

The Gulf of Carpentaria

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Overview

The Gulf of Carpentaria is a large (370,000 km²) and shallow (avg. ~60 m) epicontinental sea situated in tropical northern Australia (latitude 10-18° S) and is bounded to the north by Indonesia and Papua New Guinea. The Gulf is one of the most remote and pristine semi-enclosed seas in the world, characterised by few industrial developments, highly regulated fisheries and sparse population (avg. 0.1 person per km²). Sea surface temperatures typically range between 23-34°C. Freshwater inflow from the southern Gulf catchments constitutes around one quarter of Australia's annual freshwater discharge [1], with most rivers only flowing during the Austral summer.

Perhaps the most relevant and positive environmental management influence is the strict management of commercial fisheries and the reduction of illegal international fishers inside the Australian waters. Major threats to the Gulf environment are climate change and the accumulation of vast amounts of marine debris. However, establishing an environmental management plan for the Gulf of Carpentaria is a major challenge due to complex tiers of management across jurisdictions, land owners and interest groups.

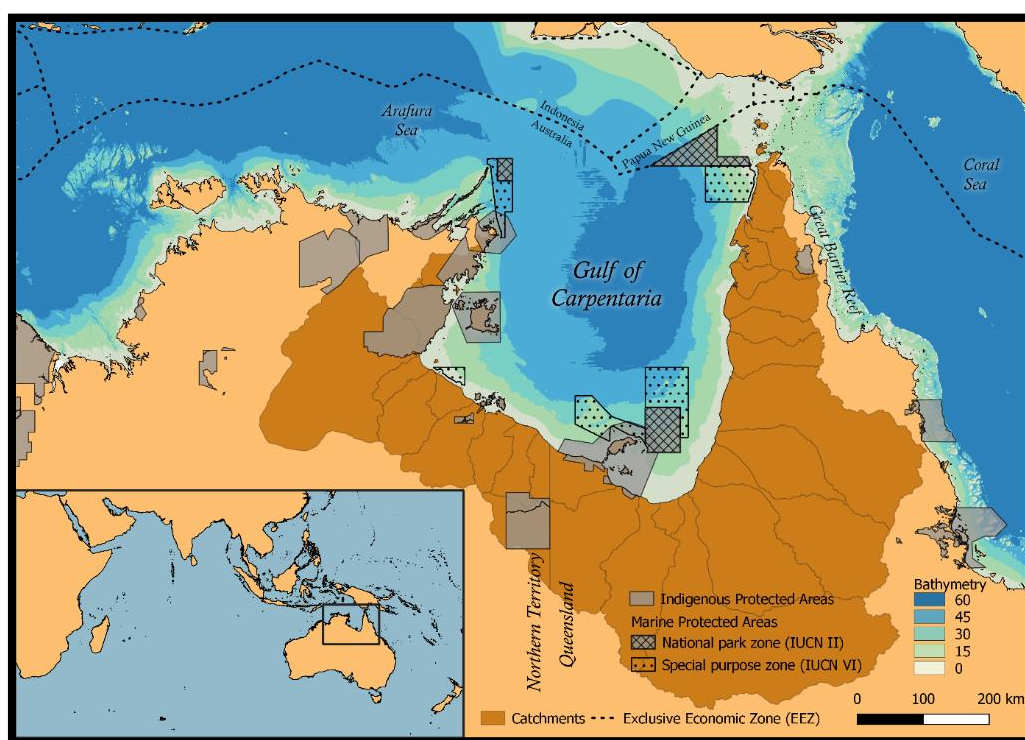


Figure 1: Gulf of Carpentaria catchments, Australian Exclusive Economic Zone (EEZ) and protected areas

Physical and Ecological characteristics

The relatively large and shallow Gulf of Carpentaria heats and cools dramatically, influencing sea surface temperatures on the Great Barrier Reef to the east [2], and contributing to the driving forces of the Leeuwin current to the west [3]. The surrounding land slopes gradually into the Gulf, which continues for much of the extent of the sea floor. Submerged shelves, mounds and drowned coral reefs occur adjacent to the coastline [4] supporting pelagic fish and marine megafauna such as dolphins, dugong, turtles, whales, crocodiles, whale-sharks and rays.

