Bureau of Mineral Resources, Geology & Geophysics

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Quaternary evolution, modern geological processes and potential impact of petroleum exploration activity in the Gulf of Carpentaria (Release 1 of 1992).

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Quaternary evolution, modern geological processes and potential impact of additional petroleum exploration activity in the Gulf of Carpentaria (Release 1 of 1992).

by

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ENVIRODAT - NATIONAL PETROLEUM DATABASE PROGRAM

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Abstract

To meet the formal requirements for the collection, interpretation and analysis of environmental baseline data the modern geological processes, Quaternary evolution and environmental features of the potential release area in the Gulf of Carpentaria (first release of 1992) are described, analysed and interpreted.

The potential release area overlies the deepest part of the part of the Gulf of Carpentaria (water depths 60 to 65 metres). Sea bottom sediments in the region are dominantly soft shelly and sandy mud and contain marine molluscs, bryozoans and marine ostracods (Torgersen & others, 1985).

The Gulf of Carpentaria is a large indented embayment on Australia's northern coastline and the continental shelf. Below its waters is a continuous platform between Australia and Papua New Guinea, much of it at a depth of 50 to 70 metres (Figure 1). Sea level changes during the Quaternary period have resulted in repeated exposure and emergence with changes ranging as much as 150 metres (Chappell, 1983).

Major ecological features of the current coastal zone adjacent to the potential release area include coastal and estuarine mangrove and seagrass communities. Human activities which can adversely affect each of these elements include such effects as increased nutrient levels from runoff and other discharges associated with human settlements and activities.

Seismic surveying and drilling are the main petroleum exploration activities likely to be undertaken in the potential release area. The transitory nature of these activities and their variable location would in normal circumstances result in no long-term visible impact on environmental conditions and at worst only very minor short-term localised disturbance. At the completion of exploration work the only visible signs of drilling would be the presence of rock fragments on the sea bottom and normal current and tidal action would disperse these within a short period. The impact of the installation of production facilities would require more specific examination beyond the scope of this analysis, possibly an environment impact analysis.

