

# Future developments in northern Australia

## FINAL REPORT - DRAFT

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## ACRONYMS

ABS	Australian Bureau of Statistics
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AIMS	Australian Institute of Marine Sciences
ATRF	Arafura Timor Research Facility
BRD	Bycatch reduction device
BRS	Australian government Bureau of Rural Sciences
CDE	Charles Darwin University
CPUE	Catch per unit effort
DEEDI	Department of Department of Employment, Economic Development and Innovation
DEWHA	Australian Government Department of the Environment, Water, Heritage and the Arts
DME	Queensland Government Department of Mines and Energy
DPI&F	Queensland Government Department of Primary Industries and Fisheries (now Department of Department of Employment, Economic Development and Innovation, DEEDI)
DoR	Northern Territory Government Department of Resources
DPIF&M	Northern Territory Government Department of Primary Industries, Fisheries and Mines (now Department of Resources, DoR)
EEZ	Exclusive Economic Zone
EMP	Environmental management plan
EP	Equivalent Persons
EPBC	Environment Protection and Biodiversity Conservation Act 1999
FFV	Foreign fishing vessel
FTO	Fishing tour operator
GDP	Gross Domestic Product
GOC	Gulf of Carpentaria
GSP	Gross State Product
IMF	International Monetary Fund
ITQ	Individual transferable quota
IUU	Illegal, unreported, unregulated fisheries
NAILSMA	North Australian Indigenous Land and Sea Management Alliance
nm	nautical mile(s)
NMR	North Marine Region
NOO	Australian government's former National Oceans Office
NPF	Northern Prawn Fishery
NTFJA	Northern Territory Fisheries Joint Authority
OESR	Queensland Government Office of Economic and Statistical Research
QFJA	Queensland Fisheries Joint Authority
SFR	Statutory fishing rights
SLA	Statistical Local Area
t	tonne(s)
TED	Turtle exclusion device

## EXECUTIVE SUMMARY

The North Marine Region (NMR) includes off-shore waters from Cape York Peninsula in the east (excluding the Torres Strait) to the WA/Northern Territory border. It encompasses Commonwealth waters which stretch from the inshore coastal boundary (which is at about 3nm) to the limit of Australia's Exclusive Economic Zone (EEZ) some 200nm from shore. For the purpose of this report, adjacent in-shore waters and land areas are also of interest due to their ecological interconnectedness with more offshore areas.

The NMR is adjacent to some of Australia's most remote land areas, which are generally sparsely populated and have the highest proportion of indigenous population in the country. Many indigenous communities adjacent to the coast rely upon the marine environment for subsistence. This marine region is also unique in the degree to which it shares borders with neighbouring countries.

The drivers most likely to influence future activities/developments in this region by 2030 are global as well as domestic and of an economic and environmental nature.

Economically, global demand for energy, base metal and food products is increasing, on the average, because of both population growth and increasing per capita demand for goods from growing economies. The world population is projected to grow from around 6 billion in 1999 to 9 billion by 2042, an increase of 50%. In particular, some industries in northern Australia primarily trade with countries that have populations projected to increase by about 600 million people. In 2030, Indonesia is expected to be the fourth most populous country in the world (~289 million) after India (~1 461 million), China (~1 392 million) and the USA (~374 million). Developing country economies are also growing; over the last 30 years these economies have averaged a growth in their GDP of 6.7%. The demand these economies are displaying for energy products, base metals and food is significant. The NMR is one source of these products.

Global environmental change will lead to increased land and sea temperatures, and changing weather patterns, which are set to affect the ecology of the NMR. The full extent of the impacts of climate change cannot be predicted but indications are that climate change will be an added source of stress to the plants and animals of the NMR by 2030.

The impact of Australian, state, territory and localised drivers—including population growth, regulation, policy and program development—will be largely subordinate to that of global drivers—including world population growth, global demand, global prices and climate change.

The effect of global drivers is already being felt in the cattle, oil and gas, mining, shipping and fishing industries. Industry expansions and planning aim to accommodate increasing global demand over the next 20 years. Increases in environmental controls are likely to reduce the per unit level of environmental impact in these industries. It is conceivable, however, that the overall volume of increased activity will, in absolute terms, cause the environmental impacts of these activities to increase. In addition, the risk of accidents increases with increases in activity.

The fishing industry could be an exception to the push towards these increasing levels of activity as fisheries management contains resource extraction within sustainable yield limits. Multiple regulated fisheries are operating within the NMR, all of which have been assessed to be operating at sustainable levels. However, the aggregate extraction of all fishing activities is unknown, as the NMR experiences illegal, unreported and unregulated (IUU) fishing, particularly from foreign fishing vessels (FFVs). Although the number of FFVs have decreased in recent times even a small number of incursions over the next 20 years can severely impact the sustainability of some of the fisheries. For context, for some fisheries, managers have decided that legal effort should comprise of only 8 or 12 boats to

ensure sustainability. At the same time, the incursion of 40 FFVs within the NMR is considered a low level of intrusion. Recreational fishing interests in the NMR are set to increase. Fishing activity increases as (especially coastal) populations grow. If inshore waters become relatively depeted of fish and more people own larger boats they will use their capability to go offshore and so the location of impacts may change over time. Recreational fishing will have a more localised impact compared to broad-scale commercial fishing.

Over the next 20 years, within the coastal waters adjacent to the NMR, environmental disturbances are most likely to be realised from either chronic conditions or acute events caused by grazing, agriculture, mining, ports and inshore fishing. This latter will be a combination of commercial fishing, fishing tours, recreational and indigenous fishing. Water quality disturbances are likely to be localised to port locations or where river plumes carry impacts from grazing, agriculture and mining activities. The effects of fishing impacts may be concentrated around the most important commercial fishing areas and around population centres. There may be broader effects of fishing upon faunal populations that use a wider range of habitat than the actual locations fished (e.g. dugong). These disturbances are likely to translate to at least some indirect impacts within the NMR itself<sup>[LF1]</sup>.

Within the NMR boundary, over the next 20 years, impacts will be realised from fishing, shipping and offshore oil and gas. Fishing impacts (including from IUU fishing) will be most dispersed throughout the region. Shipping impacts will be more concentrated especially within shipping channels in the NMR. Offshore oil and gas impacts, including building of new pipelines and any offshore terminals are likley to very localised toward the very western end of the NMR where current development and exploration activity is concentrated<sup>[LF3]</sup>. Shipping and the oil and gas industries are also likely to be the source of acute impacts. Bioprospecting in the NMR will increase but current regulations and controls will minimise impacts upon the region. Other economic activities which may be important in 2030 (e.g. aquaculture, tourism, sailing), are unlikely to be of major significance to NMR planning decisions today if existing state and federal regulations are maintained and implemented<sup>[LF5]</sup>.

Another profound impact to the NMR arises from marine debris which stays trapped and suspended in the Gulf of Carpentaria especially due to internal currents. Ghost nets, from mainly foreign but also domestic trawl and net fishing sources, are particularly damaging for already threatened species such as turtle and dugong.

Many future disturbances from industry developments, other activities, marine debris and climate change are cumulative over time and space, which adds an additional element of urgency to the NMR planning processes currently underway. The greater the ability of marine resource users and managers to build the resilience of the ecosystem by limiting impacts of activities that can be controled, the more likely the ecosystem can withstand impacts over which there is little control (e.g. climate change, marine debris and environmental accidents). The nature of the likely influences upon the NMR in twenty year's time also holds relevance for the application of the precautionary principle and of collaborative management of economic and other activities adjacent to and within the NMR.

- any conseration of ofshore energy production? Romy, I don' tknow what is meant here. I've discussed the offshore oil and gas...do they mean something else? [Bioprospecting?](#) [Any other prospective/potential activities?](#)

# 1 Introduction

Australia's marine bioregional planning program is designed to provide a clearer focus on conservation and sustainable management of Australia's marine environment. It is a process that is underpinned by the principles of ecologically sustainable development and it takes an ecosystem approach in managing Australia's marine biodiversity and environment (DEWHA 2009a).

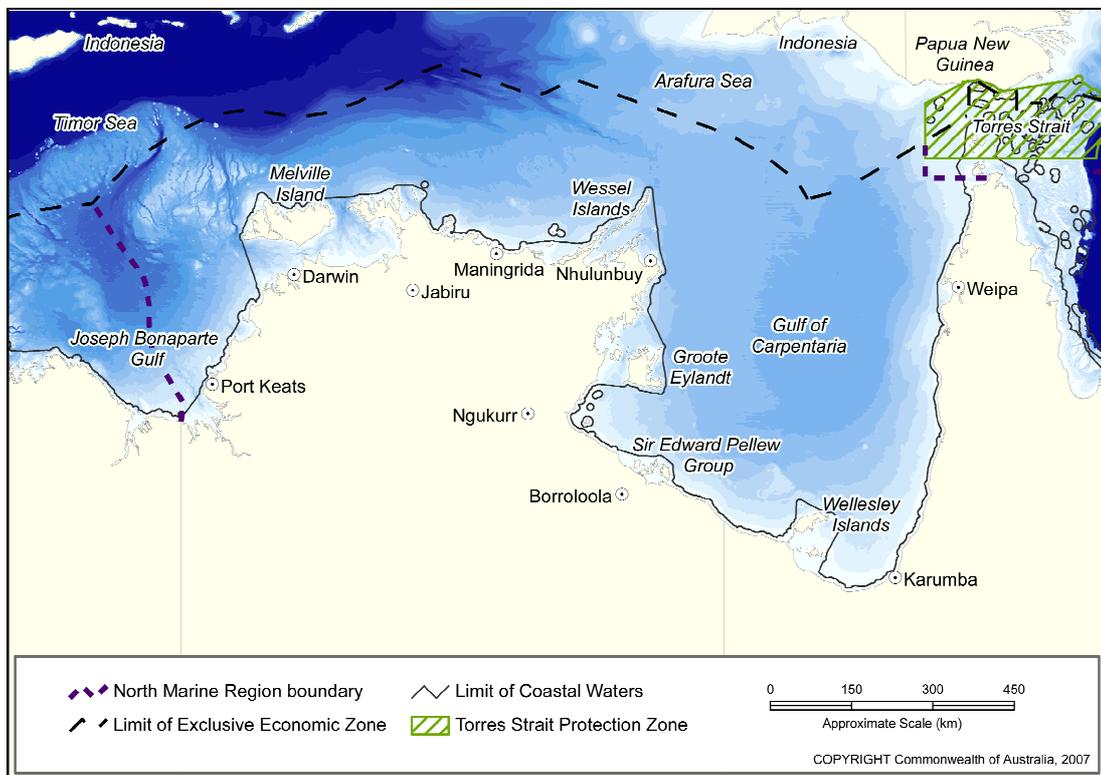
Marine bioregional planning is currently being implemented in five marine bioregional planning regions - the South-west, North-west, North, East and South-east Marine (DEWHA 2009a).

The marine bioregional planning process focuses primarily on Commonwealth waters (the area of Australian jurisdiction that extends past state/Northern Territory waters from around 3 nautical miles to the outer limits of the Exclusive Economic Zone some 200 nautical miles from the shore)(DEWHA 2009a).

Marine Bioregional Plans are being developed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and will fulfil the Australian Government's commitment to establishing a National Representative System of Marine Protected Areas as agreed by all Australian governments in 1998 (DEWHA 2009a)

This report focuses on the North Marine Region (NMR) which encompasses more than 715,000 square kilometres of ocean covering the Gulf of Carpentaria, Arafura Sea and the Timor Sea as far west as the Northern Territory–Western Australian border (Figure 1).

**Figure 1** The boundaries of the North Marine Region



The aim of the report is to consider future development activities in and adjacent to the NMR over a 20-year time frame and their influence on northern Australia's marine environment. The purpose of this work is to assist decision-making in the North marine bioregional planning process. For a full outline of the project terms of reference, see Appendix 1.

The report is divided into the following sections:

- A brief methods section
- Global, national and local drivers of future developments/activities or changes
- Implications of those drivers on the outlook of developments/activities or changes over the next 20 years
- Development hotspots and cumulative impacts
- Effects of disturbances derived from future developments/activities or changes upon NMR species and habitats over the next 20 years
- Conclusions

## 2 Methods

This report incorporates synthesis and review of relevant data including figures, maps and tables to develop its findings. Assessments were made in the following key areas:

- drivers of and impediments to future development,
- the socio-economic links between future developments of relevance to the North Marine Region and developments beyond northern Australia,
- analyses of specific future developments that are dependent on (or strongly influenced by) marine environments and species. This analysis should include consideration of changes in resource use, levels of output, scales of operations, employment, economic value, and spatial distribution of activities likely to establish and/or evolve,
- the relative significance of future development at the regional, State/Territory and national scale,
- any development 'hotspots' in northern Australian waters – geographic areas that are likely to be subject to significant development pressure over the next 20 years, and
- predicted implications of future developments on marine environments and species.

This work accessed and integrated information on generic and specific drivers of, and impediments to, future developments in and adjacent to the NMR. This analysis was then used to determine future impacts of developments on the NMR and implications for marine bioregional planning in the NMR.

The work is entirely desktop based: secondary data were the source of all information used—no new primary data were collected.

~~This [LF6] report presents and integrates information on generic and specific drivers of, and impediments to, future developments in and adjacent to the NMR to assess future impacts of developments on the NMR. The work is entirely desktop based: secondary data were the source of all information used—no new primary data were collected.~~

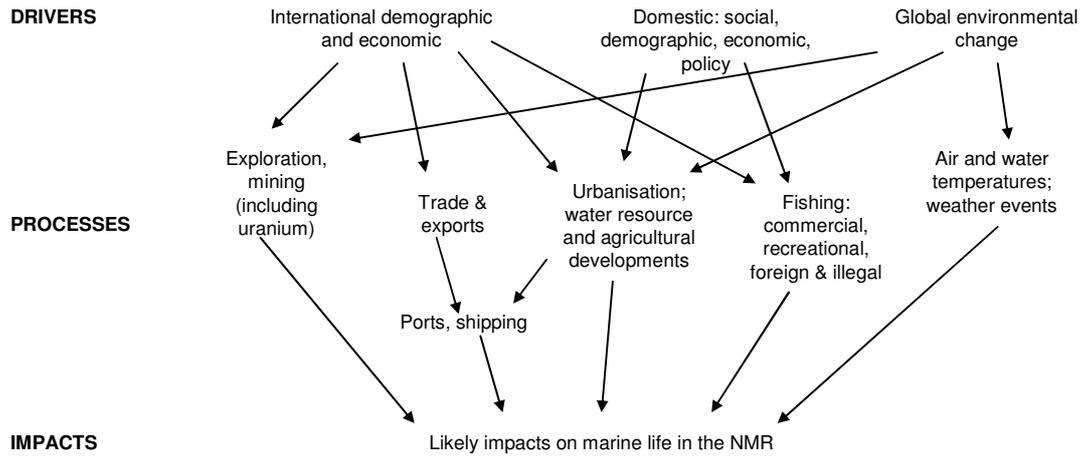
The time frame for this work is 20 years, i.e. the time span from 2010 to 2030. Where data and information were available to allow projections 20 years into the future these were applied either quantitatively or qualitatively—inferences to likely trends were drawn from historical and other available data.

Future development, including the structure and dynamics of industries operating in or adjacent to the NMR, are affected by a range of processes operating at the global, national and regional/local scales. Conceptually, future development can be grouped into drivers and processes, as is shown in Figure 2. Drivers and processes are often interlinked and include:

- global macroeconomic trends such as world economic growth, trade patterns, commodity prices, energy prices, exchange rates, interest rates and demand;
- international politics and policies, such as industry protection, development policy, and geopolitical instability;
- national macroeconomic conditions, including economic growth, consumption patterns, and labour markets;
- domestic politics and policies, including taxation, industry protection, environmental policy, industry assistance and development;

- international and national population dynamics, including changes in population growth and distribution, migration and age structures;
- regional specific trends, including land supply, native title claims, views on the environment, regional development policy, demographic and labour market change.

**Figure 2 Conceptual model of future developments**



### 3 Drivers of future development

Developments in and adjacent to the NMR are influenced by a range of socio-economic drivers. These drivers can be categorised into generic drivers of the kind that will influence developments within and beyond the NMR and more specific drivers that pertain mainly to the area of and adjacent to the NMR. These shall be explored separately.

#### 3.1 Population growth

##### 3.1.1 Population growth adjacent to the NMR

The resident population adjacent to the NMR in 2006 was 150,581 of which 70.4% resided in Darwin (Table 1). Of the remaining 29.6%, the majority resides in the Northern Territory (30,913), compared to Queensland (13,675; ABS 2007a).

Only those statistical units considered geographically adjacent to the NMR—such that developments within them might influence the NMR—provided the spatial basis of analysis. Consequently, entire Divisions were included in the analysis in some instances (e.g. Darwin), while in other instances Sub-Divisions were considered (e.g. Finniss) or Statistical Local Areas (SLAs)(see Appendix 2).

When comparing these data to previous years two factors are significant:

- In 2006, for the first time, data have been published based upon place of residence versus location at census time. These are the data presented in this report. It was estimated that over 10% of the population adjacent to the NMR were non-resident in 2001 (OESR 2004).
- In addition, the boundaries of the geographic statistical units used by the Australian Bureau of Statistics (ABS) changed from 2001 to 2006 to become smaller. In particular, where the NMR used to be adjacent to 12 SLAs, even if the boundaries of the NMR had not changed, the old NMR in 2006 became bounded by 42 SLAs. There are now 76 SLAs arguably adjacent to the NMR. These smaller SLAs mean that areas included previously as being “adjacent to the NMR”—because there was no way to discriminate further—can now be excluded. It also means that, if the data are not normalised, SLAs with the same name may have seen “decreases” in population due solely to decreases in their geographic extent.

**Table 1 Population adjacent to the Northern Marine Region in 2006**

(ABS, 2007a)

Statistical unit	Total Population	Male	Female	Indigenous	Unknown if Indigenous
<b>Northern Territory</b>					
Darwin Division	105993	55084	50909	10258	10482
Bathurst- Melville Sub-Division	2126	1090	1036	1194	15
East Arnhem Sub-Divisions	13941	7227	6714	8549	578
Finniss Sub-Division	1958	1054	904	498	373
Daly Sub-Division	3723	1876	1846	2948	105

Statistical unit	Total Population	Male	Female	Indigenous	Unknown if Indigenous
Alligator Sub-Division	5995	3178	2817	4238	419
Yugul Mangi SLA	1641	826	815	1515	26
Gulf SLA	639	354	285	431	61
Victoria SLA	890	491	399	461	103
<b>NT TOTAL minus Darwin</b>	<b>30913</b>	<b>16096</b>	<b>14816</b>	<b>19834</b>	<b>1680</b>
<b>NT TOTAL</b> (statistical areas adjacent to NMR only)	<b>136906</b>	<b>71180</b>	<b>65725</b>	<b>30092</b>	<b>12162</b>
<b>Queensland</b>					
Arakun SLA	1041	504	537	956	24
Cook SLA minus Cooktown	2129	1195	934	354	298
Injinoo SLA	417	205	212	393	12
Kowanyama SLA	1021	476	545	946	8
Mapoon SLA	240	132	108	216	0
Napranum SLA	839	427	412	781	9
Pormpuraaw SLA	598	309	289	539	0
Weipa SLA	2830	1548	1282	482	238
Burke SLA	498	311	187	126	89
Doomadgee SLA	1084	548	536	1005	15
Carpentaria SLA	1939	1033	906	734	197
Mornington SLA	1032	527	505	944	3
Unincorp. Islands	7	No data	No data	No data	No data
<b>QLD TOTAL</b> (statistical areas adjacent to NMR only)	<b>13675</b>	<b>6711</b>	<b>6453</b>	<b>7476</b>	<b>893</b>
<b>TOTAL</b>	<b>150581</b>	<b>77891</b>	<b>72178</b>	<b>37568</b>	<b>13055</b>
TOTAL NMR minus Darwin	44588	22807	21269	27310	2573
Proportion Darwin	0.704	0.707	0.705	0.273	0.803

There is a relatively high proportion of indigenous people living along the NMR coastline compared to most other areas in Australia (Table 1). In the Northern Territory, outside of Darwin, at least 64% of the population have identified themselves as indigenous (this may be up to 70% if most of those who didn't state their status were also indigenous as determined by the ABS (2007b)). In Queensland 55-61% of the census respondents adjacent to the NMR were indigenous. In Darwin, however the numbers are very different: 10% identified as indigenous (up to 20% if one includes those who didn't state whether they were indigenous or not)(ABS 2007b). These data need to be taken as estimates due to issues that can arise with indigenous data, as set out by ABS (2007b). Nonetheless, there is an order of magnitude difference between the proportion of indigenous people living adjacent to this marine planning region compared with the Australian average of 2.5% (ABS 2007b).

In considering what the population of this area may be in 2030, we can consider historical data as well as projections. While there is a general trend of increasing population, no cohesive picture of population change emerges over the past ten years, considering

population change from 1991-1996 and from 1996-2001. There are diverging trends for some SLAs between different census periods, and diverging trends between different SLAs. The ABS (ABS 2007c) has inferred that some of the (increasing) population changes are to do with changes in mining activity (e.g. Weipa) and others (decreasing) are to do with the ongoing drought leading to the departure of some people dependent upon pastoral activities (e.g. Carpentaria and Gulf SLAs). Trends within SLAs from 2001-2007 cannot be elucidated due to changes in SLA boundaries.

With the exception of Darwin Division (and, arguably, East Arnhem), the proportion of change usually means a relatively small change in actual numbers of people, for example, a proportional change of 4.6% in Mapoon represented an increase of population of 53 people (Table 2).

The ABS (2006a) projects population trends forward on a state-by-state basis based upon assumptions to do with birth rate, net migration and mortality. Projections are provided for assumptions leading to high, medium and low levels of growth and population status as at 2021, 2051 and 2101.

Queensland is projected to experience the largest increase in population between 2004 and 2051, increasing by 3.0 million people (77%) to reach 6.9 million people, resulting in Queensland replacing Victoria as Australia's second most populous state in 2041. In all scenarios, however, approximately half the growth is in southeast Queensland. Also, many of Queensland's northern towns along the east coast can be expected to continue experiencing significant growth. Along the west coast of Queensland, the Far North Statistical Division has an average growth of about 1% pa, and the North West Statistical Division has averaged a decline (ABS 2007c). The rate of population increase amongst Indigenous people in Queensland is also among the country's highest: 2.6-2.7% compared to an Australian average of Indigenous population growth of 2.2% (ABS 2010a). This increase (if it applies to that part of Queensland adjacent to the NMR) would have the effect of, approximately, doubling the baseline of 7476 (Table 1)(ABS 2010a).

The Northern Territory's population is projected to increase by 150,200 people between 2004 and 2051, to 350,000 people (ABS 2007c). Most of this growth is expected in the Darwin area; estimated to grow to between 142 000 to 189 000 by 2026 (ABS 2008e). In the Northern Territory the ABS (2010c) predict that by 2021, there will be an Indigenous population of ~81 300, an increase of some 17 300 since the 2006 census. This increase is perhaps less than might be expected because the ABS (2010a) states that Indigenous birth rates (2.2%) are much higher than Australian birth rates (1.2%). However, the ABS (2010c) states that the rate for the Northern Territory is lowest of all the states/territories at only 1.6-1.7%.

Although the numbers for the Northern Territory represent smaller absolute increases than those projected for the larger states, this is a significant proportional increase (75%, second only to Queensland's projected increase of 77%) relative to the Northern Territory's small population in 2006 of just 210,674 (ABS 2007c).

Australia is a highly urbanised country with approximately 75% of its population in urban areas (ABS 2006b). This is similar for the areas adjacent to the NMR, however there is only one urban area, Darwin. Darwin has an average density of 36.6 persons/km<sup>2</sup>. In comparison, Brisbane and Sydney have population densities of 309 and 336 persons/km<sup>2</sup>, respectively. Inner city population density for Darwin is 643, compared to Brisbane 3123 and Sydney 4355. As Table 2 shows, the density of population for people in the "urban" centres of the north (Darwin or Weipa) is vastly different to these major cities and the extremely sparsely populated areas make up the majority of the area adjacent to the NMR.

Projections indicate that this relatively low population density will continue to be a feature in the North for the next 20 years.

**Table 2 Proportional change in population and density for statistical areas adjacent to the NMR**

(ABS 2007c).

Statistical unit	% change in population 1996-2001	% change in population 2001-2006 (no. people)	Area km <sup>2</sup>	People/km <sup>2</sup>
<b>Northern Territory</b>				
Darwin Division	2.2	1.4 (7526)	3122	36.6
Bathurst- Melville Sub-Division	2.8	0.5 (57)	7492	0.3
East Arnhem Sub-Divisions	1.9	2.7 (1991)	38434	0.4
Finniss Sub-Division	0.4	3 (297)	7851	0.3
Daly Sub-Division	1.2	3 (592)	37679	0.1
Alligator Sub-Division	1.4	2.2 (703)	59041	
Yugul Mangi SLA	4.6	4.7 (397)	27899	0.1
Gulf SLA	4.7	-5.7 (-250)	60514	0
Victoria SLA	4.2	0.5 (26)	148 702	0
<b>ENTIRE NT</b> (incl non-NMR areas)	1.7	1.3 (12 906)	1 352 176	0.2
<b>Queensland</b>				
Arakun SLA	5.5	0.8 (43)	7375	0.2
Cook SLA	3	-0.1 (19)	106 188	0
Injinoo SLA	2.9	1 (23)	841	0.6
Kowanyama SLA	0	1.8 (93)	2571.9	0.4
Mapoon SLA	2.6	4.6 (53)	550	0.5
Napranum SLA	1.2	2.9 (121)	1994	0.5
Pormpuraaw SLA	2.6	0.7 (23)	4456	0.1
Weipa SLA	-2.6	6.9 (856)	10.9	279
Burke SLA	12.4	1.4 (35)	40 126	0
Doomadgee SLA	6.2	-0.3 (-20)	1863	0.6
Carpentaria SLA	3	-1.9 (-206)	64 372	0
Mornington SLA	-2.2	2.2 (114)	1232	0.9
Unincorp. Islands	0	0 (7)	16	0.4
<b>ENTIRE QLD</b> (incl non-NMR areas)	1.7	2.4 (462 600)	1 734 174	2.4

### 3.1.2 Australian population growth

For Australia as a whole, in 2006, the population was 19,855,288 (ABS 2007a). The ABS (2008e) projects that by 2026 the population will be between approximately 26 million and 29 million; by 2056 estimates are between 31-43 million. These projections are not incongruous with Treasurer Wayne Swan's prediction of a population that will grow by 65 per cent, to 35 million by 2049 (see Media Release, 2009, No. 101 at <http://www.treasurer.gov.au/listdocs.aspx?pageid=003&doctype=0&year=2009&min=wms>). By 2101, the ABS (2008e) projections are for between 34 million and 62 million people. Which trajectory Australia takes is dependent on factors such as the birth rate, net migration and mortality.

Domestic population growth will lead to increased domestic demand for food, fibre, energy and other products and services, many of which may be produced in the NMR or adjacent to the NMR.

### 3.1.3 Global population growth

The world population is projected to grow from around 6.8 billion in 2010 to 8.2 billion by 2030. The rate of population growth is decreasing over time but for this 20 year period remains just above or below 1% pa (Source: U.S. Census Bureau, Population Division, <http://www.census.gov/ipc/www/idb/worldpop.php>).

Global population growth is relevant to the NMR as it affects demand for food and other natural resources (such as fish, minerals) and relative status of Australian versus other sources of natural resources (see more under Section 3.3). If Australia husband its natural resources well, compared to elsewhere, the demand for these will increase as alternatives become scarce.

### 3.1.4 Neighbouring countries

The US Census Bureau (2010, <http://www.census.gov/cgi-bin/broker>; downloaded 24/5/10) expects that, in 2030, Indonesia to be the fourth most populous country in the world (~289 million) after India (~1461 million), China (~1392 million) and the USA (~374 million). These top four countries are therefore projected to increase by about 450 million people in the next 20 years. The Philippines is projected to have a population of ~138 million people in 2030 and Japan ~114 million (US Census Bureau 2010). Some of these countries are pertinent as trading partners, others are neighbouring countries and some are both.

## 3.2 Employment and education

Employment and education levels provide an indication of the social resilience and flexibility of communities. They also indicate potential capacity to take up new employment opportunities and, in that way, contribute to new developments, should they arise. New developments that required a skilled workforce (e.g. mines, oil and gas, ports) might either develop more slowly or more quickly depending on availability of locally-sourced, adequately trained personnel [LF8]. In addition, for the more remote communities, employment and education levels might also be linked to levels of subsistence fishing that takes place. Some data from the 2006 census is provided in Table 3.

In Queensland, on the whole, 35% of the population over 15 years old had attained year 10 level education; an additional 41% attained year 12. In the Northern Territory as a whole, the numbers do not differ much from those for Darwin (~35% attaining Yr10; ~40% attaining year 12), as this is where most of the population lives (Table 3). Australia-wide 33% of people over 15 years old had attained year 10 and an additional 42% attained year 12 (ABS 2007a). Comparatively, then, the numbers attaining year 10 level education compare favourably with Australia as a whole whereas the numbers attaining year 12 education do not (Table 3).

The majority of employment for the region adjacent to the NMR occurs in Darwin in the government sector (either departments, 4166; defence, 3946; or in schools, 2953)(Table 3). There are also some 1635 that work in the food services industry in Darwin and 1521 that work in public order and safety services.

Outside of Darwin, three main sectors prevail overall: government administration; beef cattle farming and mining. It should be noted that Indigenous people employed under the Community Development and Employment Scheme are counted within the category "Government Administration" which would account for a significant amount of the employment in this category for the areas adjacent to the NMR. This, in turn, suggests a high level of dependence on this government program for income in these communities.

**Table 3 Education and employment of people living adjacent to the NMR**

(Source: ABS 2007d except where otherwise indicated)

Statistical unit	Attain Year 10 (%) over 15 y.o.	Attain Year 12 (%) over 15 y.o.	No. employed (% of labour force) <sup>1</sup>	Main economic sector (no people)	Secondary economic sector (no people)
<b>NT</b>					
Darwin Division	28713 (35%)	33041 (40%)	72559 (98.1%)	State Government Administration (4166)	Defence (3946) [3 <sup>rd</sup> : School Education 2953]
Bathurst- Melville Sub-Division	663 (44%)	209 (14%)	935 (87.9%)	Government Administration (253)	Other social assistance services (70)
East Arnhem Sub-Divisions	2620 (27%)	2109 (22%)	6523 (95.2%)	Government Administration (835)	Basic non-ferrous metal manufacturing (668)
Finniss Sub-Division	518 (33%)	351 (23%)	920 (91.6%)	Tertiary education (80)	School education (70)
Daly Sub-Division	503 (21%)	322 (14%)	1154 (88.6%)	Government Administration (280)	Beef cattle farming (122)
Alligator Sub-Division	1034 (25%)	715 (17%)	2301 (91.0%)	Government Administration (325)	Metal ore mining (190)
Yugul Mangi SLA	258 (25%)	110 (11%)	527 (87.3%)	Government Administration (115)	Other social assistance services (755)
Gulf SLA	126 (29%)	57 (13%)	298 (89.8%)	Government	Beef cattle

<sup>1</sup> Full or part-time; source for NT employment numbers is ABS 2010a

Statistical unit	Attain Year 10 (%) over 15 y.o.	Attain Year 12 (%) over 15 y.o.	No. employed (% of labour force) <sup>1</sup>	Main economic sector (no people)	Secondary economic sector (no people)
Victoria SLA	224 (34%)	126 (19%)	487 (86.8%)	Administration (101) Beef cattle farming (193)	farming (40) Other social assistance services (79)
<b>Queensland</b>					
Arakun SLA	300 (43%)	47 (7%)	305 (91%)	Government Administration (163)	Other social assistance services (37)
Cook SLA	969 (35%)	816 (29%)	1462 (94%)	Government Administration (121)	Beef cattle grazing (119)
Injinoo SLA	114 (44%)	51 (20%)	166 (93%)	Government Administration (88)	Hospital (6)
Kowanyama SLA	375 (51%)	112 (15%)	452 (99%)	Government Administration (322)	School education (25)
Mapoon SLA	61 (34%)	30 (17%)	109 (96%)	Government Administration (55)	Other social assistance services (7)
Napranum SLA	210 (38%)	83 (15%)	249 (93%)	Government Administration (152)	Basic non-ferrous metal manufacturing (19)
Pompuraaw SLA	154 (35%)	54 (12%)	274 (95%)	Government Administration (159)	Other social assistance services (17)
Weipa SLA	873 (43%)	778 (38%)	1621 (99%)	Basic non-ferrous metal manufacturing (523)	School education (126)
Burke SLA	161 (38%)	122 (29%)	299 (100%)	Beef cattle grazing (76)	Metal Ore Mining (46)
Doomadgee SLA	317 (47%)	69 (10%)	312 (93%)	Government Administration (65)	Other social assistance services (57)
Carpentaria SLA	516 (35%)	332 (22%)	826 (95%)	Beef Cattle Grazing (186)	Government Administration (100)
Mornington SLA	267 (38%)	143 (20%)	361 (95%)	Government Administration (155)	Other social assistance services (50)
Unincorp. Islands	No data	No data	No data	No data	No data

Many jobs in the mining sector in particular are fly-in–fly-out labour to support its industry in the face of insufficiently skilled local labour (Greiner *et al*, 2006). This means that enumerated (i.e. resident-based) ABS employment statistics may underestimate the amount of labour employed in some sectors in remote statistical areas as many employees have their place of residence outside the statistical area. It also means that many of the employment benefits provided by the mining sector accrue beyond the local communities.

