Technical Appendix S3

Ichthys Gas Field Development Project: literature review of seabirds in the vicinity of Ichthys Field infrastructure in the Browse Basin, Western Australia

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1 Introduction

1.1 Background

INPEX are completing the Environmental Impact Assessment process for the proposed Ichthys Gas Field Development in the Browse Basin. INPEX require further information on the migratory and resident seabirds present in the Browse Basin, particularly for the Ichthys Field and Browse Island, within the regional context of the North West Marine Region, and have contracted Halfmoon Biosciences to provide this information. INPEX had collected seabird data between June and October 2008, during surveys conducted by the Centre for Whale Research (CWR) during 4 x 20 day at-sea surveys, through an area from just east of Browse Island to just west of Scott Reef (Jenner *et al.* 2009).

1.2 Scope of Work

The consultant, Halfmoon Biosciences, will review the previous survey data collected for the client by CWR, as well as provide a literature review of seabird distribution data from other published and unpublished sources for the region described above. The assessment of the conservation status of seabirds of the Browse Basin will be presented with reference to this data and will include the relative abundance of each species found in the area, and the significance of each species' presence (i.e. vagrant, regular visitor, breeder). This information will be compared with the greater North West Marine Region. The literature review will present the seasonality of the distribution of seabirds as well as the known location of breeding colonies. The review will also focus on those species covered by the EPBC Act, including those listed under the JAMBA, CAMBA and ROKAMBA agreements.

This report will:

- Identify the seabirds that are likely to be present in the vicinity of the proposed INPEX Ichthys Project and include their listing under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Wildlife Conservation Act 1950,* and whether they are protected by JAMBA, CAMBA and/or ROKAMBA.
- Describe the significance of these habitats in a regional context (i.e. compared to other important sites in the region).
- Describe the peak periods of seabird activity.

1.3 Nomenclature

For the purposes of this report, seabirds are defined as:

- Seabirds - those birds associated with the sea and deriving most of their food from it, and typically breeding colonially, but including the marine raptors the Osprey and White-bellied Sea Eagle.

Recently, there have been significant changes in the names of some species of birds. In some cases, and particularly for data presented on the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPC) website, names remain

unchanged. However, throughout this report taxonomy of bird species follows that presented in Christidis and Boles (2008), with the changed nomenclature.

We define water bodies after Pearson (1968) as;

- Inshore, those waters within site of the mainland coast,
- Offshore, those waters sitting from the coast to the 200m bathymetric line
- Oceanic waters, those waters that fall greater than 200m depth.

The area referred to as the "Browse Basin" in this document encompasses 185 000 km^2(Figure 2) and lies offshore of the northwest margin of the Australian mainland in water depths from 20 metres to more than 2000 metres. The area is bounded by the Leveque Shelf in the south, Ashmore Reef to the north and the Scott Plateau comprises the oceanward margin of the basin to the west.

2 Oceanographic Influences On Seabirds of the North West Marine Region

The annual distribution and abundance of seabirds in the NW Marine Region are strongly influenced by its oceanography, in particular the location of the South Equatorial Current, the strength of the Leeuwin Current, and the influence of the Indian Ocean Dipole (IOD). The foraging distributions, timing of breeding, size of breeding populations and the reproductive success of seabird species breeding in the NW Marine Region are influenced by the annual and inter-annual variability in the strength and timing of the Leeuwin Current and Indonesian through-flow, which affect the availability and abundance of prey (Dunlop *et al.* 2002, Nicholson 2002).

Recent studies on breeding seabird populations have shown marked variation in the numbers and success of breeding seabirds in relation to the El Nino Southern Oscillation (ENSO) (see Dunlop *et al*. 2001, for the most northerly assessment of this influence on Wedge-tailed Shearwaters). Other reports have identified that these changes are reflected in seabird diet and foraging habits (Surman and Nicholson 2010, Nicholson 2002). It is likely that changes in the Indian Ocean Dipole may also influence seabird breeding and foraging patterns.

Previous studies have found that seabird community assemblages in the Indian Ocean were linked to particular sea surface temperature and salinity "envelopes" (Pocklington 1979). Another study found that seabird assemblages were related to different marine environments (shelf, offshore, oceanic), with sea surface salinity having the greatest influence upon seabird distribution in oceanic waters, whilst temperature was more influential within shelf waters (Dunlop *et al.* 1988). Seabird assemblages in tropical and sub-tropical waters can be broadly grouped so that "shelf" seabirds include terns, gulls, cormorants and pelicans; "offshore" seabirds include terns, gulls, boobies, shearwaters, petrels, storm petrels and tropicbirds; while "oceanic" seabirds include terns, boobies, frigatebirds, shearwaters, petrels, skuas and tropicbirds. Within each grouping there is frequent overlap of species between marine environments. Seabird distributions that can be defined as offshore and pelagic/oceanic often overlap where the continental slope occurs (Surman and Wooller 2000).

More recently the role of meso-scale oceanic features such as the South Equatorial Current and the Leeuwin Current, and annual indicators of oceanographic and climatic phenomena

such as ENSO and the IOD, have been found to affect prey availability and distribution for seabirds, and hence the distribution of seabird assemblages themselves (Dunlop *et al.* 2002, Nicholson 2002).

2.1 The South Equatorial Current

The South Equatorial Current (the tropical convergence) is located between 12 and 14^{o}S in October but shifts southwards in April to 18^{o}39' (Dunlop *et al*. 1995). The Indonesian Through Flow (ITF) drives the South Equatorial Current, which is a major circulation feature during the south-west monsoon season (Wooller *et al.* 1991). During the north-east monsoon, the South Equatorial Current loses strength and retreats south, whilst the Equatorial Counter Current (locally the Java Current) enters from the west. Just south of Java it is drawn into the South Equatorial Current, which flows in the opposite direction. Reportedly there is some upwelling at the interface between the two current systems which is of some importance to the productivity of this part of the ocean. The deep overlying oligotrophic waters of the ITF are a major barrier to convective mixing up of nutrients, hence turbulent mixing from other processes such as equatorial currents and internal tidal mixing critically control the nature of productive processes at the local, regional and collectively at the largest basin scale. The ITF appears to be subject to the pronounced inter-annual variations of El Niño-Southern Oscillation events (Heyward *et al*. 1997). Higher seabird abundance has been found to occur on the edge of the South Equatorial Current, regardless of the season, indicating that it is an area of high marine productivity (Dunlop *et al.* 1995).