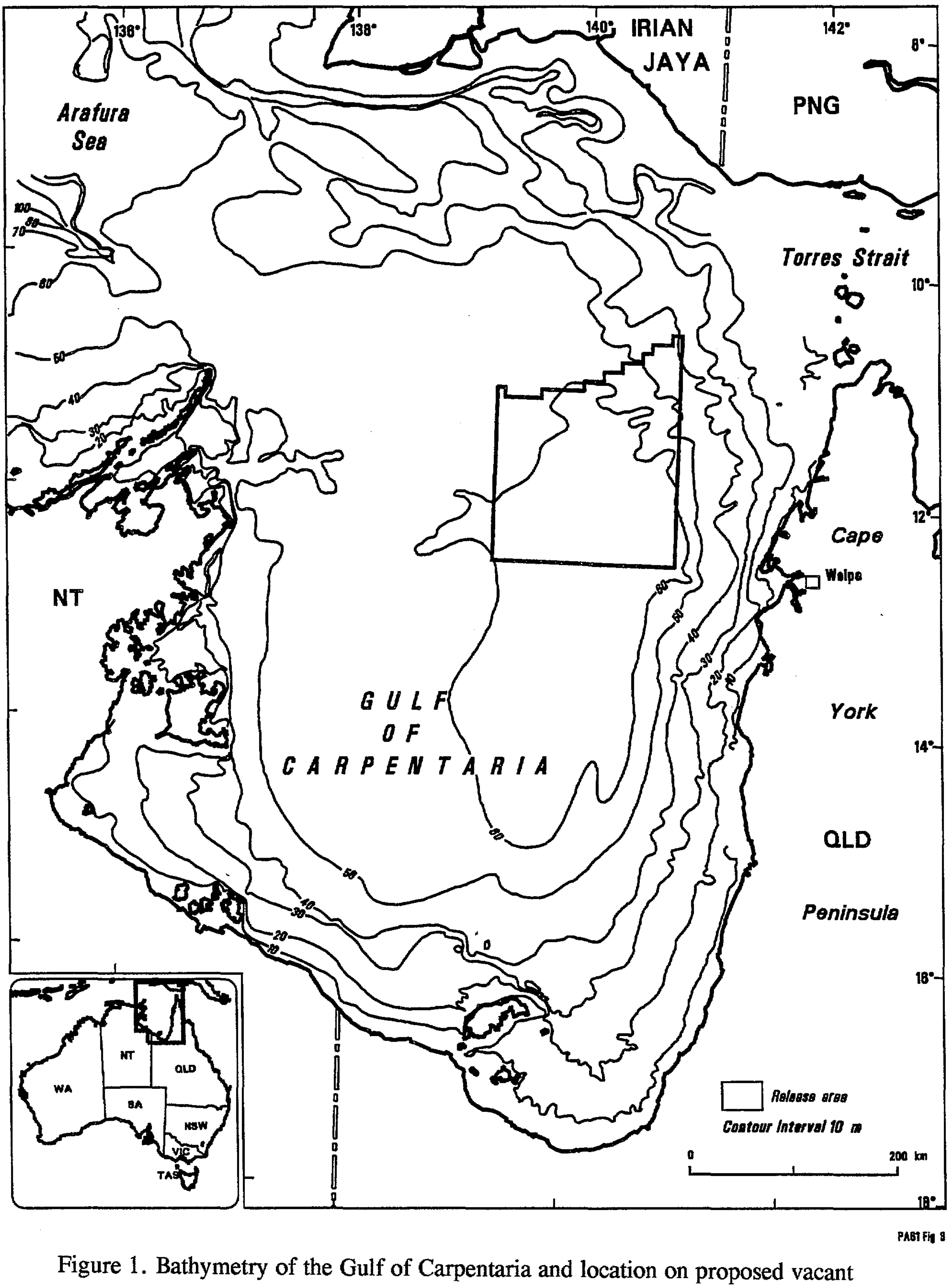

Figure 1. Bathymetry of the Gulf of Carpentaria and location on proposed vacant area.

Introduction

Petroleum operations in Australia, beyond coastal waters, are governed by Commonwealth legislation and this legislation is, in part, is administered jointly with the States and Northern Territory. The 12 million or more square kilometres of ocean waters surrounding the continent is rich in natural living resources in terms of marine life and biodiversity and is underlain by geological sequences which have proven oil and gas potential.

The recent releases of vacant petroleum exploration areas for application under Commonwealth legislation (Release of Offshore Petroleum Exploration Areas, Release No. 1 1992) have been accompanied by a list of special conditions. These special conditions require that successful exploration groups applying for the right to drill exploration wells during the course of a permit work program will have to supply to the Commonwealth with, among other things:

1. A description of the environment, both within the permit and adjacent to it, which is likely to be affected by drilling and production - where there is written material already available this has to be included.

2. A description of the potential impact of drilling and production on the environment, a description of safeguards and standards for the protection of the environment intended to be adopted and applied in connection with the drilling of the well and future production.

In response to the demand for environmental baseline data, some of which has been collected by the petroleum exploration industry during the course of its exploration and production activities, the Bureau of Mineral Resources, Geology and Geophysics (BMR) has acquired and is interpreting a wide variety of data relating to baseline environmental conditions. Major regional surveys of marine geology of Australia's continental margins provide a unique insight into the nature of the marine environment, in particular its diversity and variability. Such surveys have been undertaken by BMR as part of its Continental Margins Program and the preceding Marine Geology Program.

The potential impact of petroleum exploration and production activity on Australia's marine environment has over a 30 year period of major petroleum production proved to be negligible with a total of 350 barrels of oil being accidently released during the course of producing two and a half billion barrels of oil (Griffiths, 1991). Maritime shipping into and out of Australian ports has been responsible for the accidental release of most oil into the marine environment.

The specific requirements for environmental description has formalised a process of data collection collection and analysis which the petroleum exploration and development industry has participated in for a considerable period of time (Holloway, 1988). The special conditions which now require formal documentation of such information in applications to drill exploration wells has resulted in the presentation of such data in the following form for use by government, the industry and the public.

An area overlying part of the Gulf of Carpentaria is likely to be included in Release 1 of 1992 and it overlies the Australian continental shelf between 12-35.0' and 13-55.0' south and 139-35.0' and 141-35.0' east. Water depths in the area range from less than 60 to over 65 metres (Figure 1).

Queensland coastal zone

Coastal areas of Queensland, landwards of the waters covering the vacant area, are noted for their diverse and significant physical and biological resources. Those resources accordingly represent considerable economic, recreational and conservation values (NTDME, 1991). Up to 9700 tonnes of commercial prawns have been recovered each year by commercial trawling operations since 1963-64 (ECOS, 1983).

