and early research scientists recognised the region's exceptional marine values. Their sustained advocacy led to the declaration of a marine reserve (11 May 1991) under the FOF Act 1935. The Commonwealth followed in February 1993, proclaiming the adjoining Solitary Islands Marine Reserve (CSIMP) in offshore waters. Both NSIMP and CSIMP form part of the National Representative System of Marine Protected Areas (NRSMPA). The entire protected area was listed on the Register of the National Estate (1995) in recognition of its outstanding biodiversity and

natural beauty. However, the closure of the Register (2007) removed the additional layer of national recognition and consideration from the NSW component of the two protected areas.

In January 1998, under the NSW MP Act 1997, the NSW Solitary Islands Reserve was reclassified as a Marine Park, with conservation of biodiversity and maintenance of ecological integrity formally established as its primary objectives. A zoning plan was introduced in 2002, establishing sanctuary zones covering approximately 12% of the park. A comprehensively revised plan was approved in January 2011, following extensive community consultation that generated 6,519 public submissions. The revised plan expanded sanctuary zone coverage to 19%, incorporating new intermediate and deep-water reef habitat not previously included. However, the plan was rescinded within three months of the incoming Coalition Government taking office (Hansard, 25 May 2011; Booth & Beretta, 2025). Sanctuary zone coverage reverted to approximately 12%, the lowest proportion of any NSW marine park, well below the 30% benchmark recommended under the *Kunming-Montreal Global Biodiversity Framework* (GBF), December 2022. The park's external boundaries have remained unchanged since 1991.

1.5 Aboriginal Peoples and Marine Conservation

Aboriginal peoples managed marine resources — including the establishment of no-take areas — long before British colonisation, guided by traditional ownership, customary lore and custodianship. Their understanding of Sea Country as an extension of terrestrial Country, governed by cultural obligation rather than common property doctrine, is fundamentally at odds with the colonial framework of government-administered marine management often leading to the "tragedy of the commons" and the overexploitation of resources for personal gain rather than placing sustainability first.

Aboriginal communities were excluded from formal marine management for over a century. A 1993 Commonwealth inquiry highlighted the absence of Aboriginal representation in coastal and fisheries management, yet in the following year, the *Fisheries Management Act 1994* (FM Act 1994) failed to include Aboriginal interests. This did not improve until the MP Act 1997 established the Marine Parks Authority, mandated Aboriginal representation on advisory committees, and recognised Indigenous traditional non-commercial fishing rights. It was the first statutory acknowledgement of First Nations traditional rights to NSW's marine environment, but the MP Act 1997 only allowed limited involvement.

The Yaegl people of the lower Clarence won Native Title in 2017, including a 200-meter coastal strip of the northern part of the marine park. The current *Marine Estate Management Act 2014* (MEM Act) recognises cultural use, however, without mandating Aboriginal representation. The 2021 draft Mainland Marine Park Management Plan proposed greater Aboriginal engagement grounded in rights and native title recognition, but no further updates have been publicly provided since 2022.

2 The Current Governance and Management Framework

2.1 Recent Evolution of Marine Park Governance in NSW

2011 saw a significant setback to conservation planning, introducing a resource management model of MPAs, with the Coalition Government announcement of an "amnesty" on line fishing in 30 sanctuary zone beaches and headlands, while placing a moratorium on any new sanctuary zones and marine parks. Responding to strong community pressure, protections were restored at 20 sites in 2014, while the remaining ten were permanently downgraded.

Four NSIMP sanctuary sites had protections restored:

- Jones Beach
- Jones Point
- Freshwater Beach region
- Flat Top Point

Three NSIMP sites were permanently downgraded / rezoned:

- Minnie Water Back Beach
- Bare Bluff to Diggers Point
- Moonee Beach [2]

The MP Act 1997 was subsequently replaced by the MEM Act 2014, which abolished the independent Marine Parks Authority and replaced the traditional Comprehensive Adequate and Representative (CAR) biodiversity framework with a Threat-And-Risk Assessment (TARA), a resource management model, (see Section 2.11). The NSW Government also transferred day-to-day MPA management from an environment portfolio to DPRID (Fisheries). Conservation groups argue the changes weakened marine park protections, reduced independent oversight, and prioritised fisheries interests over science-based conservation planning. The transfer of management to fisheries resulted in MPA management being perceived as only one of multiple tools to manage threats inside MPAs, rather than the overarching framework required to manage biodiversity inside MPAs.

2.2 The Beeton Review (2012) and Subsequent Reform

The Beeton Audit was evidence-based and broadly constructive — recommending stronger science, integrated whole-of-coast governance, improved socio-economic analysis, and adaptive management. Its findings provided the foundation for the MEM Act. The Audit recommended a Threat and Risk Assessment Tool (TARA), as a useful tool within a broader conservation management framework, as complementary to the CAR approach to biodiversity protection. However, the Government's subsequent elevation of TARA, a resource management tool as a core conservation planning tool, marked a significant departure from what the Audit recommended and has been consistently challenged by scientists, including Booth and Beretta (2023).

2.3 Marine Estate Management Act 2014

The MEM Act 2014 established MEMA to coordinate NSW marine estate management across four principal agencies — DPRID, Department of Climate Change, Energy, the Environment and Water (DCCEEW), the Department of Planning Housing, and Infrastructure, and Transport for NSW — plus nine additional agencies. This multi-agency structure creates coordination complexity and potential

[2] In 2019, a further "amnesty" allowed recreational fishing (including 'catch and release', see Appendix 10.1) in six Batemans Marine Park sanctuary zones without formal rezoning, creating ongoing legal ambiguity.

conflicts of interest where departments with competing mandates and priorities share responsibility for conservation outcomes.

The arrangement may have some logistical benefits, however, a significant structural concern is that marine parks are primarily managed within DPIRD, whose mandate is sustainable fisheries extraction, rather than biodiversity conservation. The MEM Act 2014 makes it clear the primary purpose of marine parks is conservation of biodiversity and ecosystem integrity, with the secondary purpose, including sustainable resource use, permissible where consistent with the primary purpose.

For the benefit of improved future planning for NSIMP, this review recommends structural alignment between management responsibility and legislative mandate would be better served by placing marine parks under DCCEEW, consistent with the model applied to terrestrial national parks under the National Parks and Wildlife Service (NPWS).

2.4 NSIMP's Operation Plan

NSIMP's Operation Plan, created in 2003, is currently outdated, and does not address contemporary climate resilience science, the GBF's 30x30 targets, evolving Aboriginal co-management models, and modern ecosystem-scale approaches to marine conservation. The MP 1997 and MEM 2014 Act requires management rules to be reviewed every ten years, making the current review an opportunity to reassess whether existing governance, zoning, and protection settings remain fit for purpose under accelerating ecological and climate pressures.

The previous NSW Government drafted an overarching management plan for all of NSW's five mainland marine parks. Community groups and scientists have shared consistent and significant dissatisfaction with the draft across several dimensions. Key concerns included a shift from biodiversity conservation objectives toward a multiple-use resource management model driven by fisheries interests; failure to address sanctuary zone expansion beyond NSW's current 6.5% under no-take protection; absence of clear objectives, timelines or measurable performance indicators; inadequate community engagement; and action partnerships proposed in the Plan being almost exclusively fisheries-related organisations.

As of May 2026, the government has not responded to the submissions publicly, stating only the Plan is "under consideration". The network-wide approach proposed in the Plan adds complexity to an already complex system. Given each marine park represents a distinct bioregion with unique ecological, cultural and social values, dedicated park-specific management plans would be more appropriate and effective. In its current form, the Plan is already substantially obsolete and should be redrafted, with consideration to recommendations in this report, before release.

2.5 Community Engagement and Advisory Structures

Community consultation has been central to NSIMP management since its establishment. The original 2002 zoning scheme was developed through extensive public meetings, written submissions and advisory group discussions, with zoning boundaries adjusted in response to community input from commercial and recreational fishers, tourism operators, conservation groups, Aboriginal communities, scientists, and residents.

MEMA-commissioned surveys confirm broad community support for marine parks. Sweeney Research (2014) found 82% of the NSW community considered marine parks important, and 72% of recreational fishers in areas with established marine parks supported their local parks and sanctuary zones. Support from fishers increases markedly as reserves age and fishers see their catch improve (Navarro et al., 2018). Notably, 79% of recreational fishers fish for fewer than five days per year, and 48% of all fisher days occur during the January school holiday period. These findings could have significant implications for management prioritisation and enforcement scheduling.

Key engagement mechanisms include NSIMP's Advisory Committee, stakeholder consultation processes, citizen science programmes, public education, and integration of Gumbaynggirr and Yaegl Traditional Ecological Knowledge into management planning.

Committees are under-resourced and lack legislative authority, while their composition historically over-represents extractive users relative to conservation, science, and First Nations interests. There is an inherent limitation in the committee model itself: appointments are made to individuals rather than reserved representative positions. As a result, there is currently no Indigenous representative on the NSIMP committee, leaving an important knowledge system and stakeholder absent from committee discussions. This is significant given many First Nations communities take a collective and consultative approach to decision-making and caring for Country. To respond to the issue, DPRID is consulting separately with Indigenous stakeholders.

2.6 Indigenous Partnerships and Sea Country

IPAs are voluntarily protected lands and seas managed by Traditional Owners under IUCN guidelines and recognised within Australia's National Reserve System (NRS). NRS is jointly managed with Aboriginal peoples under IPA arrangements. Translating this model to Sea Country remains limited. Australia maintains two parallel systems, the NRS, which recognises traditional land ownership and therefore IPAs, and the NRSMPA, which only recognises legislated marine protected areas. The criteria for IPAs were developed in the early 1990s before native title over Sea Country was formally recognised, and there was only a poor understanding of MPAs, creating a structural gap between land and sea-based Indigenous protected area frameworks.

In April 2021, the Australian Government committed $11.6 million to the Sea Country IPA Program as part of a broader $100 million Oceans Leadership Package. Ten IPA Consultation Projects are underway nationally. The Ngiyambandigay Gaagal of the Gumbaynggirr Nation are one of the ten participating groups, with consultation work underway, recording songlines, sites of cultural significance, and species and totem knowledge. This investment into Indigenous programmes is helping to enhance the protection of culturally significant areas and restore cultural knowledge.

2.7 The Multiple-Use Marine Park Model — Benefits and Drawbacks

Benefits: The primary strength of the multiple-use model for NSW marine parks is political and social rather than ecological. Retaining fishing and recreational access across most of the marine park area, potentially maintains community and industry support, reduces stakeholder opposition and improves voluntary compliance (Voyer et al., 2012; Voyer et al., 2017). Social licence is not trivial; marine parks without community backing are demonstrably more vulnerable to political interference, and have poor compliance, as Buxton (2014) in the troubled history of NSW Marine Parks demonstrates. NSW's experience shows ecological justification and social licence is required. The zoning framework provides a practical spatial management tool concentrating human activity away from the most sensitive habitats, offering graduated protection matched to ecological value (Maguire et al., 2010). For coastal communities, it sustains the perception of economic and cultural benefits of fishing and tourism alongside conservation objectives.

Drawbacks: However, the conservation limitations of the multiple use approach are substantial. Partially protected zones, which dominate NSW's network at 81% of total area, deliver limited and contested ecological benefit (Sherman et al., 2023). The science is clear that fully protected no-take sanctuary zones are the gold standard for biodiversity recovery, fish biomass increase, and ecosystem resilience (Edgar et al., 2014; Lester et al., 2009; Sala & Giakoumi, 2018). This model creates a structural tension, framing marine parks as places where extractive use is the norm and full protection the exception, inverting the legislative priority of conservation as the primary purpose

(MEM Act 2014, s.28). In practice, the multiple-use approach has provided political cover for the progressive weakening of protection.

2.8 The Role of Sanctuary Zones

The scientific case for larger, fully protected sanctuary zones with buffer zones is compelling and well established. Globally, the evidence is unambiguous that no-take marine sanctuaries consistently outperform partially protected areas across all key conservation metrics: fish biomass, species diversity, ecosystem resilience, and recovery rates. A simplified model of large sanctuary zones buffered by moderately protected transition zones would more closely align with IUCN best-practice guidelines and deliver stronger biodiversity outcomes consistent with the legislative mandate.

The direct ecological evidence is compelling. Malcolm et al. (2018) found animals significantly larger and more abundant in SIMP sanctuary zones than in habitat protection zones, with little significant difference between habitat protection and general use zones, both open to fishing. Harasti et al. (2018) demonstrated snapper (*Chrysophrys auratus*) increased almost threefold over eight years of sanctuary zone protection at Broughton Island, with 77% more legal-size animals than in fished areas. Edgar et al. (2014; 2018) found there was negligible decline in large fish biomass in sanctuary zones while zones with restricted-fishing declined 18% and fished reefs 36% over the same period.

Marine sanctuaries protect older age classes of fish, including BOFFFFs (Big, Old, Fat, Fecund, Female Fish), which can produce significantly more offspring than younger females, enhancing the long-term resilience and productivity of fish populations, (Hixon et al., 2014).

2.8.1 Spillover Benefits

Spillover occurs when larvae and adult fish move beyond sanctuary zone boundaries into adjacent areas, becoming available to commercial and recreational fisheries. Despite strong international evidence, spillover has not been formally studied in NSW sanctuary zones, a critical data gap.

While there has been no formal research on spillover in NSW, research has documented the preconditions for spillover. Malcolm et al. (2007) found significant variation in reef fish assemblages consistent with biomass accumulation preceding spillover. A subsequent BRUV study across NSIMP and Port Stephens–Great Lakes Marine Park (2010–2018) found no-take zones supported up to 1.5 times more predatory and 1.3 times more invertivore fish[3] than outside areas (Malcolm et al., 2018; Knott et al., 2021). Evidence from comparable jurisdictions is consistent: in the California Channel Islands, targeted fish biomass was 81% higher inside sanctuary zones than outside within five years of protection, with spiny lobster biomass and size increasing substantially and spilling into adjacent fishing zones (Ovando et al., 2021). New Zealand and Canadian MPAs similarly show measurable adjacent fisheries benefits.

Operationally, two types of spillover should be considered: Ecological Spillover, i.e., the net export of juvenile, subadult, and adult biomass from sanctuary zones driven by density-dependent processes and natural migration, and Fishery Spillover, i.e., the proportion of exported biomass that becomes accessible to fisheries. Quantifying Fishery Spillover requires experimental catch data, while Ecological Spillover can be evidenced through visual census and tagging (Di Lorenzo et al., 2016*).* While the ecological benefits of sanctuary zones, including spillover of fish biomass to adjacent areas, are well established internationally, the fisheries benefit of spillover depends heavily on the intensity of prior fishing pressure and zone size. In NSW, though the conditions for spillover have been recorded, there is no local evidence. A systematic, network-wide spillover assessment is required to demonstrate the value of sanctuary zones locally and regionally.

[3] An animal that eats invertebrates.

2.9 Structural Governance System Weaknesses

The current management and consultative arrangements for NSIMP have three structural weaknesses that significantly undermine their effectiveness:

1. The placement of marine park management within DPIRD creates an inherent conflict of interest. The primary mandate for DPIRD is fisheries extraction as opposed to conservation objectives. IUCN guidelines (2008 & 2013) require that conservation is the primary objective of a protected area and that it be managed as such.

2. The advisory committee framework structure is inherently weak. The NSW Marine Parks Community Advisory Committees (CACs) are intended to provide formal stakeholder input into marine park management, but in practice they function as advisory bodies only, with no decision-making power, no ability to direct management priorities, and no formal mechanism requiring government to act on recommendations. The Marine Park Advisory Committee Handbook further limits transparency by restricting members from sharing matters raised in meetings with external groups and limiting broader input *(Marine Park Advisory Committee Handbook, 2019)*.

3. The interface between NSIMP and CSIMP lacks a formal joint management agreement, creating regulatory inconsistency and missed opportunities for coordinated conservation planning. The NSW and Commonwealth SIMPs form a single connected ecosystem, yet the absence of a formal shared management arrangement limits opportunities for ecosystem-scale planning, coordinated threat management, integrated monitoring and consistent stakeholder engagement.

Collectively, these arrangements fall short of IUCN best-practice governance standards and/or are structurally misaligned with the legislative purpose of marine parks.

2.10 Governance Reform Opportunities

The marine park reviews (NSW MPA Network Draft Management Plan and the Federal East Coast Marine Parks Review 2018 – 2028) present the opportunity to redesign governance arrangements by strengthening the advisory committee mandate, composition, and resourcing; formalising Commonwealth-State coordination; and restructuring committees to ensure genuine co-management processes with stronger Aboriginal governance, integrated citizen science, and clear accountability mechanisms. There is growing momentum for Aboriginal joint management in protected areas. The NSW Government committed to the development of an Aboriginal Joint Management model for terrestrial parks in 2024, so it is plausible this model will be applied to NSW's marine parks. Legislative reform would be required to formalise genuine power-sharing and secure dedicated funding. Considering the ecological connectivity between the two jurisdictions, further collaboration and coordination should be formalised in a joint management framework.

2.11 Principles of Effective Marine Park Management — Seven Guiding Principles

Conservation management and planning can be improved through an expanded, more effectively designed marine sanctuary network that covers a full range of habitats and provides for ecological connectivity and climate refugia, along with strengthening the use of management tools including compliance measures, expanded research and education, and funding for continuous monitoring.

A framework guide for effective marine park management includes the following, most effectively used when all principles are used in combination:

1. **NEOLI:** The NEOLI principle identifies five features of effective MPAs: No-take, Enforced, Old, Large, and Isolated. Edgar et al. (2014), reviewing 87 MPAs worldwide, found that parks incorporating at least four NEOLI features consistently showed markedly greater exploitable fish biomass, while those with only one or two features showed no measurable benefit. NSIMP

sanctuary zones are unlikely to qualify as “Large” under NEOLI, given the constraints of the NSW coastal waters but could theoretically meet the remaining four criteria.

2. **CAR:** principles provide a framework for designing MPAs covering the full range of bioregions; **Comprehensive** — are sufficiently sized and replicated to ensure long-term viability, **Adequate** — at least 30% fully protected, consistent with 30x30, (see Section 3.3) and **Representative** — include examples of all major habitat types. Fewer, larger sanctuary zones are more effective than many small ones, reducing edge effects and supporting breeding populations. Effective CAR planning requires detailed habitat mapping and ecological data, a significant gap in NSIMP given that the 2022–23 seabed mapping to a resolution of 1 m of the CSIMP did not extend to NSW state waters (Ingleton et al., 2024).
3. **TARA:** has been applied as the primary tool in developing the NSW Marine Parks 10-year Draft Management Plan: a role the Beeton Audit (2012) recommended should be included as one of a suite of management tools, not the primary tool. TARA relies heavily on stakeholder input rather than evidence-based ecological data, weighs ecological, recreational, cultural and economic values equally, and struggles to address cumulative impacts. In 2017, a TARA ranked fishing comparatively low, 13th to 25th across seven disaggregated subcategories, despite fishing being globally recognised as a primary threat to the marine environment (Booth & Beretta, 2025). Disaggregating fishing into seven separate categories while leaving other threats aggregated raises legitimate questions about the integrity of the ranking process. TARA can be a useful tool if used appropriately, in combination with other tools, but should not be used in isolation to control sanctuary zone design.
4. **The Precautionary Principle:** requires taking protective action when evidence is incomplete but potential harm to biodiversity or ecosystem health is possible. In response to climate change, species extinction and cumulative anthropogenic pressure, this principle should underpin the need for improved NSIMP sanctuary zone design, favouring larger rather than smaller zones where ecological information is uncertain.
5. **MARXAN Spatial Design Tool for Sanctuary Zones:** is a conservation planning tool that considers various mathematical combinations to identify design options for MPAs meeting biodiversity targets at minimum cost (Ball & Possingham, 2000). It can consider environmental, social and economic conditions, providing design options which reduce social conflict and make conservation planning explicit and auditable, replacing subjective or politically influenced zone placement with repeatable, evidence-based analysis. It is validated in large-scale applications including the 2004 GBR MP rezoning, which increased no-take coverage from 4.5% to 33% (Fernandes et al., 2005).
6. **Connectivity, Adequacy, Representation and Effectiveness (CARE):** the CARE principles in MARXAN planning build on the CAR principles with the addition of ecological connectivity, ensuring connection across habitats and seascapes so that species can move, disperse, migrate and adapt to environmental change, and increase resilience and the ability of the protected network to achieve measurable conservation outcomes through effective management and protection.
7. **Perimeter-to-Area Ratio in Sanctuary Zone Design**: The perimeter-to-area ratio is a key geometric principle in sanctuary zone design. A sanctuary zone’s shape is a significant design factor in MPA planning because zones with more edge compared to their total area are more vulnerable to fishing activity than those with less edge. The most geometrically efficient shape is a circle, enclosing maximum area for a given perimeter. A compact, roughly circular or square zone consistently outperforms a long, narrow or irregular zone. Good sanctuary zone design should be as compact as possible, extend boundaries beyond target habitats to include a buffer, and merge smaller adjacent zones into single larger ones where ecologically appropriate.

Expansion toward Australia's 30x30 commitment, combined with consolidation into fewer, larger, compact zones, would substantially improve conservation outcomes.

3 Strategic Conservation Context

3.1 NSIMP in the Temperate East Marine Region and Tweed–Moreton Bioregion

The Solitary Islands sit at the intersection of two different conservation planning scales: the Tweed–Moreton Marine Bioregion (regional, NSW biogeographic scale) and the Temperate East Marine Region (Commonwealth marine planning scale).

Temperate East Marine Region: In the context of the wider TEMR (approximately 1.47 million km²), which extends from the southern boundary of the Great Barrier Reef Marine Park (GBR MP) to Bermagui, southern NSW, and includes offshore waters around Lord Howe Island and Norfolk Island, only 4% is protected.

Tweed–Moreton Bioregion: The TMB extends from just south of Agnes Water, Queensland, to northern side of Nambucca Heads, NSW, covering approximately 43,034 km². The principal marine protected areas (MPAs) in the bioregion include the southern extent of the GBR MP, Great Sandy Marine Park, Moreton Bay Marine Park, Cook Island Aquatic Reserve, Cape Byron Marine Park, NSIMP and CSIMP. The total protected area of TMB (including differing levels of protection from fully to partially protected) is approximately 35% cover of the bioregion. However, this is largely protection on paper only; the vast majority of the bioregion's marine parks are open to resource extraction (partially protected areas).

The marine sanctuaries of individual MPAs vary from approximately 1–39%, totalling 2,924 km² of marine sanctuary, representing approximately 6.8% of the entire bioregion.

Notably, Queensland has a history of establishing much larger marine parks than NSW. The Great Sandy MP is approximately 8.5 times larger than NSIMP — its entire sanctuary zone area is larger than the whole of NSIMP.