Close to the shore, seagrass supports internationally significant sea turtle and dugong habitat and also provides nursery grounds for commercially harvested prawn species [5]. The intertidal area consists of mangrove stands which provides important habitat for coastal species such as commercially fished barramundi and mud crabs [6]. Supratidal salt pans make up three times the area of the total mangrove environment along the coast, and play a crucial role in the out-welling of nutrients from seasonal freshwater runoff [7]. An average of 500,000 GL of freshwater runoff from nine major rivers enters the Gulf of Carpentaria each year. However, this discharge is highly variable and can range from 250,000 GL to 1000,000 GL [1]. Seasonal weather patterns are typical of wet/dry tropics and consist of two main seasons: 1. the cool and dry Australian winter, with strong (10-30 kt) persistent south easterly winds, and 2. the humid and wet Australian summer, with dominant north westerly winds that bring convective monsoon storms, including tropical cyclones (~4 per year). The tidal range is typically 2-3 m, although there is an amphidromic point (point of zero tide) in the south east region [8]. Harmonic tides can be superseded by meteorological conditions, making daily sea-level fluctuations difficult to predict [9]. Intra-seasonal patterns have been shown to relate to larger scale processes including the Madden-Julian oscillation [10].

Remoteness and Demography

Mining towns constitute the two largest settlements in the Gulf of Carpentaria (Table 1). Generally, the Gulf is defined as 'very remote' based on the accessibility and remoteness index of Australia. A small network of minor, unsealed roads and airstrips are generally only accessible during dry-weather months (May – November). A 10-year infrastructure needs assessment for the Northern Territory (NT) Seafood industry has identified that the lack of infrastructure in Nhulunbuy has inhibited commercially harvested seafood (pers. comm. Katherine Winchester).

Table 1: Significant towns, major employment, populations and percentage Indigenous in the Gulf of Carpentaria [11]. The five largest towns are mapped in Figure 2.

Location	Major Employment	Population	Percentage Indigenous (%)
<i>Weipa (QLD)</i>	Bauxite mining	3,899	19.5
<i>Nhulunbuy (NT)</i>	Bauxite mining	3,240	14.3
<i>Aurukun (QLD)</i>	Government	1,269	90.2
<i>Wellesley Islands (QLD)</i>	Government	1,136	86.8
<i>Alyangula (NT)</i>	Manganese mining	873	8.3
<i>Angurugu (NT)</i>	Government	855	97.3
<i>Yirrkala (NT)</i>	Art/government	809	83.1
<i>Pormpuraaw (QLD)</i>	Government	749	83.8
<i>Numbulwar (NT)</i>	Government	723	94
<i>Umbakumba (NT)</i>	Government	503	95.6
<i>Karumba (QLD)</i>	Fishing/accommodation	531	6.9

In many locations the population majority are Indigenous Australians (Table 1) despite making up only 2.8% of Australia's total population [12]. Literacy rates are low and English is often spoken as a second or third language. Outside major mining towns, employment

opportunities are sparse and poverty is high relative to non-Indigenous owned areas, however state welfare reduces absolute poverty [13] [14].

A large proportion of the land and coastal intertidal regions in the Gulf are owned and managed by Indigenous people who have land or native title rights¹. Many groups refer to themselves as saltwater people [15] in recognition of the close cultural and economic relationships people have with coastal environment.

Mining leases occur on Aboriginal lands throughout the Gulf (Table 1) under Indigenous Land Use Agreements (ILUA) between native title groups, Traditional Aboriginal Owners² and the mining company. ILUA outcomes include compensation, royalty payments and employment and economic opportunities for native title holders [16].

