Convention on the Conservation of Migratory Species of Wild Animals

Secretariat provided by the United Nations Environment Programme

16TH MEETING OF THE CMS SCIENTIFIC COUNCIL

Bonn, Germany, 28-30 June 2010

UNEP/CMS/ScC16/Doc.17
Agenda Item 15.4

TAXONOMY OF ALBATROSSES AND LARGER PETRELS

(Prepared and submitted by the Taxonomic Working Group of the Agreement on the Conservation of Albatrosses and Petrels)

Taxonomy of albatrosses and larger petrels

Prepared by the Taxonomic Working Group of the Agreement on the Conservation of Albatrosses and Petrels

Abstract

During the last two decades the taxonomy of albatrosses and petrels has been the subject of extended debate and controversy. As such, the Agreement on the Conservation of Albatrosses and Petrels (ACAP) established a Taxonomic Working Group to deliver a transparent, defensible and highly consultative taxonomic listing process based upon the appropriate use of peer-reviewed publications. A set of guidelines for taxonomic decision-making were developed and these have been applied to the taxa currently listed by the Agreement, with a particular focus on the most controversial taxa.

Following a complete review of the controversial taxa, ACAP now recognises 22 albatross species, two giant-petrel species and the Spectacled Petrel as a separate species to the White-chinned Petrel. After further review, BirdLife International, which produces the avian IUCN threatened species lists, has now also adopted an identical taxonomy.

We recommend that the Scientific Council of the CMS:

- recognise that ACAP has established a thorough, robust, transparent and defensible taxonomic process for addressing the complex and sometimes controversial issues associated with the taxonomy of albatrosses and some petrels;
- recognise ACAP as the appropriate taxonomic authority for albatrosses and petrels;
- adopt the taxonomy used by ACAP.

1. Introduction

The taxonomic naming and specific separation of albatrosses and petrels has been fluid in recent years. This has led to this group being treated differently by the Agreement on the Conservation of Albatrosses and Petrels (ACAP) and the Convention on Migratory Species (CMS) (Table 1). This paper provides the case for the taxonomy adopted at present by ACAP.

2. A brief history of albatross and petrel taxonomy

The taxonomy of albatrosses and petrels has always been problematic. Over 80 albatross taxa have been formally described since the mid 1700s (Robertson & Nunn 1998) often based on specimens collected at sea that could not be assigned to breeding locations. As knowledge of breeding locations and plumage maturation improved many of these 'new taxa' were recognised to be previously described species. This in turn led to prolonged debates over the number of species and the precedence of scientific and common names (e.g. Medway 1993; Robertson & Nunn 1998; Robertson & Gales 1998; Robertson 2002).

Much of the present taxonomic confusion surrounding albatrosses followed the publication of a phylogenetic study of most albatross taxa by Nunn *et al.* (1996). Prior to this study the number of albatross species was considered to be 14. However, using data from Nunn *et al.* (1996) and other behavioural and morphometric data, Robertson & Nunn (1998) proposed a new 'interim' taxonomy which recognised 24 albatross species. Unfortunately the taxonomic decisions presented in their

book chapter were not always supported by published, peer-reviewed scientific data and thus much controversy has surrounded the decisions therein. A less controversial suggestion by Nunn *et al.* (1996) was to recognise four albatross genera (Diomedea, Thalassarche, Phoebetria and Phoebastria) rather than two. This suggestion has received universal support but as yet the CMS appendices have not adopted this nomenclature.

Following Robertson & Nunn's publication, Brooke (2004) advocated 21 albatross species, whereas Penhallurick & Wink (2004) re-analysed the genetic data published by Nunn *et al.* (1996) and argued the data supported the recognition of only 13 albatross species and only one species of giant petrel. The scientific logic adopted by Penhallurick & Wink (2004) was severely criticised by Rheindt & Austin (2005) who argued that later genetic studies (e.g. Burg & Croxall 2001; Abbott & Double 2003b; Abbott & Double 2003a; Burg & Croxall 2004) not considered by Penhallurick & Wink (2004) support the recognition of at least some of the species in the taxonomy proposed by Robertson & Nunn (1998). Most recently Chambers *et al.* (2009) presented phylogenetic data which they argue supports the recognition of at least 22 albatross species.