In some statistical areas within the NMR, large proportions of the working-age population are not part of the work force. For example, in 2006, 42% of people over 15 years old in the Tiwi Islands did not participate in the work force, 39% in East Arnhem, 46% in Alligator, 54% in the Daly, 39% in Finiss. On average, across Australia, about 33% of people of working age are not in the labour force (ABS 2007a).

As Greiner *et al* (2006) and Altman (2007) point out, there is a significant indigenous participation in the informal sector and subsistence activities, including fishing, form an important component of those activities.

### 3.3 Global economic trends

As illustrated by the Global Financial Crisis in 2009, global economic forces exert great and sometimes volatile influence upon demand for goods and services including those generated by the NMR and adjacent areas. Over a time frame of five or even ten years, interest rates and foreign exchange rates can and do influence economic development (Clifton *et al* 2007). Unfortunately, for the region adjacent to the NMR, and Northern Australia more generally, no income data is available for the most recent period of 2007–09 as an indicator of economic growth (BITRE 2009). This means that the impact on Northern Australia specifically of the recent global economic downturn could not be quantitatively illustrated (BITRE 2009).

However, even large fluctuations tend to average over a twenty year time frame (see Figure 3). Also, aside from areas with chronic political instability, short-term political instability in particular countries is unlikely to drive long term global demands for goods from the NMR. In addition, the majority of the nations to which the region's industries export (e.g. China, Japan, India) and the main foreign neighbours (such as Indonesia, Philippines, Malaysia) are relatively politically stable (see [http://info.worldbank.org/governance/wgi/sc\\_country.asp](http://info.worldbank.org/governance/wgi/sc_country.asp); accessed 17/6/2010).

Over a twenty year time frame, for the reasons discussed above and below, global demand for goods from the NMR and adjacent areas can be expected to increase both in volume and breadth. In terms of breadth, we mean that demand for goods presently not available from the region may drive development, particular in the energy industries as well as the tourism sector. Climate change contributes large uncertainty to those industries that it may impact, such as agriculture, cattle grazing and fisheries (see Sections 3.4, 4.1, 4.4 and 4.11.1. for more on this).

#### 3.3.1 Trade partners

Main nations importing from the Northern Territory include China, Japan, Hong Kong, Indonesia, India, United States and Canada; Queensland exports primarily to China, Korea, India, Japan, United States, Taiwan and the UK (ABS 2008b). The US and Canada, are still experiencing population growth although real GDP growth has temporarily slowed or ceased due to the Global Financial Crisis (CIA 2010). China is maintaining a positive growth although, presently, at a lower rate than expected (<http://www.chinability.com/GDP.htm>; sourced 26/5/10) as is India and Indonesia (CIA 2010). Their collective demand for goods produced in northern Australia, at the moment, is focussed upon metal ore and its products. Exports are driven by international demand. International demand, at its basis, is driven by population growth, economic growth and can be facilitated or constrained through trade agreements.

**Figure 3. Dow Jones Industrial monthly average since 1900 to present.**

(Source: <http://stockcharts.com/charts/historical/Print/djia1900print.html>; accessed 26.5.10)



### 3.3.2 Demand for natural resources

Currently, the main exports from the area adjacent to the MNR are derived from mining activity and the beef cattle industry. Other exports include the fishing sector. (ABS 2008b)

While an increasing world population stimulates demand, resource scarcity is becoming a global issue for some of the products derived from the area adjacent to the NMR, specifically in relation to energy and fish. Aleklett *et al* (2010) found that global oil production has very likely passed its maximum already. UNEP (2010) stated that if the world remained on its path of overfishing, fish stocks could become uneconomic to exploit, or extinct, by 2050.

An assessment of Asia’s energy future asserts that the region’s (along with the United States’) oil consumption is rising faster than production (Wu and Fesharaki 2007). This is at a time when the end of the world’s oil supply is in sight and Australia is one of the key suppliers of Asia’s energy (Wu and Fesharaki 2007). World oil production is expected to increase and peak in the next 10-15 years then decline (Aleklett *et al* 2010, Wu and Fesharaki 2007). In this environment of scarcity, oil prices are likely to rise; existing reserves that are under production will continue to be exploited and other reserves previously deemed “uneconomic” may become profitable to exploit. To date, exploration of the NMR for oil and gas, has not led to much in the way of new production sites (see Section 4.2). As global scarcity of fossil fuels increases and prices rise in the next 20 years, this may change.

Pauly *et al* (2002), Clover (2005), Pauly (2010) and UNEP (2010) found that globally, catch of fish has been declining since the late 1980s and that continuation of the trend will lead to supply shortfall. These authors assert that fisheries have rarely been 'sustainable'. Rather, fishing has induced serial depletions, which have been masked by improved technology, geographic expansion and exploitation of previously spurned species lower in the food web. And climate change only threatens to reduce the sustainability of fisheries (Pauly 2010).

As demand for resources and food increasingly outstrips supply, prices can be expected to increase. Price increases will accelerate due to the relative price inelasticity of demand for food, fuels and metals compared to, for example, non-essential items such as recreational services (Seale, Regimi and Bernstein 2003). Increasing product prices will further encourage the rate of mining of all the available stocks (including of metal ore, oil and gas and fisheries) including some that may not have been "economic" to exploit previously. In the fisheries sector, sustainability of fish stocks in the presence of these global pressures requires harvest constraint as well as actual protection from illegal domestic and foreign fishing.

### 3.3.3 Economic growth rates

In 2007, the International Monetary Fund (IMF) forecast terms growth rates of around 5 per cent in the short to medium term for the broader world economy (Clifton *et al* 2007). More recently, Global Financial Crisis has been a source of instability in the global economy with a global Gross Domestic Product (GDP) reduced to -0.8% in 2009 (CIA 2010). However, the IMF (2010) states that the global recovery has evolved better than expected, with activity recovering at varying speeds— tepidly in many advanced economies but solidly in most emerging and developing economies particularly in Asia, including some of Australia's major trading partners. Advanced economies are now expected to expand by 2¼% in 2010, and by 2½% in 2011, following a decline in output of more than 3% in 2009. Growth in emerging and developing economies is projected to be over 6¼% during 2010–11, following a modest 2½% in 2009 (IMF 2010).

Over the last 30 years, however, developing and emerging economies have averaged a growth in their GDP of 6.7%; advanced economies have averaged 1.3% and globally the average has been 3.7% (IMF 2008). However, within any 5-year-period, GDP values have varied from rises of 5% to falls of 3-4% within any one of these groups of economies (IMF 2008). These statistics highlight two things:

- in a twenty year time frame, one can almost guarantee a growth in demand for natural resources; and
- short term (e.g. 5-year) trends are not a good predictor of long term trends.

### 3.3.4 Trade agreements

Trade agreements and other international agreements, for example related to biodiversity protection, can impact upon the future functioning of economic sectors by changing the accessibility to global commodity markets.

Australia already has free trade agreements in place with New Zealand, the United States, Thailand, Chile, Singapore and the ASEAN nations and is seeking to establish similar agreements with China, the countries of the Arab Gulf, Japan, Korea and Malaysia (DFAT 2010). The feasibility of bilateral free trade agreements with India and Indonesia is being explored (DFAT 2010).

Meanwhile, the World Trade Organisation is continuing negotiations regarding access to (agricultural product) markets, specifically beef, as well as non-agricultural market access (NAMA) and services (DFAT, 2010). Agreements at this level will impact upon Australia's exports especially Australia's major agricultural export, beef, a large proportion of which is sourced from the vast grazing areas adjacent to the NMR. It is not possible to predict the timing and exact nature of these negotiations. It is, however, likely that changes are likely to be incremental and implemented over reasonable timeframes to allow sectors to adjust.

### 3.3.5 Other drivers

Developing countries are increasing their rate of per capita consumption. For example, McNally *et al* (2007) note that demand for goods such as cars and beef is increasing in China. These kinds of changes have two consequences for the NMR:

- Global demand for goods, such as supplied by the NMR and adjacent areas, will increase at a rate that exceeds the rate of population growth in Australia; and
- As workers in developing countries demand increased wages to satisfy their consumer needs (McNally *et al.*, 2007), Australian goods and services will become more competitive on a global market.

## 3.4 Climate change

Section 3.4 overviews the likely physical manifestations of climate change and provides a basis for discussion in later sections of the report (e.g. Chapters 4 and 6). Climate change is relevant to this assessment for two reasons, which are interrelated:

- Higher water temperatures, ocean acidification and other associated effects potentially impact upon marine environments directly (see Section 4.11.1 and Chapter 6); and
- It may indirectly impact because it affects the type and rate of future economic developments in the NMR and associated environmental impact (see Chapter 4).

For example, should climate change impact upon fish stocks then this is significant from both an industry development and a marine planning point of view. In this section, we provide projections regarding potential changes that climate change might bring about. Implications of these projections per industry/activity are included in the relevant parts of section 4 (Future developments/activities). Implications of these projections upon the marine environment directly are discussed in section 4.11.1.

### 3.4.1 Historical changes

Since 1950, the Northern Territory's average annual maximum temperature has increased by about 0.12°C per decade and the minimum has increased 0.17°C per decade, with greater warming in May-October than November-April (Hennessy *et al*, 2004 in Hyder Consulting 2008).

The Northern Territory has also become wetter. From 1900-2002 the Northern Territory average rainfall increased by 14.2 mm per decade during Nov-Apr and 2.5 mm per decade during May-October. Since 1950, the Northern Territory rainfall average has risen 35.7 mm per decade during November-April and fallen 0.4 mm per decade in May-October. This was mainly due to extremely wet conditions in the mid-1970s and 1999-2000. Since 1910,

the intensity of heavy daily rainfall events has risen 10% (Hennessy *et al.* 2004 in Hyder Consulting 2008).

A trend of rising temperatures has been observed in Queensland over recent decades and four of the state's seven hottest years since 1910 occurred since 2002 (DERM 2009). Annual mean temperatures since 1950 have also increased across northern Queensland (DERM 2009). Over the period 1950 to 2007, annual and summer rainfall in the far west and far north of Queensland increased while the rest of the state became drier (DERM 2009).

Sea surface temperatures in many tropical regions have increased by almost 1°C over the past 100 years (some tropical seas up to 2°C) and are currently increasing ~1–2°C per century (Hoegh-Guldberg, 1999 in Hyder Consulting 2008). As an example, sea surface temperatures on the Great Barrier Reef in early 1998 were the warmest in the past 95 years of instrumental record and were associated with significant coral bleaching (Lough 2000 in Hyder Consulting 2008).

#### 3.4.2 Temperature projections

There are no NMR specific projections of climate change. Projections have been provided for Northern Australia (CSIRO 2007, Ross *et al* 2009), which indicate that, by 2030:

- Air temperature will increase between 0.6-1.5°C with temperature increases in coastal areas being around 0.7-0.9°C—commensurate with a decrease in daily temperature range.
- Sea surface temperature will increase by 0.3-0.6°C.

BITRE (2009) has used the CSIRO data to predict temperatures for Northern Australia per region and/or Statistical Local Area (pp221-222).

#### 3.4.3 Precipitation, evapotranspiration, wind speeds and cyclone projections

There is a wide range of uncertainty in scenarios of future rainfall trends (Hadley Consulting 2008). Overall, the CSIRO (2001) scenarios indicate annual average rainfall for the tropical north may change between -5% to +5% by 2030 and -10% to +10% by 2070. Decadal scale natural variability in precipitation is comparable in magnitude to the projected changes and may therefore mask, or significantly enhance, the greenhouse-forced changes (CSIRO 2007).

Rainfall is not predicted to change significantly in the north of Australia by 2030 with any chance adjacent to the NMR being in the negative (CSIRO 2009). Annual potential evapotranspiration, however, is projected to increase right across Australia. This means that the NMR region will be drier (CSIRO 2009, Ross *et al* 2009). Largest increases in evapotranspiration will be in the north and east, where the change by 2030 ranges from little to a 6% increase, with “best estimate” of around a 2% increase (CSIRO 2007). This is equivalent to reductions in rainfall of between 15-160 mm by 2030 and 40-500 mm by 2070 and indicates that much of the continent will be subject to reduced soil moisture and runoff in the future (CSIRO 2001). Up to 20% more drought events (defined as the 1-in-10 year soil moisture deficit from 1974-2003) are expected to occur over most of Australia by 2030.

BITRE (2009: pp221-222) used the CSIRO data to predict rainfall for Northern Australia per region and/or Statistical Local Area.

CSIRO (2007) projects a tendency for increased wind speed in most coastal areas in 2030 within a range of -2.5% to +7.5% with best estimates of +2% to +5%. While there may be a decrease in the number of cyclones experienced, storm intensity will likely increase (CSIRO 2007). Ross *et al* (2009) also expect that the region will be subject to more extremes of weather, with the intensity of severe floods, tropical storms and cyclones in 2030 exceeding twentieth century averages.

#### 3.4.4 Sea level rise and ocean acidity projections

Over the period 1920 to 2000 the estimated average sea level rise around Australia was 1.2 mm per year. Global sea level rise is projected by the IPCC to be 18-59 cm by 2100, with a possible additional contribution from ice sheets of 10 to 20 cm (CSIRO 2007). By 2030, Ross *et al* (2009) estimate that since the year 2000, the sea level in northern Australia will have risen, on average, by 0.3 metres, inundating low-lying areas such as Kakadu's World Heritage-listed wetlands, and increasing the vulnerability of infrastructure such as ports and processing facilities.

Increases in ocean acidity are expected in the Australian region with the largest increases in the high to mid latitudes, affecting the capacity for shell and endoskeleton creation by marine organisms (CSIRO 2007). This is not expected to be a problem in the northern region over the next 20 years.

##### 3.4.4.1 *El Niño Southern Oscillation (ENSO)*

While there has been an increase in the frequency of El Niño events in recent years, there is no consensus amongst current climate models that global warming should cause an increase (CSIRO 2007). Regardless of any link between climate change and the ENSO events, projected changes in climate will be superimposed on natural variability including ENSO and the Inter-decadal Pacific Oscillation. This will move the region towards more El Niño-like conditions with a corresponding mean eastward shift of precipitation over the tropical Pacific and the weakening of the inter-annual ENSO-Asian-Australian monsoon connection (IPCC Working Group I, Chapter 10, 2007 in Hyder Consulting 2008).

### 3.5 Domestic policy and economic drivers

This section discusses the likely impacts of policy and economic drivers at a national, state and territory and local level, on the future development of industries and settlements. The main drivers of the economy in the region adjacent to the NMR are of a global nature, however, Australia, the Northern Territory and Queensland's economic and institutional environment are important to the future of the region as well.

There is a long history of government involvement in north Australian development, at the state and commonwealth level. Policy interest has been driven by both threats and perceived opportunities. At times this has manifested itself in the form of considerable public investment in research and infrastructure or tax incentives, and other encouragements to move people and economic activity north (Davidson 1965, Symanski 1996). There has also been considerable public policy and planning support aimed at encouraging development in the north. Recent public discussions over the effects of climate change and prolonged drought—and the apparent abundance of water in the north—have rekindled this long held interest of all tiers of government in settling and developing the north.

Recently, there has been renewed interest by policy makers in “pushing back the physical barriers that have constrained development, particularly agricultural development” (Heffernan 2006, Sydney Morning Herald 2007, Australian Government 2008). To this end the “Northern Land and Water Taskforce” was established in 2007 to explore opportunities for new sustainable economic development (see <http://www.nalwt.gov.au/>; accessed 17/6/10). They have provided advice and recommendations to government through published reports (e.g. Ross *et al* 2009).

### 3.5.1 The Australian economy

The IMF (2008) predicted annual GDP growth for Australia, in real terms, of between 3.1 and 3.5 over the subsequent 5 years. In the past 30 years Australia averaged 3.2% annual growth, with significant inter-annual variations (e.g. 6.4 in 1984; -1.3 in 1991). In the short term, growth has been far less (~1.0% GDP in 2009) due to the Global Financial Crisis (CIA 2010).

The Australian economy, in the long term, is heavily influenced by global trends, discussed above, as well as domestic population growth, skills and education base (see Sections 3.1 and 3.2) and natural resources.

Clifton *et al* (2007) discuss a number of generic national and statewide policy and political drivers for that part of Australia adjacent to and within the North West Marine Region (refer to Section 3.4). These economic, infrastructure, environmental, land and inter-governmental drivers also apply to the rest of northern Australia adjacent to and within the NMR. That discussion is not duplicated here. Particular State or Territory industry-wide drivers are discussed in more detail below.

### 3.5.2 Northern Territory economy

There are impediments to economic growth in the north. Anwar and Prideaux (2005) predicted that, in the near future at least, the NT’s growth would continue to be hampered by a small population base and a relatively small and unchanging level of participation in the labour market (see also Section 3.1.1 above). These factors offer explanations as to why the NT’s economic growth rate has consistently been the lowest across all states and territories. Combined with its small manufacturing sector (which contributes significantly to value-adding in an economy) and relative remoteness, according to Anwar and Prideaux (2005), this will lead to continued slow economic growth for the NT in the near term. At the same time, they also recognised the “unrealised potential” of the mining industry and the proximity to the Asian market. One might argue that this potential has and is now being mobilised through increases in investments. NT government figures show that in 2004-05 growth was 3.6% (third highest in Australia), in 2005-06 growth was 7.5% (the highest in the country) and in 2006-07 growth was 5.6%, second in the country only to WA. In 2006-07 growth was due, in part, to a 448% increase in exports of LNG from the Wickham Point plant in Darwin and offshore oil production (Northern Territory Treasury 2007). Although defence is an extremely important sector in Darwin (Table 3, Sections 3.5.4 and 4.8.2), mining is the mainstay of this economy—being over three times more significant than any other sector in 2006-07 (Northern Territory Treasury 2007). The global market, support of the NT government and improvements in collaborations with Native Title holders seem set to ensure the place of mining in NT’s future.

### 3.5.3 Queensland economy

In Queensland, over the year to December 2007, Queensland's GSP grew by 7.1%, well above the rest of Australia's growth of 3.1%. For fifteen consecutive quarters, annual economic growth in Queensland has been higher than for the rest of Australia. This would have little bearings for the NMR as the north-western part of the State behaves differently to QLD as a whole being largely driven, economically at least, by mining and pastoral activities. As with the NT government, the Queensland Resources and Energy section in the Department of Employment, Economic Development and Innovation (DEEDI) provides strong support to mining efforts in the State ([www.dme.qld.gov.au](http://www.dme.qld.gov.au)). As an indicator of the historical direction of mining revenue for Queensland, the gross operating surplus (and mixed income) for mining in Queensland almost quadrupled between 1996-2007 to over \$11 billion (ABS 2008d). This dwarfs the increase of the agriculture sector (including forestry and fisheries) which, over that same time, went from \$2.33 to \$3.99 billion gross revenue (ABS 2008d). The majority of revenue was generated by the cattle industry (\$3 billion in 2006; OESR 2007). Cattle grazing is the largest land use on the land adjoining the NMR and is therefore important to the NMR for environmental reasons (see Section 4.1). However, other, non-extractive land uses are assuming more importance, in particular conservation—through an expansion of not-for-profit sector investment—and [nature-based tourism](#) (Greiner *et al* 2009[LF12]). In many areas across the north, tourism now employs more people than agriculture. This provides evidence of the multifunctional transition of north Australian rangelands (Greiner *et al.*, 2009).

### 3.5.4 Local Economic Drivers

Because of the low population base and remoteness of much of northern Australia, current economic activity and potential growth across the area adjacent to the NMR is heavily dependent on:

- global markets for raw materials and food/fibre; and
- public investment in infrastructure, defence and social programs (health, education and environmental management)(Anwar and Prideaux 2005).

Overall the economy adjacent to the NMR is much less dependent on locally generated demand drivers such as tourism.

Government expenditure on defence activities in northern Australia has been increasing over the last few years. Defence personnel and their dependents now account for approximately 6 % of the total population (210,674 at the last census) of the Northern Territory (ABS 2007d). Mining has expanded recently in the southern gulf area of Queensland. The largest mine is the Century Zinc mine which is expected to remain in production until 2017 (Miley *et al* 2007).

Despite the vastness of northern Australia, major private industry is spatially concentrated, especially in Darwin and Weipa, and few other localities. Large distances separate the various communities and communications though improving is well below that in the more settled parts of the country. Travel is often constrained significantly during the monsoonal wet season. Distance and sparse population will continue to constrain growth (Gulf Regional Planning Advisory Council 2000).

Ross *et al* (2009) identify that some developments in the north will be constrained by availability of resources such as water and arable land. They see a need to address the following in order to take advantage of future development potential: transport infrastructure and viable routes to market, particularly during the wet season; power and telecommunications; skilled and affordable workers; bankable land tenure; social and

community services that support families and improve liveability; affordable housing; regulatory regimes that minimise red tape and facilitate flexible, contemporary business models; and strong and effective planning institutions that facilitate community engagement in achieving sustainable outcomes.

### 3.5.5 Legislation and policy

Greiner *et al* (2006) discuss over 70 national, state, territory and regional pieces of legislation, policy, plans and strategies that are pertinent to the NMR. The implications for NMR planning are also discussed therefore this information is not duplicated here. The implications of these pieces of legislation, policies, plans and strategies for future developments in and adjacent to the NMR are considered for each activity discussed in Section 4.

More recently the establishment of the Northern Australia Land and Water Taskforce, the definition, by the Australian Government, of a geographic area to be called “Northern Australia” and Prime Minister Rudd’s imperative to develop Northern Australia as an integrated, sustainable region is a new policy agenda indicate refreshed support for “northern” development (Ross *et al*, 2009).

If some of this support translates to addressing development constraints identified in Section 3.5.4, the level and nature of future developments will be influenced accordingly.

One area of uncertainty lies in the future national, state, territory or even global policies regarding climate change. The development implications of any form of future Australian Government carbon pollution reduction scheme are heavily debated (<http://www.climatechange.gov.au/en/government/initiatives/cprs.aspx>), Although, on 27 April 2010, the Prime Minister announced that the Government had decided to delay the implementation of the current proposed CPRS, over the next 20 years some form of carbon reduction scheme is likely and the development implications unclear. Garnaut (2008) suggest that any significant climate change mitigation (to reduce emissions to 550ppm), implemented in the short term, will reduce Australian GNP by less than 0.2%pa for the next 50 years and then it will then contribute to increases in GNP. But others dispute these analyses.

For further discussion on potential impacts of climate change on development this see Sections 3.4 and 4.11.1)

### 3.5.6 Indigenous rights and interests

As Ross *et al* (2009) state, Indigenous people of northern Australia have an inherent right to make decisions about cultural and natural resource management and must have a central role in the development, implementation and evaluation of policy and legislative or administrative measures that affect them. And Northern communities, including Indigenous communities are calling for effective partnerships with government so that they can play this central role (Ross *et al* 2009). Combining this information with the fact that the Indigenous people of northern Australia comprise a greater proportion of the population than anywhere else in the country (see Section 3.1) makes their voice in the north extremely powerful and important.

For many, this voice has been expressed, at least partly, in terms of Native Title determinations, Indigenous Land Use Agreements (ILUA) or in other types of partnerships built with government and/or business (NNTT 2010). The Australian Government

recognises Native Title out to 12nm from shore. In the Northern Territory Eighty five percent of the coastline is owned by Indigenous people, and another 13% is under claim ([http://www.nt.gov.au/d/Fisheries/index.cfm?header=Indigenous Fisheries: Moving Forward 2003](http://www.nt.gov.au/d/Fisheries/index.cfm?header=Indigenous%20Fisheries%20Moving%20Forward); downloaded 22/6/10). The Northern Territory as a whole has had 12 determinations where Native Title has been found but still 157 unresolved native title claimant applications (NNTT 2010). And there are 97 registered ILUAs in the NT (NNTT 2010). In Queensland as a whole, Native Title has been determined to exist in 44 cases. 124 claimant cases are still in determination and 213 ILUAs have been registered in Queensland (NNTT 2010). Of the areas under Native Title claim activity in Queensland, many are adjacent to or in the NMR (NNTT 2010).

For non-Traditional Owner developers of all descriptions, the factors mean that there is an imperative to work together with Traditional Owners in many instances when future developments are proposed. The success of each individual partnership can influence the success of each proposed future development whether to do with infrastructure, agriculture, mining or tourism.

As more Traditional Owners and non-Traditional Owner entrepreneurs find mutually beneficial solutions, the lessons learned can be, and are being, shared to facilitate more efficient and effective resolutions in the future (Coe 2009, Doohan 2008, Eggleston 2002). And governments and others are providing information and support to guide both parties through to successful outcomes (see <http://www.nntt.gov.au/Future-Acts/Pages/reading.aspx>; <http://www.atns.net.au/>; both downloaded 22/6/10).

The likely success of such negotiations matters for this report in terms of its implications for the development of industries (such as mining, agriculture, aquaculture, bioprospecting and tourism) and, consequently, potential impacts on the marine environment. Over a 20 year time frame we consider that the negotiation of partnerships between Traditional Owners and industry will not impede industry growth.

Traditional Owners have their own economic interests that they wish to pursue, for example, as land owners, aquaculture proponents or in tourism in Indigenous culture and conservation (Ross *et al* 2009). For Traditional Owners, as for all entrepreneurs, not all opportunities are commercially viable and proposals must link to broader social development (including education), infrastructure and economic planning (Ross *et al* 2009). For more on these factors and issues see Sections 3.1.1, 3.2, 4.5 and 4.7)

### 3.5.7 Infrastructure requirements

Each of the drivers and economic developments discussed (here in Chapters 3 and the next Chapter 4, respectively) will combine to increase the demand for greater public and private investment in infrastructure. In recent years the Adelaide to Darwin rail link has been completed largely through government funding. Considerable development is presently underway to upgrade the port of Darwin. Over the next 20 years there will be increased shipping and port development to service growth in industry and population.

The ability of Darwin and the area adjacent to the NMR to provide the ongoing infrastructure necessary to support increases in economic development is uncertain and strongly influenced by Australian and State government ability and willingness to support building of such infrastructure. As the NMR is a comparatively remote area with a low income tax base due to the low population density, building infrastructure to do with the ports, railways, road and telecommunications, is a relatively expensive exercise and lack of infrastructure could slow or impede development in some instances (Anwar and Prideaux 2005). As will be discussed in more detail below (see individual sections on different developments in Chapter 4), transport of goods to and communications with markets can

be an impediment or facilitator of future industries such as agriculture, oil and gas, mining, fisheries, aquaculture and tourism.

### 3.5.8 Access to resources

Two principal processes lead to increased production: intensification (i.e. producing more from existing land) and expansion. The mining and beef cattle industries adjacent to the NMR require access to additional land to enable future expansions. Various factors can influence land access: tenure, native title claims and negotiations.

Similarly, direct access to marine resource (e.g. fish or oil and gas) can influence developments. The amount of access and restrictions to access afforded by various licensing and management agencies can influence whether developments move forward or not. Over the years various agreements have been made, for example, with regard to the management of fisheries and as these arrangements have changed, there have been commensurate changes in the way each fishery has developed.

These are discussed in more detail per sector (below Section 4)

## 4 Future developments/activities

Northern Australia, including its marine environment, supports a wide range of economic, social and other activities. Existing, emerging and potential new activities are discussed in this section with regard to of specific future developments that are dependent on, strongly influenced by or impact upon marine environments and species. This analysis includes consideration of changes in resource use, levels of output, scales of operations, employment, economic value, and spatial distribution of activities and their relative significance of future development at the different scales. The implications of these future developments upon the marine environment and future planning in the NMR is explored here and also in Chapters 5 and 6.

### 4.1 Agricultural development

There is a long-held political and resultant public policy desire to “develop the north”, which was recently reflected in the establishment of the Northern Land and Water Taskforce. The outcomes of such initiatives, the establishment of the Ord River Irrigation Area being an example from the 1960s, affects development and hence is likely to impact to some degree on the downstream environment of the NMR. Downstream impacts can arise from changes to:

- The quantity of water that rivers discharge into the marine environment
- The quality of water discharged by rivers
- Shipping activity, and associated impacts, to provide supplies for agricultural production and take away products.

The actual environmental effect is further going to be determined by the impact of climate change on sub-tropical and temperate farming areas and the capacity of research and development to overcome the physical constraints of distance, poor soils, pests and disease in a manner that is publicly acceptable and environmentally sustainable (Cocks 1992). This assumes increasing demand for food, fuel and fibre which is expected (as discussed in Section 3.3.1). It is highly likely the demand for biofuel production is also going to increase (World Bank 2008). However the availability of land in nearby countries for biofuels is likely to be less constrained by biophysical conditions than in northern Australia and it is likely to be cheaper to produce, at least compared with the catchments adjacent to the NMR. However, the Northern Territory Government's Power and Water Corporation is exploring biofuel options now (<http://www.nt.gov.au/nreta/environment/greenhouse/emissions/energy.html>; accessed 21/6/10).

As discussed, there is only highly seasonal access to water in the North (both within and across years) and climate change may have negative impacts on north Australia's rainfall patterns. Still, the increasing shortages of food production around the world relative to increasing demand make it likely that, in the long term, there will be an expansion of horticulture (NT Government 2010b) by 100-200% to about 60 000ha (see also Ross *et al* 2009). The extent to which this development is hastened and increased by the interventions of state, territory and federal governments is difficult to predict. The National Water Initiative provides an effective and robust policy framework for the planning and sustainable management of water resources (Ross *et al* 2009). Although implementation has been slow to date, historical evidence and recent statements by governments of various political persuasions indicate that there is likely to be financial incentives provided and public infrastructure investments made which will support development of water and other infrastructure. Indeed, at a research and planning level there is evidence of

considerable government activity focused on evaluating opportunities and constraints on primary industry production in the catchments adjacent to the NMR (Camkin *et al* 2007, CSIRO 2009, Stone 2009, Ross *et al* 2009).<sup>2</sup>

Countering this government enthusiasm and search for new areas of reliable production are the physical constraints of distance, isolation, very limited areas of suitable soils, high temperatures, and pests and, as a result of climate change, low and unreliable rainfall (Cocks 1992). Growing and harvesting is likely to be relatively easy compared to the constraints imposed by a lack of transport and storage infrastructure, including easily accessible, sizeable ports able to provide necessary economies of scales (Cocks 1992).

Overall there is likely to be considerable investment, public and private, in attempting to expand agricultural production across northern Australia as evidenced by the recent trend of large corporate producers investing in the Territory and the increased number of cold storage facilities being constructed (Northern Territory Government 2010b). Thus, despite the constraints, in the longer term this is likely to result in a significant, relative, increase in the area under irrigation, albeit from a small base of only 20 000 hectares.

#### 4.1.1 Current situation

BITRE (2009) and Greiner *et al* (2006) discussed the importance of agriculture on the lands adjacent to the NMR.

