BIO-PHYSICAL & SOCIO-ECONOMIC OUTLINE

South Fly, Western Province Papua New Guinea

This report is prepared by David K. Mitchell, George Aigoma & Noel Wangunu of Eco Custodian Advocates for The Arafura and Timor Seas Ecosystem Action Phase 2 (ATSEA-2) Project.

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Cover Image: Small sailing canoe with the PNG coastline in background. Photo dkmitchell

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TABLE OF CONTENT

TABLES

FIGURES

SUMMARY

This document is to outline what is known of the biophysical and socio-economic context of the South Fly region of Western Province, Papua New Guinea.

The South Fly is the Papua New Guinean eastern sector of the Trans-Fly region of the southern body of island New Guinea. Though relatively flat this area of poor soils which supports a forest-savanna-grassland landscape is truncated by seasonal swamp and rivers that flow into the Torres Strait. The coastal fringe is of mangrove interspersed with other vegetation which slopes into coastal mud flats that are also accreted by Fly River sediments deposited through longshore drift to the west. A series of reefs are found in the eastern sector. The island township of Daru which lies offshore is the urban centre of the South Fly and the Western Province whilst several coastal villages and fishing camps are scattered along the foreshore or hinterlands.

The Papua New Guinea EEZ extends from the land border with Indonesia with a dogleg orientated south-west into the adjoining EEZs of Indonesia and Australia. The border between PNG and Australia in the Torres Strait is more complex with a series of demarcations, that through bilateral agreement determine what activities may occur in this area. This is due in part to the customary trade links between what are now the South Fly communities and island communities in the Australian Torres Strait, and the border being close to the PNG mainland.

Within this challenging environment and the confines of national sovereignty the people who have a deep history here live in a subsistence/hunter/gather/fisher/gleaner society with cash opportunities derived mostly from the sale of marine resources.

These societies are in a state of dynamic socio-economic change. Christian influence, and the forces of colonisation and pacification followed by development having taken place over the last 150 years. The land and nearshore sea resources are still however held under customary tenure by the clan/tribe/community, who also manage these environmental assets for their livelihood and wellbeing. Government services in this region however have not been maintained to the required standard as the population has grown. Whilst the level of development and cash income is low in this part of Papua New Guinea due in part to its remoteness and lack of market driven commerce.

The finding outlined here are to be considered in conjunction with the other documents of the Stakeholder Capacity Assessment and the Governance and Institutional Assessment as preliminary investigations within the scope of the ATSEA-2 project in Papua New Guinea.

1. BACKGROUND ATSEA-2

The ATSEA-2 project is designed to enhance regional collaboration and coordination in the Arafura and Timor Seas (ATS) region through supporting the implementation of the endorsed strategic action programs (SAP) with a 10-year vision with the long-term objective "to promote sustainable development of the ATS region to improve the quality of life of its inhabitants through restoration, conservation and sustainable management of marine-coastal ecosystems".

The Outcome within ATSEA 2018-2022 [2019-2024] that relates to Papua New Guinea is:

Outcome 3. Sustainable management of natural resources, biodiversity conservation, strengthened climate & disaster resilience: By 2022, Papua New Guinea demonstrates improved performance in managing environmental resources and risks emanating from climate change and disasters.

This working document outlines the known bio-physical and socio-economic characteristics of the PNG EEZ that lies within the Arafura Sea, focussing on the South Fly along the south-westernmost PNG coastline and nearshore waters.

It also investigates available information and the status of the marine species of interest within the ecosystems of the South Fly. This is to inform future actions in improving the ecosystem health through the implementation of an ecosystem approach to fisheries management (EAFM), that includes these species with the fisheries of the South Fly. These actions will offer alternative, climate adaptive, livelihood opportunities and strengthening the resilience of local coastal communities.

Also, within the regional plan PNG will contribute to the enhanced protection of endangered marine turtles endorsed through Ministerial Declaration and a local plan for customarily valuable Dugong.

2. BIO-PHYSICAL

THE ARUFURA AND TIMOR SEAS

The Arufura and Timor Seas initiative makes up the area rimmed by Timor Leste, the eastern archipelago of Indonesia, the southern coastline of island New Guinea as far to the Torres Strait Treaty Zone and the waters north of Australia (see Figure 1).

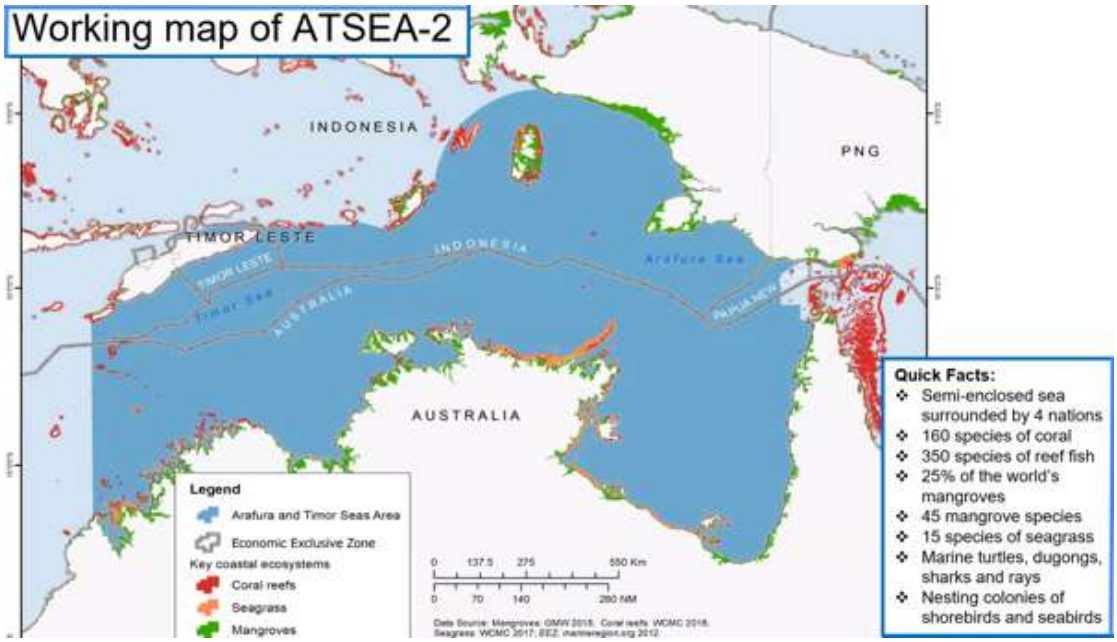


Figure 1. Map of the ATSEA area of interest

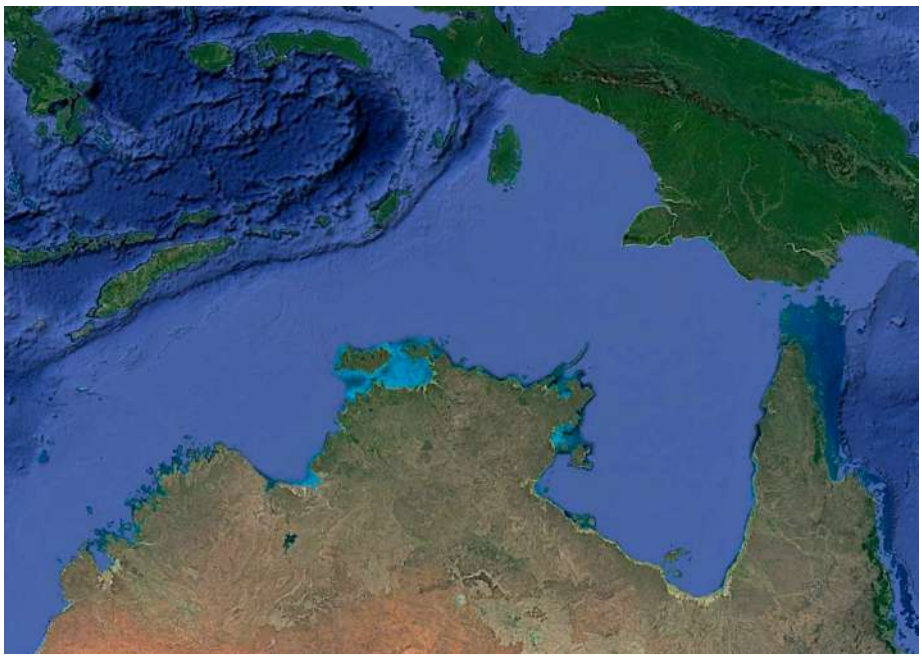


Figure 2. Satellite image with main seabed floor features, Google Earth 2021

Though the seabed floor is complex in other parts of the region within the PNG EEZ it is less so with shallow waters within the Torres Strait between PNG and Australia (see Figures 2 & 3).

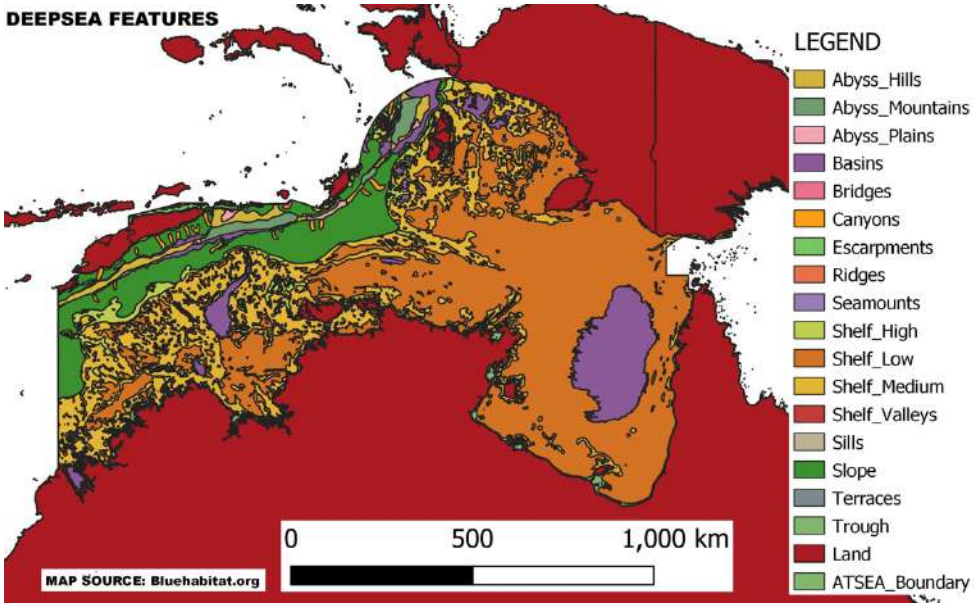


Figure 3. Deepsea features within ATSEA, adapted from Mariembi & Bun (2021) with permission

PNG EEZ WITHIN THE ARAFURA SEA

The boundary of what is now Papua New Guinea with Indonesia and Australia is now defined. It is part of the recent 2019 delineation of the maritime boundary of the PNG EEZ, which having been established now defines the area of our national sovereignty (see Figure 4).

Figure 4. The defined PNG Boundary

The management of the sovereignty of the boundary, and activities within the EEZ of the Independent State of Papua New Guinea are determined by national laws /regulation /ordinances, policy and management plans which are implemented by various agencies. Within the EEZ as per UNCLOS there are further defined zones

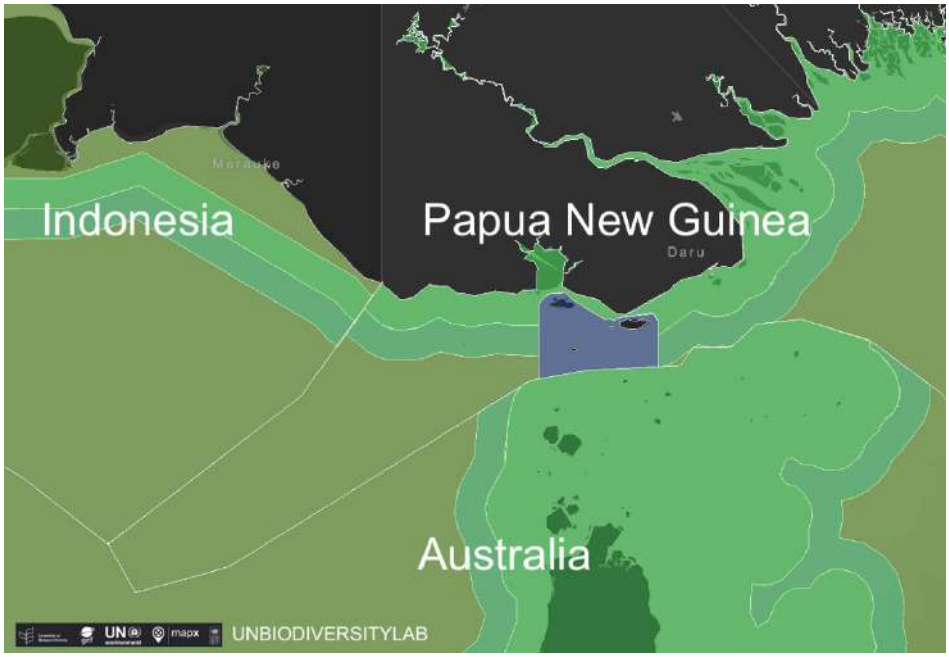


Figure 5. Zones within the EEZ

Within the defined EEZ are the Internal waters, the 12nm (nautical mile) Territorial Sea, and the 24nm Contiguous Zone. The purple area in Figure 5. is the defined Torres Strait Treaty Zone which lies outside of the ATSEA area of interest.

The international borders are the legacy of prior colonial boundaries that were drawn up by the Dutch East Indies now Indonesia and Colony of Queensland, now a state of the Commonwealth of Australia, that have carried over to the current defined boundary

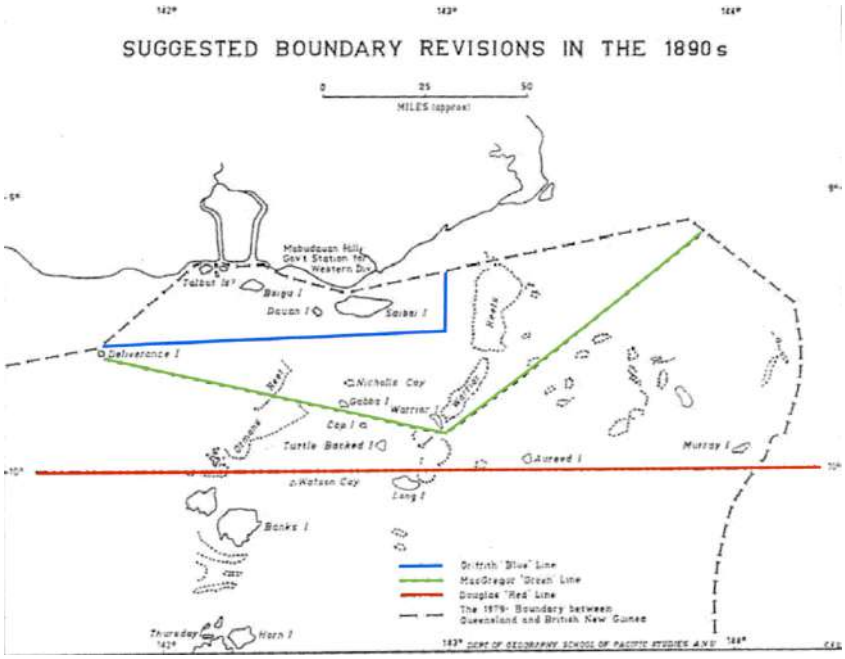


Figure 6. British New Guinea (PNG) - Australian border discussions 1890's

Though there were early discussions on the Torres Strait border by Administrators of British New Guinea MacGregor, 'green' line and Douglas 'red' line the border remains through to the present. These discussions were likely due to the Torres Strait being a grey zone within which intertrade, intermarriage and other relationships existed rather than a clearly defined line (see Figure 6). The only concession now being the Torres Strait Protected Zone (see Figure 7). It is very likely that the boundary was defined so close to the New Guinea coastline so that the Queensland Colony could control the fisheries within the Torres Strait at that time.

In this context the British New Guinea *Pearl Shell and Bêche-de-mer Fishing Ordinance* 3 of 1891 was essentially to licence vessels and employed divers in its waters. Later however there was pressure by the Queensland Government to amend this Ordinance so that Fishing licences could only be issued to white men as of the Queensland Statute of 1898 however the BNG Administrator Robinson (1904) did not agree as he saw that it would exclude not only many colure natives of the South Seas of full or mixed blood, who may be Natural born British subjects or natives of the Possession who were naturally adapted to engaging in the industry. This included natives of Saibai who possessed a two-masted lugger in the Western Division (Robinson 1904). This was an early example of trying to apply British common law in Australia to the situation of British New Guinea.

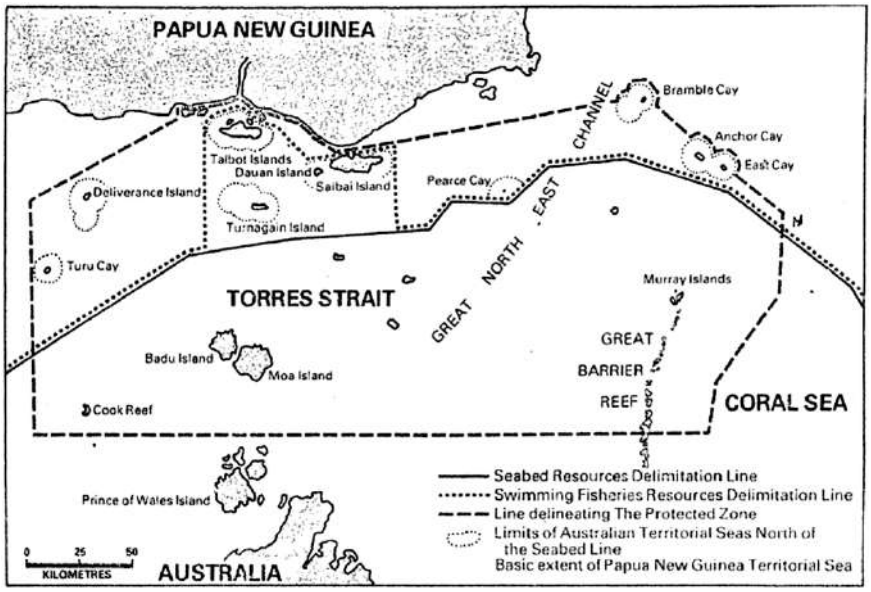


Figure 7. Various zones across the Torres Strait Treaty Report 1979

TOPOGRAPHY

Figure 8. Topography of Western Province

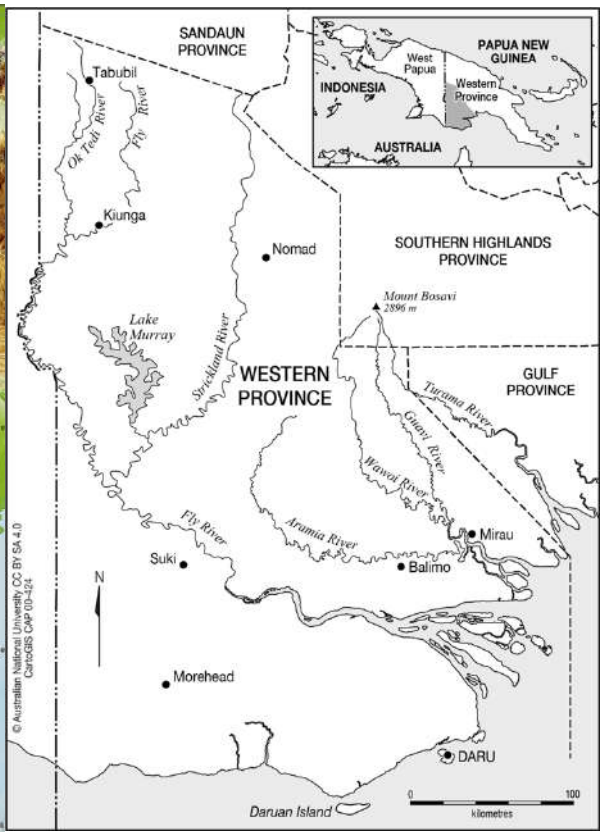


Figure 9. Major rivers within this topography

The topography of most of Western Province is low elevation plains which is dissected by the Fly-Strickland Rivers and associated drainage basins. These rise in the ranges of the central cordillera of New Guinea (see Figures 8, 10 & 11).

The coast of the South Fly is also truncated by minor rivers that become seasonally inundated and which are influenced by tidal salt water upstream, some for kilometres due to the slight gradient of river flow (see Figures 9, 10 & 11).

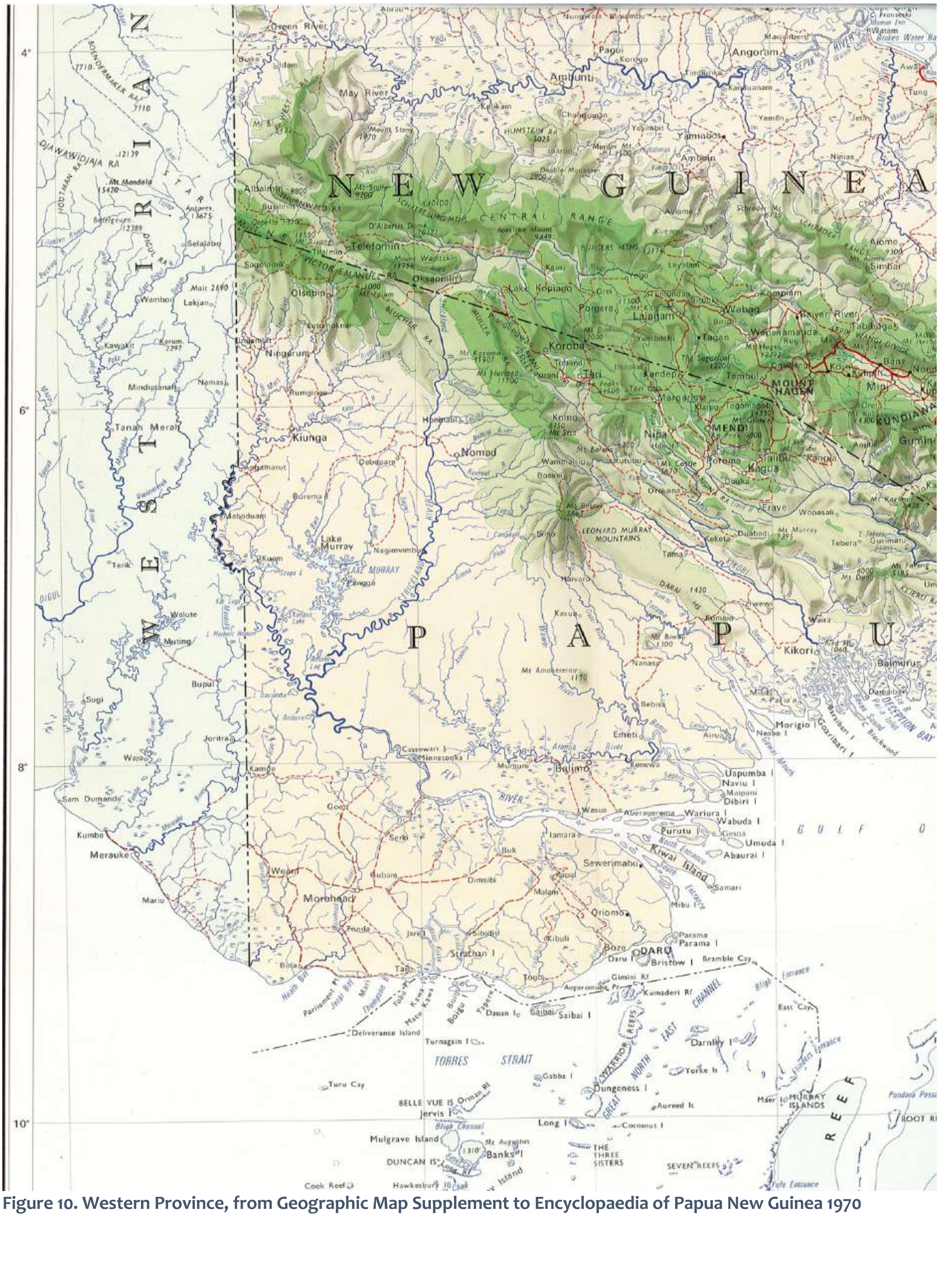


Figure 10. Western Province, from Geographic Map Supplement to Encyclopaedia of Papua New Guinea 1970

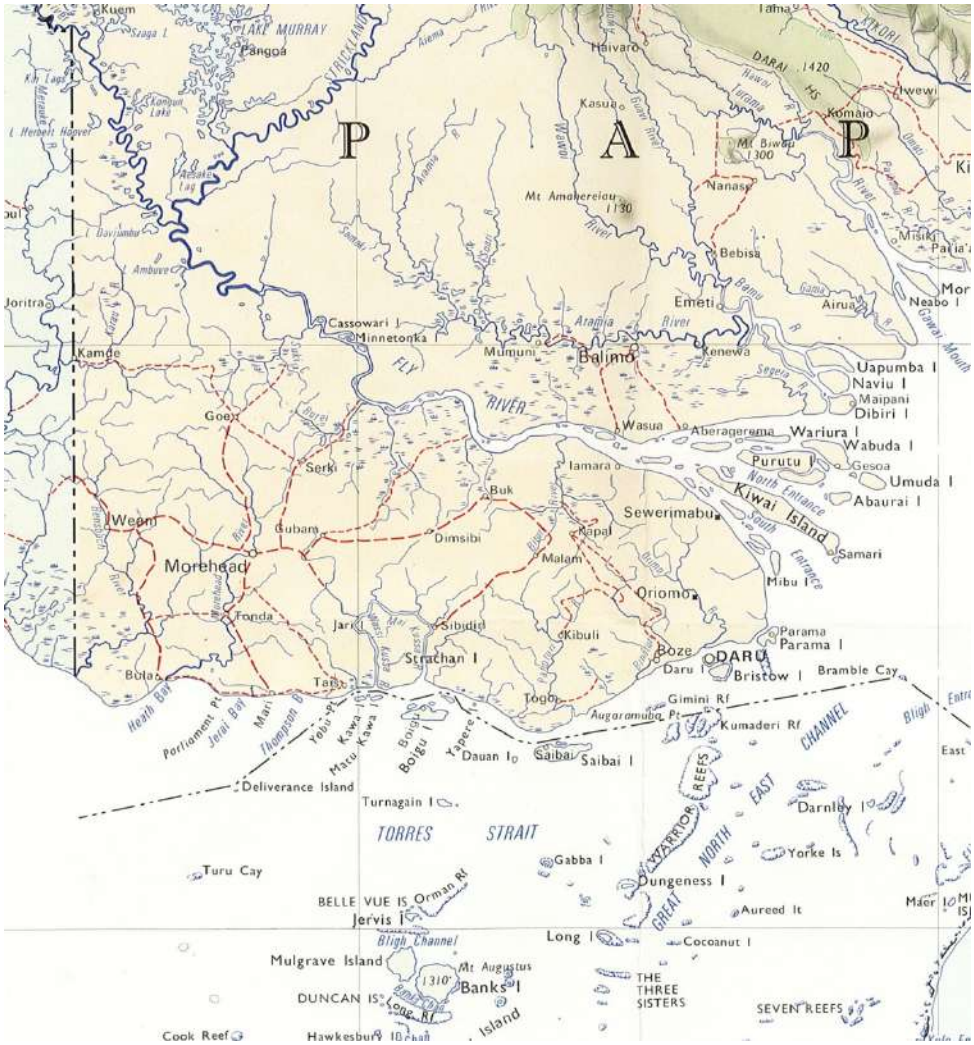


Figure 11. Enlargement of the South Fly, from Geographic Map Supplement to Encyclopaedia of Papua New Guinea 1970

VEGETATION

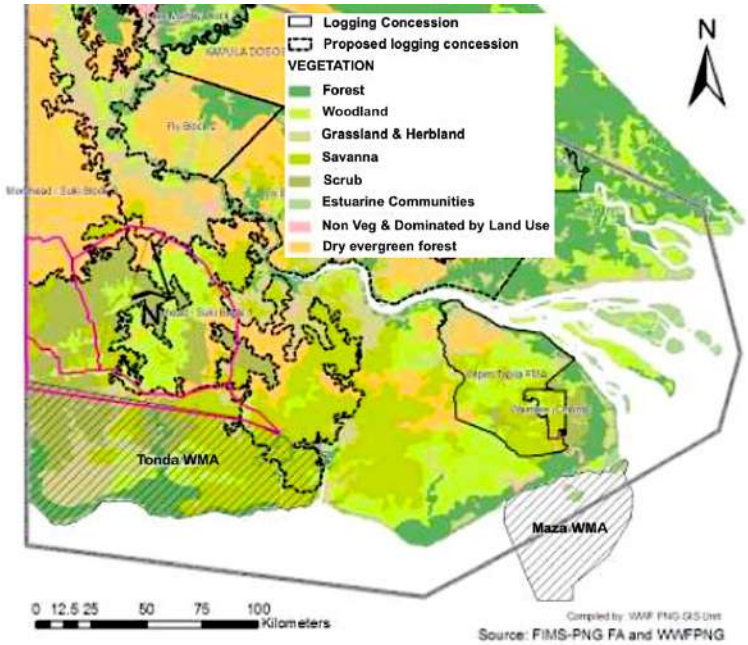


Figure 12. Vegetation types of the South Fly

The dominant vegetation along the coastline is Forest interspersed with Woodland and Savanna. The western sector from Strachan Island to the PNG-Indonesian border lies within the Tonda Wildlife Management Area (see Figures 12 & 13) whilst in the east the Maza WMA a marine protected area fringes the coastline (see Figure 12). During the dry season much of this is burnt leading to much of the vegetation influenced by a fire regime.