Given the controversy surrounding the taxonomy of albatrosses and some of the larger petrels ACAP recognised the importance of directly addressing this issue.

3. ACAP's Taxonomic Process

Article IX 6 (b) of the Agreement on the Conservation of Albatrosses and Petrels (ACAP) requires the Advisory Committee to "endorse a standard reference text listing the taxonomy and maintain a listing of taxonomic synonyms for all species covered by the Agreement".

Resolution 1.5 of the First Session of the Meeting of the Parties (MoP1) to ACAP provides for the establishment by the Advisory Committee of a Working Group on the taxonomy of albatross and petrel species covered by the Agreement. The objective of the Taxonomic Working Group was to establish a transparent, defensible and highly consultative taxonomic listing process. The Scientific Meeting that preceded the first session of ACAP's Meeting of the Parties (MoP1; ScM1; Section 4.3) stated that "…given the importance that species lists have upon conservation policy and scientific communication, taxonomic decisions must be based on robust and defensible criteria. It is important to resolve differences in a scientific and transparent manner with appropriate use of peer-reviewed publications."

4. ACAP's Taxonomy Working Group (TWG)

The first action for the TWG was to agree on a set of guidelines for taxonomic decision-making and recommend them to ACAP's Advisory Committee. The guidelines adopted by ACAP's Advisory Committee (Annex 1) were strongly based on those described by Helbig *et al.* (2002) of the taxonomic sub-committee of the British Ornithologists' Union. These guidelines justify the adoption of a particular species concept and make the decision-making process transparent. They facilitate the assessment and assimilation of potentially influential studies while guarding against poor science. The guidelines also consider the inevitable limitations of species lists and the benefits of taxonomic stability.

The TWG has since applied these guidelines to the taxa currently listed by the Agreement with a particular focus on the more controversial species splits. Annex 2 summarises the taxa reviewed in detail and provides links to the associated Advisory Committee report; an example is provided at Annex 3.

Table 1. Current listings of species by ACAP and CMS

	Species listed under ACAP	**Associated species as currently listed in CMS appendices (Appendix I & II)**	**Common name**
	FAMILY DIOMEDEIDAE - ALBATROSSES		
1	*Diomedea exulans*	*Diomedea exulans* (II)	Wandering Albatross
2	*Diomedea dabbenena*		Tristan Albatross
3	*Diomedea antipodensis*		Antipodean Albatross
4	*Diomedea amsterdamensis*	*Diomedea amsterdamensis* (I)	Amsterdam Albatross
5	*Diomedea epomophora*	*Diomedea epomophora* (II)	Southern Royal Albatross
6	*Diomedea sanfordi*		Northern Royal Albatross
7	*Phoebastria irrorata*	*Diomedea irrorata* (II)	Waved Albatross
8	*Phoebastria albatrus*	*Diomedea albatrus* (I)	Short Tailed Albatross
9	*Phoebastria immutabilis*	*Diomedea immutabilis* (II)	Laysan Albatross
10	*Phoebastria nigripes*	*Diomedea nigripes* (II)	Black Footed Albatross
11	*Thalassarche cauta*	*Diomedea cauta* (II)	Shy Albatross
12	*Thalassarche steadi*		White-capped Albatross
13	*Thalassarche salvini*		Salvin's Albatross
14	*Thalassarche eremita*		Chatham Albatross
15	*Thalassarche bulleri*	*Diomedea bulleri* (II)	Buller's Albatross
16	*Thalassarche chrysostoma*	*Diomedea chrysostoma* (II)	Grey-headed Albatross
17	*Thalassarche melanophris*	*Diomedea melanophris* (II)	Black-browed Albatross
18	*Thalassarche impavida*		Campbell Albatross
19	*Thalassarche carteri*		Indian Yellow-nosed Albatross
20	*Thalassarche chlororhynchos*	*Diomedea chlororhynchos* (II)	Atlantic Yellow-nosed Albatross
21	*Phoebetria fusca*	*Phoebetria fusca* (II)	Sooty Albatross
22	*Phoebetria palpebrata*	*Phoebetria palpebrata* (II)	Light-mantled Albatross
	FAMILY PROCELLARIIDAE - PETRELS		
23	*Macronectes giganteus*	*Macronectes giganteus* (II)	Southern Giant-petrel
24	*Macronectes halli*	*Macronectes halli* (II)	Northern Giant-petrel
25	*Procellaria aequinoctialis*	*Procellaria aequinoctialis* (II)	White-chinned Petrel
26	*Procellaria conspicillata*		Spectacled Petrel
27	*Procellaria parkinsoni*	*Procellaria parkinsoni* (II)	Black Petrel
28	*Procellaria westlandica*	*Procellaria westlandica* (II)	Westland Petrel
29	*Procellaria cinerea*	*Procellaria cinerea* (II)	Grey Petrel

