

Procellariiformes observed around Papua New Guinea including the Bismarck Archipelago from 1985 to 2007

NEIL CHESHIRE

Abstract

Procellariiformes were recorded during research voyages to the maritime Exclusive Economic Zone of Papua New Guinea between 1985 and 2007. Species seen, but not previously recorded in the area, were Herald Petrel *Pterodroma heraldica*, Bulwer's Petrel *Bulweria bulwerii*, Christmas Shearwater *Puffinus nativitatus*, White-faced Storm-Petrel *Pelagodroma marina*, Leach's Storm-Petrel *Hydrobates leucorhoa* and Matsudaira's Storm-Petrel *Hydrobates matsudairae*. Seasonal distribution of Streaked Shearwater *Calonectris leucomelas*, Wedge-tailed Shearwater *Ardenna pacifica*, Short-tailed Shearwater *Ardenna tenuirostris*, Tahiti Petrel *Pseudobulweria rostrata*, Black-bellied Storm-Petrel *Fregetta tropica* and Matsudaira's Storm -Petrel is discussed. Sightings of Heinroth's Shearwater *Puffinus heinrothi* and a probable sighting of Black-footed Albatross *Phoebastria nigripes* are documented.

INTRODUCTION

This paper presents distribution data of Procellariiformes I saw during 20 research vessel voyages between 1985 and 2007 to the seas around Papua New Guinea including the northern Coral Sea, the Solomon Sea, the Bismarck Sea and the adjacent Equatorial Pacific. The area considered in this survey is limited to the Exclusive Economic Zone (EEZ) of Papua New Guinea (see Fig.1). This zone extends up to 200 nautical miles (370km) offshore and gives a good sample of inshore and oceanic habitat. Prescott, in Carter (1983a) recommended the EEZ of a state as a logical and gazetted sea area for a checklist to consider. The occurrence and abundance of Procellariiformes

in PNG waters is not well documented and breeding status is poorly known. Early information came from German colonists such as Finsch (1879) and was summarised by Reichenow (1899). The Whitney South Sea Expedition visited the eastern part of the study area and specimens obtained mainly by Rollo Beck were documented by Murphy (1928 and 1930). An overall summary of seabirds in the southwest Pacific that included Papua New Guinea was made by Mayr (1945). Sea-going members of the Royal Naval Birdwatching Society recorded seabirds during occasional voyages through the area from the late nineteen fifties onwards (Bourne and Dixon 1973; Bourne 1983, 1998; Simpson 1990). Observations of Procellariiformes were made by Greensmith (1975) during a yacht voyage through the Bismarck and Solomon Seas. Around the same time members of the New Guinea Bird Society made boat trips to outlying islands producing several interesting records (Coates 1970a; Finch 1981b, 1983c). Hadden rediscovered Heinroth's Shearwater *Puffinus heinrothi* on Bougainville Island in 1979 (Hadden 1981). Seabirds around the Madang area from September to November 1989 were recorded by Bailey (1992). Dutson (2001) reported on seabirds seen on passage during 1997-98 when he visited many islands in the PNG area. Shirihai made a short voyage in 2003 and another in 2007 in the area of the eastern Bismarck Archipelago and Buka resulting in the rediscovery of Beck's Petrel *Pseudobulweria becki* (Shirihai 2004, 2008). Procellariiformes recorded in New Guinea were listed by Beehler and Finch (1985). Their list covers the whole island of New Guinea, its satellite islands and the western and eastern Papuan islands but excludes the

Bismarck Archipelago and Bougainville. The authors did not define the exact sea area that their list covers. Coates (1985) in a chapter on Procellariiformes considered the area covered by the political boundaries of Papua New Guinea, including the Bismarck Archipelago and Bougainville, but again did not define the sea area covered. A summary of current knowledge as I understand it is given in Table 1.

METHODS

Oceanographic Environment and Climate

The seas of the Papua New Guinea EEZ can be divided into four distinct geographical and environmental areas: the northern Coral Sea, the Solomon Sea, the Bismarck Sea and Equatorial Pacific waters (Fig. 1). January and February is the time of the maximum southerly extension of the northwest monsoon with April and May the time of transition. In July and August the

southeast trade wind belt reaches its maximum northerly extent followed by September and October as the time of transition.

Coral Sea

In this study the northern Coral Sea includes the Gulf of Papua and waters south of Papua New Guinea and south of the Louisiade Archipelago. The shelf area where depths are less than 200 m is narrow being from five to twenty km along most of the coast widening to 180 km in the western Gulf of Papua. Elsewhere depths range mostly between 2000 and 4000 m. The area lies within the westward flowing South Sub-Tropical Current, though in the northwest there is some eastward flow from the Torres Strait during the Austral summer. During this study sea surface temperatures ranged from 25.6°C (Aug) to 29.5°C (Feb) and the salinity from 34.64‰ (parts per thousand) to 35.03‰. Salinity is lower where large rivers such as the Fly enter the Gulf of