Managing the Gulf of Carpentaria

Inshore Waters

Most of the Gulf of Carpentaria coastline including the intertidal zone (to 0 m astronomical tide) is Aboriginal owned land, recognised under the Aboriginal Land Rights Act (ALRA) 1976 and the Commonwealth Native Title Act 1993. Two categories of native title exist: exclusive possession and non-exclusive possession. Any person entering exclusive possession areas requires a permit, including commercial and recreational fishers. In non-exclusive possession areas native title can co-exist with non-Indigenous shared interest or property rights (e.g. pastoral stations). Indigenous customary fishing (including threatened and protected species catch) is mostly exempt from state and territory fisheries management laws and regulations. Following the Blue Mud Bay case³, the NT Fisheries Act (1988) was amended in 2015 to allow exclusive commercial fishing rights to the intertidal zone of Indigenous owned land by Indigenous-lead groups under an Aboriginal Coastal Fishing Licence (ACFL) [17], although a permit waiver is in place until 28th June 2019. Aboriginal ranger groups undertake hands-on natural resources management such as national park maintenance and environmental monitoring in some areas around the Gulf.

Other activities between 0 and 3 nm are mostly associated with recreational and commercial fisheries and are managed by the adjacent Queensland (QLD) state or Northern Territory (NT) government. Size and catch limits are examples of how recreational catch is regulated. Shallow coastal areas in the western Gulf have been marked for seabed exploration. However, a moratorium was imposed in 2012 until at least March 2021 due to the scarcity of research into ecological consequences of such a development [18]. Mining discharges are regulated by jurisdictions (QLD and NT governments) and their respective waste discharge licence requirements.

Offshore Waters

Offshore management has been almost exclusively a fisheries and maritime border protection matter given the adjacent international borders. Australia declared its sovereign rights to the areas within the Australian continental shelf in 1953, however, international fishing fleets from other countries such as Taiwan, Thailand and the Soviet Union frequented the Gulf of Carpentaria both with and without permission. In 1979, following the third United Nations

¹ *Native Title or Native Title Rights and Interests* means the communal, group or individual rights and interests of Aboriginal peoples or Torres Strait Islanders in relation to land or waters, where: (a) the rights and interests are possessed under the traditional laws acknowledged, and the traditional customs observed, by the Aboriginal peoples or Torres Strait Islanders; and (b) the Aboriginal peoples or Torres Strait Islanders, by those laws and customs, have a connection with the land or waters; and (c) the rights and interests are recognised by the common law of Australia (Commonwealth Native Title Act 1993, Australia).

² *Traditional Aboriginal Owners*, in relation to land, means a local descent group of Aboriginals who: (a) have common spiritual affiliations to a site on the land, being affiliations that place the group under a primary spiritual responsibility for that site and for the land; and (b) are entitled by Aboriginal tradition to forage as of right over that land (Aboriginal Land Rights (NT) Act 1976, Australia).

³ "In 2008, the High Court of Australia declared that a group of traditional owners in the Blue Mud Bay region of north east Arnhem Land in the NT have exclusive access rights to intertidal waters (to the water and land between the high and low tide – approximately 1 nautical mile) overlying inalienable Aboriginal freehold land granted under Commonwealth legislation, the Aboriginal Land Rights (Northern Territory) (ALR) Act (1976)" excerpt from Jentoft et al, 2019 [16].

Conference of the Law of the Sea (UNCLOS, 1973) the Commonwealth of Australia established a 3-200 nm fishing zone, in which all fisheries activities must be licenced under Australian law. The Gulf of Carpentaria's proximity to international coastlines prompted bilateral international treaties and cooperative agreements between Australia, Indonesia and Papua New Guinea. Currently, the Australian Exclusive Economic Zone (EEZ) delineates the international boundary to the north of the Gulf of Carpentaria (Figure 1 and Figure 2).

Australian international border protection has been enforced since the 1980s when the Commonwealth of Australia began apprehending illegal fishing vessels. These vessels were burned due to biosecurity concerns and high caretaking costs. Illegal fishing vessel apprehension peaked in the early-mid 2000s when illegal Indonesian fisher numbers grew [19] (Figure 2), triggering a response from Australia's border security to increase the amount of funding available to manage Illegal, Unreported and Unregulated (IUU) fishing in northern Australia. The occurrence of IUU fishing has remained low since 2006 (Table 2).

