Secretariat provided by the Australian Government

Scientific Meeting

Hobart, Australia, 8-9 November 2004

Agenda Item No. 6

ACAP/ScM1/Inf.11

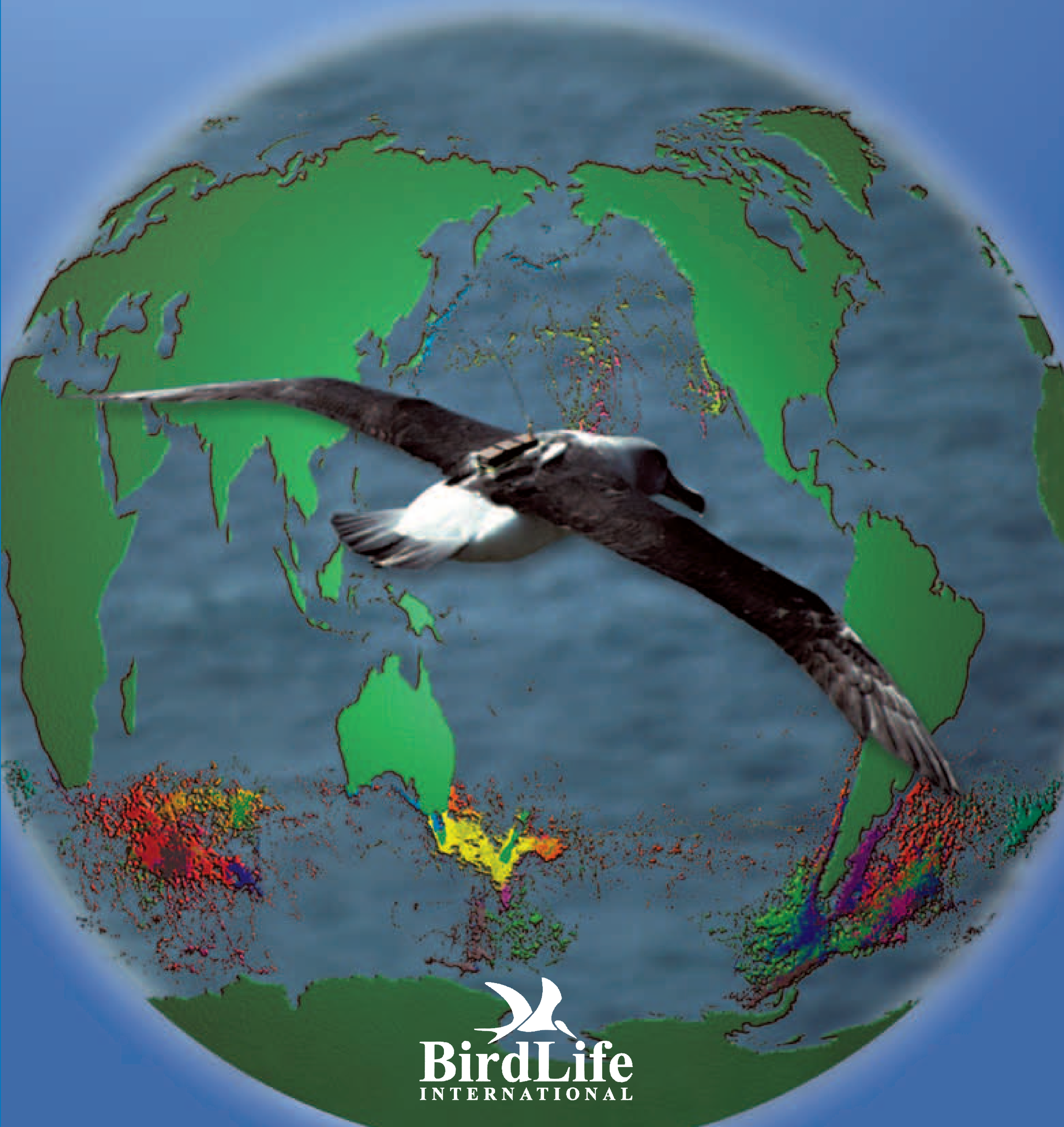
A paper by BirdLife International

Tracking Ocean Wanderers – The global distribution of albatrosses and petrels

TRACKING OCEAN WANDERERS

The global distribution of albatrosses and petrels

Results from the Global Procellariiform Tracking Workshop,
1–5 September, 2003, Gordon's Bay, South Africa



BirdLife INTERNATIONAL

What is BirdLife International?