5. ACAP Taxonomy

The taxonomic review process will continue and the TWG will review relevant scientific papers as they are published. However, the first complete review of the taxa currently listed by ACAP was largely completed following the presentation of the TWG's report to AC5 in April 2010.

The taxonomy currently adopted by ACAP recognises 22 species of albatross and two species of giant-petrel (Table 1). The ACAP taxonomy has been recognised and adopted by Birdlife International who also provide the avian IUCN threatened species lists (see Annex 4).

6. Remaining taxonomic controversies

Given the disagreement that has surrounded the taxonomy of the albatrosses and petrels over the last few decades it is perhaps not surprising that controversy still remains. However, in most cases the disagreement surrounds relatively few taxa and certainly those that are very closely related or where data are few. For example, very recently the New Zealand Checklist Committee finalised its most recent checklist and recognised all species listed by ACAP except Shy and White-capped Albatrosses which were recognised as subspecies (see Annex 4).

Drastically different views do remain. Christidis & Boles (2008) recently published a book on the systematics and taxonomy of Australian birds and their treatment of albatrosses and large petrels largely followed that espoused by Penhallurick & Wink (2004) – see Annex 4. This treatment was reviewed by the TWG in their most recent report to the ACAP AC and their conclusions were as follows:

The TWG acknowledges the impressive scope of the work published by these well-respected avian taxonomists but it is our opinion that they sometimes apply a contradictory and uncritical genetic-distance based approach to taxonomy. The albatross species recognised by Christidis & Boles (2008) would suggest they are swayed by the views and approach of Penhallurick & Wink (2004) who recognise taxa at the species level entirely based on genetic distances at a single gene and without any consideration of other informative data. Penhallurick & Wink (2004) do not recognise taxa at the species level unless the genetic distance is 'sufficient' but their determination of sufficient is based on the genetic distance between arbitrarily selected 'good species'. That two taxa must reach a threshold of genetic divergence at a single gene before being recognised as separate species, irrespective of other informative data, is a taxonomic approach that has been severely criticised in the literature (Rheindt & Austin 2005).

Importantly, Christidis & Boles (2008) do diverge from Penhallurick & Wink (2004) in recognising Northern and Southern Giant Petrels as separate species despite their low genetic divergence (0.6% at cytochrome b gene). These Giant Petrels represent one of the few cases among the albatrosses and petrels where contentious sister taxa breed sympatrically and so perhaps where non-genetic data are more difficult to ignore. The behavioural, ecological and genetic data show these taxa are distinct (González-Solís et al. 2000; González-Solís et al. 2002a; González-Solís et al. 2002b; Techow et al. 2010) which is perhaps why, in this case, Christidis & Boles do not apply the rules of uniform genetic divergence between species as espoused by Penhallurick & Wink.

7. Current membership of the ACAP Taxonomy Working Group

Name	Institution	Party
Dr. Mike Brooke	Cambridge University	Birdlife International
Dr. Geoff Chambers	Victoria University	New Zealand
Dr. Michael Double	Australian Antarctic Division	Australia
Dr. Diego Montalti	Instituto Antártico Argentino	Argentina
Dr. Peter Ryan	University of Cape Town	South Africa
Mark Tasker	Joint Nature Conservation Committee	United Kingdom

See Annex 5 for References cited.

Annex 1

GUIDELINES FOR THE IDENTIFICATION OF SPECIES BOUNDARIES AMONG TAXA LISTED BY THE AGREEMENT ON THE CONSERVATION OF ALBATROSSES AND PETRELS (ACAP) TAXONOMIC WORKING GROUP

1. Introduction

Resolution 1.5 of the First Session of the Meeting of the Parties (MOP1) to ACAP provides for the establishment by the Advisory Committee of a Working Group on the taxonomy of albatross and petrel species covered by the Agreement.