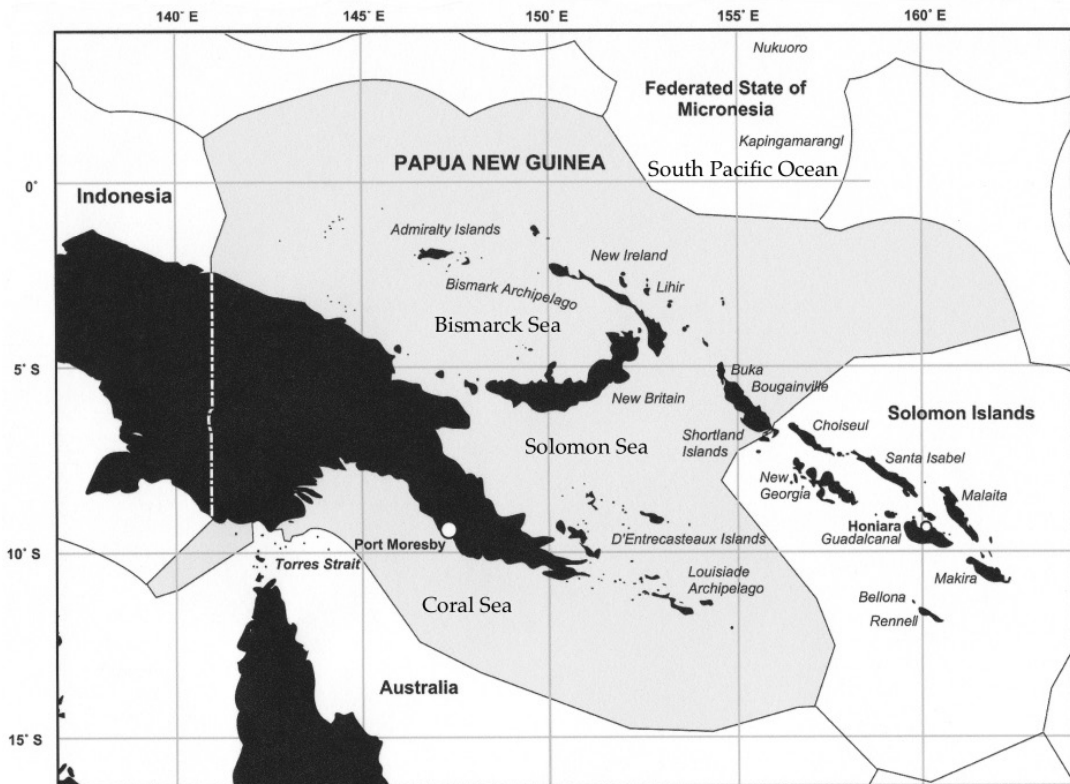


Figure 1. the Exclusive Economic Zone (EEZ) of Papua New Guinea (shaded). Youngmi Choi of the Secretariat of the Pacific Community gave permission to use this map.

SPECIES	CORAL SEA		SOLOMON SEA		BISMARCK SEA		EQUATORIAL PACIFIC		REFERENCES
	A	B	A	B	A	B	A	B	
Black-footed Albatross								1 ?	
Southern Giant-Petrel	Ba								Hudson & Conroy 1975
Tahiti Petrel	2-10 S	> 10		> 10	> 10	> 10	2-10	> 10	Greensmith 1975; Coates 1985
Beck's Petrel			2-10 S						Shirihai 2008
<i>Pseudobulweria</i> sp.					2-10		1		Shirihai 2004, 2008
Kermadec Petrel					S?				Finsch 1879
Herald Petrel		2-10							
Providence Petrel			1						Shirihai 2004, 2008
Gould's Petrel	1				1 S?				Bourne & Dixon 1973; Finsch 1879; Mayr 1941
Pycroft's Petrel			Ba						Pierce 2010
Fairy Prion	S ?								Mayr 1941
Bulwer's Petrel		1					2-10	2-10	Dutson 2001
Streaked Shearwater	> 10	> 10	2-10	> 10	> 10	> 10	> 10	> 10	Greensmith 1975; Coates 1985
Wedge-tailed Shearwater	> 10Br	> 10	2-10	> 10	> 10	> 10	1	> 10	Greensmith 1975; Coates 1985; Weston 1975
Flesh-footed Shearwater	1			1	1		1		Bailey 1992; Finch 1981b
Sooty Shearwater	1 ?		2-10 ?	1	2-10 ?		1 ?		Greensmith 1975
Short-tailed Shearwater	2-10				S	2-10		> 10	Finsch 1879; Finch 1983c
Christmas Shearwater							1	1	Shirihai 2008
Hutton's Shearwater	1 ?								Finch 1983c
Trop. Audubon's Sw.		1	1		1	1	1		Dutson 2001
Heinroth's Shearwater			1	2-10	2-10 S	2-10	2-10 SBr		Dutson 2001; Murphy 1930; Hadden 1981
Wilson's Storm-Petrel	1	1				1			Roberts 1940; Coates 1985
White-faced Storm-Petrel		2-10		1					
Black-bellied Storm-Petrel	1	> 10		1					Whitney Expedition
White-bellied Storm-Petrel	2-10								Tubb 1945; Coates 1985
Leach's Storm-Petrel								2-10	
Matsudaira's Storm-Petrel					2-10	> 10		> 10	Marchant & Higgins 1990; Hadden 2004; Shirihai 2008

Table 1. Summary of Procelliformes records in the EEZ of Papua New Guinea (Fig. 1). Column A = Previous Records; Column B = This Study. (Ba = banding record, S = specimen record, Br = breeding record).

Papua. The area lies within the trade wind belt with south easterly winds persisting from May to October often reaching 25 to 30 knots (46-56 km/hr) in July and August, resulting in rough seas and heavy swells. From November to May winds are usually much lighter and tend north westerly, but during this time an average of two cyclones occur. Rainfall is high, ranging from 2500 mm/year along the south coast of PNG to 1500 mm/year further south. (Taylor 1973; Australia Pilot Vol 3 NP15, 2005).

Solomon Sea

The Solomon Sea lies between south east PNG and Bougainville/Solomon Islands with the island of New Britain forming the northern border and the Louisiade Archipelago the southern. There are extensive reef areas along the PNG coast and around the Louisiades. Elsewhere shelf areas are narrow and depths range from 2000 m in the south east to over 8000 m in the New Britain trench. The wind and current regime is similar to the northern Coral Sea except that most of the area lies north of the cyclone zone. Sea surface temperatures during the study ranged from 26.6° C (Aug) to 29.5° C (Feb) and the salinity from 33.26‰ to 34.70‰. Rainfall is high averaging 3500-4000 mm/year (Taylor 1973).