Marine Park Size and Percentage of Sanctuary Zones:

TWEED-MORETON BIOREGION	Marine Park (Hectares)	Marine Sanctuary (Hectares)	Marine Sanctuary (%)
Great Barrier Reef Marine Park	446,420	143,772	32%
Great Sandy Marine Park	617,459	79,293	13%
Moreton Bay Marine Park	342,745	54,325	16%
Cook Island Aquatic Reserve	74	29	39%
Cape Byron Marine Park	22,293	6,124	27%
Solitary Islands Marine Park (Cth)	15,232	159	1%
Solitary Islands Marine Park (NSW)	72,385	8,682	12%
TOTALS	**151,6608**	**292,384**	

3.2 Limitations of Current Marine Park Boundaries

The current legislation, under MEM Act, defines a marine park boundary below the High Tide Mark, including waters and submerged lands, with most terrestrial land excluded. Some above water zoning provisions apply to adjacent areas, such as Intermittent Closed and Open Lagoons or Lakes (ICOLLs), submerged intertidal areas, and estuaries. This presents a serious governance constraint when it comes to managing run off and downstream water quality issues impacting on marine parks values; ecologically significant connected habitats are excluded from marine park design, including upstream freshwater rivers and riparian corridors.

Contemporary MPA systems globally are incorporating freshwater management, including run off and water quality issues into reserve planning, such as the GBRMPA reef water quality plan. NSW does not have a specific water quality plan for each marine park but considers the issue of water quality across the state under the Marine Estate Management Strategy (MEMS), which is an inadequate scale for the management of individual NSW MPs.

NSIMP does not cover the full Coffs Harbour local government area coastline, stopping at Mutton Bird Island in the heart of the city, excluding southern areas like Sawtell Beach, Boambee Creek, Bonville Creek, and the natural areas adjacent to Bongil Bongil National Park (part of the Great Koala National Park).

Additionally, while the NSIMP and CSIMP boundaries adjoin, they are separated from the offshore Central Eastern MP by unprotected waters. This lack of continuity may reduce the overall resilience and effectiveness of the broader NSW and Commonwealth MPA network as it limits protection for ecological linkages, species movements, and climate-driven range shifts between coastal and offshore habitats. This is an important shift in MP management design as it has been demonstrated that several species may migrate to deeper waters in response to heat stress and warming sea water temperatures in the shallower waters.

3.3 Global Biodiversity Framework and Applying the Federal Commitment to 30x30 Locally

The Australian Government has set out a framework for the states to deliver on the GBF targets via Australia's Strategy for Nature 2024-2030. Significant targets relevant to NSIMP planning include Target 3 to protect 30% of the ocean via principles including ecologically representativeness and connectivity; Target 2 to restore 30% of degraded ecosystems; and Target 4 to prevent new extinctions. 'Ecologically representative' should be applied on a bioregional basis to ensure the MPA system protects the full range of species and ecosystems at a large enough scale to ensure their long-term survival.[4] By applying the target locally, protected areas can also help to safeguard species at risk of extinction. Notably, Australia has also committed to zero extinctions, which makes a return to science-based CAR planning of NSW marine parks even more important.

The Federal Minister for the Environment, Murray Watt, reaffirmed his commitment to deliver on the GBF target of 30% in a communique in March 2026, interpreting 30% to mean 'highly protected' waters. The Australian Government interprets 'Highly protected' to mean IUCN categories Ia and II — otherwise known as no take marine sanctuaries, the highest zoning level of protection, governed by the NRSMPAs and IUCN frameworks and principles. Federal and state Ministers agreed to work collaboratively, including through coordinated engagement to ensure targets have 'ecological representation'.

3.4 Opportunities to Strengthen Regional Protection — NSW's Return to a Science-Based Approach

[4] A bioregional approach complements IUCN 30x30 guidelines, Dudley et al.'s (2023), definition of 'ecological representativeness' as an ecologically representative network of protected areas which include a full range of species and ecosystems at a large enough scale to ensure their long-term survival. Success requires that all species, plus important and representative ecosystems, are adequately represented in the network.

The NSW Minister for the Environment, Penny Sharpe, made an announcement at the 3rd NSW Marine Parks Forum, Maritime Museum, 30 May 2026, signalling a shift back towards traditional marine conservation planning. (See Appendix (10.2) for an excerpt of the announcement). The Minister indicated the NSW Government will ensure the secondary purpose of marine parks does not conflict with the primary purpose of conservation in planning. The government will bolster conservation expertise on the Marine Estate Management Panel, and it will apply CAR principles to the upcoming planning and review process for NSW's marine protected area network, both Marine Parks and Aquatic Reserves. Significantly, the NSW Government will align marine park planning with NSW's Plan for Nature and to international nature positive goals (as set out under the GBF). The Minister signalled the rules and review process as an opportunity to achieve 30% protection for NSW waters in line with the global goal of 30% protection by 2030; a goal Australia has committed to.

3.5 30x30 — an Opportunity to Update the Tweed-Moreton Bioregion Sanctuary Network

The NSW marine parks review process, combined with Australia's commitment to 30x30, is an opportunity to deliver on NSW's Plan for Nature's nature positive goals by boosting no take marine sanctuary protection for the largely under-protected TMB and the TEMR. No take marine sanctuaries are a proven mechanism to improve biodiversity outcomes, yet NSIMP has the lowest level of full no take protection in NSW. NSIMP's sanctuary zones are small, fragmented and lack clear ecological connectivity, yet still deliver better outcomes than habitat protection and general use zones. To rebalance this, the NSIMP requires significant expansion of sanctuary zones toward the 30% benchmark, with stronger protection for habitat protection zones as buffer zones and active management of general use zones rather than the largely unregulated access that currently prevails. A rebalanced framework, anchored in the CAR principles and connectivity, would deliver stronger conservation outcomes while retaining sufficient community access and support to maintain the required social licence.

The review processes are an opportunity to consider NSIMP in the context of how it is connected to the broader state-Federal MPA network design and whether current park boundaries are sufficient. On a state level, the reserve category of Aquatic Reserves (a typically smaller reserve area than a marine park) is an additional tool that can be used to plug 'no take marine sanctuary' gaps between marine parks.

4 Values of the Solitary Islands Marine Park

4.1 Overview of NSIMP in the Bioregional and National Context

NSIMP occupies a pivotal position within both the Tweed–Moreton Bioregion (TMB) and the broader Temperate East Marine Region (TEMR). At a bioregional scale, the TMB is one of Australia's 60 marine bioregions and NSW's northernmost bioregion. The bioregion extends from the Deepwater National Park in southern Queensland to Nambucca Heads in NSW, and is recognised for its exceptional biodiversity, driven by the influence of the southerly EAC and the confluence of the northerly currents of the temperate Tasman Sea providing an overlap of tropical, subtropical and temperate species. This confluence of tropical and temperate conditions and periodic upwellings converge to produce an overlap of tropical, subtropical, and temperate biota found nowhere else along the Australian coast.

NSIMP is one of two marine parks (including Cape Byron MP) within the NSW network safeguarding the unique tropical–temperate transition zone of northern NSW. For many species, NSIMP represents either their northern or southern distributional limit, conferring exceptional biodiversity significance at the bioregional scale.

NSW and CSIMP form part of Australia's NRSMPA, which seeks to establish and manage a CAR marine reserve system to contribute to the long-term ecological viability of marine systems and protect Australia's biological diversity at all levels. NSIMP is the only marine park in NSW that captures the full ecological transition between tropical and temperate systems (as previously recognised when it was listed in the Register of the National Estate) — making it irreplaceable within the NRSMPA and a critical node in the broader network of protected areas along the East Coast. Its contiguity to CSIMP and its position at the southern boundary of the Coral Sea ecosystem give it disproportionate national conservation significance relative to its size.

NSIMP also abuts the terrestrial North Coast Bioregion, adjacent to Yuraygir National Park (31,898 hectares, established 1980), Coffs Coast Regional Park (562 hectares, established 2003), and the new Great Koala National Park (GKNP), which will transition 176,000 hectares of unprotected state forests into the national reserve system, totalling 476,000 hectares when combined with the existing National Parks and Wildlife Estate. The GKNP includes three existing World Heritage assets, including recognition of outstanding significance for its remnant ancient Gondwanan rainforest, and extensive eucalypt forests, some of the most diverse in the world, and one of the largest, most stable koala populations in NSW. The GKNP has secured significant national attention and funding ($140 million) which will strengthen the long-term resilience of NSIMP by protecting the forested catchments, rivers and estuaries that directly influence coastal water quality and marine ecosystem health. When combined with the CSIMP, all four protected areas form one of Australia's most significant connected land–sea conservation landscapes, supporting biodiversity, ecological integrity, tourism, recreation, cultural values and regional economic resilience.

4.2 Conservation, Education and Scientific Values

NSW and CSIMPs are uniquely placed in NSW as a hub for marine science and education. After decades of conservation management, the two SIMPs provide a valuable scientific baseline for biodiversity, ecological integrity and natural processes across a diverse range of habitats. Their position at the convergence of tropical and temperate currents makes it especially significant for studying species distribution, reef resilience, climate change responses and ecosystem processes, including anthropogenic impacts.

Research programmes address four core areas: biodiversity and ecological processes; ecologically sustainable use; Aboriginal and non-Aboriginal cultural heritage; and anthropogenic impacts.

Southern Cross University's National Marine Science Centre (NMSC) is the primary research institution for the two SIMPs, producing high-impact research on marine ecosystem resilience, contributing to national long-term monitoring datasets, and delivering curriculum-based education across primary, secondary and university levels. Many other universities visit the SIMPs to conduct research annually. NMSC's Solitary Islands Aquarium provides public interpretation of park values, while the Coffs Coast Wildlife Sanctuary (CCWS) complements this through wildlife rescue, conservation research and additional education programmes.

A new marine research station is planned for Diggers Camp, Yuraygir NP, announced May 2026, with the goal to turn the region into a hub for whale monitoring, wildlife conservation, and hands-on education.[5] This announcement, combined, with large government investment into the newly enlarged network of terrestrial protected areas secures the Coffs Coast region as a flagship Australian natural asset and showpiece for conservation education, research and tourism.

Southern Cross University*:* The university's Solitary Islands Aquarium receives 13,000 visitors annually; 2,500 school students participate in the School Engagement Activities (SEA) annually; 300 people attend the Marine Discovery Series public lecture program annually; and 150 Undergraduate Students and 50 Postgraduate Students study marine science annually. SCU also partners, or has an affiliation, with more than a dozen domestic and international universities, (pers. comm., Soule, SCU, June 2026).

Coffs Coast Wildlife Sanctuary: the Wildlife Sanctuary receives 50,000 visitors annually, with visitations growing. Visitors include 4,500 students aged from three years old to university students, with hundreds of individual schools ranging from Sydney, Brisbane, Adelaide to Perth. Students also visit from overseas, such as Japan and the United States. The CCWS programmes span experience, adventure school program, disadvantaged youth programmes, and culture experiences, (pers. comm., Cross, CCWS, June 2026).

4.3 Cultural, Heritage and Socioeconomic Values

NSIMP and its associated islands hold deep cultural significance for both First Nations and non-Indigenous communities. These values reinforce rather than compete with conservation objectives. Protecting the ecological integrity of NSIMP is important for cultural heritage preservation, the local economy, and community stewardship.

4.3.1 Indigenous Heritage

The marine and island environments form part of the traditional Sea Country for First Nations, who have maintained connections to land and sea for tens of thousands of years. Marine resources have long provided food, materials and spiritual connection, and NSIMP continues to support cultural practices, traditional ecological knowledge and community identity. Totem species, ancestral heritage and spiritual ties to Sea Country remain central values. Efforts are underway to develop IPAs for Sea Country and co-management arrangements that embed Indigenous engagement and traditional knowledge in conservation planning. In 2015 and 2017, the Federal Court formally recognised the first recognition of sea country native title rights, awarded to the Yaegl People between Woody Head and Wooli, acknowledging their enduring cultural connection and customary fishing rights within marine environments.

4.3.2 Non-Indigenous Heritage

NSIMP carries significant maritime heritage, most notably the South Solitary Island lighthouse complex in continuous operation since 1880; valued as one of only two lighthouse islands in NSW. To

[5] The new field station is a collaboration between SCU's NMSC, Ocean Warriors Australia, Gowings Whale Trust and Ngiyambandigay Wajaarr Aboriginal Corporation.

the south, Smoky Cape lighthouse complex in Hat Head National Park was listed on the State Heritage Register, but the South Solitary Island lighthouse group has not yet been listed. It is recommended to be listed in the Plan of Management for the Solitary Islands Reserves (2016). Fifteen shipwrecks (1833-1976) are known to have occurred in the Coffs region. These values, alongside scenic coastal landscapes and remarkable underwater features, including submerged pinnacles, sea caves and drop-offs, were recognised as nationally significant when NSIMP was listed on the Register of the National Estate and its declaration as the first NSW marine park in 1998. This Register has been frozen/closed since 2007 (DCCEEW). Urgent efforts should be made to transfer the list under the current Australian National Heritage List (created in 2003). This would contribute to establishing a comprehensive approach to managing the area.

4.4 Social, Recreational, Wellbeing and Economic Values

NSIMP is a vital economic and social asset of the Mid North Coast; its ecological health underpins diverse industries. Beyond revenue, NSIMP contributes to regional wellbeing, particularly to the network of village towns and regional city of Coffs Harbour that are nestled within the Coffs Coast Regional Park adjacent to NSIMP, providing opportunities for recreation, social gathering, a sense of place and which serves as an important educational hub for schools and university experiences, inspiring generations of students. NSIMP provides mental health and wellbeing through activities, such as coastal walking, surfing, diving, snorkelling, fishing, kayaking, paddle boarding, and whale watching.

4.4.1 Economic Activity is Anchored by Seven Interdependent Sectors

1. Tourism: includes scuba diving, snorkelling, whale watching, kayaking, sky diving, surfing schools, nature appreciation and wildlife experiences, including the turtle hospital and aquarium at the CCWS and SCU aquarium, sporting and recreational competitions, and fishing charters.
2. Commercial fisheries: includes Ocean Trap and Line Fishery, Ocean Hauling Fishery, Ocean Trawl Fishery (including prawn trawling), Estuary General Fishery, Eastern Rock Lobster Fishery, Spanner Crab Fishery, and Oyster Aquaculture.
3. Recreational fishing: fishing charters, competitions, tackle stores and ancillary support such as boat sales and maintenance.
4. Emerging Indigenous-led Sea Country Tourism: see Section 4.4.2.
5. Passive ocean sports clubs and local competitions: include surf lifesaving clubs, board rider clubs, Coffs Harbour Yacht Harbour and regular yacht races, coastal running events, which require permits to operate in the park, coastal and littoral walking trails.
6. Education and Research: Visiting universities, SCU education and research programmes, CCWS education and schools' engagement programmes.
7**. Hospitality and accommodation businesses:** particularly those nestled within the network of villages and Coffs city adjacent to NSIMP-Coffs Regional Park, mainly dependent on nature-based experiences.

4.4.2 Indigenous-led Sea Country Tourism

Sea Country tours represent an emerging and strategically important component of the local economy, offering a model of tourism that is culturally authentic, sensitive, ecologically aligned, and locally beneficial. Programmes by First Nations Sea Rangers create direct employment and skills development in marine management, environmental monitoring, and tourism guiding. Indigenous-owned small business generates strong local multiplier effects, retaining a greater proportion of tourism expenditure within the community.

The recording of songlines, cultural significance and traditional species knowledge, currently at risk of generational loss, transforms intangible cultural heritage into a sustainable economic asset, providing the foundation for educational programmes, school engagement, and specialised eco-

tourism products. This cultural dimension adds a distinctive layer to regional tourism, attracting the growing market of culturally and environmentally motivated travellers and strengthening NSIMP's competitiveness as a national and international destination. Importantly, Sea Country tourism can be synergistic with conservation when tours combine cultural storytelling with habitat monitoring and environmental stewardship.

4.4.3 The Great Koala National Park — Opportunities for Marine Tourism Growth

The full positive effect on marine tourism with the creation of its terrestrial counterpart, the GKNP, is yet to be realised, with an estimated 9,800 new jobs in park management, tourism and rehabilitation expected for the region (Ryan, 2021). This includes a September 2025 announcement of 100 new ranger jobs and tourism business grants for small businesses.

4.4.4 Full Economic Evaluation

No NSIMP-specific economic valuation disaggregating these sectors has been publicly published. At the regional level, tourism generates $755.7 million in total sales across the Coffs Harbour City LGA annually (economy.id, 2022–23), while commercial fishing generates $12.9 million in income in the Clarence Valley region and $6.9 million in income in the Coffs Coast region (DPIRD, 2021–22).

At the statewide level, the NSW marine environment contributes $16.2 billion in value added and 103,800 jobs, with 63% of that income dependent on a healthy marine environment (DPIRD/Deloitte, 2021–22). The only NSIMP-specific economic study remains Hoisington (2013), which attributed a 20% increase in local business turnover to marine tourism generated by NSIMP's establishment. A dedicated economic valuation of NSIMP, disaggregated by sector, is a significant knowledge gap and a priority for future research. Hoisington (2013) frames marine parks as "essential infrastructure for regional economies", with benefit growth over time. Key beneficiaries include dive operators, charter fishing businesses, accommodation and hospitality providers and whale watching operators and ancillary businesses. Research indicates the benefits from protection largely offset any costs, with no significant negative impacts on regional employment.

The long-term economic prosperity of the region is directly linked to the ecological health of NSIMP. Maintaining the ecological health of NSIMP is particularly essential to maintaining the region's ECO Destination Certification, as a nature-based tourism economy. The certification requires ongoing commitment to environmental protection, sustainable tourism and the maintenance of high-quality natural experiences. Protecting NSIMP's ecological integrity therefore contributes directly to Council's ability to maintain its certification, its international eco-tourism reputation, and supporting local businesses that rely on healthy marine ecosystems.

Three Key Management Considerations Underpin NSIMP's Economic Value: Conservation values, biodiversity, and resource improvements, resulting from formal protection over time. A greater understanding of how and why the displacement of fishing effort has optimised the effectiveness of protected areas, and the additional benefits it provides to the local economy, is needed. This includes creating long-term local socioeconomic monitoring and evaluation of cost-benefit ratios for both SIMPs and surrounding terrestrial parks, combined to inform adaptive management to help balance and optimise conservation for regional prosperity.

4.5 Marine Habitat Values

Rocky Reefs (inshore and offshore): Rocky reefs extend from the intertidal zone to approximately 50 metres depth at the seaward boundary, with the five main Solitary Islands and associated offshore reefs forming the ecological centrepiece. Rocky reef habitat extends seaward into the adjacent CSIMP to the 50-metre depth contour, with Pimpernel Rock, a submerged pinnacle rising to within a few metres of the surface as the CSIMP centrepiece. Rocky reefs support exceptional diversity of sessile invertebrates, corals, and fish assemblages. The offshore island reefs, particularly South

Solitary Island and Pimpernel Rock, are the most ecologically significant, supporting over 100 coral species and critically endangered Grey Nurse Sharks. “Fish Soup”, off North West Rock, holds among the highest fish diversity sites in the park.

Offshore Island Habitats: Groups of offshore islands are an uncommon feature along Australia’s south-east coast, making the Solitary Island Reserves, several kilometres from shore, a rare refuge for both marine species and seabirds. The islands’ rocky shores, including the intertidal zone below the high-water mark, are transition zones between marine and terrestrial environments. The islands are significant refugia for critical nesting, roosting and breeding seabirds, including migratory birds protected under international agreements, and as detailed above, create a mosaic of rocky reefs, cliffs, caves, gutters and sheltered waters that support an exceptional diversity of marine life.

Beaches and Intertidal Areas: Sandy beaches and intertidal shores provide nesting habitat for marine turtles. Green and Loggerhead Turtles have been recorded nesting on several beaches within NSIMP. The estuaries, beaches and island habitats support nationally significant shorebird breeding populations, including the Australian Pied Oystercatcher, Sooty Oystercatcher, and the endangered Little Terns. The Beach Stone-curlew is listed as Critically Endangered in NSW, one of the most imperilled shorebirds in the state, with a total NSW population estimated at fewer than 15 adult birds. The presence of breeding pairs within estuaries, including the Sandon River, gives the park critical national significance for this species.

Soft Sediment Habitats: Soft sediments, including sandy plains, muddy substrates and mixed sediment areas, are dominant subtidal habitat types by area within the NSIMP, covering most of the seafloor between reef structures from the inshore to the seaward/eastern boundary. These habitats support invertebrate communities, juvenile fish, rays, and adult foraging species.

Coral Reefs: The coral communities contain unique associations of tropical species close to the edge of their southern latitudinal range, and subtropical species absent or rare in the GBR. However, temperate species dominate in terms of percentage cover. With over 100 coral species recorded, NSIMP supports one of NSW’s most diverse coral assemblages (alongside Lord Howe Marine Park) and one of Australia’s most significant high-latitude coral communities.

Estuaries and Coastal Lakes: NSIMP encompasses 15 estuaries, including creeks and rivers and five ICOLLs, within its landward boundary, providing critical nursery habitat for fish and invertebrates, supporting extensive seagrass beds, salt marshes and mangroves. The park’s estuaries and coastal lakes include those of exceptional ecological significance, such as the Sandon River, flowing through Yuraygir NP into the sea between Brooms Head and Wooli, widely recognised as one of NSW’s cleanest river systems, enjoying an underdeveloped catchment and minimal artificial modification. Interconnected coastal waterways are an important link between terrestrial, estuarine and marine ecosystems, contributing significantly to NSIMP’s overall biodiversity and ecological resilience.

Seagrass Beds: The most common seagrass species in northern NSW estuaries are *Zostera muelleri* (Eelgrass or Ribbonweed) and *Halophila spp*. (Paddleweed). These are the dominant species within the estuaries and coastal lakes of NSIMP. *Posidonia australis* (Strapweed), the largest and slowest-growing NSW seagrass, is limited to more marine-dominated estuaries of central and southern NSW and does not occur within the northern range of the NSIMP. *Zostera muelleri* forms the most extensive meadows within NSIMP’s sheltered estuaries and tidal creeks, providing critical nursery habitat for juvenile fish, invertebrates, and foraging habitat for Green Turtles. The smaller, fast-colonising paddleweeds occupy both shallow and deeper estuarine areas and are more tolerant of turbidity and disturbance. Seagrass beds provide important shoreline protection from wave energy and play an important role in carbon sequestration.

Mangroves: Two mangrove species dominate within NSIMP — Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*), occurring in sheltered estuarine environments and

tidal creek systems throughout the area. Mangroves provide essential ecosystem services within NSIMP, functioning as nursery habitat for commercially and ecologically important fish and invertebrate species, feeding grounds for shorebirds and waders, and critical refugia for species including the critically endangered Beach Stone-curlew. They stabilise shorelines, trap sediments, filter catchment runoff, and sequester significant quantities of blue carbon, making them important buffers against both catchment-sourced pollution and coastal erosion. Mangrove-derived organic matter forms a key component of estuarine food webs throughout the NSIMP. Critically, poorly managed mangrove areas can result in the release of more carbon dioxide and methane that a healthy mangrove stand can sequester, and the release of sulphuric acid stored in the acid sulphate mangrove soils which can have negative impacts on adjacent marine environments.