For definition purposes only, the 'coastal area' exists seawards to 25 nautical miles offshore or the 25 metre depth contour, whatever is greater from shore, and extends onshore to include all landforms which are subject to coastal processes, including mobile sand dunes and chenier beach ridges (NTDME, 1991) (Figure 2).

Three basic divisions of the coastal area are readily made, based on the dominant sedimentological processes as well as the biofauna inhabiting each major geographical element (Figure 2).

The first division is the intertidal zone which includes the areas between high and low tides levels. Elements such as mangroves, salt marshes, some seagrass beds,

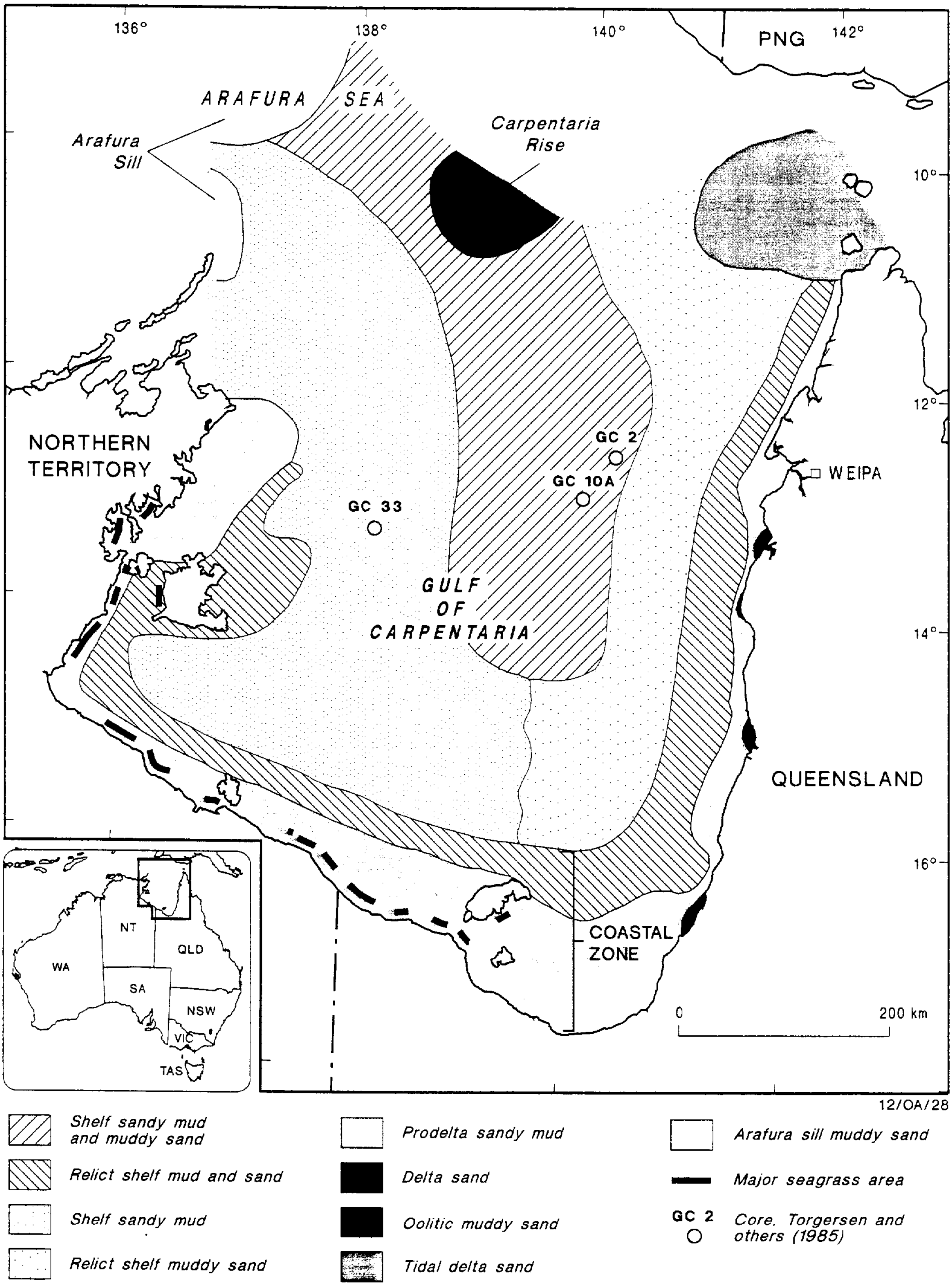

Figure 2. Major sediment types.

mudflats, sand flats, with lesser sandy beaches and dune systems may be present (NTDME, 1991).