Bismarck Sea and Equatorial Pacific

The Bismarck Sea includes waters between New Britain and New Ireland extending to waters between northern PNG and Admiralty Islands south of latitude 2° S. There is a narrow shelf area ten to twenty km wide along the north coast of PNG and extensive reef areas south and

west of the Admiralty group. Elsewhere depths range between 1000 and 2000 m. There are many small islands of volcanic origin, some still active. The Equatorial Pacific waters within the EEZ of PNG are considered those north of 2° S latitude and north east from New Ireland and Bougainville. There are almost no shelf waters as the islands of the area rise abruptly from the surrounding deep ocean. Depths range from 1000m along the north coast of New Ireland and Bougainville to over 5000m in the West Melanesian Trench and the Equatorial area. The Bismarck Sea and Equatorial Pacific waters of PNG are in the immense pool of surface waters warmer than 28°C in the equatorial region between the central Indian Ocean and 180° longitude. The area is between the major trade wind belts and is subject to monsoonal winds. Average winds are mostly light, but locally strong in Vitiaz Strait between New Guinea and New Britain. During my voyages sea surface temperature and salinity ranged from 27.1°C to 30.2°C and 33.08‰ to 34.60‰ in the Bismarck Sea and 29°C to 30.2°C and 33.53‰ to 35.02‰ in the Equatorial Pacific. A feature of the Bismarck Sea is that it receives considerable run off of nutrient rich waters from river systems such as the Sepik. Both areas lie within the South Equatorial Current. Annual rainfall is high, from 3000mm in the Bismarck Sea to 4000mm north of the Equator (Pacific Islands Pilot Vol.1 NP60, 2007; Taylor 1973).

Observational Methods and Coverage

I made observations of seabirds during 20 voyages to PNG waters from two CSIRO research vessels, 'Franklin' (length 55m) in

Table 2. Sampling effort (see text)

Locality	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Coral Sea	11	8	2	29	6	8	109	6	8	55	6	0	248
Solomon Sea	33	18	7	43	7	25	61	4	20	17	6	0	241
Bismarck Sea	47	9	11	7	86	0	84	37	50	18	2	1	352
EQ. Pacific	55	9	0	0	65	16	33	75	6	19	2	0	280
TOTAL	146	44	20	79	164	49	287	122	84	109	16	1	1121

1985 (July, August, October), 1986 (January, February, April), 1988 (January, April, May, July), 1990 (July, September, October), 1991 (July, September, October), 1992 (April, June, July, Nov), 1993 (November), 1997 (July, August, October), 2000 (January, February, April), and 2002 (March) and 'Southern Surveyor' (length 66m) in 2007 (August, September). When research work permitted, opportunistic counts of ten minutes duration were made of all seabirds visible through 360° using 7 x 50 or 10 x 40 binoculars from the ship's bridge ten metres above sea level whilst steaming at 10-11 Knots (18-20 km/hr). In total I made 1121 counts as per Table 2.

RESULTS AND DISCUSSION

BLACK-FOOTED ALBATROSS *Phoebastria nigripes*.

The Black-footed Albatross breeds in the North Pacific in the Hawaiian Archipelago and on Torishima and Bonin Islands off Japan (Onley & Scofield 2007). There are records from the western tropical North Pacific at Wake Island, Marshall Islands and the Northern Marianas (Pyle and Engbring 1985). I had distant views at approximately 800 metres of a dark black-brown albatross: 4 August 1985, 1°01'N 150°01'E 138 nm NNE from Mussau PNG (nm = nautical miles, 1 nautical mile = 1' latitude = 1.852 kilometres) Later in the day, with the ship still on station at this position, an albatross passed within 100 m of the stern. It was seen by Alan Poole of CSIRO who described it as 'similar to a Sooty Albatross (a bird he has seen during voyages to the Southern Ocean), but pale at the base of the bill and definitely not a Giant Petrel'. The bird was likely to have been an immature Black-footed Albatross. In Bourne (1967), D.H.Mobberly reported four probable Black-footed Albatross at 1°00'N 158°45'E, NE from New Ireland, on 30 Sept.1965, and a positive sighting of the species the next day at 7°00'N 156°30'E.(both positions outside PNG EEZ).

BULWER'S PETREL *Bulweria bulwerii*.

Bulwer's Petrel breeds in the eastern tropical and subtropical Atlantic, and the northwest and central Pacific areas. In the central Pacific it breeds on several islands including the Marquesas, the Hawaiian group, the Phoenix group and Johnston Islands (Onley & Scofield 2007). On the more northerly Pacific islands it breeds from May to September, but in the Phoenix group breeding takes place throughout the year (Jouanin *et.al.*1979). There is one published record from north-eastern Australia, in the Coral Sea offshore from Townsville in November 1985 (Cheshire 1989), and several were recorded nearby in December 2006 (M.Carter in litt 2010). It is now regularly seen off north-western Australia between September and April (Harrison 1980; Dunlop *et al* 1988a; M.Carter in litt 2010). Dutson recorded a total of six birds in equatorial PNG waters between Kavieng, Tench Island and Mussau Island between 1 July and 6 July 1997 (Dutson 2001). During this study I saw this species in the Gulf of Papua and in PNG equatorial Pacific waters:

12/7/1990	8°34'S 145°27'E	2
30/1/2000	0°43'N 147°27'E	2
30/1/2000	0°37'N 147°48'E	1

These small petrels were identified by their distinctive shape – long pointed tail and long narrow pointed wings, combination of blackish brown plumage with pale brown upper-wing bar on the greater coverts and distinctive flight-close to the sea surface with several quick wing beats followed by a long erratic glide and sudden changes of direction.

TAHITI PETREL *Pseudobulweria rostrata*.

The Tahiti Petrel breeds on New Caledonia, the Society Islands, Marquesas Islands, and Gambier Islands and possibly elsewhere in the central and western Pacific (Onley & Scofield 2007). The breeding season is prolonged with egg laying dates between March and December on New Caledonia and throughout the year in Polynesia, peaking between March and

Table 3. Records for selected species. Column A = percentage of 10min counts in which species recorded; Column B = density index, total number birds divided by number of 10min counts; Column C = Maximum number of birds in any 10min count.