BirdLife International is a Partnership of non-governmental conservation organisations with a special focus on birds. The BirdLife Partnership works together on shared priorities, policies and programmes of conservation action, exchanging skills, achievements and information, and so growing in ability, authority and influence.

What is the purpose of BirdLife International? – Mission Statement

The BirdLife International Partnership strives to conserve birds, their habitats and global biodiversity, working with people towards sustainability in the use of natural resources.

Where is BirdLife International heading? – Vision Statement

Birds are beautiful, inspirational and international. Birds are excellent flagships and vital environmental indicators. By focusing on birds, and the sites and habitats on which they depend, the BirdLife International Partnership is working to improve the quality of life for birds, for other wildlife (biodiversity) and for people.

Aims

Birdlife's long-term aims are to:

- Prevent the extinction of any bird species
- Maintain and where possible improve the conservation status of all bird species
- Conserve and where appropriate improve and enlarge sites and habitats important for birds
- Help, through birds, to conserve biodiversity and to improve the quality of people's lives
- Integrate bird conservation into sustaining people's livelihoods.

Guiding principles

BirdLife International works with all like-minded organisations, national and local governments, decision-makers, land-owners and managers, in pursuing bird and biodiversity conservation.

The global work of the BirdLife Partnership is funded entirely by voluntary donations. To find out more about how you could support this work, please contact the BirdLife International Secretariat, Wellbrook Court, Girton Road, Cambridge CB3 0NA, United Kingdom.

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The BirdLife Global Seabird Programme

Seabirds are often highly migratory. They travel widely across oceans and between different territorial waters, and spend considerable time in high seas areas, where no national jurisdiction exists, making it essential to address seabird conservation at a range of scales: national, regional and global.

Consequently in 1997, BirdLife International established a BirdLife Global Seabird Conservation Programme. This programme, international in its nature and scope, operates through a developing alliance of regional task groups, supplemented by close links to BirdLife Partners based in, or closely linked to, each region.

The main focus of the programme, exemplified by BirdLife's 'Save the Albatross' campaign, is the seabird mortality caused by bycatch in longline and other fisheries. It is the most critical conservation problem facing many species of seabirds. BirdLife works across a range of levels: working with fishers to encourage the use of onboard mitigation measures to reduce seabird mortality, and lobbying governments and international organisations to develop and implement appropriate regulatory frameworks and international agreements.

The Partnership played a key role in drafting the Agreement on the Conservation of Albatrosses and Petrels (ACAP, drafted under the guidelines of the Convention on Migratory Species), and has worked closely with the Food and Agriculture Organization of the United Nations' International Plan of Action for Seabirds (IPOA–Seabirds), including direct involvement in the drafting of National Plans of Action for Chile, Brazil, New Zealand and the Falkland Islands (Malvinas).

The strength of the programme lies in international collaboration between BirdLife Partners, scientists, industry and governments. We urge everyone to be involved in future initiatives. Please feel free to contact us.

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INTERNATIONAL

Recommended citation
BirdLife International (2004). *Tracking ocean wanderers: the global distribution of albatrosses and petrels. Results from the Global Procellariiform Tracking Workshop, 1–5 September, 2003, Gordon's Bay, South Africa.* Cambridge, UK: BirdLife International.

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BirdLife International is a UK-registered charity 1042125

ISBN 0-946888-55-8

British Library-in-Publication Data
A catalogue record for this book is available from the British Library

First published 2004 by BirdLife International

Designed and produced by the **Nature**Bureau Limited, 36 Kingfisher Court, Hambridge Road, Newbury, Berkshire RG14 5SJ, United Kingdom

Printed by Information Press, Oxford, United Kingdom

Available from: BirdLife Global Seabird Programme, RSPB, The Lodge, Sandy, Beds SG19 2DL, UK;
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ACKNOWLEDGEMENTS

This report was compiled, and all maps prepared, by Frances Taylor, assisted by Janet Silk and the authors of the individual sections. The report was edited by John Croxall.