Generally landwards of the intertidal areas are such features as dunes and chenier beach-ridges, as well as low-lying areas which become water-logged during the monsoon season including, paperbark swamps and monsoonal vine thickets. Such areas are the supratidal zone and comprise a buffer between the intertidal zone and non-marine environments.

The final element is that of subtidal zone - marine or estuarine areas below low tide level. Elements in this group are major tidally-influenced channels, coastal lagoons, seagrass banks and shoals, as well as marine shelf areas.

A variety of cultural, social, biological, geological and geographical values are attributed to many of the coastal features. Some are considered likely to be sensitive to the impact of activities associated with exploration and development work where that activity includes dredging, drilling and seismic exploration.

Features which have been identified as being likely to be adversely affected by such activities include marine and estuarine protected areas, sacred sites, occupational reserves, fisheries reserves and undeclared areas. Other undeclared areas such as seagrasses, mangroves, turtle or bird breeding areas, shipwrecks, recreational sites and potential aquaculture development sites are also the subject of considerable interest.

No declared protected areas are listed by the Australian National Parks and Wildlife Service (ANPWS, 1984) in the Carpentaria Basin area suggested for Release 1 of 1992.

Climate

All of northern Australia including the coastal regions closest to the vacant area is subject to a monsoon climate, with a wet season during the northwest monsoon (summer) and a dry season during the southeast tradewinds (winter) from May to October. The area has a marked variation in temperature, salinity, rainfall and wind regimes. Rainfall is heaviest in the northwest monsoon of the Austral summer with a drier period during the dry southeast trade winds.

The southeast trade winds can generate moderate to rough seas, the main swell being from the southeast. During much of the monsoon season seas are calm and smooth except for the disturbance caused by tropical cyclones. Swells developed during cyclones come from the southwest, west and northwest.

Humidity levels are high year round with an average relative humidity at 9 am of 80 per cent in January and 70 per cent in July (Division of National Mapping, 1986). Median annual rainfall is 800 mm per year with an intensity of 4 mm per hour. The year round average temperature is above 18 degrees Celsius (Division of National Mapping, 1986).

The seasonality in temperature and wind regimes has a significant effect on the salinity levels in nearshore areas and water temperature. Nearshore waters can vary in temperature (by 10 degrees C) and salinity range of 12 (Poiner & others, 1987) but this variation is less marked in offshore areas. Much of the nearshore variation is related to the volume (and sediment load) of runoff from coastal river systems. In the central part of the Gulf seasonal water temperature varies 5 degrees C and salinity 3. Water from the Coral and Arafura Seas can intrude into the Gulf and modify these local patterns (Poiner & others, 1987).

Geomorphology

The Gulf or Carpentaria is the largest embayment on the coastline of Australia and has an opening some 500 kilometres wide to the north. It is connected to the Coral Sea to the east via the Torres Strait between Australia and Papua New Guinea and to the Arafura Sea to the west via a 500 kilometre gap between the Northern Territory and Papua New Guinea.

The continental shelves between Australia and Papua New Guinea are continuous beneath the Gulf in water depths of 40 to 67 metres (Jones & Torgersen, 1988). The margins of the Gulf are relatively narrow and moderately steep in contrast to the central area which is gently undulating. The vacant area covers much of the deepest part of the Gulf where water depths exceed 65 metres west of the Cape York Peninsula.

A large number of river systems flow into the Gulf particularly during the summer monsoon period when the dominant wind direction is from the northwest. During the dry winter periods the southeast trade winds prevail. As a result of this pattern, fluvially-derived sediments comprise a major part of coastal sedimentation.

Quaternary history

In the Tertiary much of the present coastline of northern Australia, including the marine shelf underlying the vacant area, was elevated above sea level and subjected to subaerial erosion (Jongsma, 1974; Hughes, 1978). During the Pleistocene several changes in sea level occurred and were followed by a final Holocene transgression. These processes were identified by Jongsma (1974) and are apparently reflected in the development of several features.