Species	Locality	Jan-Mar			Apr-Jun			Jul-Sept			Oct- Nov		
		A	B	C	A	B	C	A	B	C	A	B	C
Tahiti Petrel													
	Coral Sea	5	<1	1	0	0	0	7	<1	2	5	<1	1
	Solomon Sea	3	<1	1	3	<1	1	5	<1	2	9	<1	2
	Bismarck Sea	10	<1	2	4	<1	3	21	<1	4	14	<1	1
	EQ. Pacific	5	<1	2	4	<1	1	4	<1	9	0	0	0
Streaked Shearwater													
	Coral Sea	0	0	0	5	<1	5	6	3	255	0	0	0
	Solomon Sea	12	2	50	9	<1	5	1	<1	3	0	0	0
	Bismarck Sea	28	24	800	1	<1	8	1	<1	1	0	0	0
	EQ. Pacific	20	14	500	0	0	0	0	0	0	0	0	0
Wedge-tailed Shearwater													
	Coral Sea	38	20	400	14	<1	10	57	2	70	23	4	140
	Solomon Sea	9	<1	6	4	<1	2	14	<1	15	13	<1	4
	Bismarck Sea	5	<1	10	2	<1	1	15	6	1,000	14	<1	2
	EQ. Pacific	1	<1	1	6	62	5,000	34	4	300	29	2	30
Short-tailed Shearwater													
	Coral Sea	0	0	0	0	0	0	0	0	0	0	0	0
	Solomon Sea	0	0	0	0	0	0	0	0	0	0	0	0
	Bismarck Sea	0	0	0	4	1	100	0	0	0	0	0	0
	EQ. Pacific	0	0	0	33	6	250	0	0	0	0	0	0
Black-bellied Storm-Petrel													
	Coral Sea	0	0	0	0	0	0	15	<1	3	12	<1	4
	Solomon Sea	0	0	0	0	0	0	1	<1	1	0	0	0
	Bismarck Sea	0	0	0	0	0	0	0	0	0	0	0	0
	EQ. Pacific	0	0	0	0	0	0	0	0	0	0	0	0
Matsudaira's Storm-Petrel													
	Coral Sea	0	0	0	0	0	0	0	0	0	0	0	0
	Solomon Sea	0	0	0	0	0	0	0	0	0	0	0	0
	Bismarck Sea	0	0	0	0	0	0	11	<1	3	0	0	0
	EQ. Pacific	0	0	0	0	0	0	26	<1	4	0	0	0

July on Tahiti (Villard et al 2006). There are a few previous records from both northern and southern PNG waters, (Coates 1985).

Shirihai made the remarkable rediscovery of Beck's Petrel (*Pseudobulweria becki*) in the Bismarcks with probable sightings in August 2003 and later confirmed this when he obtained a specimen and numerous flight photographs of the species from the same area off southern New Ireland from 30 July to 7 August 2007 (Shirihai 2008). In August 2007 he found Beck's Petrel more abundant off southern New Ireland than Tahiti Petrel (80-90% of total numbers observed) with both moulting post breeding adults and fresh juveniles observed. He proposed a likely breeding area for Beck's Petrel in the montane forests of southern New Ireland. Beck's Petrel has a bill about 25% smaller and wing and tail measurements about 15% smaller than Tahiti Petrel. When observing them side by side Shirihai described Beck's as appearing 10-20% smaller and narrower winged with a shorter wing span. With identical plumage and despite some differences in flight and behaviour, separation of the two species at sea would be difficult unless a direct comparison or good photographs were obtained. During my study I found Tahiti type petrels were shy of the ship and did not approach closer than 250 metres, sometimes staying at least 400 to 500 metres away. In these circumstances it is possible that previous observations and my own observations of Tahiti Petrels in the Solomon/Bismarck Sea area may have included some Beck's Petrels. I was certainly aware of the possibility of Beck's Petrel in the general area of the type locality off New Ireland. With reference to Table 3, in the PNG sector of the Coral Sea I found Tahiti Petrel widely distributed in small numbers between July and March. In the Solomon Sea it was present in all months with a slight increase in distribution during the October - November period. In PNG Equatorial Pacific waters it was seen from January to September.

In the Bismarck Sea it was more widely distributed with a low point in April and May and the maximum from July to September with a greater density at this time possibly due to confusion with post breeding adult and juvenile Beck's Petrel in the area.

In the Coral Sea area the birds I saw had dark brown upperparts, head, throat and upper breast with a clear cut division from the white lower breast and belly. A paler brown area at the base of the upper tail was sometimes apparent on birds that were seen well. The underwings were dark greyish-brown with a pale greyish-white line along the centre from the axillaries to the base of the primaries, formed by pale edges to the underwing coverts. Tahiti Petrels of this type were described by King (1963) and Holmes (1981) and a photograph was published in Lindsey (1986).

In the Solomon, Bismarck and Equatorial Pacific area about 40% of birds I saw throughout the year had a more extensive area of white plumage along the centre of the underwing. The white central part was up to one third the width of the inner underwing and tapering before ending at the base of the primaries. In all other respects these birds appeared to be normal *rostrata*. This may be a feature of age, moult, wear and/or variation between different populations. Shirihai (2008) also commented on the variation and extent of white in the underwings of *rostrata* and *becki* and is conducting an ongoing study into variation in Tahiti Petrels.

HERALD PETREL *Pterodroma heraldica*.

The Herald Petrel breeds on Raine Island (11°36'S 144°02'E) near the northern end of the Great Barrier Reef between February and August, and has been collected at Chesterfield Reef (19°55'S 158°20'E) midway between New Caledonia and Australia (King 1984). It also breeds further east in the Pacific in Tonga and the Marquesas Group (Onley & Scofield 2007). Although Raine Island is only 225 nautical miles

south-west from Port Moresby, it has not been recorded before from PNG waters. I had sight records from the Coral Sea along the south coast of PNG:

3/10/1985	11°57'S 147°07'E	1
4/10/1985	10°39'S 149°18'E	1
29/10/1985	13°55'S 155°20'E	1
12/7/1990	8°45'S 145°35'E	1

All were pale morph birds as are those breeding at Raine Island (King 1984). In the fresh (25 knot) trade winds the birds I saw had fast arcing flight typical of the Pterodromas. They appeared similar in size to the Great-winged Petrel *Pterodroma macroptera*. Their upperparts were greyish brown with the throat, chin, lower breast and belly white. There was a light greyish brown breast band that was not clean cut, but graded into the adjoining white plumage. The underwing was distinctive, appearing greyish brown with a white patch on the outer wing, tapering along the rear of the wing towards the body. The white patch was divided by a darker line formed by the dark tips of the greater coverts. The bird I saw on 29 October had some asymmetrical whitish marks on the upper wings, presumably caused by moult.