In 2006-07, the gross value of agriculture in the Northern Territory was \$343 million of which 71% was livestock related (ABS 2008f). An estimated 61.2 million hectares or 45% of the Northern Territory's land area was used for agricultural activity in 2006-07. Most agricultural land was used for large-scale cattle grazing on unimproved range lands (ABS 2008f). Other agriculture products reported by the ABS (2008f) for 2006-07 in the NT are bananas, mangos, rock and cantaloupe melons and watermelons. Adjacent to the NMR, in 2009, there was about 5681ha of land dedicated to these crops around the Darwin and adjacent Daly Region and another 35,000ha of forestry plantations which have not yet yielded a harvest (NT Government 2010a). Fruit production values have been relatively stable in recent times (NT Government 2007a). The area planted to vegetables, especially cucumber, is expected to increase as drought conditions persist in southern states (NT Government 2007a, NT Government 2010a). Over the past 27 years the NT Government has investigated the viability 156 different crops of which about 25 were found to have potential to be produced as a commercial crop (NT Government 2007b). The irrigation water for NT crops is typically drawn from rivers or groundwater supplies as there are few dams in the NT.

In the North West Statistical Division of Queensland, which borders the southern Gulf of Carpentaria, in 2010, approximately 27, million hectares of land (~88% of land area) was dedicated to grazing, almost exclusively of cattle (ABS 2010b). In 2001<sup>3</sup>, the gross value of agriculture in the NW SD was \$392.7 million of which 99.6% was cattle. For the Far

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<sup>2</sup> For another example see <http://www.csiro.au/science/EnvironmentalMonitoring.html> [http://www.nrm.gov.au/cgi-bin/projects/get\\_nht\\_region\\_data\\_from\\_pa.pl?nht\\_region=Northern+Gulf&program\\_names=NHT2&start\\_record=0&orderby=title](http://www.nrm.gov.au/cgi-bin/projects/get_nht_region_data_from_pa.pl?nht_region=Northern+Gulf&program_names=NHT2&start_record=0&orderby=title)

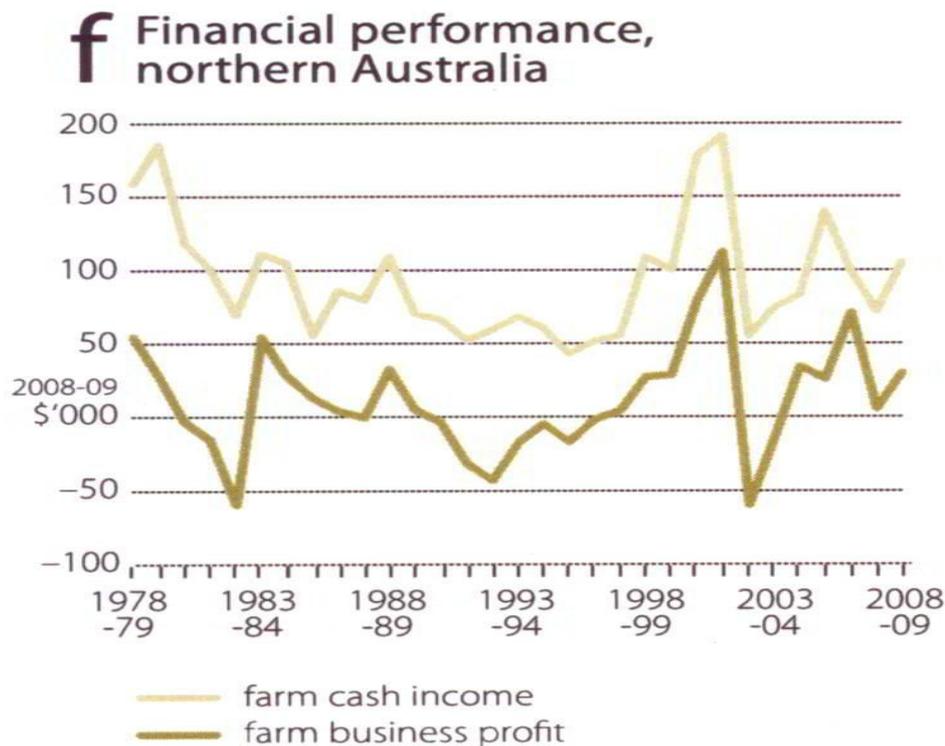
<sup>3</sup> The year 2001 appears to be the most recent year for which data available at lower statistical units.

North Balance of the Statistical Division<sup>4</sup> about 53% of land area is dedicated to grazing of livestock (cattle) production in 2001 was valued at \$193.2 million. Greiner *et al* (2006) pointed out that the productivity of these lands is low (averaging just \$2 per hectare in 1998/99). This explains the typically very large size of grazing properties in this area, which can be tens of thousands of hectares large (Bortolussi 2005). There are only small pockets of other agriculture (crops) such as horticultural crops along some Gulf streams (e.g. the Gilbert River).

Recent times have seen relatively good financial returns for graziers across the areas adjacent to the NMR, as shown in Figure 4. High profitability has been one factor in driving the strong rise in capital values, after adjustment for inflation, to an average of about \$10 million, which represents about five times the value of the early 1990s.

**Figure 4 Financial parameters for beef cattle enterprises in Northern Australia**

(Source: MacKinnon, 2009)



Adaptation by the pastoral industry, specifically intensification of grazing systems, continues to reshape the use of and impacts upon rangelands (Stokes *et al* 2006). The

<sup>4</sup> Far North SD Bal. excludes Cairns but includes the east coast of Queensland north from Cairns as well as the rest of Cape York to the north.

land adjacent to the NMR can be impacted by cattle grazing if stocking rates cause soil erosion. The benefits of intensified grazing are uncertain (Stokes *et al* 2006):

- Intensification involves multiple simultaneous changes to enterprise operations and the benefits and trade-offs of each component need to be better understood.
- If intensification proceeds without addressing constraints to implementing these management options sustainably, then overuse and degradation of rangelands is likely to occur
- Further fragmentation of rangelands (from increased internal fencing) could compromise potential benefits derived from landscape heterogeneity in connected landscapes.

Greiner & Gregg (2010a) have demonstrated that many graziers across the tropical savannas, including the grazing lands adjacent to the NMR, have a strong conservation ethic and are intrinsically motivated to conserve the natural resources and environmental assets, such as biodiversity, on their land. However, financial constraints provide a key impediment to the realisation of many planned conservation activities—particularly in the minds of graziers who are less conservation minded. As land values increase, financial pressures on graziers, particularly those new to the industry and/or with high debt, are likely to inhibit on-farm conservation action, unless there is funding provided.

#### 4.1.2 Dams

Agricultural development in northern Australia is currently dependent upon the availability of artificial water resources during dry seasons (winter). Dams are required to capture the plentiful runoff of water during wet seasons. Dams in the Northern Territory adjacent to the NMR include the Darwin River Dam, and the Manton Dam (a backup supply for Darwin). Currently, dams are used for residential water supply rather than for irrigation purposes ([http://www.powerwater.com.au/powerwater/aboutus/darwin\\_river\\_dam.htm](http://www.powerwater.com.au/powerwater/aboutus/darwin_river_dam.htm) Downloaded 18/6/08).

Stage 2 of the Ord River Scheme Irrigation Scheme, in the very south west corner of the NMR is now proceeding. The supplying Ord River Dam is already in existence just west of the NT/WA border but the new irrigation areas comprises the Keep River black soil plains in the NT. These plains are suitable for broad acre cropping such as sugar cane, cotton or leuceana as well as horticultural crops (<http://www.nt.gov.au/nreta/environment/assessment/register/ord/description.html> Downloaded 18/6/08).

#### 4.1.3 Agriculture in 2030

The main use of the lands adjacent to the NMR is cattle, especially if including Indigenous-owned pastoral properties. Data from the ABS (2008a) show that cattle numbers in Australia, over any twenty year average, have slowly been on the rise since 1886. More recently, improved cattle breeds, infrastructure and intensified grazing regimes have accelerated the trend despite a hiatus during the 2005-06 drought (Mackinnon 2009). As land price trends attest, there is expectation for further increases in productivity and profitability, based on a combination of increased production and increased product prices.

Intensified grazing systems, combined with monsoonal weather patterns, lead to an increased probability of enhanced erosion from grazing areas adjacent to the NMR, which might be further exacerbated under climate change scenarios.

Fruit and vegetable production is likely to be positive with commensurate increases in land area dedicated to such agricultural production (and land clearing) and increases in access to water via, especially, the significant groundwater resources in the region (approximately 600 gigalitres, CSIRO 2009) and associated irrigation infrastructure. Ross *et al* (2009) suggest increases of up to 100-200% area in irrigated agriculture using groundwater supplies, with the Wiso and Georgina areas being prospectively, relatively productive areas for expansion.

While the NT Government is keen to support enhanced food production (NT Government 2009), O’Gara (2007 p.13 in BITRE 2009) states that on the whole, in the NT “most soils are highly erodible, difficult to manage under conventional cultivation and have relatively poor natural fertility and low water holding capabilities...”. This is likely to cap agricultural expansion in the NT. In addition, CSIRO (2009) consider that proposed increases in levels of extraction from groundwater may lead to reduced river flow, for example, in the Daly River, which may impact associated habitats including estuarine and coastal marine habitats.

Large, new dams are not extremely likely, according to Ross *et al* (2009), as relatively little of the rainfall occurs in the upper reaches of rivers where the topography allows for dam construction.

Impacts of this trend in cropped agriculture upon the NMR in twenty years time are difficult to predict. The extent and nature of impacts will depend on the efforts made to mitigate potential environmental damage that may have downstream effects. The location of any impacts will reflect the location of most increases in production. These are expected to be centred around Darwin, including the Daly River region and the Ord Irrigation Area due, largely, to proximity to water, ports and access to transport.

The main implications of this industry to the NMR are related to the its potential or likely impacts on the marine environment and, thus, the ability of marine management plans to help build the resilience of marine ecosystems to withstand impacts from land-based sources.

## 4.2 Offshore oil and gas

### 4.2.1 Status

In total, offshore oil and gas accounts for around one-fifth of the Territory’s Gross State Product (GSP)(NT Government 2010b). The NT Department of Resources administers petroleum exploration and production activities in Commonwealth waters adjacent to the NT and in the Territory of Ashmore and Cartier Islands area on behalf of the Commonwealth of Australia (Figure 5). In 2009, the offshore fields of Laminaria, Corallina, Jabiru and Challis and Puffin continued to produce oil via four Floating Production, Storage and Offloading Facilities (FPSOs) (Othman 2009, DoR 2010). This comprised all of the Territory’s offshore oil production in 2008. A decline in oil production and an expected rise in water cut were the dominating features associated with production from these fields. A substantial proportion of Territory offshore oil and gas reserves are located within the JPDA. The resources in this area are shared equally between Timor-Leste and Australia, with Australia’s half share allocated to the Territory (NT Government 2010b).

In 2008 there was also extensive exploration and drilling in the NMR and the adjacent north-west shelf including spudding of 14 offshore exploration wells, three geophysical survey and awarding of eight new exploration permits (Othman 2009).

Presently two gas pipelines traverses the marine environment of the NMR: one from Darwin to the Joint Petroleum Development Area adjacent to the northwest of the NMR; and a new marine pipeline runs from Blacktip gas field (on the NT side of the middle of the Bonaparte Gulf) to shore and thence to Darwin (<http://www.abc.net.au/news/stories/2009/09/15/2686757.htm> downloaded 2/6/10).

**Figure 5** Onshore and Offshore Petroleum Areas administered by NT Department of Resources

Source: DoR (2008; downloaded 29/5/10 from [http://www.nt.gov.au/d/Minerals\\_Energy/index.cfm?newscat1=&newscat2=&header=Onshore and Offshore Areas administered by DoR](http://www.nt.gov.au/d/Minerals_Energy/index.cfm?newscat1=&newscat2=&header=Onshore and Offshore Areas administered by DoR))



There are five different petroleum areas in the Northern Territory. Four of these are administered by the **Northern Territory Government** and the fifth is administered by the **Timor Gap Designated Authority**, independent of the Australian government.

- 1** Area 1: Onshore area: 1.35 million km<sup>2</sup> of land.
- 2** Area 2: Territorial Waters: three nautical miles around the Northern Territory coastline.
- 3** Area 3: Northern Territory Adjacent Area: 0.501 million km<sup>2</sup> between the Territorial Waters line and the international borders. This area is administered by DPIFM on behalf of the Commonwealth of Australia.
- 4** Area 4: The Territory of Ashmore and Cartier Islands Adjacent Area: 77187km within the Western Australian Adjacent Area; this area is administered by DPIFM on behalf of the Commonwealth of Australia.
- 5** Area 5: A fifth Joint Petroleum Development Area (JPDA); is administered by a Joint Authority, independent from the Australian Government.

There are also major offshore reserves under development in the Bonaparte Basin including at Bayu-Undan, Greater Sunrise, Caldita, Evans Shoal, Blacktip and Petrel Tern (<http://www.theterritory.com.au/index.php?menuID=163>; downloaded 30/5/10)

#### 4.2.2 Offshore oil and gas – 20 years from now

In the last 20 years offshore oil production has been highly variable with production fluctuating from about 8.5 million barrels in 1987, to 12 million barrels in 1988, to 26 million barrels in 1992, 5 million barrels in 1998, 54 million barrels in 2000, 12 million barrels in 2004 to only 5.8 million barrels in 2008 (Othman 2009).

In the future, as the economic drivers indicate (Section 3), demand for oil in particular will probably be on a steadier incline as reserves regionally and globally decline and oil prices increase accordingly. With increasing prices there will be likely changes to the economic feasibility of unexploited reserves that have been discovered. The demand for oil and gas can be expected to be met from:

- An increasing rate of exploitation of current production wells; and
- New wells being brought into production.

To spur exploration and production, the Northern Territory government has committed \$480 million from 2009-2013 (29% more than the previous 5 year period) to the Principle Northern Territory Offshore Area which, while supporting 17 exploration permits and 3 retention leases, including world-class gas discoveries, had no hydrocarbon production in 2008 (Othman 2009).

Both the Northern Territory and the Commonwealth government have released significant offshore petroleum exploration areas (Othman 2009; Department of Resources, Energy and Tourism [http://www.ret.gov.au/resources/upstream\\_petroleum/offshore\\_petroleum\\_exploration\\_in\\_australia/](http://www.ret.gov.au/resources/upstream_petroleum/offshore_petroleum_exploration_in_australia/) downloaded 21/6/10). Othman (2008) predicted that the level of activity planned to be undertaken in the next five years ranks the Northern Territory as a world-class petroleum province.

As in the past, it is likely that, despite these drivers, production will continue to fluctuate in the future as it has done in the past.

On average, demand will also continue to increase for the transport of oil and gas products which are exploited in the North West Region (outside the NMR) and often conveyed out of Australia via Darwin port (see Section 4.3.3 and 4.3.4).

Data indicate that many gas and oil reserves have been discovered in the western-most parts of the NMR (and beyond) but have not yet been brought into production (Othman 2007, Othman 2009). We suggest that offshore oil and gas production will continue to be focussed on the same area as at present but with main movements in activity being between wells and between fields already discovered. Pipelines are likely to be built to the (presently undeveloped) Blacktop and Petrel gas fields.

Aside from physical disturbance to the environment (in the form of impacts of wellheads and pipelines) the footprint of oil and gas mining can be relatively contained. A significant risk would be an oil spill either from a production platform, exploratory drilling or in transport of the product as occurred in August 2009 with the Montara Wellhead Platform that leaked an unconfirmed 64 tons of crude oil per day for about 3 months (AMSA 2010). A biodiversity impact survey by Watson *et al* (2009) and WWF (2009) found direct impacts upon multiple species of cetaceans, seabirds, seasnakes and sea turtles. WWF (2009) identify longer-term toxic effects as likely while Watson *et al* (2009) considered the possibility deserved of further exploration. Increasingly high environmental standards are

being required of oil and gas companies that assist in mitigating such risks however these are clearly not failsafe.

### 4.3 Mining, shipping and, ports

Much of the shipping and ports activities in and adjacent to the NMR is driven by transport of metalliferous ore and other mining products. It is therefore helpful to consider these industries together for the purposes of this study.

#### 4.3.1 Mining and onshore oil and gas: status now

Presently the main mining activities adjacent to the Queensland portion of the NMR are bauxite mining (concentrated around Weipa) and mining in the southern Gulf catchments for copper, zinc, lead and silver (BITRE 2009, <http://www.dme.qld.gov.au/mines/> accessed 28/5/10; Cooper pers. comm.). There are also scores of permits for mineral exploration adjacent to the Gulf in Queensland (over 2000 throughout the state) (<http://www.dme.qld.gov.au/mines/> accessed 28/5/10). In the NT, bauxite is being mined at Nhulunbuy (Gove), manganese on Groote Eylandt, zinc and lead southwest of Borroloola, uranium oxide in Arnhem Land and mineral sands on the Tiwi Islands ([http://www.nt.gov.au/dpifm/Minerals\\_Energy](http://www.nt.gov.au/dpifm/Minerals_Energy)).

The three major potential sources of impacts, mostly within 3nm but with likely repercussions beyond, are

- pollution (especially of waterways),
- reduction of flow volume in rivers and streams, or diversion of waterways, and
- accidents in ports or at sea during transport.

The risk of these impacts occurring and the size of (potential) impacts are mitigated by government regulations and mine operators' commitments to minimise environmental impacts of activities as well as requirements/commitments to rehabilitate mine sites. The requirements reflect environmental best practice much more in the areas adjacent to the NMR although disagreements about best practice still occur and can impact development as well as impact likelihood of environmental damage (e.g. proposed diversion of MacArthur River in the mid- 2000s; [http://www.ecnt.org/html/cur\\_mining\\_mcarthur.html#4](http://www.ecnt.org/html/cur_mining_mcarthur.html#4)).

Past mining activities adjacent to the NMR have some relevance to marine resource management as some of the defunct mines continue to have downstream impacts (Mitchell River Watershed Management Inc. 2000, Greiner *et al* 2006).

Previous exploration activities in Queensland adjacent to the NMR have not identified any reserves of oil or gas. There are no petroleum production leases or facility or pipeline licenses adjacent to the Gulf of Carpentaria. There are, however, coal exploration permits south of Kowanyama near Staten River and around Normanton (<http://www.dme.qld.gov.au/mines/>). In the Northern Territory, mining leases and applications are also very common along the coast south of Darwin, along the top and down the eastern side of Arnhem and around Borroloola ([http://www.nt.gov.au/dpifm/Minerals\\_Energy](http://www.nt.gov.au/dpifm/Minerals_Energy)).

These mining activities are presented in more detail in BITRE (2009; Section 9.3), Greiner *et al* (2006), National Oceans Office (2003) and Environment North and Environment Science Services (2004).

#### 4.3.2 Mining and onshore oil and gas in 20 years

As discussed in Section 3, demand for base minerals and energy products are likely to continue to increase. Price increases of 85% for iron ore negotiated by Rio Tinto with Chinese customers during June 2008 illustrate that very point (<http://www.abc.net.au/news/stories/2008/06/24/2284759.htm>; downloaded 22/6/10). The relative proximity of north Australian resources to key global growth markets such as China and India provides a competitive advantage due to reduced transport costs. The Northern Territory Government has a “China Strategy” targeted significant increases in China’s investment in mining and exploration in the region (DPIF&M 2007a). This strategy has borne fruit in that Arafura Resources has recently finalised a multi-million deal with Jiangsu Eastern China Non-Ferrous Metals Investment Holding Co. Ltd (JEC) ([http://www.growingnt.nt.gov.au/growing\\_industries/mining.html](http://www.growingnt.nt.gov.au/growing_industries/mining.html), downloaded 29/5/10). In 2007, the NT Government also launched a “Bringing Forward Discovery” initiative aimed at supporting new discoveries of petroleum and minerals in the Territory ([http://www.nt.gov.au/d/Minerals\\_Energy/index.cfm?header=Exploration Initiatives](http://www.nt.gov.au/d/Minerals_Energy/index.cfm?header=Exploration_Initiatives); downloaded 29/5/10). The new Territory 2030 Strategic Plan (NT Government 2009) also identifies supporting mining, oil and gas as a priority. These initiatives, plus increasing prices will lead, amongst other things, to re-assessment of resource sites which were previously deemed unprofitable to mine.

New mines are constantly being identified, developed or expanded in the region in response to such drivers (BITRE 2009). For example, one new mine at Francis Creek opened in 2007 with an export target of 1.5 million tonnes of iron ore per year over the coming years and OM (Manganese) Limited is indicating exports of 650,000 tonnes per annum (BITRE 2009, NT Government 2006, Port of Darwin 2007). A potential new bauxite resource has been identified around the Mapoon, Weipa and Arakun area that contains 650mt of bauxite and is intended to start operation in 2011

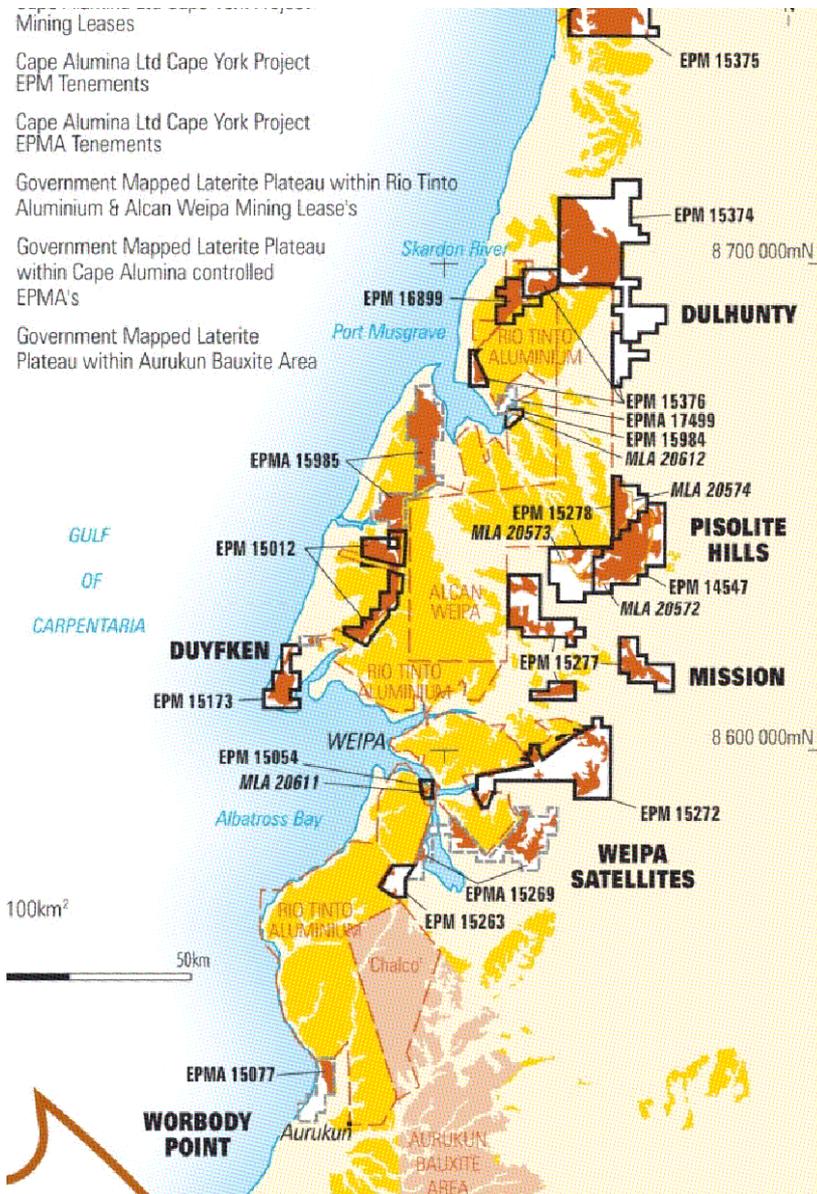
There are existing resources of iron ore and phosphate, especially north of Mt Isa, that have been previously assessed as uneconomic that may well become economic and able to use existing infrastructure (e.g. at Karumba) for export in the next 20 years (Cooper pers. comm.)

Development of adequate infrastructure and adequate skilled staff to support mining may become a limiting factor in the shorter term (Ross *et al* 2009) but within a 20 year time frame, the Northern Australia can be confident of ongoing mining developments with increases in the number of mine sites as well as the volume of mining at existing sites. Many are using the fly-in-fly-out/drive-in drive out option for labour where it is not available locally (Greiner *et al* 2006, BITRE 2009) and this is likely to continue.

Requirements for, and impacts upon, groundwater by mining activities may, eventually, have trickle down effects into some near shore waters that support marine ecosystem breeding cycles, food supplies and growth rates. The greater the proximity of mine to coast, the more likely the impact (e.g. Nhulunbuy (Gove), Groote Eylandt, Weipa).

**Figure 6 Location map of Western Cape York mining and exploration tenements**

(Source: Cape Alumina, Quarterly Report, December 2009, www.capealumina.com.au)



It is foreseeable that global demands for energy — combined with concerns about the impacts of climate change—will also drive demand for uranium as an alternative energy source. Mining of uranium ores is currently permitted in the NT and although only one mine is active there are 11 sites identified by DPIF&M (2008) as significant undeveloped deposits. There are also known resources of uranium in Queensland within the catchments adjacent to the NMR (<http://www.dme.qld.gov.au/mines/> accessed 28/5/10). Currently Queensland does not allow uranium mining. However, exploration activities are underway, e.g. around the Einasleigh uplands in the Southern Gulf of Carpentaria. This policy may change and is likely to be subjected to pressure as other CO<sub>2</sub> emitting energy sources become scarcer and technology allows for greater security in the mining of uranium (World Nuclear Association 2008).

#### 4.3.3 Shipping and ports – current status

Much of the economic activity in the north of Australia, as well as other parts of Australia, relies on ports to export goods such as livestock, mineral and petroleum products. Port activities and port development, potentially, can be a significant source of marine environmental impacts, which are discussed in detail in Section 4.3.3.2.

The Port of Darwin is the main port adjacent to the NMR. Offshore oil is produced off Ashmore and Cartier Islands—being outside the NMR but generating shipping traffic within the NMR. Other ports that service the NMR include Gove, Milner Bay on Groote Eylandt, Bing Bong, Karumba and Weipa. Weipa, Karumba and Gove are the most important of these in terms of ship traffic as well as volume and value of cargo. The NT has also, since 2005-06, started exports directly from offshore terminals and rigs. In 2007-08 this accounted for 497,000 tonnes of product (BITRE 2009).

In 2008/09, the Port of Darwin handled in excess of 3.7 million tonnes of cargo (Darwin Port Corporation 2009). On average the volume of cargo handled has been increasing over recent years with an overall increase of 38% in the 2008-09. Exports were dominated by dry bulk goods followed by petroleum, chemicals and livestock (Darwin Port Corporation 2009). The key product increases were in iron ore, and copper concentrates which were being exported for the first time in 2008/09. However, export of energy commodities has also grown strongly, especially in 2006–07 and 2007–08 (BITRE 2009). Darwin port services much of Northern Australia, not just the areas adjacent to the NMR and, increasingly, mining companies are using the Territory's infrastructure to export their minerals. Both the Bootu Creek manganese project near Tennant Creek, 1000km south of Darwin, and the Frances Creek iron ore project near Pine Creek, 200km south of Darwin rely on the Adelaide to Darwin railway to transport their ore to Darwin's East Arm Port for export to China ([http://www.omholdingsltd.com/subsidiary\\_omm.htm](http://www.omholdingsltd.com/subsidiary_omm.htm); <http://www.territoryresources.com.au/projects/frances-creek-project.html> downloaded 22/6/10). They use purpose-built railway cars to haul the ore, which is loaded in Darwin via the Port's new \$25 million bulk handling facilities.

Traffic through Darwin Port over the last 5 years has increased from about 4500 to over 5600 vessels in 2008-09 of which about 1/3 of trading vessels and 2/3 non-trading vessels (Darwin Port Corporation 2009). Non-trading vessels were identified as including, in order of number, fishing associated vessels (around 3600 vessels), patrol boats or other (~140), tugs (~80), naval vessels (~50), pleasure boats, research ships, pearlers and sailing boats. Trading vessels included the barges, rig tenders, container/general cargo, livestock, bulk carriers, tanker, cruise ships and car carriers (Darwin Port Corporation 2009). Cruise shipping is on the rise with an increase from 22 cruise ships in 2004-05 and 47 in 2008-09. This trend is likely to continue with the Port of Darwin having a new Cruise Ship Terminal at Fort Hill Wharf that was completed in 2008 (Darwin Port Corporation 2009). The Port is the supply, service and distribution centre for the nearby Timor Sea oil and gas reserves and was Australia's second liquefied natural gas hub (Darwin Port Corporation 2009).

Darwin Port has recently seen the emergence of a greater bulk mineral trade assisted by the construction of the Australasia railway line between Alice Springs and Darwin and the new bulk material handling system built at East Arm Wharf of Darwin Port (Darwin Port Corporation 2009). New in 2007 was also the inaugural delivery of liquid sulphuric acid (versus dry) to service Jabiru Mine. This import led to increases in trade in this commodity (Darwin Port Corporation 2009). Darwin Port continues to plan upgrades, dredging and new facilities to accommodate anticipated increases in vessel and cargo traffic including increases in the size of vessels (Darwin Port Corporation 2009).

The Port of Weipa handled 396 ships in 2008–09, carrying over 20 million tonnes of bauxite (another record figure for Weipa), approximately 69 000 tonnes of fuel and about

40 000 tonnes of general cargo. During 2006–07, a capital dredging project to deepen and widen the South Channel was completed and a second bauxite loading facility installed. The need to boost capacity in the channel was the direct result of planned and executed port expansions. The bauxite is mostly being shipped to Rio Tinto's Yarwun Alumina Refinery in Gladstone and to a lesser extent exported. Rio Tinto Aluminium plans to replace its current fleet of ships with the wider Post Panamax vessels which have superior cargo carrying capability. (Ports Corporation Queensland 2007; Ports Corporation Queensland 2009; <http://www.nqbp.com.au/index.cfm?contentID=16>)

In 2007–08, the Port of Karumba exported 997,477 tonnes of zinc, 58,747 tonnes of lead, 10,272 tonnes of general cargo (which includes fisheries products) and 12,659 head of livestock. A total of 64 ships visited the port in 2007–08. The number of ships and zinc and livestock exports were considerably up on the previously year while other tonnages had not changes significantly. Zinc arrives in Karumba as zinc slurry via a 304km pipeline from Century Mine. It is dried and loaded onto a 5,000 tonne transfer vessel for the 40km journey to the export ships, which anchor in deep water about 24 nautical miles off the coast. There is the potential to use this infrastructure beyond the current mining purposes. ([http://www.cairnsports.com.au/content/portsnorth-standard2.asp?name=Port\\_Karumba](http://www.cairnsports.com.au/content/portsnorth-standard2.asp?name=Port_Karumba); downloaded 22/6/10; Ports Corporation Queensland 2007)

Situated in Melville Bay leeward of Gove Peninsula, Rio Tinto Alcan Gove's port facility loads approximately 90 ships annually. Another 30 ships visit the port each year to deliver fuel oil, limestone and caustic soda. The port is adjacent to the refinery which is now able to produce 3.8 million tonnes of alumina per annum (2 325 000 tonnes in 2008)([http://www.riotinto.com/annualreport2007/operationsfinancialreview/aluminium\\_group/bauxite\\_alumina/index.html](http://www.riotinto.com/annualreport2007/operationsfinancialreview/aluminium_group/bauxite_alumina/index.html); downloaded 22/6/10, Rio Tinto Alcan 2009). The refinery is connected to the mine by a 3 kilometre conveyor loading a maximum of 2,000 tonnes of alumina or bauxite per hour.

#### 4.3.3.1 Shipping routes

National Ocean Office (2004) illustrated shipping routes being used within the NMR. A major route crosses along the north of the region as vessels move from the west to the east coast of Australia and vice versa. Other shipping routes are clearly linked to the ports of, for example, Weipa, Karumba, Bing Bong, Milner Bay, Gove and Darwin<sup>[LF15]. [TH16]</sup>

As demand for Australian goods grows and Australia's demands for imported products also grows, these shipping routes can be expected to see increases in traffic. The main traffic burden (the east: west route) is also likely to be the shipping route that experiences the heaviest vessel traffic into the future. In the GBR, a form of "gouging" of the seabed has been recorded in shipping lanes (see Section 4.3.3.2.5). Shipping routes in the NMR may also increase in volume to a point where such 'gouging' impacts are realised in the more shallow water areas. The Torres Strait is the main passageway for ships moving east to west and back and currently has a maximum recommended draft limitation of 12.2m (Maritime<sup>[LF18]</sup> Safety Queensland 2003). Any future shipping which chooses to use currently recognised passages within the Torres Strait will need to account for this limitation when deciding appropriate vessels to support their operation.