The objective of this Working Group (WG) is to establish a transparent, defensible and highly consultative taxonomic listing process. The Scientific Meeting (MOP1; ScM1; Section 4.3) stated that "…given the importance that species lists have upon conservation policy and scientific communication, taxonomic decisions must be based on robust and defensible criteria. It is important to resolve differences in a scientific and transparent manner with appropriate use of peer-reviewed publications."

The guidelines to identify species boundaries among taxa listed by ACAP are listed below. These guidelines are largely based on those presented by Helbig *et al.* (2002). This document should not be considered an original piece of work but an adaptation of the guidelines presented by Helbig *et al.* (2002).

It is worth recalling the following paragraph written by Helbig *et al.* (2002) when reading these guidelines:

"No species concept so far proposed is completely objective or can be used without the application of judgement in borderline cases. This is an inevitable consequence of the artificial partitioning of the continuous processes of evolution and speciation into discrete steps. It would be a mistake to believe that the adoption of any particular species concept will eliminate subjectivity in reaching decisions."

2. Species concepts

Helbig *et al.* (2002) adopt the General Lineage Concept (GLC: de Queiroz 1998; de Queiroz 1999) a concept very similar to the Evolutionary Species Concept (ESC: Mayden 1997) but stresses that "differences between concepts are largely a matter of emphasis" and that the tenets of other common concepts such as the Biological Species Concept, the Phylogenetic Species Concept (PSC: Cracraft 1983) and the Recognition Species Concept are largely encompassed by the GLC.

The General Lineage Concept defines species as:

"…population lineages maintaining their integrity with respect to other lineages through time and space; this means the species are diagnosably different (otherwise we could not recognize them), reproductively isolated (otherwise they would not maintain their integrity on contact) and members of each (sexual) species share a common mate recognition and fertilization system (otherwise they would not be able to reproduce)." (Helbig *et al.* 2002)

Helbig *et al.* (2002) state that to produce a practical taxonomy for West Palaearctic birds the species definition must only include taxa "for which we are reasonably certain that they will retain their integrity no matter what other taxa they encounter in the future."

The WG considers this criterion difficult or impossible to apply to predominantly allopatric taxa such as procellariiform seabirds. The WG therefore restrict its considerations to only the first of the two questions posed by Helbig *et al.* (2002) in order to delimit species. They were:

1. Are the taxa diagnosable?

2. Are they likely to retain their genetic and phenotypic integrity in the future?

By adopting this strategy the WG applies the less stringent GLC (de Queiroz 1998; de Queiroz 1999) and ESC (Wiley 1978) which recognise species that are currently maintaining their integrity but "do not require species to maintain their integrity in the future" (Helbig *et al.* 2002).

Below we list a set of guidelines the WG will use to decide if taxa are diagnosable and if they therefore warrant specific status.

3. Guidelines to identify species (Diagnosability)

Taxon diagnosis is based on characters or character states. Characters used in diagnosis must be considered, or preferably shown to have a strong genetic (heritable) component and not likely to be the product of environmental differences. Characters known to evolve rapidly in response to latitude must be considered less informative e.g. morphometrics, timing of breeding and moult patterns.

In the assessment of diagnostic characters the WG, whenever possible, will only consider primary data published in peer reviewed journals. Conclusions drawn by such studies must be supported by appropriate statistical analyses. Once established the Taxonomy WG will aim to maintain the stability of the ACAP List of Taxa. Modifications to the List will only be considered when a study published in a peer reviewed journal suggests change.

As stated by Helbig *et al.* (2002), taxa are diagnosable if:

A. "Individuals of at least one age/sex can be distinguished from the same age/sex class of all other taxa by at least one qualitative difference. This means that the individuals will possess one or more discrete characters that members of the other taxa lack. Qualitative differences refer to presence/absence of a feature (as opposed to a discontinuity in a continuously varying character)."

B. "At least one age/sex class is separated by a complete discontinuity in at least one continuously varying character (e.g. wing length) from the same age/sex class of otherwise similar taxa. By complete discontinuity we mean that there is no overlap with regard to the character in question between two taxa." To detect a discontinuity the number of individuals compared should be based on sound judgement.