STREAKED SHEARWATER *Calonectris leucomelas*.

The seas to the north of Papua New Guinea are regarded as the main wintering area for this large distinctive shearwater which breeds in the north-west Pacific on islands off Korea, China and Japan (Marchant & Higgins 1990). It is now known to visit the Arafura Sea and the northern Gulf of Carpentaria in significant numbers (Carter 1983b and pers.obs.) and in most years a few are seen south to about 38°S on the east and west coasts of Australia. With reference to Table 3, I found it widely distributed in the Bismarck Sea and nearby Equatorial waters during January to March with maximum 'distribution' and 'density index' in the Bismarck Sea. Flocks seen of more than 100 birds are listed:

13/1/1986	4°01'S 148°36'E	c. 100
13/1/1986	0°46'S 148°47'E	c. 800
15/1/1986	1°50'S 147°33'E	c. 200
17/1/1986	0°00' 144°22'E	c. 150
2/2/1986	0°00' 150°00'E	c. 500
27/1/2000	2°29'S 143°00'E	c. 200
8/3/2002	4°25'S 146°08'E	c. 150
12/3/2002	3°25'S 144°41'E	c. 200

I observed significant numbers in the Gulf of Papua during July 1997 which I consider to be over-wintering birds, rather than early arrivals from the northern hemisphere:

2/7/1988	10°13'S 147°55'E	1
10/7/1990	11°21'S 147°16'E	1
25/7/1997	8°43'S 144°51'E	20
25/7/1997	8°50'S 144°57'E	40
25/7/1997	8°56'S 145°01'E	255

Most observations of Streaked Shearwaters were of birds feeding over schools of tuna or other fish in mixed flocks with species such as Sooty Terns *Onychoprion fuscata*, Common Noddies *Anous stolidus*, Black Noddies *Anous minutus* and Brown Boobies *Sula leucogaster*.

WEDGE-TAILED SHEARWATER *Ardenna pacifica*.

The Wedge-tailed Shearwater breeds throughout the tropical and sub-tropical, Indian and Pacific Oceans (Onley & Scofield 2007). Populations at northern and southern extremes of range are migratory whilst tropical populations may spend the non-breeding season near breeding islands (King 1974). Jenkins (1979) presented a convincing case for the migration of the sub-tropical Kermadec and Tongan population of Wedge-tailed Shearwaters to the eastern Equatorial Pacific and he remarked on the different migration regime of the eastern Australian population. In central New South Wales most breeding Wedge-taileds arrive

during the last week of August and depart during April and May (Rogers 1975). A considerable banding effort in NSW has yielded a number of long distance returns, most in the southern autumn and winter, from the Philippines area at the western boundary of the equatorial Pacific (Recovery Roundup 1981, 1982, 1983, 1987). The exact migration route has yet to be discovered, but the most likely track would be east of the main island of New Guinea, through the Louisiades, Solomon Sea into the Bismarck Sea and then to the western equatorial Pacific. A route through the narrow reef and island strewn waters of Torres Strait is unlikely and no large scale migration of Wedge-taileds has been reported from the area. Breeding in PNG has been recorded on Bavo Island near Port Moresby (Weston 1975). It is very likely that other breeding colonies exist, given the numerous islands and atolls in PNG. With reference to Table 3, in the PNG sector of the Coral Sea, Wedge-tailed Shearwaters are widely distributed throughout the year consistent with a resident non-migratory population. Kikkawa (1976) in his study of Great Barrier Reef birds noted they are summer breeders arriving at the breeding islands in October and laying in November-December. In the Solomon and Bismarck Seas and Equatorial Pacific there is a marked increase in the distribution, density and abundance of Wedge-taileds between May and October suggesting an influx of migrant Wedge-taileds. It would appear that the productive seas north of PNG are exploited in different seasons by summer breeding Wedge-tailed and Streaked Shearwaters migrating from the southern and northern hemispheres. Among many sightings of Wedge-taileds, particularly large assemblages included:

20/08/1985	5°00'S 146°00'E	c. 1,000
06/05/1988	0°10'S 148°57'E	c. 5,000

Most of the birds I saw on 6 May 1988 were at rest on the water, and all those that flew on the approach of the ship were in heavy moult with notched wings and paler marks across

the upper wings. Presumably these were adult birds undergoing their post-nuptial moult after arrival at their 'wintering' grounds as described by Marshall & Serventy (1956). I saw pale morph birds (indicated below with asterisks) on a few occasions with only one Coral Sea record and these altogether represented only 0.08% of birds I recorded in Papua New Guinea waters:

4/8/1985	1° 00' N 150° 00' E	1*
4/8/1985	1° 05' N 150° 00' E	1* + 3
24/1/1986	2° 01' N 150° 00' E	1*
28/9/1990	2° 00' N 147° 00' E	1* + 60
27/7/1997	10° 53' S 148° 01' E	1* + 20
23/1/2000	3° 08' S 145° 22' E	1* + 10

In the Pacific, pale morph birds predominate in all breeding colonies north of 10°N except the Marianas where only dark birds occur. In the South Pacific, except for 1% of the Phoenix Islands' population, pale morph birds have not been reported breeding (King 1974). In Australia pale morph birds breed regularly only at Shark Bay, Western Australia, where they make up 20-30% of the small population (Serventy 1972).

FLESH-FOOTED SHEARWATER *Ardenna carneipes*.