2.2 The Leeuwin Current

The main oceanographic feature of the NW shelf of Western Australia, and indeed the whole Western Australian coastline, is the Leeuwin Current. This is a body of warm (>24˚C), low-salinity (<35‰) water which flows southward from the ITF along the continental shelf of Western Australia, in a broad and shallow band (200km wide by 50m depth) at speeds of up to 2 km.h^{-1} (Cresswell 1990, Pearce and Walker 1991). It flows principally in winter, and its strength and temperature is affected by El Nino Southern Oscillation (ENSO) events. In ENSO years the Leeuwin Current is weaker, resulting in cooler, more saline water along the outer continental shelf (Pearce and Walker 1991). In non-ENSO years higher sea levels and warmer sea temperatures occur along the Western Australian coastline, resulting in the Leeuwin Current having a stronger southward flow (Cresswell *et al.* 1989). Reduced breeding participation and reduced breeding success has been observed in Wedge-tailed Shearwater colonies during seasons influenced by ENSO events (Nicholson 2002, Dunlop *et al.* 2002, Surman and Nicholson 2008).

The Leeuwin Current inhibits upwellings of cooler, nutrient rich waters, resulting in low biological productivity. As a consequence, seabird abundance in the NW Marine Region is much lower, and tropical species occur much further south, than at equivalent latitudes off the west coasts of Africa and South America, which possess northward-flowing currents and strong coastal upwellings (Wooller *et al.* 1991).

2.3 The Indian Ocean Dipole (IOD)

The IOD is measured by an index which is the difference between the sea surface temperature between the western and eastern equatorial Indian Ocean (Saji *et al.* 1999, cited in www.bom.gov.au/climate/IOD). Whether the IOD is positive (cooler than normal water in the tropical eastern Indian Ocean, while it is warmer in the western Indian Ocean) or negative (warmer than normal water in the tropical eastern Indian Ocean, cooler in the western) has an influence upon the climate of Australia and other countries surrounding the Indian Ocean Basin. The difference in ocean temperature may also affect prey distribution and availability for seabirds, and hence their breeding distributions, timing of breeding, breeding participation and breeding success from year to year. It may also affect non-breeding birds foraging distributions.

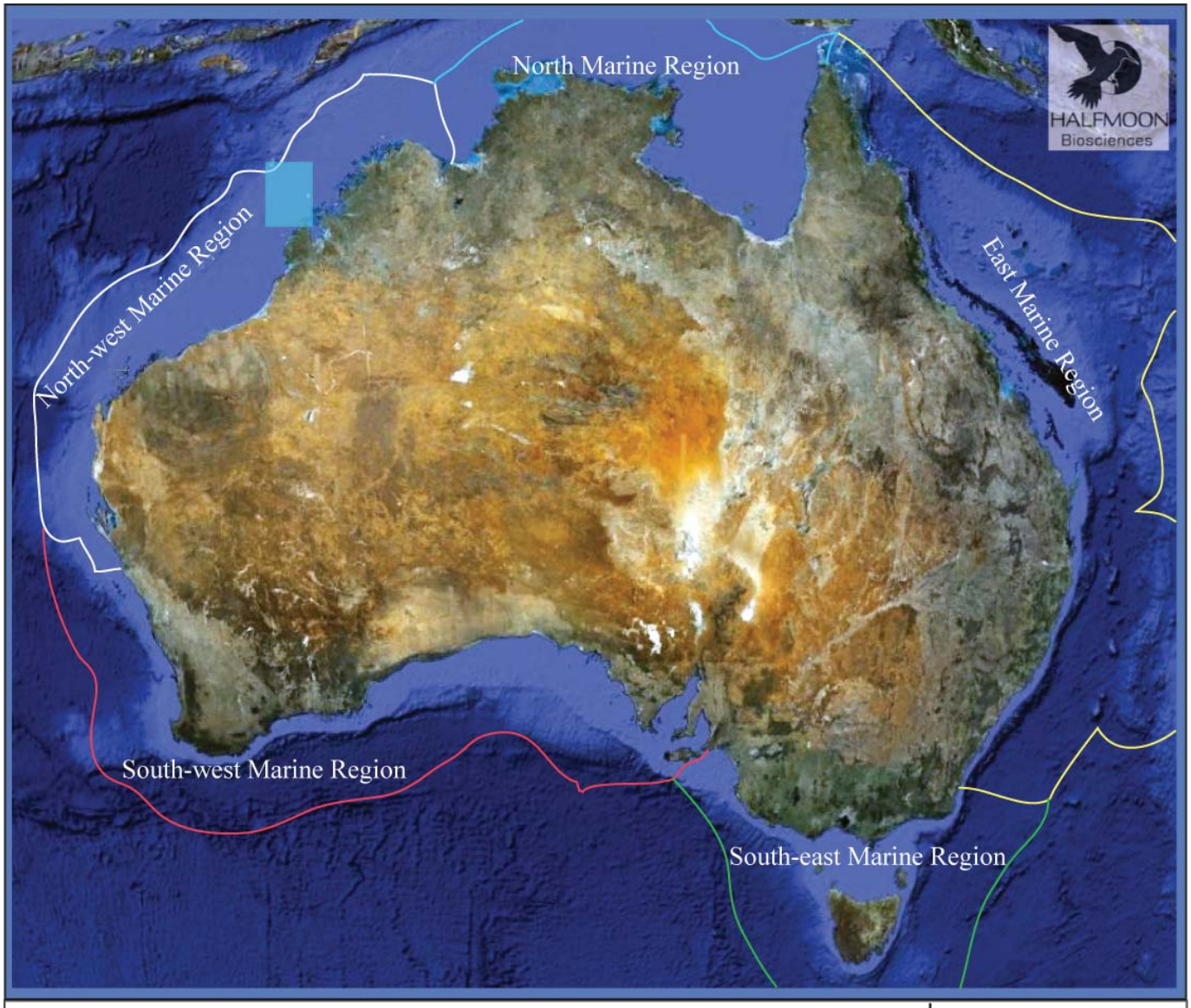

Figure 1: Figure of Australia showing the Marine Regions as defined by the Marine Bioregional Planning under the EPBC Act (1999) as well as the area of interest covered in this report (light blue). The regions are those referred to in Ross *et al*. (1994).

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Date: 1 February 2011

3 Seabirds of the North West Marine Region

The most recent and comprehensive summary of Australia's seabirds is presented in Ross *et al.* (1994). This document lists estimated populations of breeding seabirds for each Region described by the Department of Sustainability, Environment, Water, Population and Communities Marine Bioregional Planning (Figure 1). The proposed INPEX Ichthys site is contained within the Browse Basin, which is part of the North West (NW) Marine Region (Figure 1). Approximately 230 000 pairs of seabirds from 22 species have been estimated to breed on islands across the greater NW Marine Region (Shark Bay to the Northern Territory border) (Ross *et al.* 1994). This number probably underestimates the total numbers of breeding pairs, as more recent surveys have identified new breeding grounds. Thirty nine species of seabirds have been observed "at sea" in this area (also known in the literature as the "tropical East Indian Ocean") (Dunlop *et al.* 1995), some of which are southern species that move into waters north of 23˚ S during the winter period. Few southern species extend into the region under consideration here.