Saltmarshes: Coastal saltmarsh communities occupy the upper intertidal fringe (supralittoral zone) of estuaries and tidal creeks within NSIMP, forming a narrow but ecologically critical zone between mangroves and terrestrial vegetation. Coastal saltmarsh is a threatened ecological community in NSW, with an estimated 50% loss since European settlement, which makes NSIMP's saltmarshes unique. Saltmarsh provides vital habitat for migratory and resident shorebirds — including the critically endangered Beach Stone-curlew, as well as nesting and foraging habitat for rails, herons and raptors. In tandem with mangroves, they act as a natural buffer against storm surge and coastal erosion, filter nutrient and sediment runoff from adjacent catchments, and sequester blue carbon at rates comparable to mangroves. Saltmarsh also supports invertebrate communities that form an important component of the estuarine food webs.

Pelagic and Open Water: The influence of the EAC and periodic upwelling events enrich offshore waters, supporting migratory species including Humpback and Southern Right Whales, dolphins, pelagic fish, and seabirds.

Algae and Kelp: Studies within the Solitary Islands region have identified 162 species of benthic macrophytes, with tropical algal genera, including *Halimeda*, *Valonia* and *Galaxaura,* accounting for 55% of species, and warm temperate genera such as *Ecklonia* and *Homosira* a further 42% (Millar, 1990). Distribution and density of algae are determined by substrate stability, water temperature, nutrient input and herbivore grazing pressure (Copeland et al., 1992). The discovery that NSIMP hosts a genetically distinct haplotype of *E. radiata*, restricted to this subtropical location, means NSIMP is not simply at the northern edge of a continuous kelp distribution, it harbours a genetically adapted unique population found nowhere else and presumably better able to cope with the local conditions making it a site of distinct evolutionary and conservation significance to be full protected (Nimbs, Davis, Champion & Coleman, 2023). Additionally, the only known occurrence of a critically endangered marine alga, ***Nereia lophocladia,*** can be found near Muttonbird Island.

4.6 Marine Biodiversity

Fish Species: The park supports more than 550 species of reef fish, including 24 species of tropical butterflyfish (family *Chaetodontidae*), as well as iconic species such as the Protected Estuary Cod (*Epinephelus coioides*), Giant Queensland Groper (*Epinephelus lanceolatus*), Eastern Blue Devilfish (*Paraplesiops bleekeri*) and Potato Cod (*Epinephelus tukula*; protected in Queensland waters). The Solitary Islands also represent the southern extent of established, self-sustaining adult populations for the Flame Hawkfish (*Neocirrhites armatus*) and Spotted Hawkfish (*Cirrhitichthys aprinus*). The park is also recognised as one of the key strongholds for the vulnerable Black Rockcod (*Epinephelus daemelii*) around South Solitary Island, Anemone Bay and NW Rock (Harasti & Malcolm, 2013).

Recreational fishers, including during club meets and competitions, chase prized species including Snapper (*Chrysophrys auratus)*, Kingfish and Mackerel. NSIMP research shows recreationally and commercially targeted species of snapper, Grey Morwong (*Nemadactylus douglasi)*, Pearl Perch (*Glaucosoma scapulare)*, and Venus Tuskfish *(Choerodon venustus),* were more abundant and larger in marine sanctuaries compared to partially protected areas, (Malcolm et al., 2018).

Anemonefish: North Solitary Island supports exceptionally high Anemone and Anemonefish densities, with the highest recorded density of host sea-anemones in the world and a significant stronghold of the endemic Broadband Anemonefish. Long-term surveys at four sites within the North Solitary Island sanctuary zone recorded increases of up to 532% in *Entacmaea quadricolor* density and 133% in *Amphiprion akindynos* density between 1994–95 and 2008, attributed to sanctuary zone protection (Scott et al., 2011).

Sharks: Warm-water tropical sharks, including Bull, Tiger and Reef Sharks, and cool-water temperate species, such as the Great White, Grey Nurse Sharks and Wobbegongs can be encountered at the same NSIMP sites at different times, reflecting the mesoscale oceanographic variability at 30°S. Elasmobranch assemblage variation in NSIMP is explained by the influence of the EAC and associated climate transitions, providing a baseline for assessing future climate-driven impacts (Schultz et al., 2020).

Grey Nurse Sharks (*Carcharias taurus*): on the East Coast are listed as Critically Endangered under the *Environmental Protection and Biodiversity Conservation Act* (EPBC Act). The NSIMP and CSIMP contain several of the East Coast's most significant aggregation sites. North and South Solitary Islands are designated aggregation sites, with smaller numbers regularly observed at Groper Island, Split Solitary Island, and Pimpernel Rock in CSIMP. Recent close-kin mark-recapture research estimated the eastern adult population at approximately 2,000 individuals, increasing at 3% per year — indicating existing conservation measures are having a positive effect.

During peak season, schools of over 100 Grey Nurse Sharks have been observed at South Solitary Island, with a year-round resident population of 30–35 sharks present outside peak months. Grey Nurse Sharks are NSIMP's most iconic wildlife attraction and a cornerstone of the regional dive tourism economy. Sanctuary zones at key aggregation sites directly sustain this population and the tourism value it generates. The case for maintaining and expanding no-take protection and effective buffer zones at these sites is ecologically and economically compelling.

Invertebrates: NSIMP supports a rich and diverse invertebrate fauna. Over 700 species of molluscs have been recorded and more than 100 coral species. At depths greater than 25 metres, the seafloor is dominated by sponges and invertebrates, with species including sea-whips, black corals (*Antipatharia*), sea-squirts, and bryozoans competing for space with tropical and temperate algae. On shallower reefs, tropical giant anemones, lush soft corals, and ascidians jostle for space alongside sponges and sea tulips, an assemblage found nowhere else in Australia. Commercially and recreationally important crustaceans are well represented, including Mud Crabs (*Scylla serrata*), Blue Swimmer Crabs (*Portunus pelagicus*), Spanner Crabs (*Ranina ranina*), Penaeid Prawns, Eastern Rock Lobster (*Jasus verreauxi*) and Slipper Lobsters (*Scyllarus* spp.). Echinoderms; sea urchins, sea stars, brittle stars, and sea cucumbers, are ecologically important across reef and soft sediment habitats. Butcher (2004) found no-take zoning produced Giant Mud Crabs (*Scylla serrata*) averaging 9.9 mm larger than in fished zones, supporting the productivity value of estuarine sanctuary zones, while sea cucumbers maintain a healthy aerated sediment.

Marine Turtles: Four Marine turtle species, including Green (*Chelonia Mydas*), Loggerhead (*Caretta caretta*) and Hawksbill (*Eretmochelys imbricata*), are regularly recorded and occasionally Leatherback Turtles (*Dermochelys coriacea*). All turtles are listed as Vulnerable under the EPBC Act, while Leatherback Turtles are listed as Endangered. Opportunistic nesting by Green and Loggerhead Turtles has been recorded on several beaches, but nesting is infrequent. The primary conservation significance for turtles in NSIMP is as foraging and migratory habitat. The park lies within the southern migratory corridor of east coast populations whose primary nesting grounds are in Queensland. Post-hatchling dispersal routes pass through NSIMP waters via the EAC.

Cetaceans: At least 30 marine mammal species have been recorded. Short-beaked Common Dolphins (*Delphinus delphis*) and Common Bottlenose Dolphins (*Tursiops truncatus*) are year-round residents, regularly sighted in inshore waters and riding bow waves offshore. The Indo-Pacific

Bottlenose Dolphin (*Tursiops aduncus*) is not a confirmed resident of NSIMP — its nearest confirmed resident population of 90–120 individuals occur within the Port Stephens–Great Lakes Marine Park to the south. Humpback Whales (*Megaptera novaeangliae*) are regularly encountered through June to November during their annual migration between Antarctic feeding grounds and Queensland breeding areas. Blue Whales (*Balaenoptera musculus*) and Southern Right Whales (*Eubalaena australis*), both listed as Endangered under the EPBC Act, have also been recorded in NSIMP waters.

Seabirds: NSIMP supports a diverse seabird community including Osprey, threatened shorebirds, Australian Pied Oystercatcher, Sooty Oystercatcher and Beach Stone-Curlew, and periodically hosts endangered species including Gould's Petrel, Wandering Albatross and Southern Giant Petrel at their northerly extent.

Little Tern (*Sternula albifrons*): is listed as Endangered in NSW, breeding on beaches near Coffs Harbour between October and February before migrating to eastern Asia. NSW colonies have contracted markedly, from 52 nesting colonies in the 1950s to around 10 active colonies currently (BirdLife Australia, 2024).

Wedge-tailed Shearwater (*Ardenna pacifica*) — Climate Sentinels: are a significant breeding species across the Solitary Islands, with approximately 12,400 ± 6,127 breeding pairs estimated on Muttonbird Island in 1982. A 43-year dataset of chick banding and resighting across Muttonbird Island, South West Solitary Island and North Solitary Island is one of the region's most rigorous long-term seabird monitoring records.

Crested Tern (*Thalasseus bergii*): use North, North-West and South Solitary Islands for nesting, with approximately 8,000 breeding pairs recorded on North Solitary Island in 1971. Classified as Least Concern globally with a stable population, the species is nonetheless a useful ecosystem health indicator within NSIMP given its dependence on pelagic fish abundance.

4.7 Opportunities to Enhance and Promote Protection for NSIMP Values

Combined, the GKNP (476,000 hectares), Yuraygir NP (31,898 hectares), Coffs Coast RP (562 hectares), NSIMP (72,000 hectares) and CSIMP (15,200 hectares), totals 595,660 hectares of protected areas. This large, connected ridge-to-reef reserve network, from the Great Dividing Range to the coastal plains and out to inshore and offshore marine areas, should be nationally and globally recognised, considering few protected area systems in Australia connect both intact upland forests to globally significant marine ecosystems in a contiguous manner. Packaged together, these expanded protected area regions, beyond ecological benefits, offer immense tourism potential, combining opportunities like diving, fishing, whale watching, surfing, koala walks, rainforest walks, paddling and other wildlife and conservation education experiences within a single internationally marketable conservation landscape.

CSIMP Review: The forthcoming and timely Commonwealth review of the Temperate East Network of marine parks, with management plans due for renewal by 2028, presents a direct opportunity to primarily strengthen the ecological and regulatory connections between the two SIMPs. Considering preparations for the NSW Marine Parks Review process has begun, this report recommends the two parks be contiguous and managed together. Further consideration should be given to connectivity with the far offshore Central Eastern MP, which is largely disconnected from the two SIMPs, but can contribute to continental shelf and slope protection. The review processes should work together under a joint management framework, as an opportunity to actively enhance protection of NSIMP values for future generations.

Below is a potential process for developing a two-tiered funding and management structure where responsibility is shared between the federal and state levels, rather than sitting entirely with one government or the other.

Federal Level — Australian Marine Parks Authority

- Provides the funding pool — drawing on Commonwealth resources and potentially international conservation grants.
- Sets the overarching policy framework — national standards, conservation targets, research priorities.
- Ensures consistency across Australian waters, which span multiple state and federal jurisdictions.
- Manage cross state boundary issues such as migratory species and routes, pollution and climate change.

State Level — Operational Partners

- Deliver on-the-ground management — ecological monitoring, enforcement compliance and incident response, implementation of local management rules and regulations, and community engagement and education programmes.
- Bring local knowledge — of specific coastlines, communities, and ecosystems.
- Adapt federal priorities to local conditions.

Why does this model make sense for management of migratory species and global threats, such as climate change and pollution?

- Migratory animals have no respect state borders — federal oversight ensures a nationally coordinated approach.
- But while migratory animals are within NSW waters such as NSIMP, the state agencies are best placed to manage them practically.
- Funding often flows more reliably from Commonwealth level, while states have the existing ranger and regulatory infrastructure.

Under this mechanism, the federal authority acts as the financier and sets overall standards, while state governments act as the implementing arm. This mechanism mirrors models already used in other Australian environmental programmes like the Reef 2050 Plan for the GBR.

World Heritage Consideration: NSW community groups have produced a GKNP World Heritage Values Report (February 2025), proposing the GKNP region for World Heritage status, building on a previous proposal by local groups in 2024. If a GKNP World Heritage feasibility study were to be conducted, it should consider the adjoining SIMPs, as together these areas form an exceptional land-sea conservation corridor linking significant Gondwana Rainforests, Eucalypt forests, and Koala habitat in a largely intact coastal catchment, which abuts a unique protected marine ecosystem. The area functions as a major tropical-temperate transition zone like Ningaloo, with the absence of a large river system outflow from the adjacent coast. This means there is minimal pollution and dilution with large quantities of fresh water which can impede coral growth. This area is a temperate ecosystem zone comparable with Ningaloo and the GBR, as a land-sea World Heritage area that would complement the ridge-to-reef approach over protected area landscapes.

A summary comparison between the Coffs Coast and existing World Heritage Project proprieties with ridge-to-reef values:

- **Coffs Region, NSW:** 595,660 hectares, from the Great Dividing Range to coastal plains, incorporating Gondwana subtropical rainforest, escarpments, tall Eucalypt forests, with significant Koala populations, and estuaries, offering largely contiguous transitioning to unique blend of tropical, subtropical and temperate species and habitats.
- **Ningaloo Reef & Cape Range, WA:** 604,500 hectares, marine and terrestrial UNESCO World Heritage Property with arid limestone ranges, subterranean cave network, transitioning from a dry desert to one of the longest near shore reefs in the world with fringing tropical corals.

- **Wet Tropics of Queensland (WTQ) & GBR, QLD**: 893,453 hectares (WTQ), stretches 450 kms, at the northern end of the GBR UNESCO World Heritage Property (34,870,000 hectares), with tropical rainforest transitioning to expansive tropical coral reef networks, the world's largest collection of coral reefs. However, the northern-connected UNESCO-recognised protected area network is disrupted by major agricultural developments in the coastal catchment areas.

WH protection should be considered as a long-term goal. The institutional capacity to manage a new large-scale site, across marine and terrestrial landscapes, does not currently exist. However, steps to include NSW and CSIMPs on the National Heritage Register should be initiated.

National Heritage Consideration: One illustrative criterion includes *NH Criterion (b) — Uncommon, rare, or endangered aspects of Australia's natural history.* The combined two SIMPs appear to strongly satisfy this criterion for inclusion on Australia's NH List, which recognises places of outstanding heritage value assessed against natural, Indigenous, and historic criteria. The NSIMP and CSIMP protect a rare and distinctive marine ecosystem at the convergence of tropical and temperate influences, including one of the world's southernmost and most diverse coral communities (approximately 100 coral species), unique subtropical reef ecosystems, high densities of anemonefish and sea anemones, and critical habitat for threatened species including Grey Nurse Sharks, marine turtles, and migratory seabirds.

NH listing would provide several strategic advantages. It would recognise the ecological and cultural values of the entire Solitary Islands ecosystem, helping bridge the administrative divide between state and Commonwealth marine parks. NHL values are protected under the *Environmental Protection and Biodiversity Act (EPBC Act),* meaning actions likely to significantly impact listed values require federal assessment and approval, an additional protective layer beyond existing State marine park legislation. Listing could also provide a platform for formally recognising the area as a UNESCO Man and the Biosphere Reserve, further strengthening its international profile and long-term protection.

4.8 Summary — Values of NSW's Solitary Islands Marine Park

NSIMP is one of Australia's most important subtropical/temperate marine ecosystems, sitting at the meeting point of tropical, subtropical and temperate waters and species. It supports exceptional biodiversity, including high-latitude coral reefs, threatened marine fauna, significant seabird colonies, estuaries, seagrass, mangroves and culturally important Sea Country. The park is a nationally significant centre for marine science, education, recreation and tourism, underpinning regional jobs, community wellbeing and the Coffs Coast's nature-based economy. Together, with the adjacent Commonwealth marine park, GKNP and Yuraygir NP, it forms a rare, connected ridge-to-reef conservation landscape of national significance.

5 Ecological Condition and Threats

5.1 Overview of NSIMP's Ecological Condition

The small parts of NSIMP that are fully protected are in relatively good ecological condition. However, the whole park is at risk; as anthropogenic pressures accumulate, ecosystems become increasingly vulnerable to tipping points beyond which recovery is uncertain, threatening ecological, social and economic values. NSIMP is experiencing increasing pressure from multiple threats, including climate change, southward species migration, declining water quality from catchment runoff (urban and horticultural development), marine debris, invasive species, recreational and commercial fishing pressure, and even political interference in management decision-making. Notable management gaps exist in monitoring, mapping, research, compliance, effective governance, and adaptative management.

5.2 Research and Knowledge Base

5.2.1 Assessing Ecological and Biodiversity Health

Early ecological work established that coral communities are reproductively viable despite their marginal subtropical location, with 24 of the 27 Scleractinian coral species across 10 genera, tracked between 1994 and 1996, showing annual sexual reproduction with gamete release between December and April, albeit with less synchronicity than on tropical reefs. This work demonstrated that the coral communities around the islands are reproductively viable and form long-term reef communities, despite their marginal southern location (Wilson, J.R. & Harrison, P.L., 2003).

Reef fish assemblage studies using diver counts and baited video have documented species richness, abundance and biogeographic patterns across gradients from shore to depth and distance, showing fish assemblages vary systematically with these environmental factors, highlighting the need for sanctuary zone design to account for this ecological variation (Malcolm et al., 2010; 2015). The existing fragmented sanctuary zone network fails to capture NSIMP's abundance of biodiversity and biogeographic patterns.

5.2.2 Citizen Science

The Solitary Islands Underwater Research Group (SURG) has been active since 1985, conducting habitat mapping, coral health monitoring, marine debris assessments and fish species monitoring. The 2015 SURG coral health project involved over 12,000 individual coral assessments across multiple sites, providing medium-term large-scale baseline data for detecting long-term change. This community-led monitoring underpins management decisions and represents a model for cost-effective, sustained ecological observation. This should be encouraged and supported.

5.2.3 Recent Findings

A 2023 study found newly established subtropical coral beds in temperate south-eastern Australia can facilitate high densities of both tropical and temperate reef fishes, suggesting novel coral habitats may help accommodate poleward-moving tropical species (O'Connell et al., 2023). This signals a potentially shifting baseline for reef community composition across NSIMP and south-eastern Australia, underscoring the need for ongoing adaptive management.

A 22-year long-term database of NSIMP coral reefs shows the corals have a remarkable ability to recover, despite repeated impacts from climate change, storms and other environmental pressures, highlighting the importance of protecting these unique corals as potential refuges in a warming ocean (Malcolm et al., 2026) and the value of long-term datasets.

5.2.4 Fisheries and Estuarine Research

Earlier research on estuarine mud crabs highlighted the difficulty of distinguishing the effects of marine park zoning from natural environmental variability on mud crab populations. However, subsequent long-term monitoring demonstrates NSIMP sanctuary zones consistently support higher mud crab abundances and populations responded positively to protection and negatively to reopening to fishing (Butcher et al., 2014). This echoes a broader finding from Malcolm et al. (2015), who demonstrated that habitat protection zones provided no measurable benefit over unprotected areas for snapper populations, effectively questioning the conservation value of partial protection, such as habitat protection zones for fisheries species, and highlighting the value of sanctuary zones.

5.2.5 Invertebrates

The invertebrate fauna of NSIMP is poorly documented relative to fish and coral communities, representing a significant knowledge gap, particularly for deep-reef sponge assemblages and soft sediment invertebrate communities, which are the least studied and among the most vulnerable.

5.3 Overview of Habitat Condition

Soft Sediment Habitats: Comprehensive high-resolution characterisation of soft sediment habitats across the NSW state waters component remains incomplete, representing a significant knowledge gap for conservation planning. These habitats are highly vulnerable to demersal trawling disturbance, which remains permitted in general use zones in the NSIMP and special purpose zone (Trawl) in the CSIMP.

Estuaries and Coastal Lakes: These systems are highly vulnerable to catchment runoff, pollution, and land-based development pressures originating outside the park boundary.

Seagrass Beds: Destruction of seagrass beds risks releasing more stored carbon into the atmosphere than future potential sequestration. All seagrass species within NSIMP are under increasing pressure from catchment runoff, elevated turbidity, sedimentation, boat and propeller scarring, and warming water temperatures associated with climate change — threats that originate largely outside the park boundary and are therefore difficult to address through marine parks management processes alone. The intermittent blockage of Coffs Creek, such as from woody debris, has compounded this, periodically preventing turtle access to seagrass beds within the park. Whole-of-catchment management to reduce sediment and nutrient loads is a priority recommendation of this review.

Mangroves: NSIMP's mangroves are the most southerly point on the East Coast where all seven species of mangroves are found. They face multiple pressures including sea level rise and coastal squeeze, where natural landward migration is blocked by development. This represents the most significant long-term threat. Increased flooding frequency and intensity from extreme weather events damages root systems and accelerates erosion. Catchment runoff delivering excess nutrients, sediment, and contaminants degrades water quality within mangrove systems. Altered hydrology from upstream water management, foreshore clearing, and direct disturbance from recreational boating and personal watercraft further degrade mangrove condition. These threats originate largely outside the park boundary and cannot be addressed through marine park management alone, reinforcing the need for integrated whole-of-catchment management as a priority recommendation of this review.

Saltmarshes: Saltmarshes are listed as an Endangered Ecological Community in NSW. In NSIMP, they remain vulnerable to threats from human activities including vehicles, drainage, levees, grazing, and invasive weeds, as well as climate change-induced sea level rise. Coastal squeeze, occurs where rising seas push mangrove landward, but development barriers prevent saltmarsh landward retreat. Mangrove encroachment into saltmarsh, driven by rising sea levels, is an additional and documented pressure across south-east Australia. Changes in tidal levels from modifications to estuary entrances further compound impacts on saltmarsh condition and extent.

As with mangroves and seagrass, the primary threats to NSIMP's saltmarsh communities originate outside the park boundary, again reinforcing the need for integrated catchment and coastal zone management alongside marine park protection.

Kelp Beds: The projected 257 km southward range contraction and 30% loss of kelp biomass on Australia's east coast under future climate scenarios (Davis et al., 2022) makes the protection of remnant subtropical populations like *E. radiata* in NSIMP an urgent conservation priority. If the NSIMP population is lost through warming, increased sedimentation, pollution, urchin barrens, or inadequate sanctuary zone protection, a unique evolutionary lineage and potential genetic reservoir for climate adaptation disappears with it. This strengthens the case for expanding sanctuary zone protection of reef habitats within NSIMP and targeted monitoring of kelp condition as a key ecological indicator for the park.