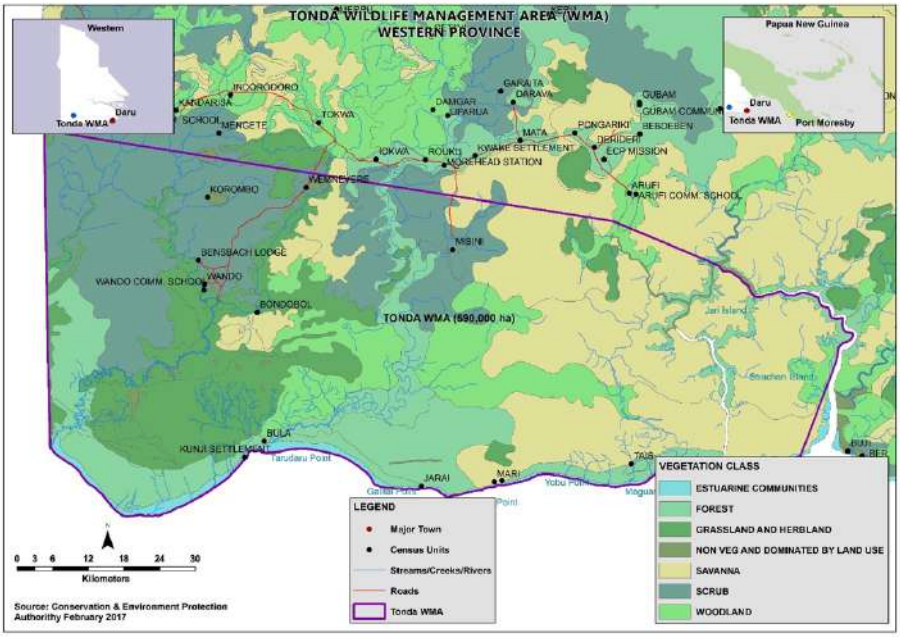


Figure 13. Vegetation types of the Tonda WMA

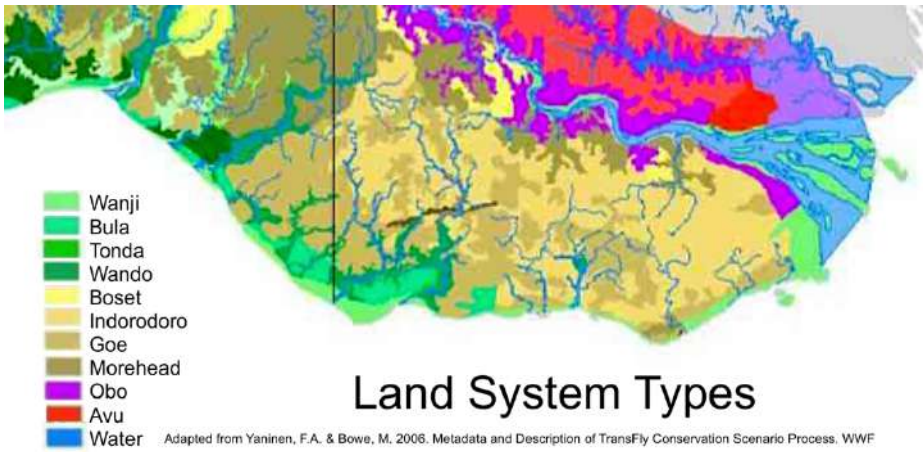


Figure 14. Land Systems of the Trans-Fly

On the coastline Wanji/Wunji is a narrow fringe of coastal beach ridges and swales, Bula Recent Grassy Plains, Wando seasonally inundated flood plains of large rivers (see Figure 14). The topography being relatively flat is influenced by the wet rain season with inundation of lower lying areas (see Figure 14). Inner areas in the east are undulating dissected with ridges, which are well grassed with belts of forest made up of bloodwood, *Eucalyptus* and Melaleuca, with monsoon shrub and grassland, or swamp in depressions. The frequent lighting of fire has an impact on modifying the vegetation (Piper 1977) (see Figure 15).

Figure 15. Fire events South Fly 2020, from FireWatch

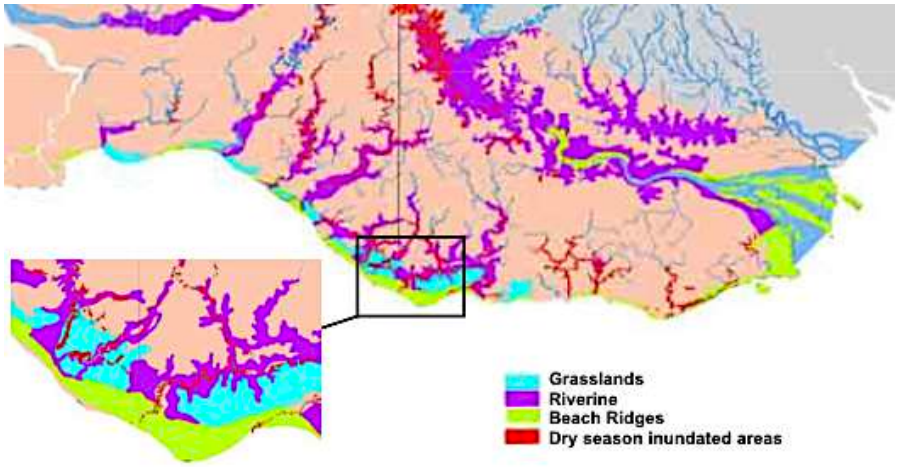


Figure 16. Riverine systems and areas of seasonal inundation

The riverine floodplains have a major influence on the surrounding ecosystems (see Figure 16). Along with soil fertility, and natural vegetation cover these have impact on potential settlement and resultant population demographics across the landscape.

3. SOCIO-ECONOMIC

CUSTOMARY SETTLEMENT & TRADE

Customarily the people of the South Fly used to live in temporary settlement camps but with the coming of Colonial administration a village *mamus* system was introduced with the appointment of chief and *mamus* to lead and organise the people to live in villages as we recognise them today.

There are now a series of villages, that are scattered along the southern coast of the PNG mainland (see Figures 17-21). These are split into hamlets which are traditionally made up of different clusters of clans. In the South Fly these are patrilineal societies, hence land tenure and usufruct is the right of male members of a lineage. Though female members can advise they do not have these rights (Sullivan *et al*. 2013). Marine tenure tends to be linked to the adjacent community on the coastline

and extends to reefs and islands along traditional trade paths. This traditional marine tenure was based on a totemic system determining the clan.

Figure 17. Mawatta Village 1903


Figure 18. Hamlet on mainland across from Daru 2021 d.k.m.

A major challenge is how to encourage greater cooperation among and between these village communities given the vast ethno-cultural diversity. While 'bonding-type' social capital can be strong, 'bridging-type' social capital is often weak and changeable based on rapidly shifting social alliances (Sullivan *et al*. 2013). Though some villages have had in-migration over many years recent influxes of people displaced by the impacts of Ok Tedi mine on the Fly River and flood plains causes social distinctions and tension.

Figure 19. Tureture Village aerial view

Figure 20. Ber Village aerial vie

Figure 21. Buzi Village aerial view

The ownership and user rights of the original village communities and their clans over their natural resource territory must be sanctioned and legitimised, as is recognised within the goals and directive principles of the PNG National Constitution. Land owners have primary rights over their resources and in how to sustain their use of these, based on the experientially gained knowledge of past generations. The ongoing maintenance of these resources is the basis of the peoples' subsistence and an informal income that sustains their livelihood and wellbeing, a sense of being linked to and a belonging to place, identity and culture. Underpinning this is customary law, which is defined, recognised and upheld through National Laws.

Customary fishing and trade across the Torres Strait, though it still takes place, is now highly restricted due to the conditions in place in crossing this international border (see Figure 22).

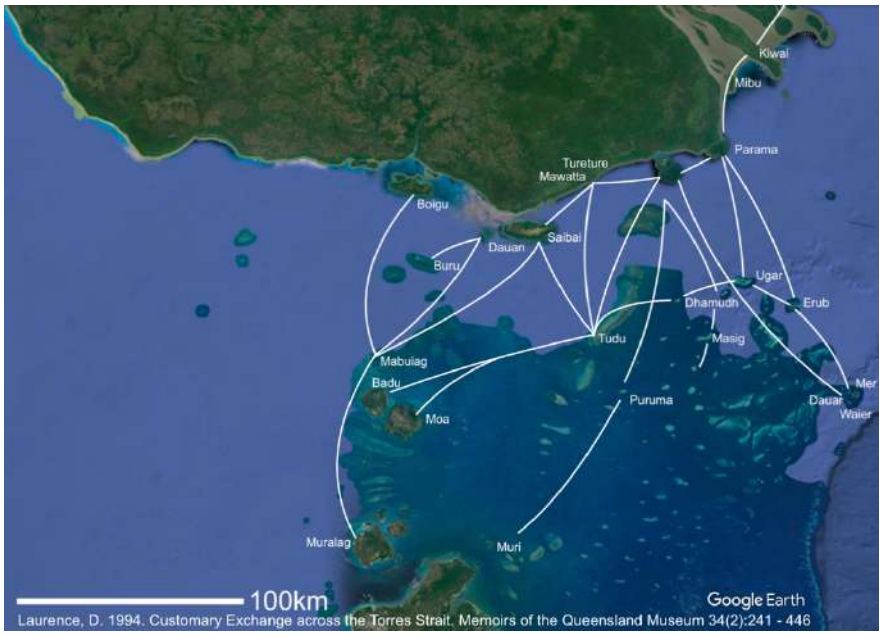


Figure 22. Precolonial Customary Trade across the Straits that is linked to inland trade, not shown here

Relations with Marind-anim Tribe =Tugeri of Indonesia

It is regarded that the Tugeri peoples migrated from the interior down the Strickland River across the Fly and down the Merauke River and settled in this area. The Tugeri were known as a nomadic and ferocious raiding tribe. Their raids extended far to the east, and in Macgregor (1891) they were reported some 3 miles inland on the tributaries of the Mai Kusa River in from Boigu, where they had attacked and annihilated the Dumirang Tribe. This whole area from the border of the Possession [Indonesia-PNG] to the Western Division Government Station with an armed constabulary at Mabudauan Hill had been depopulated in consequence of the incursions of the Tugeri (Macgregor 1891). 'The Boigu natives have for many years been hunted like water rats by the Tugeri and compelled to hide in the mangrove swamps of their island or to flee for refuge to Duaun [Island] (Anon 1893)'. It was only on occasion that they had trading relations with eastern tribes (Riesenfeld 1950). This area that is now within the Tonda Wildlife Management Area continues to have few villages and a sparse population.

Overlying the rights and participation of clans are the hierarchy of laws of the Independent State of Papua New Guinea, The Constitution, Organic Laws and Acts, Provincial and Local level Government Laws as allowed under the *Organic Law on Provincial Governments and Local-level Governments* (2015).

It is usual for Legal and Institutional Frameworks to be outlined in the cascading order of National, sub-National to community level. However, the level at which the ATSEA-2 initiative aims to make positive change, the sustainable fishery lies at the level of the community. Often this point is missed even within PNG development documentation but the rights of ownership of land and marine resources within PNG lies with the tribe/clan and higher levels of Policy, Law and Conventions do not always address the variance of customary practice, customary law across the socio-linguistic mosaic that make up the Independent State of PNG.

Customary laws which have localised reach are supremely recognised by the PNG *Underlying Law Act* (2000).

I wish to therefore emphasise the importance and value of customs, associated customary laws and trade relationships developed over millennia, which were defined in the past, but which have been impacted by relatively recently drawn international borders and state laws. Both of which have impacted and altered the social-economic and environmental relationships people held in this region. Customary fishing grounds and trade routes should be factored into development planning, policy and legal oversight in this region to reenforce these underlying relationships. From a positive perspective higher level management and policy that factor and build upon the local context are more likely to be supported and practiced by communities

Customary law is oral and not codified. It is therefore tied to each of the languages/dialects and customs of the people of the South Fly. Even within clans there will be variations of customary law,

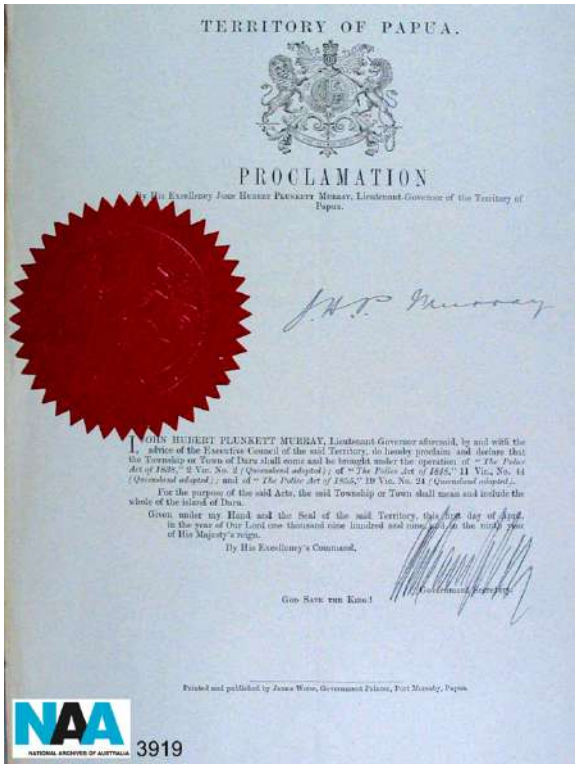
such as the prohibition of hunting clan totems of which a man may have one two, three or four, (e.g. Mawatta, Turituri villages; cassowary, wallaby, rock snake, dog, tortoise, crocodile, ground shark and sting ray (Beaver 1920)). This is fundamental and is tied to the rights of the clan and individuals.

Recommendations

1. Determine the underlying strength of customary law in marine management in each of the coastal villages and determine the potential for its application in the South Fly EAFM plan.

2. Determine the strength of the tribal/clan governance in the management of natural resources, in particular the customary tenure of estuarine and marine ecosystems.

THE IMPACT OF DARU


TERRITORY OF PAPUA.

PROCLAMATION

By His Excellency John Hubert Plunkett Murray, Lieutenant-Governor of the Territory of Papua.

I, JOHN HUBERT PLUNKETT MURRAY, Lieutenant-Governor aforesaid, by and with the advice of the Executive Council of the said Territory, do hereby proclaim and declare that the Township or Town of Daru shall come and be brought under the operation of "*The Police Act of 1888*," 52 Vic. No. 1 *(Queensland adopted)*; of "*The Police Act of 1865*," 11 Vic. No. 14 *(Queensland adopted)*; and of "*The Police Act of 1865*," 29 Vic. No. 24 *(Queensland adopted)*.

For the purpose of the said Acts, the said Township or Town shall mean and include the whole of the island of Daru.

Given under my Hand and the Seal of the said Territory, this first day of April, in the year of Our Lord one thousand nine hundred and nine, and in the ninth year of His Majesty's reign.

By His Excellency's Command,

Lieutenant-Secretary.

GOD SAVE THE KING!

Printed and published by James Watts, Government Printer, Port Moresby, Papua.

NAA NATIONAL ARCHIVES OF AUSTRALIA 3919

Figure 23. Proclamation of Daru Township 1909

The initial government station of the Western Division was at Mabadauan Hill however the main centre was moved to Daru in 1893. The pacification of surrounding communities under the application of adopted Queensland and Papuan law was therefore an initial function of Daru. Though it must be noted that in July 1871 at Old Mawatta (Katau) the London Mission Society also brought pacification earlier through the Christian message they brought (Piet 2019).

As Daru developed it reaffirmed this status when the entire island was proclaimed a township in 1909 bringing it under various Police Acts (see Figure 23). This settlement of the public service also required to be supported by commercial settlement and trade, through the port of Daru, all of which generated revenue. Settlement also meant a school, hospital, (up to the 1960's segregated European and 'native'), hotels, a market, communication and banking facilities and churches. Villages proximal to Daru therefore were influenced by and influenced the opportunities that this presented.

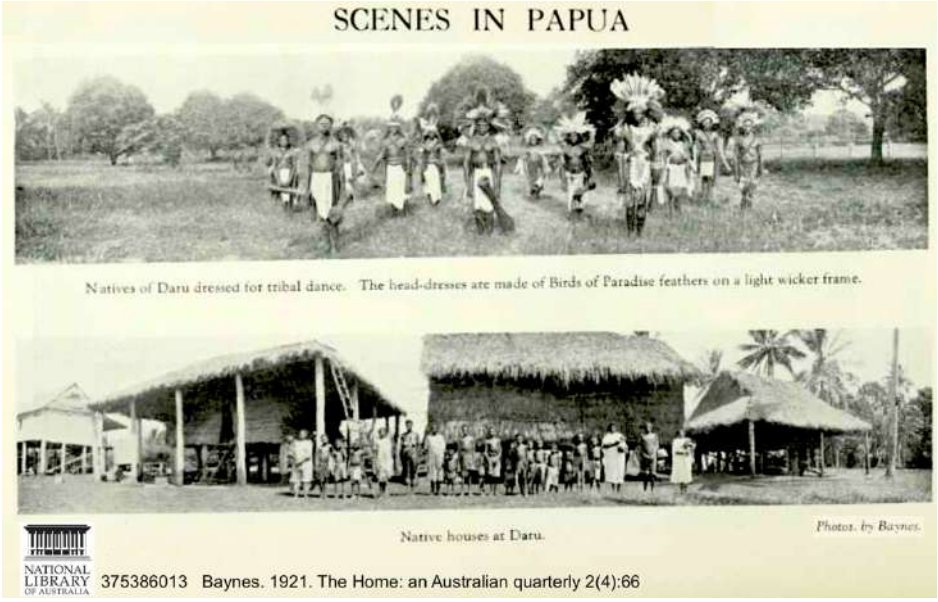


Figure 24. Early scenes Daru 1921

The current purpose of Daru has therefore been developed over the last 130 years from its initial establishment (see Figure 24). It remains essentially a centre of government agencies with fisheries extension and inspection a sector within this. The establishment of Local Level Governments and the Provincial Government also added the dimension of being a point where representative assemblies discuss and approve development budgets. Generated out of Daru therefore are many of the development decisions that impact the coastal villages, the people and their resources. There is some level of decentralised function politically and in public service program implementation, that fall within National, Provincial and Local government laws.

As Daru is also near the international border between PNG and Australia and the more distant PNG-Indonesian border, many decisions relating to these and other matters of National interest are also determined in Port Moresby.

Daru is the most populated and only urban centre in the South Fly with a population in 2011 of 14, 373. It is a commercial centre of trade with wholesale retail trade stores, the Bank of South Pacific and several Marine Produce buyers and exporters (see Figures 25-27).

There are mobile network and postal services. The Port is capable of shallow draft vessels and the airstrip which is sealed can take short take-off and landing aircraft and is serviced by Air Niugini and PNGAir prop aircraft.

Figure 25. Early Daru left and 2021. d.k.m.

Daru now has continued to provide these services and as an urban centre is a point of urban drift.

Figure 26. Daru and environs

Figure 27. Daru

MERAUKE

The major township over the PNG-Indonesian border from the South Fly is Merauke. This was initially set up in 1902 by the Dutch Government as a military outpost to prevent the raids of the Marin-anim into British New Guinea and the Torres Strait islands of Boigu, Duaun and Saibai. This was followed by the Catholic MSC (Missionaries of the Sacred Heart) mission in 1905 and it became a town made up of many people of foreign origin.

It is now a growth centre of the Merauke Regency with a population of 102, 351 in the 2020 census (see Figures 28 & 29). As a point of commerce, it has major influence in this corner of Papua Province that extends into PNG, with several marine produce buyers and exporters in Merauke.

There is a port and an airstrip serviced by Garuda Indonesia.

The state run Masamus Merauke University gained this status in 2006. One of its faculties is in agriculture

Figure 28. Merauke environs

Figure 29. Merauke

It was from Merauke in the 1920s, that the missionaries, in compliance with the colonial government, endeavoured to systematically establish model *kampong*s in south Dutch New

Guinea. These kampong were first set up along the south coast, where the Marind-anim tribe lived Derksen (2016) (see Figure 30).

Figure 30. Man and two children from the Merind-anim in the thoroughfare through the model *kampong* of Kumbe, *circa* 1924 from Derksen (2016)

Recommendation

3. The current trade potential of South Fly marine produce through Merauke via a border free trade zone to be researched.

LANGUAGES

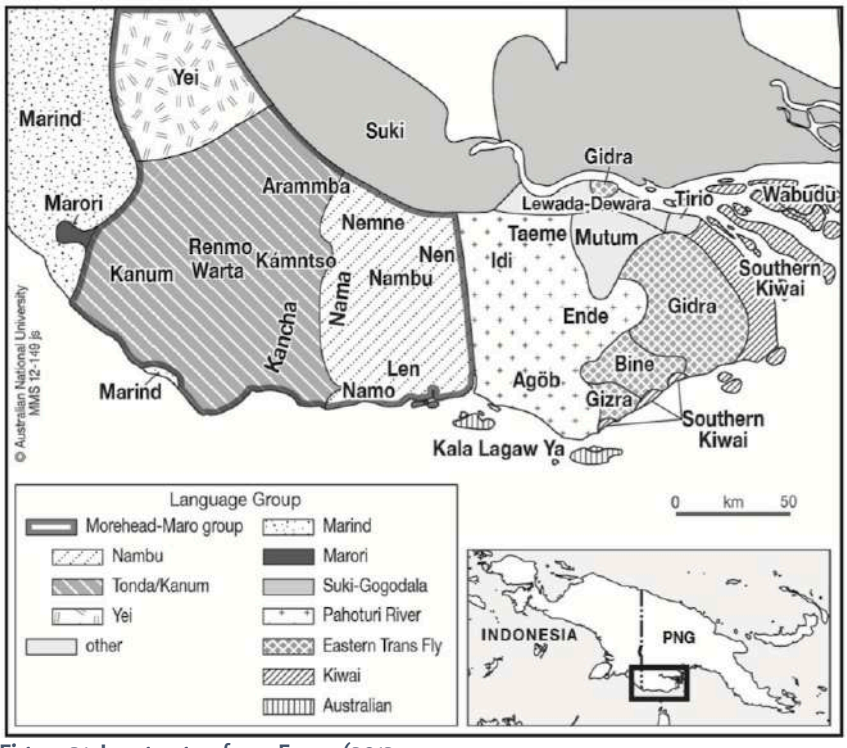


Figure 31. Languages, from Evans (2012

Language is integrally linked to culture as it connects words and expressions to the relationships that exist in a place, between people and their environment. Within PNG environments and cultures are highly diverse. Those who speak the same language are often bonded within a tribe, village, clan and household (see Figure 31).

Within the 4th Goal and Directive Principal of the National Constitution:

(3) recognition that the **cultural**, commercial **and ethnic diversity** of our people is a **positive strength**, and for the **fostering of a respect for, and appreciation of, traditional ways of life and culture, including language, in all their richness and variety**, as well as for a willingness to **apply these ways dynamically and creatively for the tasks of development**; and

(4) **traditional villages and communities to remain as viable units of Papua New Guinean society**, and for active steps to be taken to **improve their cultural, social, economic and ethical quality.**

Recommendation

4. It is therefore imperative that all development planning and decisions are thought through in the local languages of the groups involved.