#### 4.3.3.2 Sources of impact

##### 4.3.3.2.1 Dredging

All ports undertake maintenance dredging. The activity of dredging disturbs the marine seabed (both where dredging occurs and where it is dumped), temporarily enhances turbidity and can enhance sedimentation. The location of the impacts depends upon the

local currents and tides and can be exacerbated through co-incidence with rainfall and catchment run-off. The location of dumping sites for dredge spoil can be on land or at sea and, if sea dumped, the activity is controlled by the *Environment Protection (Sea Dumping) Act 1981* and guidelines (Environment Australia 2002). These controls require ongoing monitoring which, to date, has not detected any cumulative impacts at sea dumping sites (Hore pers. comm.). Upgrading of port capacity does not necessarily require increase in dredging activity and will depend upon the size of ship being catered for. As many ports will limit their ship size to enable passage through the Torres Strait, significant capital dredging may not be required as ports expand to accommodate a greater volume of traffic (Hore pers. comm.).

#### 4.3.3.2.2 *Pollution*

The National Oceans Office (NOO 2004) and the National Pollutant Inventory (DEWHA 2008a) identified all ports as sources of pollution. Darwin Harbour, for example, has been identified as a source of 9 contaminants including nitrogen, phosphorus, zinc, lead as well as other mainly metallic pollutants. Distribution of pollutants from ports into the broader environment is driven by tides, which can be very large, currents or monsoonal wet seasons which drive water from port areas (and catchments) into the marine environment. Individual surveys at some ports, for example, Weipa and Karumba, have identified reductions in extent of seagrass beds which may be linked to dredging activities; ongoing monitoring is underway to determine the linkage (Ports Corporation of Queensland 2009). Saalfeld and Marsh (in Keissling 2003a) suggest that such damage could impede the ability of dugongs to move between feeding grounds in the south-east GoC.

Darwin Port is a long distance from the NMR as the Beagle Gulf (the area between the mainland and Bathurst and Melville Islands to the north) is state waters. It is likely that pollution impacts of port activity diminishes with distance. The ports of Weipa, Karumba and Gove are closer but still more than 3nm from the NMR. Consider, though, the recent suggestion of the dumping of 88 tonnes of alumina into Gove Harbour in April 2010 and a more recent spill of about 70,000 litres of petrol that had leaked into the ground on this occasion <http://www.abc.net.au/news/stories/2010/04/22/2879740.htm>; <http://au.biz.yahoo.com/100613/31/2dlc.html>; downloaded 22/6/10). Accidents such as these are likely to have impacts within Commonwealth waters albeit in a manner that is indirect and/or difficult to detect on a case-by-case basis.

The significance to the NMR environment of impacts from these ports may not be direct but may be indirect through impacting habitats used by fauna of the NMR. If there are direct impacts it would be more likely through cumulative impacts of a variety of pollutants transported from the source of an accident (adjacent to the NMR) into the NMR itself.

#### 4.3.3.2.3 *Marine pests/pathogens*

Vessels can be a source of new marine pests or pathogens in three main ways: from fouling organisms external to the hull; through transport and exchange of ballast water in foreign waters and sourced from inside internal seawater pipes of commercial and recreational vessels. At the moment, the National Introduced Marine Pests Information System has identified at least 7 introduced species in Northern Territory and Queensland waters of the NMR (<http://adl.brs.gov.au/marinepests/>; Hewitt *et al* 2002).

#### 4.3.3.2.4 *Port expansion/upgrading*

Coastlines, bays and/or estuaries are usually physically altered upon the introduction of or expansion or upgrade to a port. This may involve the need to ensure a greater area is protected within a harbour (e.g. using breakwaters) or building of wharves and associated infrastructure that require clearing of coastal habitats or hardening of shorelines. For

example, the expansion of port facilities around Weipa to include Boyd Point would require completely new infrastructure in that area (about 40km southwest of Weipa) and alternations in some shipping activities which will impact upon the coastal habitats (Ports Corporation Queensland 2007).

#### 4.3.3.2.5 Shipping routes

In the Great Barrier Reef lagoon, multi-beam sonar data have identified disturbance (gouging) of seabed in relatively shallow waters in the inshore shipping route due to water movement by propellers when ship propellers are within about 5m of the substrate (Steiglitz pers. comm.). The parts of the waters of the NMR that are similarly shallow and contain shipping routes can be expected to demonstrate similar impacts. The ecological consequences of such disturbances have not been explored but are likely to alter the epi- and infaunal communities given recurring impact.

#### 4.3.4 Shipping and ports – 20 years from now

The main ports adjacent to the NMR are all planning forward and ensuring adequate infrastructure for increases in vessel traffic, volumes of cargo and size of vessels. As an example of how industry can drive port development, the proposed new Aurakun Bauxite Development mentioned in Section 4.3.2 is driving development of a new port (or possibly an extension of Weipa Port) as Boyd Point as a multi-user bauxite export facility from which to export the bauxite (Ports Corporation Queensland 2007). There is the potential for bauxite exported from the Weipa port(s) to triple in the next 20 years (Cooper pers. comm.). More broadly, evidence to date and the likely future of the industries upon which ports rely for cargo to trade indicate that these increases will be realised although the rate of the change along for each commodity or each industry is harder to predict.

The impacts that can be anticipated to increase are to do with pollution, ongoing ocean dumping of dredge materials, direct physical impact upon coastal habitats of the ports themselves and the seabed of vessel traffic and introduction of marine species or pathogens.

Port expansions and increases in vessel traffic will occur. Commensurate environmental impacts, however, will be relatively less due to greater diligence towards environmental impacts than in the past. None-the-less, the absolute (if not relative) environmental impact can be expected to be greater over time. That is, while the environmental impact per vessel or per tonne of cargo moved might decrease, we anticipate that the volume of activity overall will increase to such a degree that the impacts will be greater in sum than a scenario of no industry [growth](#)[LF19].

The impacts can be expected to increase in severity locally and in geographic extent. However, it is anticipated that on an Australia-wide scale, the environmental impacts will remain relatively localised. Their significance in the NMR will depend upon the degree to which impacts are realised outside the 3nm boundary or upon mobile species that cross state and federal jurisdictions. The significance of the environmental impacts will also depend upon the resilience, importance and status of the species and habitats that might be impacted.

#### 4.4 Commercial fishing

The most important commercial fisheries in or adjacent to the NMR include prawns, shark, barramundi, mud crab and Spanish mackerel. Their current status, including management arrangements, have largely been mapped by NOO (2005b) and described by NOO (2003) and Greiner *et al* (2006) and will not be duplicated here. This work will update that information and tease out any dimensions of the fisheries as they pertain (a) to impacts and (b) to a twenty year timeframe. Particular attention is given to this industry as it has been and is likely to remain one of the most significant activities within the NMR itself.

Drivers discussed in Section 3 that may influence the 20 year outlook for these fisheries include global and domestic demand for product and government policies and management actions to do with environmental sustainability. Ross *et al* (2009) also highlight that many northern Australian fisheries are critically dependent on the quality and quantity of river flows from adjacent lands.

Given population projections within Australia and within countries with which Australia's fishing industry trades (e.g. Japan, China and South-East Asian countries), demand for product will only increase. This is true across all fisheries in the NMR so is not discussed separately below.

Fisheries management is about ensuring the biological and economic sustainability of fish harvest. Economic sustainability does not mean maximum profitability. In this, there lies a tension and the challenge for government management interventions. Fisheries management has three main types of instruments available:

- Limit the number of participants in the fishery (through licenses);
- Limit harvest of the targeted stock in the fishery (through quotas); and
- Control the extent and manner fishing impacts on ecological sustainability, e.g. to reduce bycatch and limit physical impact (of bottom trawl) on marine habitats.

Many of the fisheries discussed below have been subjected to management actions aiming to reduce latent effort. While largely successful, a degree of latent effort remains in many of the fisheries (either through unused or underused licenses) and could become a source of future negative impacts upon the fishery.

Fishery impacts exist outside the fishery itself. For example, marine debris from fishing can have negative consequences on marine fauna and flora that are not directly part of the fishery. Kiessling (2003b) estimates 9% of plastic debris and 12% of discarded fishing nets are of domestic origin. As another example of fishery impacts outside the fishery itself, we consider illegal fishing. Domestic and foreign illegal or under- or unreported fishing is not so well recorded. Illegal activities may include, for example, local sale of fish products by unlicensed fishers or underreporting of take by licensed fishers. DPIF&M (2006b) stated, for example, that it is well known that less restrictive catch controls (on recreational Spanish mackerel in possession limits) allow increased opportunities for black market fish trading. Earlier, DPIF&M (2004) expressed concerns about a black market in the coastal line black jewfish fishery. Foreign fishing vessels also infringe into Australia's northern EEZ and impact fish stocks.

*The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* requires that every fishery in Australia be assessed for its ecological sustainability including all the fisheries in the NMR. Criteria for ecological sustainability are not limited to the status of the fished stocks but include broader criteria to do with ecosystem impacts, interactions

with protected species and threatened ecological communities as well as ecological impacts of fishing operations overall (Department of Environment and Water Resources 2007).

There has been enhanced focus on these EPBC Act assessments since the Bureau of Rural Sciences (2003) found that of the 70 principal species of fish taken in Commonwealth managed fisheries, 16 were classified as over fished, 16 as fully fished, 4 as under-fished and 34 were classified as uncertain. At this stage, no new licenses are being issued for commercial fishing within the Northern Territory and virtually none in Queensland

(<http://www.nt.gov.au/dpifm/Fisheries/index.cfm?header=Fishery%20Licences>;  
<http://www2.dpi.qld.gov.au/fishweb/16159.html> downloaded 6/6/08). This report will now briefly consider the current status and likely future of each fishery within a 20 year timeframe.

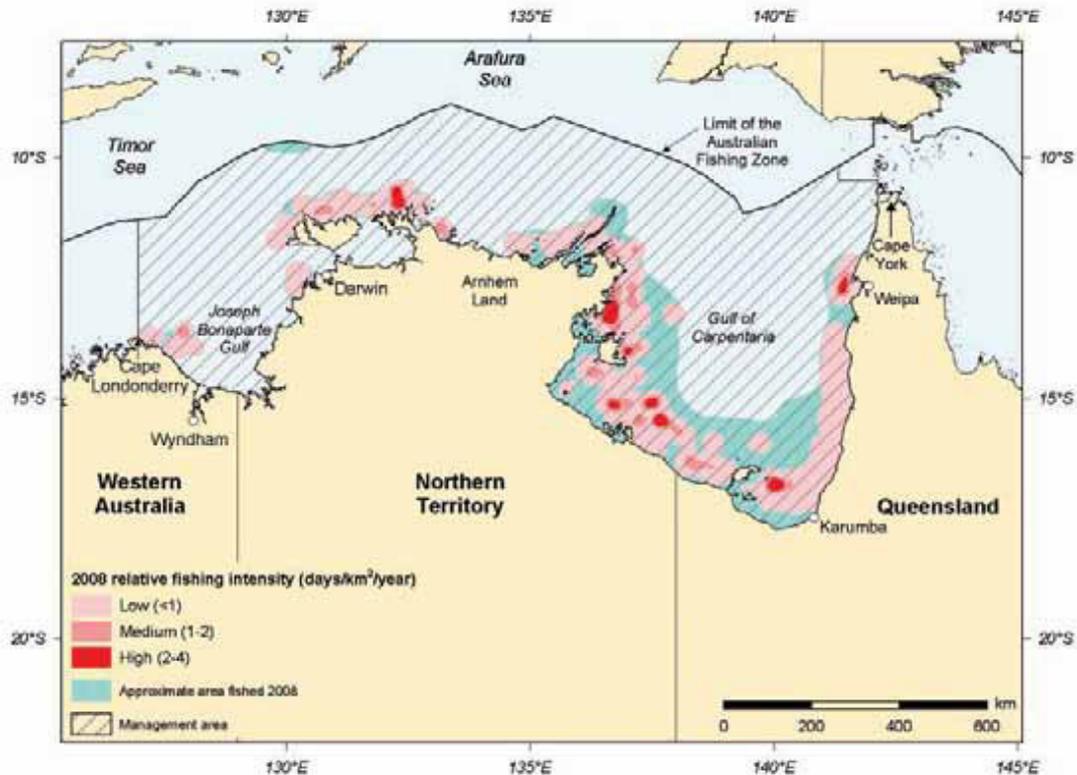
#### 4.4.1 Northern Prawn Fishery

##### *4.4.1.1 Status and management now*

This fishery occurs across the NMR from the low water mark to the extent of Australia's Fishing Zone but most effort occurs in the Gulf of Carpentaria (Figure 7).

**Figure 7 Relative fishing intensity in the Northern Prawn Fishery (NPF), 2008**

The management area is indicated by the diagonal lines (Wilson *et al* 2009)



The report by the Bureau of Rural Sciences (2007) and Wilson *et al* (2009) both indicated that the tiger and banana prawn taken by the Northern Prawn Fishery are not over fished although the status of the endeavour and king prawns was uncertain. (In 2003, the Bureau of Rural Sciences had identified the tiger prawn as being over fished). There has also been a decade of decline in the catch of king prawns.

Bycatch, of both fish and non-fish species, is a recognised problem with this fishery. In 2000, Turtle Excluder Devices (TEDs) and in 2001 Bycatch Reduction Devices (BRDs) became mandatory in this fishery and have reduced the level of interaction with turtles, sea snakes and other by catch (Wilson *et al* 2009). In 2001, the fishery itself initiated a ban on the retention of shark products which has likely reduced the impact on shark and ray populations (BRS 2007).

The Australian Government structural adjustment package (the Securing Our Fishing Future Package) resulted in a 45% reduction in vessel statutory fishing rights (SFRs) and a 34% reduction in gear SFRs from the start of 2007. The Australian Fisheries Management Authority (AFMA) has moved the fishery to the use of individually transferable quotas (ITQs) which can lead to a greater level of ownership and husbandry of stocks (BRS 2007 Wilson *et al* 2009). However, Wilson *et al* (2009) report significant increases in total gear in the fishery in 2008.

The 2005 Ministerial Direction to AFMA specified that the broader environmental impacts of fishing should be managed. Environmental issues within the NPF include the high proportion of bycatch (typical of prawn trawl fisheries- up to 90%), interactions with protected species such as sea turtles and seasnakes and the potential impacts of trawling

on benthic communities (BRS 2007). In addressing this, AFMA developed a Guide to Addressing Bycatch in Commonwealth Fisheries, establishing a target of 50% reduction in bycatch by 2008. In the NPF most of the bycatch comprises small fish and invertebrates. The latest approved BRD—the Popeye Fishbox— reduced small-sized bycatch by up to 48% and bycatch of sea snakes by up to 87% in trials (Wilson *et al*, 2009). There do not appear to be data on the in-situ success of the BRDs.

The NPF was the first fishery to develop a bycatch action plan, which was revised and released for public comment in 2007. In 2008, the NPF was approved for accreditation under the *EPBC Act 1999*, ensuring that fishers can continue to export their catch until 2014.

BRS (2007) reported that the NPF was about to commence first stage assessment under the Marine Stewardship Council Certification. This is a worldwide, independent, environmental certification programme for fisheries. The status of this assessment could not be determined (<http://www.msc.org/track-a-fishery/in-assessment/map>; accessed 30/5/10).

#### 4.4.1.2 *The NPF in 20 years*

The fishers and managers in this fishery appear to be taking actions now to ensure it is economically sustainable into the future. ABARE considers the fishery economically sound (Wilson *et al* 2009). For these reasons, in 2030 we anticipate that this fishery will still be in place with controlled levels of effort and controls on its environmental impacts. ITQs will assist in controlling effort. Fishery volume, in terms of harvest and environmental impacts, is expected to be maintained at levels similar to (or perhaps marginally less than) those at present. The fishery will remain a source of impact upon benthic habitats, target species, by-product and bycatch including threatened species within the NMR.

The geographic extent of impacts is expected to co-incide with areas of greatest effort. It is expected that this will vary over time but mainly within the areas currently identified by the logbooks as being fished areas and especially along the fringes of the Gulf of Carpentaria (Figure 7). That is, some areas which were lightly fished may become more heavily fished and vice versa. It is not anticipated that completely unfished areas will become a priority for this fishery due to the biology of the target species and the management arrangements that are and will be in place for this fishery.

#### 4.4.2 Inshore net fisheries

This discussion includes the Gulf of Carpentaria inshore net fishery operating inshore of 3nm, the NT barramundi fishery and the NT coastal fishery.

##### 4.4.2.1 *Status and management now*

The inshore net fishery in both Queensland and the Northern Territory comprises commercial inshore netting that targets barramundi and king (in Qld also blue) threadfin. These fisheries are discussed by Greiner *et al* (2006) and Environmental North and Environmental Science and Services (2004). Most of the commercial fishing in the NT currently takes place in Van Diemen Gulf, Anson Bay, Arnhem Bay and Buckingham Bay (Department of Resources (DoR) 2009a). In Queensland, netters targeting barramundi are focussed around the Mitchell, Norman and Flinders Rivers (Queensland Primary Industries and Fisheries (QPIF) 2009a).

In the Northern Territory, a Barramundi Fishery Management Plan (2005) sets controls over the use of gill nets in the fishery and, in 2008, allowed for 24 licenses (DoR 2009a). Previous stock assessment models in the NT suggest that less than 10% of the total barramundi stock is harvested annually (DoR 2009a). Queensland has no stock assessments for any of the targeted species in these fisheries (QPIF 2009a). This fishery's management is through Queensland's Fisheries Act 1994, Fisheries Regulation 2008, the Fisheries (Gulf of Carpentaria Inshore Fin Fish) Management Plan 1999 (Gulf Management Plan) – which is under review and a new plan is to be in force this year (QPIF 2009a). In 2008, there were 86 licenses in the fishery, of which 76 were active.

In the Queensland Gulf of Carpentaria, catches of barramundi in 2005 were the lowest since 1997, although catch rates were similar to 2003 and 2004 (DPI&F 2006) and have risen slightly since then (QPIF 2009a). King threadfin showed a similar harvest trend over the years since 2003 (DPI&F 2006, QPIF 2009a). DPI&F (2006) attributed the trend to regional drought conditions since 2001 but recent rains have seen no significant increase in either catch or CPUE. Data from the NT indicate that the barramundi is recovering from overfishing during the 1970s and 1980s due to management interventions (DPIF&M 2006). However, the Department of Resources (2009a) state that in certain accessible areas, such as Chambers Bay, Finniss, Daly and Roper Rivers, the combination of heavy recreational and commercial fishing pressure may be increasing the total harvest to full use levels. Management of these specific areas is under review (DoR 2009a).

More generally, the full effects of removing numbers of predators, such as barramundi, and quantities of biomass from such systems are unknown (DoR 2009a).

Most of this fishing effort and impact is within the 3nm limit but there is also impact beyond the 3nm with regard to the interactions with bycatch, including protected species such as dugong, turtle, crocodile, sawfish, shark (some of which are by-product), inshore dolphin (Kiessling 2003a). For example, NAILSMA (2005) estimate that about 400 marine turtles are killed each year in ghost nets some which may have been used in this fishery in the Gulf of Carpentaria. Saalfeld and Marsh (in Kiessling 2003a) point out that fishing activities which could potentially affect dugong populations are commercial barramundi fishing using set nets, inshore shark fishing using pelagic nets, bait fishing using nets and staked coastal nets used by coastal net fishery. In Borroloola, data from the early 2000s suggested that 42% of dugong mortality was not connected with indigenous hunting and a significant proportion was linked to commercial fishing (Saalfeld and Marsh in Kiessling 2003a).

Several initiatives have been introduced which have the potential to reduce the bycatch of threatened species. In the Queensland portion of this fishery (*Fisheries (Gulf of Carpentaria Inshore Finfish) Management Plan 1999*):

- the barramundi mesh net fishery is closed between early October and the end of January
- several spatial closures to netting have been introduced
- changes to net fishing regulations in the Wellesley Island Protected Wildlife Area, the most important dugong area along the Queensland Gulf Coast
- the ban on setting nets across waterways or channels within 100 m of another net
- the encouragement of commercial fishers to undergo an Endangered Species Awareness Course as part of their code of conduct (Marsh 2000).

The NT Seafood Council has developed a set of guidelines to minimise the incidental capture of dugong. In addition, a dugong protection area is in place in the south-western Gulf of Carpentaria, which effectively excludes commercial fishers from fishing and anchoring in this area (DPIF&M 2006a). Also in the NT, the shark taken as by-product is

restricted to 500 kg of converted whole shark weight on board each vessel at any time although data on shark stocks do not appear to be available (DoR 2009a). Despite this, 23 interactions with threatened species were recorded in the Queensland fishery in 2008 (QPIF 2009a) and 98 for the NT (DoR 2009a).

Other ecosystem impacts include discarded bycatch, which is estimated to be just under 10% of total catch in the NT in 2008 (DoR 2009a).

Barramundi (*Lates calcarifer*) is a prized recreational fish which is caught by line. In the NT and Queensland, many fishing tour operators target barramundi, which is also a priority target for independent recreational fishers, most of them tourists to the region during the dry season. While a high proportion of recreational catch (independent and fishing tour based) is released, the absolute number of fish taken has been increasing because there are no controls on the number of participants (DPIF&M 2006a, DoR 2009a, and QPIF 2009a).

There is also a coastal small-mesh net fishery operating within 3nm of the NT coast that comprises 5 licences and operates mainly in defined areas around Darwin, Gove and Borrooloola (DPIF&M 2006a, DoR 2009a). This fishery rarely interacts with threatened species or non-coastal species due to its mesh size and is not considered further here.

#### 4.4.2.2 *The inshore finfish fishery in 20 years*

Effort is being controlled in these fisheries, which allows them to be sustainable in the long term, especially the fishery under the NT jurisdiction. Confounding factors are climate extremes such as drought which may be the cause of, or the partial cause of, declining catches in the Queensland part of this fishery. Alternatively, the drought may be exacerbating or disguising effects of overfishing. The certainty of the future of this fishery is also impacted by recreational and indigenous effort that targets these same species (Sections 4.5 and 4.6).

We anticipate that these fisheries will still continue to exist in the inshore waters adjacent to the NMR in 20 years time and therefore their impacts upon bycatch, including threatened species, will continue to be realised over that time. We do not consider that this fishery will be greatly expanded in terms of effort levels and thus in terms of impacts upon species of moment to NMR planning efforts. The fishery will, however, continue to cause impacts upon these species, many of which are long-lived, every year in the intervening 20 years. This creates an imperative for management to offer enhanced protection to these species where possible.

#### 4.4.3 Offshore net fishery

This discussion encompasses that part of the Gulf of Carpentaria's "inshore" net fishery operating beyond 3nm (and which is part of the GoC net fishery) and the NT offshore net fishery.

##### 4.4.3.1 *Status and management now*

The Queensland offshore net fishery comprising 5 licences (3 active in 2008) operates within the NMR from about 7-25nm from shore and targets shark (Australian blacktip whaler (*Carcharhinus tilstoni*) and sorrah whaler (*Carcharhinus sorrah*)) and grey mackerel (*Scomberomorus semifasciatus*) (DPI&F 2006, QPIF 2009a). Set mesh nets are used in this fishery. Those netters targeting Grey Mackerel are spread north from Karumba to the tip of Cape York (QPIF 2009a). The harvest of Grey Mackerel, sharks and rays is

managed jointly between the State and the Commonwealth through the Queensland Fisheries Joint Authority (QFJA)(QPIF 2009a).

The NT net fishery operates largely within 12 nm and targets the same species of blacktip sharks and grey mackerel as the Queensland fishery with a variety of other sharks and pelagic finfish also landed. Most of the 13/17 operating licenses in this NT fishery work within the coastal zone (within 12 nm of the coast) and immediately offshore in the Gulf of Carpentaria although the permitted area of operation goes to the perimeter of the Australian Fishing Zone (DoR 2009a). In the NT, this fishery uses pelagic nets and is combined with a long-line fishery that targets these same species. Bottom-set gill nets are prohibited due to previously recorded interactions with turtles. The fishery is managed by the NT Fisheries Joint Authority (NTFJA), in accordance with the NT *Fisheries Act 1988*. Day-to-day management of the fishery is undertaken by Department of Resources (DoR).

In the NT, recognition of the life history and consequent vulnerability of shark to overfishing led, recently, to a 3-for-1 licence reduction scheme, resulting in effort from 1800 boat days in 2003 to 899 boat days in 2006 (DPIF&M 2007c). Catch rates in the NT of both these shark and grey mackerel have generally been maintained over the years although there have been recent declines in catch and CPUE of all three targeted species (from 2007-2008)(DoR 2009a). This fishery takes 95% of all landed shark catch in the NT: in 2008 this was 800 tonnes of which 54% was the targeted black tip sharks; in 2006 74% of the catch was the targeted black tip sharks (DPIF&M 2007c, DoR 2009a). In the NT, other sharks caught include Pigeye Hammerhead, Tiger, Lemon and others (in order of volume). The Queensland fishery, in 2008 took 146 tonnes of black tip sharks and 39 tonne of other shark; in 2005, the fishery took 420 tonne of all shark (DPI&F 2006, QPIF 2009a). Blacktip whaler sharks (*Carcharhinus tilstoni/limbatus*) catches have been distinguished in this fishery only since 2004.

Shark fins are the most prized component of the catch sometimes reaching about \$30/kg for the fisher. Global demand for this product continues to outstrip supply, which provides an incentive to sustainably manage the industry into the future, but also encourages the illegal, unreported and unlicensed take of shark, including by foreign fishing vessels.

Queensland fisheries managers have expressed concern about the status of both shark stocks and mackerel stocks (DPI&F 2006 p11). Welch *et al* 2009 (in QPIF 2009a) identified a single genetic stock for Grey Mackerel in the GOC that is shared between Queensland and Northern Territory jurisdictions. In the performance indicators for the NT fishery, management triggers have been reached for the grey mackerel and for four by-product species. Performance measures under Queensland's Performance Management System have been triggered for grey mackerel, for by-catch and, at present, QPIF cannot reliably assess shark catch trends at the species/species group level in the fishery (QFIP 2009a). None-the-less, the Queensland and NT Governments have both recognised the vulnerable status of sharks due to their life history characteristics and risk assessments support this concern (Salini *et al* 2007). Note also that other fisheries catch and release shark – their survival rate is unknown.

Prohibition on the possession of sharks and shark product is in place for the Timor Reef, Demersal, Finfish Trawl and Spanish Mackerel Fisheries in the NT. The NT Barramundi, Coastal Net and Coastal Line Fisheries have allowances for incidental catches of sharks.

Due to the pelagic nature of the target species, the exact current and future location of effort does not describe well the location of the impacts of this fishery upon stocks. The impacts will be dispersed throughout the range of the animals being caught.

#### 4.4.3.2 The offshore net fishery in 20 years time

While demand for food products, including fish, will increase over time the relative demand and scarcity of shark fin products is enormous and has already led to extremely high prices for shark fin products (e.g. \$30/kg to the fisher). As discussed in Section 3, globally fish resources are declining and the higher order predators even more so.

The vulnerability of shark and grey mackerel has three dimensions in terms of resource planning for the NMR:

- impact on the economic viability of the fishery;
- consequent impact upon target stock;
- consequent impact upon by-catch.

Will the fishery be managed so that it will exist into the future? If so, then the environmental impacts of the fishery will remain including at least an economically maintainable level of impact upon stocks and by-catch. If not, the stock will collapse. If the stock experiences an “economic collapse” this means that the stock is insufficient for fishers to earn a living from it. Thus, with an economic stock collapse, there would be no fishery. In that case, however, will be ecological repercussions as a consequence of losing these top predators in the ecosystem and consequent, unpredictable, ecosystem cascade effects but no ongoing direct impacts otherwise.

Globally shark populations are ‘in crisis’ due to over fishing and underreporting of harvest (Clarke *et al* 2006). Aside from the ecological implications this also means, from a fishery perspective, there are not many other fishable shark stocks in the world. This makes remaining stocks, such as those in Australia, attractive to foreign fishers. The NMR shares international borders with Indonesia, Papua New Guinea and East Timor. AFMA has identified illegal foreign fishing as a compliance issue in Australian fisheries management with particular regard to Australia’s northern region (AFMA 2008 <http://www.afma.gov.au/management/compliance/illegal/default.htm>). Here, incursions have been largely made by fishers from Indonesia, the majority of who are targeting shark with a small number targeting reef fish and trepang (sea cucumber). In the past a small number of incursions have also been made by vessels from Taiwan and Papua New Guinea in the past. Recently though, the rate of IUU incursions in Australia has declined dramatically over the last three years including into the GoC (Australian Network News 2009 as reported in QFIP 2009a). Over the next 20 years, however, the threat of serious IUU fishing including by foreign fishing vessels, however, remains.

In sum, this fishery is at risk due to:

- The life history of some of the main target species (long-lived species with relatively low fecundity)
- High prices for the shark fin component of the fishery creating incentives to fish heavily
- Lack of knowledge about the main target species
- Illegal foreign fishing
- Other illegal or unreported take of the target species.

In 20 years, due to either sustained fishing of shark and grey mackerel or over fishing leading to economic depletion of shark and mackerel (and perhaps cessation of the fishery) we expect that stocks will be significantly below natural levels. Data are not available to compare current stocks with unfished levels. This means that it is not possible to predict the future degree of departure of stocks from natural levels. If fishing is ongoing, then ongoing interactions can be expected between the nets used and lost and threatened species such as dugong, cetaceans and sawfish.

#### 4.4.4 Spanish mackerel fishery

This discussion encompasses the NT Spanish mackerel fishery and the Queensland GOC line fishery (DPIF&M 2006a, DPI&F 2007a, DoR 2009a, QPIF 2009b). The latter targets only Spanish mackerel (*Scomberomorus commerson*) and, secondarily, demersal fin fish.

##### 4.4.4.1 Current status

The stocks are managed by Queensland, the NT and the Queensland Fisheries Joint Authority (QFJA). This fishery can operate seaward from the coast out to the boundary of the Australian Fishing Zone (AFZ) but effort is largely concentrated in near shore areas including around reefs, headlands and shoals. Main fishing areas include Bathurst, New Year, the Wessel Islands, the Sir Edward Pellew, Mornington Islands, northern and western Groote Eylandt, the Gove Peninsula, the western and eastern coasts of Arnhem Land, and off Weipa (DPIF&M 2006a, DPI&F 2007a, DoR 2009a, QPIF 2009b). Trolling is the major method of fishing. About 270 tonnes was caught in the NT part of the fishery in 2008 and 285 tonnes in the Queensland fishery. In the NT this represents a significant decrease in catch over the last 3 years albeit matched with both an increase and, for 2008, a decrease in CPUE (DoR 2009a). For Queensland catch over the last 6 years have been within a similar range and catch per unit effort levels have been maintained (QPIF 2009b). Across northern Australia, the Spanish mackerel have been found to be comprised of one genetic stock such that take within the Queensland fishery is from the same genetic stock as take within the NT fishery. (DPIF&M 2006a, DPI&F 2007a)

Possession limits have recently been applied to take of this species in other fisheries (e.g. Northern Prawn Fishery, recreational fishery, pelagic shark fishing and finfish trawl operations) which will assist in both the economic and ecological sustainability of the Spanish Mackerel Fishery. However, recreational take of this species is significant, especially in the Territory, albeit small as yet, and participation rates are not controlled (see Section 4.6).

Bycatch includes relatively small quantities of demersal (bottom-dwelling) fish species such as cods, tropical snappers, wrasses and sweetlip, as well as other *Scomberomorus* species (DPIF&M 2006a, DPI&F 2007a, DoR 2009a, QPIF 2009b).