Beaches and Intertidal Areas: Disturbance from recreational beach use, 4WD vehicles, dogs, and feral predators are the primary threats to nesting success — as well as foraging habitat for shorebirds and waders. 4WD vehicles also contribute to the erosion of these habitats and should be controlled. They disrupt the infauna (worms and small crustacea) that live between the sand grains and are important elements of the trophic chain.

Pelagic and Open Water: These open water environments are poorly represented in current zoning and largely absent from sanctuary zone coverage.

5.4 Marine Habitat Mapping and Knowledge Gaps and the Broader Governance Issue

NSIMP contains a diverse range of habitats including intertidal and subtidal rocky reefs, soft sediment plains, beaches, seagrass beds, mangroves, saltmarsh, estuaries, and open pelagic waters. However, despite recent advances in offshore seabed mapping within the adjacent CSIMP, important gaps remain in the fine-scale mapping and ecological characterisation of benthic habitats within NSIMP's waters. (See Appendix (10.3) for details on what has been mapped).

By comparison, the 2022–23 seabed mapping project covering Commonwealth waters identified extensive deep-reef habitats, complex inter-reef substrates and varied reef types across depth gradients (Ingleton et al., 2024). These data provide a critical baseline for long-term monitoring, zone placement and management of fishing, anchoring and extractive use for CSIMP.

For CSIMP, high-resolution seabed mapping spans across 15,200 hectares, whereas the NSW state waters component, which spans a far greater 71,000 hectares and experiences a far greater level of use and human pressure, has substantial mapping gaps. As a result, combining both Commonwealth and NSW mapping data creates a misleading impression of the overall knowledge base, overstating scientific understanding and knowledge of the NSW park — the larger and less well-documented component of the protected area complex.

High-resolution mapping of NSW state waters represents a priority for future management action, particularly for developing MARXAN spatial planning tools to improve and expand the sanctuary zone network. This should be a joint Commonwealth and State effort for developing spatial plans and planning tools across the complex.

This knowledge gap highlights the broader governance issue: the two parks share the same name, occupy contiguous waters and function as a single ecological system — yet are managed under separate jurisdictions with no formal joint management agreement, separate management plans, and separate funding streams. As referred to in the values chapter, the absence of a joint formal arrangement framework creates ongoing confusion in data reporting, policy development, and public communication. Significantly, this review recommends the two jurisdictions formalise a joint management framework, potentially combining the two parks under a single integrated

management plan with shared Commonwealth-State funding. Or, alternatively, rename the CSIMP to reduce confusion, such as adopting the bioregional name of the Tweed-Moreton Marine Reserve.

5.4.1 Ecological Condition — Key Knowledge Gaps

Four priority gaps are apparent from the literature.

1. Long-term ecological monitoring across SIMP remains limited — particularly for detecting climate-driven trends, cumulative stress and species range shifts over decadal timescales.
2. The effectiveness of current zoning for fisheries and estuarine species recovery remains poorly evidenced, particularly in estuarine and soft-sediment habitats.
3. Biological surveys of deeper and soft-sediment areas, despite recent bathymetric mapping offshore at the CSIMP, remain sparse; these zones may host unique communities vulnerable to fishing and other impacts.
4. Integration of First Nation's Traditional Ecological Knowledge into ecological monitoring and management remains limited, representing a knowledge gap and a missed opportunity for co-management.

5.5 Threats to Cultural Heritage

The compounding threats of sea level rise, coastal inundation and increased storm intensity threaten heritage infrastructure, erode culturally significant landforms, and risk impacting submerged cultural heritage assets. This is compounded by the absence of a comprehensive underwater cultural heritage management plan for NSIMP.

The physical integrity of coastal and island heritage sites — middens, burial sites, the South Solitary Island lighthouse complex, natural island assets, and submerged cultural assets including shipwrecks, are threatened by climate change, coastal erosion and rising seas. Heritage sites above and below water are vulnerable to vandalism, unauthorised island landings and anchor damage.

Urban and coastal development degrades scenic coastal values and disrupts the landscape setting that gives heritage sites their broader cultural meaning. Insufficient inclusion of Indigenous voices in NSIMP management marginalises traditional ecological knowledge and undermines potential co-management development. Without active intergenerational engagement and formal recognition, Indigenous cultural knowledge, language and connection to Sea Country risk permanent loss. Regulatory uncertainty and political interference weaken the long-term management frameworks needed to protect both Indigenous and non-Indigenous heritage values.

Culturally significant ecological features, seabird nesting sites, Pipi beds (*Donax deltoides*) and oyster reefs, lack management plans to ensure their long-term sustainability and cultural integrity.

Poorly managed visitation, littering, unauthorised boating activities and inadequate visitor oversight risk cumulative degradation of both natural and cultural heritage values. Socioeconomically, declining environmental quality directly undermines the viability of marine tourism, recreational fishing, diving and other nature-based industries that underpin the regional economy. The broader community's wellbeing, sense of place and cultural identity, are deeply connected to healthy marine environments, and are also at risk. (NSW SOE, 2024).

5.6 Threats to Social, Recreational and Economic Values

Ocean warming, acidification, urban stormwater and agricultural runoff threaten the seagrass and reef habitats that underpin tourism and fisheries. Overfishing and illegal extraction reduce fish biomass, raise operational costs and diminish the park's appeal to recreational fishers and divers. Conflict between users, compounded by discarded fishing gear and wildlife entanglements within sanctuary zones degrades the experience for all users. Regulatory uncertainty and zoning instability discourage long-term investment and erodes stakeholder confidence. Political interference in

management decisions remains the primary structural threat to the long-term viability of NSIMP as an economic and ecological asset to NSW and the local community.

5.7 Threats to Conservation and Scientific Values

The threats to NSIMP's conservation and scientific values largely mirror those to biodiversity, but with additional institutional dimensions. Ocean warming, acidification and shifting currents alter ecological baselines that make NSIMP scientifically significant. Pollution, runoff and sedimentation damage sensitive habitats. Long-term monitoring is imperative to identify these critical impacts and habitat change. Invasive and range-shifting species can displace native communities and undermine conservation outcomes. Inadequate or inconsistent government funding threatens the continuity of long-term monitoring programmes, reducing the value of accumulated datasets and weakening evidence-based management.

Illegal and unsustainable extraction depletes target species and undermines identifying spillover benefits. Frequent policy changes and political interference disrupt research continuity and erode stable management frameworks. Turnover of experienced researchers and managers, combined with underfunding of Indigenous knowledge programmes, risks losing irreplaceable ecological and cultural understanding built over decades.

5.8 Threats to Cetaceans

Vessel Strike and Disturbance: A review of 15 Australian studies (2003–2018) found vessel traffic consistently disrupted cetacean travel and resting behaviour, with existing regulations characterised as passive, inadequate and poorly enforced (Puszka et al., 2021). Field observations found 77% of dolphin sightings involved vessel interactions within 400m, with violations most severe in summer at 4.54 breaches per hour, predominantly by small recreational vessels. NSIMP lies within the east coast humpback whale migration corridor, one of Australia's highest-risk zones for vessel strike, with both commercial shipping and recreational vessel traffic present all year round. Whale watching pressure during the humpback whale migration is an additional and growing source of potential behavioural disturbance within NSIMP.

Bycatch and Entanglement of Small Cetaceans: is considered the single most serious threat to cetaceans globally, with an estimated 300,000 individuals killed annually across all fishing operations, with 84% of cetacean bycatch occurring in gillnet fisheries (Read et al., 2006). Globally, an estimated 22% of small cetacean species face extinction risk, with fisheries identified as the primary driver, and little improvement recorded over nearly 30 years (Temple et al., 2024). In NSW, commercial prawn trawling permitted in areas of the NSIMP general use zone represents a documented risk to cetaceans as bycatch. There is no reliable technical solution to reduce small cetacean bycatch in trawl nets, and dolphins are known to forage around trawl vessels, increasing incidental capture risk (Hamilton & Baker, 2019). The NSW Shark Meshing Program recorded 255 animals caught in 2023–24, of which 94% were non-target species and only 36% released alive; protected cetacean interactions included five Indo-Pacific Bottlenose Dolphins (four dead), one Common Dolphin (dead) and one Humpback Whale (released alive) (NSW DPIRD, 2024).

Crab and lobster trapping, permitted across both the general use and habitat protection zones, also carries documented bycatch risk for cetaceans. The absence of park-specific monitoring of fishing impacts on cetaceans represents a further, significant knowledge gap in NSIMP management.

Underwater Noise: Cetaceans rely on sound as their primary sense — toothed whales use echolocation for hunting and navigation, while all cetaceans use sound for communication — making ocean noise pollution a significant threat to their survival. Anthropogenic sources, including shipping, seismic exploration and naval sonar, can affect areas extending thousands of square

kilometres. Strandings and mortalities of beaked whales have been conclusively linked to naval sonar and seismic events (Weilgart, 2007). Documented effects of ocean noise include behavioural disruption, auditory masking (where background noise from vessels, sonar, or seismic activity, drowns out (disrupts) the biological sounds animals rely on for communication, navigation, foraging, mating and predator detection (effectively rendering important biological signals inaudible), habitat abandonment, elevated stress, and reduced foraging and reproductive success. Noise also affects cetaceans indirectly by impairing prey species. Marine protected areas, monitoring, and precautionary noise reduction near biologically important areas are identified as critical management responses (Weilgart, 2007).

5.9 Threats to Marine Turtles

All turtle species face common threats within and adjacent to NSIMP, including: impacts from climate change, bycatch and entanglement in commercial prawn trawl and trap fishing gear (permitted in the parts of the general use); vessel strikes, crushing their carapace; and marine debris ingestion, particularly plastics blocking their alimentary system leading to starvation. The southwest Pacific Loggerhead stock, genetically and geographically distinct from North Pacific Loggerhead (breeding in South Queensland) declined significantly during the period 1970–2001 primarily from trawl bycatch mortality, before turtle excluder devices became mandatory in 2002.

The intermittent blocking of Coffs Creek impacts foraging potential, preventing access to important seagrass beds.

Changing sea and air temperatures may encourage turtles to migrate south for breeding if current breeding beaches in Queensland become over heated. This will hopefully increase the incidence of turtle breeding on NSIMP beaches and mitigate some of the climate impacts on these animals further north. Understanding the impact of climate change, particularly warming, on turtle populations is critical to monitoring and managing this type of change.

There is no dedicated turtle monitoring programme, a significant knowledge gap given the position of NSIMP within the southern migratory and foraging range of east coast turtle populations. Establishing a dedicated local monitoring programme is a priority recommendation of this review.

5.9.1 Sea Turtle Sex Ratio and Climate Change

Sea turtle sex is determined by nest sand temperature during the middle third of incubation, with the pivotal temperature producing a 50:50 sex ratio identified at approximately 29°C across most species (Mrosovsky et al., 1988, 1992; Lockley et al., 2021). Nests below 28°C produce almost exclusively males, while nests above 29.5°C produce 95–100% females.

For east Australian populations, the pivotal temperature is slightly lower, 28.1°C for southern GBR Green Turtles (*Chelonia mydas*) and 28.4°C for Loggerhead Turtles (*Caretta caretta*). This means that just one to two degrees of warming can shift production to near-total feminisation. At Raine Island on the northern GBR, this is already occurring, with 99% of Green Turtle hatchlings now female, associated with regional average warming increase of 1.27°C. Compounding this, warmer incubation temperatures also increase embryo mortality, presenting two interacting pressures on population viability.

Research identifies a tipping point at approximately 80–85% female hatchlings, beyond which male scarcity reduces multiple paternity, a dire warning signal for population collapse. Critically, sea turtles reach sexual maturity over 25–40 years, meaning the consequences of today's skewed sex ratios at a population-level may not become fully apparent for decades.

Implications for NSIMP: For NSIMP, where Green and Loggerhead Turtles nest at the southern subtropical margins of their range, potentially representing a future refugia population, this threat requires immediate management attention. Monitoring of nest sand temperatures and hatchling sex

ratios at recognised and potential NSIMP nesting beaches is a priority recommendation of this review, along with assessment of whether interventions such as nest shading or beach vegetation restoration are warranted before the tipping point is reached.

Warming oceanic conditions may also drive turtle nesting patterns southward, with NSIMP beaches potentially developing as new natal beaches. While this process has been recorded elsewhere, natal homing is deeply hardwired, and the capacity to establish new natal beaches is slow, relative to the pace of climate change. Simultaneously, existing and potential natal beaches face erosion from sea level rise and increasingly intense storm events.

Natal beach fidelity, a strategy that has served sea turtles for over 100 million years, is becoming a vulnerability in a rapidly changing world. Whether this ancient lineage possesses adaptive mechanisms sufficient to survive the current rate of change remains one of the more consequential questions in marine conservation.

5.9.2 Unexplained Turtle Mortalities in NSIMP and Across NSW Coast

A significant and unexplained turtle mortality event along the NSW coast has added urgency to turtle conservation in the region. Beginning in mid-2025, elevated numbers of sick and dead Green Turtles (*Chelonia mydas*) were recorded, centred initially on Port Stephens but extending along the coast with approximately 250 turtle deaths recorded across NSW. The actual mortality would likely be substantially higher than recorded given many deaths would go unreported.

The number of turtles presenting to Sea Shelter at Port Stephens climbed to a total of 81 following high rain fall, and freshwater inundation of the estuary in June 2025. Investigations by NPWS, Sea Shelter, CCWC, Taronga Zoo and the EPA suggested multiple potential triggers, including climate change and contaminated seagrass from polluted runoff. Post-mortems have reported stomach sludge, malnourishment, and anaemia. To date (May 2026) no definitive cause has been determined, but the consensus is that the animals suffered from fresh water and cold-water shock making them vulnerable to viral and bacterial infection, leading to severe illness, or death (pers. comm., DPIRD May 2026).

In the NSIMP region, CCWC rescued approximately 70 turtles, of whom 30 survived, with animals still presenting at a rate of 1–2 per day as of February 2026 (pers. comm., Tiga Cross, CCWC, February 2026). This event underscores both the vulnerability of turtles using NSIMP waters and the urgent need for a dedicated NSIMP turtle monitoring programme to monitor nest and sand temperatures and for future mortality events.

5.10 Grey Nurse Sharks

The primary threat to Eastern Australian populations of Grey Nurse Shark is current and historic fishing, including bycatch by commercial and recreational fishing. The adjoining NSIMP and CSIMP contain several of the Grey Nurse Shark's most significant aggregation sites on the east coast. North and South Solitary Islands are designated aggregation sites, with smaller numbers regularly observed at Groper Island, Split Solitary Island, and Pimpernel Rock in CSIMP.

Despite increasing their population rate at 3% per year, recovery remains fragile given the species' extremely low reproductive rate, with females producing on average fewer than one pup per year.

Grey Nurse Sharks have a narrow thermal tolerance of approximately 12–24°C, with a preferred range of 17–24°C. Rising sea surface temperatures are already altering metabolic rates, behavioural patterns and migration timing, and warming waters may progressively contract suitable habitat, particularly at the northern extent of the species' range, which includes NSIMP. The seasonal peak aggregations that drive dive tourism are directly temperature dependent, occurring between June and August when water temperatures are at their coolest. As winter minimum temperatures rise,

the duration and intensity of these aggregations may shorten, reducing both conservation and economic value.

5.11 Threats to Seabirds

Little Tern: Recent seasons show encouraging recovery for Little Terns — 16 sites and approximately 430 breeding pairs in 2023–24, rising to 24 sites, 485 pairs and a record estimated 510 fledglings in 2024–25 (NSW NPWS, 2024; 2025). However, just two sites accounted for approximately 70% of 2023–24 fledglings, a concerning concentration of breeding success. Key threats include predation, human disturbance, vehicle traffic, sea level rise and adverse weather (NSW NPWS, 2003; BirdLife Australia, 2024). Despite recent gains, the species is considered likely to continue declining over the next three generations (DCCEEW, 2024).

Crested Tern: As a ground-nesting species it is vulnerable to predation from foxes, rats, cats and dogs, and to disturbance-related nest failure such as visitors to the sites.

Wedge-tailed Shearwater (*Ardenna pacifica*): The Swanson & Roman (2023) paper, based on a 43-year data set, found that fledglings weighing 380–470 g have the best survival prospects, but fledgling mass has been declining at an average rate of 1.6 g per year overall since data collection began, with the decline sharpest since 1996 at 3.8 g per year. Should the overall 1.6 g/year decline continue, the average fledgling will cross out of the survivable mass range by 2047/2048, with consequent recruitment failure and potential population collapse (Swanson & Roman, 2023). Stable adult condition alongside declining fledgling mass points to reduced prey availability (fish stocks) within foraging range, possibly linked to sea surface warming. This demonstrates the value of long-term monitoring and associated datasets.

Wedge-tailed Shearwaters feed pelagically on fish, squid, and crustaceans, with fish comprising approximately 66% of their diet. Nestlings are fed primarily on regurgitated squid and initially on stomach oil, a concentrated, energy-rich waxy oil of digested prey produced in the parent's gut.

Daily changes in sea surface temperature can affect the Shearwater's capacity to feed and provide for the chicks due to changes in prey availability. Consistently high temperatures over a breeding season can have a catastrophic impact on colonies and fledging success. This results in the breeding site at Muttonbird Island being highly vulnerable to climate-driven disruption of prey availability during the breeding season. This may warrant the inclusion of Wedge-tailed Shearwaters as an indicator species for monitoring fish stocks and climate change impacts on NSIMP.

Key threats on the nesting sites include habitat degradation from the introduction of Kikuyu Grass (*Pennisetum clandestinum*) on South Solitary Island, preventing nesting. This has been listed as a key threatening process under the *Threatened Species Conservation Act.,* replaced by the *Biodiversity Conservation Act 2016.* Introduced predators (rats and foxes on Muttonbird Island), marine debris ingestion, entanglement in abandoned fishing gear, and acute disturbance events also present serious threats. A fire deliberately lit by fishermen on South West Solitary Island directly destroyed nesting habitat, killing breeding birds, fledglings and eggs on their nests.

The long-term data set on Wedge-tailed Shearwater fledglings provides a rigorously documented early warning signal for climate-driven food web shifts in NSIMP, compounding the pressures of habitat degradation, introduced predators and marine debris that threaten the NSIMP seabird communities, and by implication, threatens other ecological communities.

5.12 Climate Change — Species Range Shifts and Ecological Impacts

Despite its protected status, NSIMP faces a range of environmental and anthropogenic threats that challenge the ecological, cultural, social and economic values it supports. Many of these threats interact synergistically, amplifying individual impacts and compounding management complexity.

Climate change impacts are the most significant long-term threat to the ecological integrity of NSIMP, operating across multiple interacting pathways. Rising sea temperatures are increasing the frequency and severity of coral bleaching events and marine heatwaves, progressively eroding reef resilience and recovery capacity globally. Ocean acidification (due to absorbing approximately 30% of anthropogenic produced CO_2) impairs calcification in corals, molluscs and echinoderms, threatening structural integrity of reefs and associated biodiversity (IPCC, 2013). Sea level rise, intensified storm surges and changing current patterns degrade seagrass meadows, mangroves, intertidal zones and seabird nesting habitat. Increased and intensified storm action increases shoreline erosion, which in turn increases suspended sediment loads in the water column, smothering reefs, seagrass beds and reducing light penetration. Low-lying coastal heritage infrastructure onshore and on the islands faces accelerating inundation risk from storm damage.

5.12.1 Species Range Shifts and the EAC Transition Zone

The EAC has extended approximately 350 km southward over 60 years, making southern waters warmer and saltier. Australian waters are warming at twice the global average in the northern areas and two to four times faster in south-east NSW. The EAC hugs the Coffs Coast, sitting at approximately 30°S, the EAC separation zone. Its close proximity to the coast makes NSIMP a globally significant biogeographic transition point and one of the most sensitive locations in Australia for detecting climate-driven ecological change.

Since range shifts were first documented in Australian waters in 2003, 198 species from nine phyla have shifted their distributions, with 87.3% moving poleward — southward along the Australian coast — at an average rate of 7.2 km per decade (Gervais et al., 2021).

Ocean warming also disrupts the seasonal timing of biological events. Spring phenology (the scientific study of the timing of recurring biological events in spring) has advanced by 4.4 days per decade, meaning spawning events, plankton blooms and other prey peaks are occurring progressively earlier in the year (Poloczanska et al., 2013). Where predators, fish, seabirds, and marine mammals cannot adjust to match their breeding timing at the same rate, their young hatch or are born after peak food availability has passed. This phenological mismatch is a subtle but serious threat: it produces no single dramatic event but drives persistent breeding failure and population decline across multiple species simultaneously (Carroll et al., 2024).

Ocean warming further alters growth rates, reproduction, and the environmental cues that trigger migration and spawning, progressively decoupling the trophic interactions on which ecosystem function depends.

Climate-driven shifts are driving tropical species, including coral trout, butterflyfish and angelfish (pers. comm., Mike Davey, Jetty Dive, February 2026), southward into NSIMP waters, temporarily increasing local species richness while displacing temperate species. This alters community structure and threatens species at the northern limit of their thermal stress range with potential local extinction, or migration south. This progressive tropicalisation directly erodes the tropical-temperate transition zone that defines much of the biodiversity and scientific value of NSIMP, moving it more towards a tropical system.

DPIRD partners with Redmap Australia to use citizen science observations from fishers, snorkellers and divers to track species range shifts along the NSW coast. Between 2012 and 2021, 234 citizen scientists logged 656 unusual or out-of-range species sightings in NSW alone. Much of the kelp and range-shift research is directly relevant to NSIMP and its position at the EAC transition zone where range-shifting species are most readily detectable (pers. comm., Mike Davey, Jetty Dive February 2026). However, a more systematic approach for recording range shift is needed.

5.12.2 Impacts of Climate Change on Habitat-Forming Species in NSIMP

The two key habitat-forming groups in NSIMP are the kelp *Ecklonia radiata* and Scleractinian corals. Both are vulnerable to ocean warming and acidification; kelp through direct thermal stress and increased herbivory from range-expanding tropical fish, corals through bleaching and disease. The decline of both groups threatens the ecological function of the most productive reef ecosystems of NSIMP. (See Appendix (10.4) for more information on depth refuge).

5.12.3 Tropicalisation of Fish Communities — Cascading Ecological Impacts

Tropicalisation is producing both winners and losers, tropical migrant species are establishing new territory while native temperate species face local extinction or southward migration. Using 17 years of BRUV data from NSIMP reefs (2002–2018), overall fish abundance and diversity increased as tropical species arrived. However, kelp loss had exclusively negative effects on temperate species. The Senator Wrasse (*Pictilabrus laticlavius*), Southern Māori Wrasse (*Ophthalmolepsis lineolatus*), and Long-Fin Pike *(Dinolestes lewini)* were the first species identified as declining from tropicalisation and habitat change in NSIMP (Smith et al., 2021). Tropical herbivores, particularly the Subtropical Surgeonfish *Prionurus microlepidotus,* increased markedly at sites experiencing kelp decline, representing a functional shift in fish herbivory toward a tropical system (Vergés et al., 2016). These trends represent ecosystem homogenisation, the progressive replacement of distinctive subtropical assemblages with broadly distributed tropical species, reducing regional ecological uniqueness even where total species counts remain stable or increase.