For the villages along the South Fly mainland this will involve speakers of the Tonda/Kunum [Kancha], Marind, Nambu [Namo], Pahoturi [Agöb] Eastern Trans-Fly [Gizra, Bine, Gidra] and Southern Kiwai language groups/languages. Each language should be a part of the contribution to the South Fly EAFM Plan and IUU. It is therefore suggested that these documents are created by bringing together and combining the 6 language group plans for their area. The final document in English would need to use key words of each language so that the speakers of these languages have a greater understanding and a sense of ownership in the plan or document.

POPULATION

Western province covers a huge area and villages are scattered across the landscape. The natural growth rate along the coastal villages is 2% whilst for the district the population growth rates is near 3% (FRPG 2019) which leads to a doubling of the population every generation of near 30 years (see Figure 33 & Table 1).

The communities in the South Fly are scattered, isolated and spread out and still include transient fishing camps (see Figure 32).

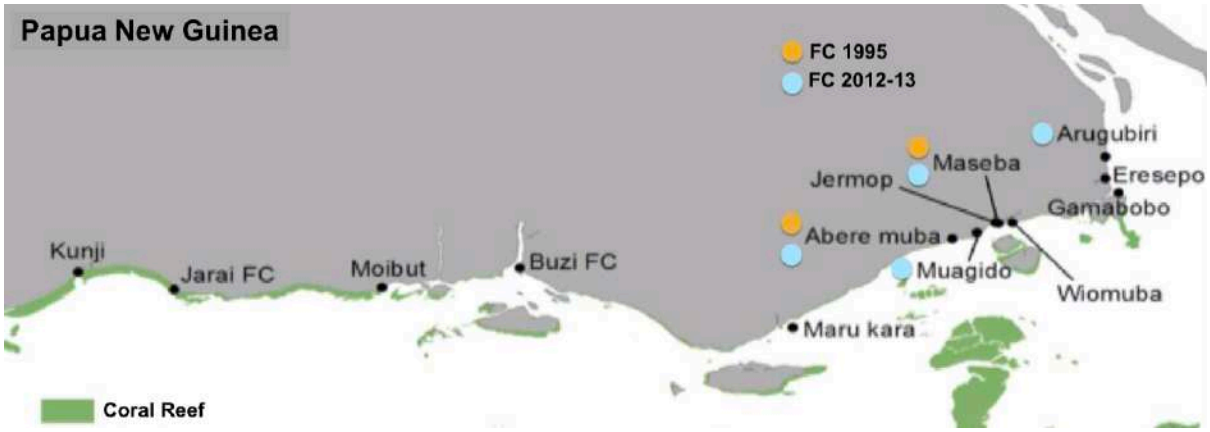


Figure 32. Fishing camps recorded 2012-2013, adapted from Busilacchi *et al*. (2014)

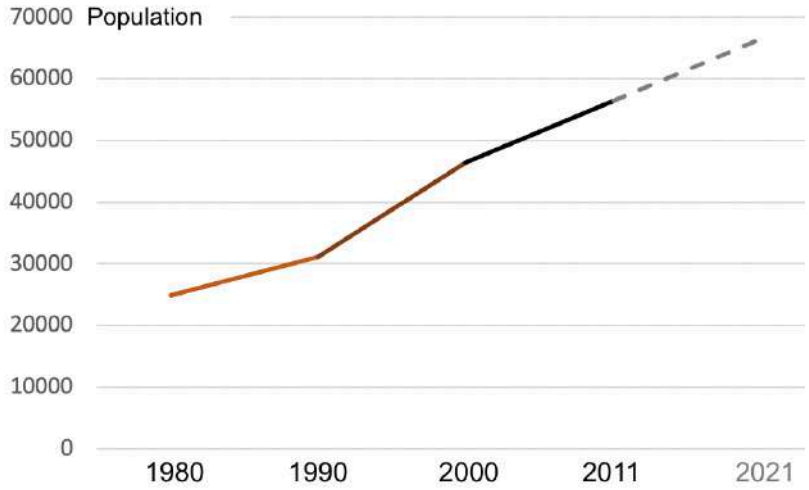


Figure 33. South Fly Population growth 1980-2011 and projection to 2021

Table 1. Population South Fly 2011

			Age			
LLG Area	Male	Female	<15	15-64	>65	Total
Kiwai	8,821	8,166				16,987
Morehead	7,281	7,163	44%	54%	2%	14,444
Daru Urban	7,538	6,835	52:48	51:49	48:52	14,373
Oriomo-Buturi	5,310	5,280				10,590

As is the trend in Papua New Guinea the population of the South Fly is dominated by younger age groups with few over the age of 65. Many of the youth are also in formal primary and secondary education.

Figure 34. Population of coastal village census points and Daru Island (green, male; red, female) NSO (2014)

The main population is within the villages in the central and eastern sectors of the South Fly with more scattered and fewer villages in the western sector (See Figure 34).

Recommendation

5. The development of an EAFM based South Fly Management plan that factors in local illegal fishing will need to consider the fishery of each coastal village and associated fishing camps. This will include seasons for different target species, and the amount of take disaggregated by subsistence and for trade or sale (either in legal or illegal trade).

Population Density

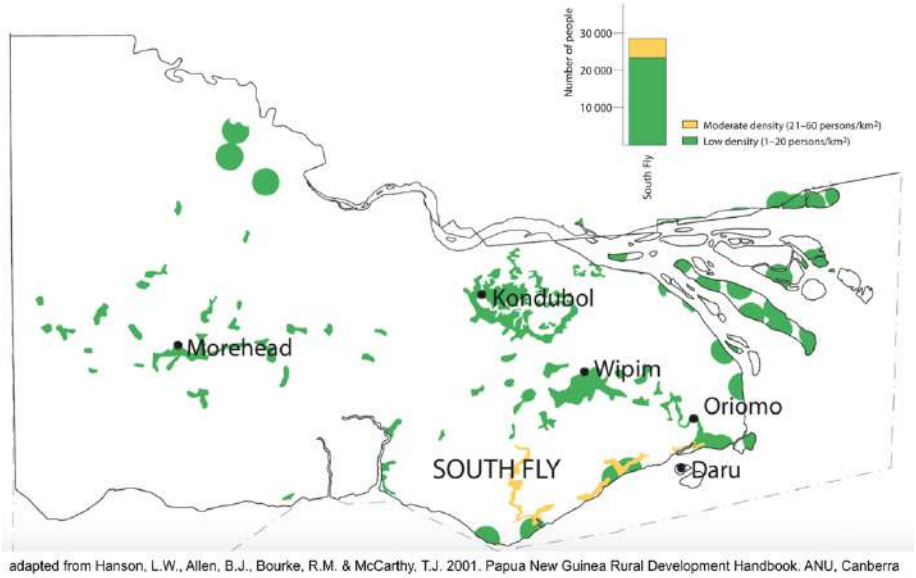


Figure 35. Population Density of the South Fly 2001

Table 2. Population Density South Fly 2011

LLG Area	Total	Area km^2	People/km^2
Kiwai	16,987	1,712	9.9
Morehead	14,444	12,840	1.1
Daru Urban	14,373	428	33.6
Oriomo-Buturi	10,590	6,420	1.7

The population densities in the rural areas are low and well within the limits of being sustained from a subsistence agriculture food production system (see Figure 35 & Table 2). Though within the SFRD (2019) report it mentions that the increasing population pressure, is placing and increasing pressure of the coastal ecosystems and marine resources. It went on to note that the population has overtaken the development needs of the people creating a vicious cycle of poverty in the district and a huge development bill (SFDG 2019). There is an in-migration into Daru, the only township, especially of youth, which leads to dependency rather than relying on the resource base for their needs .

Recommendation

6. From the 2021 Census that preliminary data on people staying in place of origin and people from other areas/and place of origin are clearly defined for all population centres in the South Fly.

EDUCATION

When education is considered, it is biased towards the formal education learnt in schools, taught and guided by a national curriculum that standardises learning. In the lower levels of school most students walk to or from the school and therefore also are educated in the ways of the household, tribe/clan and community. Such skills as fishing/gleaning, sailing being learnt from observation, with guidance from others and in the application of it practically. Students who attend high/vocational school mostly leave the village and board at the school in these latter formative years. A level where more proficient and advanced levels of reading, writing, numeracy, individual thought, are developed to the level of formal education attained (see Figure 36).

Community members in the village will apply what knowledge they have for the needs that they have day-to-day. Local language will be used, and English, Pidgin or Bahasa depending on the circumstance or another community's language during trade, where tact, guile and cunning may need to be employed. Where numeracy skills are needed, they will be applied, as most people have such knowledge. There will be varying mixes of customary, village learning with different levels of formal education. Some due to social position, gender, opportunity or personal preference.

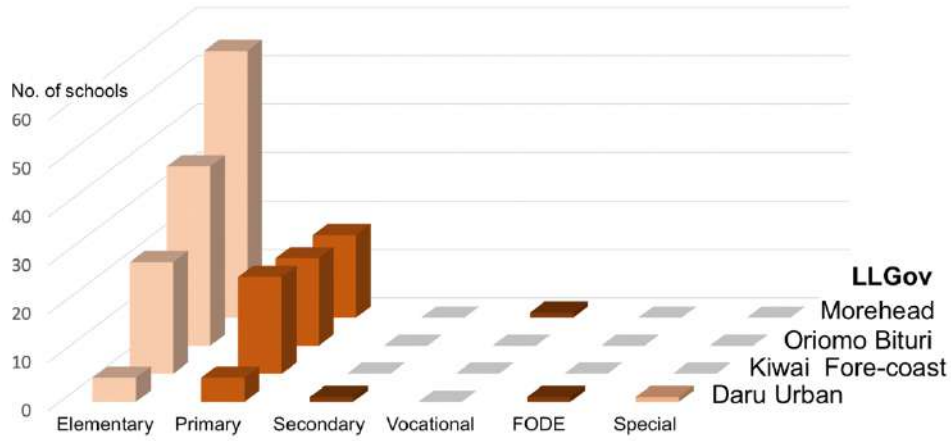


Figure 36. Schools of the South Fly 2006

In the Western Province Education Plan 2007-2016 the then Provincial Administrator though highlighting that nation building has been greatly contributed to by people from the province, that there is a concern on the current low standard of education (Hungrabos 2007). Education to many is seen as a way to advance from being a subsistence farmer/fisher to paid employment and in doing so the current education system continues to alienate our younger generations from the realities of life in the village. At the elementary and primary school level the majority are church agency schools whilst secondary schools are government run.

The recent generation of educated youth went through a teaching system where local language was the language of instruction at the elementary level. Within primary level, subjects in the environment and community life also were an aspect of the syllabus, to develop an appreciation of their place in the local environment. This syllabus was recently changed though, with a greater emphasis now on science and technology, such that the next generation will have been taught with a different perspective.

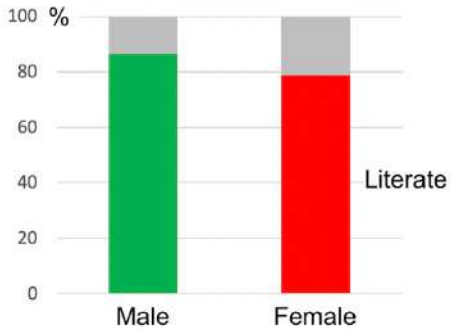


Figure 37. South Fly Literacy rate 2011, from (Hungrabos 2007)

Despite this literacy rates in the South Fly as indicated in the last census 2010 are relatively high with literacy of males slightly higher than females (see Figure 37). Many people within the villages however may not openly speak in English often, because they believe that they do not speak it well or they hear and understand, but find it difficult to speak. There is no data on those who are literate

in Bahasa and this is a data gap. Local languages are the language of the household in the coastal villages.

As it is suggested that future marine management planning is built on the experiential customary knowledge and management of the natural resource base, that this is done in the local language. In this way perception as expressed within the language will be said in key words, that when identified can become a part of English documentation. The application of Traditional Ecological Knowledge (TEK) and applied science in natural resource management potentially enhances the resilience of social-ecological systems by providing a diversity of knowledge for problem solving and related cross-scale and adaptive governance networks (Berkes 2009). In the process discussions in communities to be in the local language and this to be informed by and later turned back into English. Though meaning may be lost in the translation it is hoped that a higher level of understanding is maintained and that the perspective from communities is well outlined. This is also a recommendation of Butler *et al*. (2012) in the integration of TEK in Torres Strait fishery management where it was suggested forums be established to encourage learning and the evolution of adaptive co-management. In this way encouraging the contemporary extent and characteristics of TEK to emerge (Butler *et al*. 2012).

AGRICULTURE

Subsistence Agriculture

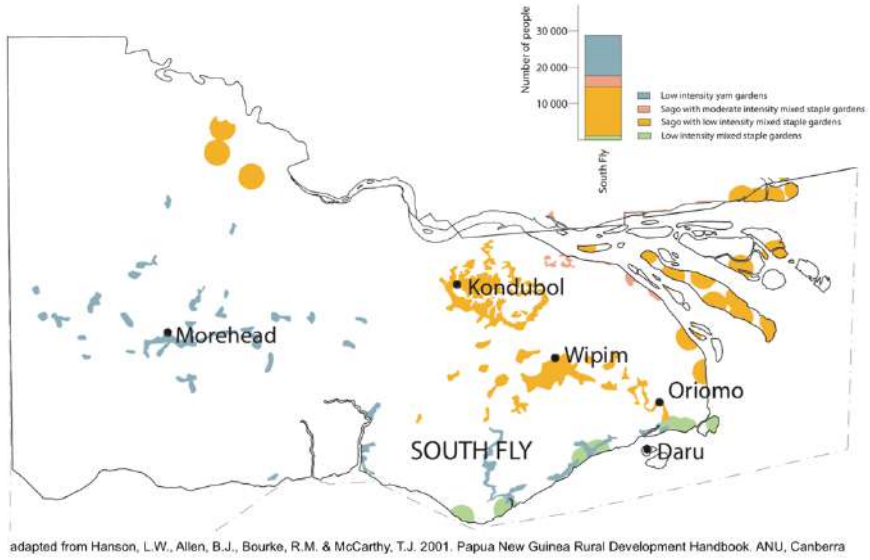


Figure 38. Subsistence Agriculture South Fly 1994

Subsistence agriculture along the coastal villages is low intensity gardens of mixed staples. In the 1994-5 Agriculture systems research across PNG in the area of Mawatta and Tureture Allen *etal*. (2002) stated that the relative unimportance of agriculture is underscored by the reported consumption data of the 1982/83 National Nutrition Survey. In this survey 97 per cent reported

eating sago, 30 per cent coconut, 8 per cent sweet potato, 7 per cent banana, 1 per cent cassava and none yam or taro whilst 46 per cent reported eating fresh fish (see Figure 38). In 1936, Mabadauan village was described as having no sago, and people traded turtles for sago with Kiwai Islanders (Archbold & Rand 1940). The importance of fishing for food and trade has frequently been stated. The villages of Mawatta and Tureture as mainly dependent on fishing, the surplus of which they traded to inland villages such as Masingara (Beaver 1920). They also purchased their sago (especially Mawatta) from Kiwai Island. In 1992 the major source of cash income was the sale of crayfish, turtles and barramundi, mainly in Daru. There were minor sales of fresh food; some sea cucumber is also collected and sold (see Figure 39).

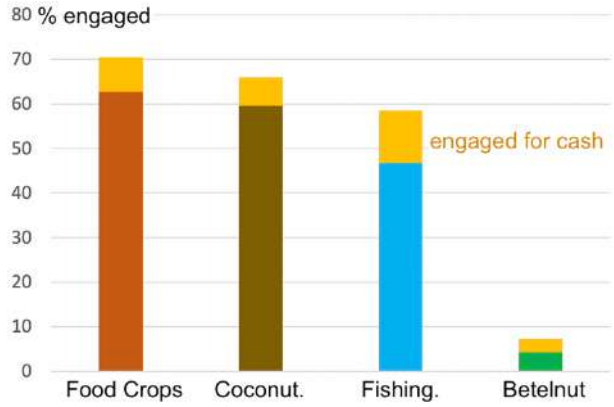


Figure 39. Subsistence/cash activity by household 2011

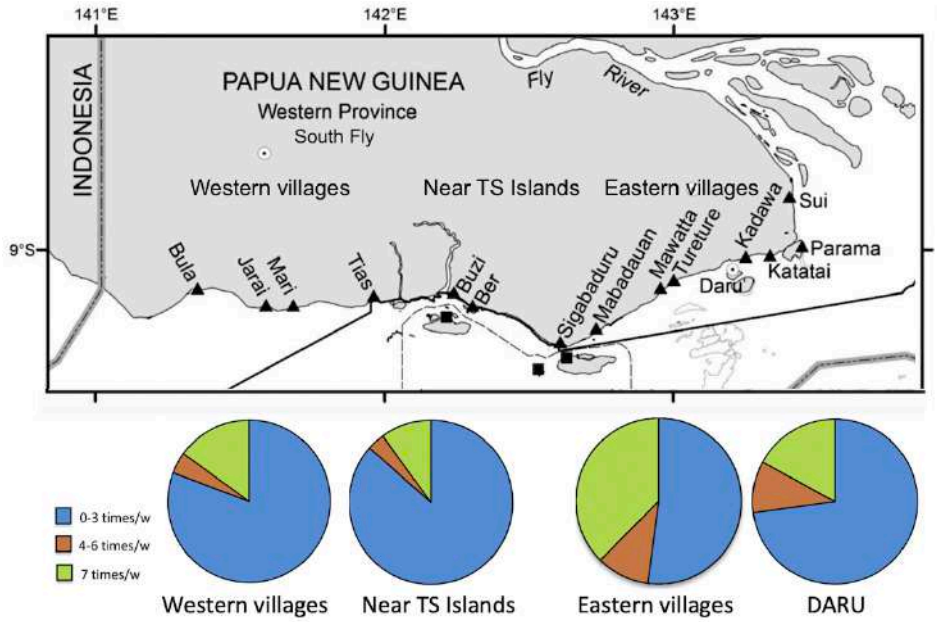


Figure 40. Fish in meals, times a week, adapted from Busilacchi *et al.* (2014)

With subsistence agriculture on marginal soils there is a greater reliance on the marine resource however based on research from Busilacchi *etal.* (2014) the number of times a week that fish are consumed each week is not regular except for the eastern villages. Daru where there are a greater number of salary earners the consumption of fish is still not high (see Figure 40).

Recommendation

7. The current level of reliance on marine resources for food and income, which species and the interrelationship of these within each village/fishing camp needs to be determined

Agriculture Potential

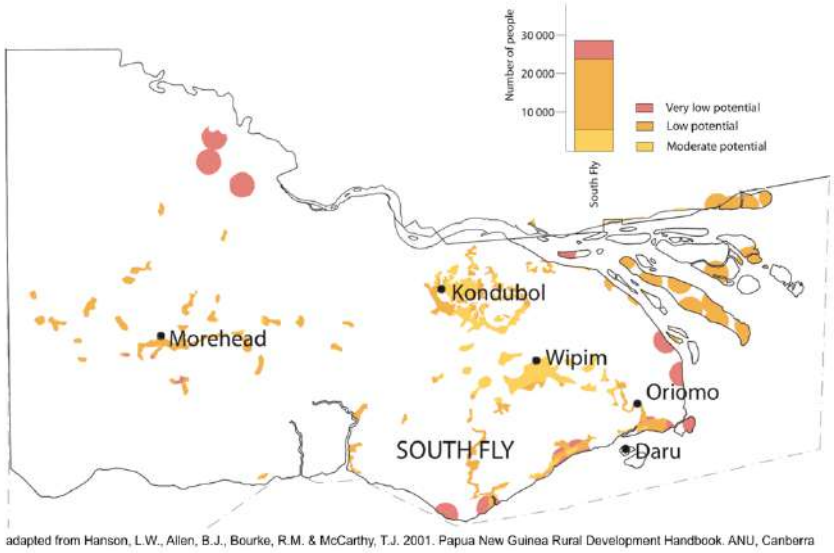


Figure 41. Agriculture Potential 2001

Agriculture potential is tied to the productivity of the soil. If this is marginal for subsistence it is unlikely to be productive without input for commercialised agriculture. Access to markets and profit margins will also inform the viability of commercial agriculture. The agriculture in the villages on the coast of the South Fly has a very low to low potential (see Figure 41). Communities as a result will depend heavily upon the opportunities from marine products. This is evident from the cash income along the eastern and central coastal villages having a higher income that the hinterland of the South Fly.

CASH INCOME

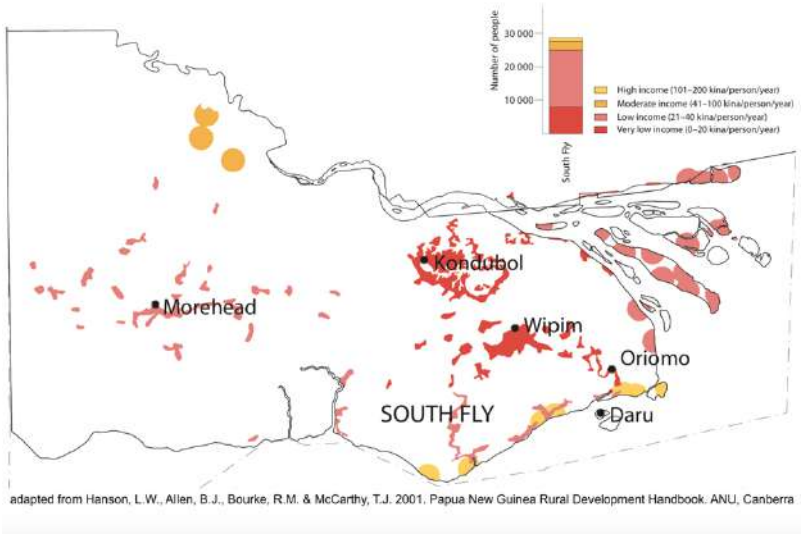


Figure 42. Cash Income South Fly 200

The cash income generated is mostly through trade into the Torres Strait and from marine produce through Daru or with produce buyers from or in Indonesia (see Figure 42).

More intensive comparative cash income survey effort by Busilacchi *et al*. (2014) in the period 1995 and 2012-2013 was done and is summarised in Table 3. Over this time, it was found that on Daru that the fishing effort doubled but that the quantity (number or weight?) of finfish caught increased by 18% however the reef component of this decreased by 30%. A greater reliance was made upon coastal fish.

Now a decade on the status of the coastal fish (barramundi, jewfish, croakers and threadfin) is likely to have decreased in productivity from this fishing pressure. This is to be determined.

Table 3. Natural resource exploitation for cash by village based on percentage of respondent, adapted from Busilacchi et al. (2014)

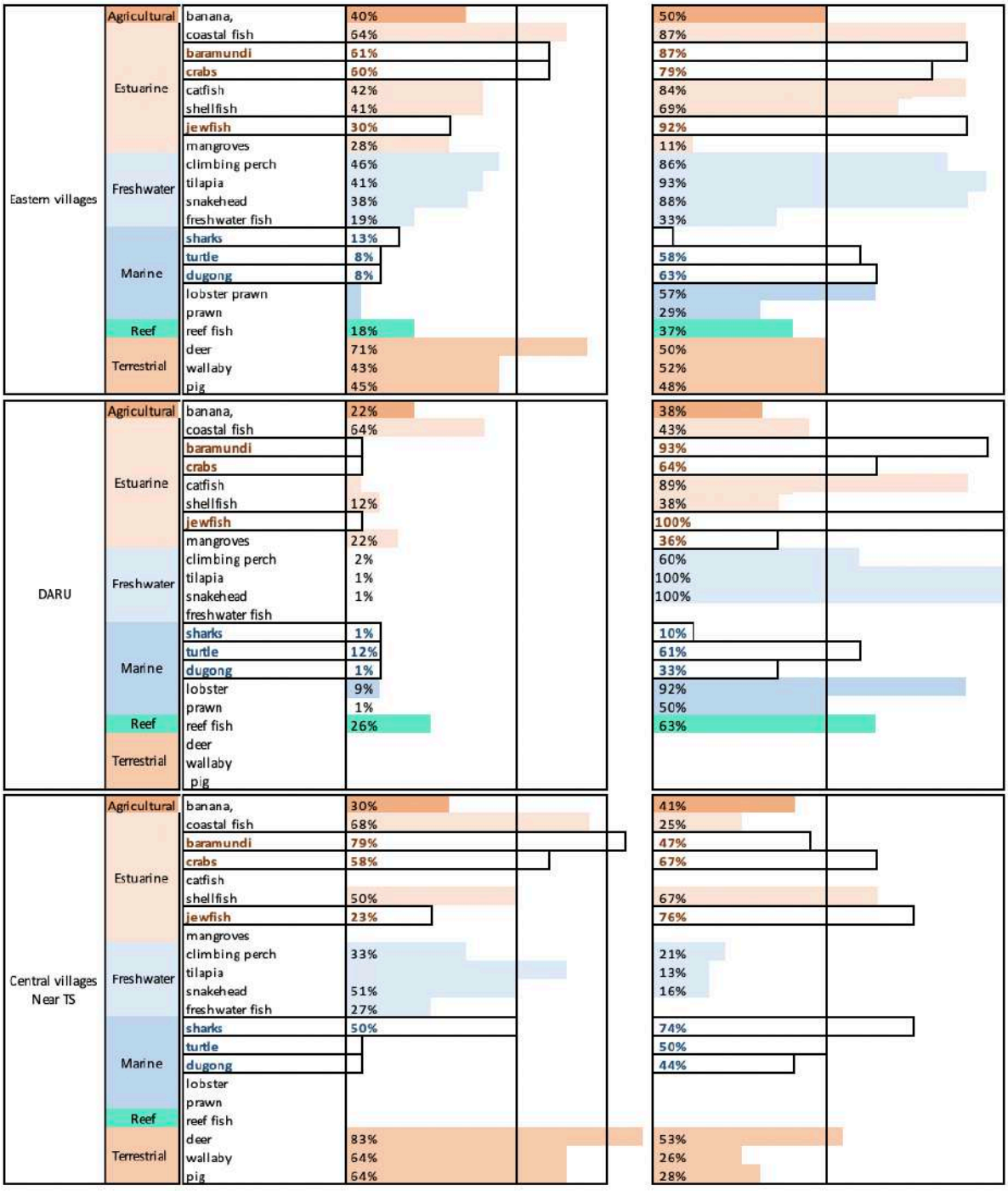


Figure 43. Daru foreshore fuel market for outboards on canoes and dinghies 2021 g.a.

With an emphasis of travel to and from Daru other informal sector income activities have sprung up. This has led for example to the sale of zoom for outboard motors on the foreshore from 200l drum to smaller containers (see Figure 43).

Figure 44. Daru fish market 2021 g.a.