Low sea levels in the Pleistocene, prior to the Holocene transgression, are suggested by Torgersen & others (1985) to have resulted in subaerial exposure of the Gulf of Carpentaria and a drier climatic regime. Their analysis of three core samples down to 2 metres below the sea bottom from sites within or near the vacant area indicate that several changes have taken place since 36 000 years B.P.

Sedimentation from a marine to brackish water body is evident from the ostracod and foraminifera-bearing sequence dated as 36 000 years B.P. in the base of core GC2 which was collected immediately north of the vacant area (12-31.18' south, 140-21.14' east). A period of subaerial exposure followed forming a soil horizon in this sequence. From 36 000 to 26 000 years B.P. a fresh to brackish water body deposited sediments evident from shell remains and foraminifera. After that period some calcite precipitation took place in a similar setting. From 26 000 to 10 000 years B.P. ostracod and foraminifera faunas indicative of lake conditions were developed. After 10 000 years B.P. sea level rose sufficiently to inundate the margins of 'Lake Carpentaria' and restored full marine conditions (Torgersen & others, 1985).

Other detailed investigations in onshore dunefields by Lees & others (1990) are complimentary to the offshore core studies. The dune studies indicate that they developed in an episodic fashion - the first period of dune and chenier building falls between 2 600 and 1 800 years B.P., a second period falls between 8 500 and 7 000 years B.P. and a third between 81 000 and 171 000 years B.P.

Each of these periods of dune building and development identified by Lees & others (1990) coincides with drier climatic change, higher evaporation and lower precipitation. Reduced vegetation cover has resulted from the drier climate and seasonally persistent winds have resulted in greater dune mobility. Rising sea levels further contribute by eroding foredunes initiating blowouts and the development of transgressive dune sequences (Lees & others, 1990).

Stabilisation of dune systems by vegetation halts the process and this usually coincides with periods of increased rainfall. Past studies have highlighted the additional contribution of local sediment budgets, glacial low sea level stands, marine transgressions, cycles of storms and anthropogenic disturbances as the source(s) of processes leading to dune formation and emplacement (Lees & others, 1990).

A specific examination of the strandline units at Point Stuart, approximately 15 kilometres east of the mouth of the Mary River, on the coast of Van Diemens Gulf east of Darwin by Lees (1987) has identified at least five chenier ridges which have formed in the last 1270 years. Major storms over an 80 to 200 year frequency appear to have built the five ridges closest to the coast. A further five ridges landwards of this set have a much lower proportion of carbonate and shelly material and differences between the two sets are explained by a major change in the pattern of sediment supply (Lees, 1987). The switching of the Adelaide River system from Chambers Bay to Adam Bay and the abandonment of a single channel for the Mary River to several discharge channels may be the cause of the differences between the two sets of chenier systems.

The beach ridges at Point Stuart and others around the coastal fringes of northern Australia are formed by storm waves where wave base reaches deeper and further offshore than normal. Wave-winnowing can excavate shelly material and remove fine-grained sediments, allowing coarse-grained sediments and shell debris to accumulate on the strandline or at storm-surge level landwards of the normal strandline.

Recent sedimentation

Each of the major coastal features identified above is noted for the development of a suite of sediment types, including fluvial channel and floodplain sequences landwards of the coastal system. These sediments comprise silt, fine sand, mud, minor gravel and alluvium up to a total of 5 metres in thickness in meander channels, swamp depressions and even cut-off meanders. Towards the hinterland

and in between such units are red sandy and mottled grey to yellow sandy soils up to 10 metres thick which form in colluvial and eluvial environments (Hughes, 1978). The latter are generally developed as a result of the erosion and dissection of Tertiary and possibly older consolidated sequences.

In coastal and offshore areas littoral, aeolian, intertidal deltaic and estuarine sand, shell and coral debris, organic rich mud and silt are being deposited in sequences up to 20 metres thick. Beach and littoral strandline sands are evident on present coastlines and as low vegetated ridges. Along some shoreline and other areas Pleistocene coquina, calcarenite and conglomerate have formed in sequences up to 8 metres thick (Hughes, 1978). The extensive estuarine systems are evident at the mouths of major river systems developed where marine inundation drowned existing river valleys.