5.12.4 Anemonefish

North Solitary Island supports exceptionally high Anemone and Anemonefish densities. However, warming and strengthening of the EAC show fine-scale fluctuations in juvenile, subadult and adult numbers that track two key factors: water temperature and the availability of host Anemones. Anemonefish are obligate symbionts, they cannot survive without their host Anemone, meaning their population at any given site is limited by availability of healthy anemones. When water temperatures rise above tolerance thresholds, Anemones bleach and die, directly removing the habitat on which Anemonefish depend. Juveniles are particularly vulnerable as competition for the limited number of remaining healthy Anemones intensifies. (Scott et al., 2011; Malcolm & Scott, 2017). Anemonefish therefore serve as both a conservation target, in their own right, and a useful indicator species for long-term reef health monitoring within NSIMP sanctuary zones (Scott et al., 2011; Malcolm & Scott, 2017).

5.12.5 Predator–Prey Disruption, Disease Risk and Novel Ecosystems

Ocean warming is restructuring food webs in NSIMP through trophic mismatch, where the timing of predator requirements and prey availability become decoupled and through the arrival of novel predator prey relationships as range-shifting species enter the system. Tropical herbivorous fish now exert grazing pressure on temperate kelp communities for which no evolutionary co-existence has occurred, fundamentally altering competitive and trophic dynamics.

Range-shifting species may also introduce parasites and pathogens into regions where native species have no evolved resistance. A consequence of climate-mediated physiological stress is that host resistance to pathogens and parasites can be compromised, and temperature-induced disease outbreaks in corals have occurred simultaneously with bleaching events, resulting in increased mortality. Coral disease was documented at NSIMP as early as 2002–04, when white syndrome was recorded spreading through multiple genera at South West Solitary Island (Dalton & Smith, 2006).

Species with narrow thermal ranges and limited mobility face local extinction if they cannot shift their distributions. As native coastal species are unable to redistribute further poleward beyond Tasmania, that region represents a ‘species sink’ where the rate of novel species arrivals is likely to outpace the rate of local losses, leading to entirely new ecosystem assemblages (Gervais et al., 2021). NSIMP, as a transition zone at approximately 30°S, is itself undergoing accelerating community restructuring, a process that, while currently showing more winners than losers in terms

of increased fish diversity, carries significant long-term risk for endemic species at their thermal limits.

5.12.6 Ascidians (Sea Squirts) and reef health

Sea squirts *(Herdmania grandis)* are becoming increasingly abundant on subtropical reefs. These organisms are a natural part of reef ecosystems, but the shift from kelp, a nitrogen absorbing state, to ascidian-dominated, nitrogen excreting, communities accelerate the microbial pathways that leak N_2O to the water column and ultimately the atmosphere, altering nutrient cycling and increasing the production of nitrous oxide, a greenhouse gas that influences climate and ocean processes, (Dindar et al, 2025). This is an emerging area of research, but with important implications for changing reef communities.

5.12.7 Kelp Loss and Tropicalisation

Ecklonia radiata, Common Kelp, forms the structural foundation of temperate rocky reef ecosystems, providing habitat, food and shelter for diverse fish and invertebrate assemblages. The NSIMP region represents the northern thermal range for *E. radiata* in eastern Australia, making it particularly vulnerable to ocean warming.

Between 2002 and 2012, long-term BRUV data collected by Hamish Malcolm (NSW DPI, Smith, S.M., et al., 2021) recorded a year-by-year kelp decline across all NSIMP study sites, with kelp disappearing completely from all sites and a concurrent tripling of tropical and subtropical herbivorous fish abundance (Vergés et al., 2016). Three species drove this loss: Sawtail Surgeonfish (*Prionurus microlepidotus*) consumed carpet-forming algae, preventing kelp recruitment; while Rabbitfish (*Siganus fuscescens*) and Drummer (*Kyphosus bigibbus*) consumed adult fronds at an average rate of 300 bites per hour in transplant experiments. Subsequently, kelp forests have been replaced by low-biomass algal turfs, with reef communities becoming increasingly tropicalised.

Statewide, the NSW State of the Environment report (2024) recorded kelp cover declines at all six monitored sites between 2019 and 2023, ranging from 25% to 62% of 2019 baseline values. While these sites are not confirmed as being within NSIMP, the trend is consistent with conditions documented in the NSIMP. Since 2019, the MEMS Climate Change Monitoring Project, led by DPIRD, has surveyed 1,000 km of NSW coastline and recorded large kelp declines particularly around the Solitary Islands (Davis et al., 2021).

5.12.8 The role of Sea Urchins and Kelp Decline

The Long-spined Sea Urchin (*Centrostephanus rodgersii*) is native to NSW waters, with NSIMP representing its northern thermal range limit at approximately 30°S. Where it occurs in large numbers it overgrazes kelp and macroalgae, converting reef habitat to “white rock” barrens extending from less than 7m to 27m depth (Worthington & Blount, 2003). Barrens are present and considered stable at the northern range limit of NSIMP, with over 30 years of research showing they have remained stable in shallow NSW waters since the 1960s, but limited earlier data prevent identification of longer historical patterns. Once established, and having grazed down the kelp, urchins switch to encrusting algae that persist under intensive grazing. This prevents kelp recruits (juvenile sporophytes) from re-establishing. Paradoxically, climate projections suggest *C. rodgersii* may disappear from northern NSW including NSIMP as temperatures exceed its thermal tolerance, while populations expand further south (Przeslawski et al., 2025).

5.12.9 Predators of the Sea Urchin C. Rodgersii

Recent research has revised the understanding of which species effectively control urchin populations. The Eastern Blue Groper (*Achoerodus viridis*) accounted for 75% of observed predation events and large Eastern Blue Groper (>600mm) is considered the only fish capable of consuming urchins across the full size range studied (16–110mm), making their protection within sanctuary zones critical.

Four smaller fish species, the Crimson Banded Wrasse, Six-spined Leatherjacket, Yellowfin Bream and Southern Māori Wrasse, accounted for the remaining 25%, targeting only smaller urchins under 25mm (Day et al., 2023). Tethered urchin experiments found the Crested Horn Shark (*Heterodontus galeatus*) responsible for 45% of predation events, readily consuming *C. rodgersii* of up to 121mm test diameter, well beyond the size previously thought to be exempt from predation.

Eastern Rock Lobster showed very low predation rates of just 4% despite repeated filmed observations of lobsters walking past tethered urchins (Day et. al., 2024). These findings highlight the potential significance of previously overlooked predators such as the Crested Horn Shark and challenge the assumption that Eastern Rock Lobster is the key predator controlling *C. rodgersii* populations in NSW.

Gut content analysis confirms that Snapper and Port Jackson Sharks show low predation rates on *C. rodgersii* (Gaston, 2025). Blue Groper and Crested Horn Shark are emerging as the most ecologically significant urchin predators (Day et al., 2023; 2024).

The broader significance of both these studies is that they collectively challenge the long-held assumption that Blue Groper, Snapper and Rock Lobster are the key predators regulating *C. rodgersii* in NSW. This has important implications for the management rationale of sanctuary zones in NSIMP, where protection of these species has been partly justified on urchin control grounds. On this basis, protection should be extended to include the identified species.

5.12.10 Kelp and Management Implications

C. rodgersii and range-expanding tropical herbivorous fish act in concert. Urchins create and maintain barrens while tropical grazers prevent juvenile kelp re-establishing. NSIMP sits at the frontline of kelp tropicalisation in NSW. The combination of direct thermal stress, tropical fish herbivory, and loss of genetic diversity at the range edge makes *E. radiata* recovery in NSIMP (and elsewhere) increasingly unlikely without active intervention and protection of key urchin predators and possibly the physical removal of urchins from selected sites. The combination of the ecological importance of the NSIMP kelp beds and their unique genetic holotype as discussed above further strengthens the argument for extending sanctuary zones to fully protect all kelp beds within NSIMP. Furthermore, this should be applied across the NSW Marine Parks Network.

5.12.11 Scleractinia Corals

NSIMP sits at a subtropical transition zone where tropical and temperate coral species co-exist, making it both ecologically distinctive and highly vulnerable to thermal stress. Coral bleaching was first recorded in NSIMP during the 1997–98 ENSO event, when above-normal sea surface temperatures caused bleaching in families including *Acroporidae, Pocilloporidae* and *Dendrophylliidae*. Minor bleaching was subsequently recorded between 2005 and 2007, affecting *Poritidae* and *Dendrophylliidae* species (Dalton & Carroll, 2011).

NSIMP's threshold for bleaching is estimated to be 26.5–26.8°C, approximately 1–2°C above the maximum monthly mean, substantially lower than for tropical reefs, reflecting the cooler baseline temperatures at this higher latitude subtropical location (Dalton & Carroll, 2011). The 2016 marine heatwave was the most intense heat stress event on record at NSIMP, causing the endemic *Pocillopora aliciae* to suffer a 51% decline in colony density. The highest mortality was among subtropical endemic species surveyed across inshore, mid-shelf and offshore sites (Cant, *et. al*., 2021).

Despite these pressures, long-term monitoring shows considerable resilience. Over a 23-year period from 1990 to 2013–14, cosmopolitan coral cover decreased at all six islands sampled, while subtropical coral cover showed no consistent directional change and there was no evidence of broadscale tropicalisation of coral assemblages.

Biophysical modelling indicates very low probabilities of larval dispersal from the southern GBR to NSIMP, reflecting the considerable distance, prevailing current patterns, and the limited pelagic larval duration of most coral species. This isolation has a critical conservation implication. NSIMP's coral communities largely self-recruit or depend on connectivity within the local region rather than being replenished from tropical sources to the north. If a species is lost from NSIMP, through bleaching, disease, or habitat destruction, natural reseeding from the GBR is unlikely.

This makes protection and connectivity of existing coral communities within NSIMP, and the maintenance of local larval source populations through expanded sanctuary zones, a critical conservation management priority that cannot be deferred.

As discussed earlier, recent analysis of long-term monitoring of shallow mid-shelf reef corals over 22 years indicates coral cover has increased in the face of multiple cumulative disturbances, driven particularly by healthy growth of *Turbinaria* sp. and *Paragoniastrea* sp. (Malcolm, H, A., et al 2026)

While larval connectivity with the southern GBR is insufficient to replenish lost reef communities, the strengthening EAC is accelerating the southward transport of tropical species to NSIMP. This is a distinct process that is progressively reshaping reef community composition, even as structural ecological impacts on native communities at the outer islands remain limited to date.

The loss of kelp on inshore reefs, combined with increasing frequency and intensity of marine heatwaves, represents the most significant threat to native reef assemblages, reducing ecological complexity and resilience of mixed coral–algal reefs, particularly for subtropical endemic coral species that have already demonstrated high bleaching susceptibility and mortality at thermal thresholds well below those triggering bleaching on tropical reefs.

5.13 Threats to Fish Stocks and Populations

5.13.1 Recreational Fishing Pressure

Recreational fishing represents a significant species-variable proportion of the total catch, sufficient to require integration into stock management strategies alongside commercial quotas. Recreational fishing removes more than three million fish, crustaceans and molluscs from NSW coastal waters annually (DPIRD), primarily, snapper, kingfish and mulloway. Snapper is the most heavily targeted recreational species in NSIMP. Snapper is significantly more abundant in sanctuary zones than in habitat protection zones or unprotected areas, with habitat protection zones providing no measurable benefit over completely unprotected areas (Malcolm et al., 2015). As a significant invertebrate predator, snapper depletion carries potential cascading effects on benthic communities and food chains. Ghost fishing by abandoned crab pots has been documented as an ongoing source of unmonitored fishing mortality in NSIMP estuaries (SURG Research Report, 2018) while abandoned fishing line causes entanglement of birds and turtles.

5.13.2 Commercial Fishing

DPRID reports (2006-7) that 70 commercial fishers from Coffs Harbour, Woolgoolga, Arrawarra, Wooli, Minnie Water (and from further north in Iluka) operate within the park and surrounding waters. In addition, a small number of licensed commercial fishers from other areas access the park.

Commercial prawn trawling, widely regarded as the most damaging fishing method impacting seabed habitat, is legally permitted within a designated corridor of the NSIMP General Use Zone, covering approximately 13% of the park area near North Solitary Island and key inshore whiting grounds. Prawn trawling is well documented as one of the most ecologically destructive fishing methods, causing direct physical disturbance to seabed habitats and generating high levels of bycatch of non-target species including juvenile fish, invertebrates, and threatened species (Watling & Norse, 1998). Its continued operation within a marine park whose primary legislative purpose is

biodiversity conservation represents a fundamental inconsistency that this review recommends be addressed in the current management plan revision.

The NSW Ocean Trawl Fishery catches 130–150 species of fish, molluscs and crustaceans, highlighting the broad ecological footprint of trawling operations adjacent to NSIMP. Bycatch Reduction Devices are now compulsory in all NSW ocean and estuary prawn trawl nets, with square-mesh panels reducing bycatch by up to 40% in the ocean prawn trawl fishery (DPIRD Primefacts).

5.13.3 Fisheries Stock Assessments

NSW DPIRD contributes to the biennial Status of Australian Fish Stocks (SAFS) assessments. This is the most comprehensive national reporting framework for wild-capture fish stocks.[6] The national picture shows most stocks are sustainably managed, but the overall trend is concerning. Data quality is declining, climate change is an increasing threat to stock assessment reliability, and a growing proportion of stocks are moving into uncertain or undefined categories, meaning less is known about their condition, not that they are necessarily healthy.

The NSW State of the Environment (2024) report notes that declining coastal and marine habitat condition, coupled with concerns over the status of numerous fish stocks, indicates the ecosystems that support NSW fisheries are under increasing pressure, a trend expected to intensify with coastal population growth and climate change.

For NSW state waters and NSIMP specifically, the picture is concerning for several key species:

Pearl Perch: Pearl Perch in NSW has carried a depleted status, with ongoing review of the assessment reflecting continued concern about stock recovery. Pearl Perch is one of the most prized reef fish species in NSIMP and the broader northern NSW coast.

Black Rockcod: Populations declined severely through the 1950s–70s from heavy spearfishing pressure, until the Black Rockcod was fully protected in NSW in 1983. Despite over 40 years of legal protection, recovery remains severely constrained. Overfishing of larger males before species protection was introduced in 1983 may have impaired subsequent recruitment and recovery. The 2023 broadscale NSW survey recorded just 66 individuals at 27 of 83 sites, compared to 117 individuals at 34 sites in 2009–11; a 42% reduction in relative abundance (Harasti & Malcolm, 2024).

This slow recovery reflects the extreme biological vulnerability of this species. Black Rockcod are protogynous hermaphrodites, all individuals are born female and transition to male at approximately 100–110 cm and 25 years of age, meaning all large old fish are male. Illegal take disproportionately removes these large males, severely compromising reproduction even where females remain. Replacement males can only come from females that have grown for decades, making the impact of a loss of even a small number of large, male or female individuals, ecologically disproportionate. This is compounded by late age at maturity (Black Rockcod are long lived, to at least 65 years) and post-release barotrauma mortality from incidental capture, (Harasti & Malcolm, 2013; Francis, Harasti & Malcolm, 2016). Illegal recreational fishing (poaching) may be another driver of the slow recovery.

Snapper: the NSW component of the Snapper stock is assessed as being in better condition than Queensland, though fishing pressure on this ecologically and recreationally important species remains a management focus.

A Critical Gap: Stock assessments are conducted at the jurisdictional or regional level, not at the individual marine park scale. This means there is no park-specific data on the recovery of key species within NSIMP sanctuary zones versus adjacent fished areas. This is a critical gap in the evidence base

[6] Each stock is classified as Sustainable, Recovering, Depleting, Depleted, or Undefined based on catch, effort, biological and fishery-independent data. The sixth edition, released in 2024, covers 155 species and 503 individual stocks, with 316 stocks assessed as sustainable.

for evaluating conservation effectiveness, particularly on the hot topic of fisheries recovery, and a priority recommendation for targeted research.

5.13.4 Zoning and Stock Assessment Gaps in the Recreational Fishery

NSIMP sanctuary zones cover just 12% of park area, with 88% remaining open to some form of fishing. The proposed 2011 expansion to 19% sanctuary cover, remains unimplemented. Recreational fishing is a significant resource extraction activity within the park, but no stock assessment exists for the NSIMP recreational fishery as a discrete management unit. The NSW Recreational Fisheries Monitoring Program, while providing statewide catch and effort data, cannot be disaggregated to individual marine park level and was not designed as a stock assessment tool. This is a significant structural gap for evidence-based management of recreational fishing impacts within NSIMP.

5.13.5 Compliance and Enforcement

Since the repeal of the MP Act 1997, there is no independent compliance body for NSW marine parks. As a result, marine park compliance must compete with broader fisheries management priorities beyond marine parks, potentially limiting the resources and attention devoted to protecting marine park values. Enforcement is now undertaken solely by Fisheries Officers under the FM Act 1994.[7]

Several factors constrain overall effectiveness. The framework is legally sound, but resource-constraints, geographical challenges, and lack of dedicated independent oversight weakens the process. NSIMP covers over 72,000 hectares of coast, estuaries and offshore waters, a large area relative to the available number of officers. Enforcement is reactive rather than continuous, relying on patrols and community reports. The jurisdictional split between state waters (DPIRD) and Commonwealth waters (Parks Australia) adds complexity and funding disparity.

The absence of published NSIMP-specific compliance data makes it difficult to assess the actual level of sanctuary zone non-compliance within the park.[8] Evidence from other Australian marine parks is concerning. Systematic aerial and vessel surveys at Ningaloo MP found that 8–12% of recreational fishing vessels were observed fishing within sanctuary zones (Smallwood & Beckley, 2012). While direct comparison with NSIMP is not possible, this finding underscores that sanctuary zone non-compliance is a documented and potentially significant problem across Australia's marine park network, and that without systematic, park-level monitoring, its extent at NSIMP remains unknown.

Community reporting via the Fishers Watch hotline (1800 043 536) and FishSmart app remains the primary detection mechanism, a structural weakness that reflects under-resourcing of compliance officers, rather than adequate deterrence.

5.13.6 Cumulative Impacts of Recreational and Commercial Fishing

Fishing was ranked only 18th in NSW Government's 2017 TARA, an outcome partly achieved by disaggregating fishing methods into eight separate subcategories, masking its cumulative ecological impact. This represents extremely inadequate, poor or bias reporting.

Overfishing and non-compliance deplete key species, disrupt trophic relationships and damage benthic habitats through destructive gear use, such as trawling. Bycatch of threatened species, including Grey Nurse Sharks, Black Rockcod, marine turtles and rays pose cascading ecological risks. Overall, chondrichthyan (sharks, rays, and chimaeras) extinction risk is substantially higher than for

[7] Fisheries Officers possess extensive powers to board, search and seize vessels, vehicles and fishing gear, issue penalty notices and prosecute offences, with penalties of up to $22,000 per breach.

[8] In 2023–24, DPIRD detected 5,511 fisheries offences across NSW, issuing 2,904 written warnings and 2,092 penalty notices totalling $719,780 in fines, and commencing 212 prosecution actions. Over 2,900 fin fish and 23,900 invertebrates were seized (DPIRD Fisheries Compliance Enforcement, 2023/24).

most other vertebrate groups, with only around one-third of species currently considered at low risk (Dulvy et al., 2021). Removal of large predatory fish can trigger trophic cascades that fundamentally alter reef community structure. Boating, anchoring and increased maritime traffic physically damage coral reefs and seagrass beds and disturb seabirds and marine mammals. While tourism can derive conservation awareness and significant economic value, inadequate visitor management risks degrading the ecosystems that underpin NSIMP's natural appeal.

5.14 Invasive Marine Species

Principal pathways for non-native species include hull fouling, ballast water, anchor chains, fishing gear and discarded aquarium organisms. There is an increasing urgent need for active bio-surveillance with climate-driven southward range species shifts.

Pacific Oyster (*Magallana gigas*, formerly *Crassostrea gigas*): occasionally recorded in NSIMP, the Pacific Oyster can outcompete and displace the native Sydney Rock Oyster (*Saccostrea glomerata*) through faster growth and greater metabolic efficiency (Krassoi et al., 2008; Bayne, 2002), competing for space on hard substrates, with rapid colonisation impacting food web dynamics and reducing native invertebrate biodiversity. CSIRO has identified it among the top ten most damaging introduced marine invasive species in Australia and has declared it a noxious species in NSW waters.

Crown-of-Thorns Starfish (*Acanthaster* cf. *Solaris,* formerly *A. planci*): although native to the Indo-Pacific, can cause significant ecological damage at elevated densities. Aggregations have been recorded at the Solitary Islands and Lord Howe Island, with documented coral cover loss, reduced biodiversity, and degraded reef fish habitat. Recovery is typically slow. Increased nutrient availability from coastal catchments is considered a likely contributor to increased outbreak frequency through enhanced larval survival, though the causal pathway remains an active area of research.

Wakame (*Undaria pinnatifida*): is a native alga of the cool temperate waters of Japan, Korea, China and Russia. It is listed among the world's 100 worst invasive species and is on Australia's Priority Marine Pest List. It is an opportunistic annual seaweed that spreads primarily via hull fouling, forming dense underwater forests up to three metres tall, out-competing native species including Kelp for light and space. In Australia, it was first identified in Tasmania (1988) and in Port Phillip Bay (late 1990s) and is now established in Tasmania and Victoria. It is not yet known to occur in NSW, but DPIRD lists it as a notifiable marine pest and any sighting should be reported immediately. For NSIMP, Wakame represents a credible biosecurity threat. Targeted management actions have had minimal success once established, making early detection and prevention the only effective management strategy. Warming water may restrict its expansion northward towards NSIMP, but vigilance in marinas and aquaculture/aquarium facilities within and adjacent to NSIMP should be a priority biosecurity measure.

European Green Crab (*Carcinus maenas*): A documented threat to NSW marine habitats, the European Green Crab competes with and preys on native crab species and affects commercially important fisheries (Geller, Carlton & Larson, 2010). Its specific presence within NSIMP is not formally confirmed but should be part of bio-security surveillance monitoring programmes.

Caulerpa taxifolia: is an emerging risk; a Class 1 noxious species under the FM Act 1994, confirmed in 14 NSW estuaries south of Coffs Harbour since first detection at Port Hacking in April 2000. NSIMP has no confirmed infestation, but its position between the natural northern range (Moreton Bay, Queensland) and its known invasive southern populations makes NSIMP a genuine risk corridor. All known NSW infestations are associated with frequently used anchorage and fishing sites, conditions NSIMP shares with many infested areas. Active DPIRD monitoring has concluded, and distribution maps will no longer be updated, meaning any new arrival in NSIMP estuaries could go undetected. Community and diver reporting is now the primary detection mechanism and should be actively supported through education and engagement programmes.