This species was recorded off Port Moresby and near Kavieng, New Ireland, in Jan 1970 and 1976 by Coates (1970a, 1985) and between Madang and Karkar Island by Finch (1981b). I saw one bird in the western Solomon Sea on 14 January 1988, at 10° 09' S 150° 47' E, in the Goshen Strait. This large dark brown shearwater was feeding over a tuna shoal in company with a large flock of Black Noddies *Anous minutus*. I watched it closely seeing the diagnostic pale dark-tipped bill and pinkish-flesh legs and feet. The nearest known breeding place to PNG is Lord Howe Island in the western Tasman Sea where it is present from October to May before migrating to the northern hemisphere between May and September. These isolated records are presumably of vagrant non-breeding birds.

SOOTY SHEARWATER *Ardenna grisea*.

Greensmith (1975) reported this species in small numbers in the Bismarck and Solomon Seas between October and January. Coates (1985) rejected these records on the basis of confusion with Heinroth's Shearwater. During this survey I saw one large all dark shearwater in the western Solomon Sea I considered to be a Sooty rather than the similar Short-tailed Shearwater on 23 July 1985 at 6°41'S 148°55'E, 31 nm S from Cape Merkus, New Britain. I identified the bird on the basis of dark sooty-brown plumage with whitish primary and median underwing coverts and a general impression of size and shape particularly the long pointed wings and sloping forehead.

SHORT-TAILED SHEARWATER *Ardenna tenuirostris*.

This species breeds in immense numbers around south-eastern Australia and Tasmania (Marchant & Higgins 1990). It is a trans-equatorial migrant, the bulk of the population departing in April and May for the North Pacific and returning in October and November (Serventy *et al.* 1971). Beehler and Finch (1985) quoted H.L. Bell for PNG sight records, but gave no locality. Coates (1985) discounted as doubtful the old records by Finsch (1879), quoted in Reichenow (1899) for the Duke of York Islands and New Britain. However, in the light of my records during this survey these records are very likely valid. During this study I saw a significant northward passage of the species in the New Britain and New Ireland area in May 1988 with 120 northbound birds in 1 hour on 11 May 1988 at 4° 25' S 152° 30' E in the southern approaches to St. Georges Channel between New Britain and New Ireland. Additional records were 60 birds/hr flying N on 13 May 1988 at 1° 54' S 152° 52' E, 52 nm NNE from Mahur Is between 0830-1130 hrs, and c. 250 flying NNW at 1° 27' S 152° 52' E, 106 nm NNE from New Ireland, later on the same day. On the 15 May 1988 at 0° 11' N 152° 59' E, 200 nm NNE from New Ireland, between 0800-1100, 20 bird/hr were recorded

flying NNW. From the 15 to 18 May 1988, when my ship was working along the equator between 153°E and 147° E, I saw the species throughout each day moving north to NNW in small flocks. These birds were flying 1-10 metres above the sea in the fast and direct manner typical of this species on migration. With reference to Table 3, my observations in this study suggest the northward migration of Short-tailed Shearwaters in the SW Pacific is on a relatively narrow front passing through the Solomon Islands and mostly to the east of Bougainville and New Ireland, but with some birds going through St. Georges Channel between New Ireland and New Britain as per above observations. On 11 May 2000, in less than two hours, I saw a northerly passage of at least 20 000 Short-tailed Shearwaters through Ghizo Strait west of New Georgia, Solomon Islands (Hadden 2004). These birds would have almost certainly continued north through the eastern equatorial waters of PNG.

CHRISTMAS SHEARWATER *Puffinus nativitatus*

There are a number of breeding stations in the tropical and sub-tropical central and eastern Pacific (Onley & Scofield 2007). I saw one bird in Equatorial Pacific waters of PNG on 4 August 1985, at 1° 20' N 150° 00' E, 155 nm NNE from Mussau, PNG. The Christmas Shearwater was immediately distinguished from nearby Wedge-tailed Shearwaters by its smaller size, short tail and faster flight with more wing flapping (wind speed 5 knots). It came closer to the ship than the Wedge-taileds, passing a few metres off the stern. At this close range, I saw clearly the very uniform dark-brown plumage, which included the underwing and its black bill. This is likely to be the first sighting in PNG waters as previous reports of this species in the PNG area by Finch (1981b) and Coates (1985) are questionable as they mention "whitish underwing flashes" and "a narrow pale area on the underwing" and may refer to Heinroth's Shearwater. I also saw three on the equator at 154° 58'E, just outside of PNG waters, on 14 Nov 1993. There has been one subsequent record in PNG waters near the

Feni Islands at 3°45'S 153°50'E on 1 August 2007 (Shirihai 2008).

TROPICAL (AUDUBON'S) SHEARWATER

Puffinus bailloni.

Austin *et al* (2004) published a new molecular phylogeny of the worldwide Little-Audubon's Shearwater complex and this has for the most part been adopted by Onley and Scofield (2007). The tropical Pacific and Indian Ocean shearwater formerly included in the Audubon's group is now classified as Tropical Shearwater *Puffinus bailloni*. In the Pacific region the subspecies *dichrous* breeds at Tahiti, Marianas Is, Nauru, Fiji, Phoenix, Samoa, Tonga, Line Is, Marquesas Is, Gambier Is and Vanuatu (Onley and Scofield 2007). Dutson (2001) reported three sightings, in the Bismarck Sea off New Ireland in July 1997 and off Bougainville in 1987 which he considered the only records for PNG. I had reasonable views of three birds in PNG waters that I identified as this species. Two birds were seen on 7 October 1985 at 11° 00' S 156° 36' E, 46 nm ESE from Pocklington Reef, Coral Sea and one on 5 February 1986 at 4° 06' S 152° 30' E, 3 nm NE from Duke of York Is, Bismarck Sea. Description: these small to medium sized shearwaters had white underparts and blackish upperparts with the dark feathering extending to the lores and to just below eye level on the sides of the head. No white flank patches were seen. Chin, throat, breast and belly were white with dark under-tail. The underwings were white with dark primaries and narrow dark margins. Flight in the Coral Sea with 20 knot winds was five or six seconds of quick wing-beats followed by a glide, close to sea.