Historically, there were significant landings of Spanish mackerel taken by the Taiwanese gillnet fleet off northern Australia between 1974 and 1986, with annual catches perhaps as high as 1000 tonnes in the late 1970s. Foreign fishing vessel landings of Spanish mackerel then stabilised to about 400-500 tonnes per year in the 1980s. Since the mid-1990s the fishery has been much more controlled and exploited by Australian fishing vessels according to DPIF&M (2006a) and DoR (2009a). Indications are, on the basis of increasing CPUE the stock is recovering from earlier over-exploitation (DPIF&M 2006a, DoR 2009a). Illegal, unreported and unregulated (IUU) foreign fishing vessel incursions into GOC waters still poses a potentially serious threat to the sustainability of northern Australian fisheries including mackerel (see also Section 4.11.2; DPI&F 2007a).

In the NT, the fishery operated with 17 licenses in 2008 and in the GoC, 31 of 47 licenses were operating in the fishery. In 2004, a Byproduct Action Plan introduced stringent restrictions for the incidental harvest of Spanish mackerel in the Offshore Net and Line Fishery and Trawl Fisheries and a 'no take' requirement for all other NT fisheries.

The NT, assessment workshops held during the 1997 and 2000 and the 2004 assessments underlined the need for better information on harvest rates or abundance, but pointed out that the NT stocks of Spanish mackerel may now be close to being fully used (DPIF&M 2006a, DoR 2009a). DPI&F (2007a) reported the same.

#### 4.4.4.2 The Spanish mackerel fishery in 20 years

The commercial Spanish mackerel fishery appears to be close to or at fully exploited. The older age classes still appear to be absent (DPIF&M 2006a). There is a small but growing proportion of take of the stock on the parts of recreational fishers either through charter fishing operations or through individual take (DoR 2009a). At this stage, there are no controls on the number of participants in the recreational fishery and world trends, including in the NT, are towards increases in recreational, guided and charter fishing (DPIF&M 2006a). If recreational participation rates continue as at present (i.e. game fishing more than doubling in 2008 compared with 1995)(DoR 2009a) then by 2030 recreational fishing participation in game fishing might be around 30% and take of Spanish mackerel could be in the order of 180 tonnes. This additional pressure is unlikely to be sustained by a stock that is now almost fully used. This very crudely developed scenario assumes no absolute increase in recreational fishing, only a shift towards more game fishing. If recreational fishing levels also increase and commercial take remains at or above best estimates for allowable take, then the impacts may be more significant.

From an NMR marine resource planning point of view, the ecological consequences would be focussed around the loss of a major top predator in the NMR ecosystem.

#### 4.4.5 Finfish trawl fishery

This discussion covers the NT Finfish Trawl Fishery and the Queensland GoC Developmental Finfish Trawl Fishery (Figure 8).

##### 4.4.5.1 Current status

Demersal fish trawling by foreign and domestic operators has occurred extensively across northern Australia since the 1970s.

The Gulf of Carpentaria Developmental Finfish Trawl Fishery (DFTF) is a limited-entry, quota managed, semi-demersal trawl fishery that has operated under Queensland Fisheries Joint Authority (QFJA) jurisdiction since June 1998 (DPI&F 2007b, QPIF 2009c). This fishery now operates within the NMR on the Queensland side of the GOC and mainly beyond 3nm. DFTF operators predominantly capture red snappers (*Lutjanus erythropterus*—crimson snapper and *L. malabaricus*—saddletail snapper). Most of the product is sold to domestic processors as whole fish. Harvest in 2008 was 755 tonnes by 3 commercial boats (QPIF 2009a).

**Figure 8 Area of the Developmental Fin Fish Trawl Fishery**

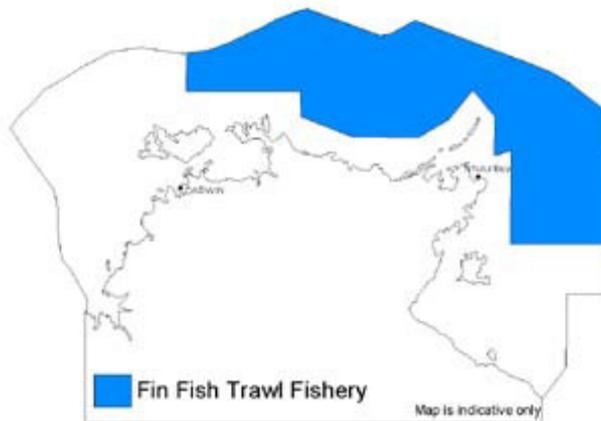


NT also has a Finfish Trawl Fishery comprised of a single Finfish Trawl operator fishing in offshore waters east of Darwin and includes the northern region of the Gulf of Carpentaria (Figure 9; DoR 2009a). The target species of the NT fishery are the same as that of the Queensland fishery and the NT Finfish Fishery overlaps in space with the NT Demersal fishery although the operator in that fishery does not use that part of his “fishable” area (DoR 2009a).

A genetic population study in 2006 has shown that the GOC crimson and saddletail snapper stocks are separate from those in Indonesia (which were considered to be over fished)(DPI&F 2007b). We were unable to determine whether the high level of Indonesian trawl fishing in the Arafura Sea adjacent to the AFZ (DPIF&M 2006a, DoR 2009a) targets the Indonesian stock of snapper or the Australian stock.

**Figure 9 Fishing area available to the NT Finfish trawl fishery**

(DoR 2009a)



Documentation and assessment of bycatch in the DFTF was undertaken through the fisheries observer program from one trip in 2006 and one in 2008, where it was estimated that 43% and 47% of the catch by weight (respectively) was discarded as bycatch and mainly comprised unmarketable finfish, sharks and rays and invertebrates (DPI&F 2007b, QPIF 2009c). In the NT, DoR (2009a) report that only 18% of the catch is discarded. They state that the main discard, by weight, was sharks and rays. Operators in the DFTF occasionally encounter threatened species (DPI&F 2007b). In 2008, observer trip reports indicate that the level of interaction (Number of individuals/hr) decreased by approximately 45% from pre 2007 levels (DEEDI 2010).

#### 4.4.5.2 Finfish trawl fishery in 2030

The overlap in target species between the state-territory jurisdictions and with the NT Demersal and Timor Reef fisheries (Section 4.4.6 below) appears to be being addressed by fisheries managers. For example, it is proposed to re-allocate potential red snapper catch from the Demersal Fishery to the Finfish Trawl Fishery through a license reduction scheme (DPIF&M 2006a).

The exposure to and impact of FFVs and IUU fishing upon this fishery (and the Demersal and Timor Reef Fisheries) could be significant (see Section 4.11.2) but are unknown. This uncertainty places the fishery in a precarious situation which is somewhat mitigated by the very low level of participation coupled with relatively strong controls upon Australian controlled fishers. Adequate data about either the level of FFVs and IUUs and their precise impact upon stocks is unlikely to be available soon (DPIF&M 2006a). Thus the future of this fishery rests upon the Australian fisheries managers in the NT and Queensland to track stock status using only Australian data. If current management regimes continue, we are optimistic that this fishery will remain in 2030.

This small fishery is significant in the NMR as one of the few fisheries that can impact directly upon the benthos of much of the NMR by trawling. In addition, much of the area within which the fishery is permitted to operate has relatively little or no history of trawl activity. In this way, by 2030, this fishery may have exposed possibly "pristine" seabed to inaugural trawling impacts.

#### 4.4.6 Demersal and Timor Reef fisheries

This section presents information about the NT Demersal and the Timor Reef Fisheries.

##### 4.4.6.1 Current status and management

The Demersal Fishery in the NT targets three species of goldband snapper (*Pristipomoides multidens*, *P. typus* and *P. filamentosus*), but also catches increasingly significant quantities of red snappers (*Lutjanus malabaricus*, *L. erythropterus*), with the remainder of the catch comprising red emperor (*Lutjanus sebae*) and cods (Family Serranidae) (DPIF&M 2006a, DoR 2009a). The Timor Reef Fishery also targets goldband snapper and other *Pristipomoides* as well as significant quantities of the red snappers (DoR 2009). The Demersal and Timor Reef Fisheries both use dropline and baited trap gears. The Demersal Fishery operates in waters 15nm from the NT shoreline to the outer limit of the Australian Fishing Zone (AFZ), excluding the area of the Timor Reef Fishery (in the north-western corner of the NMR). The eight active licenses in the Demersal Fishery expend most of their effort adjacent to the Timor Reef (DoR 2009a).

The number of Timor Reef licences has been reduced from 60 in 1993 to 12 today but some of these also hold demersal licences (DoR 2009a). There are now eight demersal fishing licences.

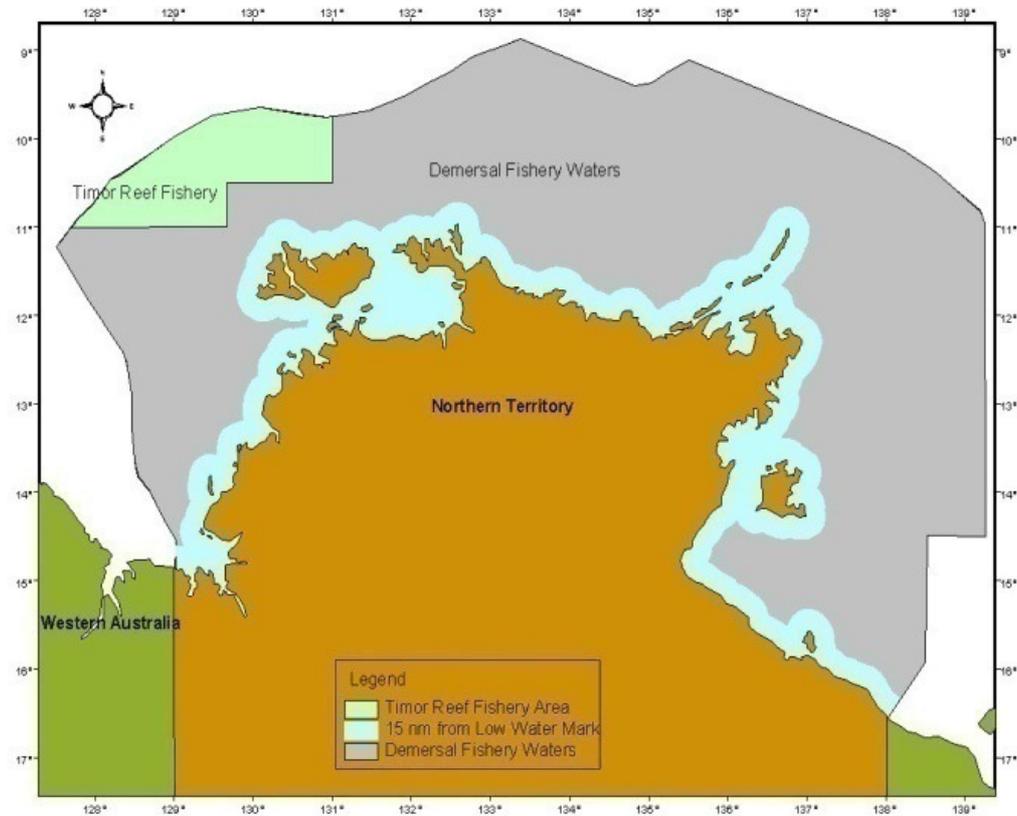
In 2006, the lingering displacement effects of oil and gas exploration companies carrying out seismic surveys within the more productive regions of the Timor Reef Fishery in combination with business decisions to more actively target the Demersal Fishery has led to an expansion of fishing effort in the Demersal Fishery from mid 2006 onwards (DoR 2009a).

Limited supply, enhanced product quality, improved marketing techniques and a greater acceptance of red snapper by the Australian public has led to an increase in product prices. In turn, these factors have made previously underutilised red snapper stocks within the Demersal Fishery a more attractive prospect. Catch in this fishery went from some 70 tonnes in 2005 to over 330 tonnes in 2007 of which 39% was the red snapper, *Lutjanus malabaricus*. In 2008, however, additional effort was not reflected in an increase in catch (CPUE decreased).

In the Timor Reef Fishery, catch and catch per unit effort have been relatively steady or increasing since 2000. In 2008, 895 tonnes of catch were recorded by 10 licensees; the catch comprised 56% goldband snapper and 25% saddletail snapper (DoR 2009a).

Management responsibility for the Demersal and Timor Reef Fishery was passed to the NT Fisheries Joint Authority (NTFJA) in 1995. NTFJA is a joint management arrangement between the Commonwealth and the NT given the likelihood of shared resources with adjacent national and international jurisdictions. Department of Resources undertakes day-to-day management of the Timor Reef Fishery. In the Timor Sea, outside the Australian Fishing Zone goldband snappers are also legally targeted by Indonesian long line vessels as well as Australian trap and drop line vessels (DoR 2009a).

**Figure 10 Area of the NT Demersal and Timor Reef Fishery**



To protect the habitat of the target species, a prohibition on fish trawling within the area of the Timor Reef Fishery was declared in the late 1980s (DPIF&M 2006a). This protection does not extend, however, to the area of the Demersal Fishery. Also, anecdotal reports from domestic fishers suggested illegal foreign fishing catches were increasing significantly in the mid-2000s, especially in the Timor Reef area, and this is still seen as an issue today (DPIF&M 2006a, DoR 2009a).

#### 4.4.6.2 The Demersal and Timor Reef fisheries – in 20 years

Issues that may impact the future of this fishery include maintenance of stocks that are fished by multiple fisheries (including legal foreign fishers), habitat damage and the consequences of IUU harvest. Trawling was identified in the 1980s as being damaging to the benthic habitat upon which goldband and red snapper rely, and led to banning of fish trawling in the area of the Timor Reef fishery (DPIF&M 2006a).

Fish trawling is allowed throughout the area of the Demersal Fishery and the NPF allows prawn trawlers to operate year round in offshore waters throughout northern Australia although their current operations do not co-incide greatly with the area of the demersal fishery. One can infer that to the degree that trawling occurs in the habitat of the target snapper species, there is a negative impact upon the likely future sustainability of this fishery. The degree of impact is unknown; to date there is not great overlap between the area trawled in the Finfish Trawl Fishery and the Demersal Fishery but this could change.

The issue of stocks being fished by multiple fisheries, FFVs and IUU are the same issues discussed in Section 4.4.5.2 so will not be repeated here.

The future of this fishery is reliant on ongoing vigilance on the parts of fisheries managers who must consider overlapping pressures on the stocks in the absence of adequate information. The low numbers of fishers that participate in this fishery enhance management's ability to control take to within sustainable levels and if participation levels are maintained then the fishery will likely be able to continue into the future.

#### 4.4.7 Coastal line fishery

##### 4.4.7.1 *Current status and management*

This NT fishery especially targets black jewfish but also targets a range of other reef fish, such as snapper, emperor and cod (DoR 2009a). It operates from the low water mark out to approximately 15nm although most of the fishing is closer inshore. From the high water mark to 2nm allowable gear includes multi-hooked vertical, cast nets (for bait only), scoop nets and gaffs; multi-hooked rope lines and a maximum of five fish traps per licence may also be used from 2 nm out to the 15 nm limit (DoR 2009a).

Catch has increased significantly since 1999. Before this time, in the NT catch was between approximately 50-100 tonnes; in 2004 catch peaked at 311 tonnes and has declined ever since to 205 tonnes in 2008. CPUE has also declined since 2006 (DoR 2009a).

In 2008, in the NT there were 23 active licenses in this fishery (DoR 2009a). The NT government is implementing a licence reduction program will resulted in a maximum of 45 fully transferable licences; there are currently 54 licences (DoR 2009a). This compares to 160 licences in 1993 (DoR 2009a).

This commercial fishery shares target stocks with indigenous fishers, recreational fishers and fishing tour operators. These latter two sectors have been conservatively estimated to take more of the target stocks than the commercial fishery (DoR 2009a). In addition, black jewfish form large spatially and temporally-predictable aggregations and as such, are vulnerable to over-fishing (DPIF&M 2006a; DoR 2009a). There is an extensive body of evidence derived from stocks throughout the tropics that indicates target fishing of aggregations can rapidly deplete fishery stocks (DPIF&M 2006a).

Recognising these issues, the NT government aims to manage all components of the fishery as a whole. Recreational personal possession limits (five for black jewfish and golden snapper) are in place to help regulate the impact of the recreational sector. As a precautionary measure, it was proposed (in 2005) to reduce the recreational possession limit for jewfish from five to three (DPIF&M 2006a). This has not yet occurred (DoR 2009a). But, according to new research (Greiner and Gregg, forthcoming), even recreational anglers suggest that a bag limit of 1—or possibly 2—jewfish per person would be more appropriate.

DoR (2009a) consider that the total harvest from the fishery by all sectors, including the indigenous fishing component, is moving toward the upper estimate of the original stock assessment. Localised depletions had already been identified in 1996 (DoR 2009a).

#### 4.4.7.2 Coastal line fishery in 20 years

While controls on the commercial fishery are strengthened, the number of recreational participants in the coastal line fishery is not controlled. The future of the commercial fishery and indigenous fishing also, is inextricably tied to the future of the recreational fishery.

In the last 10 years, take within this fishery has increasingly targeted black jewfish both relative to other species taken in this fishery and in absolute terms. The species is particularly vulnerable to over fishing due to its tendency to form aggregations. It is possible that, in 20 years, given the multiple sectors involved and the vulnerability of the current key target species that this fishery will see change in the relative proportions and absolute amount of take of target species.

For the NMR, this fishery operates, at least partly, outside its boundaries. Where the target species form part of the NMR ecosystem, their role will be under threat in 20 years time. Impacts on the NMR from stock depletions in adjacent waters will be realised as an ecosystem cascade effect arising from whatever ecosystem changes are wrought inshore that have implications more offshore. Unfortunately, these are difficult, if not impossible to predict.

#### 4.4.8 Other fisheries

The fisheries discussed in this section operate either entirely outside the NMR with little potential environmental impact upon it or are relatively small scale.

##### 4.4.8.1 *Mud crab fishery*<sup>[H22]</sup>

The<sup>[LF23]</sup> commercial mud crab fishery comprises 49 licences and the fishery as a whole is considered to be fully exploited in the NT (DPI&F 2006a, DoR 2009a). In Queensland, the mud crab fishery, comprising 431 licences, extends throughout all coastal waters both within the Gulf of Carpentaria and the East Coast (DPI&F 2007c). In 2002, the Northern Gulf region of the fishery suffered the loss of the major air cargo carrier from Weipa and the subsequent movement of crabbers to alternative regions that allow for improved transport of product to east coast markets. Despite this, the performance measurement system for the Queensland Mud Crab Fishery triggered a review of low catch levels in the northern Gulf of Carpentaria region in 2007 and this issue remains today (DPI&F 2007b, DoR 2009a).

The Queensland GoC mud crab fishery overall has maintained a catch of between 135-163 tonnes since 2003; this latter being the catch for 2008 (QPIF 2009d). In the NT the catch is much higher: 412 tonnes in 2008.

In Queensland, no female crabs can be taken which will assist in the sustainability of this fishery into the future.

The future of the commercial mud crab fishery is inextricably linked to the recreational fishery. The future impacts of this fishery upon the NMR ecosystem, however, are likely to be limited and indirect, due to the ecosystem role of the target species in the coastal environment and the consequently limited linkages with the NMR.

Within the NMR, the broader multi-species recreational and charter fishery do occur. Where the attraction of being able to access mud crabs is part of the attraction to the region for fishing more broadly, the future of the commercial mud crab fishery matters. If

the commercial fishery impacts on mud crab stocks so that they are unavailable to other fishers, then this may potential influence future development of the multi-species recreational and charter fisheries within the NMR. However, this linkage is tenuous at best.

There are extremely minimal implications for NMR planning activities of this activity.

#### *4.4.8.2 Bait fisheries*

In 1992, NT Coastal Net Fishery licences were made available only to persons who held an existing special purpose (haul net) fishery licence, or a bait fishery licence. At that time, there were four special purpose (haul net) fishery licences—of which one remains current as Coastal Net Fishery licences—and almost 60 Bait Net Fishery licences, of which four remain current as Coastal Net Fishery licences and two as Bait Net Fishery licences (DoR 2009a). Bait is targeted by other fisheries both in Queensland and the NT solely for use within those fisheries. For example, bait nets are used in the Spanish mackerel fishery and cast nets in the Coastal Line fishery and mud crab fishery to catch bait used to target black jew fish or mud crabs respectively.

It is not anticipated that in 20 years time these activities will have significant environmental impacts within the NMR.

#### *4.4.8.3 Aquarium fish*

In 2008, 6/12 aquarium fish/display licences were active in the NT. that permit the collection and sale of all aquatic life, including freshwater and marine fishes, plants and coral (DoR 2009a). Commercial harvesting of marine species is concentrated in coastal waters near Nhulunbuy (which includes coral reefs), although some also occurs in the greater Darwin area (DoR 2009a). DPI&F in Queensland do not report any aquarium fish activity in the Gulf of Carpentaria.

Since 1995, over 1.3 million individual aquatic organisms (excluding shrimps) have been harvested by licensees working in the Aquarium Fishery of the NT (DPI&M 2006a). Although data are difficult to compare over the years due to methodological problems, the impact of the fishery may be considered to be low due to the low number of participants, low harvest levels, multiple species targeted, a large area of habitat available to these species and the selective nature of the fishery. The fishery is also subject to natural seasonal closures. However, there is a risk that the fishery, if focussed on key areas, can cause the local depletion of “aquarium” species.

If the participation rate remains low, in twenty years time, the environmental impact of this NT fishery is expected to remain low and most of the impacts will continue to be outside the NMR. Thus the implications of this activity for NMR planning purposes are minimal.

## **4.5 Indigenous fishing and management**

Many indigenous groups live on the coast adjacent to the NMR and depend on the sea for social, cultural and subsistence benefits. Subsistence fishing is an important part of Indigenous culture in Northern Australia as well as a traditional source of protein (DoR 2009a). Subsistence fishing is therefore also economically important in some indigenous communities adjacent to the NMR, albeit in the informal versus formal market economy.

The main source of information for indigenous fisheries in Northern Australia remains the Northern Australia Indigenous Fishing Survey (NAIFS), (<http://www.daff.gov.au/brs/fisheries-marine/data/rec-indig/indigenous-survey>, downloaded 31/5/10) that was part of the 2000–01 National Recreational and Indigenous Fishing Survey (NRIFS; Henry and Lyle 2003). The methodology used to obtain indigenous harvest data, however, remains contentious and the accuracy of results is questionable.

According to the NAIFS, about 2500 indigenous people were surveyed from coastal and urban communities adjacent to the NMR. Results showed that 91.7% of people over 5 years old had fished at least once in the previous year. The survey also found that the most preferred fishing method was with lines, which represented 53% of all fishing events. Bait was used in preference to lures. Other popular fishing methods included hand collecting (26%), surface spear-fishing, and cast netting.

In much of their fishing activities, target species overlap with species also targeted by recreational and/or commercial fishers. For example, the survey results indicate that seaperch/snappers and emperors (11% of the total catch composition), barramundi and salmon are amongst the species groups more commonly harvested by the Indigenous sector, as well as mackerels albeit that the latter was only about 0.6% of total catch (Henry and Lyle 2003).

There is also geographic overlap between indigenous and non-indigenous fisheries in that 55% of indigenous fisheries occur within 5km<sup>5</sup> of the shoreline; less than 1% of indigenous effort occurs outside 5km from shore (Henry and Lyle 2003). Locally, however, there is a high level of variability as to whether indigenous fishers share the same exact fishing locations with other fishers which has possible implications regarding localised depletions.

Some other, non-fish taxa (such as mussels, oysters and other molluscs) are harvested in significant numbers mainly by indigenous communities. Other taxa are also harvested by indigenous people but in smaller numbers (e.g. prawns, crabs, yabbies and baitfish).

The survey indicated that about 1600 dugong were harvested in the year 2000-2001 from Northern Australia (this includes WA, the Torres Strait and the northern east coast of Queensland)(Henry and Lyle 2003). Because there is little suitable habitat for dugong on the west coast of Cape York (excluding the Wellesley Islands and parts of the northern part of Cape York) there can be presumed to be little take of dugong there (Saalfeld and Marsh in Kiessling 2003a, NAILSMA 2005). In the NT dugong are hunted by almost all coastal Indigenous communities along this coastline (Saalfeld and Marsh in Kiessling 2003a) . Other data about dugong harvest are unreliable and so knowledge of dugong harvest adjacent to the NMR is limited (NAILSMA 2005).

In 2000-2001 the NAIFS reported that over 6500 marine turtles were harvested by indigenous people in Northern Australia and over 40 000 eggs (note that this includes the Torres Strait, Western Australia and east coast of northern Queensland)(Henry and Lyle 2003). Some Traditional Owners in north-east Arnhem Land have expressed concern about a reduction in green turtle numbers (NAILSMA 2005). Unsustainable indigenous harvest of the range of turtle species and their eggs is one of the many sources of concern for the future of these populations (NAILSMA 2005).

Larson *et al* (in Kiessling 2003a) consider it probable that the main non-commercial take of sharks and rays are by coastal indigenous communities along the NMR coast although they state that the impacts of this take are unknown.

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<sup>5</sup> 5km equals 2.7 nautical miles; therefore this fishing occurs within 3nm

Few data exist to distinguish information about indigenous take from communities adjacent to the NMR from indigenous take across northern Australia more broadly.

Turtle and dugong are known to cover large distances and their movements may take them outside the area of the NMR and, for some species, outside Australian waters (NAILSMA 2005). This, then, limits the degree to which NMR planning efforts can control impacts upon these species.

#### 4.5.1 Land and sea management

The NAILSMA report (2005) discusses efforts to enhance dugong and turtle management and this discussion is not repeated here. Overall there has been increased involvement of and collaboration with indigenous communities in the matter of management of the marine environment and also in surveillance programs.

Increasing indigenous involvement is illustrated in the increasing number of land and sea ranger groups operating across the NT and, to a lesser extent, elsewhere. The first groups emerged in the 1980s when they had little or no government support. Some 46 indigenous land and sea management groups with around 500 members were operating in the NT in 2007 (Putnis *et al.*, 2007). The groups are principally supported in their operations by the Indigenous land councils while the 2003-founded North Australian Indigenous Land & Sea Management Alliance (NAILSMA 2005; 2009), which also operates in northern Qld, and northern WA, plays an important advocacy role.

In Qld, Indigenous caring for country activities tend to align with regional NRM groups, which—under the auspices of the Statewide Indigenous Network Coordination Project—employ Indigenous facilitators and fund traditional owner involvement in caring for country activities (Qld Regional Group Collective 2009). Some traditional owner groups are self-organised as Indigenous land and sea management or ranger groups, while others operate under state government auspices (e.g. Wild River rangers; Qld Government 2009).

The portfolio of caring for country activities include, for example, feral animal and weed control, biodiversity monitoring, threatened species protection, fire management and coastal rehabilitation. Some groups conduct surveillance and quarantine related activities. An important aspect of Indigenous land and sea management is the continued growth of social and human capital through training and education programs, policy and planning, advocacy, and community development projects.

To support its response to illegal fishing the NT Government has also been increasing its support of indigenous rangers, which includes rangers from the Dhimurru Land Management Aboriginal Corporation, Lianthawirriyarra, Numbulwar and Anindilyakwa Sea Ranger groups. In 2009, 16 Indigenous sea ranger groups operated across the Territory and the government provided funding for eight of the groups (DPIF&M 2007b, DoR 2009b).

Government funding for land and sea management activities, including quarantine and surveillance, provide important income to remote indigenous communities. Conceptually speaking, this funding provides 'payments for environmental services' (Greiner 2010).

#### 4.5.2 Indigenous fishing in 20 years

Presently, there appears to be a confluence of opportunity, resources and political will to support indigenous aspirations for management of their saltwater or sea country coupled with a higher priority of marine resource management in Australia more broadly. The

drivers discussed in Section 3 indicate that there will not be huge absolute increases in indigenous population adjacent to the NMR<sup>[H24]</sup>, so direct pressures upon the marine environment are not expected to increase from this group more than non-Indigenous people. Exceptions will exist where land and sea management fails in some very localised areas and fails with regard to slow growing, low fecundity species preferred by Indigenous peoples (e.g. dugong, turtle, sharks, rays, sawfish)(Keissling 2003a) <sup>[LF25]</sup>.

Indigenous fin-fish and invertebrate-targeted fishing impacts little on the NMR as it largely occurs outside the NMR. Dugong and turtle hunting and take of shark, rays and sawfish does impact on populations that are part of the NMR environment (Keissling 2003a). For example, Saalfeld and Marsh (in Keissling 2003a) state that take of the dugong population in the region (including the large numbers of dugong in the Torres Strait) should be about 100 animals a year. But anecdotal information that they report identify levels of take much higher just within areas located adjacent to the NMR.

Due to the multiple adverse impacts upon dugong, turtle, shark, ray and sawfish populations, combined with their life history and movement patterns (Keissling 2003a), even 100% control of indigenous hunting of these animals may not guarantee their future. Keissling (2003a) identifies multiple, ongoing threats that impact upon all these animals of which indigenous take is only one.

However, collaborative indigenous and government land and sea management efforts can and do contribute to the sustainable use of the NMR, in particular, through contributing to management of dugong and turtle, management of external impacting activities to do with IUU fishing and marine debris.

#### 4.6 Recreational fishing

Recreational fishers in the NT and Queensland's part of the Gulf of Carpentaria target barramundi as a prize fish. Part of the great appeal of barramundi fishing is the diversity of fish species, habitats and fishing methods that anglers experience. In the NT, saratoga, sooty grunter, threadfin salmon, golden snapper and mangrove jack are some of the species that are often caught on the same lures, baits and flies anglers use to target barramundi (DPI&M 2006). NT recreational fishers also target mullet, jewfish and mudcrabs.

Of recreational fishing activity in the NT, over 25 per cent occurs in Darwin Harbour, Shoal Bay and the offshore area adjacent to Darwin (DoR 2009a<sup>[LF27]</sup>). Twenty-two percent of NT recreational fishing activity occurs within 5 km of the coast, 6% occurs further from the coast and the rest is almost all in rivers, creeks and estuaries (DoR 2009a).

In the Queensland section of the GOC, almost all recreational fishing occurs within rivers, creeks and estuaries or within 3nm of shore, based on RFISH data from 1997, 1999 and 2002 (DPI&F 2007d). It is estimated that recreational fishers living in Queensland took 101 tonnes of GOC Inshore Finfish Fishery-related species in 2005, mostly grunter, barramundi, blue threadfin, mangrove jack and shark (DPI&F 2007d). In addition, between 10-13 tonnes of mackerel and trevally are harvested annually in the GOC by Queensland recreational fishers (DPI&F 2007d). These data includes retained and released fish.

It is known, however, that a large proportion of fishing effort in northern waters is from interstate tourists. Greiner and Patterson (2007) surveyed 1050 recreational fishers in Karumba during the March-September 2006 tourist season and noted that >50% were from interstate with 27% from NSW and 18.5% from Victoria. They estimated total recreational harvest of tourist anglers was between 197-234 tonnes with about 250,000-307,000 specimen caught and approximately 94,000-112,000 kept. Grunter accounted for

about half the harvest (100-118 tonnes), followed by blue salmon (32-38 tonnes). In comparison, local residents' recreational harvest was estimated between 1.7 and 3.7 tonnes for the whole of 2006 (Greiner & Patterson, 2007).

The majority of fishing effort by tourist anglers in Karumba was in-shore and in the estuary (40% and 36% of total time spent fishing, respectively) with 18% of effort targeted offshore and 6% in rivers (freshwater; Greiner & Gregg forthcoming). Of 365 tourist angling parties with completed fishing trip activities, 109 (30%) recorded going offshore (distance from coast >3nm) at least once and spending on average 2.8 hours per trip fishing offshore. Offshore anglers tended to target Spanish mackerel more than other anglers and were less interested in blue salmon, bream and jewelfish—but harvest patterns were quite similar with grunter being the dominant harvested species (Greiner & Gregg, forthcoming). For tourist anglers to Karumba the principal use of harvested fish was to “freeze and take home to eat”, which was even more pronounced among those anglers who fished offshore.

Recreational fishers' main reason for venturing into the NMR is game fishing. Game fishing comprises only a small, albeit increasing, portion of the overall recreational fishery: about 8% of recreational fishing effort in 2000; up from 2% in 1995 (DPIF&M 2006a). Recent indications, based on qualitative research, are that the offshore capability and fishing activity has increased significantly in recent years. Boat affordability has increased and the types of boats are tending towards larger, better equipped vessels, capable of offshore fishing (Greiner & Gregg, forthcoming).