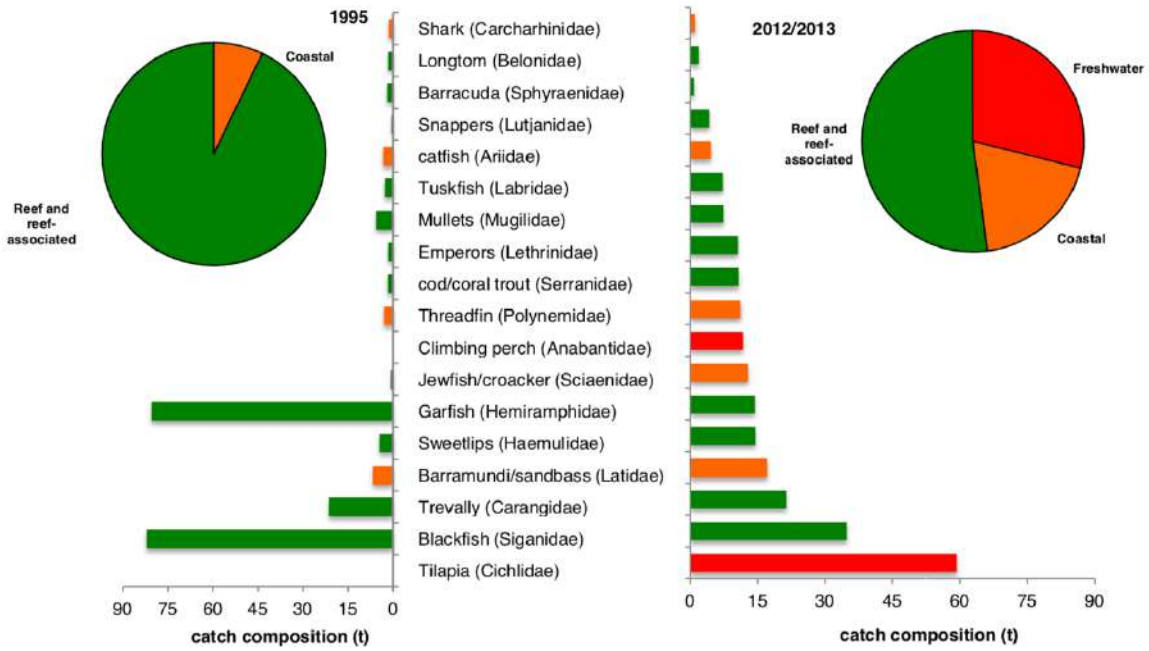


Figure 45. Fish marketed at Daru 1995 and 2012/2013 adapted from Busilacchi *et al.* (2014)

With emphasis on fishing villages proximal to Daru, they are selling their catch at the market there (see Figure 44). This has led to a multi fin-fish market based on what is available as catch or by-catch that has varied in composition and volume in this time (see Figure 45), with the increasing population of Daru having buying power.

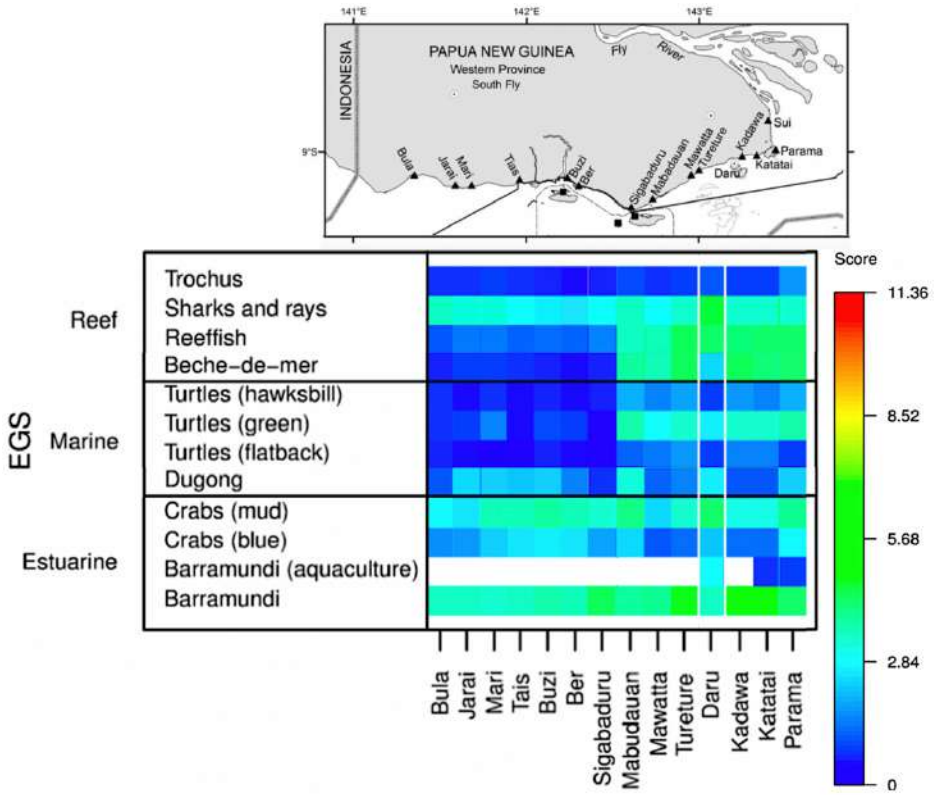


Figure 46. EGS, adapted from Busilacchi *et al.* (2014)

An EGS (Ecosystem Goods and Services) assessment is a measure of how different elements within ecosystems are used as goods or in provisioning service (see Figure 46). In interpreting this figure the relative production score increases from blue to green, with none reaching the high levels of yellow or red. For the eastern village there are more substantive reefs leading to marine production from this ecosystem. Daru with a high population exerts pressure on resources from harvesting and the eastern villages are also more proximal to Daru Market with a greater areas of adjoining and nearby reefs.

ILLEGAL TRADE

Although the people of the Western village of Bula and Central village of Sigabadaru had some idea on border treaties, and the regulations in regard to the harvest and trade of marine resources, they did not regard crossing border trade as illegal (Busilacchi *et al*. 2018). This is in part likely due to the long-standing trade practices and what rights people feel that they have over their resources. What is to their advantage such as attaining the best deal in the sale of produce is taken. Studies that look at illegal trade will therefore be impacted by how people perceive this and if they become reserved in their responses in relation to it (see Figure45) .

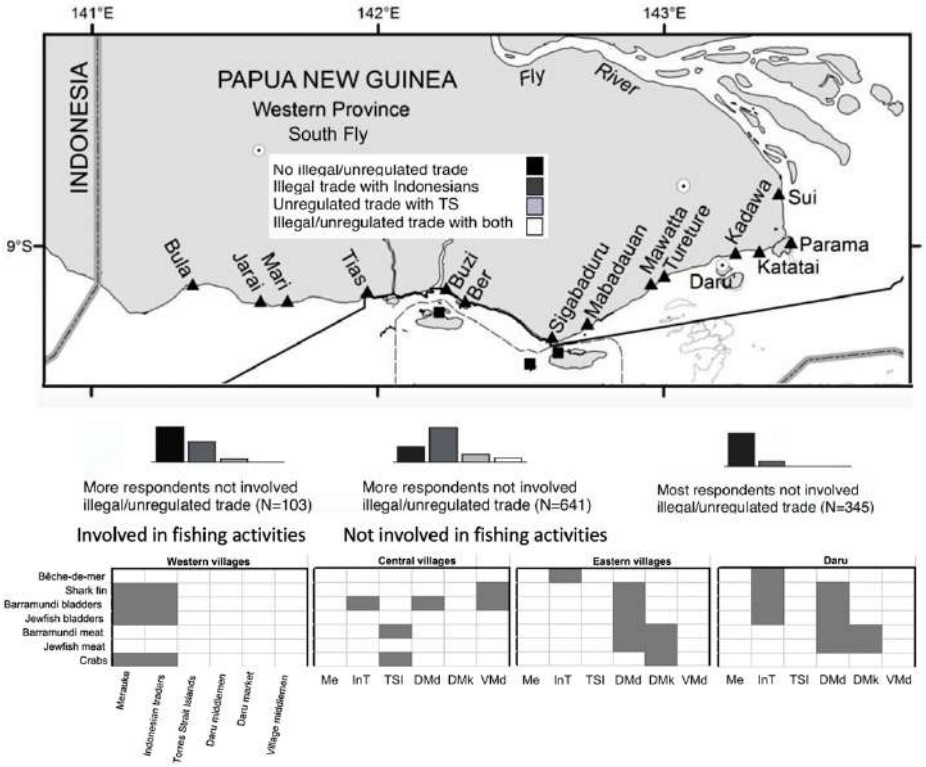


Figure 47. Illegal trade based on respondents, adapted from Busilacchi *et al.* (2018)

People of the western villages have fewer income options, being distant from PNG markets and therefore trade towards Indonesia, especially for high value marine products such as fish bladders from Jewfish and Barramundi, Shark fin and Mud Crabs.

Eastern villages and Daru used to fish sea cucumber for beche-de-mer on their home reefs however these have now been overharvested and there is increased illegal unlicenced fishing within the Australian side of the Torres Strait within the Protected Zone for sea cucumber (Busilacchi *et al*. 2018) (see Figure 47). Many of these are sold to Indonesian traders though there are buyers of beche-de-mer in Daru (Busilacchi *et al*. 2018) most probably because they offer higher prices or cheaper trade items.

Illegal trade is driven by cash poverty in Daru (Busilacchi *et al*. 2018) whilst in other communities it is an opportunity for different individuals.

LEVEL OF DISADVANTAGE IN COMMUNITIES

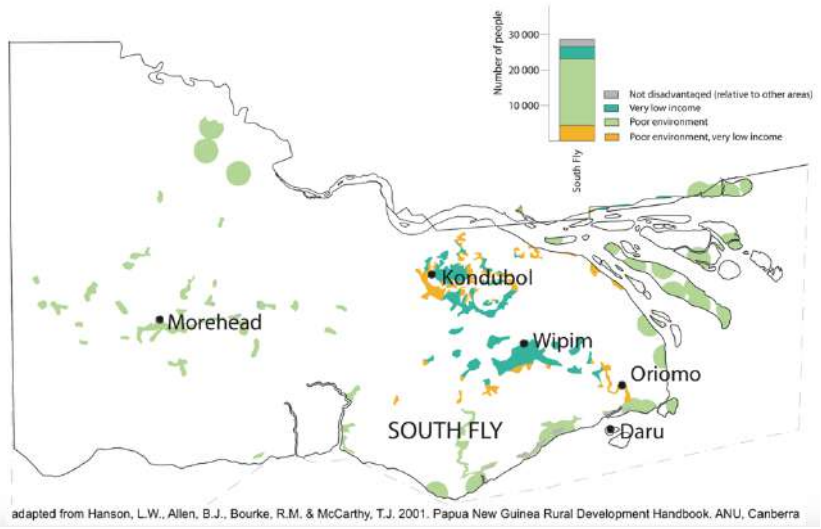


Figure 48. Levels of disadvantaged population South Fly 2001

Disadvantage as measured by the Multidimensional Poverty Index (MPI) is an attempt to bring the HDI down to a household level in order to measure [cash] poverty with [cash] poor people being multiple deprived with respect to education, health and living standards. The combined indicators of poverty being within the Household (HH) of: 1. Enrolment status grade 1-8; 2. a member of with 5< years of education; 3. death of 1 or more children raised in HH; 4. Malnutrition [not measured in study]; 5. Electricity; 6. safe water supply; 7. improved sanitation; 8. malaria proof house; 9. cooking facilities; 10.possession of boat with motor and 11. at least 2 other appliances. It is of note that 10 is not independent of 5. Busilacchi *et al*. (2014; 2018) measured this across the villages of the South Fly and Daru (see Figures 49, 50 and 48).

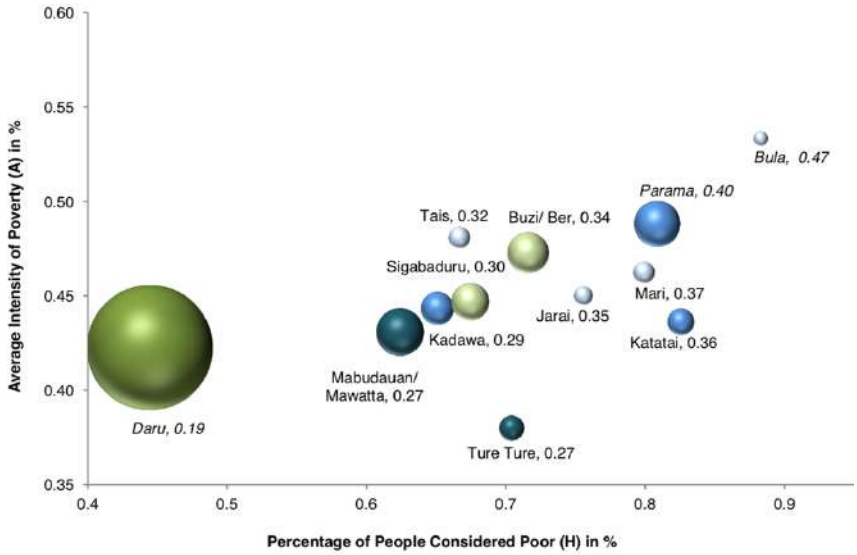


Figure 49. MPI for coastal villages and Daru, from Busilacchi *et al*. (2014)

The MPI score is given for each village (circle the size of which is representative of the population). The MPI is H x A with H being the number of poor/total population and A, intensity of poverty being the proportion of weighted indicators/ number of poor people multiplied by the number or indicators.

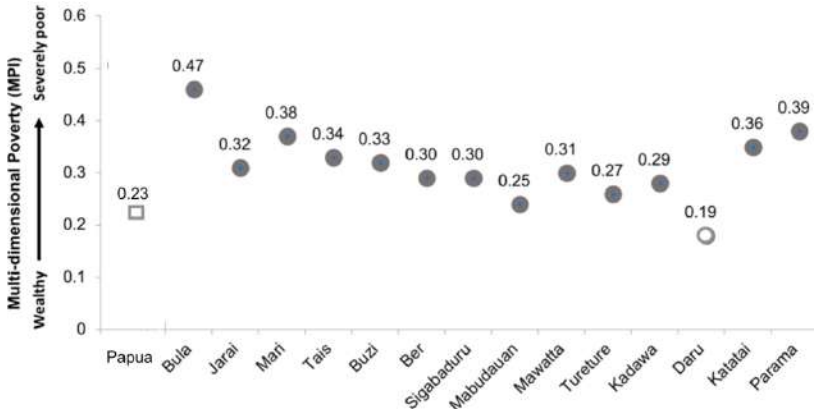


Figure 50. Multidimensional Poverty Index for the South Fly villages and Daru adapted from Busilacchi *et al*. (2018)

In looking at these MPI results the central villages that have access to services on the islands of the Torres Strait tend to have lower scores.

Though Daru has the lowest score this could be influenced by the provision of electricity, but also is likely skewed in that Busilacchi *et al*. (2018), mentioned that in Daru there were safety concerns associated with entering some neighbourhoods and consequently, only 19% of households were surveyed. On Daru there are many settlements of in-migrants who are not in paid employment and have no customary resources to maintain their wellbeing. There is likely a distinct stratification on

Daru of those with income and those without and that the survey is skewed towards the former and should be disregarded until a survey across all classes is done.

For a full outline of the research methodology, and interpretation see Busilacchi *et al.* (2018).

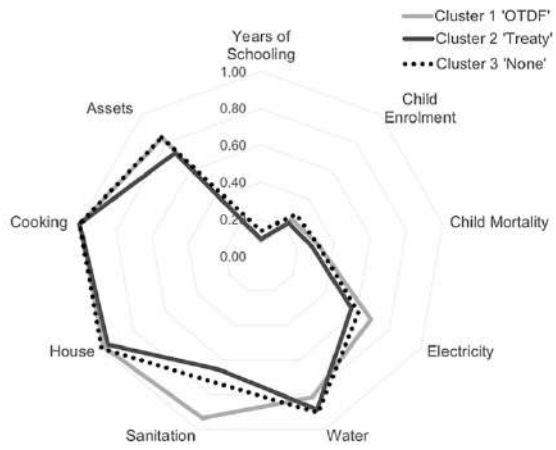


Figure 51. Diagram of selected MPI indicators in relation to clusters. Deprivation increasing from 0 to 1

In determining the impacts since the 1985 'Treaty' villages were clustered based in OTML support Cluster 1 'OTDF' the villages of Sui, Parama, Katatai, Cluster 2 'Treaty' Mabuduan, Sigabaduru, Ber and Buzi, Cluster 'None' Tureture, Mawatta, Tais, Mari, Jarai and Bula. A comparison of selected MPI indicators for different village clusters was done. Cluster 1 has been targeted by OTDF with compensation and development projects since the CMCA of 2001, Cluster 2 have greater access to the Torres Strait and Cluster 3 does not have these opportunities. There appears to be minimal impact (see Figure 51).

HUMAN DEVELOPMENT INDEX HDI

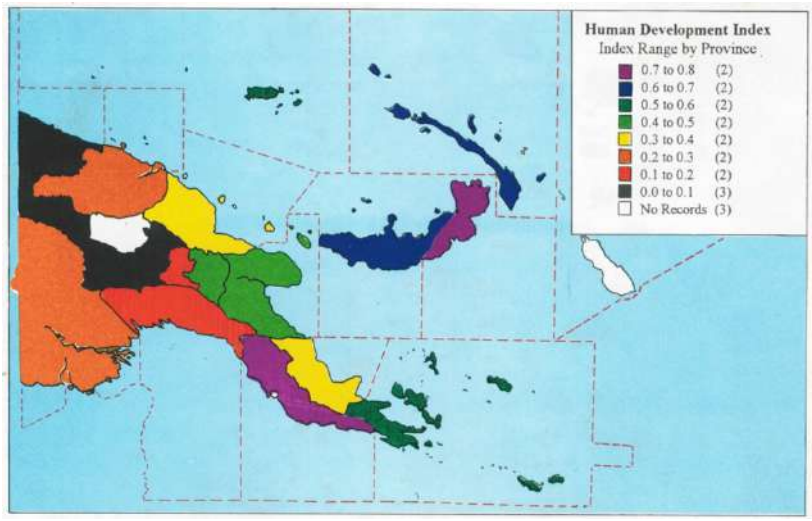


Figure 52. HDI by province PNG 1994. Source Yumi Wankain (1994)

The Human Development Index (HDI) was created to emphasise that the capability of people should be the criteria for assessing the development of a country and in Figure 52, this is also broken down into the various provinces of PNG. It is an indicator used extensively by the United Nations Development Program (UNDP). The HDI is a combination of a Life Expectancy Index, an Education Index and a GNI (Gross National Income) index that is used to reflect the standard of living.

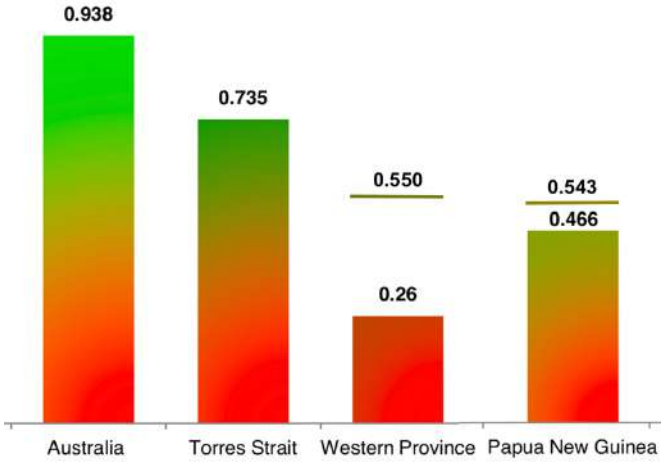


Figure 53. HDI 2011 Western Province in comparison to TS, Australia and PNG, adapted from Busilacchi *et al*. (2014) and lines for Western Province and PNG 2018 HDI

The Human Development Index for the westernmost provinces in Papua New Guinea were the lowest in 1994 with Western Province at 0.2-0.3. Despite the major development of the Ok Tedi mine within the province since 1981 this had not led to any overall improvement of the HDI of this province to 2011 still lying within this range at 0.26. Half the National average and a stark contrast to the communities of the Australian Torres Strait. In the last decade however the Western Province HDI has reached and slightly exceeded the PNG National average from mine investment (see Figure 53). There remains however a contrast across the border between South Fly villages with the villages of the Torres Strait of Australia clearly visible in the living conditions either side of the border that has led to articles (Moran & Curth-Bibb2020), and papers (Busilacchi *et al*. 2018; Moran & Curth-Bibb 2020) on this. It has also led to a 'Treaty Village' program of both Australian and PNG 'treaty villages'.

The government development approach with the fisheries sector is a triple bottom line of social equity, environmental concern and economic development supported by good governance. And that this ideally leads to resource access and use that is sustainable and which leads to equitable sharing of the wealth generated (see Figure 54).

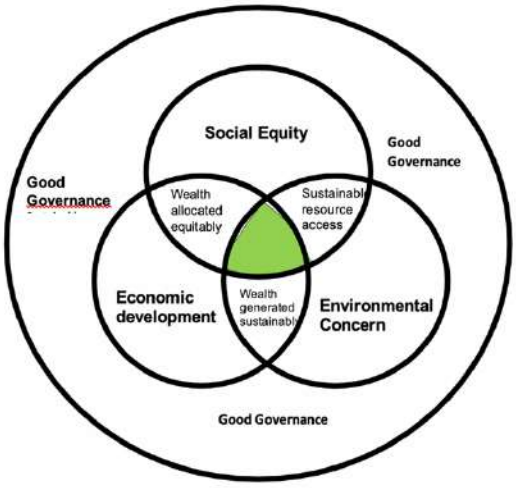


Figure 54. Sustainable Development Framework, Division of Fisheries and Marine Resources Western Province

Recommendation

8. To build on the Division of Fisheries and Marine Resource development framework in the development of the ATSEA-2 supported South Fly EAFM Plan.

SOUTH FLY DISTRICT FIVE YEAR DEVELOPMENT PLAN 2018-2022 AS A CALL FOR DEVELOPMENT

Yet within the South Fly District Five Year Development Plan 2018-2022: Voice of the rising sun: a call for development after 43 years it aimed to be:

A premier district that accelerates to be transformed by empowerment of its citizens in wealth creation through means of coalition participation towards improving; a wealthy, educated and healthy sustainable livelihood for all citizens by maximizing litigation of their cultural ways, and resources extraction for better future by 2022.

The main Activities in this Plan that relate to the ATSEA-2 outcomes are outlined here:

2.11: Sea Areas

The shallow reef area near the coastline is where traditional subsistence fishing activities are done by locals. The sea boundaries extend beyond the Maza reef but much of this is on the Australian side of the border which limits the PNG customary fishing boundaries. Fishing rights in the Border area are only given to commercial companies while similar arrangements for traditional fishing rights have been absent resulting in the illegal fishing in the reef areas.

Indications are that, coastal fishers, men and women are engaged on an "as needed" basis in this activity, not fulltime. There are no full-time fishermen, as no one person is dependent on fishing for subsistence or cash income. Fishing is one source of food and income along with other income earning activities. The multiple sources of income in the villages amongst the island and coastal communities makes it difficult to construct an economic profile for each.

2.17: International Border Security

South Fly as a district situated next to two international borders, requiring measures to be taken in terms of diplomatic agreement, customs, military and quarantine, that factor the consequences of trade, environmental degradation and infectious disease.

A small amount of commercial fishing activities in the wild is occurring now on the Kiwai coastal villages but there are hardly any artisan fisheries activities to increase people's participation in the fishing industry. The current species hunted wild by the coastal villages which are of higher value are, barramundi, crayfish and Jewfish sold to Maru Marine, Aquila Enterprise and other marine buyer/exporters.

4. SPECIES STATUS

One of the Environmental Objectives of the ATSEA Strategic Action Plan developed during the first phase of ASTEA is; 4. The protection of key marine species, which is a further extension of Goal 5 Threatened Species Improving, of the CTI Regional Plan of Action (ProDoc).

The key species of interest in the PNG program within ATSEA are;

SOCI (Socio-Economic & Cultural Importance)

- Dugong*****
- Green Turtle*****

Fishery Species

- Barramundi*****
- Black Jewfish*****
- Mud Crab*****
- Black Teatfish*****
- White Tip Reef shark*****

Those with an asterisk * which is all listed, are also species of interest in the Indonesia program within ATSEA.

Customary species Dugong and Turtle

Two marine species within the South Fly of the Torres Strait are of significant cultural importance, the dugong and the marine turtle which pose particular challenges for, and test the capacity of, PNG and Australia to secure their future survival. This bilateral responsibility between these governments to manage marine turtle and dugong resources comes under the *Torres Strait Treaty 1984* which allows for marine turtles and dugongs to be hunted in Torres Strait waters by Australian and PNG Torres Strait Traditional Inhabitants (Roe 2010) (see Figure 55).

The Treaty recognises the rights of both countries to Protected Zone commercial fisheries. This recognition is implemented through cooperative management and catch sharing provisions of Part 5 of the Treaty. Since the Treaty was ratified, Australia and PNG have entered into formal arrangements under Article 22 to cooperatively manage six fisheries, referred to as 'Article 22 fisheries'. These are the commercial fisheries for prawns, tropical rock lobster, Spanish mackerel, pearl shell, and traditional fisheries for turtles and dugong.

Figure 55. Past catch of dugong and turtle

The dugong is deemed to be a threatened migratory mammal and recorded as Vulnerable A2bcd+4bcd version 3.1 (2015) on the IUCN Red List of Threatened Species and is listed in Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The convention recognises them as animals threatened with extinction which are or may be affected by trade. The Green turtle is Endangered A2bd version 3.1 (2004).

The challenge for Australia and PNG is to find the right balance that allows traditional inhabitants to hunt turtle and dugong, while ensuring that the species remain both culturally and ecologically sustainable.

Within PNG Rights-based Management (Strengthen Collective Values) means working with subnational stakeholders, including the Provincial Administration, Local Level Government Administrations, and the Treaty Villages Council, to design and deliver an awareness campaign focused at the community level. Awareness activities will include understanding the value of endangered species including marine turtles and dugongs. Scope: The Treaty villages (ProDoc 2.1.1-13).

Management

These two species are often lumped together due to their customary significance though the hunting of both is subtly different. This has led to their management also being brought together within the *Moro Momoro Gamo* [Dugong and Marine Turtle] Management Plan 2014-2017 that is yet to be revised. See Figure 56 for the area covered under this plan and proposed management zones.