HEINROTH'S SHEARWATER *Puffinus heinrothi*.

Heinroth's Shearwater was known only from a few specimens obtained off the north eastern tip of New Britain and nearby Watom Island during the early twentieth century (Reichenow 1919). It was rediscovered on Bougainville Island when a recently fledged bird was found at Arawa in August 1979. Later in July 1980 an adult was captured at Panguna and it is thought to breed

in the Crown Prince Range (Hadden 1981).

Greensmith (1975) reported small numbers of Sooty Shearwaters in the Bismarck and Solomon Seas between October and January, but I would agree with Coates (1985) that these sightings may refer to Heinroth's Shearwater. Simpson (1990) recorded a flock of 12 birds on the sea close to the east coast of Bougainville in January 1990 and Bailey (1992) recorded seven birds at sea off Madang in September and October 1989. Several observers have subsequently recorded the species from seas around Bougainville and in the Bismarck Sea (Onley & Scofield 2007). Despite keeping a good lookout I did not see the species until 1990. I list below all sightings I made during this study:

9/9/1990	5° 58' S 152° 24' E	5
9/9/1990	4° 43' S 152° 27' E	1
13/9/1990	3° 48' S 149° 02' E	1
14/9/1990	3° 49' S 148° 57' E	5
30/9/1991	3° 43' S 151° 38' E	1
30/9/1991	3° 42' S 151° 36' E	1
2/7/1992	4° 54' S 152° 53' E	1
19/7/1992	2° 58' S 145° 39' E	2
27/3/2002	6° 23' S 152° 27' E	1

In all but one sighting Heinroth's was seen in association with mixed species flocks feeding over schools of Tuna sp. Accompanying species sometimes included Wedge-tailed Shearwater, Sooty Tern *Onychoprion fuscata*, Common and Black Noddy *Anous sp*, Brown Booby and Lesser Frigatebird *Fregata ariel*. Description: A small sooty brown shearwater appearing short winged and long bodied with a distinctive long slender bill (wing / tail ratio c.2.4, compared to c.3.27-3.36 for Sooty and Short-tailed Shearwaters). Their underwings had broad dark margins with a variable white central area or streak extending from primaries across the secondaries. In favourable viewing conditions with a low sun behind me I was able to see a pale belly patch on some birds. Sitting on the

water they appeared to be about half the size of a nearby Wedge-tailed Shearwater and the plumage much blacker in comparison. The flight in 15 knot winds consisted of about nine fast wing beats then a glide and shallow soar. In winds below 10 knots, four to six fast wing beats then a short glide.

WILSON'S STORM-PETREL *Oceanites oceanicus*.

Wilson's Storm-Petrel breeds around the coast of Antarctica and on some sub-Antarctic islands (Marchant & Higgins 1990). During the austral winter it migrates north to tropical and temperate seas around the world. Surprisingly, there have been very few records from PNG waters, but there are a few from nearby in the Solomons (Dutson 2001). The Whitney South Seas Expedition collected two off Bougainville on 30 April 1928 and there is a report of the species off southern PNG in August (Coates 1985). I saw clearly and positively identified a single Wilson's Storm-Petrel in the northern Coral Sea and two in the Bismarck Sea; one on 5 October 1985 at 11° 14' S 150° 58' E, 7 nm S from Uluna Reef, and two on 14 August 2007 at 5° 14' S 146° 41' E 20 nm W from Long Island, Bismarck Sea, PNG.

WHITE-FACED STORM-PETREL *Pelagodroma marina*.

Large populations of this species breed around southern Australia *P.m.dulciae*, and around New Zealand *P.m.maoriana* (Marchant & Higgins 1990). They are migratory with western Australian birds wintering in the north Indian Ocean and Arabian Sea (Bourne 1960) and New Zealand birds wintering in the eastern tropical Pacific (Imber 1984). Imber also suggested that the eastern Australian birds winter near the South Tropical Convergence, particularly north of New Zealand in the area of the Kermadec Islands. From 16-22 May, 36 were recorded in Australian waters in the NE Coral Sea (Stokes & Corben 1985). A solitary White-faced Storm-Petrel was seen for a few minutes close to the ship (30 metres) in the Solomon Sea on 21 August 1985 at 7° 26' S 149° 04' E, 69 nm

NE from Cape Ward Hunt. This sighting is a long way from any known wintering area and is the first record for PNG waters. I am familiar with this distinctive species from many voyages around Australia and New Zealand. Description: primaries and secondaries dark brown, wing coverts and back brownish with prominent pale diagonal bar from carpal towards body on upperwing. Tail dark brown contrasting with light grey rump. Crown dark. Sides of face white with diagnostic dark area through eye on to ear coverts. Underparts white. Underwing white with broad dark posterior margin formed by primaries and secondaries. The flight was buoyant and weaving, the bird banking and showing its underside as it flew parallel to the ship's course. The feet extended well beyond the end of the tail. In PNG Coral Sea waters I had close views of two birds of this species both with a pale grey rump on 13 July 1990. One at 10° 36' S 146° 01' E, 97 nm SW from Port Moresby, another at 11° 31' S 146° 00' E, 140 nm SSW from Port Moresby.

BLACK-BELLIED STORM-PETREL

Fregatta tropica.

The Black-bellied Storm-Petrel has a circumpolar breeding distribution at various antarctic and sub-antarctic islands during the austral summer (Marchant & Higgins 1990). During this study, see Table 3, it was found to be widely distributed in small numbers in PNG waters of the northern Coral Sea during the southern winter and spring. The only previous records for the area are two birds the Whitney South Seas Expedition collected on 8 September 1928 between the Solomons and Samarai on the south coast of PNG. A single bird I saw in the Louisiade Archipelago was the most northerly observation of the species during this study on 8 July 1988 at 10° 40' S 151° 59' E, 6 nm N from Lunn Island. These birds were all clearly distinguished from the similar White-bellied Storm-Petrel *Fregatta grallaria*, which I did not see in the area. All showed feet projecting 10-15mm beyond the tail and some showed the characteristic black belly line. Lightly marked

birds had black breast plumage extending lower on breast and more extensive black undertail coverts than typical *grallaria*.