C. "If there is no single diagnostic character we regard a taxon as statistically diagnosable if individuals of at least one age/sex class can be clearly distinguished from individuals of all other taxa by a combination of two or three functionally independent characters." Body measurements are not considered independent characters.

A useful example here is the one presented by Helbig *et al.* (2002). *Larus michahellis* and *L. armenicus* "can be distinguished by a combination of wing-tip pattern, darkness of mantle and mtDNA haplotypes, although none of these characters is diagnostic on its own."

Because of the difficulties assessing reproductive isolation in allopatric taxa, Helbig *et al.* (2002) apply more stringent criteria to allopatric than sympatric taxa. They suggest that allopatric taxa should be recognised as species only if "they are fully diagnosable in each of *several* discrete or continuously variable characters relating to different function contexts, e.g. structural features, plumage colours, vocalisations, DNA sequences, and the sum of the character differences corresponds to or exceeds the level of divergence seen in related species that exist in sympatry."

See Annex 5 for References.

Annex 2. Taxa reviewed in detail by the ACAP Taxonomy Working Group

Taxon names	Putative species names	ACAP AC Report
Shy & white-capped Albatross	*Thalassarche cauta &* *T. steadi*	AC2 Doc 11
Gibson & Antipodean Albatross	*Diomedea gibsoni &* *D. antipodensis*	AC2 Doc 11
Buller's & Pacific Albatross	*Thalassarche bulleri &* *T. platei*	AC2 Doc 11
Northern & Southern Royal Albatross	*Diomedea sanfordi* *D. epomophora*	AC3 Doc 12 and see Annex 3
Atlantic & Indian yellow-nosed Albatross	*Thalassarche chlororhynchos &* *T. carteri*	AC3 Doc 12
Chatham & Salvin's Albatross	*Thalassarche eremita &* *T. salvini*	AC3 Doc 12
Southern & Northern Giant-petrels	*Macronectes giganteus* *M. halli*	AC3 Doc 12
White-chinned & Spectacled Petrels	*Procellaria aequinoctialis &* *P. conspicillata*	AC3 Doc 12
Wandering & Amsterdam Albatross	*Diomedea exulans* *D. amsterdamensis*	AC4 Doc 12
Black-browed & Campbell Albatross	*Thalassarche melanophris &* *T. impavida*	AC4 Doc 12
Black & Westland Petrels	*Procellaria parkinsoni &* *P. westlandica*	AC4 Doc 12
Wandering & Tristan Albatross	*Diomedea exulans* *D. dabbenena*	AC5 Doc 12

Annex 3 An example of the application of ACAP's taxonomic guidelines

Southern *Diomedea epomophora* and Northern *D. sanfordi* Royal Albatrosses

Recent taxonomic history

The Northern form of the Royal Albatross was formally described by Murphy (1917) but this taxon has generally been treated as a subspecies (*Diomedea epomophora sanfordi*) along with the Southern Royal Albatross (*Diomedea epomophora epomophora*) (e.g. Marchant & Higgins 1990). More recently Robertson & Nunn (1998) resurrected the specific status of these taxa although they provided few data to substantiate their case.

Primary publications or reviews of data relevant to the taxonomy of Northern and Southern Royal Albatrosses

1. **Harrison (1979; 1985)** described age-based criteria for differentiating *epomophora* and *sanfordi* at sea.
2. **Marchant & Higgins (1990) s**ummarised the available morphometric data for *sanfordi* and *epomophora*. They show strong morphological differentiation between the taxa.
3. **Nunn *et al*. (1996)** published sequence data from the mitochondrial cytochrome b gene for *sanfordi* only.
4. **Nunn & Stanley (1998)** published sequence data from the mitochondrial cytochrome b gene for both *epomophora* and *sanfordi* but made no taxonomic inferences.
5. **Robertson & Nunn (1998)** identified *epomophora* and *sanfordi* as terminal taxa and suggested they be recognised as separate species.
6. **Robertson (1998)** and later summarised by **Taylor (2000)** reported pairings of *epomophora* and *sanfordi* at Taiaroa Head and Enderby Island (Auckland Islands).
7. **Penhallurick & Wink (2004)** showed the divergence between the available cytochrome b sequences for *epomophora* and *sanfordi* (a single individual for each taxon) to be only 0.0009%. These authors argued that although these taxa are divergent, because the level of divergence is "smaller than … good species of albatross," they should be classified as subspecies.
8. **Rheindt & Austin (2005)** challenged Penhallurick & Wink (2004) on their methods of analysis and their interpretation of species concepts. They suggested because Penhallurick & Wink (2004) "use their own divergence estimates to override morphological, behavioural and genetic studies that have already established the species status of a number of taxa in question" they fail to follow their adopted multidimensional species concept.