Table 2: Illegal fishing vessel apprehensions in the Gulf of Carpentaria, (supplied by the AFMA)

Year	Illegal vessel Apprehensions
2000	11
2001	14
2002	27
2003	57
2004	60
2005	85
2006	120
2007	14
2008	2
2009	3
2010	3
2011	3
2012	1
2013	0
2014	0
2015	0
2016	1
2017	0
2018	0

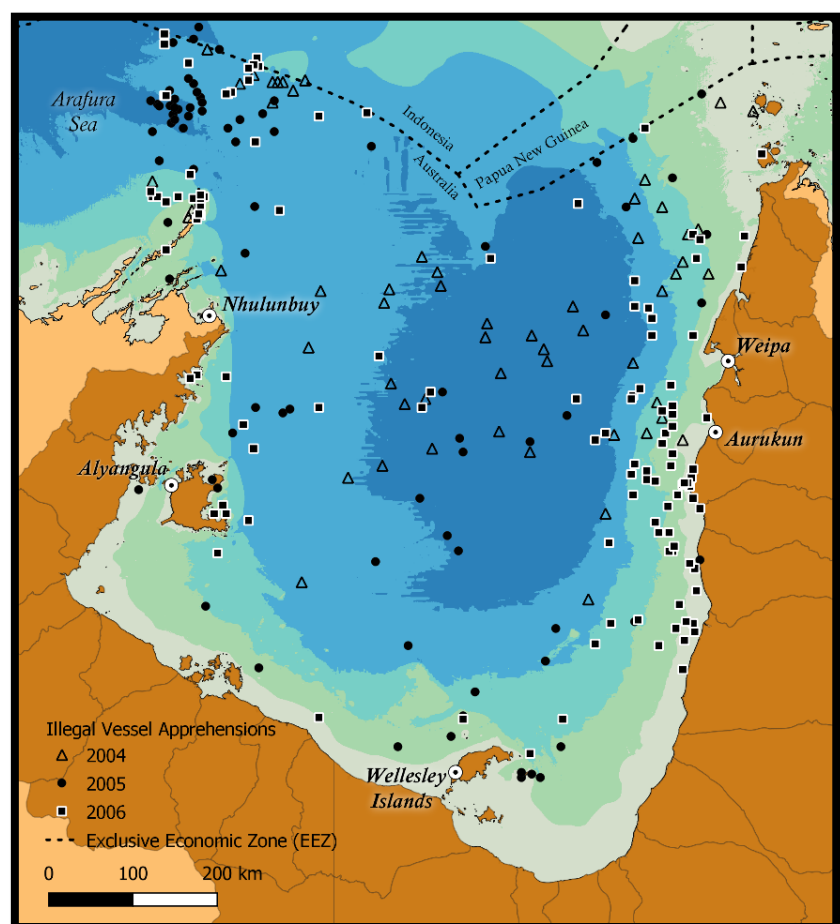


Figure 2: Illegal international fishing vessel apprehensions in for 2004, 2005, 2006 (Table 1) and the five largest towns (Table2) (Apprehension data supplied by AFMA)

Fisheries management

Australian fisheries are among the most highly regulated and progressive fisheries in the world. In the Gulf of Carpentaria an offshore constitutional settlement exists between the Commonwealth, NT and QLD governments. In this agreement, one agency manages each fishery on behalf of others. Generally, the QLD and NT governments manage commercial crustacean, demersal and pelagic fisheries whilst the Northern Prawn Fishery (NPF) is co-managed by the Commonwealth (Australian Fisheries Management Authority (AFMA)) and an industry association (NPF Industry Pty Ltd). With the exception of the NPF, catch, effort and economic value statistics are reported for the separate jurisdictions, therefore data for the Gulf of Carpentaria as a whole are difficult to attain. The NPF extends from Western Australia (WA) to the Torres Strait Islands and includes the Gulf of Carpentaria, which is one of the most densely fished areas for banana and tiger prawns in the fishery. The NPF is the most valuable domestic commercial fishery in Australia, with a net economic return of AUD \$31.4 million in 2015-16 [20]. The Gulf of Carpentaria contributed an average of 65% of banana prawn catch and 94% of tiger prawn catch to the total NPF catch between 1994 and 2017 [21].