Vision

A health South Fly Ocean with sustainable populations of dugongs and marine turtles and other species to meet the aspirations of the Treaty Community people protect their natural and cultural heritage.

The plan was developed through a consultative process of representatives from South Fly Coastal Villages

Of note within the plan, it aimed to:

i. To eliminate illegal commercial or semi-subsistence harvest of turtle and dugong by the traditional inhabitants, and to

ii. Collect and maintain relevant marine turtle and dugong data.

And to have *Moro Momoro Gamo* rangers to, in part, oversea these and other aspects of the plan.

It seems these aims were not achieved, and therefore determining the reasons from the members of the *Moro Momoro Gamo* Plan Steering Committee, representing a broad range of communities, government agencies and local NGOs is important, as it was to inform a TAC. Without extensive catch data by village this can-not be achieved.

Within the plan cultural protocol was outlined and if within language represents Customary Law that can be built upon in addition to applying the *Flora (Protection & Control) Act* (1978) in revisiting the plan, its future revision and implementation. The plan and froward planning would also benefit from population and catch survey data. In its absence the precautionary principle needs to be applied.

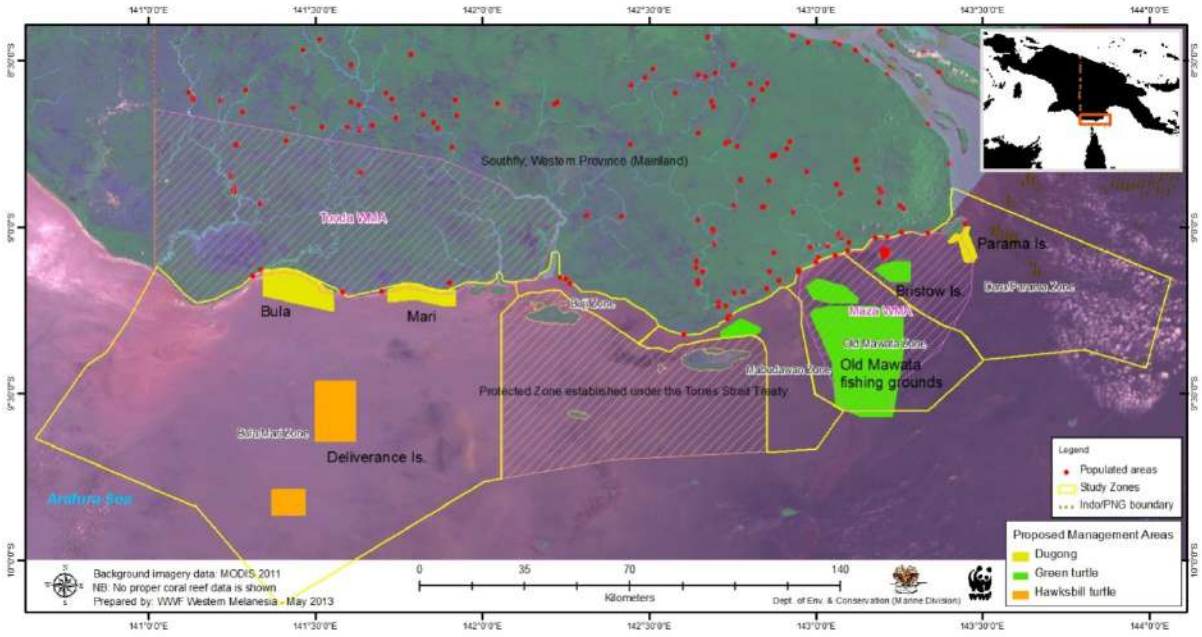


Figure 56. Map of the *Moro Momoro Gamo* area indicating proposed dugong and turtle management areas

DUGONG *DUGONG DUGON* (MÜLLER, 1776) PALMER, 1895

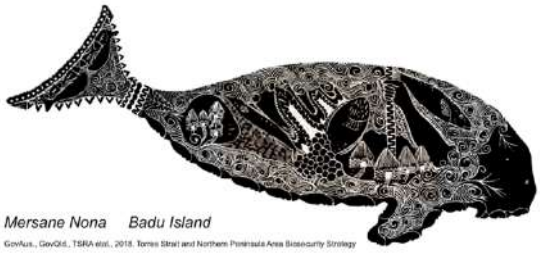


Figure 57. Dugong painting, by Mersane Nona

Figure 58. Dugong Hunting Charm, Kiwai

Summary Status

Current and past harvest estimates by the communities along the Papua New Guinea coast are not known because data from these areas are not available (Marsh *et al.* 2004).

Recommendations

9. In the absence of survey informed estimates of Dugong in the South Fly that efforts are made to determine their population numbers. It is suggested that dugong sightings and catch, utilised for custom or sold the Daru market is recorded and maintained by the Village Recorder. Basic data on date, place, sighting, method of take and what was done with the dugong. For dugong sold in the Daru Market additional data on prices to be recorded.
10. The definition of customary take and customary use of dugong is revisited and redefined.
11. That the rules in relation to Dugong take and use within Maza WMA is revisited and also to inform discussion on take outside of the Maza WMA.
12. That this data informs adaptive revision of a rolling *Moro Momoro Gamo* Management Plan

Habitat

The ecological zone within which dugong are found are extensive seagrass beds that they graze. When feeding on the preferred seagrasses, dugongs dig up the whole plant including the nutrient-rich rhizomes (Heinsohn & Marsh 1978; Marsh *et al*. 1982). This produces the distinctive feeding trails that are seen particularly in low biomass seagrass beds. Dugongs consume between 28 and 40 kg of seagrass each day.

There is evidence also that where there is periodic dieback of the seagrass beds that dugong require for foraging, that this may cause heightened mortality and large-scale movements such as those observed in the Torres Strait (Marsh *et al.* 2004). Episodic dieback of hundreds of kilometres of seagrass beds have been recorded in association with extreme weather events such as cyclones and floods that cause increased turbidity and inadequate light environments for seagrass growth (Johannes & MacFarlane 1991; Preen *et al*. 1995; Poiner & Peterkin, 1996). The effect of such dieback on dugongs is twofold. Some remain in the area but lose body condition, delay breeding and suffer increased mortality, while others move hundreds of kilometres with unknown consequences (Preen & Marsh, 1995; Marsh *et al*. 1996). This underlying ecological reality must therefore be considered in understanding variable dugong numbers in our data.

Life History

Life history studies of dugongs indicate that the dugong has a lifespan of up to 70 years, a minimum pre-reproductive period of 9 to 10 years, with the female bearing one calf at a time at intervals of 3 to 7 years. Low juvenile and adult mortality rates are required to maintain a dugong population and the most optimistic schedule of reproduction and juvenile mortality demands an adult survivorship of about 90percent per year for-population maintenance (Marsh 1984).

Therefore, the life history of dugongs with low fecundity and slow development, does not provide the necessary potential population growth to sustain large harvests and areas closed to hunting

are unlikely to be effective when harvesting rates elsewhere remain high. We urge a target reduction of harvesting to no more than 100 dugongs per annum in the Torres Strait, bearing in mind that even these rates of harvest entail a high risk of quasi-extinction if the dugongs breed at the slower rate used in our models (Hudson 1986).

The overall population.

Despite this localised hunting the dugong meta-population in eastern Australia and New Guinea is contiguous, with potential movements over hundreds of kilometres (Marsh & Rathbun 1990; Preen 1995). High rates of harvest in one area may be offset by a low rate in an adjoining area.

There are large fluctuations (range=13319–27881 dugongs) that cannot be accounted for by the effects of either harvest or intrinsic population growth alone. Marsh *et al*. (2004) concluded that large numbers of dugongs periodically move into and out of the Torres Strait, probably as a result of dieback of important seagrass beds. Thus, it is difficult to determine how much of a population decrease is due to migration versus harvesting.

Though Marsh *et al*. (2004) and Heinshon *et al*. (2004) modelled that current rates of Dugong harvest in the Torres Strait are unsustainable many factors used in this assessment have been critiqued leading to a more optimistic projection (Helene Marsh pers comm 2021). This does not disregard the need for local community involvement in the management to establish sustainable rates of dugong harvest however. Marsh *et al*. (1997) observed that dugongs and the more abundant turtles are often hunted together from the same boat. Thus, search effort by indigenous people probably remains high regardless of dugong rarity.

Surveys

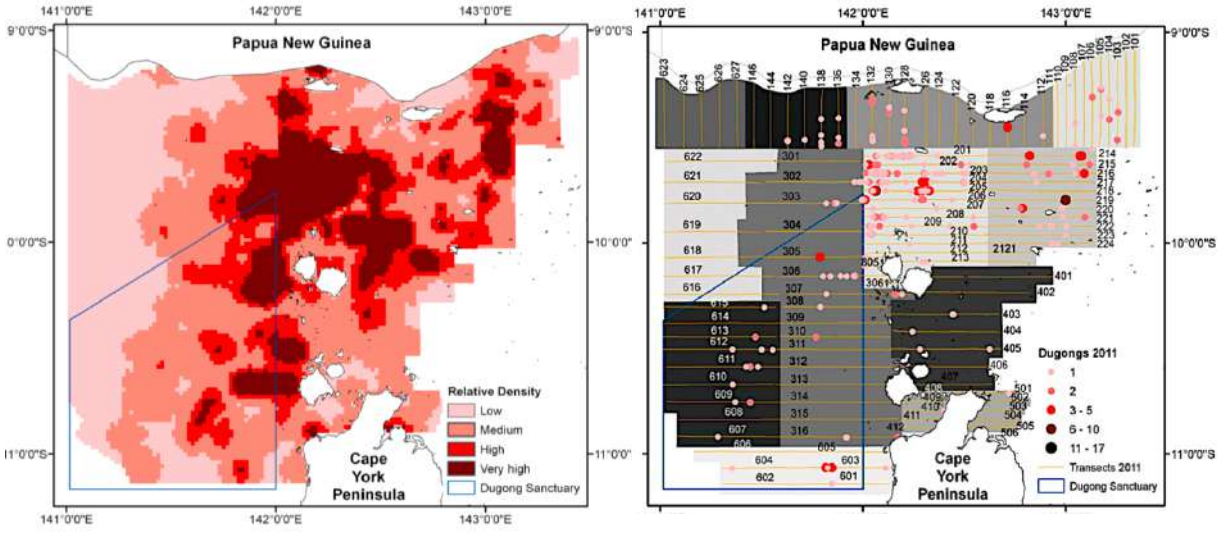


Figure 59. Dugong population model density from 1987, 91, 96, 2001, 05, 06, 11 Surveys, from Marsh *et al*. (2011)

Extensive ongoing aerial surveys for dugong have been done within the Torres Strait in the years 1987[N], 1991[N], 1994[D*],1996[N], 2001[N], 2005[N*], 2006[N]. ([N] November [D] December [*]partial survey) (Grech 2011). However, these have not within the proximity of the coastline where waters are often turbid with runoff from the extensive river network that drain into the northern Torres Strait. The main density of dugong also lies within the central Torres Strait (see Figure 59).

The sustainable take from the Torres Strait population varies between reports. From early surveys Marsh & Saalfeld (1991) suggested that if the dugong population were increasing maximally, this region could support an unselective man-induced mortality of 700 dugongs per year.

Population estimates on which the analyses of Heinsohn *et al*. (2004) and Marsh *et al*. (2004) were based were possibly negatively biased leading to low abundance estimates (Hagihara *et al*. 2016). Whilst more recently the sustainability of the Torres Strait harvest was re-evaluated based on the relative density being significantly higher in 2013 than in any other survey year and the index of Area of Occupancy has trended slightly upward since 1987 (Marsh *et al*. 2015; Hagihara *et al*. 2016).

Locally from observation however the situation is different

"If we do not protect rare, threatened and endangered species now, they will not be there for the children. They will only be heard about in our legends. We want dugongs for their ceremonial meat and we want this to continue for future generations. There has been a serious decline in dugong numbers. When I was small, I could stand on the beach and watch my father or brother harpoon a dugong – now there is nothing out there. It is only through luck that you will find them. People are blocking their channels with nets. Improvement depends on law enforcement and implementation of the Dugong and Turtle Plan." (Management Committee member, Maza WMA) (Leverington *et al*. 2017).

Within these extensive surveys those proximal to Daru and were hunted by PNG based hunters are within the survey block A1. Also, incomplete market survey figures were taken 1979 and 1981 though trending downwards offer a base figure (see Figure 60). Dugong as bycatch in nets used to target other fish e.g. Jewfish has increased, a factor that now needs greater consideration.

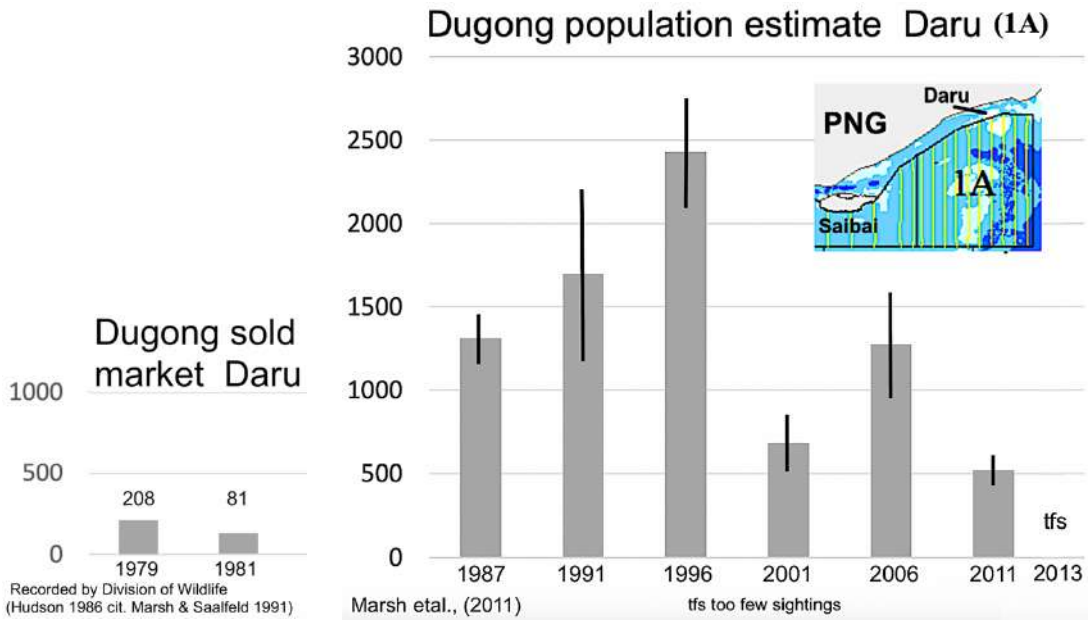


Figure 60. Dugong Survey Data near Daru

Customary Hunting

Along the SW coast canoes were used for hunting dugong and turtle. In former times, dugong were also hunted from stationary harpooning platforms (*narato*) (Lawrence 1994) (see Figure 59).

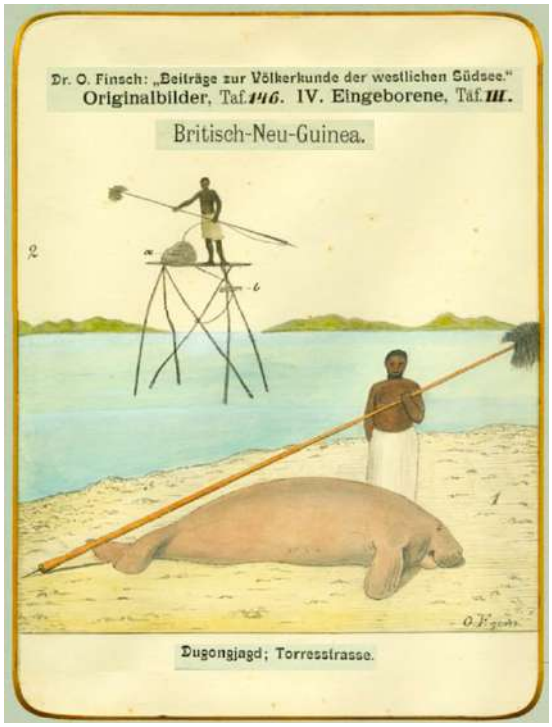


Figure 61. Traditional platform hunting Finsch *circa* 1912; b charm as in heading

The technique of using a dugong harpoon was taught to the coastal Papuans by the Torres Strait Islanders along with rituals and magic used in association with hunting (Landtman 1933 cit. Lawrence 2010) (see Figure 61).

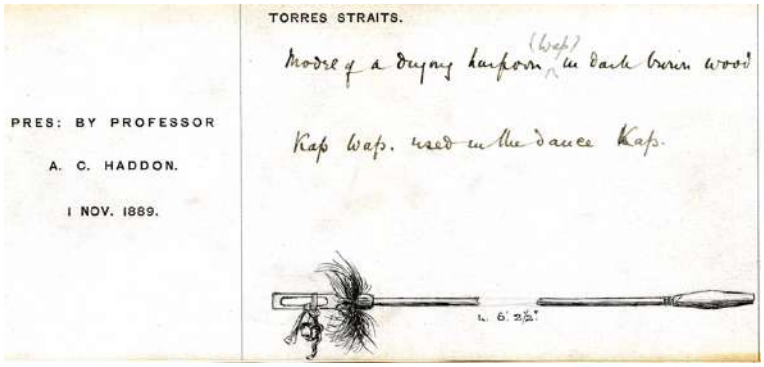


Figure 62. Drawing of harpoon by Haddon (1889) in the British Museum

The harpoon *wapo* (Kiwai) was used by both Islanders and coastal Papuans in hunting dugong. This consisted of a small barbed head, often made from a piece of broken harpoon shaft, inserted into a terminal hole in the butt end of the harpoon. The harpoon dart was attached to a long buoyant rope which was tied, either to the canoe, or in former times, to the dugong platform (see Figure 62). The harpoon, especially the butt end, was often made from *wongai* wood traded from the Papuan mainland, which was considered more suitable to that found on many Torres Strait islands. The shaft ends of the harpoons, in former times, were often decorated with cassowary feathers and the butt end finely carved or incised (Haddon 1912).


NATIVES AT BADU NEW GUINEA-CUTTING OF DUGONG

Week, Friday 9 Dec 1910 pg. 21

Figure 63. Early interest in hunted dugong 1910

"Speaking on behalf of Papuan dugong hunters in Torres Strait, Olewale and Sedu (1980) said:

Older people know a lot about the biology of these animals. We want to work with scientists, but we do not want to see money wasted on finding out things we already know. We can provide this information if we are asked. We are not saying that we know everything about them, but that we, the village people, and you, the scientists, must co-operate and share knowledge, because we want to learn more too. " (emphasis added);

The dugong is *regarded as a very important animal among the Gizra Tribe generally. It* is *known as "Gisu" or "malubarr pam" meaning man of the deep sea. Gisu we believe is a human being in a form*

of a dugong. The dugong resembles a human being in many ways in appearance and in behaviour and senses.

Members of Gizra tribe not allowed to eat dugong because of the dugong's large size and strength, many islanders and inland groups believe that use of certain parts in ritual ceremonies would make plants and humans strong and healthy and so they claim it as a totemic animal. They believe the dugong has magical religious powers associated with agriculture fertility rituals. It is used to fertilize the Gizra Tribe's gardens and crops.

The dugong is a totem animal for some clans of inland villages like Dimiri and Kupiru (Kupere).

Residents of the five villages occupied by members of the Gizra Tribe have also been engaged in traditional cross-border movements since long before Papua New Guinea's Independence in 1975 through to the present day. Residents of the five villages of Barnap, Kupere, Ngomtomo, Togo and Waidoro occupied by members of the Gizra Tribe have also been engaged in traditional cross-border movements since long before Papua New Guinea's Independence in 1975 through to the present day and residents of those five villages have been acknowledged amongst traditional inhabitants in Papua New Guinea and Australia.

The local cultural perception of the dugong is unbelievably widespread throughout the entire Torres Strait Region, the inland Papuan villages and the coastal Papuan villages.

Dugongs sense movements of men during the day and in the night. It has acute hearing and sensing ability. The dugongs' behaviours show that they can sense tide movements, the weather and different feeding areas (O'Gorman 2009).

Hunting

Historically, the Kiwai were subsistence hunters and prior to World War 2 probably killed only 25 dugongs per year. This increased to about 75 per year during the 1950s and 1960s, as the Kiwai population increased and became more westernized. A commercial fishery introduced in the 1970s used strong nets to trap barramundi, but these nets could also entangle dugongs and as a result an expanding market for dugong meat was established. Dugong numbers declined rapidly. In 1976 the Papua New Guinea government made the dugong a protected animal, allowing only traditional hunting and usage. The government suggested to the Kiwai that they become involved in the management of their dugong population, through creation of a Wildlife Management Area. An extensive community education and conservation programme was funded from 1978-81, and was successful in engendering enthusiasm for conservation measures. However, the conservation measures appear to have come too late, as numbers of dugongs sighted continue to decline. The interaction of commercial fisheries with non-target species needs to be evaluated in any future case before new technology is introduced (Hudson1986).

Within Chapter 154D of the *Fauna (Protection and Control) Maza Wildlife Management Area Rules* 1979 [as in force 2001 dated 2006];

2. TRADITIONAL HAND-HARPOON METHOD MAY BE USED.

A person may at any time take or catch a dugong within the Area by the traditional hand-harpoon method from a canoe, whether powered by out-board engine or otherwise (see Figure 64).

3. RESTRICTION ON NETTING DUGONGS.

(1) A person must not take or catch a dugong within the Area by means of a net except–

(*a*) during the months of May, June and July; and

(*b*) in the immediate area of Daru Island.

(2) Where a net is used to take or catch a dugong the mesh size must not exceed 25.4cm.

5. SELLING OF DUGONGS.

(1) A dugong taken or caught within the Area may only be sold in the market at Daru (see Figure 65).

Prior to sale it is supposed to be shown to a Wildlife Officer [none now in Daru], a Maza WMA Committee or anyone authorised by these. It is presumed to determine how it was caught and to maintain a record of the characteristics of the individual. However, the market at Daru is such that fishers come and go through any hours

Figure 64. Traditional dugong hunting from canoe

Figure 65. Dugong for sale Daru Market 2021 g.a.

GREEN TURTLE *CHELONIA MYDAS* (LINNAEUS, 1758)

Figure 66. Turtle Charm Western Province.

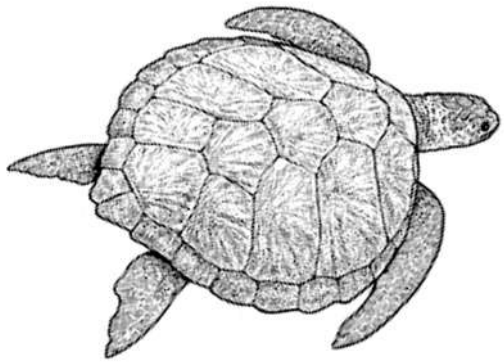


Figure 67. Line diagram adult Green turtle

Summary Status

As for dugong current and past harvest estimates of turtles green and hawksbill by the communities along the Papua New Guinea coast are not known because data from these areas are not available. Which migrating populations these come from i.e. nesting rookeries on the Solomon Islands, Eastern PNG, or Cape York/north Great Barrier Reef is also unknown

Recommendations

13. In the absence of survey informed estimates of Green [and Hawksbill] turtle in the South Fly that efforts are made to determine their population numbers. It is suggested that turtle sightings and catch, utilised for custom or sold the Daru/other markets is recorded and maintained by the Village Recorder. Basic data on date, place, sighting, method of take and

what was done with the turtle. For turtle sold in the Daru Market additional data on, size, sex and prices to be recorded.

14. South Fly District Five Year Development Plan 2018-2022The definition of customary take and customary use of turtle is revisited.
15. That the rules in relation to turtle take and use within Maza WMA is revisited and also to inform discussion on take outside of the Maza WMA.
16. A program of DNA sampling of turtle take, to determine which population they are from.
17. That this data informs adaptive revision of a rolling *Moro Momoro Gamo* Management Plan

Habitat

Within the South Fly this is mainly adult stage habitat of feeding grounds, sea-grass during a migration, both male and female, though the male may migrate annually the female every two, three or four years (Hirth 1993).

Life History

Turtles are a migratory species that spend large periods of time in a narrow range of foraging ground and in seasons migrate to rookery sites where females lay a series of clutches of eggs (see Figure 68). Both of these critical environments and to some extent ocean currents are being altered by sea surface temperature, sea level rise and seasonal variation. Many rookery sites are being eroded due to sea level rise and sea surge. Also, more nests lie within higher temperature ranges leading to female turtles in the order of >95% female in our region.

Figure 68. Satellite track map of Green turtles from rookeries Milne Bay, by ECA (2018)

Fishermen in Daru caught and sold at the market in Daru an estimated 222 green turtles in 2012/2013, which was lower than the estimated 608 green turtles in 1995. The greatest decline in catches was observed on the home-reefs around the PNG Islands and reefs adjacent to the villages. In 1995 green turtles sold at the market in Daru were exclusively taken during dedicated hunting

expeditions, while in 2012/2013 half the turtles sold at the market were caught as by-catch during fishing trips whose main target were other species. Harpoons were still the main fishing gear used for turtles in 2012/2013, but the use of other fishing gears such as dragnets and gillnets had a 46% increase. No turtles were recorded in Sigabaduru during the surveys, while in Bula only 10 green turtles were caught in 2012/2013 (Busilacchi *et al.* 2014).

While in 1995 turtles were caught half of the time on reefs around the villages, in 2012/2013 most of the turtles were taken on Auwo maza. In 1995 turtles sold at the market were exclusively taken during hunting expeditions, since the traditional harpoon was the most used method (see Figure 69). The situation changed in 2012/2013 when, presumably, turtles sold at the market were caught in half of the cases as by-catch, during fishing trips whose main target were other species.