We are very grateful to the Wallace Research Foundation for supporting the workshop and publication and distribution of this report, and to Gerard Bertrand and John Fanshawe of BirdLife International for their key role in facilitating this. We also thank Census of Marine Life for assisting with final report adoption and planning for the future. BirdLife International, particularly through John Fanshawe, helped in many ways with the planning of the meeting. Peter Creed (NatureBureau), Cleo Small (RSPB/BirdLife), Melanie Heath (BirdLife) and Helen Dobie (NatureBureau) facilitated the production of the report. BirdLife South Africa, in particular Deon Nel and Samantha Petersen (with the encouragement of Aldo Berruti), were exceptional hosts in respect of all aspects of the organisation of the workshop. We owe particular thanks to Deon Nel for his contribution to the vision which inspired the workshop and to Frances Taylor, without whose commitment and skill this report would not have been produced.

CONTENTS

EXECUTIVE SUMMARY

BACKGROUND AND INTRODUCTION

Seabirds belonging to the order Procellariiformes (albatrosses and petrels) are amongst the most pelagic of seabirds and occur in all of the world's oceans. They are, therefore, excellent potential indicators of the state of marine ecosystems, especially high seas.

The status and trends of albatross breeding populations are well documented and, with 19 of 21 species now globally threatened and the remainder Near Threatened (BirdLife International 2004a); albatrosses have become the bird family most threatened with extinction. Many petrel species are also globally threatened. Although albatross and petrel species face many threats at their breeding sites, the main problems they encounter currently relate to the marine environment, particularly involving interactions with fisheries, notably the many thousands of birds killed annually by longline fishing.

Many of the solutions to these problems require accurate knowledge of the distributions of albatrosses and petrels throughout their annual and life cycles. Such data are also invaluable for understanding many aspects of the ecology and demography of these species and their role in the functioning of marine systems—including their potential susceptibility to changes in these.

In terms of remote-tracking to reveal their at-sea distribution (a key to understanding how they function in marine ecosystems), albatrosses (and giant-petrels) are the most studied of all marine species. Given the substantial potential of these data for conservation applications, including for marine analogues of terrestrial Important Bird Areas (IBAs), pioneered by BirdLife since the 1980s, BirdLife convened an evaluation workshop to explore the data and concepts with the main dataholders. This report presents the results of the workshop.

AIMS

The main strategic aims of the workshop were:

1. To assess how at-sea distribution data from remote-tracking studies of seabirds can contribute to:
   i. the development of criteria for defining Important Bird Areas (IBAs) in the marine environment;
   ii. current initiatives for the establishment of high seas Marine Protected Areas (MPAs) especially by IUCN.
2. To scope the extent to which these data can be used to quantify overlap between marine areas used by albatrosses and the location of fishing effort, especially longline:
   i. to identify areas of higher risk, especially for the development of appropriate mitigation measures for the fisheries involved;
   ii. to identify the Regional Fishery Management Organisations (RFMOs) with prime responsibility for the management of fisheries with significant risk of incidental bycatch of globally threatened non-target species, especially albatrosses and petrels.
3. To establish a Geographic Information System database to maintain detailed information on remote-recorded range and distribution of seabirds, as an international conservation tool.

RESULTS

Data and methods

- Over 90% of all extant albatross and petrel tracking data was submitted to the workshop, representing 16 species of albatross, both species of giant-petrel and White-chinned Petrel. A GIS database was developed to facilitate analysis, visualisation and interpretation of these data.
- Standard analytical procedures were developed and applied to the satellite tracking (PTT) data from raw data records submitted by dataholders.
- Consistent procedures were developed for the presentation of geolocator tracking (GLS) data—the main source of information for distributions in non-breeding seasons.
- Appropriate analytical procedures were agreed for transforming location data into density distributions, a crucial step in the visualisation, analysis and interpretation of multiple data sets.
- Protocols for data access and use, acknowledging the need to make available information to the international conservation community while safeguarding the proprietary rights of the individual data contributors and data users, were agreed.