Seabird assemblages observed foraging over differing marine habitats will shift spatially and temporally, consistent with oceanographic and climatic changes affecting prey distribution and abundance (as outlined in Section 2). Whilst foraging distances from the breeding colony can be determined for various seabird species by their breeding strategy, morphology and physiology, their migratory and non-breeding distribution is also likely to be influenced by prey distribution and those mechanisms that make prey available to seabirds (i.e. the distribution of tunas or cetaceans; Ballance *et al* 1997. Harrison *et al*. 1983, Diamond 1983, Surman and Wooller 2003).

3.1 Seabirds Species Breeding in the NW Marine Region

The seabird fauna of the NW Marine Region consists of predominantly tropical and sub-tropical species such as boobies, frigatebirds, cormorants and tropicbirds, as well as tropical terns and noddies. Breeding species include Brown Boobies *Sula leucogaster* , Masked Boobies *Sula dactylatra*, Lesser Frigatebirds *Fregata ariel* , Wedge-tailed Shearwaters *Ardenna pacifica*, Crested Terns *Thalasseus bergii*, Bridled Terns *Onychoprion anaethetus*, Roseate Terns *Sterna dougalli* and Pied Cormorants *Phalacrocorax varius* (Surman *unpubl. obs*, Ross *et al*. 1994). Bridled Terns and Wedge-tailed Shearwaters migrate to the NW Marine Region to breed, taking advantage of temporary abundances in food sources.

3.2 Migratory Seabird Species in the NW Marine Region

Non-breeding species include many Pacific Ocean pelagic species such as Streaked Shearwaters *Calonectris leucomelas*, Tahiti Petrels *Pseudobulweria rostrata*, Hutton's Shearwaters *Puffinus huttoni* and Matsudaira's Storm-petrels *Hydrobates matsudaira*. These species migrate into the NW Marine Region from the Pacific via the Indonesian Through-flow (Wooller *et al.* 1991). Others, such as the Wilson's Storm Petrel *Oceanites oceanicus* move into waters of the NW Region, and into the Timor sea, during the austral winter (Dunlop *et al*. 1995, Harrison 1983).

Large numbers of seabirds breeding in more southern colonies migrate into or through the NW Marine Region during their non-breeding period. For example, Wedge-tailed Shearwaters tend to move into waters north of 12˚S, passing through areas south, between May and September. Large numbers of shearwaters have been observed foraging off the North-west Shelf between May - August (Surman *unpub obs*.). Bridled Terns that nest in colonies in offshore islands of the mid-lower west coast are known to migrate along the shelf waters of the NW Marine Region to potential over-wintering areas in Borneo and the Philippines (Dunlop and Johnstone 1994). Lesser Crested Terns *Thalasseus bengalensis* and Brown Boobies *Sula leucogaster* are resident in the NW Marine Region throughout the year, although they may forage long distances over the open ocean.

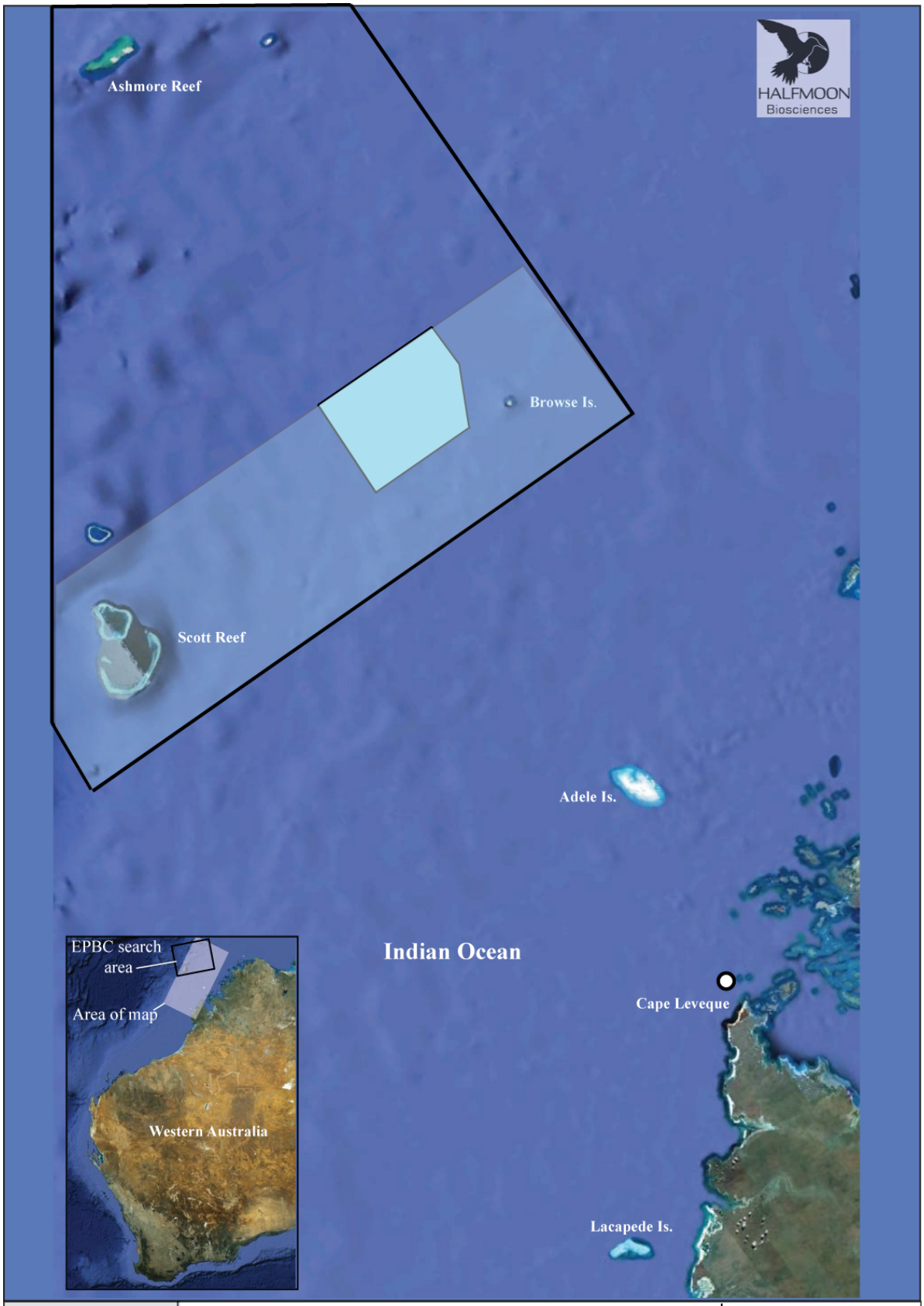

Figure 2: Location map of areas mentioned in the text adjacent to the Browse Basin. The approximate project area is highlighted in light blue, and the area surveyed by Jenner *et al*. (2009) is shown in white. The area covered by the EPBC Protected Matters search is outlined in black.