Historical Terrestrial Invasives: Introduced domestic animals (including cattle) on South Solitary Island during the lighthouse-keeper era destroyed vegetation and eroded topsoil, collapsing Wedge-tailed Shearwater nesting burrows. Kikuyu grass (*Pennisetum clandestinum*), established in the aftermath, continues to dominate South Solitary Island.

5.15 Catchment Management Water Quality, Runoff and Marine Debris

Estuarine habitats, mangroves, seagrass and saltmarsh, and near shore coastal waters of NSIMP are vulnerable and significantly affected by runoff from a heavily modified catchment landscape, from agriculture and infrastructure development. SCU research identified Hearnes Lake, Woolgoolga Creek and Coffs Creek as priority catchments, with approximately 50% of nitrogen inputs sourced from overuse of horticultural fertilisers and the remainder from sewage overflow.

Urban expansion around Coffs Harbour has intensified sedimentation, nutrient pollution and contaminant loads entering the NSIMP via rivers and stormwater, while agricultural runoff from blueberry and macadamia growing areas introduces pesticides and fertilisers into the NSIMP estuaries, ICOLLs and riverine systems. Elevated nutrients promote algal blooms that can lead to eutrophication and Harmful Algal Blooms and outcompete corals and seagrasses, while increased turbidity and sediment loading impairs photosynthesis, recruitment and recovery (NSW SOE, 2024).

Marine debris compounds these pressures, including ghost fishing gear, lost or abandoned equipment that continues to trap animals long after being discarded.

5.16 Plastic Pollution

Plastic pollution poses a significant and growing threat to NSIMP's marine wildlife. An Australian-first Broadscale Microplastic Assessment conducted across 120 NSW coastal waterways listed Coffs Creek in NSW among the State's top ten contaminated waterways with the North Coast region exhibiting moderate to high microplastic pollution overall, despite low level urban development in the area (NSW Environmental Protection Authority, 2026).

Marine animals are attracted to plastic debris through multiple sensory pathways, including an olfactory trap. Marine-seasoned plastics produce dimethyl sulphide (DMS), which closely resembles a chemical released naturally when phytoplankton cells are broken down by grazing zooplankton, primarily Copepods. This chemical functions as a foraging cue indicating productive feeding grounds for some seabirds, turtles, and some marine mammals (Savoca et al., 2016) though some debate remains around this mechanism). The visual resemblance of some plastic to prey compounds the risk further. Once ingested, plastics cause harm through multiple mechanisms: gut blockage, false satiation suppressing feeding behaviour leading to starvation, internal lacerations, and the leaching of associated chemicals directly into tissues. Plastics and microplastics accumulate throughout the water column and sediments, with associated plasticisers and persistent organic pollutants (POPs) and endocrine disrupting chemicals (EDCs) biomagnifying through the food chain with consequences for apex predators including marine mammals, seabirds, and humans carrying the highest loads with sub-lethal effects on reproduction, immune function and impacts that are not yet fully understood. Plastic pollution has serious impacts on NSIMP's ecology and should be a priority management action to engage with Council and State Government to improve plastic pollution controls.

5.17 Cumulative and Synergistic Stressors

Even within designated MPAs, species and habitats remain exposed to significant and interacting threats (Womersley et al., 2023). While individual stressors are relatively well understood, their interactive effects are not. Combinations of ocean warming, acidification and eutrophication can

create multi-stress conditions exceeding the tolerance thresholds of habitats and species, potentially triggering non-linear or irreversible change. Ecosystem collapse is rarely the product of a single impact, it is the accumulation and interaction of stressors across ecological, physical and human dimensions that erodes resilience and can push systems past tipping points from which recovery is uncertain. Such cumulative pressures risk irreversibly eroding the ecological, cultural, social and economic values that make NSIMP an irreplaceable asset.

6 Selected Threat Hotspots Across NSIMP

The following five areas represent locations where ecological pressure or the likelihood of regulatory breach is greatest.

6.1 Pimpernel Rock — Critical Risk

Pimpernel Rock lies within the CSIMP beyond the three nautical mile limit of NSW state waters, protected under Marine National Park Zone (IUCN Category II, equivalent to a marine sanctuary in NSW) and managed by Parks Australia in partnership with DPIRD who undertake regular monitoring of the site. Though technically outside the NSIMP, it is the most ecologically significant feature of the broader reserve complex, a submerged pinnacle rising to within a few metres of the surface providing critical habitat for Grey Nurse Sharks, Black Rockcod, marine turtles, pelagic fish and diverse benthic communities. Illegal fishing and Grey Nurse Shark disturbance are the primary threat concerns.

6.2 North Solitary Island/Anemone Bay — High Ecological Vulnerability

North Solitary Island hosts the east coast's most important breeding site for the regionally endemic Wideband Anemonefish (*Amphiprion latezonatus*), and Anemone Bay is reported to support the largest clownfish/anemone population on the Australian coast. *A. latezonatus* is characterised by a small geographic range, low local abundance, extreme habitat specialisation on a single host anemone species (*Heteractis crispa*) and limited larval connectivity across only four isolated populations. All characteristics that elevate extinction risk (Steinberg et al., 2020; Scott et al., 2016). Long-term monitoring within the sanctuary zone recorded anemone and anemonefish density increases of up to 532% and 133% respectively between 1994–95 and 2008, providing compelling evidence of sanctuary zone effectiveness (Scott & Malcolm, 2011). The island is also one of two designated Grey Nurse Shark critical habitat sites within NSIMP, with the use of wire trace fishing gear prohibited within 500 metres.

The principal threats converge on the fragility of the anemone-anemonefish system. Host anemones contain zooxanthellae and are susceptible to thermal bleaching, like corals. Loss of host anemone would eliminate *A. latezonatus* habitat, with limited capacity for natural recovery given the species' restricted range and single host dependency. Dive tourism at Anemone Bay introduces the risk of physical disturbance from diver contact, anchor damage and substrate disturbance. Collection of anemonefish and host anemones for the aquarium trade warrants active monitoring. Fishing compliance within the 500-metre Grey Nurse Shark buffer remains an ongoing enforcement concern, with illegal or non-compliant fishing posing a continuing risk of bycatch and disturbance to this critically endangered species.

6.3 South Solitary Island — High Multi-Pressure Hotspot

South Solitary Island is the most ecologically significant and heavily visited dive site within NSIMP. Situated 8.5 nautical miles offshore, its position at the mixing zone of tropical and temperate water masses produces exceptional biodiversity. It is the most significant Grey Nurse Shark aggregation site within NSIMP. Manta Arch hosts up to 60 sharks during winter and they are now recorded year-round. This is one of two designated critical habitat sites with wire trace fishing prohibited within 500 metres. The island supports Black Rockcod, Loggerhead Turtles, Eagle Rays, Wobbegongs, and schooling pelagic fish. This site is believed to host the northernmost breeding aggregation of Giant Cuttlefish (*Sepia apama*).

The wreck of the Wyong adds shipwreck heritage values, and the South Solitary Island Historic Site, 11 hectares incorporating the lighthouse and keepers' cottages operational since 1880, represents significant maritime heritage.

Threats are multiple and compounding. The Grey Nurse Shark population is concentrated at this aggregation site, heightening vulnerability to disturbance, bycatch, entanglement and diver harassment. Despite wire trace restrictions, accidental bycatch of Grey Nurse Sharks and Black Rockcod during legal fishing activities in adjacent waters remains a risk. Both species have slow reproductive rates and are highly susceptible to even low levels of incidental mortality. High visitation occurs, with the island serving as the primary destination for the region's sole dive operator. Overuse of the site risks behavioural disturbance to shark aggregations and anchor damage to reef substrate by visiting boats. The Giant Cuttlefish breeding aggregation, as a marginal population, may be particularly sensitive to thermal shifts, breeding season disturbance and southward-migrating tropical competitors. The lighthouse complex faces accelerating deterioration from storm exposure and coastal erosion without dedicated heritage maintenance. The offshore location restricts consistent patrol capacity and is a critical gap given the concentration of critically endangered species and high visitor pressure at this site. Illegal fishing has been recorded regularly at this site during periods of inclement weather (pers. comm., Mike Davey, Jetty Dive), alternative live stream cam technology should be investigated for effective surveillance.

6.4 Northern Estuaries — Sandon, Wooli Wooli and Corindi Rivers — High Pollution Risk

The northern estuaries form a critical complex at NSIMP's northern boundary, bordering Yuraygir National Park and encompassing several ICOLLs. This juxtaposition of protected marine and terrestrial estate gives the area exceptional conservation significance. Saltmarsh communities (listed as endangered ecological communities in NSW), mangroves and seagrass beds of Eelgrass (*Zostera capricorni*) and Paddleweed (*Halophila* spp.), provide nursery, feeding and shelter habitat for commercially and recreationally important species, as well as flood mitigation, erosion control and sediment trapping. The catchment supports an endangered coastal Emu population and the endangered Swamp Foxglove (NSW Environment and Heritage, 2022).

The Corindi River, Corindi Beach rock platform and Sandon River carry deep cultural significance to local Aboriginal communities, used for thousands of years for resources, cultural gatherings and storytelling. The Corindi and Sandon catchments are exposed to pesticide and fertiliser runoff from horticulture and grazing, elevating nutrient loads, promoting algal growth and stressing seagrass and estuarine biota.

The Wooli Wooli River, with over 98% of its catchment within Yuraygir NP and adjacent Forestry Corporation land, remains one of the healthiest catchments in the region.

Several estuaries function as ICOLLs, periodically trapping high levels of pollutants/nutrients when closed to the sea, triggering episodic hypoxic conditions and fish kills.

Sea level rise and intensified storms threaten saltmarsh, mangroves and estuarine habitats through inundation, erosion and coastal squeeze, where hard infrastructure blocks landward habitat migration.

Limited ranger presence restricts monitoring surveillance and compliance across remote northern estuaries, increasing the risk of overextraction of culturally and ecologically significant species.

6.5 Coffs Harbour Nearshore Reefs — Moderate to High Human Pressure

Coffs Harbour's nearshore reefs form the southern gateway to NSIMP and its most accessible and heavily used reef habitats. Muttonbird Island Nature Reserve, linked to the mainland by a causeway and marking the NSIMP southern boundary, hosts an estimated 5,500–12,400 Wedge-tailed

Shearwater (*Ardenna pacifica*) breeding pairs, one of the most significant accessible colonies on the NSW coast. But its accessibility makes it vulnerable to visitor disturbance and introduced pests, requiring active management. The surrounding reef complex supports diverse tropical, subtropical and temperate assemblages, with Korora Reef and inshore reefs northward supporting key recreational target species including snapper, kingfish, Spanish mackerel, mulloway and bream.

Schultz et al. (2014) further found that unconsolidated habitats support substantially different species assemblages to rocky reefs, recommending depth and distance-from-shore categories be incorporated into an expanded Habitat Classification System and sanctuary zones to improve biodiversity representation in marine park zoning.

Threats are primarily anthropogenic and cumulative. Concentrated fishing pressure on snapper, kingfish and mackerel risks depleting local populations with limited refuge outside sanctuary zones. Elevated nutrient and sediment loading from urban stormwater, coastal development and the boat harbour complex suppress coral recruitment, promote algal growth and degrade reef and seagrass habitats. Harbour infrastructure compounds these impacts through vessel traffic, anchor damage, fuel contamination and altered sedimentation.

Nearshore reefs are particularly vulnerable to thermal stress at shallow depths, with limited recovery capacity under concurrent water quality and fishing pressures. Active compliance monitoring and community education are essential management responses given the accessibility and demonstrated fishing pressure at these sites (Malcolm et al., 2015; NSW DPIRD, 2024).

Threat Hotspot Summary

Rank	Area	Risk Level	Main Threats
1	Pimpernel Rock	Critical	Illegal fishing, shark disturbance
2	North Solitary Island / Anemone Bay	High	Coral and anemone damage, tourism pressure, fishing compliance
3	South Solitary Island	High	Tourism, debris, habitat disturbance, accidental bycatch & capture
4	Northern Estuaries (Sandon / Wooli / Corindi)	High	Agricultural runoff, sediment, fishing pressure
5	Coffs Harbour Nearshore Reefs	Moderate–High	Recreational pressure, fishing pressure, boat traffic

7 Management Responses and Future Directions

7.1 Overview

Effective management of NSIMP must address both acute and chronic threats to long-term ecological integrity. Significant gaps exist in surveillance coverage, data collection, jurisdictional coordination, and dedicated resourcing, alongside the need for active interventions including pest control, habitat restoration, and threat mitigation. Protecting NSIMP's values requires a holistic, multi-pronged approach. Limitations of current NSIMP and CSIMP boundaries create a significant gap with ecological connectivity and management uncertainty. Co-management requires authorities to share the pedestal; for example, education and other project activities can be contracted to NGOs for success.

7.2 Managing Cumulative and Synergistic Stressors

Adaptive and Precautionary Management: The uncertainty surrounding cumulative stressor interactions demands a precautionary approach. Zoning, compliance regimes, and management rules must be reviewed regularly against current threat assessments and adapted as circumstances change. Static regulatory settings are insufficient for managing non-linear ecological change.

Integrated Threat Management: Managing threats in isolation is ineffective. Future NSIMP management must explicitly address stressor interactions, particularly the compounding effects of climate change, water quality degradation, fishing pressure, and coastal development. This requires cross-agency coordination between DPIRD, DCCEEW, local councils, universities, Environmental Protection Authority, Parks Australia, and First Nations Sea Ranger groups and community to address threats originating outside park boundaries. MEMA's current structure may not be capable of delivering this level of coordination.

Compliance and Enforcement: Current protection levels, administered by already stretched fisheries officers, are insufficient to eliminate non-compliance and illegal fishing. Increased surveillance technology and dedicated marine park rangers (including volunteers) are essential. Meaningful enforcement requires marine parks to be managed under an independent authority aligned structurally with the conservation mandate the legislation demands, not as a subordinate function of fisheries management.

Ecosystem-based Management: Management must shift from single-species or single-threat approaches toward whole-of-ecosystem frameworks accounting for trophic relationships, habitat connectivity between inshore and offshore environments, and cumulative impacts. Key ecological features include Grey Nurse Shark aggregation sites, seagrass beds, and reef systems, kelp beds, which must be managed as functional units, with ecological corridors established between sanctuary zones.

Climate Adaptation Planning: A dedicated NSIMP climate adaptation plan is required to anticipate and respond to ocean warming, acidification, sea level rise, and increased storm intensity. Priority habitats and species most vulnerable to thermal stress should be identified. Monitoring triggers should be identified for management intervention of tropicalisation and tracking the southward movement of tropical species and the contraction of temperate species from NSIMP.

State–Federal Coordination: The GBR joint state/federal management model provides the foundation for a national framework capable of delivering more stable funding and consistent governance for marine conservation across State and Federal waters. It provides a directly applicable

governance model for the two SIMPs and the more distant Central East MP and will support the move to 30x30 more effectively.

Indigenous Co-management: Progressing IPA arrangements and embedding Traditional Ecological Knowledge in management planning strengthens both cultural and ecological outcomes. Indigenous Sea Ranger programmes, including accredited training, must be resourced as a core, long-term component of adaptive co-management, not a project-funded addition.

7.3 Research Priorities

Cumulative Stressor Interactions: Priority research is needed on how combinations of ocean warming, acidification, eutrophication, and fishing pressure affect key species, habitats, and ecological processes, particularly at NSIMP's tropical-temperate transition zone, where synergistic effects remain poorly understood.

Long-term Ecological Monitoring: Sustained, standardised monitoring of reef health, fish biomass, water quality, seagrass extent, and threatened species populations is essential for detecting early warning signals and evaluating management effectiveness. Continuity of existing NMSC and DPIRD monitoring programmes must be protected from funding interruption and political interference.

Tipping Points and Resilience: Identifying ecological tipping points under combined stressor scenarios, particularly for reef systems, seagrass beds, and fish communities, is critical for establishing precautionary management triggers and enabling pre-emptive rather than reactive responses.

Spillover Quantification: No formal spillover studies have been conducted in NSW sanctuary zones. Quantifying ecological and fishery spillover from NSIMP sanctuary zones would provide the evidence base needed to build fisher support for sanctuary zone expansion and address a critical gap in the scientific justification for the current zoning framework.

Socioeconomic Valuation: The only NSIMP-specific economic impact study (Hoisington, 2013) is now more than a decade old. An updated valuation incorporating non-market values, existence value, cultural significance, wellbeing, and ecosystem services would substantially strengthen the evidence base for management investment and political commitment.

Underwater Cultural Heritage: A systematic survey of underwater cultural heritage within NSIMP, including shipwrecks and potential archaeological sites is needed to establish a management baseline and identify assets at risk from environmental change and anthropogenic disturbance.

Traditional Ecological Knowledge Integration: Formal research programmes documenting, validating, and integrating First Nations Traditional Ecological Knowledge into scientific monitoring and management frameworks are needed to support cultural heritage objectives and improve cultural and ecological understanding across Sea Country.

7.4 MARXAN: Spatial Planning for Sanctuary Zone Redesign

MARXAN is a spatial conservation planning tool that uses mathematical optimisation to identify the most efficient arrangement of protected areas to meet biodiversity targets at minimum cost (Ball & Possingham, 2000). It simulates thousands of potential zone configurations, selecting combinations that collectively represent target biodiversity features, habitats, species, and ecological communities, while minimising defined costs such as fishing displacement or management complexity. The result is a set of near-optimal solutions identifying consistently selected

"irreplaceable" sites, providing a transparent, evidence-based, and publicly defensible foundation for zoning decisions. Its validity at scale is well established; the 2004 GBR rezoning used MARXAN to increase no-take sanctuary coverage from 4.5% to 33% (Fernandes et al., 2005).

MARXAN has been specifically identified as the appropriate tool for NSIMP, integrating seafloor habitat mapping, fish assemblage patterns, long-term monitoring datasets, fishing effort data, and socioeconomic values into sanctuary zone design (Malcolm et al., 2011; Breen, 2007). Its key strength is replacing subjective or politically influenced zone placement with repeatable, evidence-based analysis that makes trade-offs between conservation objectives, 30x30 commitments, and competing interests explicit and defensible.

However, MARXAN is only as good as its inputs. Incomplete habitat mapping systematically underrepresents poorly surveyed habitats and species. Socioeconomic and cultural values require careful integration to avoid technically optimal but socially unacceptable solutions, and outputs can be misrepresented to support predetermined outcomes where transparency is lacking (Kukkala & Moilanen, 2013).

Completing high-resolution seabed mapping of NSIMP is a prerequisite for MARXAN to deliver meaningful sanctuary zone design recommendations and a priority for joint NSW–Commonwealth investment, particularly ahead of the CSIMP management plan review due by 30 June 2028.

7.5 Sanctuary Zone Effectiveness — The Case for Redesign and Expansion

The scientific case for sanctuary zone expansion is unambiguous. Turnbull et al. (2021) found partially protected areas had no more fish, invertebrates, or algae than unprotected areas, while fully protected areas supported 30% more fish species and more than twice the fish biomass. Fully protected areas also attracted twice as many divers and three times as many snorkellers — a direct conservation and tourism dividend. Partial protection showed no measurable ecological or social benefit over open access. Critically, most fishers surveyed accepted the science and supported sanctuary zones in their area.

The BOFF concept — Big Old Fat Fecund Female Fish (Hixon et al., 2014) is directly relevant: sanctuary zones provide optimal refuge for the largest and most reproductively productive individuals, sustaining healthy fish populations and supporting adjacent fisheries through spillover. NSIMP has the lowest sanctuary zone coverage of any NSW marine park at 12% — well below the GBF 30% benchmark. Expanding full protection through a MARXAN-informed redesign should be a priority outcome of the current management plan review.

The Edge Effect — Perimeter-to-Area Ratio: The perimeter-to-area ratio is a key design principle in sanctuary zone planning. Edge areas are most vulnerable to external pressures; long, narrow, and fragmented zones have proportionally more boundary and less protected core. Ohayon et al. (2021) found edge effects extend approximately 1 km into no-take zones, with populations near boundaries around 60% smaller than in core areas. The smallest 64% of global no-take zones — those under 10 km² — may support only 45–56% of expected populations.

A simple illustration: two 4 km² zones — one square (2×2 km, perimeter 8 km, ratio 2:1) and one narrow rectangle (8×0.5 km, perimeter 17 km, ratio 4.25:1) — have identical area but the rectangle has more than twice the perimeter-to-area ratio and a far smaller genuinely protected core. NSIMP's sanctuary zones are small and irregularly shaped, drawn around specific habitat features rather than for geometric efficiency. Good design should maximise compactness, extend boundaries beyond target habitats to include a buffer, avoid narrow corridors as standalone designations, and merge smaller adjacent zones into single larger ones where ecologically appropriate. One large zone

will almost always outperform several small zones of equivalent total area. MARXAN modelling combined with socio economic (area use) studies should underpin future zone redesign to deliver ecologically and cost-effective outcomes consistent with 30×30 commitments.

The Edge Effect: Perimeter-to-Area Ratio: sanctuary zone boundaries are defined by geographic coordinates rather than visible physical markers, making precise location difficult for users and compliance officers without GPS. The FishSmart app provides real-time GPS-based zone mapping but relies on voluntary adoption. Offshore zones are inherently difficult to monitor given remoteness and limited patrol presence. Boundary ambiguity — genuine or claimed — is a common prosecution defence. The current zoning structure, with four zone types carrying different rules, increases the risk of inadvertent non-compliance. This reinforces the need for zone consolidation, boundary simplification, and increased compliance resourcing.

7.6 Fishing Pressure and Recreational Fisheries Management

The existing sanctuary zone framework must be maintained and strengthened as the foundation for sustainable fisheries, tourism, and marine ecosystem health.

Fishing rules across estuarine zones, particularly for spearfishing, crab trapping, and invertebrate collection should be reviewed and simplified, as current complexity impedes both compliance and enforcement. Engaging recreational fishing clubs, charter operators, and spearfishers is strategically important: these groups represent both a compliance risk and a potential conservation ally through co-management arrangements, education programmes, and voluntary stewardship agreements. First Nations should be engaged in formal co-management with cultural fishing practices supported within a Caring for Country conservation framework.

The role of citizen science groups in long-term biological monitoring should be formalised and resourced as an integral component of evidence-based adaptive management including in relation to recreational fisheries management.

7.7 Remote Surveillance Technology

Given NSIMP's geographical scale and resource constraints, a layered technology approach offers the most practical and cost-effective compliance coverage.

Unmanned Surface Vehicles (USVs): Bluebottle USVs, developed by Ocius Technology and trialled by Parks Australia in Geographe Bay and between NSW–Commonwealth marine park waters, offer continuous solar, wind, and wave powered monitoring, vessel identification, and real-time reporting from remote areas without crew or refuelling. Deployment in NSIMP's remote offshore sanctuary zones is a logical progression under existing cooperative management arrangements between NSIMP and Parks Australia.