Fisheries licencing requirements have improved significantly along with our improved understanding of, and ability to model, fish population ecology. Strict laws apply for seasonal and regional closures to protect the fisheries and ensure a high-quality product and profitable market. Fishing gear is routinely inspected and limitations on net size, material and weave are imposed. This means that it is possible to identify whether the origins of derelict fishing nets are from either Australia or international fisheries. As catch per unit effort has increased due to improved digital technology, fishing equipment and techniques, and for economic reasons, the number of licences available has been reduced. Thus, fisheries stock abundance can never be calculated based on commercial catch estimates alone [22]. Every commercial fishery in the Gulf of Carpentaria is considered 'sustainable' according to NT, QLD and Commonwealth fisheries regulatory bodies.

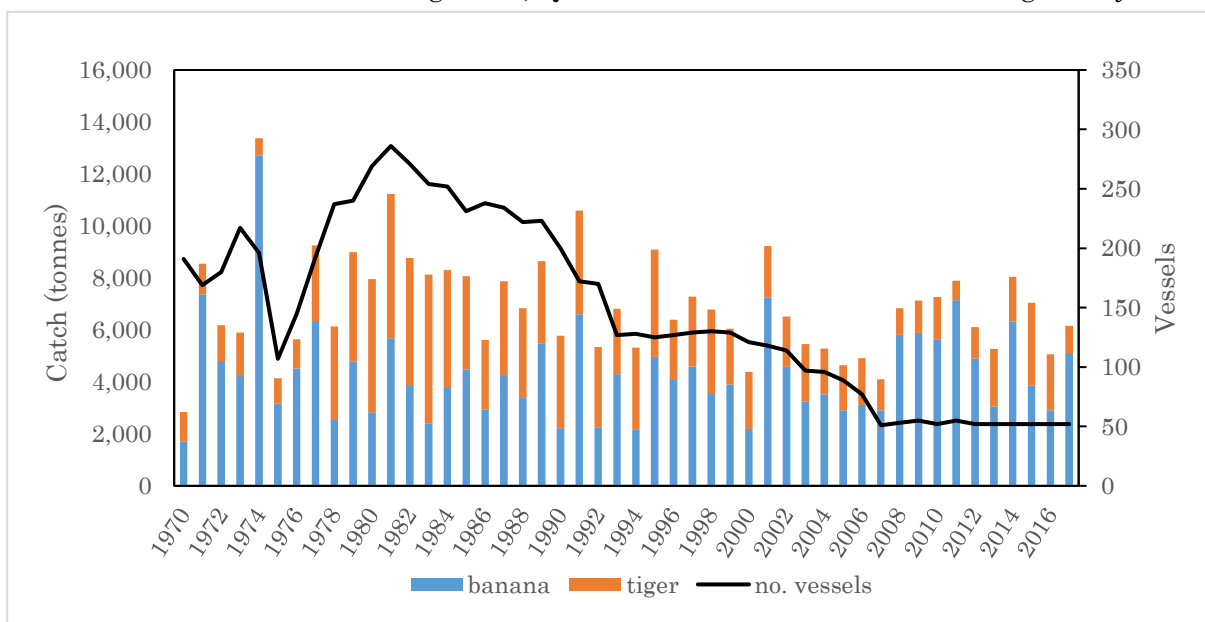


Figure 3: Prawn catch and number of licenced commercial prawn fishing vessels in north Australian waters

Neighbouring Fisheries

The Gulf of Carpentaria is technically recognised under the Arafura and Timor Seas region. The four countries (Indonesia, PNG, Timor-Leste and Australia) neighbouring the Seas have collaborated to implement the Arafura and Timor Seas Ecosystem Action Programme (ATSEA). ATSEA aims to ensure cooperative and integrated, sustainable ecosystem-based management through the adoption of a regional Strategic Action Programme (SAP) and National Action Plans [23]. Funded by the Global Environmental Facility, the ATSEA project identified environmental concerns in the region in a transboundary diagnostics analysis [24], a SAP and established a coordinating governance mechanism for addressing transboundary threats. ATSEA 2 Program is the second phase of ATSEA and is commencing implementation of the SAP in 2019.