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Table 1: Protected Matters Seabird Results for the Browse Basin Area in the NW Marine Region. Data from the EPBC Protected Matters search tool.

Species	Status		Type of Presence
	Migratory	Marine	
Wedge-tailed Shearwater *Ardenna pacifica*	✓	✓	Breeding known to occur within Browse Basin
Streaked Shearwater *Calonectris leucomelas*	✓	✓	Species or species habitat may occur within Browse Basin
Lesser Frigatebird, Least Frigatebird *Fregata ariel*	✓	✓	Breeding known to occur within Browse Basin
Great Frigatebird, Greater Frigatebird *Fregata minor*	✓	✓	Breeding known to occur within Browse Basin
White-tailed Tropicbird *Phaethon lepturus*	✓	✓	Breeding known to occur within Browse Basin
Masked Booby *Sula dactylatra*	✓	✓	Breeding known to occur within Browse Basin
Brown Booby *Sula leucogaster*	✓	✓	Breeding known to occur within Browse Basin
Red-footed Booby *Sula sula*	✓	✓	Breeding known to occur within Browse Basin
Brown Noddy *Anous stolidus*	✓	✓	Breeding known to occur within Browse Basin
Bridled Tern *Onychoprion anaethetus*	✓	✓	Breeding known to occur within Browse Basin
Caspian Tern *Hydroprogne caspia*	✓	✓	Breeding known to occur within Browse Basin
Australian Lesser Noddy *Anous tenuirostris melanops*		✓	Breeding known to occur within Browse Basin **Also listed as Threatened and Vulnerable**
Red-tailed Tropicbird *Phaethon rubricauda*		✓	Breeding known to occur within Browse Basin
Crested Tern *Thalasseus bergii*		✓	Breeding known to occur within Browse Basin
Roseate Tern *Sterna dougalli*		✓	Breeding known to occur within Browse Basin
Black Noddy *Anous minutus*		✓	Breeding known to occur within Browse Basin

4 Seabirds in the Browse Basin

4.1 Seabird database and survey data

Several EPBC Protected Matters Searches were undertaken for seabird species likely to be found in the Browse Basin. A broader database search encompassing Ashmore Reef, Scott Reef and Browse Island, revealed a total of 16 Marine Species, 11 of which were also migratory and one, the Lesser Noddy, was listed as Threatened and Vulnerable (Table 1). The search area is shown in Figure 2 and was bounded by the following co-ordinates, covering 80,000km^2 (250 x 320 km search area):

14.35^{o}S, 123.92^{o}E,
14.39^{o}S, 120.96^{o}E,
12.12^{o}S, 123.92^{o}E
12.12^{o}S, 120.96^{o}E

A more limited search, focussing on the immediate proposed INPEX Ichthys development area (Figure 2), listed the Streaked Shearwater only. For the purposes of this report, we will consider those species listed under the broader search area in the first instance, as this list reflects those seabird species that have been regularly observed by recent surveys in the Browse Basin region, and which can be assumed to use the waters in the development region also (AES 2004, 2008, Milton 1997, Birding Australia 2010). This apparent limitation of lack of information in the EPBC Protected Matters Tool is of some concern when assessing those species that may be impacted by potential developments. The observed occurrence of seabirds observed directly within the proposed INPEX Ichthys development site is presented in Table 2 and discussed in Section 4.3.

Seabird species that have been recorded in the Browse Basin, inclusive of Scott and Ashmore Reefs, were identified using the Department of Conservation and Land Management (now Department of Environment and Conservation) Seabird Breeding Island Database (SBIDB - DEC 2006), unpublished data from scientific and seismic surveys undertaken by J.N. Dunlop and C. Surman between 1996-2007, the CWR surveys (Jenner *et al.* 2009), as well as published and unpublished scientific reports from the NW Marine Region (AES 2004, AES 2008, Birding Australia 2010). Thirty nine seabird species were identified, along with their status under the EPBC Act, and are presented in Table 2.

Table 2 Seabird species recorded at sea in the Browse Basin and their status under the EPBC Act 1999. Data sourced from Jenner *et al*. (CWR surveys, 2009) and unpublished observations recorded during "at sea" surveys between Broome and Ashmore Reef between 2004-2010 (AES 2004, AES 2008, Birding Australia 2010). Included are those species observed directly over the proposed INPEX Ichthys Field site which were recorded during the CWR surveys.

Species		CWR Survey Jun/Jul 2008	CWR Survey Oct/Nov 2008	INPEX Ichthys Site 2008	AES Tour Transect 2004	AES Tour Transect 2008	BA Tour Transect 2010	EPBC Status	Migratory
Herald Petrel	*Pterodroma heraldica*	✓					✓	Critically endangered, Marine	
Tahiti Petrel	*Pseudobulweria rostrata*				✓	✓	✓	Marine	
Jouanin's Petrel	*Bulweria fallax*				✓		✓		
Bulwer's Petrel	*Bulweria bulwerii*		✓	✓	✓	✓	✓	Marine	
Streaked Shearwater	*Calonectris leucomelas*		✓	✓	✓	✓	✓	Migratory, Marine	ROKAMBA, JAMBA, CAMBA
Wedge-tailed Shearwater	*Ardenna pacifica*			✓	✓	✓	✓	Migratory, Marine	JAMBA
Short-tailed Shearwater	*Ardenna tenuirostris*	✓						Migratory, Marine	ROKAMBA, JAMBA
Hutton's Shearwater	*Puffinus huttoni*			✓	✓	✓	✓	Marine	
Wilson's Storm Petrel	*Oceanites oceanicus*	✓	✓	✓	✓	✓	✓	Migratory, Marine	JAMBA
Leaches Storm Petrel	*Oceanodroma leucorhoa*				✓			Marine	JAMBA, CAMBA
White-faced Storm Petrel	*Pelagodroma marina*	✓						Marine	
Matsudaira's Storm Petrel	*Hydrobates matsudaira*		✓	✓	✓	✓	✓	Marine	
Swinhoes Storm Petrel	*Hydrobates monorrhis*				✓				
Little Black Cormorant	*Phalacrocorax sulcirostris*					✓			
Australian Pelican	*Pelecanus conspicillatus*					✓		Marine	
Red-footed Booby	*Sula sula*				✓		✓	Migratory, Marine	JAMBA, CAMBA
Masked Booby	*Sula dactylatra*	✓				✓	✓	Migratory, Marine	JAMBA, ROKAMBA
Brown Booby	*Sula leucogaster*	✓		✓	✓	✓	✓	Migratory, Marine	ROKAMBA JAMBA, CAMBA
Abbotts' Booby	*Papasula abbotti*	✓	✓			✓	✓	Endangered, Migratory, Marine	JAMBA
Red-tailed Tropicbird	*Phaethon rubricauda*	✓			✓		✓	Marine	
White-tailed Tropicbird	*Phaethon lepturus*		✓				✓	Marine	
Great Frigatebird	*Fregata minor*			✓				Migratory, Marine	JAMBA, CAMBA
Lesser Frigatebird	*Fregata arial*	✓		✓		✓	✓	Migratory, Marine	ROKAMBA, JAMBA, CAMBA
Christmas Island Frigatebird	*Fregata andrewsi*	✓	✓					Vulnerable, Migratory, Marine	CAMBA
Arctic Skua	*Stercorarius parasiticus*					✓		Migratory, Marine	JAMBA
Long-tailed Skua	*Stercorarius longicaudus*							Migratory, Marine	JAMBA
Silver Gull	*Chroicocephalus novaehollandiae*	✓		✓				Marine	