Present-day sedimentation patterns in the Gulf of Carpentaria are dominated by the nearshore high to moderate sedimentation rates in water depths of less than 50 metres. Within such areas, however, sedimentation rates are variable and depend on the proximity to major sources such as river systems, and the degree of exposure to tidal and wave energy (Jones, 1987). Summer rainfall produces much of the runoff responsible for nearshore sedimentation processes. During winter, dry conditions and southeasterly winds result in some degree of reworking of sediments along the shallower parts of the west coast of the Gulf (Jones & Torgersen, 1988). Sandy sediments accumulate in the nearshore areas as delta sands at the mouths of major river systems and may be reworked *in situ* or end up as part of adjacent beach ridge of chenier shoreline systems. Suspended sediment load is deposited as a zone of prodelta sandy mud around the entire coastline of the Gulf and extends out to water depths of approximately 20 metres. Nearshore tidal patterns of sediment transport are parallel to the coastline while cyclone-induced sediment transportation is anti-clockwise around the margins of the Gulf (Phipps, 1980).

Offshore areas of the Gulf have comparatively low rates of sedimentation and as a result some of the major features are relict lithotypes (Figure 2). Relict sandy mud and muddy sand seawards of the area of present prodelta sedimentation is, according to Jones and Torgersen (1988), a relict alluvial sequence likely to be an extension of large alluvial fan systems deposited during lower sea level periods. These fans are extensions of the fans described in onshore areas by Grimes & Doutch (1978) and in nearshore areas of the Gulf they are concealed by present-day prodelta sediments (Jones & Torgersen, 1988). Other relict sediment forms include a tidal delta system west of Torres Strait, ooid-rich sediments on the Carpentaria Rise and channel erosion and back-fill units on the Arafura Sill which are related to closure of the Carpentaria Basin in the Late Quaternary.

Major ecological features

Mangroves

These are essentially marine tidal forests and are adapted to colonising loose wet soil types which are subject to periodic tidal submergence. On the Gulf of Carpentaria coastline conditions favourable to their development are widespread, particularly around coastlines in bays, tidal channels and estuaries. The overall control on the occurrence of mangrove forests is the minimum air temperature, although mangroves are known to range into temperate parts of the Australian coastline (Hatcher & others, 1989). Locally such conditions as soil salinity, frequency of tidal inundation, sedimentation, rainfall variation and frequency of tropical cyclones all contribute to the richness of tree species in mangroves (Smith & Duke, 1987). There is some debate over whether mangroves are the cause of sediment aggradation and accumulation or the opportunistic consequence of existing sedimentation processes. They are generally regarded as the means of stabilising sediments deposited by the prevailing physical forces rather than the cause of sedimentation.

Optimum conditions for mangrove development are generally present in brackish water areas. The theory that mangroves are important sources of outwelled dissolved nutrients has been challenged by Boto & Wellington(1988) who suggest that no net annual exchange of organic or inorganic nutrients occur in mangroves and that they require a significant import of dissolved phosphorus for growth. They are however important areas for the development of juvenile fish and prawns (*Penaeus merguiensis* in particular) (Staples & others, 1985). Mangroves in northern Australia have been demonstrated to contain in order of magnitude greater a number of juvenile fish and prawn species than adjacent seagrass, bay and estuarine areas (Robertson & Duke, 1987).

Major causes of disturbance to mangroves from human activities are generally those which result in reclamation of intertidal areas for industrial or other uses. The presence of iron pyrite (iron sulphide) in the anaerobic subsoil of such areas can render them unsuitable for use in agriculture and aquaculture (Hatcher & others, 1989). There is a very close correlation between the areal extent of mangroves on the Carpentaria coast of the Northern Territory and the size of commercial prawn catches in adjacent coastal waters (Kirkwood & Somers, 1984).

While spillages of crude oil are very rare and mainly occur as a consequence of maritime transportation mishaps they can have a significant impact - the effects can be cumulative for mangroves exposed to the side effects of high-density maritime traffic. The presence of 2.4 per cent crude oil by weight in the sediments of mangroves has been shown to be sufficient to prove fatal in two months resulting from the interruption of water supply to the leaves (Allaway, 1987). The speed of recovery is potentially related to the period required to degrade the crude oil.