Activities associated with ATSEA with relevance to the Gulf of Carpentaria relate to the management and impact of fisheries occurring in Indonesia and PNG. The transboundary diagnostics analysis [24] indicated marine environmental degradation and fisheries resource depletion in neighbouring countries occurs due to overfishing. This is demonstrated by comparing catch in tonnage (Table 3). The northern Australia commercial fisheries catch is only 5.8% (13,340 t) of the total catch (228,165 t) in the neighbouring province of Papua (Table 3). From an economic point of view the value of the Australian catch is around 410% the Papua catch value, and 1600% the Maluku catch value. Environmental degradation in neighbouring countries due to fisheries is a very complex socio-economic and political issue. These figures clearly highlight the result of Australia's effective and sustainably managed fisheries resource.

Table 3: Number of fishers, total reported catch and reported value of catch across the Arafura and Timor Seas Including the Gulf of Carpentaria in 2009 (adapted with permission from ATSEA, 2011 [25])

Country	Region	Fishers	Catch (t)	Value (million AUD)	AUD per t
Indonesia	Maluku	88,778	341,966	175.5	513.21
	Papua	57,631	228,165	460.2	2,016.96
Australia	Arafura and Timor Seas (including Gulf of Carpentaria)	625+	13,340	110.3	8,268.37

Environmental management of Fisheries

Arguably the most significant environmental management strategy adopted by the Commonwealth of Australia has been to enforce border protection at the northern EEZ from IUU fishing. The strict controls placed on Australian fishers provides a framework for maintaining ecological biodiversity and fisheries sustainability. However, other challenges to fisheries management in the Gulf of Carpentaria still exist.

Management goals are difficult to determine without adequately understanding historical stocks and harvests. From a fisheries perspective, the Gulf of Carpentaria is likely in recovery-mode given

the many decades of unregulated and likely unsustainable fishing prior to the mid-1980s. For example, Spanish mackerel catch by the Taiwanese in the Northern Territory between 1974 - 1986 has been estimated at up to 1100 t p.a., while since under Australian regulation catch has rarely exceeded 320 t p.a. [26]. Although it is thought that most early industrial fisheries targeted mackerel and shark, targeted species and catch by early commercial fishers is unknown.

Ecological connectivity and physical processes across the Gulf as a singular system are poorly understood due to few long term and broad scale scientific studies and the disjointed cross-jurisdictional management of fisheries. Understanding marine animal movement, genetic delineations, population connectivity and responses to physical environmental indicators are crucial for fisheries and successful environmental management. This is particularly relevant in view of the development plans to secure water security in the Gulf by damming natural waterways [27], and potentially removing valuable environmental triggers for spawning and survivorship.

Fisheries bycatch

Australian fisheries managers have implemented various management strategies to mitigate impacts on the marine environment. Turtle Exclusion Devices (TEDs) and Bycatch Reduction Devices (BRDs) became mandatory for all prawn trawlers in the early 2000s and reduced megafauna bycatch significantly. More recently the NPF has developed and implemented new BRDs (Kon's covered fisheyes, FishEX70 and Toms Fisheye) to reduce demersal bycatch. These devices reduce bycatch by up to 44 % (unpublished). In addition, the NPF allows a range of bycatch species in specific yields to be sold in addition to prawn catch. AFMA provides observer coverage across 2.5% of effort in the NPF to record non-target species catch. In addition, a 'crew member observer' program run by NPF Industry Pty Ltd with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) provides additional coverage (average 15%) to monitor and record interactions with Threatened, Endangered and Protected Species (TEPS). TEPS are published in the NPF annual data summary. An ecological risk assessment is undertaken every 5 years using both TEPS and bycatch data. Fisheries-reported bycatch across NT and QLD managed fisheries is likely to be underreported due to reservations by individuals for being reprimanded.

Environmental Management

Protected areas

Indigenous Protected Areas (IPA) are areas of 'land and sea country owned or managed by Indigenous groups' and are part of Australia's national reserve system [28]. Six Indigenous Protected Areas exist in the Gulf of Carpentaria, with a further two in the Torres Strait Islands (Figure 1).