Species		CWR Survey Jun/Jul 2008	CWR Survey Oct/Nov 2008	INPEX Ichthys Site 2008	AES Tour Transect 2004	AES Tour Transect 2008	BA Tour Transect 2010	EPBC Status	Migratory
Crested Tern	*Thalasseus bergii*	✓	✓	✓	✓	✓	✓	Migratory, Marine	JAMBA
Gull-billed Tern	*Gelochelidon nilotica*	✓						Marine	
Bridled Tern	*Onychoprion anaethetus*	✓	✓	✓	✓	✓	✓	Migratory, Marine	CAMBA, JAMBA
Roseate Tern	*Sterna dougalli*				✓	✓	✓	Marine	
Brown Noddy	*Anous stolidus*	✓	✓	✓	✓	✓	✓	Migratory, Marine	CAMBA, JAMBA
Black Noddy	*Anous minutus*					✓		Vulnerable, Marine	
Asiatic Common Tern	*Sterna hirundo*		✓	✓		✓		Migratory, Marine	ROKAMBA, CAMBA, JAMBA
Little Tern	*Sternula albifrons*		✓			✓		Migratory, Marine	ROKAMBA, CAMBA, JAMBA
Fairy Tern	*Sternula nereis*							Marine	
Sooty Tern	*Onychoprion fuscata*		✓	✓	✓	✓	✓	Marine	
Lesser Crested Tern	*Thalasseus bengalensis*	✓		✓		✓		Migratory, Marine	CAMBA
White-winged Black Tern	*Chlidonias leucopterus*					✓			CAMBA, JAMBA
Whiskered Tern	*Chlidonias hybridus*					✓		Marine	

* Data sourced from Jenner *et al*. (2009), AES (2004, 2008), Birding Australia 2010.

4.2 Seabird breeding and roosting observations on islands in the Browse Basin

Breeding seabird records for islands in the Browse Basin, inclusive of the designated search area given in Section 4.1 and Figure 2, are shown in Table 3. Nineteen seabird species have been recorded for this area.

4.2.1 Browse Island.

There are very few records of breeding seabirds on Browse Island in the literature, probably due to limited access by researchers. The island habitat is suitable for colonial species such as Brown Boobies, Sooty Terns and Brown Noddies, with sandy areas for itinerant breeders such as Lesser Crested Terns and Crested Terns. It is highly possible that breeding records have been missed for this island.

Serventy *et al.* (1971) noted that the island was heavily mined for guano, which presumably accumulated from Brown Booby nesting activity, however there was no breeding at the time of these researcher's visit. Abbott (1979) recorded 300 Crested Terns nesting on the NE of the island, although some of the colony had been destroyed by a nesting turtle. Johnstone and Storr (1998) also listed Crested Terns nesting on the island. At this stage Crested Terns are the only species recorded for this island (Table 3).

The DEC (2006) SBIDB lists no seabirds as nesting at this location.

4.2.2 Scott Reef

There are few records of seabirds nesting on the sand cays of Scott Reef. The CALM SBID lists Brown Noddies breeding in small numbers on Sandy Island. Seventy nests were reported in 1986, and 50 nests in 1991. However, numerous seabird species have been reported roosting on the beaches of Sandy Island, including Crested Terns, Lesser Crested Terns, Brown Boobies, Sooty Terns and Lesser Frigatebirds (Woodside 2007). Brown Boobies have also been recorded breeding at this location (Johnstone and Storr 1998) (Table 3).

4.2.3 Lacapede Islands

The Lacapede Islands contain some of the most important seabird breeding colonies in the region. Fourteen seabird species have been recorded breeding at this location (Table 3). There are major seabird breeding colonies of the Masked Booby, Brown Booby, Pied Cormorant, Australian Pelican and Lesser Frigatebird (Anon 2010). Approximately 17, 000 pairs of Brown Boobies nest at this site, making the colony one of the largest in the world (Mustoe and Edmunds 2008).

4.2.4 Adele Island

Adele Island has some of the largest breeding seabird colonies after Ashmore Reef. Burbidge *et al.* (1987) recorded 7,500 pairs of Brown Boobies, 320 pairs of Masked Boobies and 5,700 pairs of Lesser Frigatebird nesting on the island. In addition, Red-footed Boobies, Pied

Cormorants *Phalacrocorax varius*, Pelicans *Pelecanus conspicillatus*, Great Frigatebirds *Fregata minor*, Caspian Terns *Hydroprogne caspia*, Crested Terns and Silver Gulls have also been recorded breeding on the island (Anon. 2010). Ten seabird species have been recorded at this location (Table 3).

4.2.5 Ashmore Reef

Ashmore Reef has three small, vegetated islands (West, Middle and East Islands) and supports some of the most important seabird rookeries in the NW Marine Region (www.environment.gov.au/coasts/mpa/ashmore/index.html). Seventy-eight bird species have been recorded at Ashmore, and of these, thirteen seabird species have been recorded breeding there (Table 3). Ashmore Reef supports large colonies of Sooty Terns and Brown Noddies (up to 50,000 breeding pairs), as well as smaller breeding colonies of Black Noddies *Anous minutus*, Brown Boobies, Lesser Noddies, White-tailed Tropicbirds *Phaethon lepturus* , Red-tailed Tropicbirds *Phaethon rubricauda* , Roseate Terns and Crested Terns (Johnstone and Storr 1998). Thirteen seabird species have been recorded breeding at this location (Table 3).