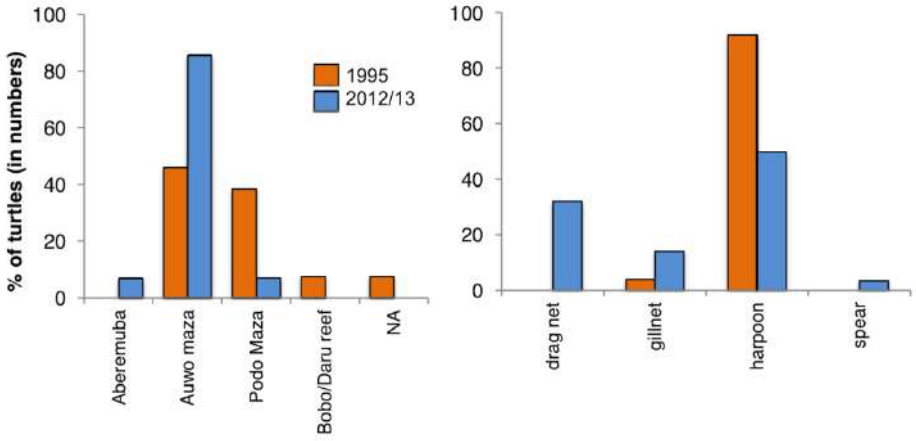


Figure 69. Percentage of Green turtles hunted by area and by method, from Busilacchi *et al.* (2014)

Whole turtles were selling at PGK200-300 or in pieces PGK15-30, in the Daru 2013/14 (Busilacchi *et al.* 2014)

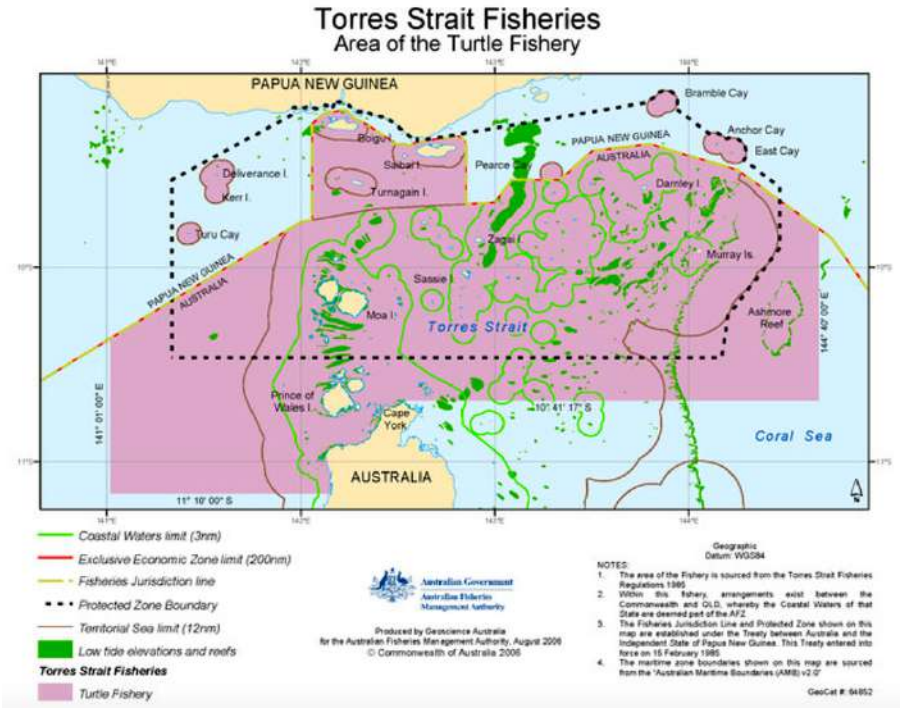


Figure 70. Turtle Fishery within the Torres Strait Protected Zone and greater Torres Strait

Data collation of these two species is very vague especially from Papua New Guinea side but from the Torres Strait Islands there have been workshops conducted to show how to collect data, so data is available on harvests migration and other information on dugongs and turtles.

Lack of information or reports from various government agencies that critically look into illegal harvests, trade and exchange of these two species at a larger scale requires resolving. Such data is required to help resolve the concern of unsustainable harvest and trade of dugongs and turtles. Greater emphasis and responsibility should be placed on local participation by communities in the South Fly coastal villages to collect data on catches and trade of dugongs and turtle (see Figure 70).

Adaptive co-management requires monitoring data that is accessible and credible to the resource users (i.e. the local fishers and communities a) that is clearly linked to the management objectives determined by communities with agency input . Otherwise, community members might not trust management decisions or see the need for investing in monitoring (Jillian 2011).

Workshops and Trainings

Workshops programs developed by donors often target Government official, NGOs, and only a handful of local people to participate, neglecting the whole community at large. Often the results are not very successful because whatever information is received from the workshop is not put to its full use.

From the Australian perspective illegal trade of these species has been a major problem in these two regions of the Torres Strait because not every catch is regularly monitored or were it ends up is not regulated. Countless awareness trainings and workshops have been conducted in Daru and the Torres Strait Islands yet illegal trade is not stopped and harvests of dugongs and turtles are still seen in Daru market today. Torres Strait Islanders have strongly supported the idea of strong law enforcements to curb over harvesting of dugongs and turtles and also want the PNG side to do the same.

Recommendations

18. Develop audio-visual materials such as a video, resource material workbooks, posters in English and local language. These to target intergenerational customary legends, recalled past hunting with a target of students and hunters.

19. Learn from initiatives within the communities in Torres Straits Islands such as indigenous ranger programs, research extension and management of turtles in their context and within the *Moro Momoro Gamo* Management Plan develop a cross border program.

BARRAMUNDI *LATES CALCARIFER* (BLOCH, 1790)

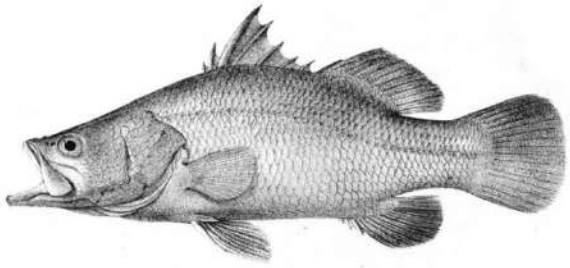


Figure 71. Line Diagram of Adult Barramundi

Status

Currently there are no recent surveys that indicate the status of the stocks of Barramundi in the South Fly. Though once abundant in the estuaries and inshore areas the fishery was overfished and stocks collapsed from the early 1990s.

Life History

The migration of barramundi in Western Province; adults migrate out of the lake and river systems of the Western and Gulf provinces of Papua New Guinea to spawn in the coastal waters west of Daru Island. Larval barramundi then migrate into the coastal swamps along the western margin of the Western Province where they transform into juveniles. Later these juveniles migrate into

coastal waters from March to August from where they penetrate upstream into the river systems of the Western and Gulf Provinces (Moore 1982) (see Figure 72).

A small scale commercial artisanal fishery is based on this annual migration pattern of the barramundi along the Daru coastline from Sui village in the east to Mabadauan village in the west. A small scale commercial artisanal barramundi fishery is also based in the inland waters.

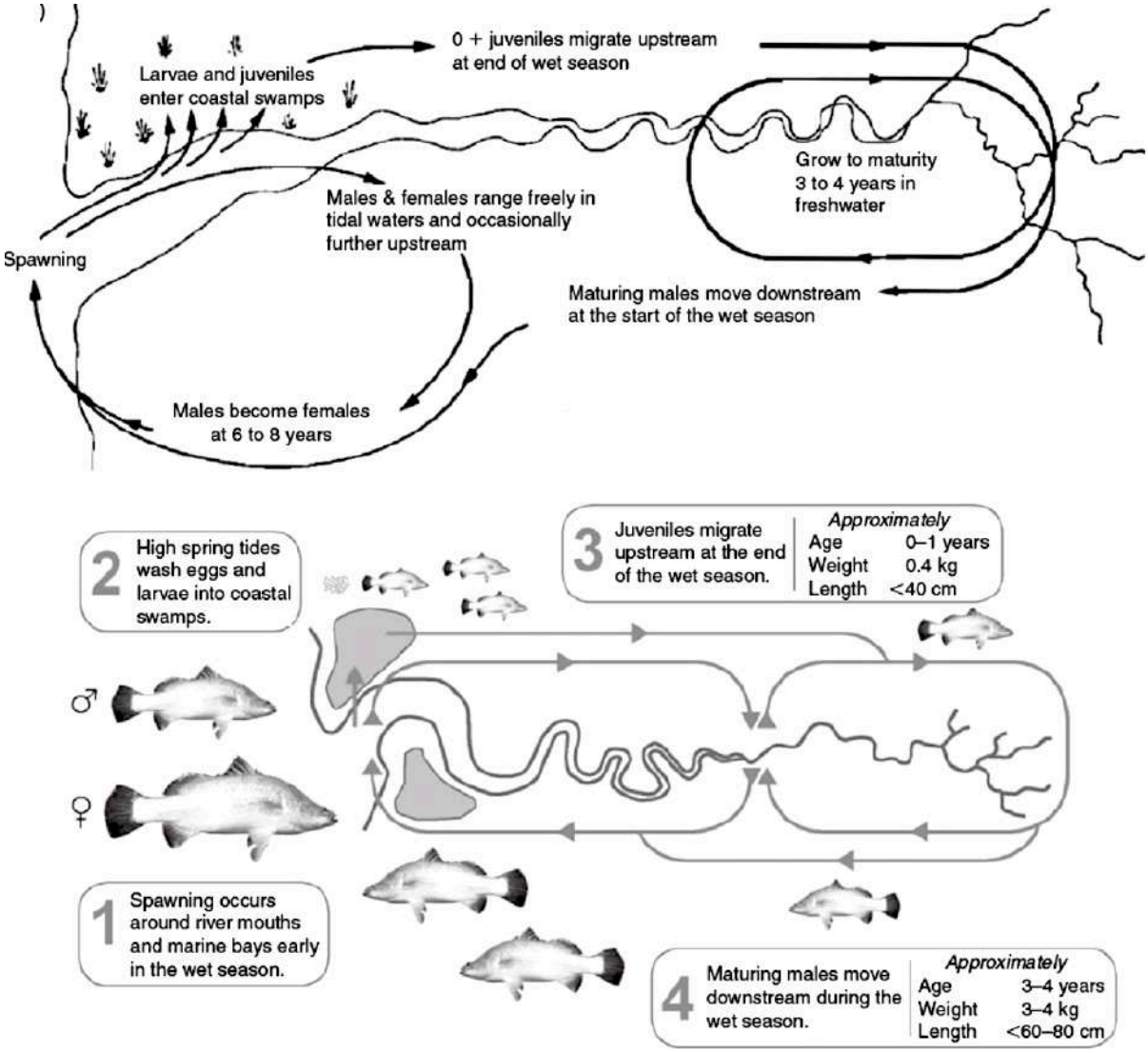


Figure 72. Life History of Barramundi

Regulations and the Barramundi Fishery Management Plan

The BFMP was passed into PNG law on the 15th of April 2003 and gazetted by the PNG Government on the 16th April.

The objectives of the BFMP are:

1) To protect the barramundi stock in the management area from depletion or stock decline;

2) To ensure sustainable fisheries development practices for the participation and benefit of traditional resource users.

The management measures in the plan include the following key elements:

1) There are licensing requirements for fish buyers, fish export facilities, fish storage facilities and collector vessels - under the plan, licences cannot be issued to non-citizen companies, individuals or joint venture arrangements and preference is given to traditional resource owners. The plan also prevents products for export from being moved to another province for sale or export without clearance from the NFA.

2) The total allowable catch (TAC) is 260 tonnes per annum - the NFA is required to close the fishery as soon as the TAC is reached.

Fishing prohibitions include:

1) Size restrictions preventing barramundi with a total length of less than 36 cm from being taken for sale or export;

2) The owners of licensed collector vessels are prevented from catching barramundi;

3) There are gear restrictions on the nets that can be used in the fishery, in particular the plan prohibits the use of:

    a. gill nets and beach seine nets with a mesh size greater than 6 inches (15 cm);

    b. gill and beach seine nets with mesh size between 2.5 inches (6.35 cm) and 5 inches (12.7 cm) during the peak period of juvenile recruitment (1 March – 30 April) in the coastal waters from Sui village in the east to the PNG/Irian Jaya border in the west;

    c. gill nets with a mesh size greater than 5 inches (12.7 cm) during the peak migration period (1 September – 31 October) in the coastal waters from Sui village in the east to Buzi village in the west.

4) The main spawning and breeding grounds between Sigabaduru village and the PNG-[Indonesian] border are closed to commercial fishing during the peak spawning period (1 September – 31 October) each season;

5) There are reporting requirements for exporters and collector vessels.

An important part of the management plan was the formation of the Barramundi Management Advisory Committee (BMAC) composed of government, technical, community and industry representatives. According to the BFMP, the committee should meet once a year to monitor, review and recommend any changes required to the legislation as the fishery changes. However, this has not happened.

The TAC of 260 tonne was not reached by the commercial catch of 200–300 tonnes of barramundi per year during the late 1980s and therefore was set above the maximum sustainable catch. There is also no village level TAC provision within the plan.

Fundamentally, this means that the BFMP does not address the issue of property rights. There therefore remains an incentive for individuals (or villages) to contravene the regulations

Despite these regulations, their enforcement has been almost non-existent.

Recommendation

20. Modifications in the regulations now in place should be undertaken and the powers for the enforcement of the regulations should be given back to the local level Governments as a strategy to support localised enforcement of the management of localised fished resources in collaboration with the District Fisheries and gazetted Fisheries Inspector

In earlier management of barramundi in 1983 (Prohibition notice (No. G67)) to preserve the stocks of barramundi and prevent growth overfishing, management directives banning the sale of undersize or juvenile barramundi 10-50 cm fork length (age classes 0+, 1+ and 2+) in the market on Daru Island. Then and now, undersized or juvenile barramundi have become a common item at the market in Daru, the main urban centre, mainly because of an increase in the population of unemployed people who settle around the town. Before the collapse of the commercial fishery between 20-60 undersized barramundi were sold daily at the Daru market, representing an annual harvest of about 15,000 fishes (1989 personal observation cit. Mobiha 1995).

Commercial artisanal fishermen in their fishing licences were required to and kept barramundi catch and/or purchase data in log books produced by the Department of Fisheries and Marine Resources. This was then analysed to determine total numbers caught, sizes caught, sex ratios of the individuals caught, total weights of the individuals caught, areas they catch the barramundi and times (months) at which catches/purchases were made.

A lot of inspection and surveillance work has never been done and this led to fishers breaking the measures set in part due to lack of properly trained and qualified staff and lack of staff initiatives to enforce these regulations.

The past fishery

The commercial barramundi fishery was established in the late 1960s and early 1970s, with processing and distribution centres set up in the province. By 1969 there were three types of commercial operations established (Blaber 2003):

i) Daru-based artisanal coastal fishery was using gill nets to target mainly adult barramundi that were migrating to breeding grounds west of Daru near Sigabaduru village during September–January (late dry season – early wet season);

ii) Refrigerated fishing vessels were operating with their own gill nets and also bought catch from artisanal fishers;

iii) Village-based freezers of five tonnes capacity had been set up at selected villages in the middle Fly River and the Fly River mouth regions. These freezers were operated by village cooperatives that sold their catch to the Daru wholesalers or the refrigerated boats.

By the mid 1980s, the total catch of the commercial fishery had reached around 200–300 tonnes/year, caught mainly in the Daru area. However, the annual catch of the Daru-based fishery declined significantly in the early 1990s, to as low as 4 tonne/year. This decline led to the closure of much of the commercial fishery.

Artisanal fishers in the coastal region around Daru and in the Fly River delta mostly sell their catch to the three commercial fish processors based in Daru. Freezing facilities were established at selected villages, but not all of these are still functional. The fishing companies based in Daru send collector vessels to pick up the catch from nearby villages. The Daru-based fishing companies are privately owned and sell the processed barramundi mainly in domestic markets, although barramundi are at times exported to Australia (M. Maina pers. comm. 2009 cit. Fisher 2010).

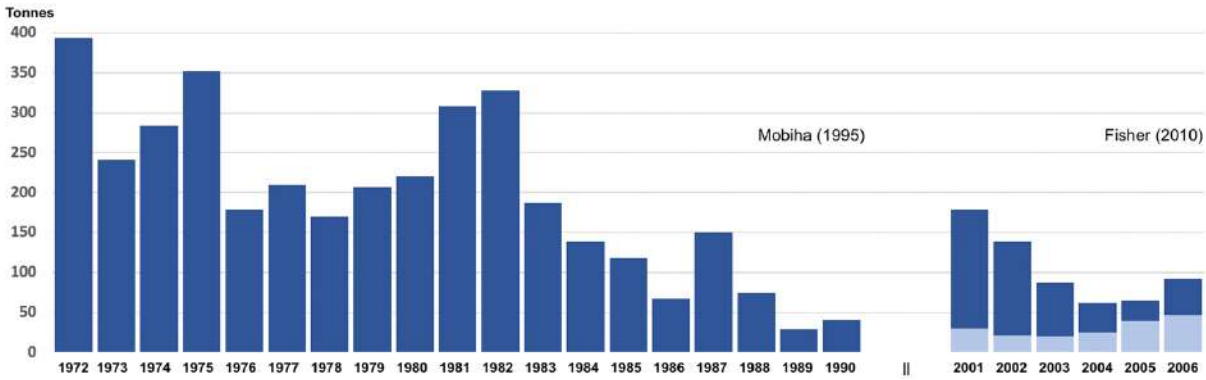


Figure 73. Barramundi catch landings Western Province (from 2001 light blue, Daru; dark blue, Obo, Middle Fly)

The unregulated commercial operations collapsed because catches had plummeted to about 4 tonnes/year. Although the commercial fishery virtually ceased, the fish nevertheless remained important economically for artisanal fishers in Western Province (see Figures 73 & 74).

Rehabilitating the barramundi populations in Western Province thus became an important issue.

Several other factors seem to have prevented the BFMP from delivering greater benefits to the community:

1. Inadequate enforcement;
2. Failure to deal with the problem of over-fishing with lures;
3. A total allowable catch that appears to be too high and may not be enforceable anyway.

Without meaningfully restricting fishing effort (including restrictions on entry), any fisheries management plan is unlikely to deliver significant long-term benefits to fishers.

It is essential for fisheries plans to be updated regularly as circumstances change and to carefully consider the size of the markets (Mobiha 1995).

The period 2001-2006 to the present

While there are no data measuring the catch sold in local markets and for own consumption, it is estimated that these outlets account for around 40% of the total barramundi catch in Western Province (I. Middleton pers. comm. 2009 cit. Fisher 2010).

Lure fishing has therefore become increasingly popular among artisanal fishers in the region. Lures cost around 35–40 kina, compared with around 2,000 kina for a gillnet. Artisanal fishers have also become increasingly skilled at catching barramundi using lures (I. Middleton, pers. comm., 2009 cit. Fisher 2010). It is now estimated that most barramundi in the coastal fishery are caught using lures (M. Maina pers. comm. 2009 cit. Fisher 2010) and their use is also increasing in the middle Fly region (I. Middleton pers. comm. 2009 cit. Fisher 2010).

The increasing use of lures is likely to erode both the benefits (the lower probability of total stock collapse) and the costs (the lower annual catch) of the BFMP.

The reduction in total annual barramundi landings each year has been due largely to recruitment overfishing (i.e. catching of juveniles above) and growth overfishing (i.e. the catching of adults before they can spawn). Growth overfishing has occurred for the PNG barramundi fishery since it started as the fishery targeted the annual spawning run. The spawning stock are caught before they can get to the spawning site and spawn. To avoid the problem of growth overfishing, the coastal fishery should operate only every second or third year and or not be allowed to operate in the months of September and October each year (Mobiha 1995).

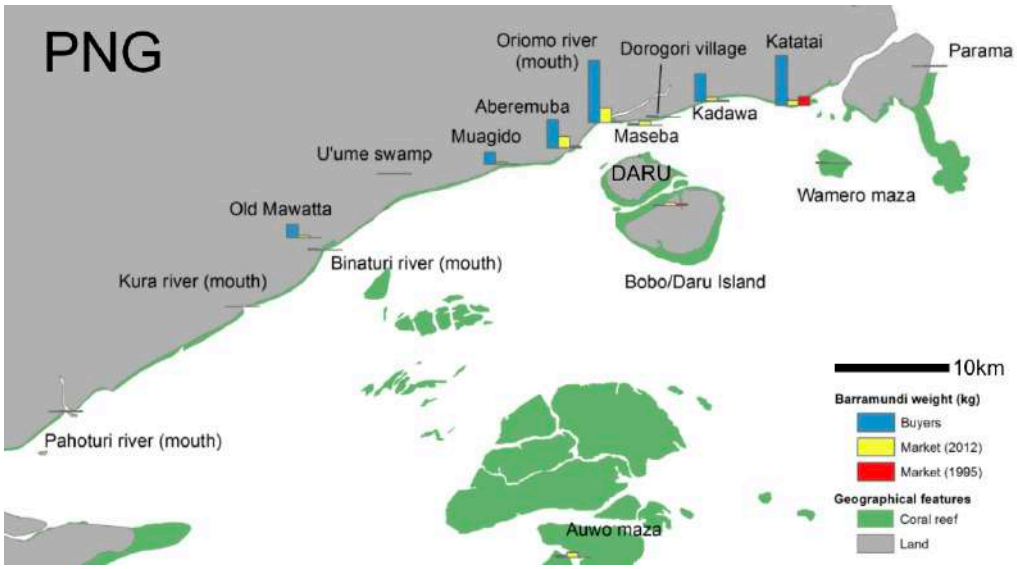


Figure 74. Barramundi annual catch Daru, artisanal 1995 (red bars) 2012/13 (yellow bars) and commercial fishery 2012/13 (blue bars), from Busilacchi *et al*. (2014)

Ecological and social impacts

Total collapse of the barramundi stock would reduce biodiversity in the Fly River and adjacent coastal region, which is an environmental cost. More effective preservation of breeding females therefore reduces the risk of incurring that environmental cost. Total collapse of the barramundi stock could also have flow-on effects for the ecosystem.

However, these possible environmental benefits are difficult to quantify and this has therefore not been attempted.

The BFMP is unlikely to contribute significantly to poverty reduction in the long run, since under open-access conditions artisanal fishers are unlikely to receive more than their opportunity cost of labour at the bioeconomic equilibrium. With few alternative employment opportunities in the region, the opportunity cost of labour is likely to be low.

The BFMP may, however, temporarily contribute to poverty prevention to the extent that it averts the complete collapse of the barramundi stock.

Bené (2006) noted:

... that the role of small-scale fisheries as a poverty prevention activity for the rural poor is crucial from a social point of view, especially in remote areas where alternative employment may be scarce and social security programs either minimal or non-existent.

The possible contribution to poverty reduction also encompasses an increase in food security. Since barramundi is mainly fished for income, this contribution is mainly indirect. However, some barramundi in the region is also fished for own consumption.

Invasive species: Snakehead

There have been reports that exotic species are becoming established in the region, which could have a significant impact on the barramundi fishery. In particular, the Asian Snakehead fish has recently appeared near the main spawning grounds. This species is a predator of juvenile Barramundi (B. Figa pers. comm. 2009 cit. Fisher 2010). The arrival of Asian Snakehead fish will increase the probability of total Barramundi stock collapse (Fisher 2010).

By 2013/2014 Snakehead represented near 2 tonne (8%) one of the most abundant species of the finfish catch and Barramundi/Sandbass 9.2t (38%) in Sigabaduru, whilst in Bula no Snakehead were caught and Barramundi 8t (47%) of the total catch (Busilacchi *et a*l. 2014).

Barramundi Hatchery Daru

The Papua New Guinea Sustainable Development Program Limited (PNGSDP) Board approved a PGK28 million aquaculture funds and started the Daru Hatchery Civil Construction Project. Located next to Daru Airport, its main site includes a barramundi hatchery, storage, administration building and staff accommodation. A world-class bio-filtration and aeration facility, with customised water supply equipment, is capable of producing up to 500,000 barramundi 'fingerlings' (around 10cm) per annum.

The project commenced in late 2007 and in 2010 was operating on a trial basis, with the first batch successfully spawned in November 2010 (Anon 2012).

The fingerlings will supply local farms along the Fly River and cage aquaculture in the Middle and South Fly River. The cage aquaculture is also a social development project funded by the PNGSDP Board (Salim 2008).

This operation wound down and has been reinitiated by South Fly Agribusiness and Aquaculture that is a joint venture between the PNGSDP and Innovative Agro Industries to restock riverine systems with barramundi (Anon 2019).

Black Jewfish *Protonibea diacanthus* (Lacepède, 1802)

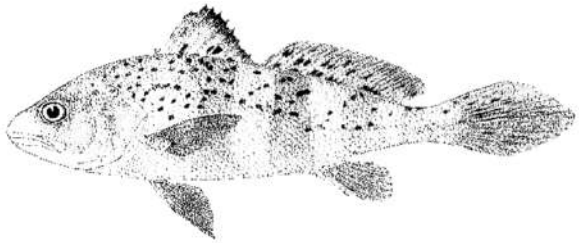


Figure 75. Line diagram of Juvenile Black Jewfish

Status

There are no records of the current status of Black Jewfish stocks in the South Fly, as a high value species that is targeted for its bladder, which is sold on the local market or 'illegal' market. Therefore, there is a high likelihood of overfishing. The amount of 'illegal' sales across the PNG-Indonesian border is unknown.

Black Jewfish is considered a delicacy and aphrodisiac in Asian markets (Sibson 2019). Due to high market demand, there has been stock collapse within its range overseas and in parts of its range in Australia, where insufficient information is available to confidently classify the status of the stock (Saunders *et al.* 2013). In Australia also fishery harvest data for the species are also limited. In particular the contribution of Indigenous subsistence fishers to the total catch is unknown (Saunders *et al.* 2013). From a resource management perspective. there is a dearth of information on northern Australia's Black Jewfish and the demands made on those stocks by the various fishery sectors. Similarly for the South Fly.

Life History

Black Jewfish grow to around 30-45 kg and 1.5 meters long, with a rapid growth rate, reaching 60 cm in around 2 years and sexual maturity in around 4 years at 80-90 cm. It was found that Black Jewfish live for around 12 to 14 years however their growth rate slows up at around 10 years of age.

It appears Black Jewfish possess life-history characteristics which render them particularly vulnerable to over-exploitation in forming predictable aggregations by place and time. Intensive fishing of such aggregations has the potential to seriously compromise the viability of fish stocks. They should therefore be the point of research and management (Sadovy 1996).

Catches of Black Jewfish are very closely correlated with the state of the tide. Black Jewfish came on the bite once the tidal current had changed direction (following the peak of the flood or bottom of the ebb tide) and had attained some momentum.

Catches of Black Jewfish at Muttee Head and Peak Point on the tip of Cape York were greatest during periods at which the moon was near full. Typically. larger catches began three days prior to the full moon and typically remained high for at least six or seven days following (Phelan 2002).

Environmental effects on Black Jewfish

The impact of environmental factors on Black Jewfish is largely unknown. However, juveniles mainly inhabit coastal estuaries and bays, making these phases of their life cycle sensitive to ocean current strength and direction; rainfall; river flow; water temperature, salinity and acidity (DOF 2014).