In the NT, Spanish mackerel are highly prized as a sport and table fish, and most are taken by recreational fishers from waters within easy reach of the major coastal population centres of Darwin, Nhulunbuy and Borroloola. Surveys of recreational anglers in 1995 and 2000-01 found that most (47 per cent) of the targeted effort for game fish (for example, mackerel) occurred in the Nhulunbuy area (DPIF&M 2006a). DPIF&M (2006a) also reported that recent survey work done with recreational fishers in the NT showed that 49 per cent of the mackerel catch was thought to be Spanish mackerel. This information provided an estimated recreational sector harvest of 47.1 tonnes of Spanish mackerel alone (DPIF&M 2006a).

Henry and Lyle (2003) recorded that, in 2000-2001, 8000 sharks were harvested in the NT by recreational fishers. Although they also reported high release rates for sharks and rays, survivorship post-release is unknown.

Available information suggests that recreational fishers release a significant portion of their catch. For example, in the NT an estimated 47% of caught barramundi is released, of which an estimated 90% survive (DoR 2009a).

The extent to which recreational anglers release caught specimen back into the water varies for different fish species. A survey was conducted of recreational fishers in Karumba, in the Gulf of Carpentaria, during the tourist season of 2006. It found that while most barramundi, catfish (*Arius sp.*, *Euristhmus spp* and *Paraplotosus sp*) and grunter (*Pomadasy kaakan*) were released, a majority of blue salmon (*Eleutheronema tetradactylum*), king salmon (*Polydactylus macrochir*) and Spanish mackerel (*Scomberomorus commerson*), were kept (Greiner & Patterson 2007; Greiner & Gregg 2010a). For some species, recreational take was small compared to commercial harvest (e.g. barramundi, king salmon). For other species however, recreational take significantly contributed to total harvest in the Gulf of Carpentaria waters, and in some instances exceeded commercial harvest (in particular for grunter, Spanish mackerel, spotted mackerel and blue salmon). For these species in particular it is essential to consider recreational fishing impact in fisheries management (Greiner & Gregg, 2010a).

Residents of the NT fished an average of five days in 2000-2001, a decline from the average eight days per year recorded during the 1995 survey, which was known as Fishcount 95 (Henry and Lyle 2003; DPIF&M 2006a). However, the number of hours visitors to the NT spent fishing increased from 23 per cent in 1995 to 37 per cent in 2000-01 (DPIF&M 2006a).

#### 4.6.1 Fishing tour operator (charter fishers)

In the NT, fishing tour operator (FTO) licences were issued free of charge with no limits on numbers as early as 1994. In 1994 there were 93 licenses and 62 active licenses (DPIF&M 2006a). In 2008 in the NT, 145 licences were issued although less than 100 are active (DoR 2009a).

Most FTOs target barramundi in coastal and inland areas with a few operating offshore, targeting other species. Seventy-six to 85% of FTO catch is released (DoR 2009a). While barramundi fishing effort (and catch) has somewhat stabilised since 2005, the effort put into game fishing and, especially, reef fishing has increased over the last ten years (DoR 2009a). For example, the catch of Spanish mackerel in this sector again increased in 2008 with a total harvest of 1850 fish (52% had been released). And reef species, such as Spanish flag and tricky snapper, have also been making up significant parts of the catch (DoR 2009a). In the NT, there is no limit on licences.

In Queensland, the Gulf of Carpentaria charter fishers are reported upon within the Inshore Finfish Fishery (QPIF 2009a) and the Gulf of Carpentaria Line Fishery (QPIF 2009b) separately. Twenty-six charter licences contributed to 41 tonnes of fish harvested in 2008 which is similar to previous years although the number of licences has been decreasing from 43 in 2003 (QPIF 2009a). Notable exceptions to these catch statistics were decreases in the amount of Barramundi and Coral Trout retained (0.4t and 2t respectively) and released in 2008 (3.7t and 0.4t respectively (QPIF 2009a). Main species retained include Blue Threadfin (11.2t), Spanish mackerel (3.9t), School Mackerel (2.2t) and Coral Trout (despite the decline in total catch of the latter). Main species released included Queenfish (15.7t), "other fish" (11t), Tuna – other (7.8t), unspecified Trevally (4.1t) and Golden Trevally (4t).

More generically, data indicate that about 65% of charter fishing catch in Queensland is released (QPIF 2009a). No new charter fish licences are being issued by Queensland at this time ([www.dpi.gov.qld.au](http://www.dpi.gov.qld.au) downloaded 15/6/08).

#### 4.6.2 Recreational and fishing tour operations (charter fishers) in 2030

Increasing boat ownership, coupled with bigger and better equipped boats, will contribute to increased private offshore recreational fishing effort, which will include direct impacts in the NMR. Fishing tour operator activity in the NMR is likely to continue to increase steadily.

While participation rates in recreational fishing have remained stable over time in the NT, (1995-2001 at ~32%; DoR 2009a), as population increases this represents an absolute increase in fishing pressure. The 2005 recreational fishing survey in Queensland identified a small statewide decline in recreational fishing participation although a continual increase in catch statewide (MacInnes 2008). As, in Queensland, a significant increase in population adjacent to the GoC is not expected we anticipate pressure from recreational fishers on the resource to remain similar to the present.

Fishing tour operator data from the NT indicated a fourfold increase in NT resident fish clientele over the 12 years to 2005 (DPIF&M 2006a). Non-NT Australians in particular, contributed to this increase (6-fold to approximately 37,000 clients in 2008; DPIF&M 2006a, DoR 2009a). The local resident proportion of clientele on fishing tours has consequently declined from 33% in 1994 to 23% in 2006.

These trends can be expected to continue over the next 20 years. Pressure upon the near shore component of the recreational and CTO fisheries in the NT will therefore continue to increase with population increases and as non-resident fishing effort levels also increase. It should be noted that the fishing charter industry along the Queensland part of the GoC has not changed significantly in terms of catch and numbers of licences have decreased; in 20 years time, therefore, on average we anticipate much less change in pressures upon the marine environment from these fisheries in this area – with possible exceptions in some localised areas (e.g. around Weipa).

Another change over the next 20 years could arise if there are increases in demand for and, possibly, some declines in the quality of the inshore recreational fishing experience. Recreational fishers may turn more offshore. As Section 4.4.4.2 also indicated, there are already increasing trends towards offshore fishing. Continuation of these current trends towards more reef or game fishing (which targets, amongst other things, Spanish mackerel) could contribute to a decline in shared stocks such as Spanish mackerel stocks if not carefully managed. Such declines could hinder both the economic future of recreational and fishing tour operations commercial fishers as well as impact negatively on the marine ecosystem through loss of a key top predator.

For management of the NMR, the potential for flow-on effects of pressures upon inshore fisheries resources to be realised in the NMR should be anticipated and addressed proactively. Specifically, current threats to species occurring within NMR that are likely to continue into the future include threats to Spanish mackerel and sharks, red emperor and coral trout.

## 4.7 Tourism

### 4.7.1 Tourism now

In 2008-09, 1.403 million people visited the Northern Territory. They stayed for 9.8 million nights and spent over \$1.7 billion (Tourism NT 2010a). It is estimated to contribute \$1.526 billion directly in Gross Value Added, or 10.3%, to the NT economy. Tourism provides 18,000 jobs for Territorians, or 16.3% of total employment in the NT, a much higher proportion than the national average (8.3%) (Tourism NT 2010a). The number of visitors have not fluctuated greatly since 2000 (Tourism NT 2010b) and a decline in tourism is expected to emerge from the 2009 and 2010 data due, in part, to the Global Financial Crisis; however the outlook is that numbers should increase again in 2011 (Tourism NT 2010b).

The main destinations for most interstate and international visitors are icons such as Uluru-Kata Tjuta National Park in Central Australia, Nitmiluk National Park near Katherine and Litchfield and Kakadu National Parks in the Top End. Two of the main reason tourists visit the Northern Territory are the natural environments and interest in Aboriginal cultures. (Department of Infrastructure, Planning and Environment 2005) Most bird watching, wildlife or wilderness tours, Aboriginal cultural tours, adventure tours occur on land and have little to no impact upon the NMR.

Tourism does occur, however, in the marine environment albeit as a smaller component of the sector. Aside from FTOs (discussed above in Section 4.6), yachting, indigenous tourism, other island-based tourism, cruise vessels and non-fishing charter boats occurs in the NMR or adjacent coastal waters. Tourism NT (2008) has identified over 100 indigenous products and experiences currently available in the NT some of which include using the coastal and marine environments. The Arnhem Land Barramundi Nature Lodge, while heavily focussing on fishing in rivers, creeks and estuaries, advertises that one can explore “beautiful coral islands” as part of the experience ([http://en.travelnt.com/search/product-service.aspx?product\\_id=9001209&service\\_id=9002235&category=TOUR](http://en.travelnt.com/search/product-service.aspx?product_id=9001209&service_id=9002235&category=TOUR)).

There are charter yachting businesses that operate in coastal waters along the top end. The Arafura Sailing Charter operation, for example, can take tours from Darwin Harbour to the Cobourg Peninsula and Tiwi Islands ([http://en.travelnt.com/search/product-detail.aspx?product\\_id=9001551&category=TOUR](http://en.travelnt.com/search/product-detail.aspx?product_id=9001551&category=TOUR)).

Darwin Dive Centre mainly offers “dives around Darwin Harbour” and, due to tides, can only operate for about 3 days per fortnight ([http://en.travelnt.com/search/product-service.aspx?product\\_id=9001186&service\\_id=9002121&category=TOUR](http://en.travelnt.com/search/product-service.aspx?product_id=9001186&service_id=9002121&category=TOUR)). Gove Sports Fishing and Diving Charters use Wigram Island as a base not just for fishing but also for snorkelling, diving, bird watching and walking. Wigram Island is just to the northwest of Nhulunbuy (south of the English Company’s Islands) <http://www.govefish.com.au/>

From the information available these kinds of tourism operations appear to occur almost entirely outside the NMR. They tend to be dominated by fishing tour operations that also offer other experiences.

Cruise shipping does occur within the NMR boundaries. The Darwin Ports Corporation (2010) has seen over 20 000 passengers and crew of 13 cruise ships dock in the last 3.5 months alone and a 33.5% increase in 2008-09 over the previous year.

In 2008, Tourism NT was discussing how tourism businesses in the NT reported a 77% increase in sales and a 57% increase in profitability over the five years to 2007 although the nature of the tourists has changed over that time from a majority of international to a majority of interstate visitors. The stronger Australian dollar had been influencing that change. Now, in their update, they are warning of negative growth in the tourism industry in the short term due to the Global Financial Crisis (Tourism NT 2010a).

#### 4.7.2 Tourism in 2030

The World Tourism Organisation had forecast that the global tourism market would grow to over 1.56 billion international travellers by 2020 (Tourism NT 2008). However, tourism is a vulnerable industry, both in terms of unexpected global shocks and in regard to its high reliance on consumers’ discretionary spending ability and competition for consumers’ *share of wallet* from other leisure activities (entertainment and shopping) or life commitments (mortgage, education expenses) (Tourism NT 2008). As an example, after the GFC, the United Nations World Tourism organisation (UNWTO) predicted international tourism activity to decline between -4% to -6%; data from early 2009 indicate an actual decline of 8% globally (Tourism NT 2010b).

Tourism NT (2008) has identified travellers seeking “culture” and “nature” as their target audience and is planning strategically to attract this market sector more successfully. So aside from a growth in the FTO sector, one can expect a slow increase in non-fishing based tourism over the next 20 years, especially coupled with the fishing experience as a “package deal”.

Globally cruise shipping continues to grow. This component of the tourism sector can be expected to grow within the NMR. There are also smaller tourist developments proposed elsewhere, including a large resort development at Dundee Beach, south-west of Darwin.

From the perspective of managing the NMR however, the projected tourism activities are unlikely to be of significance in terms of environmental impacts within its boundaries even in 2030.

## 4.8 Defence and surveillance activities

### 4.8.1 Current situation

On 2 May 2009, Prime Minister Rudd launched the Defence White Paper which outlines the Government's vision for Defence into the future (Department of Defence 2009, Australian Defence Business Review (ADBR) 2009). In broad strokes, some main directions outlined in the White Paper are that the Defence sector will, over the next 20 years, have to "watch its pennies" more so than previously with limited growth in budget and shortfalls to be found through offsets internally (Department of Defence 2009, ADBR 2010). The Defence White Paper identifies "Defence of Australia" as a priority with subsequent priorities of particular significance to the NMR. Amongst others these include contributing to stability and security in the South Pacific, Indonesia, PNG & East Timor; contributing to military contingencies in the Asia-Pacific region, including in relation to assisting our Southeast Asian partners to meet external challenges. Specifically, the future defensive posture envisaged by the Government in the White Paper embraces a fundamentally maritime strategy, that foresees operations of 'decisive effect' being undertaken throughout the northern maritime and littoral approaches to Australia, and the ADF's primary operational environment more generally (Department of Defence 2009, ADBR 2010). Supplementary tasks envisaged for the ADF include the provision of appropriate support to civil authorities in relation to domestic security and emergency response efforts, such as border protection & counter-terrorism (Department of Defence 2009, ADBR 2010).

Given this context, non-traditional security threats are increasingly coming to dominate the national domestic security environment (Yates 2007). The Lombok Treaty (signed between Australia and Indonesia in 2006), for example, lists non-traditional threats such as people smuggling, drug trafficking, illegal traffic in arms and illegal fishing as some of the crimes require cooperative law enforcement efforts (<http://www.dfat.gov.au/GEO/indonesia/ind-aus-sec06.html> downloaded 17/6/08). Commonwealth Budget Papers in 2006 placed pandemics and threats to energy security in the same category as terrorism under the classification - "adverse external shocks" (Yates 2007). The Australian Federal Police Commissioner, Mick Keelty, told an Adelaide conference, "if we are to believe some of the world's leading climate scientists, the mass displacement of people (from climate change effects), particularly in the Asia-Pacific region, could create a great deal of uncertainty and unrest in the region" (Yates 2007). This reflects thoughts on the impacts of climate change by global experts: UK Government's chief scientific advisor, Sir David King, recently described it as "a far greater threat to the world than international terrorism"(Yates 2007).

An interagency response to FFVs has, apparently, been successful (Canberra Bureau Report 2007). The dramatic downturn in observed FFVs activity within Australia's northern waters in recent times can be attributed to a number of factors, including the rising price of fuel through to a range of inter-Governmental agency efforts in FFV source countries to deter illegal fishermen, capped off by Australia's increasingly hardline border enforcement response (Canberra Bureau Report 2007). In one month during early 2006, border

surveillance, directed by the Canberra-based Border Protection Command, logged 365 sightings of larger, motorised illegal FFVs in the Gulf of Carpentaria alone. In 2007, in the same month, officials reported only 36 sightings, consisting of ten separate vessels, with six being apprehended. The Australian Customs Service (2007) particularly credit the record number of apprehensions in the previous twelve months as impacting considerably on the number of FFV incursions, and expect that the number of sightings of FFVs will continue to decline.

Recent and ongoing increases in border surveillance “assets” in the north include new “Armidale”-class Patrol Boats (which have had some teething problems), a new Australian Maritime Identification System, a new fleet of Coastwatch maritime patrol aircraft and deployment of some Royal Australian Navy patrol boats (Canberra Bureau Report 2007). Since mid-2006 Department of Foreign Affairs has also been working with the Indonesian Government to deter FFVs from entering Australian waters, with acknowledged success (Canberra Bureau Report 2007).

Foreign vessels have in the past also been used to transport illegal immigrants to Australia. In recent years more generally, the zero-tolerance approach to so-called “queue jumpers” and the “Pacific Solution”, while contentious and costly, has led to a massive drop off in attempted illegal landings of foreign vessels (Canberra Bureau Report 2007).

#### 4.8.2 Defence and surveillance in 2030

The efforts described above (Section 4.8.1) indicate that the Australian Government is both willing and able to (a) maintain and build on an effective defence presence in our north and (b) effectively deter border intrusions and apply defence force resources to do so. The Border Protection Command has warned that “people smuggling” would be relaunched at any sign of a lack of resolve in the Australian border protection efforts (Canberra Bureau Report 2007). It has also been acknowledged that as the pressures of the depletion of Indonesian fish stocks, combined with climate change and/or population growth see demand (relative to supply) for fresh fish increasing. This could well lead to a sudden resurgence in illegal fishing in the NMR (Canberra Bureau Report 2007).

The priorities laid out in the Government’s Defence White Paper, discussed in Section 4.8.1, confirm an actual funding commitment through to 2030 to maintaining and increasing defence resources including those that are or will be based in Australia’s north including seagoing vessels which will use the NMR. Of the commitment the White Paper has identified over 40 new seagoing vessels to be added to the Navy (from submarines, to warships and multi-purpose ships). And Darwin (with Townsville) has been identified as a critical port for operations in the defence of Australia thus will likely see some of these new resources deployed there. Australian Government commitments to enhance facilities at this port (e.g. wharf and fuelling facilities) support this premise. (Department of Defence 2009)

The multi-faceted threats and benefits of maintaining secure border patrols, and the Federal Government priorities for defence more generally are likely to lead to an overall increasing in defence activities and resources including border patrol activity in the NMR over the next 20 years. These defence activities will likely continue to be based out of Darwin but will be deployed to areas of concern as well as for routine patrols.

While, from an NMR planning perspective, the negative environmental impacts of this increase in activity are likely to be extremely minor, the positive impacts, in terms of limiting impacts on marine resources in the NMR of FFVs, are likely to be significant.

## 4.9 Urban development

### 4.9.1 Current situation

Darwin is currently the only urban centre adjacent to the NMR with a population of just over 100,000 (Section 3.1.1). The city has been expanding with the satellite city of Palmerston also growing quickly. Commercial space in the CBD has doubled in the past four years. With the Darwin Waterfront and Convention Centre and Chinatown development projects, this trend looks certain to continue ([www.theterritory.com.au](http://www.theterritory.com.au) downloaded 31/5/10). It should be noted, however, that DNRETA (2005) estimated that only 1.2% of the Darwin harbour catchment was classified as urban residential and an additional 5.7% as rural residential. The majority of the catchment was classified as remnant native vegetation cover (51.5%), surface water supply (7.3%) or other conserved areas (6%).

One main impact of urbanisation can be localised land clearing for houses, roads and ancillary infrastructure although compared to the land clearing and/or degradation that has occurred for other purposes (e.g. agriculture, grazing, mining) the physical expanse of the impact is relatively small. In fact, the Northern Territory's NRM Management Plan (Department of Infrastructure, Planning and Environment 2005) does not identify urbanisation as an issue.

Discharge of raw sewage can be a major inshore impact of urbanisation. In 1999, NRETA began a series of projects to improve the quality and capacity of sewage treatment and disposal in Darwin. This allowed for population growth and diversion of flows from the CBD and Larrakeyah which were discharging through the Larrakeyah outfall without treatment. Ludmilla plant was to be augmented by addition of an extended aeration tank and sand filters to further treat sewage and allow effluent reuse during dry weather. The previous plant capacity was approximately 27,000 equivalent persons (EP) and load is about 24,000 EP. The first stage plant added approximately 12,000 EP capacity, with a second stage of 38,000 EP expected within 10 years depending on requirements. In addition, measures were implemented to encourage effluent reuse and improve sludge treatment and disposal. In the past, sludge had been incinerated and/or buried on the Ludmilla site. Whilst it is intended to continue to incinerate sludge, the upgrade plant will produce better quality sludge that may be suitable for reuse in agriculture, mine site rehabilitation, or for municipal landscaping. (<http://www.nt.gov.au/nreta/environment/assessment/register/ludmillawaste/> Downloaded 31/5/10)

Cullen Bay Marina is the main marina adjacent to the NMR. Others exist and at least one is planning to grow (e.g. Bayview Marina, Tipperary Waters Marina <http://www.bayviewmarina.com.au/marina.html#navigation> downloaded 31/5/10). All are located within the natural harbour of Darwin, however, so the likelihood of their activities impacting upon the Commonwealth waters is low.

Smaller towns around the NMR have been growing too, often associated with increased mining activity. A new subdivision development is currently underway in Weipa and there is talk about a possible development of a marina in Weipa (R. Greiner, personal communications June 2008).

#### 4.9.1.1 Telecommunications

As Darwin (and the population adjacent to the NMR more generally) grows so too will requirements for enhanced telecommunications. Taking the NT as an example, already in 2006, 69% of non-indigenous households and 23% of indigenous households had internet

or 60% of households overall (ABS 2008c). In 2001, only 14% of people in the NT had used the internet at home. Businesses also rely more on the internet. Tourism NT (2008), for example, has identified facilitating greater access to NT's tourism opportunities needs to occur, amongst other things, via the internet. We have not found that these changes, to date, have been identified as having environmental impacts upon the marine environment (e.g. Department of Infrastructure, Planning and Environment 2005)

#### 4.9.1.2 *Monitoring environmental consequences of urbanisation*

Charles Darwin University undertakes various research projects that monitor the status of Darwin Harbour's environment, for example, the impacts of stormwater on mangroves in Darwin Harbour (<http://www.cdu.edu.au/ehs/science/mangrove/research.html> Downloaded 31/5/10) or coral biomonitoring (<http://www.cdu.edu.au/ehs/efmp/chemistry/coral.html> Downloaded 31/5/10). Such work can provide information indicating the effects of urbanisation upon the adjacent estuarine and marine environments. To date, the water quality in Darwin Harbour has been subject to the impacts of urban development and industrial growth but remains good overall with some localised water quality issues (e.g. some excess nutrients in Buffalo Creek and metals around Iron Ore Wharf) (DNRETA 2005, Townsend 2007 in <http://ext.cdu.edu.au/newsroom/a/2007/Pages/2384.aspx> downloaded 31/5/10).

#### 4.9.2 Urbanisation in 2030

From the data supplied by the ABS (Section 3.1.1), one might expect Darwin to have a population of about a quarter of a million people by 2051. Other estimate put the population at around that level by 2021 ([www.theterritory.com.au](http://www.theterritory.com.au) downloaded 21/6/08). Road and other infrastructure, including telecommunications, will be built to support the population growth. At the moment there are concerns that sewage is only subject to secondary (not tertiary) treatment and some of the treatment plants have insufficient capacity to handle stormwater as well as other waste during the wet season (NRETA 2005). Marina development in the area can be expected to increase with commensurate increase in potential threats to the marine environment. However, implementation of the planned Water Quality Action Plan (<http://www.nt.gov.au/nreta/water/quality/index.html> downloaded 31/5/10), the Darwin Harbour Regional Management Plan and ongoing monitoring of Darwin Harbour should assist in both mitigating and monitoring impacts of urbanisation upon the estuarine environment (NRETA 2005, <http://ext.cdu.edu.au/newsroom/a/2007/Pages/2384.aspx> downloaded 31/5/10).

NRETA (2005) estimates that 69% of the volume of Darwin Harbour flows in and out with spring tides. Even though Darwin's harbour is quite deep (NRETA 2005) and well contained from oceanic influences (albeit not tidal influences) one might not expect, by 2030, that the impacts of urbanisation will have extended significantly beyond the harbour. Water quality impacts would most likely be transported in tidal flows possibly to adjacent coastal waters. Any clearing of or damage to mangroves may also have implications beyond the harbour boundaries for any local fish stocks who inhabit waters in the NMR but rely on the mangroves as nurseries.

By 2030, the level of urbanisation that we expect in other regional centres adjacent to the NMR will be minor compared with other areas both within Australia and within northern Australia and its consequent impacts will also be minor compared with the impact of other activities that will occur at or around those regional centres (e.g. mining, port and pastoral activities).

## 4.10 Emerging industries

### 4.10.1 Aquaculture

#### 4.10.1.1 Status

Aquaculture in Queensland does not presently occur to any significant degree adjacent to the Gulf of Carpentaria (Lobegeiger and Wingfield 2008). In Queensland, there are some nascent efforts in or near Karumba, Kowanyama, Injinoo, Weipa and in the Mitchell River delta (Greiner *et al* 2006, DPI&F News Release 11/1/2008) but most forward planning efforts are not focussed on this area<sup>[LF28]</sup>.

In the NT, in 2008, there was aquaculture production of barramundi and pearls (DoR 2009a). In 2008, mud crab aquaculture (three farms) ceased and in 2007 the one prawn aquaculture operation ceased (DoR 2009a). Four of six barramundi operations produced marketable fish in 2008; in fact, production increased by 41% in 2008 to 544 tonnes of whole fish. These were all pond-based operations on land (DoR 2009a). The level of pearl production is expected to remain relatively constant in the next few years and is based in three sites in the NT. The value of production is expected to fall due to reduced prices as a consequence of the global economic crisis (DoR 2009a). Aquaculture operations tend to be struggling with technical issues, for example, to do with viral diseases, bacteria and feed.

Pond-based farms are required to have discharge licences and all farms are subject to environmental and aquaculture licence compliance audits. All new farms are required to have an Environmental Management Plan (EMP) and old farms are being encouraged to develop an EMP as well. (DPIF&M 2006a)

#### 4.10.1.2 Aquaculture in 2030

Further development of the NT barramundi industry is expected and supported by the government and will require assessment of new inland and offshore farm sites (DoR 2009a). Areas in Darwin and Tiwi Islands region are the most likely for expansion in the short-medium term. It is predicted that the value of the NT pearling industry will eventually increase, partly due to refined production practices, industry rationalisation and increased marketing opportunities (DPIF&M 2006a). However, the main reason will be increased production.

While global demand for food continues to rise and is commensurate with increasing global scarcity of wild-harvested seafood the opportunities for aquaculture over the next 20 years can be expected to increase. Trade policy also plays a role: Australia has banned the importation of raw prawns for biosecurity reasons, thus reducing prawn supply and causing retail prices to increase (<http://www.abc.net.au/pm/content/2007/s1987229.htm>). However technical issues related to feeding, optimal water exchange, management of pathogens and sourcing of spat, fingerling or broodstock are not minor and will require years of trials to resolve. Twenty years of research at the Australian Institute of Marine Science, for example, has not resolved all the challenges within the tropical prawn aquaculture industry (<http://www.aims.gov.au/docs/research/sustainable-use/tropical-aquaculture/prawns.html>).

The pearl oyster and barramundi aquaculture industries are best developed in the areas adjacent to and outside of the NMR. These may be expected to continue a moderate level of expansion over the next 20 years, albeit with fluctuations in growth within that period. Other aquaculture efforts, if pursued, are expected to be minimal in terms of size and also located outside the NMR.

The implications of this activity for the NMR by 2030 can be expected to be extremely limited if the locations of operations remain coastal and controls on environmental discharge (including accidental releases) are adequate and complied with.

#### 4.10.2 Research

##### *4.10.2.1 Current status*

Research activities within the NMR over the last 20 years have expanded have been supported by enhanced capabilities in the region. and some examples of this expansion are provided here. For example, here has been the establishment of Charles Darwin University (CDU) in 2003 (an amalgamation of the Northern Territory University and other education providers, <http://www.cdu.edu.au>) The Tropical Rivers and Coastal Knowledge hub was established in 2007 ([www.track.gov.au](http://www.track.gov.au)) although the physical operations of this research (in terms of marine planning for these users in the NMR) are mainly working in catchments and estuaries with only a little work in the marine environment. This “land-based” research is relevant as it pertains to informing managers of the nature and extent of any downstream impacts of catchment development that may be realised within the NMR. Marine work at CDU that does require interaction with organisms in the NMR environment includes work on sawfish, saltwater crocodiles and sharks. The Australian Institute of Marine Science (AIMS) has placed a small branch in Darwin located within the Arafura Timor Research Facility (ATRF). The ATRF facility is the product of collaboration between AIMS and the Australian National University in recognition of the rich marine biodiversity of the Timor and Arafura Sea and aims, in part, to redress the lack of knowledge about this biodiversity. The Department of Natural Resources, Environment and the Arts (NRETA) has a marine biodiversity group that also conducts research that includes habitat mapping and work on threatened and iconic species in the NMR.

##### *4.10.2.2 Bioprospecting*

AIMS has a program of biodiscovery that includes surveying the environment of the NMR ([www.aims.gov.au](http://www.aims.gov.au), NOO 2004). Biodiscovery activities, by their nature, expand knowledge regarding species diversity and require the take of a certain amount of “sampling”, i.e. removal of a certain number of specimens. We cannot discover any evidence that this activity has led to localised depletion of any populations of species.

##### *4.10.2.3 Research (including bioprospecting) in 2030*

Optimistically, the enhanced research focus on Australia’s northern marine region will provide important understanding and data to underpin marine resource planning and management. It will also lead to enhanced interactions, on the part of researchers, with the marine environment and marine communities including for the purposes of biodiscovery or bioprospecting. AIMS’ strategic direction document, for example, specifically lists the Gulf of Carpentaria and the Timor and Arafura Seas as areas of research focus under “Direction 1: Understanding tropical marine ecosystems and processes” (AIMS 2007).

It is not anticipated that the enhanced level of research expected in the NMR will have a negative implications for the Commonwealth marine environment.

## 4.11 Other sources of impact

### 4.11.1 Climate change

Climate changes predictions have been discussed in section 3.3.5 as climate change is both a potential driver of future developments as well as a potential threat to the marine environment directly. The broad implications of climate change for the NMR environment are discussed here.

The vulnerability of tropical marine habitats and species, such as those found in the NMR, to the impact of climate change was assessed in detail for the Great Barrier Reef ecosystem (Johnson and Marshall 2007). The predictions for climate change in the north of Australia are not dissimilar to those made for the Great Barrier Reef region although the latter were applied to a 100 year timeframe. We have used Johnson & Marshall's report (2007) to consider potential impacts of climate change upon the NMR. Unless otherwise stated, this section uses information provided by the 86 experts who contributed to that report.

Due to the relative stability of tropical marine environments, tropical marine organisms have evolved narrow environmental tolerances. Unlike the GBR ecosystem, which has an extensive latitudinal range, habitats and species in the NMR are constrained in their southern distribution by the Australian coastline.

Johnson and Marshall (2007) predict that there will be varying degrees of impacts of climate change upon microbial communities (responsible for nutrient cycling, some symbiotic relationships, disease levels for example), some calcifying plankton, macroalgae, seagrass, mangroves, corals, other benthic invertebrates, fishes, sharks and rays, seabirds, marine reptiles and mammals, coral reef habitats, pelagic environments, coastal habitats, islands and cays. These are discussed in more detail in Section 6. Johnson and Marshall (2007) warn of interactions between not only these impacts but the compound effect of climate change impacts and other sources of stress (e.g. water quality, overfishing, cyclones) upon the marine environment.

All these changes are predicted to lead to community level changes, that is, changes to the relative distribution and abundance of marine organisms. The consequent impacts on marine ecosystem functions (productivity, reproduction, nutrient cycling, mortality etc) have not been able to be predicted.

Likely disturbances to be caused by climate change include:

- Chemical—to do with changes in acidity; changes in precipitation may also cause changes in salinity
- Temperature
- Mechanical change (e.g. to coastlines)
- Other: increases to intensity but not frequency of cyclones, sea level rise, changes to ocean circulation.

### 4.11.2 Foreign fishing vessels (FFVs) and illegal, unreported and unregulated (IUU) catch

Not all illegal, unreported and unregulated fishing is conducted by FFVs. Domestic IUU have been discussed in Section 4.4. This section focussed on FFVs that are conducting IUU fishing activities within Australia's NMR.

#### 4.11.2.1 Current situation

The number of FFVs entering Australia's waters reached a peak in 2005, when there were an estimated 8,000-13,000 FFV sightings in Australian waters with more than 600 boats captured in northern waters (GBRMPA 2008). Australian Customs Service (2007) assessed the numbers of FFVs apprehended for 2006-07 as 400 and the number of illegal foreign fishers apprehended as 2,990. The revised figures reflect a significant reduction in the number of FFV incursions. The Australian Customs Service (2007) cite the record number of apprehensions in the previous twelve months as impacting considerably on the number of FFV incursions, and expect that the number of sightings of FFVs will continue to decline. In 2008-09, there were still (of 351 foreign vessel boardings) 216 illegal foreign fishers apprehended and processed (Australian Customs and Border Protection Service 2009). The lower level of apprehensions was attributed to the effective deterrence effect of our air and sea presence in northern waters, foreign fishing vessels have retreated from, but remain just outside of, Australian waters (Australian Customs and Border Protection Service 2009). However this same report records a 289% increase in foreign vessel sightings in Australian waters in 2008-09 compared to the previous year, after two previous years of declines in sighting.