Assessment of diagnosability (see Annex 1)

Based on data provided in the studies described above:

A. Same age/sex individuals of *epomophora* and *sanfordi* can be distinguished by one or more qualitative differences.
B. Same age/sex individuals of *epomophora* and *sanfordi* can be distinguished by a complete discontinuity in one or more continuously varying characters.
C. Same age/sex individuals of *epomophora* and *sanfordi* can be distinguished by a combination of two or three functionally independent characters.

Decision

These taxa meet the diagnosability criteria described in Annex 1. There are consistent plumage and morphological differences between these taxa that allow them to be distinguished at sea. The little genetic data available suggest divergence but clearly these taxa are very closely related and there is some evidence for contemporary gene flow. Currently, we recommend that these taxa continue to be recognised as separate species, namely:

Diomedea epomophora (Southern Royal Albatross)

Diomedea sanfordi (Northern Royal Albatross)

This follows Robertson & Nunn (1998) and concurs with recent wide-ranging works on Procellariiformes (Brooke 2004; Onley & Scofield 2007) and the current taxonomy of BirdLife International (2007).

Comments

This is clearly a case where more data are required. Phylogenetic, phylogeographic and population genetic data from each of the main breeding islands (Taiaroa Head and the Chatham, Campbell and Auckland Islands) are required and given the observed cases of hybridisation such data may be highly influential. More detailed morphometric and behavioural data would also be desirable as would quantitative analyses of plumage and plumage maturation. Upon production of these data this decision will need to be revisited.

See Annex 5 for References.

Annex 4 Comparison of the taxonomies adopted for Albatrosses and some Procellariidae petrels

Taxa are presented in order of their phylogenetic relationships. Shaded boxes indicate the species is not recognised and has been subsumed under the scientific name listed above the shaded cell.