Sales

Jewfish/Croaker as a percentage of the family level catch sold in Daru increased from 1% in 1995 to 12% in 2013/14 (Busilacchi *et al*. 2014).

The Jewfish meat was returning between PGK40-90 whole in Daru, and PGK20-60 from Indonesian buyers The more valuable Bladder PGK80-200 in Daru and by Indonesian buyers PGK100 at Parama and IDR2000 in Merauke [error of magnitude as this equates to <PGK1] (Busilacchi *et al*. 2014).

Nearby Australian stocks

In the nearby Gulf of Carpentaria (Queensland) management unit, Black Jewfish are taken by commercial net fishers and recreational anglers. Commercial catches 1990-2006 decreased from a reported historical high of 33 tonnes (t) in 1990 to less than 0.5-<6.0t. The overall downward trend in catches and the reduced spawning biomass, combined with the vulnerable biology of Black Jewfish (late maturing, aggregating to spawn), resulted in a 2-year ban on fishing for Black Jewfish in key aggregation areas. In 2002, Queensland prohibited the harvest of Black Jewfish in the north Cape York region (north of Crab Island). No studies have been undertaken to measure recovery in this region or the overall biomass of Black Jewfish in the Queensland part of the Gulf of Carpentaria.

There are no reliable estimates of recreational harvest for Black Jewfish in the Queensland Gulf of Carpentaria, but it is known as a popular recreational species in the region. The Queensland legal size limit (60 cm total length) in the Gulf of Carpentaria is well below the reported age of first maturity for females (85–90 cm total length) and may not be effective in protecting spawning females from fishing. A conservative possession limit (two fish) reduces recreational fishing pressure on the stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock** (Saunders *et al*. 2014).

MUD CRAB *SCYLLA SERRATA* (FORSSKÅL, 1755) *S. SERRATA* VAR *PARAMAMOSAIN* (ESTAMPADOR 1949)

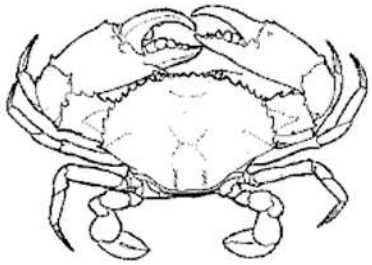


Figure 76. Line diagram Adult Mud Crab

Status

The preliminary crab stock assessment by NFA 2018 for the entire Western Province of 1,176.23km^2 of mangroves at 8.85/ha with a mean weight of 0.346 kg has a biomass of 360 tonnes. The TAC calculated for Western Province is 180 tonnes (NFA 2019).

Data on Mud Crab has been inconsistent in the Daru artisanal fishery and a lack of data for villages. Across its range along the South Fly there is therefore a lack of data. It is anticipated however that the sizes of individuals caught in each village will be an indicator of past fishing pressure.

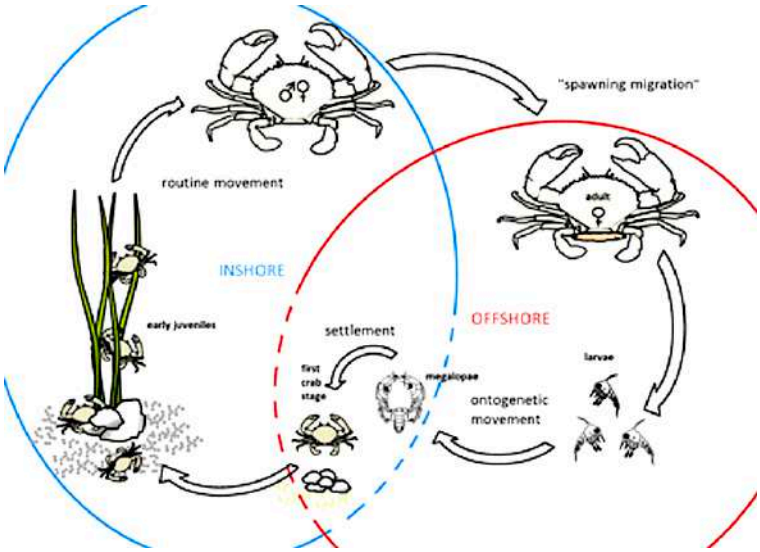


Figure 77. Life history of Mud Crab

Mud Crabs have a life history interaction between the mangrove/inshore and offshore ecological zones. Mud Crab are often found in muddy areas such a mangroves often in burrows, sub adults in shallow water and juveniles are found in more protected areas. Their home range is very localised and therefore management also must be localised. Maturity in the tropics is at around 18 months with the female carapace at 9cm at latitude 10° S. Fertilisation can occur within 48 hours of a soft-shell moult. Females lay 2-6 million eggs which attach to the abdomen whilst offshore in the

lifecycle. Egg incubation is 10-17 days, larvae stage of 5 moults 21 days with tidal movement towards estuarine areas, and the zoeal series around 16 days to the point of first stage crabs with a carapace of 2-8cm (see Figure 77) (Brown 1993).

Along the South Fly coast there is a smaller red/brown variety and a larger greenish variety *Scylla serrata* var. *paramamosin* (Molean 1991) with a carapace length near 20cm and weighing near 2kg. In populations of Mud Crabs in 1991 and 2013/14 there are more males, but this could be a preference that women have to eating female crab and buying preference in local markets. The red/brown variety is caught in estuaries, the mouth of small creeks, and river banks whilst the greenish variety are caught further upstream in creeks and rivers (Lari 1995) (see Figure 78).

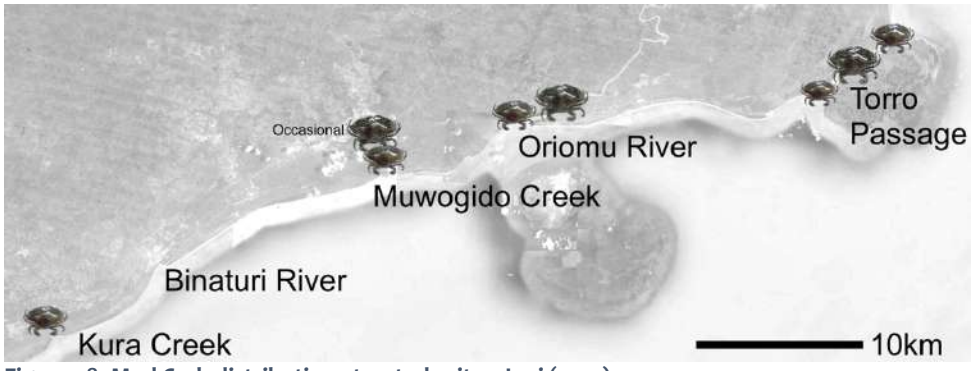


Figure 78. Mud Crab distribution at 4 study sites, Lari (1995)

In 1992/93 the mean carapace length of all crabs at the 4 sites was; female 10.6cm at Kura - 11.7cm at Torro Passage, male 11.7-11.9cm all sites (Lari 1995). Abundance peaks were in June/July and September/October (see Figure 79).

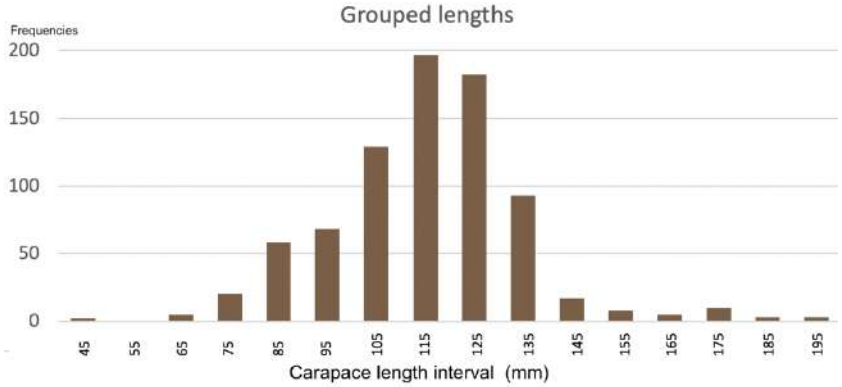


Figure 79. Base data, sizes of combined Mud Crabs *S. serrata, Lari* (1995)

National Mud Crab Fishery Management Plan 2019

This was gazetted G812 on the 7th of October 2019 states that there no commercial fishing and collecting of Mud Crabs though bycatch of prawn trawlers in the Gulf of Papua. The crab fishery is a subsistence fishery in remote coastal areas and as an artisanal fishery for coastal areas close to or accessible to urban local markets.

5.a.i.a. **Licencing**; that persons buying Mud Crabs from fishers require a Mud Crab Buyers Licence.

5.a.i.e Hotels, Guesthouses, Restaurants, Retail Shops and other related business buying mud crabs from the fishermen will require a Buying Permit to enable them to buy mud crabs from the fishermen who come and sell at their doorsteps. A buying permit only allows for the buying of mud crabs at the doorsteps. A full Buyers Licence is required if the business wants to buy mud crabs direct from the fishermen located in the markets and villages.

6.1.*a.* **Prohibitions;** Fishing for Mud Crabs shall be restricted only to traditional resource owners employing allowable fishing methods.

6.1.c The taking, buying, exporting and trade of mud crabs less than 12 cm carapace width for all species of mud crab is prohibited

6.1.d Taking of mud crabs in moult stage is prohibited

8.1.a **Recording;** In accordance with the Act, licensed mud crab buyers shall submit data on catch (number of individuals and their total weight), as well as the area where the crabs were caught, name of fisher(s), date of receipt and price paid, to the licensing and data management section of the National Fisheries Authority on a monthly basis.

9.a. **Customary Rights;** Traditional and customary management measures which are consistent with the Management Plan will be encouraged. The traditional resource owners are encouraged to notify the National Fisheries Authority of any traditional or customary management measures.

Catch

From research in Sigabaduru 2012/13 Busilacchi *et al*. (2014) indicated that 2114***** [1375-2843] crabs were caught of which near 50% were male, near 20% female and 30% unknown. Also 40% of the catch was sold in Saibai.

For Bula 751***** [481-1001] annual catch. Much of this catch is sold across the PNG-Indonesia border.

*****note that in Busilacchi et al. (2014) the daily average catch is switched between Sigabaduru and Bula and it has been taken that the totals given are correct.

The Mud Crab are usually caught by women and sold by them or the men.

Sundarrao *et al*. (1991) found that Cu, Zn, Hg, As and Se concentrations were significant in Daru crab (collected 1000 km from the vicinity of a copper mine) and were two to five times higher than

the concentrations in mud crabs from Port Moresby. Now after a further 30 years of mine operation the level of these heavy metals requires redetermination.

Recommendation

21. Being a detritus feeder the levels of copper (Cu) and other heavy metal concentrations in claw meat of the South Fly need to be determined in light of potential pollution of the riverine disposal of mine tailings of the Ok Tedi mine which discharge from the Fly River.

BLACK TEATFISH *HOLOTHURIA NOBILIS* (SELENKA, 1867)

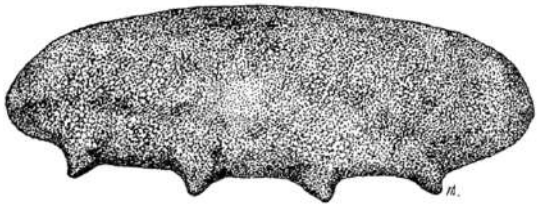


Figure 80. Line drawing Black Teatfish, FAO

Status

Beche-de-mer is a multispecies fishery with high value species targeted for collection and as each is depleted other species down the value chain become targeted whilst other low value species are also opportunistically collected (see Figure 81). Due to depleted stocks across the fishery the BDM seasons were closed from 2009-2015. The density of Black Teatfish across the South Fly is at this time very low and poorly known. This has led to a 0 TAC.

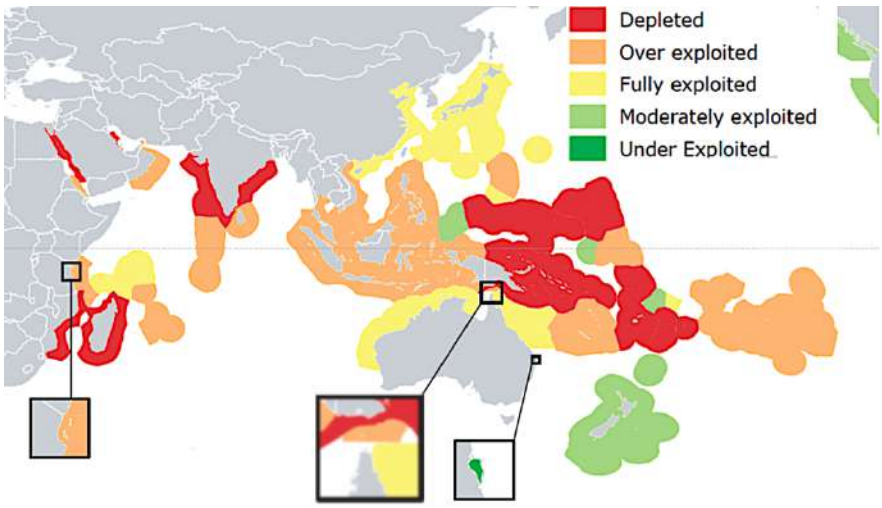


Figure 81. Status of Sea Cucumber, adapted from Purell *et al.* (2013)

Life History

The habitat of this species is on inner reef slopes and passes which may extend when interspecific competition decreases such as from the harvest removal of other species. Densities of Black Teatfish have been found to 275/ha in West New Britain (Lokani 1991).

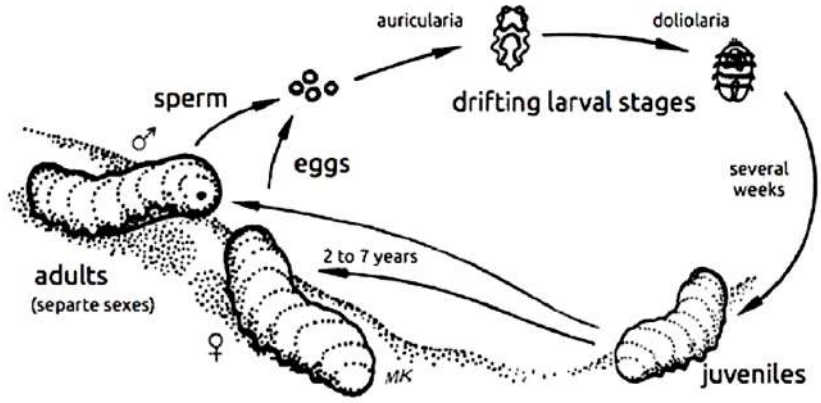


Figure 82. Life history of sea cucumber, from King (2011)

Whilst most species of sea cucumber spawn in the warmer months i.e. November-**December**-**January**-February the Black Teatfish spawns in the cooler months **June-July**-August (Conand 1989) and is also synchronised to tide and lunar cycles within these months. Fertilisation of gametes is externally in the salt water, therefore spawning male and female need to be proximal. Any open season for the harvest should occur after spawning to allow recruitment of following seasons stock. This is problematic for Black Teatfish, *Holothuria nobilis* being the 'odd' species out. The estimate of size at first maturity for this species is 16.5cm with a total live weight of 165g (110g 'drained) which occurs at 2 to 7 years. The drifting larval and juvenile stages are cryptic and rarely seen (Preston 1993) (see Figure 82).

However Black Teatfish (*H. nobilis*) at the CITES 30th meeting of the animals committee in 2018 was raised that because of the past and current exploitation aiming to satisfy international demand, matching with criteria for the inclusion in Appendix II. An inclusion of Teatfish in CITES Appendix II will permit to manage and sustain their trade in the greatest interest of fishermen, exporters and importers, while preserving these species and therefore let them play their ecological role, and responding to the future generations need (Bruckner *et al*. 2003; CITES 2018). As a result, Black Teatfish in the 2020 season was CITES II listed (CITES 2019). The TAC in Western Province and the Torres Strait in 2020 was 0 tonnes.

Ecological role

Sea Cucumber's high commercial value, ease of capture their vulnerability (due to their biological characteristics, population dynamic and specific habitat type) and high value encourage their overexploitation and therefore contribute to stocks shrinking seen in some areas. Holothurians are

easily overexploited due to their life history (low mobility of adults, late sexual maturity, density-dependent reproduction and low recruitment rates), their ease of capture (adults are large, often diurnal, easy to see and pick up, that does not require complex fishing or processing methods) (CITES 2018).

Some areas without Holothurians become unsuitable for other organisms, because Holothurians dig sand by feeding on organic matter that are in, and the nutrients they secrete can be absorbed by algae and corals (Purcell *et al*. 2013).

The BDM TAC from 2000 was set at 17 tonnes, which was close to being fished out in the preceding years up to closure in 2009 (see Figure 83)

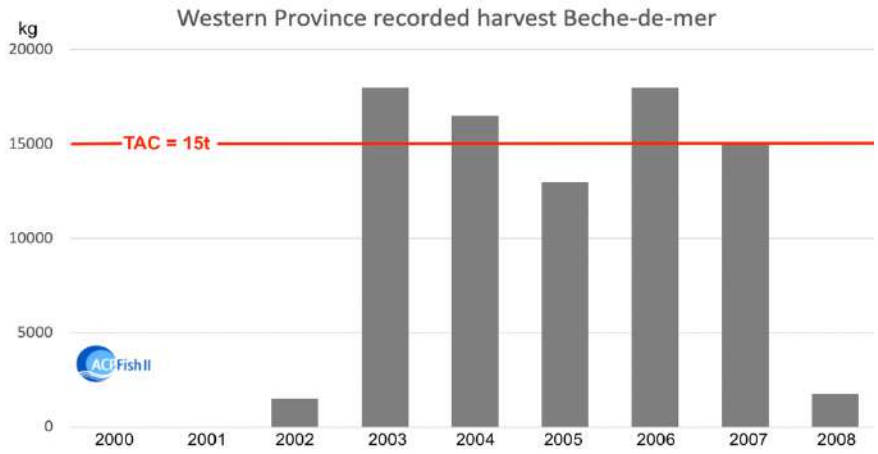


Figure 83. Record of Bech-der-mer harvest Western Province 2000-2008

However, what amount of this was IUU from the Torres Strait Protected Zone, or not recorded being sold in Port Moresby or across the PNG-Indonesia border is not known. The volume of this unrecorded trade, especially of high value species such as Black Teatfish is significant.

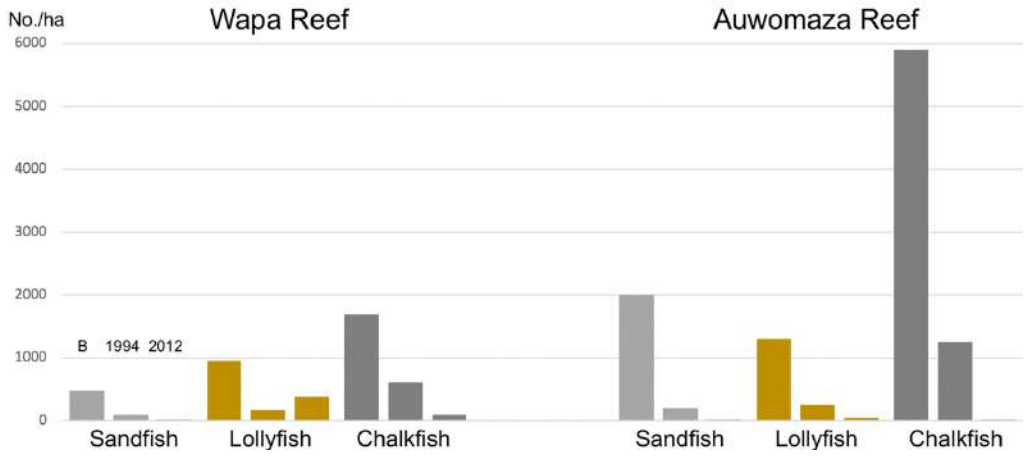


Figure 84. Density of Sandfish, Lolly Fish on Wapa and Auwomaza reef, (B-Base, 1994 & 2012)

Survey data of high, mid and low value sea cucumbers of two of the Western Province reefs show consistent trends of a decreasing density from Base stocks compared to 1994 and 2012 which was 3 years after closure. It is indicative that all commercial species have been fished to densities that were too low for recovery in the short term (see Figure 84).

The BDM fishery in Western Province in 2020 was set at 3 tonnes. It was the first province to reach its set TAC, with the season opening on August the 17th and closed on the September 17th. The Black Teatfish (0 TAC in Western) has a current market value of near PGK700 per kg which makes it a potentially illegally traded species (Anon 2020).

Black Teatfish in relation to the Torres Strait

The population of Black Teatfish in the Torres Strait are passively part of the population of the Great Barrier Reef-Coral Sea ecoregions (see Figure 85).

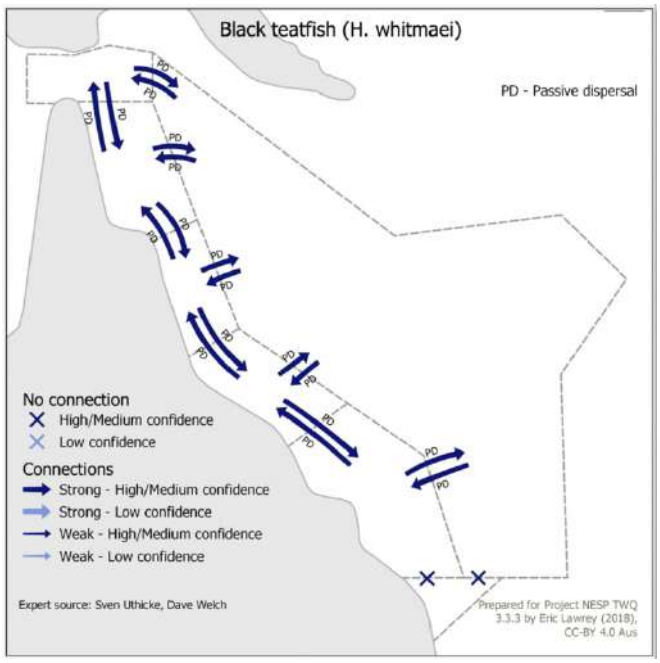


Figure 85. Black Teatfish passive dispersal eastern Australia

In the Torres Strait Black Teatfish (*Holothuria nobilis, H. whitmaei*) had no reported catch in 2019 and without survey the trend was of stock recovering. BDM are mainly fished in the eastern sector of the Torres Strait Management area, from the Great North East Channel, Erub (=Darnley) Island, Kerged (=Don Cay), Cumberland Passage and the Great Barrier Reef (see Figures 86 & 87).

Collection is by free diving without assisted air i.e. hookah, scuba with most fishing effort down to around 10m.

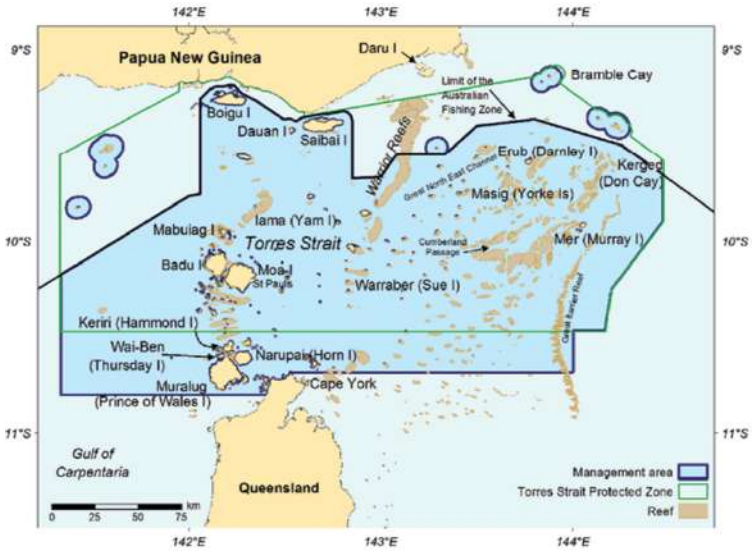


Figure 86. Area of the Beche-de-mer (and Trochus) fishery Torres Strait, Butler & Steven (n.d.)

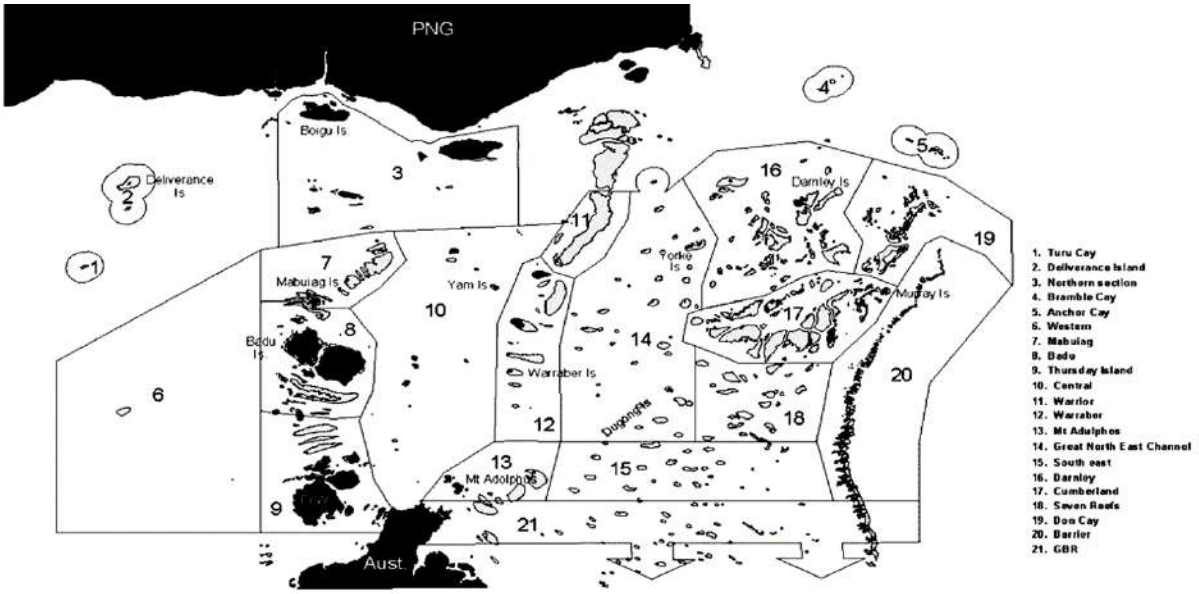


Figure 87. More detailed map of BDM fishery in the Torres Strait, Australian perspective

Within this fishery in Australia participation is tied to Traditional Inhabitant Boat (TIB) licence holders, and Traditional Fishers which includes those of PNG origin but of Australia residency.