Several Commonwealth marine reserves were established in 2012 from 3 nm (Figure 1) which consist of International Union for Conservation of Nature (IUCN) categories. In the Gulf, two main categories exist: 1. IUCN VI where authorized industries (e.g. trawl and non-trawl fisheries) are allowed to operate, and 2. IUCN II where no commercial fishing is allowed, but other activities such as authorized underwater construction and commercial shipping transits are allowed [29].

Environmental, societal and policy problems

Few funding opportunities and sometimes competing interests makes collaborative work between both regional and national research institutions a challenge. Environmental studies that have been undertaken are typically short-lived and underfunded, with the exception of research on some commercially fished species. The Gulf of Carpentaria is generally poorly understood in terms of ecological connectivity, which is a problem when it comes to managing a single system as separate jurisdictional entities, particularly from a fisheries perspective and in the face of major threats such as climate change and marine debris pollution.

Climate change and marine debris are the two most important issues in the Gulf of Carpentaria. Paradoxically, the population in the Gulf of Carpentaria contribute very little to either. The large and shallow characteristics of the Gulf make it susceptible to extreme heating from climate change. An estimated 10,000 ha of mangrove dieback was recorded in 2016 when a climatic event of high temperatures and low rainfall was recorded [2, 30]. This extreme weather event caused significant coral bleaching on coral reefs worldwide. The ecological consequences for both commercial and non-commercial species are largely unknown. Similarly, a combination of the shape, narrow entrance and seasonal wind driven surface currents makes the enclosed sea susceptible to the accumulation of marine debris.

Marine Debris

Synthetic marine debris such as household, industrial and fishing waste from surrounding countries and fishing vessels began accumulating on beaches in the Northern Territory around the mid-1980's [31]. Derelict and illegally discarded fishing gear, also known as ghost nets, cause immense destruction to marine life in the Gulf of Carpentaria. Recently the numbers of ghost nets found in the Gulf has reduced significantly due to a political clampdown on illegal fishers in Indonesia [32]. However, tonnes of domestic and industrial marine plastics wash up on remote beaches in the Gulf. Ranger groups who undertake annual clean-ups report that a significant proportion of the marine debris that has labelling is written in Indonesian.

There is currently no overarching body or organisation addressing the accumulating marine debris in the Gulf of Carpentaria. The number of studies addressing the potential damage or loss of marine wildlife due to the debris is small. A non-profit organisation, GhostNets Australia, provided a framework for funding ranger groups to clean-up and catalogue ghost-nets around the Gulf of Carpentaria coastline from 2004 until 2013.

Since 2013 some ranger groups have been independently collecting, sorting and categorising tonnes of marine debris. In late 2018 Austral Fisheries funded Sea Shephard – a non-profit 'direct-action' conservation organisation – to partner up with Dhimurru Aboriginal Corporation in a marine rubbish clean-up of a stretch of beach within the Dhimurru Indigenous Protected Area (IPA) in the western Gulf of Carpentaria. This collaboration highlights the potential for organisations with opposing core philosophies to work together toward improving the environment. This also reflects the power of a small community in tackling an immense environmental problem that no authority has taken responsibility for.

Conclusion

Environmental management in the Gulf of Carpentaria is complex due to cross jurisdictional governance, international boundaries, complexities in access and ownership to land and sea areas and legislative arrangements, several diverse interest groups and significant scientific knowledge gaps. This scenario offers a multifaceted and challenging management position for a very small population in a large and extremely remote location.

Arguably the most significant and positive environmental management aspect of the Gulf of Carpentaria has been the management and regulation of the fishing industry. Prior to the mid-1980s fishing in the Gulf of Carpentaria was unregulated and likely fished unsustainably by fishers from a broad range of countries, including Australia. The Australian Gulf commercial fisheries (e.g. NPF, Mackerel fisheries) are now fished to a very small proportion of historical catch estimates.

An opportunity exists in establishing a unified environmental management strategy for the Gulf of Carpentaria to preserve its current pristine condition. Such a plan would see standardised reporting system for Gulf fisheries regions between NT and QLD so that data can be compiled as a singular system. An established strategy would also provide a chance for both internal and external threats to be mitigated, and long-term scientific research objectives identified.

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