	Convention on Migratory Species	ACAP (2010)	Brooke (2004)	Birdlife & IUCN	NZ Taxonomic Checklist (2010)	Penhallurick & Wink (2004)
No. albatross species	14	22	21	22	21	13
No. giant-petrel species	2	2	2	2	2	1
Wandering Albatross	*D. exulans*	*D. exulans*	*D. exulans*	*D. exulans*	*D. exulans*	*D. exulans*
Tristan Albatross		*D. dabbenena*	*D. dabbenena*	*D. dabbenena*	*D. dabbenena*	
Antipodean Albatross		*D. antipodensis*	*D. antipodensis*	*D. antipodensis*	*D. antipodensis*	
Gibson's Albatross						
Amsterdam Albatross	*D. amsterdamensis*	*D. amsterdamensis*	*D. amsterdamensis*	*D. amsterdamensis*	*D. amsterdamensis*	
Southern Royal Albatross	*D. epomophora*	*D. epomophora*	*D. epomophora*	*D. epomophora*	*D. epomophora*	*D. epomophora*
Northern Royal Albatross		*D. sanfordi*	*D. sanfordi*	*D. sanfordi*	*D. sanfordi*	
Waved Albatross	*D. irrorata*	*P. irrorata*	*P. irrorata*	*P. irrorata*	*P. irrorata*	*P. irrorata*
Short-tailed Albatross	*D. albatrus*	*P. albatrus*	*P. albatrus*	*P. albatrus*	*P. albatrus*	*P. albatrus*
Laysan Albatross	*D. immutabilis*	*P. immutabilis*	*P. immutabilis*	*P. immutabilis*	*P. immutabilis*	*P. immutabilis*
Black-footed Albatross	*D. nigripes*	*P. nigripes*	*P. nigripes*	*P. nigripes*	*P. nigripes*	*P. nigripes*
Shy Albatross	*D. cauta*	*T. cauta*	*T. cauta*	*T. cauta*	*T. cauta*	*T. cauta*
White-capped Albatross		*T. steadi*		*T. steadi*		
Salvin's Albatross		*T. salvini*	*T. salvini*	*T. salvini*	*T. salvini*	
Chatham Albatross		*T. eremita*	*T. eremita*	*T. eremita*	*T. eremita*	
Buller's Albatross	*D. bulleri*	*T. bulleri*	*T. bulleri*	*T. bulleri*	*T. bulleri*	*T. bulleri*
Pacific Albatross						
Grey-headed Albatross	*D. chrysostoma*	*T. chrysostoma*	*T. chrysostoma*	*T. chrysostoma*	*T. chrysostoma*	*T. chrysostoma*
Black-browed Albatross	*D. melanophris*	*T. melanophris*	*T. melanophris*	*T. melanophris*	*T. melanophris*	*T. melanophris*
Campbell Albatross		*T. impavida*	*T. impavida*	*T. impavida*	*T. impavida*	
Atlantic Yellow-nosed Albatross	*D. chlororhynchos*	*T. chlororhynchos*	*T. chlororhynchos*	*T. chlororhynchos*	*T. chlororhynchos*	*T. chlororhynchos*
Indian Yellow-nosed Albatross		*T. carteri*	*T. carteri*	*T. carteri*	*T. carteri*	
Sooty Albatross	*P. fusca*	*P. fusca*	*P. fusca*	*P. fusca*	*P. fusca*	*P. fusca*
Light-mantled Albatross	*P. palpebrata*	*P. palpebrata*	*P. palpebrata*	*P. palpebrata*	*P. palpebrata*	*P. palpebrata*
Southern Giant-petrel	*M. giganteus*	*M. giganteus*	*M. giganteus*	*M. giganteus*	*M. giganteus*	*M. giganteus*
Northern Giant-petrel	*M. halli*	*M. halli*	*M. halli*	*M. halli*	*M. halli*	
White-chinned Petrel	*P. aequinoctialis*	*P. aequinoctialis*	*P. aequinoctialis*	*P. aequinoctialis*	*P. aequinoctialis*	*P. aequinoctialis*
Spectacled Petrel		*P. conspicillata*	*P. conspicillata*	*P. conspicillata*	*Not relevant*	

Annex 5 References cited

Abbott, C. L. & Double, M. C. (2003a). Genetic structure, conservation genetics, and evidence of speciation by range expansion in shy and white-capped albatrosses. *Molecular Ecology* **12**:2953-2962.

Abbott, C. L. & Double, M. C. (2003b). Phylogeography of shy and white-capped albatrosses inferred from mitochondrial DNA sequences: implications for population history and taxonomy. *Molecular Ecology* **12**:2747-2758.

BirdLife International. (2007). Species factsheet: *Diomedea epomophora* http://www.birdlife.org.

Brooke, M. (2004). Albatrosses and petrels across the world. Oxford University Press, Oxford.

Burg, T. M. & Croxall, J. P. (2001). Global relationships amongst black-browed and grey-headed albatrosses: analysis of population structure using mitochondrial DNA and microsatellites. *Molecular Ecology* **10**:2647-2660.

Burg, T. M. & Croxall, J. P. (2004). Global population structure and taxonomy of the wandering albatross species complex. *Molecular Ecology* **13**:2345-2355.

Chambers, G.K., Moeke, C., Steel, R. and Trueman, J.W.H. (2009). Phylogenetic analysis of the 24 named albatross taxa based on full mitochondrial cytochrome b DNA sequences. *Notornis*, **56**:82-94.

Christidis, L. & Boles, W. E. (2008). Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Melbourne.

Cracraft, J. (1983). Species concepts and speciation analysis. *Current Ornithology* **1**:159-187.

de Queiroz, K. (1998). The general lineage concept of species, species criteria, and the process of speciation. In: Endless forms: species and speciation' (Ed. Howard, D. J. & Berlocher, S. H.). Oxford University Press, Oxford.

de Queiroz, K. (1999). The general lineage concept of species and the defining properties of the species category. In: 'Species: New Interdisciplinary Essays' (Ed. R. A. Wilson.) pp. 49-89. MIT Press: Cambridge, Massachusetts.

González-Solís, J., Croxall, J. P. & Briggs, D. R. (2002a). Activity patterns of giant petrels, *Macronectes* spp., using different foraging strategies. *Marine Biology* **140**:197-204.