Table 3: Breeding seabirds recorded on Ashmore Reef, Scott Reef, the Lacapede Islands, Adele Island and Browse Island.

	Species	Browse Island	Scott Reef	Lacapede Islands	Adele Island	Ashmore Reef
Pied cormorant	*Phalacrocorax various*			✓	✓	
Australian Pelican	*Pelecanus conspicillatus*			✓	✓	
Red-footed Booby	*Sula sula*				✓	✓
Masked Booby	*Sula dactylatra*			✓	✓	✓
Brown Booby	*Sula leucogaster*		✓	✓	✓	✓
Red-tailed Tropicbird	*Phaethon rubricauda*					✓
Great Frigatebird	*Fregata minor*				✓	✓
Lesser Frigatebird	*Fregata arial*			✓	✓	✓
Silver Gull	*Chroicocephalus novaehollandiae*			✓	✓	
Crested Tern	*Thalasseus bergii*	✓		✓	✓	✓
Caspian Tern	*Hydroprogne caspia*			✓	✓	
Bridled Tern	*Onychoprion anaethetus*			✓		✓
Roseate Tern	*Sterna dougalli*			✓		✓
Brown Noddy	*Anous stolidus*		✓	✓		✓
Black Noddy	*Anous minutus*					✓
Fairy Tern	*Sternula nereis*			✓		
Sooty Tern	*Onychoprion fuscata*					✓
Lesser Crested Tern	*Thalasseus bengalensis*			✓		✓
White-bellied Sea Eagle	*Haliaeetus leucogaster*			✓		
TOTAL		1	2	14	10	13

* Sources: DEC (2006), Anon (2010), Johnstone and Storr (1998).

Table 4: The percentage (%) of seabird sightings observed over the following bathymetric profiles; continental shelf waters (<200m depth), continental slope waters at the Ichthys Field (250-300m), continental slope waters (250-300m) not on Ichthys field and oceanic waters (>300m depth). Data represents pooled data for the June/July and October/November periods (compiled from Jenner *et al.* 2009).

Species	June/July					October/November			
	Shelf	Slope		Oceanic		Shelf	Slope		Oceanic
	<200m	Ichthys Field 250-300m	Off Field 250-300m	>300m		<200m	Ichthys Field 250-300m	Off Field 250-300m	>300m
Bridled Tern	62.5	12.5	0	25.0		78.3	0	0	21.7
Crested Tern	58.2	8.9	8.9	23.9		0	0	0	0
Unidentified terns	68.6	5.9	10.4	14.9		54.9	3.3	5.5	36.3
Brown Booby	54.3	4.3	4.3	36.9		53.8	3.3	3.3	39.6
Bulwer's Petrel	0	0	0	0		10.0	0	10.0	80.0
Frigatebird *spp*.	62.2	2.7	5.4	29.7		0	0	14.3	85.7
Lesser Frigatebird	0	0	0	0		0	0	100.0	0
Shearwater *spp*. (unidentified)	14.3	14.3	28.6	42.8		56.7	3.3	0	39.9
Wilson's Storm Petrel	66.7	0	0	33.3		14.8	11.1	29.6	44.4

4.3 Seabird species recorded during the CWR Surveys

During the CWR marine survey conducted for INPEX in 2008, four surveys were conducted across the Browse Basin, including waters covered by the proposed INPEX Ichthys development area, between June and November 2008 (Jenner *et al.* 2009). Twenty four identified seabird species were recorded in the CWR survey area (Figure 2) (in addition to several unidentified species), and of these 16 species were recorded within the proposed INPEX Ichthys development area (Table 2). Unidentified terns comprised the largest group of seabirds, consisting of 44.6% of the total observations; presumably these were Bridled Terns and Sooty Terns *Onychoprion fuscata*, as they can be difficult to tell apart for the casual observer. The identified terns included Bridled Terns, Sooty Terns, Gull-billed Terns *Gelochelidon nilotica*, Lesser Crested Terns and the Brown Noddy. The next most significant group was the Brown Booby, which was more commonly sighted during survey 2 (6-20 July) and survey 3 (18 Oct-3 Nov) and comprised 14.6% of the total seabirds observed. Wilson's Storm Petrel and Bulwer's Petrel *Bulweria bulwerii* were also prominent in the area and are among the transient species which migrate through the NW Marine Region (discussed in 3.2). Bulwer's Petrels breed in the tropical north-Pacific Ocean, and like the more inshore-feeding Streaked Shearwater, move into the area through the Indonesian Archipelago during their inter-breeding period. Similarly, Wilson's Storm Petrel and the White-faced Storm Petrel *Pelagodroma marina* also migrate through the region between April and October, although they may be observed at all times.

4.3.1 Seabird observations in the proposed INPEX Ichthys development area

Table 4 shows the percentage of seabird observations for key species during surveys conducted in 2008 by CWR (Jenner *et al*. 2009). For comparative purposes, the survey area was divided into four water bodies of unequal size, according to their bathymetric profiles. These were;

- continental shelf waters (<200m depth),
- continental slope waters at the Ichthys Field (250-300m),
- continental slope waters 250-300m not on Ichthys field
- oceanic waters (>200m depth).

The importance of understanding such distributions helps to formulate a suite of seabirds likely to be in the vicinity of the proposed INPEX Ichthys development. The Ichthys site lies over continental shelf slope waters ranging from 250-300m deep. From the data given in Table 4, a higher proportion of Bridled Terns, Crested Terns and Wilson's Storm Petrels, but lower proportions of frigatebirds and Bulwer's Petrels, would be expected to occur near the proposed INPEX Ichthys development. However, both the Brown Booby and "unidentified" shearwaters are nearly equally distributed over both water bodies. By understanding the likely presence of species, we can determine the potential impacts upon them, and their potential interactions with any installations.

4.3.2 Limitations with interpreting the CWR Seabird Data

The seabird data set from these surveys had a number of limitations. Firstly, only part of one transect in each of the four surveys covered the 250-300m contour of the Ichthys site. This means that a large proportion of the site was not sampled. Secondly, many of the seabirds observed could not be specifically identified. Of the 2,466 birds sighted over the four surveys, 1,389 (56.3%) of these were terns. Of the 1,389 terns recorded, 79.1% could not be identified to species level. Similarly, two important seabird groups in Browse Basin, the shearwaters and frigatebirds, were under-represented due to lack of identification to species level. Of the total 138 shearwaters observed, 112 (84.2 %) were unidentified, and of the 108 frigatebirds recorded, only 10 (9.2%) were identified to species level (Jenner *et al*. 2009). In addition, only those data points able to be clearly assigned to each species group (based on colour in the Appendix E1-E4) could be used. In some cases it was not possible to differentiate clearly between species of seabirds due to the quality of the original figures and the inability to access the raw data.