FFV pose significant environmental and biosecurity risks to Australia's marine resources through the presence of marine pests on the vessel hulls, the discarding of marine debris and, especially, through illegal fishing. Many of the FFV intercepted in the past were found with large catches of reef fish, sea cucumber, trochus shell and shark fin (GBRMPA 2008).

FFV have been found with both Asian green mussels and striped zebra mussels on their hulls—both constitute major risks to our natural reef communities. Asian green mussels are the number one marine pest threat for Australia as they can grow rapidly on virtually any substrate and at most depths, out competing and replacing the naturally occurring species (GBRMPA 2008).

According to Queensland's DPI&F (2007a), increases in IUU fishing vessel incursions into GOC waters pose a serious threat to the sustainability of northern Australian fisheries, including mackerel, shark and other pelagic fish, although demersal finfish are also taken. Concerns are also held for protected species and other species of conservation interest (DPI&F 2007a).

The lack of accurate information on IUU harvest levels may affect the accuracy of resource assessments and in turn may influence the effectiveness of sustainable management practices in the region. DPI&F are awaiting results of assessment by the AFMA on levels of IUU effort and catch (DPI&F 2007a). While this assessment does not appear to be available AFMA does state that FFV incursions into Northern Australia are largely made by fishers from Indonesia and Papua New Guinea, targeting shark, reef fish, tropical rock lobster or trepang (sea cucumber) (<http://www.afma.gov.au/management/compliance/illegal/default.htm>; downloaded 31/5/10)

Projects were underway to quantify the level of IUU fishing for red snappers by foreign vessels in the GOC as this issue is of particular concern to DPI&F (2007b). Investigation of the effect of IUU fishing on red snapper and shark stocks was also been identified as a priority by Northern Australian Fisheries Management forum and the Northern Stock Assessment Group (DPI&F 2006). QPIF (2009) and DoR (2009) however, make no reference to any progress in these priorities.

While it is accepted that most IUU fishers are primarily targeting sharks, apprehended vessels holding significant quantities of red snapper was becoming more prevalent. One should also note that these FFVs, for example in the case of the red snapper, are imposing upon a fishery that, legally, supports approximately 20 active licenses. So an incursion of, say, "only" 40 FFVs could be extremely significant in terms of the future of this fishery; it

could, potentially, increase the effort by 200%. Similar comparisons of number of legal fishers and numbers of illegal FFVs can be drawn with the shark fishery.

#### 4.11.2.2 FFVs and IUU in 2030

We have explored drivers such as increasing populations, economic growth, increasing demands for food and income, and scarcity of fish stocks outside Australian waters in Sections 3.1, 3.3.2, 3.3.3 and 3.3.5. As discussed in the previous section, the last many years has seen variable but mainly increasing pressures from FFV and IUU. Only significant and sustained border patrol efforts have mitigated against illegal fishing activities (Section 4.8.1).

Given these drivers and trends to date, the incentives for illegal FFV and IUU fishing activity will certainly increase over the next 20 years. The Australian Customs Service regards comprehensive surveillance and apprehension of FFVs as an effective deterrent (Section 4.8.1) and the Australian Government has also identified illegal fishing as a priority for the Navy (Department of Defence, 2009). In the next 20 years, we expect that only significant state and federal Australian government efforts in surveillance will mitigate against the potential expansion and associated negative impacts of FFVs and foreign and domestic IUU within the NMR.

#### 4.11.3 Marine pollution

##### 4.11.3.1 Current situation

Marine pollution can be considered to comprise two main components: impacts upon water quality and solid marine debris. Potential future impacts upon water quality will largely be driven by activities adjacent to the NMR and will mainly have influence within the coastal environments over the next 20 years as already discussed above within relevant sections.

Solid marine debris has two sources: domestic and foreign and both are of concern in the NMR although foreign-sourced debris seems to be the major problem (DPIF&M 2006; Kiessling 2003b). The volume of marine debris in the NMR seems to be greater than in any other part of Australia's waters and oceanographic patterns mean that the debris tends to be concentrated on the water before being deposited on shore (Kiessling 2003). Kiessling (2003b) identified eight main areas adjacent to the NMR region where highest densities of marine debris have been recorded. Coastal surveys of the coast of the Gulf of Carpentaria and across the Top End indicate that a very high number of fishing nets are washing ashore (Roelofs *et al* 2005, Kiessling 2003b). While fishing nets comprise only a small proportion of debris items overall, they are the most significant item by weight and potential impact. Turtles, whales, dugong, and sawfish have been recorded entangled in fishing debris especially foreign fishing nets and it is understood that the level of mortality is significant in northern Australia (Kiessling 2003b).

The NAILSMA (2005) discusses efforts to try and address some marine debris issues where especially foreign fishing gear is impacting upon marine turtle and dugong. For example, the Lianthawirriyarr Sea Ranger Unit works to address marine debris. The Australian Government has also allocated \$2 million from the Natural Heritage Trust to fund the *Carpentaria Ghost Net Programme - Saltwater People Working Together* (NAILSMA 2005). In 2009, the Australian Government released a Threat Abatement Plan for Marine Debris (DEWHA 2009b). It is unclear what resources will be mobilised to enable implementation of the plan.

#### *4.11.3.2 Marine debris in 2030*

As discussed above, (Section 4.11.2.2) with only increasing global and regional demand for food, including seafood, and increasingly scarce fish stocks within more densely populated countries' waters, foreign fishers will be moving towards fishing in more lucrative grounds. Where these grounds include water either adjacent to or within Australia's EEZ, the foreign fishing activities will be generating more marine debris including ghost nets. The international cooperation required for foreign fishers to help address marine debris is significant and unlikely to be resolved before the impacts of the marine debris are significantly enhanced. Action to target removal of marine debris is the main mechanism, over the next 20 years, whereby its impacts upon the marine vertebrates of the NMR can be mitigated.

#### 4.11.4 Regional Impacts

The "region" referred to in this context is taken to be the northern countries located outside of but adjacent to Northern Australia. Changing policy regimes and developments in nearby areas such as Papua New Guinea and Irayan Jaya could have significant implications for the NMR over the next 20 years. Significant agricultural, aquaculture and mining development is occurring in large catchments in the region to Australia's north. It is unlikely there will be adequate, timely management of resultant runoff and pollution. It is possible this will impact on some parts of the NMR given its proximity and connectivity especially in the Gulf of Carpentaria with its shallow waters and circular mixing of water. The relatively 'closed' system of the Gulf of Carpentaria could see amplified effects of any major polluting event concentrated; and this would be in addition to any domestic pollution.

## 5 Aggregate impacts and development hot spots

### 5.1 Summary of disturbances

This section explores what kinds of disturbances to the NMR are likely from which activities in 20 years time. NOO (2002) defined a set of disturbance categories by which to group threats. These are presented and defined in Table 4 and applied in the assessment below.

We have added excess sedimentation (due to adjacent land erosion) to the set of “chemical” changes. Although sedimentation from catchments is natural, an increase in levels of sediment in water from erosion can often be connected to negative changes in turbidity and nutrient levels, for example.

**Table 4. Disturbance categories used to define impacts per activity**

Source: NOO (2002)

Disturbance Category	Description
Chemical change	Changing the concentration or properties of compounds naturally occurring in the ocean, such as changes to salinity, sedimentation, nutrients, and dissolved oxygen.
Contaminants	Introducing substances that are not normally found in the marine environment, such as heavy metals, PCBs and litter.
Temperature change	Changing the marine environment's natural temperature range.
Mechanical change	Removing or changing structural (biological and physical) components of the ecosystem.
Nuclear radiation	Introducing radioactive isotopes into the marine environment.
Electromagnetic radiation	Introducing radiation that consists of electromagnetic waves.
Noise	Increasing the level or amount of sound in the marine environment beyond its natural range (this includes boat motors).
Biological interaction	Removing or damaging organisms.
Introduced pathogens	Introducing disease-producing organisms to the marine environment, either from terrestrial or marine sources.
Introduced marine species	Introducing species that do not occur outside of the naturally or historically.
Turbidity/light	Changing the extent to which light penetrates the water column.
Artificial light environment.	Introducing a source of light that would not naturally occur in the marine

Table 5 summarises likely disturbances by 2030. This includes known minor and major disturbances. Whether an activity is known to cause any particular type of disturbance is labelled, after NOO (2002) as:

- **Known or very likely (+)**  
It is known or very likely that this activity will cause this type of disturbance within the boundaries of the Northern Marine Region by 2030
- **Possible (~)**  
It is possible that this activity will cause this disturbance by 2030 within the boundaries of the NMR, but there is no certainty of this

- Unknown (?)  
It is unknown if the activity will cause this type of disturbance within the boundaries of the Region by 2030.
- Known not to occur (blank)  
It is known or very likely that this activity will not cause this type of disturbance in the Northern Marine Region in 2030.

**Table 5 Anticipated disturbance of environment within the NMR by activity in 2030**

Note: Tourism impacts within NMR in 2030 largely derived from cruise shipping component of tourism sector; Climate change includes consideration of increased intensity of cyclones and increases in wind speeds

Activity	Chemical	Contaminants	Temperature	Mechanical	Nuclear radiation	Electro-magnetic	Noise	Biological interaction	Introduced pathogens	Introduced species	Turbidity	Artificial light
Agriculture	?	?									?	
Offshore oil and gas		+		+			+	?	?			+
Mining & Processing		?										
Ports		?						?	?	?	?	
Shipping	?	+		+			+	?	+	+		
Northern Prawn Fishery		+		+			+	+				
Inshore net fishery		?						+				
Offshore net fishery		+					+	+				
Spanish mackerel fishery		+					+	+				
Finfish trawl fishery		+		+			+	+				
Demersal fishery		+					+	+				
Coastal line fishery		?					?	~				
Mud crab fishery		?										
Trepang fishery												
Bait fisheries								+				
Aquarium fish fishery								~				
Indigenous fishing							~	~				
Recreational fishing		?					+	+				
Fishing tour operators		?					+	+				
Tourism		+					+		~	+		
Defence & surveillance		+					+					
Urban development	~	~									~	
Aquaculture	?	?		?				?	?	?	?	
Research							+	+				
Climate change	+		+	+							+	
FFVs & IUU		+					+	+	+	+		
Marine pollution		+						+	+	+		

When considering some of the impacts, it is clear that an activity may have the identified impact but it is expected to materialise closer to the coast and outside the NMR boundary. Whether the impact will have sufficient geographic extent to be realised within, or have indirect effects upon the NMR by 2030 is often unknown. In some cases, therefore, a lack of knowledge as to the extent with which waters adjacent to the NMR bring impacts into the NMR is reflected in some of the question marks in Table 5. For this reason, Table 6 provides the same assessment for the marine, coastal and estuarine waters adjacent to the NMR including creeks and rivers. For some activities it is much more certain that an impact will occur in these environments.

**Table 6 Anticipated disturbance of environment in coastal waters adjacent to the [H30]NMR by activity in 2030[LF31]**

Activity	Chemical	Contaminants	Temperature	Mechanical	Nuclear radiation	Electro-magnetic	Noise	Biological interaction	Introduced pathogens	Introduced species	Turbidity	Artificial light
Agriculture	+	+									+	
Offshore oil and gas												
Mining & Processing	+	+		+							+	
Ports		+		+			+	+	+	+	+	+
Shipping	+	+		+			+	?	+	+		
Northern Prawn Fishery		+		+			+	+				
Inshore net fishery		+					+	+				
Offshore net fishery												
Spanish mackerel fishery		+					+	+				
Finfish trawl fishery		~		~			~	~				
Demersal fishery												
Coastal line fishery		+					+	+				
Mud crab fishery		+					+	+				
Trepang fishery		+					+	+				
Bait fisheries		+					+	+				
Aquarium fish fishery		+					+	+				
Indigenous fishing		+					+	+				
Recreational fishing		+					+	+				
Fishing tour operators		+					+	+				
Tourism		+					+					
Defence & surveillance		+					+					
Urban development	+	+		+			+					+
Aquaculture	+	+		+					+	+		
Research							+	+				
Climate change	+		+	+							+	
FFVs & IUU		+					+	+				
Marine pollution		+						+	+	+		

## 5.2 Development hotspots in 2030

Development hot spots will be discussed along two dimensions: those adjacent to and those within the boundaries of the NMR. This discussion draws upon the information collated, analysed and presented in the previous sections.

### 5.2.1 Development hotspots adjacent to the NMR

Adjacent to the NMR the major hot spot for development will be around Darwin, as a population centre, as the major urban development, as a port, as a location of processing plants and refineries, as a catchment with agricultural development, as a base for marine tourism and for research. Because the harbour is deep and large (twice the size of Sydney harbour), much of the environmental consequence of being a development hotspot is likely to be contained within the harbour or may be transported, by tidal flow, to adjacent coastal habitats. For these reasons, even by 2030, we do not expect the impacts of these developments in and around Darwin to have transported to within the boundaries of the NMR.

Other areas adjacent to the NMR that will be important, from a development perspective, in 2030 are likely to include Nhulunbuy on the Gove Peninsula and Weipa—these being connected to expansions in mining related activities (see Section 4.3). Areas to the north of Mt Isa may become subject to larger degrees of mining activity by 2030, particularly for iron ore and phosphate. This area is part of the Leichhardt and Flinders River catchments which have significant and highly seasonal rainfall and drain into the Gulf of Carpentaria.

### 5.2.2 Development hotspots within the NMR

Within the NMR by 2030 we expect that development is likely to be focussed on maximising value of the fisheries, increases in shipping traffic along existing routes, and development of some new offshore oil and gas fields.

Based upon the information presented in Sections 3.4, 4.11.1 and 4.11.3, we also expect that marine debris and climate change will be significant impacts upon the marine environment of and adjacent to the NMR.

## 5.3 Geography of impacts within the NMR in 2030

The geography of the developments, that is, their physical locations, are pertinent to how they may impact upon the marine ecosystem of the NMR. Therefore, the geography of developments is also pertinent to any management planning conceived to address the impacts.

Poiner *et al* (1998) found that at least 5-25% of seabed life is removed with each pass of a trawl and 7 passes of a trawl remove 50%, ~13 passes remove 70-90%. By 2030, fisheries impacts upon the benthic environment will concentrate where the Northern Prawn Fishery is most active and where the NT Finfish Trawl Fishery and Queensland Developmental Finfish Trawl Fishery operate. Figure 7 shows the current distribution of NPF fishing effort; future effort can be expected to overlap at least to some degree with these locations. Of course, by 2030, if trawling has been heavy in any particular area, there may be little seabed life left to remove.

While Figure 8 and Figure 9 show the potential extent of impact of two, very small fisheries, their trawling effort is usually concentrated within particular areas. For example, in 2008 the Queensland Developmental Finfish Trawl Fishery (which had 3 active permits in 2008) expended 80% of its effort in the southern part of the fishing area (QPIF 2009). In 2006, however, catch and effort were effectively spread throughout the fishery area with good catches of key target species recorded from the south-western corner of the fishery (DPIF 2007). NT Finfish Trawl Fishery, with one operator in 2008, focussed effort in offshore waters east of Darwin, including the northern region of the Gulf of Carpentaria (DoR 2009).

Best estimates of the geography of the trawl impacts in 2030 would be informed by historical analysis of effort hot spots over time and movements within those. Managers will also need to remain vigilant of the stock of red snappers (*Lutjanus erythropterus*—crimson snapper and *L. malabaricus*—saddletail snapper) as some of these stocks are shared between two fisheries: the NT Demersal and Timor Reef Fisheries and legal Indonesia fishers. Their stock status is reported formally as “uncertain” (QPIF 2009). If the stock collapses that would have two impacts upon the NMR: removal of a key ecosystem species and changes to the fishing behaviour and impacts of fishers relying on these stocks.

Fisheries impacts upon species that are part of the pelagic environment of the NMR will be generated in those locations where the fishers take the largest amount of catch (whether the Spanish Mackerel Fishery, recreational fishery or shark fishery) but the effect of those impacts will be spread throughout the range of those populations within the NMR. These effects will be exacerbated by any IUU FFV activity.

Shark of various species occur throughout the offshore waters within the NMR right through to the near- and in-shore water to in creeks and rivers (Larson *et al* in Kiessling 2003a). Spanish (and other) Mackerel are a diverse pelagic/epipelagic group that are generally confined to marine waters and have fairly restricted coastal ranges (Stapely *et al* in Kiessling 2003a). Thus, the locations where impacts upon the stocks would be felt in the NMR in 2030 would match these natural habitats of the fish.

Commercial netting is known to impact dugong (Saalfeld and Marsh in Kiessling 2003a) and consequently the location of commercial netting will be the location of most impact upon dugong from netting. About 36-48% of Queensland's Inshore Net Fishery Barramundi catch has been harvested from three 30 nautical mile (nm) grids along the Mitchell, Norman and Flinders Rivers. The rest of the fishery operates reasonably spread along the coast. Net fishing for grey mackerel in Queensland was historically occurred from Karumba to the tip of Cape York. Most of the commercial Barramundi net fishing in the NT currently takes place in inshore waters of Van Diemen Gulf and Anson, Arnhem and Buckingham Bays. Net fishing for shark and mackerel in the NT occurs within 12 nautical miles (nm) of the coast and immediately offshore in the Gulf of Carpentaria.

Direct effects of indigenous take of dugong or turtle will be most concentrated adjacent to small communities in inshore waters adjacent to the NMR.

Movements of dugong appear to be individualistic (Saalfeld and Marsh in Kiessling 2003a). Most animals restrict their movements to tens of kilometres within the vicinity of seagrass beds. But a number of animals have been observed to travel large distances – up to 600 km in a few days (Saalfeld and Marsh in Kiessling 2003a). While most of the direct impact of the net fishery upon dugong would be located outside the NMR, any loss will impact biodiversity in the NMR because the species uses part of the NMR ecosystem. By 2030, the fishery impacts might be very small if either the populations of those threatened species are extremely reduced or the fishery no longer operates.

As turtles move sometimes quite large distances, ecosystem impacts of turtle take or bycatch in 2030 will be located within their habitats in the NMR ecosystem-wide though the direct impacts (e.g. turtle mortality) occur more locally. Habitats that they use include rocky and coral reefs, seagrass pastures, estuaries, intertidal water and the extensive,

deeper soft-bottomed habitats, for example, those used by the NPF (Limpus and Chatto in Kiessling 2003a).

Where increases in shipping activity and expansion of the volume of traffic within shipping routes coincides with shallow waters (less than 5 meters deeper than the draw of ships), one might expect enhanced mechanical interactions of ships with the benthos by 2030. Water movement by hulls and propellers may shift, possibly gouge, the seabed to a greater extent than presently experienced. Using shipping and bathymetry maps from NOO and others (NOO 2005a, NOO 2005b, Rothlisberg *et al* 2005), the coincidence of shallow water (<20m) and shipping is more apparent near ports (e.g. Darwin, Weipa, Nhulunbuy, Karumba, Milner Bay on Groote Eylandt) and along the northern part of the NT coast from Groote Eylandt through to around Croker Island, inshore of Melville Island and along the coast also south of Darwin; this pattern of use (and therefore impact) will only be exacerbated by 2030.

Most offshore oil and gas fields (both active and undeveloped) are located within the North West Marine Region. But some are located within the NMR at its western-most extent: there are some undeveloped but discovered oil fields in waters less than 100km to the north of the WA-NT border; one or two undeveloped gas field further north along the NMR and NWMR border and a couple of undeveloped gas fields in the north western part of the NMR. By 2030, we expect development of at least some of these fields with commensurate, largely localised environmental impacts. Off-shore gas and oil is prone to accidents, which can result in major oil spills. Such incidents occurred in Australia in 2009 and in the Gulf of Mexico in 2010. With increasing off-shore activity, the likelihood of accidents increases.

Marine debris is a problem with particular relevance to the Gulf of Carpentaria, in part due to the flow of currents around the Gulf that seems to capture and concentrate marine debris Fog Bay near Darwin, the north-west coastline of Bathurst Island and the northern coast of Arnhem Land between Maningrida and Milingimbi including the Crocodile Islands have also recorded large volumes of marine debris (Kiessling 2003b). The debris has been particularly noted along the sandy shorelines. However, this may not be the location of most of the environmental impacts. Kiessling (2003b) noted that many items will never float ashore. Many, particularly nets, become entangled underwater on rocky outcrops and reefs and can continue to interact with marine fauna. Much of the marine debris is foreign sourced (Keissling 2003b). Controlling such foreign sources of marine debris is beyond Australia's jurisdiction and so marine debris is likely to remain a problem within the NMR and probably increase in severity by 2030.

The impacts of climate change cannot be pinpointed so well, geographically. Where the NMR contains shallower habitats (Figure 12), by 2030 one can expect greater mechanical and turbidity impacts of both intensified cyclone and wind activity. Coupled with increases in sea temperature, shallower areas might suffer greater impacts than deeper parts of the NMR. Given the nature and geography of the threats discussed above we would like to emphasize the relatively shallow depths of much of the NMR (Figure 12).

Figure 11 Monthly mean depth-averaged currents for the dry season (July)

Source: Rothlisberg *et al* (2005).

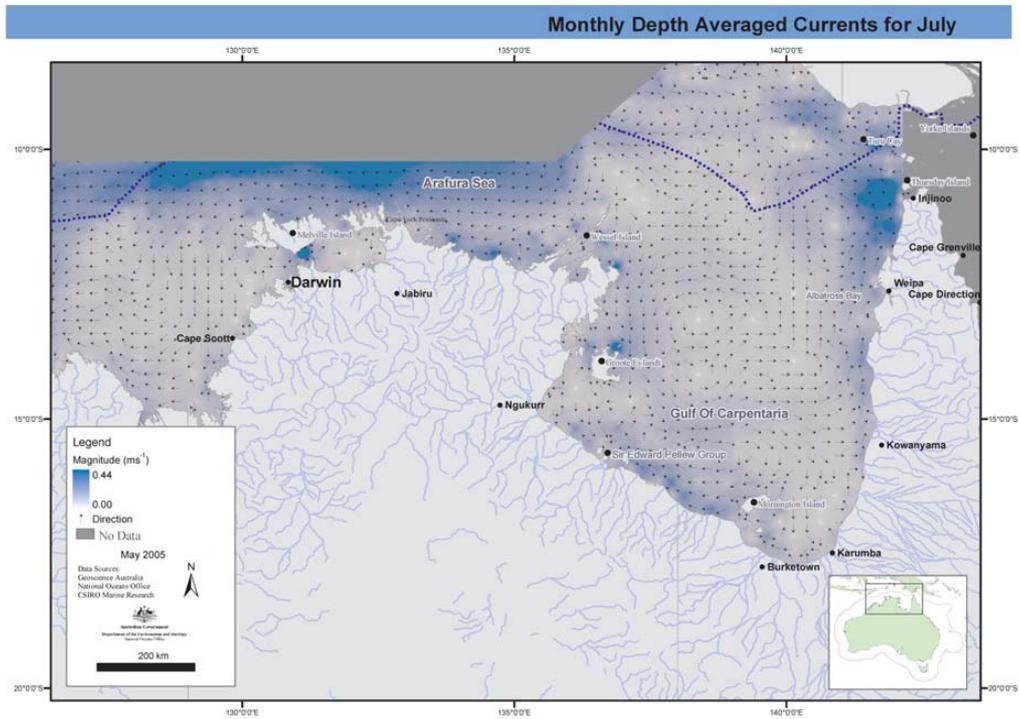
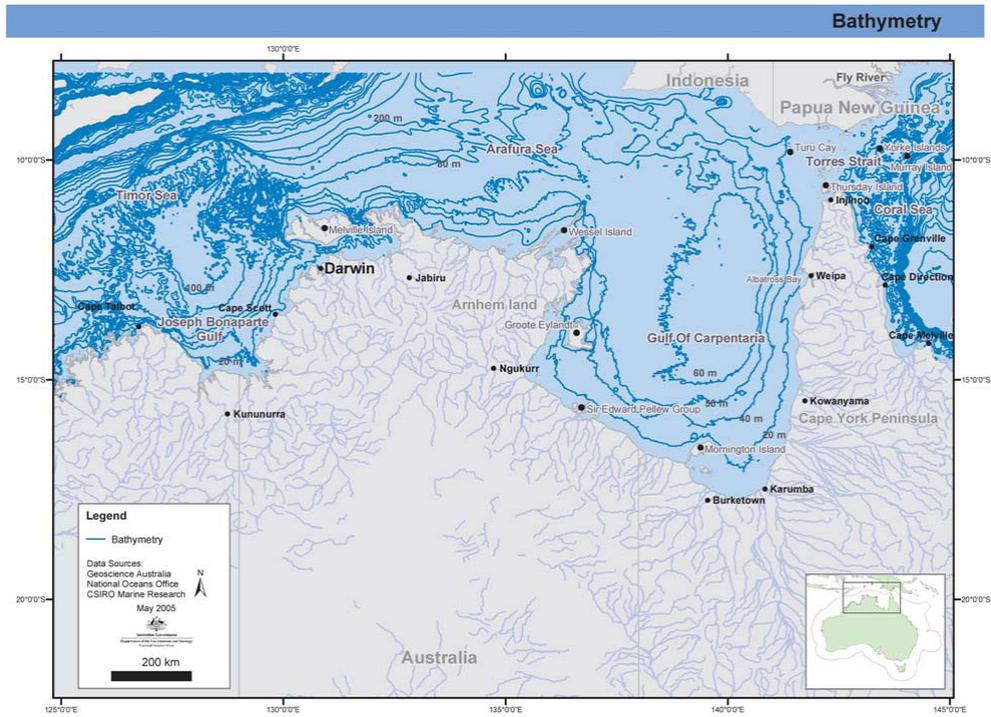


Figure 12 Bathymetry contours from the National 250m Bathymetry Grid

Source: Geoscience Australia in Rothlisberg *et al* (2005)



## 6 Future impacts of developments upon the NMR environment

Given the kinds of disturbances that are linked to various activities (Section 5.1) what kind of impact might these activities have upon the species and habitats of the NMR in 20 years? Here we briefly discuss the impacts of all the developments, activities and global change upon each component of the marine environment of the NMR. These discussions compile previous information laid out in this report and apply it to describe possible future impacts upon species, habitats and water quality. The timeframe for each discussion is 20 years and discussions are focussed on habitats and species within the NMR boundary. For a discussion of more immediate threats to NMR species and habitats see Kiessling (2003a).

### 6.1 Impacts on water quality

Water quality is important to the flora and fauna of the marine environment of the NMR. Various activities will impact on water quality in the estuarine and near shore environments either through chronic events (e.g. agriculture including, especially cattle grazing, mining, ports and urban development) or acute events (e.g. shipping accidents). Activities in catchments adjacent to the NMR will, by 2030, alter sediment and nutrient levels in some waterways, introduce contaminants, alter water flows and physically alter wetland and riparian systems that naturally “filter” waters from catchments. During monsoon events, water flowing from northern catchments into the marine environment is therefore likely to be higher volume and of poorer quality. By 2030, this may impact on marine flora and epibenthos particularly but also near shore benthic communities and mobile fauna (e.g. fish, dugong) that rely upon them.

In addition, due to increased industrial activity, there are likely to be impacts on water quality of the NMR through acute events such as oil and/or gas industry accidents or shipping incidents. The degree and nature of these impacts are, however, impossible to predict but will exacerbate any chronic impact.

Catchment activities such as those described above (and in Chapter 4) lead to mainly chronic, low level and localised impact adjacent to the NMR. These will persist and increase into 2030 and, in many instances, will occur simultaneous to other impacts on marine habitats and species.

### 6.2 Seagrass

Seagrass beds have been found in intertidal area of the Gulf of Carpentaria but *Halophila ovalis* and *Halophila spinulosa* seagrass beds have also been found further offshore in waters up to 20m deep (Coles *et al* in Kiessling 2003a). The World Conservation Monitoring Center (2007) has mapped seagrass along the western shore of the Gulf of Carpentaria and along the north of Arnhem Land including up through the Wessel Islands. This mapping has not been ground-truthed. Ground-truthing is difficult, in any case, due to the ephemeral nature of seagrass.

By 2030, inshore seagrasses not protected by trawling closures are likely to be subject to the effects of both poor water quality and bottom trawling for prawns in particular locations. Offshore, in 2030, the main impact is likely to be trawling especially from the NPF.

Unfortunately the location of the offshore, deeper water seagrass within the NMR has not been well mapped.

As port and shipping activities increase towards 2030, so too does the risk of introduced species, physical impacts in shallow waters or accidents which could harm intertidal and possibly deeper water seagrass beds. The impacts will depend on the location of the incidents relative to the location of the seagrass beds. Aquaculture is certain to co-occur, in some locations, with seagrass beds by 2030 and where this occurs it is likely to damage the seagrass. The impact will probably be highly localised as most of the intended aquaculture in the marine environment, as far as we can predict, is not intensive in nature.

The impacts of climate change are difficult to predict over the next 20 years. In 20 years, where more intense cyclones co-occur with shallower seagrass beds one might expect enhanced damage to these habitats. Where wind speeds are greater and enhance turbidity one might expect a reduction in the area of seagrass beds (which can be light limited). The impacts of increases in sea temperature and acidity are unlikely to be realised within 20 years but could lead to loss of or shifts in community structure. (Waycott *et al* in Johnson and Marshall 2007)

Natural events (such as “big wet” seasons) have, in the past, been linked to seagrass dieback and will certainly be a source of mortality for seagrasses in the NMR in the next 20 years especially if coupled with poorer water quality.

### 6.3 Coral communities

Coral communities have been recorded off northern Australia and while they have mostly been near shore and outside the NMR and data suggest that there are unsurveyed deepwater, hard bottom seabed that may also support coral communities if not actual reefs (Kiessling 2003a). The discovery of Big Reef in the Gulf of Carpentaria attests to this possibility (Kiessling 2003a).

Coral communities may be targeted for harvesting; this is not expected to be a significant industry by 2030. Fishing for coral reef species seems to be increasing in popularity and we expect this to have some impact on the composition and function of coral communities into 2030, potentially making them less robust systems. Coral communities may also be impacted by shipping accidents especially where their location co-occurs with or is adjacent to shipping routes that will increase in traffic.

Climate change and El Niño events are a major long term threats to the shallow water corals of the NMR despite that the limited data do not indicate that the NMR corals suffered from bleaching in 1998 or 2002 as did corals on the west and east coast of Australia. Ocean acidification will reduce ability of corals to build skeletons and, consequently, reefs. (Hoegh-Guldberg *et al* in Johnson and Marshall 2007).

### 6.4 Soft seabed communities

Where there is no hard substrate within the NMR and no seagrass, other soft seabed communities exist. No data to describe the fauna and flora of these habitats could be found. In an interconnected marine system, however, it is presumed they are an integral part of the broader NMR ecosystem.

Sections 4.4.1, 4.4.5 and 5.3 discuss the trawling and its potential future development and impacts. For seagrass, the main impact in 2030 will be from trawling in the Northern

Prawn Fishery. The future of the NT Finfish Trawl Fishery and Queensland Developmental Finfish Trawl Fishery could be significant to this habitat however we feel unable to predict what DEEDI will decide with regard to this latter fishery.

In the next 20 years, soft seabed communities will also be subject to the impacts of shipping accidents, perturbation by passing ships, offshore oil and gas activities in a very few limited locations, possibly mariculture in a few limited locations, water quality impacts in some inshore areas and climate change.

## 6.5 Sharks, Rays and Sawfish

There are about 45 species of sharks, rays and sawfish that may be found within the NMR (with an additional 9 species limited to the freshwater, coastal habitats)(Kiesling 2003a). Because their population numbers and habitat distributions are poorly known it is not possible to determine exact risks posed by key threats to these taxa. Many of these species have been identified as at risk due to their life history characteristics and vulnerability to fishing (Salini *et al* 2007). BRDs can and have reduced impact of trawling on shark in the NPF and the NT FinFish Trawl fishery (BRDs have not been introduced to the Queensland Developmental Finfish Trawl Fishery as at 2009)(QPIF 2009c). Set nets and trawlers have been recorded to interact with sawfish (QPIF 2009a, 2009c).