González-Solís, J., Croxall, J. P. & Wood, A. G. (2000). Foraging partitioning between giant petrels Macronectes spp. and its relationship with breeding population changes at Bird Island, South Georgia. *Marine Ecology-Progress Series* **204**:279-288.

González-Solís, J., Sanpera, C. & Ruiz, X. (2002b). Metals and selenium as bioindicators of geographic and trophic segregation in giant petrels Macronectes spp. *Marine Ecology-Progress Series* **244**:257-264.

Harrison, P. (1979). Identification of Royal and Wandering Albatrosses. *Cormorant* **6**:13-20.

Harrison, P. (1985). Seabirds: An Identification Guide. Croom Helm, London.

Helbig, A. J., Knox, A. K., Parkin, D. T., Sangster, G. & Collinson, M. (2002). Guidelines for assigning species rank. *Ibis* **144**:518-525.

Marchant, S. & Higgins, P. J. (1990). Handbook of Australia, New Zealand and Antarctic birds. Oxford University Press, Melbourne.

Mayden, R. L. (1997). A hierarchy of species concepts: the denouement in the saga of the species problem. In: Species: the Units of Biodiversity (Ed. M. F. Claridge, H. A. Dawah and M. R. Wilson.) Chapman & Hall, London.

Medway, D. G. (1993). The identity of the Chocolate Albatross *Diomedea spadicea* of Gmelin, 1789 and of the Wandering Albatross *Diomedea exulans* of Linnaeus, 1758. *Notornis* **40**:145-162.

Murphy, R. C. (1917). A new albatross from the west coast of South America. *Bulletin of the American Museum of Natural History* **37**:861-864.

Nunn, G. B., Cooper, J., Jouventin, P., Robertson, C. J. R. & Robertson, G. G. (1996). Evolutionary relationships among extant albatrosses (Procellariiformes: Diomedeidae) established from complete cytochrome-b gene sequences. *Auk* **113**:784-801.

Nunn, G. B. & Stanley, S. E. (1998). Body size effects and rates of cytochrome b evolution in tube-nosed seabirds. *Molecular Biology & Evolution* **15**:1360-1371.

Onley, D. & Scofield, P. (2007). Albatrosses, Petrels and Shearwaters of the World. Christopher Helm, London.

Penhallurick, J. & Wink, M. (2004). Analysis of the taxonomy and nomenclature of the Procellariiformes based on complete nucleotide sequences of the mitochondrial cytochrome *b* gene. *Emu* **104**:125-147.

Rheindt, F. E. & Austin, J. J. (2005). Major analytical and conceptual shortcomings in a recent taxonomic revision of the Procellariiformes - a reply to Penhallurick and Wink (2004). *Emu* **105**:181-186.

Robertson, C. J. & Nunn, G. B. (1998). Towards a new taxonomy for albatrosses. In: Albatross biology and conservation (Ed. G. Robertson and R. Gales.) pp. 13-19. Surrey Beatty, Chipping Norton.

Robertson, C. J. R. (1998). Factors influencing the breeding performance of the Northern Royal Albatross. In: Albatross Biology and Conservation (Ed. G. Robertson and R. Gales.) pp. 20-45. Surrey Beatty, Chipping Norton.

Robertson, C. J. R. (2002). The scientific name of the Indian yellow-nosed albatross *Thalassarche carteri*. *Marine Ornithology* **30**:48-49.

Robertson, G. & Gales, R. (1998). Albatross biology and conservation. Surrey Beatty, Chipping Norton.

Taylor, G. A. (2000). Action Plan for Seabird Conservation in New Zealand. Threatened Species Occasional Publication No. 16, Biodiversity Recovery Unit, Department of Conservation, Wellington, New Zealand.

Techow, N. M. S. M., O'Ryan, C., Phillips, R. A., Gales, R., Marin, M., Patterson-Fraser, D., Quintana, F., Ritz, M. S., Thompson, D. R., Wanless, R. M., Weimerskirch, H. & P.G., R. (2010). Speciation and phylogeography of giant petrels Macronectes. *Molecular Phylogenetics and Evolution* **54**:472-487.

Wiley, E. O. (1978). The evolutionary species concept reconsidered. *Systematic Zoology* **27**:17-26.