4.3.3 Seabird distributions in shelf, slope and oceanic waters of the INPEX Ichthys site.

It can be seen from Table 4 that some species exhibit preferences for different marine habitats. Previous maritime seabird surveys (Ballance *et a*l. 2006, Dunlop *et al.* 1988, 1995, 2001) clearly show that seabird distributions are characteristic to each species but also reflect preferred foraging areas and foraging ranges. The Bridled Tern, although it undergoes a long, trans-equatorial migration, is nearly always observed over shelf waters. The data in Table 4 shows that this is also true for Crested Terns. Similarly, the unidentified terns were largely observed over continental shelf waters. Unidentified frigatebirds were observed most often over shelf waters during the June/July surveys, but over oceanic waters during the October/November surveys. The unidentified shearwaters were found across all water bodies, but most often over oceanic waters during June/July and continental shelf waters in October/November. This may reflect differences in species' foraging ranges due to breeding seasons. For example, Wedge-tailed shearwaters breed between October- April across the NW Shelf, and so would not forage as far from their colony as they would return to it most evenings. Bulwer's Petrels were only observed during the October/November surveys, and nearly always (90%) over oceanic waters. Wilson's Storm Petrels during June/July were most often observed over shelf waters, but during October/November over oceanic waters.

Low proportions of seabirds were observed at the 250-300m contour for the Ichthys field (Table 4). However, the off-field survey area over the 250-300m contour contained a much higher proportion, which would indicate that these species could also be potentially encountered over the Ichthys field. As the surveys were more intensive over continental shelf waters and oceanic waters than either of the 250-300m contour areas, the information gained for this offshore contour is less conclusive. As discussed previously (Section 2) the area of the continental shelf slope could be expected to have a wide range of seabirds which overlap between offshore and oceanic foraging grounds.

Twenty-eight seabird species have been identified from the literature as being likely to utilise the Ichthys field (Table 5). Eight of these species were not observed during the CWR survey, and hence are not listed for the INPEX Ichthys site in Table 2. However they have been included here as they have regularly been encountered in other surveys in the Browse Basin.

The Short-tailed Shearwater has been included, as it was recorded in the CWR survey, however this species is most likely a misidentification as it breeds in south-eastern Australia and migrates to the Alaskan region. It has never before been recorded in this area.

Table 5: Seabird species likely to utilise the Browse Basin and in particular the proposed INPEX Ichthys field and their status (breeding, migratory, regular or vagrant) and the distance to the nearest breeding colony. Data sourced from Johnstone and Storr (1998), Jenner *et al.* (2009), AES (2004, 2008), DEC (2006), Anon (2010), Birding Australia 2010.

Species	Status in Field	Distance to nearest colony (km)
Bulwer's Petrel	Regular visitor	NA
Tahiti Petrel	Vagrant	NA
Hutton's Shearwater	Regular visitor	NA
Streaked Shearwater	Regular visitor	NA
Wedge-tailed Shearwater	Regular visitor	197
Short-tailed Shearwater	Vagrant	NA
Wilson's Storm Petrel	Regular visitor	NA
White-faced Storm Petrel	Regular visitor	NA
Matsudaira's Storm Petrel	Regular visitor	NA
Leach's Storm Petrel	Vagrant	NA
Swinhoes Storm Petrel	Vagrant	NA
Red-tailed Tropicbird	Occasional visitor	197
White-tailed Tropicbird	Occasional visitor	1,900
Brown Booby	Breeds in region/Regular visitor	160
Masked Booby	Breeds in region/occasional visitor	160
Red-footed Booby	Breeds in region/occasional visitor	197
Lesser Frigatebird	Breeds in region/Regular visitor	160
Great Frigatebird	Breeds in region/Regular visitor	160
Christmas Island Frigatebird	Vagrant	1,900
Arctic Skua	Occasional visitor	NA
Silver Gull	Breeds in region/Regular visitor	160
Bridled Tern	Breeds in region/Regular visitor	197
Sooty Tern	Breeds in region/Regular visitor	197
Crested Tern	Breeds in region/Regular visitor	30
Lesser Crested Tern	Breeds in region/Regular visitor	30* (?)
Asiatic Common Tern	Regular visitor	NA
Brown Noddy	Breeds in region/Regular visitor	167
Black Noddy	Breeds in region	197

*In the North West Marine region Lesser Crested Terns invariably breed amongst the larger colonies of the Crested Tern (Nicholson 1998).

5 Peak Periods of Seabird Activity in the NW Marine Region

There are two distinct peak periods in seabird activity across much of the NW Marine Region, the summer period and autumn/winter period. These periods are characterised by a suite of breeding seabirds moving into the area to commence their breeding attempt on islands in the

Region (Adele Is., Browse Is., Scott Reef,, etc), or passing through the Region to breed on islands further south (i.e. Bedout Is., Montebello Is.). Table 6 shows the seasonal timing of peak foraging and/or breeding activity for seabird species which have been recorded in the Browse Basin. As discussed below, most species that breed in the Browse Basin do so between April and October. As outlined in Section 3, the NW Marine Region is also visited by regular passage migrant species that pass through the Browse Basin during their interbreeding period. These species migrate from northern hemisphere breeding grounds in the western Pacific Ocean.

5.1 Summer Breeders

In contrast to areas further south in the NW Marine Region, Table 6 shows that no species of seabirds recorded from islands within or adjacent to the Browse Basin breeds during the Austral summer. Summer breeding by seabirds appears to be limited to islands south of Bedout Island in the Pilbara.

5.2 Autumn/Winter Breeders

The majority of breeding seabirds at the Lacepedes, Adele Is. and Ashmore Reef breed during the Austral winter months (Table 6). For example, the Bridled Tern nests on offshore islands from the Kimberley southwards to Cape Leeuwin. From the Pilbara southwards it breeds during the summer months (November-April), while on islands in the Kimberley the same species nests in autumn/winter (April-July) (Johnstone and Storr 1998). The large Brown Booby, Brown Noddy and Frigatebird colonies found at Ashmore Reef and Adele Island have peak breeding periods from May to July (Burbidge *et al*. 1987, Johnstone and Storr 1998, Mustoe and Edmunds 2008).