Of note the DSEWPC acknowledged the inherent difficulties in estimating levels of illegal, unreported and unregulated (IUU) fishing, in the Torres Strait Beche-de-mer Fishery [by PNG fishers]. It was regarded that the risk of illegal take decreased when the Papua New Guinea Sea Cucumber Fishery was closed in 2009 (Anon 2011), yet if fishers were illegally selling to Indonesian buyers this might not have been the case. With the recent reopening of the BDM harvesting in PNG in 2019 and buyers in Daru there is further potential for illegal harvest. However, if fishers feel that

they have used these fishing grounds customarily in the past they may not regard themselves as 'illegal' but that their customary rights are being denied by the regulations set across the PNG-Australian border. With and unknown level of illegal take the DSEWPC saw an ongoing need to continue to improve estimates of all removals from sea cucumber stocks to ensure that total allowable catch recommendations are based on the best possible information (Anon 2011).

Stock assessment Torres Strait

The Torres Strait Black Teatfish stock was surveyed in 2009 (Skewes *et al*. 2010). This survey showed increases in the mean density (from <1 individual/ha to 10/ha), with and increased mean length of near 6% and increase of mean weight >11% of Black Teatfish compared with the 2005 survey 4 years earlier. However these figures have a level of considerable potential error. Based on this data Skewes *et al.* (2010) recommended reopening the fishery for Black Teatfish, in proposing a TAC of 25 t, which would be an extraction rate of about 4% .

It also acknowledged that a level of precaution was required in developing the fishery to minimise the risks of exceeding the TAC, localised depletion and unsustainable harvest of other species. As a result, the PZJA endorsed a 1-month trial of fishing for Black Teatfish in 2014 and 2015, operating under a conservative 15 t TAC. Some over-catch was recorded in both years.

CSIRO surveyed sea cucumbers, including Black Teatfish, in late 2019 and early 2020, so an updated estimate of biomass is expected to be available later in 2020 (Butler & Steven n.d.).

With regards to Black Teatfish, the preliminary results indicate that the stock in the Torres Strait has recovered close to base biomass levels following its closure in 2003, further confirming the stock recovery observed in the 2009 stock survey. Preliminary biomass dynamic modelling analysis was also undertaken as part of the current stock survey to test the impact of different harvest levels on the biomass and productivity of the Black Teatfish stock over time (Murphy *et al*. 2020). From this a constant annual TAC of 20 tonnes was found to be sustainable. The Maximum Sustainable Yield (MSY) estimate was in the range 17-28t (with 22t estimates for the version identically matching the survey biomass level) and hence the MSY estimate of 21 tonnes was considered relatively robust.

Upon consideration of the preliminary survey and modelling results at their 7 August 2020 meeting, HCWG members formulated their advice and recommendations to the PZJA on the to the proposed trial re-opening of the Black Teatfish fishery in 2021 (AFMA 2020).

In support of these arrangements Australia and PNG commit to consult and co-operate with each other to prevent violations of the Protected Zone commercial fisheries arrangements and ensure

that legislation and regulations adopted by each Party are as far as practicable consistent with the legislation and regulations of the other Party (Article 28).

As the BDM Fishery is currently not an Article 22 fishery, it is therefore, not managed under formal catch sharing arrangements with PNG. Updates on the status of the fishery are however considered at bilateral meetings. Agreements between PNG and Australia on catch sharing arrangements and related matters usually take place at annual fishery bilateral meetings and meetings of the Torres Strait Joint Advisory Council (JAC) established under Article 19 of the Treaty.

Subsequently in the Torres Strait there was a Black Teatfish trial opening in 2021. The TAC was set at 20 tonnes and the season opened 30th of April and was closed 5th May at the point of 17.26 tonnes caught. With such an intensive harvest receivers must send an image/photo of your completed CDR electronically to AFMA on the same day you receive the catch.

Australia and PNG meet annually to discuss and agree on catch sharing arrangements based on the agreed shares set out in Article 23 as well as historic catch by both countries. Non-Article 22 Fisheries being Finfish, Sea Cucumber, Trochus and Crab have no formal arrangements made and there are no catch sharing provisions in place. However, either country could nominate one of these fisheries to also be managed cooperatively under the arrangements outlined in Article 22 of the Treaty.

Figure 88. Juvenile Green turtle as opportunistic bycatch of sea cucumber fishery in Western Province, photo J. Kinch in Kinch *et al.* (2008)

Recommendations

22. That discussion between Australia and PNG on Sea Cucumbers becoming an Article 22 Fishery in areas of traditional Turtle and Dugong fishing grounds as a strategy to regulate what is now IUU of sea cucumbers.

23. That PNG learn from, be trained and establish a more robust fish catch record in the BDM fishery in villages that have mobile connectivity.

WHITE TIP REEF SHARK *TRIAENODON OBESUS* (RUPPELL, 1837)

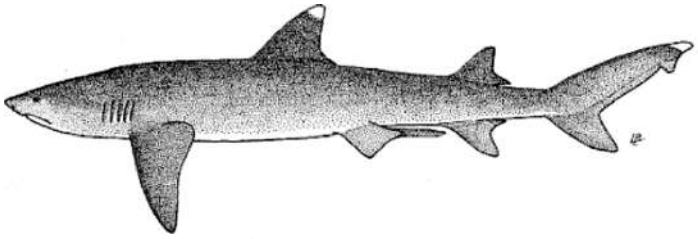


Figure 89. Whitetip Reef Shark, adult

Status

The artisanal Shark Fin fishery is a multi-species fishery of both estuarine and marine species found within the South Fly. There had been no extensive research undertaken on the status of shark stocks in PNG waters. Hence there is an urgent need to assess whether the current management plan is sufficient to ensure sustainable use of these resources into the future. Recent research on Indonesian shark fisheries (the largest in the world) has highlighted the need for better management of shark resources and the importance of understanding the level at which stocks of key species are shared with northern Australia (Blaber *et al*. 2009) (see Figure 90). There is an ongoing important need to understand the extent to which PNG shark stocks are shared with Australia and Indonesia and to determine whether co-operative management between countries with shared stocks needs to be improved.

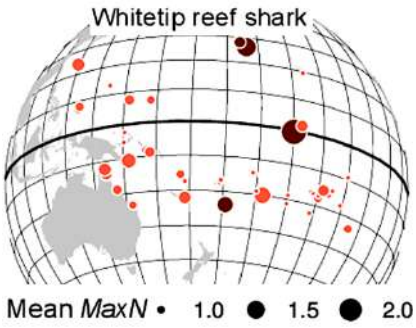


Figure 90. Whitetip Reef Shark in the Pacific adapted from Dwyer *et al.* (2019)

The annual quantity of all sharks caught from the artisanal fisheries in Daru decreased from 2t to 1t from 1995 to 2012/2013.

Annual quantities of sharks caught in Bula and Sigabadaru were both 2t. Requiem sharks (Carcharhinidae) were the most common family in the catch of all three locations contributing 98% of the Daru catch in Daru, 80% in Bula and 75% in Sigabaduru. A mix of coastal sharks (e.g. Sandbar

Shark, Blacktip Shark, Pigeye Shark and Spot-tail Shark) and deeper water sharks (e.g. Grey Shark, Tiger Shark and Hammerhead Sharks) were also present in the catch. The Blacktip Shark catch of all sharks caught represented <1% of catch in Sigabaduru, 2% of Bula and 3% of Daru catch (individuals) (Busilacchi *et al.* 2014).

Life history

This species habitat is associated with reef with a relatively narrow home range. During the day it returns to often the same resting place, on the bottom, under ledges and forages at night. The female reaches maturity at around 8 years at a length of 1.05-1.22m TL and males after about 7 years slightly smaller at 1-.4-1.16m. They grow to a maximum size of 1.7m TL. Females reproduce usually every two years with 1-2-3-5 pups which are 0.52-0.6m long at birth. The female lives to 19 years (White *et al.* 2017).

In October 2014 surveys were undertaken in a variety of locations in a diversity of environments that included the Daru region in Western Province (including Daru, Katatai, Kadawa, and small fishing camps). This survey included the high level of inshore gillnetting targeting barramundi and jewfish, which would result in shark catches. The muddy inshore environment also differs from many of the other more coral reef dominated locations. CSIRO, JCU and NFA staff conducted this survey, with assistance obtained from an NFA observer, provincial fisheries staff (Daru) and a local police officer.

Shark fin

In 2012 a total of 344 kg of shark fins were bought by the only local buyer for dry products in Daru. These quantities could not be converted in total fish weight and thus were not included in the estimation of the total catches. The compulsory purchase logbooks gave only the total monthly weight of shark fins bought with no other information useful to estimate total catch or species composition of the sharks caught by the Daru commercial fisheries (Busilacchi *et al.* 2014).

ACRONYMS

AFMA	Australian Fisheries Management Authority
As	Arsenic
ATS	Arafura and Timor Seas
ATSEA (-2)	Arafura and Timor Sea Ecosystem Action - Second Phase
BDM	Beche-de-mer
BFMP	Barramundi Fishery Management Plan
BMAC	Barramundi Management Advisory Committee
CEPA	Conservation and Environment Protection Authority
CITES	Convention on International Trade in Endangered Species [of Wild Fauna and Flora]
cm	centimetre
CMCA	Community Mine Continuation Agreement
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTI	Coral Triangle Initiative
Cu	copper
DOF	Department of Fisheries [Australia]
DSEWPC	Department of Sustainability, Environment, Water, Pollution and Communities [Australia]
EAFM	Ecosystem Approach to Fisheries Management
ECA	Eco Custodian
EEZ	Exclusive Economic Zone
FAO	[UN] Food and Agriculture Organisation
FRPG	Fly River Provincial Government
GNI	Gross National Income
GDP	Gross Domestic Product
HCWG	Hand Collectables Working Group
HDI	Human Development Index
Hg	Mercury
IAI	Innovative Agro Industries
IDR	Indonesian Rupiah
IUCN	International Union for Conservation of Nature
IUU	Illegal Unreported and Unregulated
JAC	Joint Advisory Council
JCU	James Cook University
kg	kilogram
LLG	Local Level Government
MPI	Multidimensional Poverty Index
MSC	Missionaries of the Sacred Heart
MSY	Maximum Sustainable Yield
NFA	National Fisheries Authority
nm	Nautical Mile [1nm = 1.582 km]
NSO	National Statistical Office
OTML	Ok Tedi Mining Limited
PGK	Papua New Guinea Kina
ProDoc	Project Document
PZJA	Protected Zone Joint Authority
SAP	Strategic Action Plan
Se	Selenium

SW	South-west
t	tonne
TAC	Total Allowable Catch
TIB	Traditional Inhabitants Boat
UNDP	UN Development Program
WMA	Wildlife Management Area
Zn	Zinc

g.a. & d.k.m are authors images used

REFERENCES CITED

Allen, B.J., Hide, R.L., Bourke, R.M., Akus, W., Fritsch, D., Grau, R., Ling, G. & Lowes, E. 2002. Western Province: Text Summaries, Maps, Code Lists and Village Identification. *Agricultural Systems of Papua New Guinea Working Paper* No. 4. Land Management Group, Department of Human Geography, Research School of Pacific and Asian Studies, The Australian National University, Canberra. Revised edition

Anon. 1893. Papuan Invaders *Australian Star* Friday January 6, page 8

Anon. 2019. SDP Refurbishes Daru barramundi hatchery *Post Courier* 27 November

Anon. 2010. *Chapter 2 Torres Strait and the Treaty*

Anon. 2011. Assessment of the Torres Strait Beche-der-mer Fishery Department of Sustainability, Environment, Water, Population and Communities

Anon. 2012. Barramundi project spawns opportunity, *Business Advantage PNG*

Anon. 2020. NFA closes Western Harvest. *The National* September 17

Archbold, R. & Rand, R.L. 1940. *New Guinea Expedition: Fly River Area, 1936-1937*. New York, Robert M. McBride & Company

Baynes, 1921. The Home an Australian quarterly 2(4):66

Beaver, W.N. 1920. *Unexplored New Guinea: A record of the travels adventures and experiences of a Resident Magistrate amongst the head hunting savages and cannibals of the unexplored interior of New Guinea*. London

Bené, C. 2006. Small-scale fisheries: assessing their contribution to rural livelihoods in developing countries. FAO Fisheries Circular No. 1008. FAO: Rome

Berkes, F. 2009. Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management* 90:1692-1702

Box, J. de la. R., Dalton, D., Ellingson, D., Epps, J., Gillett, R., Karani, P., Kiele, J., Mohamed, N., Soerjani, M. & Tekwie, D. 1994. *Yumi Wankain*. Report of the United Nations Joint Inter-Agency Mission to Papua New Guinea on Sustainable Development

Blaber, S. 2003. The biology, socioeconomics and management of the barramundi fishery in the Fly River and adjacent coast of Papua New Guinea: final report on project FIS/1998/024. ACIAR: Canberra

Blaber, S.J.M., Dichmont, C.M., White, W., Buckworth, R., Sadiyah, L., Iskandar, B., *et al.* 2009. Elasmobranchs in southern Indonesian fisheries: the fisheries, the status of the stocks and management options. *Reviews in Fish Biology and Fisheries* 19:367-391

Brown, I.W. 1993. Mangrove Crabs, Chapter 18 in Wright, A. & Hill, L. (eds.) 1993. *Nearshore Marine Resources of the South Pacific: Information for Fisheries Development and Management*. Institute of Pacific Studies Suva

Bruckner, A., Johnson, K. & Field, J. 2003. Conservation des Holothuries: une inscription aux listes de la CITES pour pérenniser le commerce international ?. *La bêche-de-mer, bulletin de la CPS*, 18:24-33

Busilacchi, S., Butler, J.R.A., Rochester, W. & Posu, J. 2018. Drivers of illegal livelihoods in remote transboundary regions: the case of the Trans-Fly region of Papua New Guinea. *Ecology and Society* 23(1):46

Busilacchi, S., Butler, J.R.A., Skewes, T., Posu, J., Shimada, T., Rochester, W. & Milton, D. 2014. Characterization of the traditional fisheries in the Torres Strait Treaty communities, Papua New Guinea

Butler, I. & Steven, A.H. n.d. Chapter 19 Torres Strait Beche-de-mer and Trochus fisheries, Department of Agriculture

Butler, J.R.A., Tawake, A., Skewes, T., Tawake, L. & McGrath, V. 2012. Integrating traditional ecological knowledge and fisheries management in the Torres Strait, Australia: the catalytic role of turtles and dugong as cultural keystone species. *Ecology and Society* 17(4):34

CITES. 2018. Draft Proposal for the inclusion of the subgenus *Holothuria HOLOTHURIA (Microthele)* in Appendix II. Thirtieth meeting of the Animals Committee Geneva (Switzerland), 16-21 July 2018 Convention on International Trade in Endangered Species of Wild Fauna and Flora

CITES. 2019. Eighteenth meeting of the Conference of the Parties Colombo (Sri Lanka), 22 May – 3 June 2019 Consideration of Proposals for Amendment of Appendices I and II. Convention on International Trade in Endangered Species of Wild Fauna and Flora

Conand, C. 1989. Les Holothuries Aspidochirote du Lagon de Nouvelle-Caledonie: Biologie, Ecologie et Exploitation. PhD thesis University of Western Brittany France

Derksen, M. 2016. Local Intermediaries? The Missionising and Governing of Colonial Subjects in South Dutch New Guinea, 1920–42, *The Journal of Pacific History*, 51(2):111-142

Dwyer, R.G., Krueck, N.C., Udyawer, V. & Simpfendorfer, C. 2019. Individual and Population benefits of Marine Reserves for Reef Sharks. *Current Biology*

Evans, N. 2012. Even more diverse than we had thought: The multiplicity of Trans-Fly languages Language Documentation & Conservation Special Publication No. 5 pp. 109–149 in Nicholas Evans, N. & Klamer, M. (eds.). 2012. *Melanesian Languages on the Edge of Asia: Challenges for the 21st Century*

Fisher H. 2010. The biology, socioeconomics and management of the barramundi fishery in Papua New Guinea's Western Province. *ACIAR Impact Assessment Series Report* No. 67. Australian Centre for International Agricultural Research, Canberra. 51 pp

Fly River Provincial Government. 2019. South Fly Five Year Development Plan 2018-2022: Voice of the Rising Sun, A call for development after 43 years

Grayson, J. 2011. Characteristics of traditional dugong and green turtle fisheries in Torres Strait: opportunities for management. PhD thesis, James Cook University

Hagihara, R., Cleguer, C., Preston, S., Sobtzick, S., Hamann, M., Shimada, T. & Marsh, H. 2016. *Improving the estimates of abundance of dugongs and large immature and adult-sized green turtles in Western and Central Torres Strait.* Report to the National Environmental Science Programme. Reef and Rainforest Research Centre Limited, Cairns 53pp

Hanson, L.W., Allen, B.J., Bourke, R.M. & McCarthy, T.J. 2001. *Papua New Guinea Rural Development Handbook.* The Australian National University, Canberra

Heinsohn, R., Lacy, R.C., Lindenmeyer, D.B., Marsh, H., Kwan, D. & Lawler, I.R., 2004. Unsustainable harvest of dugongs in Torres Strait and Cape York (Australia) waters: two case studies using population viability analysis. *Animal Conservation* 7:417–425

Hirth, H.F. 1993. Marine Turtles, Chapter 10 in Wright, A. & Hill, L. (eds.) 1993. *Nearshore Marine Resources of the South Pacific: Information for Fisheries Development and Management*. Institute of Pacific Studies Suva

Holland, J. 2018. Australian authorities seize illegal catch near Saibai Island 29 May

Hudson, B.E.T. 1986. The hunting of dugong at Daru, Papua New Guinea, during 1978-1982: community management and education initiatives. [Seminar address] James Cook University of North Queensland, Townsville Australia

Hungrabos, N. 2007. Western Province Education Plan 2007-2016: Partnership and Self Reliance for a better future. Division of Education, Western Province Administration

Johannes, R. & MacFarlane, J.W. 1991. Traditional Fishing in the Torres Strait Islands. CSIRO Division of Fisheries, Hobart, Australia

Joint Committee of Foreign Affairs and Defence. 1979. The Torres Strait Treaty Report and Appendixes, Canberra Australian Government Publishing Service

Kinch, J., Purcell, S., Uthicke, S. & Friedman, K. 2008. Papua New Guinea: a hotspot of sea cucumber fisheries in the Western Central Pacific. in Toral-Granda, V., Lovatelli, A. & Vasconcellos, M. (eds.) 2008. Sea cucumbers. A global review of fisheries and trade. *FAO Fisheries and Aquaculture Technical Paper*. No. 516. Rome, FAO. 57-77

Lari, R.W. 1995. Results of investigations into aspects of the ecology of the Mudcrab, *Scylla serrata*, (Forscal) in Western Province, Papua New Guinea, South Pacific Commission. Joint FFA/SPC Workshop on the management of South Pacific Inshore Fisheries. Noumea, New Caledonia 26 June-7 July 1995

Lawrence, D. 1994. Customary Trade Exchange across the Torres Strait *Memoirs of the Queensland Museum* 34(2):241-446. Brisbane

Lawrence, D. 2010. *Gunnar Landtman in Papua : 1910 to 1912*. Australian National University Press, Canberra

Leverington, F., Peterson, A. & Peterson, G. with Jano, W., Sabi, J. & Wheatley, A. 2017. Assessment of management effectiveness for Papua New Guinea's protected areas 2017. Final Report. SPREP, Apia, Samoa

Lokani, P. 1991. Survey of commercial sea cucumbers (beche-de-mer) in West New Britain Province, Papua New Guinea. Department of Fisheries and Marine Resources, Fisheries Research and Surveys Branch Kavieng

Marinjembi, M. & Bun, L. 2021. Map Deepsea Features ATSEA

Marsh, H. & Rathbun, G.B. 1990. Development and application of conventional and satellite radio-tracking techniques for studying dugong movements and habitat usage. *Australian Wildlife Research* 17:83-100

Marsh, H. & Saalfeld, K. 1991. The Status of the Dugong in the Torres Strait Biological Environment 187-

Marsh, H., Corkeron, P., Lawler, I.R., Lanyon, J.M. & Preen, A.R. 1996. The status of the dugong in the Southern Great Barrier Reef Marine Park. *Great Barrier Reef Marine Park Authority Research Publication* 41. Townsville, Queensland. GBRMPA

Marsh, H., Grech, A. & Hagihara, R. 2011. Aerial survey of Torres Strait to evaluate the efficacy of an enforced and possibly extended Dugong Sanctuary as one of the tools for managing the dugong fishery. Report to the Australian Marine Mammal Centre and the Torres Strait Regional Authority. James Cook University, Townsville, Australia

Marsh, H., Harris, A.N.M. & Lawler, I.R. 1997. The sustainability of the Indigenous dugong fishery in Torres Strait, Australia/Papua New Guinea. *Conservation Biology* 11:1375-1386

Marsh, H., Lawler, I.R., Kwan, D., Delean, S., Pollock, K. & Alldredge, M. 2004. Aerial surveys and the potential biological removal technique indicate that the Torres Strait dugong fishery is unsustainable. *Animal Conservation* 7:435-443

Marsh. H. n.d. Dugong: Status Report and Action Plans for Countries and Territories

Mobiha, A. n.d. The management of the coastal barramundi fishery in the Western Province South Pacific Commission, Department of Fisheries and Marine Resources, Kavieng PNG

Molean, C. 1991. A Feasibility study of the Fisheries Resources of the Murik Lakes area & Recommendation for Development, Fisheries Research & Surveys Branch. *Research Report* 91-01: 22-25

Moran, M. 2020. Destitution on Australia's hardening border with PNG - and the need for a better aid strategy *The Conversation* April 13

Moran, M. & Curth-Bibb, J. (eds.). 2020. *Too Close to Ignore: Australia's Borderland with PNG and Indonesia*. Melbourne University Press

National Fishery Authority. 2019. National Mud Crab Management Plan, Port Moresby

National Statistical Office. 2014. 2011 National Population and Housing Census, Ward Population Profile Southern Region. Port Moresby

O'Gorman, D. 2009. Inquiry into matters relating to the Torres Strait Region. To the Committee Secretary, Senate Foreign Affairs, Defence and Trade, References Committee from Dan O'Gorman Barrister-at-law. 19 Oct 2009

Phelan, M.J. 2002. Fishery biology and management of Black Jewfish *Protonibea diacnthus* (Sciaenidae) aggregations near Injinoo community far northern Cape York. Fisheries Development Corporation

Piet, E. 2019. To where the gospel first landed in PNG. The National August 9

Piper, L. E. 1977. Subsitence economies on the southern plain of New Guinea. B.A. Honours Thesis, University of New England, Armidale, New South Wales

Poiner, I.R. & Peterken, C. 1996. Seagrasses. In Zann, L.P. & Kailola, P. (Eds.) 1996. *The state of the Marine Environment Report for Australia. Technical Annex* 1:40-45 in Townsville, Queensland: Great Barrier Reef Marine Park Authority

Preen, A.R. & Marsh, H. 1995. Response of dugongs to large scale loss of seagrass from Harvey Bay, Queensland. *Wildlife Research* 22:507-519

Preen, A.R. 1995. Dugongs, 'hot spots' and meta-herds. in *Proceedings of the 1995 Scientific Meeting of the Australian Mammal Society and Mammals of the Wet Tropics Symposium*: 1. Townsville, Queensland. Australian Mammal Society

Preen, A.R., Lee Long, W.J. & Coles, R.G. 1995. Flood and cyclone related loss, and partial recovery, of more than 1000 km^2 of seagrass in Hervey Bay, Queensland, Australia. *Aquatic Botany.* 52:2-17

Preston, G.L. 1993. Bêche-de-mer, Chapter 11 in Wright, A. & Hill, L. (Eds.) 1993. *Nearshore Marine Resources of the South Pacific: Information for Fisheries Development and Management*. Institute of Pacific Studies Suva

Purcell, S.W., Mercier, A., Conand, C., Hamel, J.F., Toral-Granda, M.V., Lovatelli, A. & Uthicke, S. 2013. Sea cucumber fisheries: global analysis of stocks, management measures and drivers of overfishing. *Fish and Fisheries* 14(1):34-59

Riesenfeld, A. 1950. The Megalithic Culture of Melanesia, Hallstrom Pacific Collection

Robinson, C. 1904. Letter to His Excellency [The Right Honourable Henry Stafford Northcote] the Governor General of Australia from Christopher Robinson Acting Administrator British New Guinea 9th May 1904

Roe, D. 2010. *Marine Turtle and Dugong Awareness Program for Western Province, Papua New Guinea: Outcomes of Development Workshop, 10 June 2010, Daru.* Report prepared for the Marine and Tropical Sciences Research Facility. Sea Turtle Foundation, Townsville 25pp

Sadovy, Y.J. 1996. Reproduction of reef fishery species. in Polunin N.V.C. & Robe11s C.M. (Eds.) Reef fisheries. Fish and Fisheries Series 20. Chapman and Hall. London. 15-60pp

Salim, L. 2008. Papua New Guinea Approves $7 million for Barramundi Hatchery. SeaFood Source

Saunders, T., Roelofsb, A. Newmanc, S. & Erritya, C. 2014. Black Jewfish *Protonibea diacanthus* Department of Fisheries Report

Sibson, E. 2019. Jewfish dominate black market to meet Asia demand *ABC News* Saturday 13 August

Skewes, T.D., Murphy, N.E., McLeod, I., Dovers, E., Buridge, C. & Rochester, W. 2010. Torres Strait Hand Collectables, 2009 survey: Sea cucumber. CSIRO, Cleveland. 70pp

South Fly District Five Year Development Plan 2018-2022: Voice of the rising sun: a call for development after 43 years

Sullivan, N., Keleba, K. & Tosa, W. 2013. Social Assessment for the World Bank's PNG Rural Service Delivery and Local Governance Pilot Project

Sundarrao, K., Tinkwrame, J., Kaluwin, C. & Matsuoka, T. 1991. Lipid content, fatty acid and mineral composition of mud crabs (*Scylla serrat*a) from Papua New Guinea. *Journal of Food Composition and Analysis* 4(3):276-280

Tom, L. 2019. National Mud Crab Fishery Management Plan *National Gazette* G813 7th October

Western Province Administration. 2006. Education Sector Plan 2006-2015: Partnership and Self Reliance for a Better Future. Division of Education

White W.T., Baje, L., Sabub, B., Appleyard, S.A., Pogonoski, J.J. & Mana, R.R. 2017. Sharks and rays of Papua New Guinea. *ACIAR Monograph* No. 189. Australian Centre for International Agricultural Research: Canberra. 327 pp

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