Seagrasses

Seagrass communities develop below the low tide zone and in estuaries, bays and the open ocean into water depths of up to 30 metres. Water clarity is the factor which controls the depths of seagrass development. In turbid water they grow in very shallow depths due to a low level of light penetration. Their significant effect on the substrate is in binding sediment particles together by means of a fine mat of roots thus stabilising it. The effect of widely vegetated substrates is that they can reduce the height of storm surges and provide a physical baffle against tidal and current flows (Hatcher & others, 1989). The latter development can encourage the settlement of benthic larvae in areas of sheltered water and thus significantly increase local species diversity. Seagrass communities are known to be present on the coastal fringes of the western part of the Gulf of Carpentaria (Figure 2).

Seagrass communities are also important nursery grounds for juvenile tiger and endeavour prawns which are of major importance in the prawn catch from northern Australia (Poiner & others, 1987). The seagrass communities of the Northern Territory coastline contain similar species to those in the eastern Gulf of Carpentaria and inhabit intertidal to shallow subtidal areas. Species of *Cymodocea*, *Halodule*, *Enhalus*, *Thalassia*, *Syringodidium* and *Halophila* are most commonly present (Poiner & others, 1987). The seagrass assemblages evidently occur in both depth-limited associations along open coastlines as well as mixed-species associations from the intertidal zone. The depth-limited communities tend to be dominated by a single species such as *Syrinodium* sp. , *Thalassia testudium* and/or *Cyodocea serrulata* (Poiner & others, 1987) .

On open coastline areas monospecific stands of *Halophila ovalis* and *H. uninervis* dominate the intertidal zone, whereas *C. serulata* and *S. isoetifolium* are the major species in the subtidal areas (Poiner, & others, 1987).

The western part of the Gulf of Carpentaria has been closely investigated for the interaction between prawn populations and seagrasses (Poiner & others, 1987). Of the four types of seagrass community in reef-flat, open coastline, sheltered embayment and river mouth areas, juvenile prawns are least well represented in the river mouth area, are most prevalent in the sheltered embayment and of intermediate numbers in the reef-flat and open coastline areas (Poiner & others, 1987).

Human activities which can most seriously impact on seagrass communities are the dredging and infilling habitat areas. Significant side effects can also develop without direct disturbance because of turbidity or the resuspension of unconsolidated sediments (Hatcher & others, 1989). Increased nutrient levels in runoff from the landsurface can also lead to widespread mortality and habitat loss. Even with only mild disturbance habitat changes can occur and be sufficient to cause a turnover from the more diverse subtidal species assemblage to the hardier intertidal forms.

Prawns

The banana and tiger prawn species of the Gulf of Carpentaria region are part of naturally-occurring populations present in Australia waters as far south as 29 degrees. The prawn species spawn offshore but migrate into rivers and estuaries as juveniles and return to the sea as adults (CSIRO, 1983). Their main diet is protozoans, small molluscs, crustaceans and polychaete worms. The southeastern part of the Gulf is the main spawning area year round but peak spawning activity takes place during spring and autumn.

Juvenile prawns migrate into rivers during peak flood tides from November to May but peak migration is in November before the wet season commences. Juveniles settle on the mud in shallow mangrove stands lining river channels and return to nearshore waters during autumn, progressively moving into deeper waters as adulthood is approached. The amount and timing of rainfall influence the number of adolescent prawns returning to the sea to repeat the breeding cycle. Wind and wave patterns have considerable influence over whether juvenile prawns are successful in reaching the mouths of major river systems where they can obtain access to nursery areas and repeat the migratory cycle. Some commercial catches have represented as much as 80% of the available stock and have come close to risking the viability of future fishing operations (CSIRO, 1983).

Prawn abundance studies from other parts of the world, outlined by Somers (1987), link their distribution with the organic carbon content of sediments but such a relationship could not be clearly demonstrated in the western Gulf of Carpentaria. Although juvenile forms are mainly confined to shallow muddy bays in the western Gulf adult forms are evenly distributed. A preferred depth range of around 20 to 40 metres is evident for the major prawn schools. The deeper waters of the Gulf do not support any major commercial prawn stocks (Poiner, 1987). Different species of prawn within the shallower waters of the Gulf are noted for their distinctive depth and sediment preferences (Poiner, 1987).