5.3 Passage Migrants and Winter Feeding Aggregations

The data collected during the Jenner *et a*l. (2009) surveys included "unidentified shearwater species". It can be presumed that this category would have included Hutton's Shearwaters and Wedge-tailed Shearwaters. Whilst there are no confirmed records of breeding by either of these species in the Browse Basin, there may be a colony of Wedge-tailed Shearwaters at Ashmore Reef, as some burrows of an unknown species were observed in 2009 (Watson *et al*. 2009). Wedge-tailed Shearwaters are the most common shearwater species in the eastern Indian Ocean (Dunlop *et al*. 2002) and are presumed to undertake a partial northward migration between May and September, wintering at or above the tropical convergence zone. Dunlop *et al*. (1995) identified a wintering area of Wedge-tailed Shearwaters in an area north of 12^{o}S. Unpublished data from surveys conducted at sea between Broome and Ashmore Reef regularly recorded both Hutton's Shearwater and the Wedge-tailed Shearwater (AES 2008, Birding Australia 2010). Additionally, large numbers (10 000's) of both species were observed between May and August 2005 in the southern portion of the NW Marine Region (Surman, unpublished data), and it can be presumed that their non-breeding foraging range would extend into the Browse Basin. The shelf waters of the NW Marine Region appear to be an important feeding and resting area for the Hutton's Shearwater during its migration from New Zealand, where it breeds on mountain slopes on North Island (Harrow 1965). These observations perhaps confirm Warham's (1981) suggestion that this species circumnavigates Australia. Records from the Browse region indicate that it is part of this species' migratory route (AES 2008, Birding Australia 2010)

Table 6: Key periods of seabird migratory and breeding activity within the Browse Basin. Data shown for those species recorded as either regular breeders (on Ashmore, Scott, Adele, Browse or Lacapede Islands) or regular foragers over waters of the Browse Basin. The list includes passage migrants. Light blue = potentially present in area; dark blue = breeding period on islands.

Species	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Bulwer's Petrel												
Tahiti Petrel												
Herald Petrel												
Jouanin's Petrel												
Hutton's Shearwater												
Streaked Shearwater												
Wedge-tailed Shearwater												
Short-tailed Shearwater												
Wilson's Storm Petrel												
White-faced Storm Petrel												
Matsudaira's Storm Petrel												
Leach's Storm Petrel												
Swinhoes Storm Petrel												
Red-tailed Tropicbird												
White-tailed Tropicbird												
Pied Cormorant												
Brown Booby												
Masked Booby												
Red-footed Booby												
Australian Pelican												
Lesser Frigatebird												
Great Frigatebird												
Christmas Island Frigatebird												
Arctic Skua												
Long-tailed Skua												
Silver Gull												
Bridled Tern												
Sooty Tern												
Crested Tern												
Lesser Crested Tern												
Caspian Tern												
Roseate Tern												
Fairy Tern												
Little Tern												
Gull-billed Tern												
Asiatic Common Tern												
Brown Noddy												
Black Noddy												

Source: Johnstone and Storr (1998), Anon (2010), Abbott 1979, DEC (2006), Dunlop *et al.* (1995), Harrison (1983), Milton (1999)

6 The Browse Basin in a Regional Context

The Browse Basin is species rich in terms of seabird diversity at sea. A total of 39 seabird species have been recorded over numerous surveys (Table 2), which is comparable to 39 species recorded during surveys of the East Indian Ocean (Dunlop *et al.* 1995). On a smaller scale within the Browse Basin, Jenner *et al*. (2008) recorded 16 species during their June/July surveys and 16 species during the October November surveys. Some of these species were observed during both periods, so that a total of 24 seabird species were recorded for the survey area in total. A similar number of species were recorded during several surveys undertaken between Broome and Ashmore Reef with a range of 15-21 species observed (Table 2). Within the proposed INPEX Ichthys site it would be expected that approximately 16 - 28 seabird species would be encountered regularly (Tables 2 and 5).

Within the NW Marine Region similar numbers of seabird species have been recorded at other sites. For example, Dunlop *et al*. (1995) predicted that 18 seabird species could be expected to be observed in areas around the Jabiru Venture platform, which is situated further north in the Region, while 23 seabird species have been recorded at the Lowendal Group, further south in the Region (Surman and Nicholson 2010).

The number of breeding seabird species found on islands within 345 kilometres of the proposed INPEX Ichthys site are comparable with breeding islands elsewhere in the NW Marine Region. Ten seabird species have been recorded nesting on Adele Is., 13 species on Ashmore Reef and 14 species at the Lacapede Group (Table 3, Anon 2010, DEC 2006). These numbers compare with the Lowendal and Montebello Group, where 13 species of seabirds have been recorded breeding (Surman and Nicholson 2010, Burbidge *et al.* 2000). Two islands in the Browse Basin which have fewer seabird species recorded breeding are Browse Island with one species (Crested Tern), and Scott Reef with 2 species (Brown Noddy and Brown Booby) (Table 6), which may reflect a lack of frequency of researcher access to record other possible breeding species, and/or lack of suitable habitat in the case of the latter island.

7 Conclusions

Breeding seabirds are dependent upon sources of marine food within their foraging range, which differs between species, from the breeding colony. The two closest islands to the proposed INPEX Ichthys development site in the Browse Basin maintain few breeding species, however the numbers of foraging seabirds in this area would not come from these colonies alone. Some of the species that nest on Adele Island, 160 km away, would also forage across these waters. Frigatebirds, Boobies and Crested Terns are all known to have long-distance foraging ranges (Dunlop *et al.* 2001, Nicholson 2002).

Dunlop *et al*. (2001) found, based on data collected from seas adjacent to Christmas Island, that Brown Noddies and Brown Boobies foraged within 200-250km of their breeding colony, and the Red-footed Booby foraged up to 900km away. Similarly, Lesser Frigatebirds and Great Frigatebirds foraged at least 700km from their breeding

colonies on Christmas Island. Crested Terns were observed foraging several hundred kilometres from land, over the continental shelf in the NW Marine Region (Nicholson 2002). The observation of an Abbott's Booby during the CWR survey (Jenner *et al.* 2008) was not unique (there have been at least 6 other sightings in the Scott Reef / Browse area) and demonstrates the potential importance of the Browse Basin to the Christmas Island endemic seabird species, as well as seabirds nesting at the Lacapede Group (330 km to the south of the proposed INPEX Ichthys development area) and on Adele Island (160 km south) and Ashmore Reefs (190 km to the north).

Of the 39 species of seabirds recorded from the broader area covered by this report, 16 - 28 are likely to be present and encountered regularly near the proposed INPEX Ichthys development site (Tables 2 and 5). Several species recorded are vagrants, and these include the Abbott's Booby, the Herald Petrel and the Short-tailed Shearwater (the latter probably misidentified as discussed in 4.3.3). Most species are listed under the EPBC Act as either migratory or marine or both (Tables 1 and 2). Whilst records of breeding seabirds from Browse Island and Scott Reef are poor, several species of seabirds are likely to forage in the area based on islands further afield. Brown Noddies, Brown Boobies, Red-footed Boobies, Lesser Frigatebirds, Great Frigatebirds and Crested Terns are the most likely breeding species to forage over waters adjacent to the INPEX Ichthys site.

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