By 2030, assuming the *status quo*, we expect that shark fishing and shark, ray and sawfish by-catch will have had a significant impact upon these populations. The influence of even limited numbers of FFV and domestic IUU activity will add greatly to the declined status for this group of animals by 2030.

## 6.6 Cetaceans, Dugong and Turtle

Inshore and offshore dolphins, whales (about 18 species), dugong and six species of marine turtle are inhabitants of the NMR.

If the fisheries are maintained as they are now, then in 2030 the primary anthropogenic cause of mortality for these species is fishing. All these species can be caught by inshore and offshore set mesh nets, hunted by Indigenous people and some are caught incidentally in trawl nets. In 2030, they will continue to be impacted by these activities so long as the cetacean, turtle and dugong populations still exist. Enhanced attendance rules and limits on mesh size and length of net can assist in reducing the impacts of mesh nets however the most effective manner of reducing the impacts of set mesh nets on cetaceans and dugong is to reduce effort, especially in key habitat areas (Marsh 2000).

TEDs have reduced interactions between turtle and the Northern Prawn Fishery and in 2030 we expect these devices to remain in place with even greater efficiency and effectiveness.

In 2030, dredging will continue to have at least the same level of impact on turtle mortality as now for port and channel maintenance. Therefore, it will have similar (if unknown) impacts upon turtle populations.

Turtle that use the NMR during part of their life are also susceptible to impacts beyond the NMR when they migrate. Impacts upon turtles beyond Australia's boundaries are likely to have increased by 2030 and are likely to remain the major threat to these animals and their role in the NMR ecosystem.

Increases in catchment activities by 2030 are likely to lead to an increase in green turtle fibropapilloma disease (GTFD) and possibly other diseases in part due to decreased quality of habitat such as seagrass beds and coral reefs. For turtle, increased recreational four-wheel driving along beaches is likely to continue into 2030 and will impact turtle nests as will dogs and other animals.

Indigenous hunting of dugong, turtle and gathering of turtle eggs is another source of mortality and is likely to continue into 2030.

Boat strikes have been known to kill turtle and dugong and we expect this interaction to be greater by 2030, especially in the recreational fishing sector.

Ghost nets can also be harmful to cetaceans, turtle and dugong (Kiessling 2003a) as can sonar, as used by the defence forces. These impacts, especially ghost nets, will remain a threat in 2030.

For dugong and turtle, the possibility of habitat loss can also be of significance as this is their main food source (see Section 6.2. for a discussion on threats to seagrass and coral reefs).

The impacts on turtle and dugong by FFVs is not currently known but suspected to be present; we expect ongoing impacts from FFVs on these species in 2030.

Seismic testing, to the west of the NMR, will continue to impact cetaceans in the area in 2030.

## 6.7 Fishes and seasnakes

All the targeted fish identified above (Sections 4.4, 4.5 and 4.6) will continue to be impacted upon by fisheries activities in 2030 if current fisheries management is successful in ensuring the sustainability of the fish stocks. For few species is there complete information ensuring exact knowledge on optimal levels of take; therefore implementation of the precautionary approach being advocated by the fisheries managers will be imperative to the future of these stocks in 2030 (DPIF&M 2006, DOR 2009). This is particularly true for those fisheries that have latent effort.

The future of the developmental finfish trawl fishery could be significant to the targeted fish species. Since the fishery has been operational since 1998, we anticipate that its operations, and therefore its impacts will continue for the next decade or perhaps two.

Many of these species are also subject to IUU fishing including from FFVs. Snappers, emperors and mackerels are probably targeted by FFVs both legally and illegally. In 2030, we expect low levels of ongoing FFV activity impacting upon these species.

Currently, little charter or commercial fishing targets reef fish. By 2030, we consider that near shore coral communities will be regularly targeted by these fisheries. By 2030, we believe that sophisticated use of depth sounders and GPS is likely to lead to low level but highly effective targeting of deeper water "reefs" or shoals as well for both commercial and recreational fishing purposes.

Some targeted species rely on inshore and coastal habitats as nurseries. In 2030, while unable to predict the degree of decline of mangroves and other wetlands, we are certain that there will have been a decline (due to port activity, poor water quality, and coastal development) that will have at least local significance and possible impacts on fish stocks within the NMR.

Ghost nets will continue to have impact on fish stocks in 2030.

The NMR is a significant region for seasnakes who perform an important role in the ecosystem (Guinea, Limpus and Whiting in Kiessling 2003a). Seasnakes have been significantly relieved of the major source of impact: trawl in recent years through the introduction of BRDs in the NPF. But their life history makes seasnakes vulnerable to any impact and recovery from previous impacts will be slow. In 2030, however, we don't anticipate any significant ongoing impact upon seasnakes from trawling. Increased boat traffic and increases in turbidity will occur by 2030 which will impact on the survival of seasnakes by disrupting their feeding (Guinea, Limpus and Whiting in Kiessling 2003a).

The impact of climate change upon fish stocks in 2030 is most likely to be realised through impacts upon habitats (Munday *et al* in Johnson and Marshall 2007). Changes in distribution patterns can be expected for both fishes and seasnakes, though the degree to which this impact will be realised within 20 years is uncertain (Johnson and Marshall 2007).

To the extent that fisheries have reduced the "natural" stock of the species they take, the fisheries, by 2030, will have impacted upon the "natural" role those animals play in the marine environment of the NMR. The long term biological, ecological or even commercial consequences of such an impact are unknown but, at a minimum, are likely to reduce ecosystem resilience to any additional external shocks.

## 6.8 Invertebrates

The main threat to some invertebrates in the NMR is fishing activity, especially commercial fishing. The key taxa subjected to fishing impacts are prawn, crabs and holothurians (see also Section 4.4). Here again, the nature of the threat in 2030 will be determined by fisheries management actions prior to that time (see discussion above, Section 6.7).

Other invertebrates may be subject to some limited commercial and recreational take in the NMR in 2030 (e.g. molluscs, lobsters, squid) but this take is unlikely to be significant in 2030 with the exception of some localised depletion if recreational or subsistence take is concentrated.

The impact of climate change upon invertebrates in 2030 is most likely to be realised through impacts upon habitats in the case of coral-associated invertebrates and through changes in distribution in the case of soft-seabed invertebrates (Hutchings *et al* in Johnson and Marshall 2007).

To the degree that fishing effort has reduced the "natural" stock of the invertebrate species they take, fishing, by 2030, will have impacted upon the "natural" role those animals play in the marine environment of the NMR thereby, potentially, reducing overall ecosystem resilience.

## 6.9 Seabirds

There are over 40 species of seabirds that use the NMR (Chatto *et al* in Kiessling 2003a).

By 2030, increases in even infrequent visitation to nesting sites is likely and will impact upon the breeding success of seabirds using these coastal areas as will interference from dogs, pigs and other non-native animals.

The continuing presence of marine debris in 2030 will be a continuing impact upon seabirds in the NMR.

As with most other animals, accidents (e.g. from shipping, port, mining) or chronic pollution (e.g. from agriculture, seepage from old mines) leading to impacts upon water quality either in adjacent coastal habitats used by seabirds or in the marine environment of the NMR itself can impact negatively upon seabirds and the chance of such an accident occurring will be far greater in 2030 than it is now.

## 7 Conclusions

### 7.1 Cumulative impacts

For the purposes of this study, cumulative impacts refer to:

- i. the addition of various threats upon any one geographic area or
- ii. multiple impacts upon any one attribute (habitat or species) of the NMR or
- iii. the addition of more of the same activity and associated impact or
- iv. the addition of various threats/impacts over time or
- v. the addition of impacts located next to each other.

The danger of cumulative impacts is that, in combination, the impact of individual effects can be exacerbated because of the complexity and non-linearity of ecological responses. While cumulative effects are very important, there is insufficient knowledge of the interactions between the threats to predict exact repercussions in twenty years time. However, we can provide a qualitative scenario to help inform management by drawing upon the previous sections of this report.

Future impacts must be placed in the context of past impacts. The assessment of the drivers of future development and activities in the north of Australia and then consequent linkage to the marine environment must be placed in the context of, at the minimum, the previous decades of impacts both within and outside the NMR that have effected habitats or species of the NMR. For example, the northern prawn fishery, prior to the introduction of TEDs and BRDs was responsible for the mortality of an unknown number of sharks, sawfish, hundreds to thousands of turtles and around 60,000 seasnakes per year (Kiesling 2003a). Similarly, historical mortality of many species can be attributed to other activities such as marine debris, other types of fishing including commercial netting, indigenous fishing of turtle and dugong and especially including FFVs (many of whom could legally fish in our waters until 1991) and IUU fishing more generally (Kiesling 2003b). The key message is that the NMR is not, in 2010, a “pristine” environment, it is already degraded.

In addition, many of the threatening processes which may exist in 2030 will also, to some degree, be having impacts in the intervening 20 years albeit to different degrees and in different geographies.

Also, not a single of the habitats or species groups within or adjacent to the NMR is presently, or will in the future be, subject to only one human impact.

Climate change is the most significant and overarching of the threats and implications for the marine environment in twenty years time are difficult to predict but will overlay every other anthropogenic disturbance. Impacts of fishing, both legal and illegal, have been increasing in their spatial extent over the last 20 years so that much of the NMR and adjacent areas are now subject to some impact of fishing. Similarly, marine debris is almost ubiquitous in the NMR and difficult to sample and quantify. Kiesling (2003a) considers that shoreline surveys almost certainly under-represent the volume of marine debris impacting our marine environment. These impacts are chronic and their quantity will be greater by 2030.

In parts of the NMR there are additional although more localised impacts of shipping, ports, offshore oil and gas activities, tourism and research—all of which are expected to be greater by 2030. By 2030 the NMR will quite possibly be subject, in some locations, to chronic impacts derived from land-based and coastal activities such as agriculture

(including grazing), aquaculture, mining and port activities. These localised impacts occur in addition to the three NMR-wide impacts: climate change, fishing, and marine debris.

At any time, the marine environment can be subject to an acute anthropogenic event. The event may be the sudden introduction of a marine pest, a shipping accident, a oil spill or spill of another type of cargo (e.g. liquid sulphuric acid or phosphate), a mining accident that affects near-shore, and then NMR, water quality, or an impact from defence training activities. All of these types of activities are anticipated to increase in volume over the next 20 years (see Chapter 4). Although greater environmental controls will be, and are being, put in place, the level of environmental control is unlikely to be able to completely neutralise the risks associated with the increase in growth of these potentially damaging activities. Thus, on average, the risk of acute events such as mentioned above will be greater in 2030, despite greater environment controls, simply because the level of activity will have increased.

There can be catastrophic natural events, too. Cyclones, storms, extreme wet or dry or drought add a natural level of stress to the anthropogenic stressors discussed above and, through climate change, we may expect more powerful (if less frequent) cyclones, for example.

Cumulative effects will test the resilience of the marine ecosystem of the NMR, namely its ability to resist significant ecological alteration and/or rebound after catastrophic events.

#### 7.1.1 Cumulative over time

Many of the environmental effects of activities described in Chapter 4 have already been, and will continue to be, cumulative over time and/or space. That is, many of the impacts occur constantly or repeatedly over any period of time. With trawling, for example, a once-off occurrence of trawling may remove 5-25% of seabed life; 13 passes removes 70-90% (Poiner *et al* 1998).

#### 7.1.2 Cumulative over space

Many of the environmental effects of activities also occur at multiple (or all) locations. This means that the geographic extent of the impacts is more likely to overlap with the distribution of many species or habitats. For example, a small impact of, say, line fishing in one location may not be significant to the future of the NMR but if it occurs in 200 locations or 2000 locations or 20 000 locations then it may begin to have significant impact overall. Over the next 20 years, it is likely that the spatial extent of all the anthropogenic impacts that occur in the NMR will leave few or no unimpacted "pockets" the ecosystem by 2030.

#### 7.1.3 Summary

There is uncertainty of the long term consequences of the cumulative impacts. This uncertainty calls for the application of the precautionary principle. DEWHA (2008b) and the Australian and New Zealand Environment and Conservation Council (1998) advocate a precautionary approach because it recognises that in many areas, marine resource management planning will be occur in the absence of detailed biological information and always in the absence of perfect knowledge. Allison *et al.* (2003) advocated application of an "insurance factor" to any protective measures that are proposed for the marine environment, in the face of uncertainty and to manage the risk of a severe disturbance event. Their work focussed on areas that might be considered for reserve design but the

principles can apply equally to other management measures. Their examples of two disturbance types (oil spills and cyclones) in the south of the U.S.A. apply very much to the NMR. They determined insurance factors in marine planning as varying from 1.1 to >4.0 depending, in part, on the assumed recovery time (Allison *et al.* 2003).

## 7.2 Conclusion

This report identifies the potential future importance of many activities within and adjacent to the NMR. This work highlights that, over a 20 year time frame, quantitative data with 95% confidence limits to define future impacts are not available. Available information has been collated and analysed to create potential future scenarios which may or may not be accurate. From a planning perspective, this uncertainty highlights a need for flexibility and an ability to improve plans as more and better information becomes available. Beyond flexibility, the greater the ability of marine resource users and managers to build the resilience of the ecosystem by limiting impacts of activities that can be controlled, the more likely the ecosystem can withstand impacts over which there is little control (e.g. climate change, marine debris, environmental accidents).

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## 9 Appendices

## Appendix 1. Terms of reference for this study

### Project Outline

#### **Future development in northern Australia – part 2**

*May 2010*

##### **1. Purpose**

The purpose of this project is to build on existing information on future development activities and their influence on northern Australia's marine environment as part of the Australian Government's marine bioregional planning process.

##### **2. Scope of work**

This project will build on current information on developments over the next 20 years that will impact marine environments and species within the North Marine Region as described in the draft report entitled "Marine environmental impacts of future developments in northern Australia: implications for North Marine Region planning" (Fernandes and Greiner 2008). The North Marine Region covers the area of Commonwealth waters stretching from the Gulf of Carpentaria, Arafura Sea and the Timor Sea as far west as the Northern Territory–Western Australian border (Figure 1).

The information developed as part of this project will cover, as far as possible, social, demographic, economic, infrastructural and activity-based descriptors of industries and other relevant activities likely to be established and/or evolve. Particular consideration should be given to the following;

- oil and gas industries (including laying of cables and pipelines), and the implications of developments in nuclear energy technologies,
- shipping and port industries, including dredging and infrastructure development, changes to shipping routes, and changes to the number and size of ships that frequent the Region,
- tourism activities,
- Defence and surveillance activities,
- commercial, recreational, and Indigenous fishing,
- dams and/or other changes to catchments and hydrological systems,
- population fluxes associated with future developments, including provision of infrastructure and other activities relevant to the growth and/or decline of industries,
- new and emerging industries (e.g. aquaculture, bioprospecting), and
- the implications of climate change on existing and new developments in northern Australia.

##### **3. Background**

Marine bioregional planning is a process being undertaken by the Department of the Environment, Water, Heritage and the Arts (DEWHA) that is designed to better protect marine environments, conserve biodiversity and deliver certainty to industry, the wider community and decision makers about Australia's marine conservation priorities. The Minister for the Environment, Heritage and the Arts must have regard to a Marine Bioregional Plan when making decisions under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for which a Plan has relevance. Marine bioregional planning is also the process through which the Australian

Government identifies areas within Commonwealth waters for inclusion in the National Representative System of Marine Protected Areas (MPAs).

The planning process requires up to date information on those groups and activities that use and depend on marine environments now and in the future as a foundation for decision-making. This project will improve understanding of issues to consider in developing a strategic approach to sustainable management of northern Australia's oceans.

#### **4. Methodology and output**

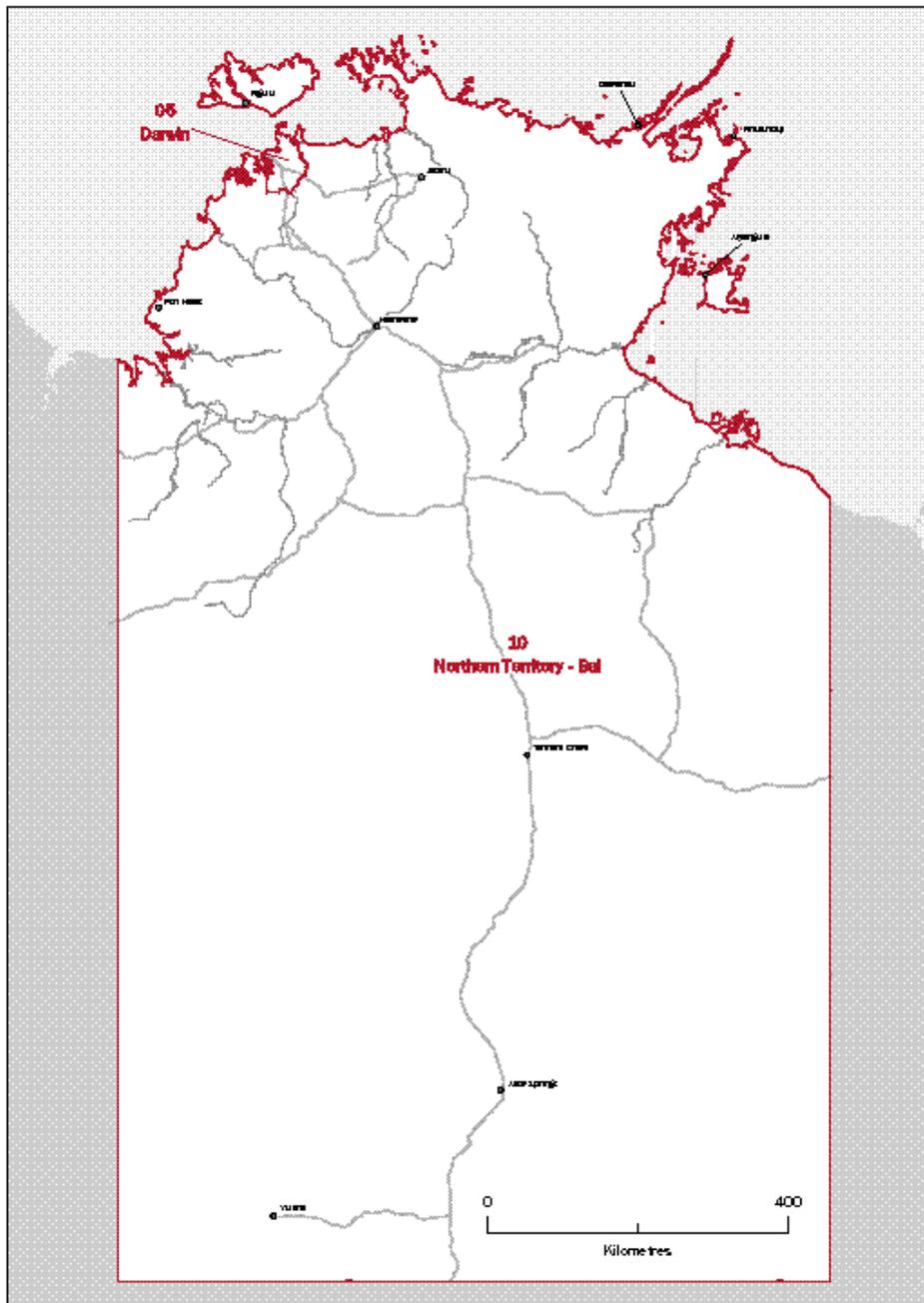
It is expected that this project will be undertaken primarily as a desktop study though the consultant may choose to consult with relevant industry stakeholders and other experts as necessary.

There will be two major outputs of the project as follows:

- a draft report for feedback by DEWHA
- a final report incorporating synthesis and review of relevant data as well as relevant figures, maps and tables to illustrate findings in the following key areas:
  - drivers of and impediments to future development,
  - the socio-economic links between future developments of relevance to the North Marine Region and developments beyond northern Australia,
  - analyses of specific future developments that are dependent on (or strongly influenced by) marine environments and species. This analysis should include consideration of changes in resource use, levels of output, scales of operations, employment, economic value, and spatial distribution of activities likely to establish and/or evolve,
  - the relative significance of future development at the regional, State/Territory and national scale,
  - any development 'hotspots' in northern Australian waters – geographic areas that are likely to be subject to significant development pressure over the next 20 years, and
  - predicted implications of future developments on marine environments and species.

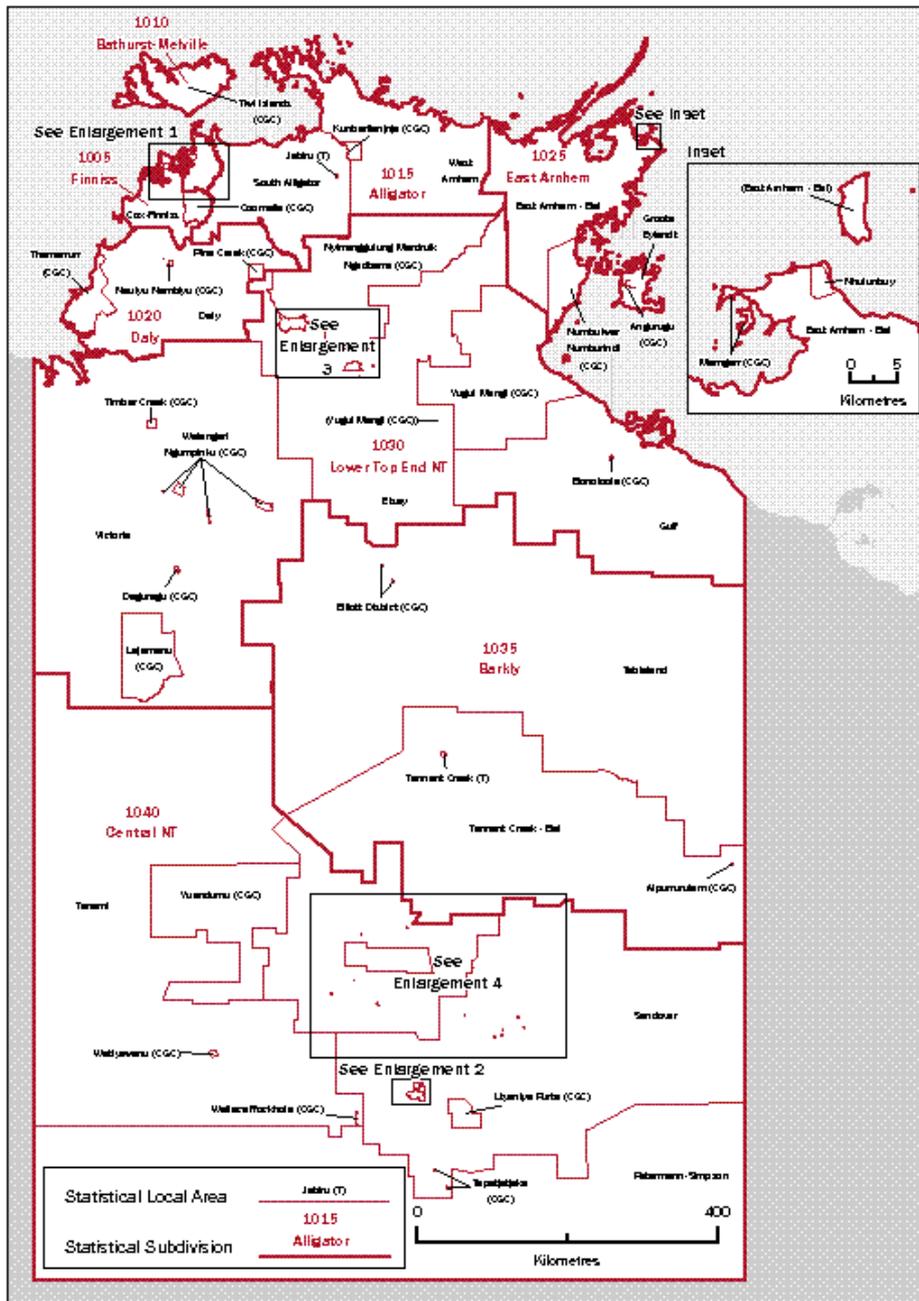
## Appendix 2. Statistical Divisions, Sub-Divisions and Statistical Local Areas in the Northern Territory and Queensland

NORTHERN TERRITORY, Statistical Divisions

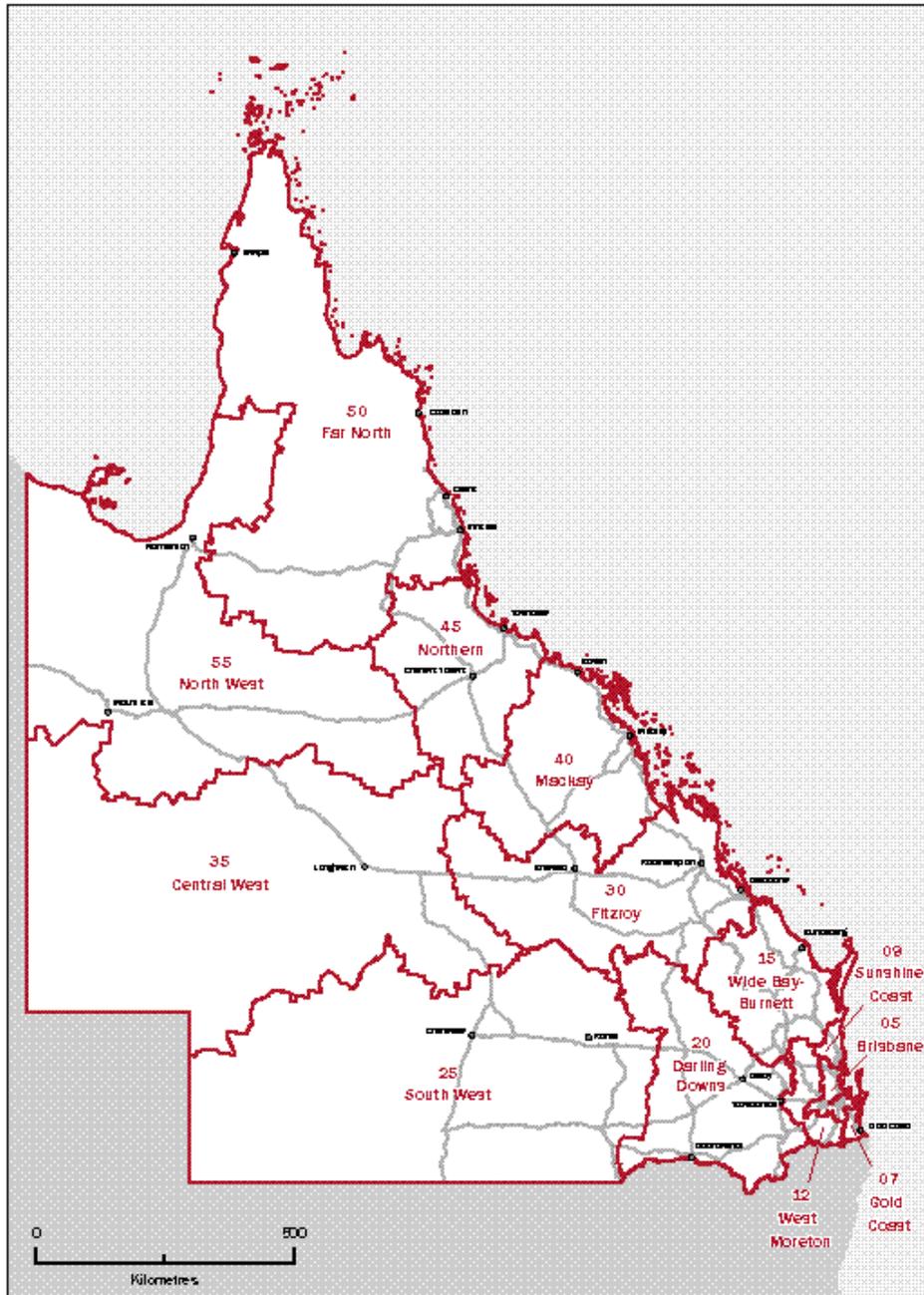


204 ABS - AUSTRALIAN STANDARD GEOGRAPHICAL CLASSIFICATION (ASGC) - 1216.0 - JUL 2006

NORTHERN TERRITORY, Statistical Subdivisions and Statistical Local Areas

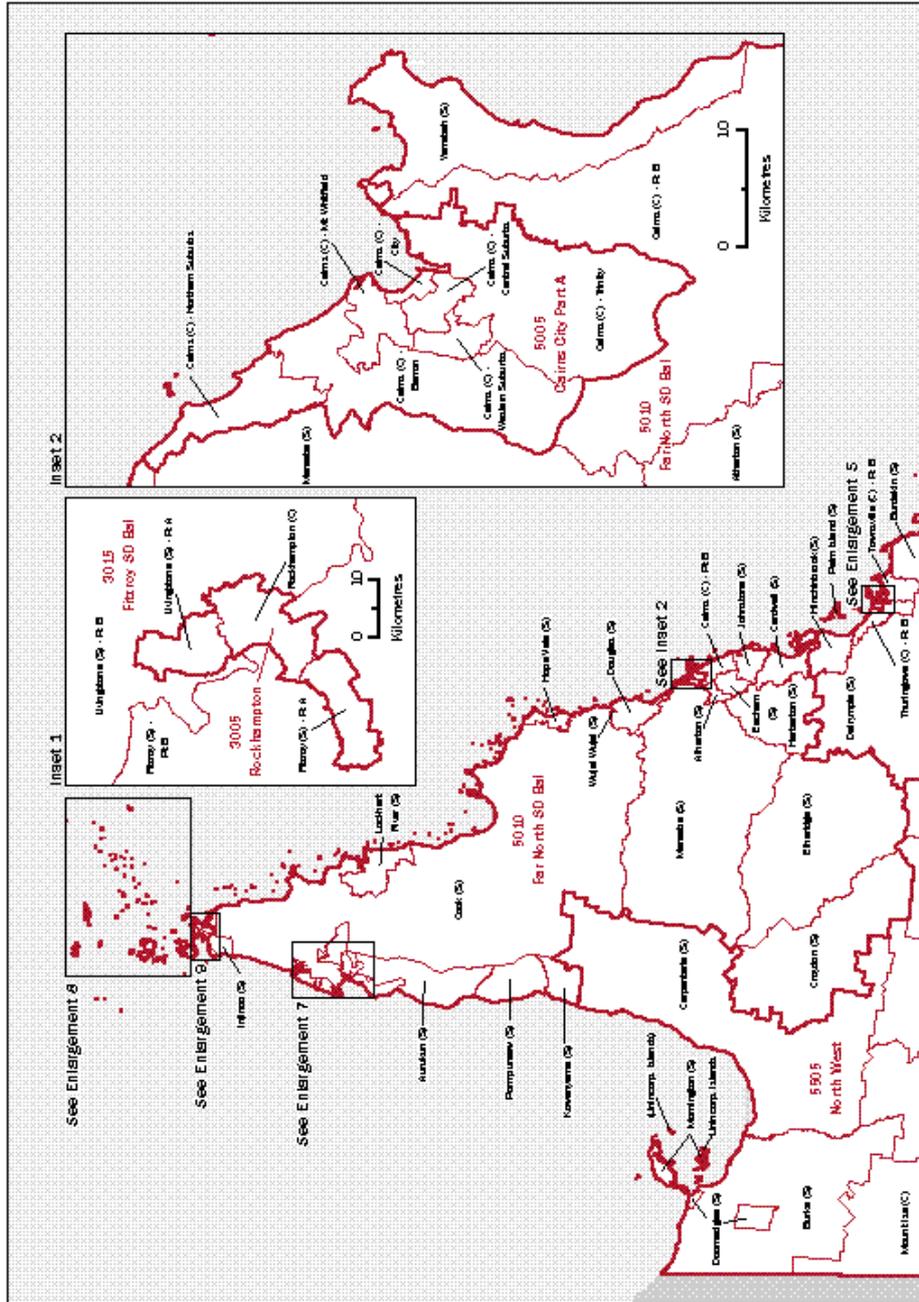


QUEENSLAND, Statistical Divisions



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QUEENSLAND, Statistical Subdivisions and Statistical Local Areas



172 ABS - AUSTRALIAN STANDARD GEOGRAPHICAL CLASSIFICATION (ASGC) - 1216.0 - JUL 2006