Drone Surveillance: Already deployed by DPIRD fisheries compliance, drones are cost-effective for targeted aerial monitoring of nearshore reefs and estuaries. However, the Solitary Islands lie beyond the operational range of most commercially available drones without dedicated launch infrastructure. Drones are best suited to targeted enforcement deployment during peak risk periods, school holidays, fishing competitions, and lobster season, rather than persistent surveillance method.

Vessel Monitoring Systems (VMS): VMS is mandated for commercial vessels in the CSIMP but not in NSW state waters, creating a passive commercial fishing surveillance gap. Automatic Identification System (AIS) is required on regulated Australian vessels across both jurisdictions but is not

mandatory for recreational and small commercial fishing vessels in NSW navigable waters. The absence of a tracking framework for these vessels leaves authorities with an incomplete picture of boating activity within NSIMP. This is significant given that recreational vessels account for a large proportion of documented sanctuary zone violations. Extending VMS to recreational vessels would face considerable political and financial resistance and is unlikely to be implemented while commercial vessel requirements remain unresolved. However, options should be investigated.

Remote Surveillance Cameras: Cameras deployed on islands and key sites are an established compliance tool with a substantial evidence base. A surveillance camera deployed at Seal Rocks no-take area (Port Stephens–Great Lakes Marine Park) from April 2017 to March 2018 recorded 108 recreational vessels illegally fishing within the sanctuary zone — an average of nine per month — and found illegal fishing was causing a measurable decline in snapper abundance and size (Harasti et al., 2019). This provides direct evidence that remote cameras can quantify illegal fishing at NSW island sanctuary zones and that remoteness alone does not protect no-take areas.

Deployment of surveillance cameras on offshore islands presents practical challenges. Some of the issues that would need to be addressed include: no grid power or communications infrastructure, requiring solar power and satellite data transmission; exposure to weather, salt spray, and biofouling; and limited access to South Solitary Island, currently restricted to twice-yearly helicopter maintenance visits. The most cost-effective deterrence is to include remote cameras and vessel monitoring tools in the immediate island vicinity.

Predictive Compliance Modelling: Davis & Harasti (2020) found sanctuary zone violations were significantly clustered around predictable variables; school and public holidays, species migration events, weekend periods, and favourable weather, providing a sound foundation for strategic patrol planning. Effective predictive modelling requires structured, georeferenced offence data that may not currently exist across the DPIRD network. Where data infrastructure exists or can be developed, predictive modelling is a low-cost, high-leverage option for improving the efficiency of limited enforcement resources but is not a substitute for physical presence.

The Davis & Harasti (2020) and Harasti et al. (2019) studies together provide a locally grounded, complementary evidence base for the compliance recommendations in this review.

Technology in Combination: A layered approach; drones for nearshore and estuarine zones, USVs for offshore sanctuary zones, remote cameras for island and headland vicinity monitoring, and predictive modelling for patrol scheduling, offers the most practical and cost-effective coverage. The cost of this system should be weighed against the ongoing cost of inadequate enforcement and the ecological values at risk.

7.8 Community Reporting and Co-management for Compliance

The absence of NSIMP-level compliance data is a significant transparency gap that undermines evidence-based management. Mandatory park-level compliance reporting should be a standard component of annual management accountability.

Community reporting is an established, low-cost compliance component. Fisheries officers have successfully responded to tip-offs supported by vessel registration numbers, descriptions, and photographs. The active local dive, fishing, research, and citizen science communities within NSIMP represent a significant and motivated observer base. Constraints include inconsistent voluntary reporting, variable report quality, response time limitations for remote offshore violations, and social reluctance to report known individuals in close-knit communities.

Co-management offers a more structured approach. Formal partnerships with local groups and individuals could formalise observational roles, extend coverage, and strengthen the evidence base. Indigenous co-management through IPAs offers legitimate authority that could directly inform compliance priorities and community engagement. Training in reporting protocols, evidence chain of custody, and conflict resolution delivered through co-management capacity building programmes would transform community reporting from an ad hoc process into a structured, accountable compliance framework.

7.9 Co-management

Co-management requires a genuine commitment to sharing governance authority between government agencies, local communities, First Nations, and other stakeholders. Gollan & Barclay (2020) identified governance as the most influential factor affecting MPA social acceptability in NSW, finding that poor top-down, non-participatory management generates greater distrust and undermines marine park legitimacy more than fishing restrictions themselves. They concluded that a failure to address the social dimension of decision-making can undermine a marine park's legitimacy regardless of its ecological merit.

Trust has been strained further where decisions were taken outside the consultative process altogether. Aboriginal communities, in particular, report feeling disempowered by a top-down system that constrains customary practice and offers limited avenues for self-determination (Gollan & Barclay 2020; NSW EPA 2024). The recent introduction of dedicated community-wellbeing monitoring under the Marine Integrated Monitoring Program, including the *Connections to Sea Country* survey, is a constructive step toward closing the engagement gap (NSW EPA 2024). However, this is a statewide approach and delivers limited local values.

Co-management directly addresses this deficit by genuinely engaging First Nations, research groups, fishing clubs, charter operators, dive communities, and individual community members to extend observational capacity, build voluntary compliance, and create shared ownership of outcomes. A strong precedent already exists. NPWS regional advisory committees are statutory bodies with legislated responsibility to advise the Minister on plans of management, meeting regularly, with members formally representing aligned organisations a demonstrably stronger governance model that NSIMP should emulate. Applied to marine parks, committee members should be selected for commitment to conservation objectives rather than to defend sectoral interests.

Effective co-management requires all parties, including fishing groups, to accept that a common problem exists and that consensus is a collective responsibility, not a negotiating position. Turnbull et al. (2021) found the majority of fishers accept the science and are willing to defer to majority decision-making. The vociferous minority opposing sanctuary zone expansion does not represent broader community sentiment.

Formal recognition of First Nations as Traditional Owners of NSIMP sea country would bring legitimate custodial authority and a long-term perspective that government agencies cannot replicate. The proposed Gaagal Wajaarr Sea Country IPA encompasses the Solitary Islands, rivers, estuaries, and headlands through formal voluntary agreements between Gumbaynggirr Traditional Owners and government. A transition to full joint management, moving beyond a voluntary framework into a legally binding, statutory co-governance arrangement is recommended.

Co-management is resource-intensive to establish and sustain. Poorly designed frameworks risk entrenching rather than resolving power imbalances, and perceived inequity in the distribution of benefits has been a persistent source of conflict in NSW marine parks. A co-management framework

for NSIMP must be explicitly adaptive, driven by long-term monitoring of fish populations, habitat condition, water quality, species distribution, and human use patterns, with structured review cycles rather than ad hoc responses. Securing reliable long-term funding early in the process is critical. Building sufficient community trust and political support inevitably extends beyond normal political cycles. Expectations must be carefully managed from the outset and a willingness to experiment, adapt and change course as conditions evolve must be fostered.

Examples of Successful Co-management

Great Barrier Reef Marine Park — Traditional Use of Marine Resources Agreements (TUMRAs) are community-based plans accredited in legislation and the most directly applicable Australian precedent for NSIMP.

Kimberley Marine Parks, Western Australia — Bardi Jawi, Mayala, and Dambeemangarddee marine parks are co-managed with Traditional Owners and the WA Government, fully gazetted in 2017 with co-designed management plans delivered in 2025.

Apo Island Marine Sanctuary, Philippines — widely cited as a successful community-led and managed marine reserve.

The common thread is unambiguous: co-management succeeds when built on genuine power-sharing from the outset, legislative backing, dedicated resourcing, and a shared understanding of the problem. Consultation models dressed as co-management consistently fail.

7.10 Education and Community Engagement

MPAs frequently face opposition driven by misconceptions and perceived loss of freedoms. Education is the primary tool for conflict resolution and the foundation upon which all other MPA management strategies depend. As Kenchington (1990) observed, support for conservation depends on one's personal assessment of its value and that depends on their knowledge and understanding of MPAs. Education programmes must aim to demonstrate the long-term benefits of sanctuary zones, and that protection outweighs the costs.

The aim of an effective MPA conservation education programme is to generate an informed community that asks questions and actively supports conservation outcomes (pers. comm., Stefan Soule, NMSC, February 2026). Reversing entrenched community misinformation requires sustained effort, clear goals, curriculum alignment, and dedicated long-term funding. Education is not cheap — but the long-term conservation cost of an uninformed community far outweighs the investment.

SCU, CCWC, and the NPWS Discovery programme contribute meaningfully to local marine science and conservation education and provide a strong foundation that DPIRD already partners with. However, education programmes must transition from project-based delivery with insecure short-term funding to being embedded in the education system with sustained, dedicated resourcing.

Update Education Resources: NSIMP's Education Tool Kit and Marine Estate Agent Passport Workbooks date from approximately 2010, predating current understanding of climate change impacts, the 30×30 framework, and many recent research findings. A partial update to the NSW Marine Estate Agents Program was completed in 2023, but a comprehensive review and update of NSIMP-specific resources is overdue and should be prioritised.

Reorient School Engagement: DPIRD's "fishing clinics" currently frame recreational fishing as the defining community relationship with the marine park. This is a missed opportunity and counterproductive to marine park and conservation objectives. School engagement should be reoriented toward biodiversity conservation, ecosystem values, and the role of sanctuary zones,

delivered in partnership with the NMSC, SCU's SEA programme, First Nations, and community organisations as part of the co-management process. Activities should be designed to assist primary and secondary teachers to meet NSW Board of Studies and Australian Curriculum outcomes.

Underwater Live-Stream Cameras: Real-time underwater footage from selected NSIMP sanctuary zones fed into classrooms and community platforms is a proven, cost-effective engagement tool supporting inquiry-based learning, species identification, and citizen science. Purpose-built feeds from selected NSIMP sites would extend educational, research, and surveillance value, generating community ownership of iconic species and sites and complement existing aquarium experiences at SCU and the CCWS. James Cook University's Classroom on the Reef provides an applicable model.

Science Communication: SCU, DPIRD, and others produce world-class peer-reviewed marine science on NSIMP, but findings rarely reach the local community. A significant body of directly relevant research sits in academic silos while misinformation spreads unchecked — not because the science is weak, but because it is poorly communicated. Complex findings on sanctuary zone effectiveness, climate change impacts, and biodiversity decline are routinely misrepresented in public debate. Sustained, accessible science communication does not need to convince everyone — it needs to reach the persuadable majority, progressively marginalising opposition driven by ideology rather than evidence. Building this capacity through dedicated science writers, a dedicated local communication strategy, and multimedia engagement, should be a defined deliverable within the NSIMP management plan.

Community Engagement: Innovative nature-based programmes are already being delivered by small operators within the park. Engagement programmes should also be developed to support Volunteer Marine Rangers, providing structured pathways for community involvement in monitoring, citizen science, and engagement. Community engagement must be continuous, not episodic, and structured into the adaptive management cycle rather than triggered by controversy or rezoning proposals.

Evaluation: All education and engagement programmes must be evaluated against measurable targets; community awareness levels, attitude shifts, compliance rates, and participation numbers. The Marine Integrated Monitoring Programme provides a useful statewide baseline, as a start, but lacks the site-specific resolution needed to evaluate engagement effectiveness within NSIMP. Local evaluation mechanisms are required.

7.11 Training and Capacity Building

Effective co-management cannot succeed if partners lack the knowledge, technical skills, or confidence to participate meaningfully in governance and management decisions. It requires sustained investment in training and capacity building across all partner groups.

Agency Staff: Fisheries officers, marine park officers, and DCCEEW staff should receive professional development opportunities in collaborative governance, evidence-based decision-making, conflict resolution, and adaptive management facilitation. These skills are not covered in traditional marine science or regulatory compliance training and must be developed. Effective co-management requires specific interpersonal and governance capabilities in staffing decisions.

Ranger Training: training should focus on delivering accredited Certificate II to Diploma level courses. The existing courses need improving and development (Marine Conservation and Ecosystem Management and Habitat Restoration). This process will provide a pool of trained individuals to be drawn on as required, improving ranger recruitment potential.

Traditional Owner Training: Training for Indigenous Sea Rangers requires the development and delivery of accredited Certificate-level training (see Appendix 10.7). This requires long-term dedicated resourcing, not ad hoc project-based activities. Core training includes Sea Country mapping, Indigenous ecological knowledge documentation, and ecological and socioeconomic monitoring skills that complement and validate traditional knowledge systems. Critically, this process should include train the trainer programmes, and developing the local capacity to deliver training as required through Indigenous Adult Centres of Education or similar local institutions.

Community Stakeholder Groups: Fishing clubs, charter operators, dive associations, and citizen science groups, including SURG, should receive training to formalise observations and standardise reporting systems, ensuring data are usable within the formal research and management framework.

Volunteer Roles: Formalised volunteer pathways need to be developed to attract a diverse range of community representation, such as Honorary Rangers, Volunteer Marine Rangers, Marine Parks Observers, Community, and School Engagement Volunteers, or other appropriate titles. Structured training should be provided for defined roles in habitat monitoring, compliance observation, education support, and habitat restoration. Such training across the NSW MPA Network would foster shared best practice and cross-park experience.

Teacher Training: Professional development workshops to develop and embed marine conservation science (see Appendix 10.6) into existing school curricula, combined with Technical Vocational Education and Training (TVET) course delivery in schools, would open pathways for students toward careers in marine conservation, fisheries, marine park management, and sustainable tourism — extending conservation awareness into the broader community well beyond the classroom.

7.12 Management Response Conclusion

The two SIMPs remain one of Australia's most important connected MPA networks, but the ecological, climatic, and social challenges facing the park are evolving rapidly. Strengthening management requires a fundamental shift from reactive responses toward an updated, integrated, and adaptive conservation framework capable of addressing cumulative pressures. To reverse decline, enhance resilience, and secure a nature-positive future, urgent attention must be given to expanding sanctuary zones in line with 30×30 commitments, improving NSW–Commonwealth coordination and funding, formalising joint management with First Nations, and building the research, education, and community engagement capacity on which evidence-based management depends. These actions would help ensure NSIMP's globally significant mix of tropical, subtropical, and temperate ecosystems is protected and passed on intact to future generations.

8 Conclusion and Recommendations

NSIMP is one of Australia's most ecologically significant and biogeographically unique marine protected areas. Situated at the convergence of tropical and temperate ocean currents, it supports exceptional marine biodiversity — including high-latitude coral communities, genetically distinct kelp populations, and habitat for numerous threatened and migratory species. The Solitary Islands are uncommon offshore features on the Australian east coast, supporting ecological communities and natural processes of national significance. NSIMP also holds deep cultural significance for Gumbaynggirr and Yaegl peoples and underpins a substantial tourism, diving, and nature-based recreation economy.

Together with adjacent terrestrial protected areas, NSIMP forms part of an interconnected conservation network spanning approximately 595,660 hectares, one of the few places in Australia where intact upland forests, coastal rivers, estuaries, high-latitude coral reefs, and offshore marine ecosystems are continuously linked. The outstanding natural, cultural, and scientific values of the two SIMPs warrant consideration for Australia's National Heritage List and rival the nation's most celebrated conservation landscapes. The twin SIMPs also represent a premier marine education and research asset producing world-class science.

Available evidence confirms NSIMP is currently meeting its planned biodiversity conservation objectives under the MEM Act, with long-term ecological studies demonstrating that sanctuary zones support higher fish biomass, abundance, and species richness than fished areas. However, significant legislative, governance, monitoring, and cross-jurisdictional deficiencies are obstructing the park's long-term conservation trajectory. The current management plan is outdated and requires urgent revision to address climate change, coastal development, pest management, boat traffic, water quality, fishing impacts, compliance, harm to marine wildlife, and tourism interactions. Compliance monitoring is inadequate and unreported at the park level and climate change is already reshaping the park's ecology with little management response. Management responsibility sits within an agency whose primary mandate is fisheries extraction, not biodiversity conservation.

Cumulative pressures risk driving ecosystems toward irreversible change. Recognising and avoiding ecological tipping points is essential to safeguarding NSIMP's natural assets, tourism, fisheries, research and education and cultural values.

In the broader context of the Temperate East Marine Region, only 4% is genuinely protected in no-take sanctuaries. Sanctuary zone coverage within NSIMP stands at just 12% — among the lowest in the NSW marine park network and a fraction of Australia's 30x30 commitment. With four years remaining until the 2030 deadline, urgent action is required. A bioregional planning approach applying Comprehensive, Adequate and Representative (CAR) principles across the two SIMPs and their connection to the Central East MP is essential.

The current NSW marine park management review, combined with the forthcoming Commonwealth review of the Temperate East Network, represents the most significant opportunity since 1998 to reset the management foundations of NSIMP. The community that fought to establish the Solitary Islands Marine Reserve in 1991 recognised something exceptional in these waters. More than three decades later, that recognition has been validated by science many times over. What is now required is management commensurate with NSIMP's ecological significance, and a commitment to pass its values intact to future generations.

The following recommendations are grounded in the best available science, consistent with the legislative mandate, and aligned with Australia's international conservation commitments. They are

achievable — not through radical reinvention, but through sustained application of political will and scientific rigour to a framework that already exists.

8.1 Strengthening Marine Protected Areas

- Expand sanctuary zone coverage to 30% consistent with Australia's GBF 30x30 commitment, applying the CAR framework and MARXAN-based spatial planning informed by comprehensive seabed mapping, building on Malcolm et al. (2011).
- Model sanctuary zone configurations at 20%, 25%, and 30% coverage scenarios to inform staged implementation.
- Re-address as a minimum starting point the proposed 2011 zoning plan that expanded sanctuary coverage to 19%, previously rescinded, as the immediate baseline for this review.
- Prioritise expansion to include deep-reef and soft sediment habitats, kelp beds, pelagic environments, and additional offshore island reef habitats not currently under no-take provisions.
- Redesign sanctuary zone boundaries for geometric efficiency, maximising core protected area relative to perimeter, with effective buffer zones particularly at Grey Nurse Shark aggregation sites at North and South Solitary Islands and across all kelp beds.
- Ensure adaptive management plans are able to meet changing circumstances, such as heat waves, major storms, and freshwater pulses, and that sanctuary zone boundaries can be adapted and changed including placement of new sanctuary zones to meet rapidly changing conditions that might affect the efficacy of the sanctuary zone or the species they are designed to protect. Information of changes can be distributed through existing fishing apps and local/social media.
- Strengthen habitat protection zone provisions to act as buffer zones to sanctuary zones and close loopholes permitting destructive fishing practices, including removal of prawn trawling from the general use zone corridor, raise general use zones to the status of current habitat protection zones – currently, general use zones have no conservation value.
- Legislate the permanent prohibition of catch and-release fishing in all sanctuary zones. Cumulative post-release mortality across concurrent users is ecologically incompatible with sanctuary protection.
- Pursue IUCN Green List status to provide international recognition and reduce vulnerability to politically motivated management interference and reversals.

8.2 Governance, Management Structure and Commonwealth Interface

- Relocate primary management responsibility for NSW marine parks from DPIRD Fisheries to DCCEEW, consistent with the national parks model and the park's primary legislative purpose of biodiversity conservation.
- Strengthen MEM Act 2014 conservation primacy provisions, requiring all management decisions to be explicitly tested against the primary objective before approval.
- Reinstate the CAR framework as the primary spatial planning tool, replacing TARA as the dominant management instrument, consistent with the 2012 Independent Scientific Audit recommendation.
- Formalise a joint management agreement between NSW and Parks Australia for coordinated management of NSIMP and CSIMP, encompassing shared monitoring, compliance, planning,

and funding, with a formal connectivity plan addressing larval dispersal, species movement, and habitat linkages across inshore, offshore, State, and Commonwealth waters. This model should be applied across the NSW Marine Parks Network wherever state parks are contiguous with Commonwealth parks.

- Actively engage in the Commonwealth Temperate East Network review — management plans due 30 June 2028 — advocating for expanded offshore protection and improved ecological connectivity for both NSIMP and CSIMP. Move the NSIMP boundary seaward to include additional continental shelf habitats or formally declare a marine protected complex with shared State–Commonwealth governance and funding.
- Investigate the establishment of an Australian Federal Marine Parks Authority, operating in partnership with the states, as the most effective structural model for delivering 30x30 on a marine region and bioregional basis.
- Secure dedicated long-term core funding independent of project-based grants.
- Pursue National Heritage Listing to include both NSIMP and CSIMP as a management unit to strengthen national recognition and support long-term conservation, research, and community stewardship.
- Resolve naming confusion by either consolidating NSIMP and CSIMP under a single 'Solitary Islands Marine Park' designation or renaming the Commonwealth reserve to reflect the Tweed-Moreton Bioregion.

8.3 Advisory Committee and Community Co-management

- Restructure the SIMP Advisory Committee as a genuine co-management body with binding advisory authority, an independent secretariat, and dedicated resourcing, modelled on the statutory framework applied to NPWS regional advisory committees.
- Require a minimum of four meetings per year with mandatory government responses to committee recommendations within a defined timeframe.
- Remove confidentiality restrictions that prevent members from sharing matters raised in meetings, which undermines transparency and broader community engagement.
- Ensure Advisory Committee appointments are made promptly at term expiry to avoid recurrence of the recent two-year lapse.
- Formalise partnerships with fishing clubs, charter operators, dive communities, environmental groups, and citizen science organisations, with a commitment to the conservation goals of the park.
- Recruit and train Volunteer (or Honorary) Field Rangers to assist in a variety of activities: observation monitoring, citizen sciences, habitat restoration, education and community engagement activities and data analysis generated by citizen science activities.

8.4 First Nations Co-management

- Establish formal co-management arrangements with Yaegl and Gumbaynggirr Nations through a Sea Country IPA framework for NSIMP. Legislative reform to the MEM Act 2014 is required to formalise genuine power-sharing, accountability, and dedicated funding.
- Integrate Traditional Ecological Knowledge into marine park planning, monitoring, and adaptive management, including cultural site protection.

- Resource Sea Country management plans and Sea Ranger and guardian programmes consistent with the terrestrial NPWS model.
- Explicitly recognise cultural values and First Nations Sea Country connections in all future management plans, zoning reviews, and impact assessments.
- Deliver accredited Sea Ranger training including train-the-trainer programmes to embed training capacity within communities rather than rely on project-based delivery.

8.5 Compliance and Enforcement

- Require DPIRD to disaggregate fisheries compliance data by individual marine park and publish annual park-level enforcement reports. The absence of NSIMP-specific data is a fundamental transparency failure and weakens management effectiveness.
- Increase compliance resources for aerial and vessel-based sanctuary zone surveillance, with priority focus on Grey Nurse Shark aggregation sites and other critical habitats.
- Deploy layered surveillance technology, drones, Bluebottle USVs, and remote island surveillance cameras to address offshore monitoring gaps.
- Introduce VMS requirements for commercial vessels operating in NSIMP waters, consistent with Commonwealth reserve requirements. Investigate other vessel monitoring systems available for smaller vessels.
- Introduce mandatory gear marking linked to vessel registration for commercial and recreational fishing within NSIMP to reduce ghost gear and strengthen compliance accountability.
- Formalise community reporting through honorary ranger and observer programmes.