LEACH'S STORM-PETREL *Hydrobates leucorhoa*.

The nominate subspecies of Leach's Storm-Petrel, *O.l.leucorhoa* is a summer breeder in the North Atlantic area and in the North Pacific from northern Japan to the Aleutian Islands and Alaska. Other sub-species breed along the west coast of North America from Alaska south to Guadalupe Island off Mexico. These tend to be smaller and have darker rump markings but there is some overlap of characteristics with the nominate subspecies (Ainley 1980, 1983; Bourne & Jehl 1982). The nominate race migrates south with maximum winter density in the central equatorial Pacific around 170°E to 160°W where many also remain during the northern summer (Crossin 1974). On 5 May 1988 a Leach's Storm-Petrel with characteristics of the nominate subspecies came aboard at 1°50'N 149°E, 186 nm NNW from Mussau PNG, being attracted to the ship's working lights at night in heavy rain. The bird was photographed, measured and released in good condition the next day (Figure. 2).

Description: The bird was in fresh plumage. The general colour was dark sooty brown with a 'leadен' bloom on the head, crown, nape, hindneck, shoulders and mantle. The underparts were a uniform dark sooty brown. There was a prominent pale brown upper wing bar diagonally from the carpal towards the body across the lesser and greater coverts,



Figure 2. Leach's Storm-Petrel

contrasting with the sooty brown primaries and secondaries. The sides of the rump/upper tail coverts were pure white, being divided by brown feathering over the central one third. The white of the rump did not extend to the flanks. The tail was forked. The bill, legs and feet were black. The iris was brownish black. Measurements: wing 160 mm, tail 82 mm, tarsus 25 mm, culmen 16 mm. The next day, 6 May 1988 I saw two more Leach's Storm-Petrels close to the ship at 0° 10' S 148° 57' E, 35 nm WNW from Mussau. Both birds had white rumps divided by dark central feathering. I saw them in association with a very large flock of Wedge-tailed Shearwaters. There do not appear to be any previous records of Leach's Storm-Petrel as far west in the Equatorial Pacific as PNG.

MATSUDAIRA'S STORM-PETREL *Hydrobates matsudairae*.

This large storm-petrel breeds in the North Pacific at Iwo Island and in the Bonin Group, where it is present between January and June. It is known to disperse to warm waters to the south west, indicated by specimens that were taken in late July between north west Australia and Indonesia, (Bailey *et al.*1968). The same authors describe a series of sight records across the equatorial Indian Ocean in light wind areas within five degrees of latitude of the equator from July to November. It is now regularly recorded in the Ashmore Reef area off NW Australia, July to November (pers.obs.; M.Carter in litt 2010).

With reference to Table 3, during 1985 between 30 July and 19 August I recorded small numbers in northern PNG waters, in the Bismarck Sea south of New Ireland, off the Sepik River estuary and north along the 150°E meridian to 3°N. (Marchant & Higgins 1990). Identifiable photographic slides were taken and compared with a flight photograph from the North Pacific supplied by Y.Tanaka. The species had not previously been recorded from the seas around PNG. During this and subsequent voyages to northern PNG waters during July and August in

1991,'92,'97 and 2007 I have made 47 sightings of Matsudaira's Storm-Petrel within the period 7 July to 19 August. My observations were from the Bismarck Sea, equatorial waters of PNG, off the south coast of New Ireland and to the east of the Nuguria Islands. My most easterly sighting was at 3°S 155°E on 7 July 1992 (Hadden 2004). The only other PNG records, by Shirihai, were also at this season, between 28 July and the 7th August 2007, off the south coast of New Ireland, west from Buka and near the Nuguria Islands.(Shirihai 2008). Selected records:

30/7/1985	3° 30' S 151° 21' E	1
1/8/1985	0° 57' S 150° 00' E	2
4/8/1985	1° 00' N 150° 00' E	4
5/8/1985	2° 00' N 150° 00' E	2
19/8/1985	3° 04' S 144° 42' E	3
17/7/1991	5° 36' S 147° 10' E	1
21/7/ 1991	0°01' N 147° 03' E	3
22/7/1991	1° 59' N 147° 06' E	4
24/7/1991	0° 31' S 146° 59' E	3
7/7/1992	3° 00' S 155° 00' E	1
19/7/1992	2° 45' S 145° 38' E	3
23/7/1992	5° 17' S 146° 03' E	1
6/8/1997	2° 47' S 145° 05' E	2
1/8/2007	4° 59' S 147° 11' E	2
7/8/2007	4° 52' S 150° 51' E	1
14/8/2007	5° 13' E 146° 21' E	1

The sea temperature range for all observations of Matsudaira's was 27.1°C to 30.9°C and the salinity range 33.32‰ to 35.02‰, average temperature 28.9°C and salinity 34.21‰. The series of records confined to July and August indicate that Matsudaira's has a post breeding dispersal from the North Pacific through northern PNG waters before moving west into the equatorial Indian Ocean. The absence of any records at other times of the year suggests a return to the North Pacific breeding colonies to the northwest through Indonesian waters. Description: the birds seen were large dark brown storm petrels showing a light brown

diagonal stripe on the upper wing from the carpal joint across the greater coverts. The tail was forked however the feature was difficult to see in flight except at close range. Many were in moult with missing primaries and occasionally missing tail feathers. A white mark distal from the carpal joint near the leading edge of the upper wing, formed by white shafts of primaries, was visible to 75 metres through binoculars. The flight consisted of three or four quick flaps followed by a bounding glide, sometimes touching the water. Longer periods of more flapping flight were also seen. I saw some birds resting on the water with folded wings during calm conditions. Several times birds were attracted to food waste from the ship and fed settled on the water with wings held at 45° giving two or three flaps every 10 seconds to maintain stability. They were inclined to follow the ship usually about 50 metres astern.

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Neil Cheshire

7 Hodge Avenue

Encounter Bay

South Australia 5211

diomedea1@bigpond.com