Potential impacts

Seismic

The initial form of exploration activity likely to occur in any potential release area comprises seismic surveying work. This activity generally is undertaken by the towing of surveying equipment, in the form of a receiver cable and acoustic signal source, along a grid of survey lines sufficient to determine the subsurface geological structure of the region. As the activity is brief and coverage of the region is generally sparse, limited if any environmental effect occurs. The impact of the periodic acoustic signal on fish and invertebrate populations is minimal unless they are within a metre or so of the signal source (Neff & others, 1987). Some concerns have been raised about the disturbance effects of such signals on larger marine mammals at close range (less than 1 kilometre) even though the noise levels generated are less than those generated by mammals during periods of vigorous activity.

Noise appears to be a significant feature of any disturbance caused by exploration activity. Under most circumstances, according to Geraci & St. Aubin (1987) marine mammals and vertebrates habituate to low level background noise. The most significant effects of exploration activity have been produced from areas around the world where such activities are of part of a widespread disturbance of the environment, resulting in subtle changes in habitat and a fundamental intrinsic stress on the environment (Geraci & St. Aubin, 1987).

Drilling

Exploration drilling involves drilling of a subsurface bore into geological sequences which may contain natural accumulations of petroleum. As drilling is undertaken using purpose-designed vessels anchoring and operation cause no specific long-term impact and limited local disturbance. Less than 40 days of operation are generally involved in the drilling of exploration wells and the main initial activity involves the installation of subsurface tubing and associated cementation.

Excavation of the well bore generates cuttings of subsurface rocks which are size-sorted and washed prior to discharge to the sea bed where ultimate dispersal by local currents readily occurs. Drilling fluids used to lubricate drill bits, maintain and clean out the well bore generally comprise a mixture of sea water and naturally-occurring clay minerals. Limited amounts of the clay mineral component may be present on the rock cuttings discharged to the sea bed. Limited quantities of fluids such as treated sanitary wastes are also discharged to the sea during such operations, as would take place during any normal maritime operation.

Production

Should the results of exploratory drilling warrant it, fixed or floating structures could be installed to commercially develop any potential hydrocarbon accumulation(s). Development for such accumulations could involve the drilling of a number of development wells from drilling/production facilities. Production will usually, in the case of crude oil production, involve the discharge of subsurface water separated from the crude oil into the sea after processing. If full processing is undertaken onboard an offshore production facility, offloading and transportation are required, otherwise a pipeline connection to shore-based facilities will be installed. The functioning and effects of such operations are beyond the scope of this analysis and the most relevant local guide to the long-term effects of such operations are production platforms and facilities of the Gippsland Basin in Bass Strait.

Major studies of the ecological impact of production facilities are available for a range of marine habitats. Some ecological changes do occur and these are largely related to artificial reef effects or changes due to the presence on the sea bottom of cuttings. Other changes are subtle and not readily detectable without great sampling effort (Spies, 1987).

Conclusions

The Gulf of Carpentaria is a large indented embayment on Australia's northern coastline and the continental shelf. Below its waters is a continuous platform between Australia and Papua New Guinea, much of it at a depth of 50 to 70 metres. Sea level changes during the Quaternary period have resulted in repeated exposure and emergence with changes ranging as much as 150 metres.

Major ecological features of the current coastal zone adjacent to the potential release area include coastal and estuarine mangrove and seagrass communities. Seismic surveying and drilling are the main petroleum exploration activities likely to be undertaken in the potential release area. The baseline data for environmental conditions in the Gulf of Carpentaria can be assessed from the information collected by the CSIRO program (CSIRO, 1983) on the prawning industry and associated publications (Poiner & others, 1987). The pattern of data from the region provides a useful reference frame with which any post-exploration patterns can be compared.

From available data it is evident that the transitory nature of exploration operations are such that minimal localised disturbance can be expected from seismic and drilling activities. Cuttings generated during drilling operations are the only significant traces of such work and these are rapidly reworked and removed by normal marine processes. At the completion of exploration work the only visible signs of drilling would be the presence of rock fragments on the sea bottom and normal current and tidal action would disperse these within a short period. The impact of the installation of production facilities would require more specific examination beyond the scope of this analysis, possibly an environment impact analysis.

No visible long term effects are anticipated from such activities if the work record of the industry attained elsewhere in Australia is maintained by future work in this region.

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Figure 1. Bathymetry of the Gulf of Carpentaria and location on proposed vacant area.

Figure 2 . Major sediment types of the Gulf of Carpentaria. Data from Jones (1987) and Jones and Torgersen (1988).