8.6 Climate Change Adaptation and Research

- Develop a formal climate change adaptation strategy for NSIMP, incorporating species vulnerability assessments, range-shift modelling, and adaptive management triggers.
- Identify and formally protect climate refugia — areas of thermal stability from upwelling or depth buffering — and prioritise these for sanctuary zone placement.
- Establish a funded NSIMP-specific coral and reef health monitoring programme with standardised protocols enabling adaptive management responses to thermal stress events.
- Implement monitoring of sand temperatures and hatchling sex ratios at known NSIMP turtle nesting beaches and assess whether active intervention is needed to prevent nest inundation, nest relocation or nest shading
- Establish a dedicated NSIMP turtle monitoring programme including tracking of migrating individuals and continue investigation of the 2025–26 NSW coastal turtle mortality event in collaboration with Taronga Zoo, NPWS, and the EPA.
- Monitor the genetically distinct NSIMP *Ecklonia radiata* kelp haplotype as a priority indicator species and investigate natural migration to deeper cooler water, and assisted restoration or translocation options in the event of population decline.

8.7 Catchment Management

- Implement a whole-of-government catchment management approach to reduce sediment, nutrient, and contaminant loads entering the NSIMP, particularly from horticulture, urban development, and road runoff. This has benefits well beyond the NSIMP.
- Establish a coordinated water quality monitoring programme for NSIMP estuaries and coastal waterways with NSW EPA, local councils, and DPIRD, with results publicly reported and linked to management plan targets.
- Strengthen planning controls and development assessment in NSIMP catchments to prevent further degradation of coastal wetlands, saltmarsh, and mangrove habitats through urban and industrial developments.
- Advocate to Council for the permanent reopening and maintenance of Coffs Creek mouth to restore turtle and fish access to seagrass beds.
- Implement estuarine habitat monitoring for seagrass, mangrove, and saltmarsh condition and engage community volunteers in the monitoring and restoration works.

8.8 Pest and Invasive Species Management

- Continue active pest control on Muttonbird Island and offshore islands.
- Address Kikuyu grass on South Solitary Island through targeted vegetation management.
- Implement marine debris removal programmes and improve infrastructure for gear disposal at ports and boat ramps.
- Institute regular monitoring for invasive marine species and range-shifting tropical species using community volunteers as part of the co-management process.

8.9 Proposed Research

- Complete comprehensive high-resolution seabed mapping of the full 71,000-hectare NSIMP state waters, including deeper offshore areas, as a prerequisite for MARXAN-based sanctuary zone planning.
- Conduct NSIMP-specific fish stock assessments for key recreational and commercial species (including Pearl Perch, Black Rockcod, Snapper, and Luderick) comparing abundance inside and outside sanctuary zones to quantify conservation effectiveness and spillover.
- Commission a systematic assessment of sanctuary zone spillover benefits to adjacent fisheries to address the evidence gap fuelling fishing industry opposition to no-take protection. Establish a baseline to compare later with extended sanctuary zones.
- Investigate deep-reef sponge assemblages and soft sediment invertebrate communities, among the least studied and most vulnerable habitats to trawling within NSIMP.
- Establish long-term biological monitoring programmes for key indicator species — Grey Nurse Sharks, anemonefish–anemone assemblages, kelp, corals, shorebirds, and marine turtles — with standardised protocols enabling trend detection and cross-study comparison.
- Maintain and update the existing long term data set on the Wedged-tail Shearwater, and other existing long term data sets, as important baseline data sets for future monitoring and assessment and management decisions.
- Verify larval connectivity data for NSIMP to determine the degree to which reef communities are self-recruiting versus dependent on external larval sources. This is critical to understanding the conservation consequences of local population loss.

- Investigate and develop the potential for habitat restoration programmes within the seagrass beds, kelp beds (see work in South Australia), coral regeneration programmes, and mangrove and wetland restoration programmes, designed as community citizen science actions in partnership with research programmes.
- Commission social and economic research quantifying the contribution of NSIMP's natural values, particularly sanctuary zones, to the regional economy.
- Continue investigation of the 2025–26 coastal turtle mortality event through post-mortem analysis, seagrass and water quality assessment, and contaminant screening, and develop contingency protocols for recurrence involving another key indicator species.
- Identify ecological tipping points under combined stressor scenarios to enable pre-emptive rather than reactive management, applying the precautionary principle.
- Identify how to engage citizen scientists in the long-term monitoring programme as part of the co-management process.

8.10 Tourism and Sustainable Use

- Develop a formal sustainable tourism strategy for NSIMP including carrying capacity assessments for key sites, particularly South Solitary Island during peak Grey Nurse Shark aggregation season.
- Formalise partnerships with tourism operators, dive businesses, and whale watch operators to support citizen science, reef health reporting, and wildlife encounter compliance.

8.11 Education, Training, and Science Communication

- Initiate stronger integration of marine conservation science into NSW primary and secondary school curricula.
- Replace DPIRD fishing clinics with a conservation science school programme developed in partnership with the NMSC, NPWS, First Nations, and conservation stakeholders.
- Develop Volunteer Marine Ranger pathways modelled on Bush Regeneration and Landcare programmes.
- Develop and deliver Marine Conservation and Ecosystem Management and Habitat Restoration Certificate II to Diploma courses as the primary accredited Sea Ranger training pathway, with Coxswain certification as a complementary rather than substitute qualification.
- Fund a dedicated science communicator within the NSIMP management team to translate peer-reviewed research into accessible public narratives, a prerequisite for building community understanding of the science, trust and voluntary compliance on which effective co-management depends.

These recommendations are grounded in the best available science as referenced in the bibliography. However, their implementation is dependent on the political commitment and sustained funding necessary to deliver them.

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10 APPENDIX

10.1 Catch and Release as a Recreational Fisheries Management Tool

Catch and release is a recreational fishing practice where fish are caught and returned alive to the water rather than retained for consumption — it would be prohibited in sanctuary zones. It is widely promoted as conservation-friendly, but the scientific evidence is mixed. Survival rates vary significantly by species, water temperature, handling time, and hook type. Even when fish survive immediate release, they may suffer physiological stress, injury, or delayed mortality. Catch and release is not a neutral conservation activity and should not be treated as an equivalent substitute for sanctuary zone protection.

DPRID previously yielded to the recreational fishing lobby and unilaterally implemented it at Batemans Bay MP without a formal rezoning process. Simultaneously, it pursued permanent rezoning to allow fishing access in sanctuary zones elsewhere. This was proposed as “low impact fishing activities” within sanctuary zones; a serious departure from both the legislative purpose of sanctuary zones and best-practice marine conservation.

A global meta-analysis found median post-release mortality of 11% and a mean of 18%, ranging as high as 95% in some species. DPIRD’s research confirms this variability, with survival broadly dependent on species and handling, only 60 – 90% of released fish survive, meaning between one and four in every ten fish caught and released die post-release under realistic fishing conditions. Fish also release lactic acid as a physiological stress response when caught, with sublethal behavioural consequences that remain poorly understood. The cumulative mortality of fish impacted by catch and release within a single sanctuary zone is ecologically unacceptable and fundamentally incompatible with the ‘no take’ purpose of sanctuary zones.

10.2 Excerpt from Minister for Environment Penny Sharpe’s Announcement

Minister Sharpe, 3rd NSW Marine Parks Forum, 31 March 2026, Maritime Museum:
"I wanted to give you an update on where we are at in New South Wales, and there's two things I really want to talk to you about. The first is the NSW Mainland Marine Park Network Management Plan. This is due to be released by myself and Minister Moriarty very soon. Since coming to government, we have spent time updating the plan that we inherited from the previous government. With the aim of strengthening the core purpose of marine parks, conserving biodiversity, and maintaining healthy ecosystems. And while our marine parks are multi-use, and we want them to be, we want to ensure that the secondary purposes do not conflict with the primary purpose of conservation. We are updating the plan to align marine park management with the NSW Plan for Nature, and international nature positive goals, including the use of comprehensive, adequate representative principles. For the first time, it brings together a consistent approach across NSW five mainland marine parks, while still recognising the unique values of each. It recognises what science is telling us clearly, and something that Aboriginal people have known forever. The ocean is one connected system. Once the plan is released, we will move on to the statutory Rules Review for Marine Parks and aquatic reserves. This really is where the rubber hits the road for managing our marine parks into the future. This is about making sure marine park rules remain fit for purpose, that they're proportionate, and they're informed by evidence, and importantly, the experience that we've had over the last 29 years. These rules will determine how NSW contributes to the 30 by 30 national target. To prepare for this work, we've strengthened governance by filling the advisory committee vacancies, and we want these committees to be active and be central to the review. We've beefed up the Marine Estate Expert Knowledge Panel to have additional conservation expertise. Decisions around zoning and permitted activities will be guided by consultation with advisory committees, scientists, fishers, conservation groups, and other stakeholder groups. And as everyone in this room knows, there are a lot of people with a lot of interest in this. I know there remains concerns, especially from those in this room, about sanctuary zones and the amnesty in place in Batemans Bay MP. This issue will be considered as part of the statutory Rules Review process, and I really am asking for all of you who are gathered here today to make sure that the voices of marine conservation are heard loud and clear on the future of marine parks, particularly the importance of sanctuary or no-go zones. I want you to really engage with this process. This is going to set up the rules for the next 30 years, and I can't overstate how important it is."

10.3 A Question of Mapping

It is important to highlight that there are two SIMPs with very different mapping status. The NSIMP 72,000 hectares out to 17 km offshore and 75 m depth and the smaller CSIMP (15,2000 ha). They have been mapped by different programmes and conflating them is a common source of confusion.

CSIMP: 2022 – 2024 saw the completion of the CSIMP mapping program, providing 100% cover at a resolution of 1 X 1 m using MBES, marine LiDAR, towed video and sediment sampling (Ingleton et al. 2024, *Mapping and characterising seabed habitats of Australia's Solitary Islands Marine Park*).[9]

NSIMP: Mapping is partial and not complete, it is a patchwork built up of different methods over two decades:

- Pre 2002, the earliest mapping covered only shallow sub-tidal habitats (<25–30 m) using aerial photography and single-beam acoustics, which informed the 2002 rezoning plan.
- 2006, a swath/multibeam acoustic program began. By the time of the Malcolm et al.'s work, that program had produced high-resolution bathymetry, backscatter and habitat maps of about 35% of the SIMP seafloor out to its maximum 75 m depth, with the main gaps concentrated in waters deeper than 30 m and on unconsolidated (soft sediment) areas. (These deep soft sediment areas are ecologically important and should be included in the Sanctuary Zoning plans. This data is required to construct the complete MARXAN program for effective Sanctuary Zone planning).
- 2009 – 2011, DECCW used vessel-based swath/interferometric side scan acoustic sonar, to map 45 km² covering almost all the southern part of NSIMP to a resolution of 2X2 m. This system is not light limited; it can map into deeper water and to a high resolution.
- 2018 the statewide marine LiDAR program is aircraft based. It collected data on seabed depth and reflectivity from the nearshore down to about 30–35 m, limited by light penetration. This provided near-continuous coverage of shallow water areas < 30m across the whole NSIMP to a resolution of 5 x 5 m.

[9] This work was done by NSW DCCEEW under contract to the Commonwealth, with Gumbaynggirr and Yaegl Sea Country Rangers involved.

The 2009 and 2018 surveys are complementary, particularly in the shallow water areas of NSIMP. In the southern part of NSIMP, the two methods overlap, with LiDAR mapping the shallow water and the side scan acoustic sonar mapping the deeper water inaccessible to LiDAR. Each method does something the other cannot. The LiDAR gives thin, continuous shallow coverage across the whole NSIMP but stops at ~30 - 35 m; the acoustic swath work gives finer 2 × 2 m detail and reaches below the LiDAR limit, but this only covers the southern area of the SIMP. Therefore, neither one "completes" the mapping process and the deeper >35 m areas outside the surveyed acoustic footprint are exactly the gap that remains and requires further mapping.

The seabed mapping in NSIMP remains incomplete. LiDAR and acoustic data overlap in the shallows, but there is no single source providing a combined percentage cover of mapped areas of reasonably high resolution in NSIMP. Based on the 35% cover of high resolution in 2011, combined with the 2018 LiDAR shallow water mapping there is probably around a third of SIMP with high-resolution habitat mapping, but the deeper >30 – 35 m and soft sediment areas beyond the surveyed acoustic footprint remain a critical gap.

The ongoing Seabed NSW program is progressively filling gaps along the coast of NSW, combining airborne laser (LiDAR) mapping in shallow water with vessel based multibeam surveys further offshore, working toward a continuous high-resolution digital elevation model for the entire NSW coast. It is recommended that high resolution mapping of NSIMP should be completed including the deeper >30m and soft sediment areas. Completing high-resolution coverage of these areas, is a prerequisite for constructing a robust MARXAN zoning model.

10.4 Depth Refuge and the NSIMP Kelp Haplotye

The genetically distinct *Ecklonia radiata* haplotype, unique to northern NSW, found in NSIMP represents a significant conservation priority. As shallow-water temperatures rise, deeper water populations of kelp are increasingly recognised as critical refugia. Species distribution modelling for *E. radiata* in south-eastern Australia predicted three spatially distinct refuge areas where kelp persists in deeper, cooler waters. This identification of these refugia is considered crucial for conservation as waters continue to warm (Davis et al., 2021).

E. radiata has a documented depth range from the shallow subtidal to greater than 40 meters, and in some locations to 70–80 meters (Richmond & Stevens, 2014, Wernberg, T. et al., 2019), with reproductive performance shown to be maintained across its depth range from 1 to 50+ meters. Further, deep kelp beds have been demonstrated to contribute to the replenishment of shallower water counterparts (Giraldo-Ospina et al., 2021). This provides strong scientific justification for prioritising the protection of deeper reef habitats within NSIMP and recognising the habitat continuity between NSIMP and CSIMP as potential thermal refugia for the genetically distinct Solitary Islands kelp haplotype. This supports the recommendation that all kelp beds and adjacent habitat within the NSIMP and CSIMP be incorporated into sanctuary zone redesign and seabed mapping priorities. It is also a further argument supporting the combining of both the NSIMP and CSIMP under one management and funding mechanism.

10.5 Fish Aggregating Devices and Artificial Reefs — Implications for NSIMP

A new offshore artificial reef comprising two units has been deployed in waters adjacent to NSIMP, off Coffs Harbour, with direct management implications for the NSIMP.[10] The Coffs Harbour artificial reef consists of two steel structures, each with a footprint of 15.6 x 15.6 m and a height of 12 m, designed to create high-quality marine habitat. These are in addition to the 34 Fish Aggregating Devices (FADs) deployed annually between Tweed Heads and Tathra.

Artificial reefs and Fish Aggregating Devices are fundamentally different tools. FADs are temporary, seasonally deployed buoys that aggregate existing fish to increase catch efficiency; artificial reefs are permanent structures (steel in the case of NSW) that create new permanent seabed habitat. While both Artificial Reefs

[10] The new artificial reef is one of two new artificial reefs funded by the NSW Government at $1.35 million each through the Recreational Fishing Trust and the MEMS, the other is installed off Ballina.

and FADs are promoted (in NSW) as fishing enhancement tools, they function differently and carry different ecological implications. FADs exploit the natural tendency of pelagic fish to aggregate around objects. Critically, they operate almost exclusively through attraction, aggregating existing fish into the area making them more available to the fishery without increasing biomass or biodiversity. The ecological risk is that FADs may increase fishing efficiency beyond sustainable levels without any enhancement of the underlying resource. In a marine park context, FADs deployed adjacent to NSIMP could aggregate fish from within sanctuary zones into adjacent fished waters, undermining conservation objectives without triggering any formal assessment.

Artificial reefs function differently. They provide hard substrate on an otherwise featureless seabed, increasing secondary production, habitat complexity, local biodiversity, and biomass over time (Pondella et al., 2022; Layman, C.A. and Allgeir, J.E., 2020). This important scientific distinction is well established (Dempster & Taquet, 2004; Cresson et al., 2014). The common practice of using the terms Artificial Reef and FAD interchangeably is therefore misleading, one aggregates existing fish to increase catch efficiency, the other creates new habitat and increases biodiversity and biomass.

Bio-economic modelling raises further concern. Samples & Sproul (1985) showed that FAD fisheries under open access regimes fail to deliver the benefits advertised and may generate unintended negative outcomes for fish stocks. Meanwhile, DPIRD explicitly states its offshore artificial reefs program is designed to boost recreational fishing, not conservation. Yet, neither FADs nor artificial reefs have been assessed against marine parks or the MEMA conservation objectives. To date, monitoring has focused on catch composition rather than economic return or conservation impact. No formal cost-benefit or economic return study specific to the NSW FAD program has been published.[11] This is consistent with a broader global pattern, where the social and economic benefits of FAD programmes have not been suitably monitored or quantified, and national authorities (elsewhere) have often been unwilling, or ceased, to continue funding their deployment as a result (MRAG, undated).

The absence of a published FAD program budget is a transparency issue. Public money drawn from over 400,000 recreational fishing licence holders annually funds a program operating across 34 coastal locations adjacent to marine parks, with questionable efficacy and without a published program-level budget.

Neither the FADs nor the artificial reef have been assessed against NSIMP's MEM Act conservation objectives or formally assessed with their interaction with NSIMP zoning. Species targeted at the artificial reef, including snapper, mulloway, and mackerel, are the same species sanctuary zones are designed to protect and rebuild. Fisheries enhancement infrastructure falls outside the integrated planning framework.

10.6 Marine Conservation Science in Local Coffs Coast Schools

Marine Conservation Science is an exceptionally effective vehicle for delivering STEAM education (Science, Technology, Engineering, Arts and Mathematics), particularly for coastal communities. Each STEAM strand maps naturally onto marine conservation science education activities: water quality testing, ecological studies and species identification deliver science; BRUVs, drones and citizen science apps engage technology; designing moorings, artificial reef structures and erosion control methods (beach profiling) provides engineering challenges; underwater photography, documentary filmmaking, art competitions, and effective delivery of scientific project results to the school or community build arts and communication skills; and population counts, habitat coverage and diversity indices provide authentic mathematical application.

NSIMP is a classroom, making abstract curriculum concepts tangible and personally meaningful, increasing engagement and fostering long-term environmental stewardship. Marine conservation science content must be demonstrated to satisfy existing curriculum requirements rather than adding to already crowded timetables. Developing and providing teacher training workshops are essential to build teacher confidence in

[11] The NSW FAD program is funded through the Recreational Fishing Trust, sourced from recreational fishing licence fees. In 2022–23, $18.4 million was drawn from the Trusts against licence fee revenue of $14.7 million; in 2024–25, $18.3 million was reinvested across programs including FADs, artificial reefs, fish stocking, and education.

the subject delivery and transfer delivery responsibility for the education programme from the marine parks to the school system.

10.7 Recommendations for Indigenous Sea Ranger Training

The current emphasis on Certificate II Maritime Operations (Coxswain) is inadequate, it addresses boat handling only and contains no ecological, habitat management or restoration content. This does not equip participants for the substantive environmental management roles that effective Sea Country co-management demands and represents a fundamental mismatch between training investment and management need.

A more appropriate and coherent pathway would be to develop the Conservation and Ecosystem Management and Habitat Restoration, Certificates II to Diploma, to meet the specific needs of Indigenous Sea Rangers. These qualifications develop practical ecological skills directly applicable to Sea Country management, can be delivered through workplace-based assessment, where field activities such as seagrass surveys, species monitoring and habitat restoration work are formally recognised as evidence for unit completion, leading to the completion of the full accreditation. These courses incorporate maritime safety elements that provide a foundation toward the full Coxswains qualification, creating a more coherent and ecologically grounded training pathway for Indigenous Sea Rangers to operate effectively within a co-management context. The Coxswain qualification becomes a complement to ecological competence rather than a substitute for it, producing Sea Rangers genuinely equipped to contribute to co-management, monitoring and conservation outcomes within NSIMP.

11 Glossary

Term	Definition
30x30 Target	The global goal to effectively conserve at least 30% of land and sea by 2030.
Bioregion	A smaller ecological area within a Marine Region that contains distinct habitats, species and ecological processes. Bioregions help identify and protect representative examples of marine biodiversity. The Solitary Islands Marine Park lies within the Tweed–Moreton Bioregion.
Climate Refugia	Areas that are relatively protected from climate impacts and may help species persist as conditions change.
Comprehensive, Adequate and Representative (CAR)	Principles used to design protected area networks that conserve the full range of habitats, species and ecosystems.
East Australian Current (EAC)	A warm ocean current flowing south along Australia's east coast that strongly influences the Solitary Islands region.
Ecologically Representative	The principle of 'ecologically representative' aims to ensure the MPA system protects the full range of species and ecosystems at a large enough scale to ensure their long-term survival. It should be applied on a bioregional basis.
Highly Protected Area	A marine sanctuary or no-take area where extractive activities are prohibited to protect biodiversity and ecosystem function.
Indigenous Protected Area (IPA)	Land or sea managed by Traditional Owners for conservation and cultural purposes.
Marine Protected Area (MPA)	An area of ocean managed to conserve biodiversity, habitats and ecosystem values.
Marine Region	A very large area of ocean that shares broad environmental characteristics, such as ocean currents, climate and geology. Marine regions are used to understand and manage Australia's marine environment at a national scale. The Solitary Islands Marine Park lies within the Temperate East Marine Region.
MARXAN	A conservation planning tool used to identify networks of protected areas that achieve biodiversity conservation objectives while minimising social and economic costs. MARXAN has been widely used in marine park planning around the world.
Nature Positive	An approach that aims to halt and reverse biodiversity loss, leaving nature in a better state than before. Referenced in NSW's Plan for Nature and in the Australian Federal Nature Strategy.
NEOLI Principles	Design principles for protected area networks that promote conservation outcomes through No-take areas, Ecological representation, Offsets avoided, Large protected areas, and Insurance against uncertainty. These principles help improve the effectiveness and resilience of marine protected area networks.
No-Take Area	An area where the removal of marine plants, animals or other natural resources is prohibited.
Perimeter-to-Area Ratio	A measure of the relationship between the boundary length of a protected area and its size. Areas with lower perimeter-to-area ratios generally experience fewer edge effects and are often easier to manage and enforce than highly fragmented areas.
Precautionary Principle	A principle of environmental management that states a lack of full scientific certainty should not be used as a reason for delaying action where there is a risk of serious or irreversible environmental harm.
Representative Habitat	A habitat type included within a protected area network to ensure all major ecosystems are conserved.
Threat And Risk Assessment (TARA)	A process used to evaluate the likelihood and consequences of threats occurring, helping managers prioritise actions and resources to reduce environmental risks.
Sea Country	The coastal and marine environments with which Aboriginal and Torres Strait Islander peoples have cultural, spiritual and custodial connections.