Analysis and case-histories

The data available allowed the demonstration of a variety of properties relating to albatross and petrel ecology and distribution, including:

- The nature and variation in range and distribution, for breeding birds, in relation to stage of breeding season, gender (sex) and year (i.e. interannual variation).
- Differences in range and distribution of breeding birds from different colonies within the same population (island group).
- Similarities and differences in range and distribution of breeding birds from different populations of the same species, using data for the two species (wandering albatross, black-browed albatross) with the most comprehensive data, which provide compelling evidence of the insights that can be generated by applying common and consistent approaches to data from a variety of studies and sites.
- Regional syntheses for providing clear indications of the potential (and challenges) for using data across a range of albatross and petrel species to identify areas of key habitat common to different species.
- Similarities and differences in range and distribution of breeding and non-breeding birds at the same time of year.
- The spectacular journeys and far-distant destinations (comprising migratory routes, staging areas and wintering ranges) of some species of albatross and petrel during the non-breeding season.

These represent very significant achievements, some indicating interesting aspects and avenues for future research, others identifying potential biases and concerns relating to analysis and interpretation of data, yet others revealing key gaps in our knowledge. Nevertheless, all indicate the potential of such data to address important questions relating to albatross and petrel ecology and conservation.

Strategic aims and applications

Definition of Important Bird Areas (IBAs) and contribution to high seas Marine Protected Areas

- Tracking data for albatrosses and petrels will make a key contribution to attempts to identify areas of critical habitat for marine organisms and hotspots of biodiversity in coastal and pelagic marine ecosystems.
- Characterising density distributions and combining (weighting) these with estimates of source population size, will be fundamental approaches for marine taxa.
- The extent to which existing definitions of IBAs, developed for terrestrial species and systems, can be extended to marine contexts requires considerable further investigation for which the albatross and petrel data are uniquely suited; however, approaches which combine data from different groups of marine animals (e.g. fish, seabirds, marine mammals) are likely to be essential in longer-term approaches to issues of marine habitat conservation.
- The albatross and petrel data represent a uniquely coherent and comprehensive data set, covering large areas of marine habitat, and are therefore especially suitable for further investigation, perhaps particularly in high seas contexts.

Interactions with fisheries and fishery management organisations

- Examples of overlap between albatross distribution (both breeding and on migration) and fishing effort illustrate the considerable importance and potential of approaches to match data on the distribution (and abundance) of albatrosses and petrels with data on fishing effort, particularly for longline fisheries.
- Difficulties in obtaining data for appropriate scales and times, even for the better documented fisheries, may constrain what can be achieved, especially in terms of analysis seeking to estimate bycatch rates and/or their impact on source populations of albatrosses.
- Nevertheless, even existing data are adequate to provide broad characterisation of the location (and timing) of potential interactions between albatross species and different longline fisheries; this is a high priority task.
- These data are used to provide a preliminary identification of the responsibilities of RFMOs for environmentally sensitive management of albatrosses and their habitat based on overlap of ranges and jurisdictions. For the Southern Hemisphere this provides very clear indications of the critical role of, in preliminary priority order, Commission for the Conservation of Southern Bluefin Tuna (CCSBT), Western and Central Pacific Fisheries Commission (WCPFC), Indian Ocean Tuna Commission (IOTC), International Commission for the Conservation of Atlantic Tunas (ICCAT) and Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).
- A similar initial review, in relation to Exclusive Economic Zones (EEZs), is also provided.
- Combined with data on overlap with fishing operations, these will enable preliminary identification of the times, places and fisheries where adverse interactions are most likely and, thereby, allow the identification of mitigation measures appropriate to the circumstances.

Maintaining the database as an international conservation tool

Participants agreed to maintain the tracking database, assembled for the purposes of this workshop, beyond the meeting and production of its report.

- The database should be maintained and reconstituted by re-submission of data on the basis of the agreed policy on data access and use.
- A policy and practice for data access and use (based on principles developed for the Census of Marine Life Ocean Biogeographic Information Service (OBIS) – SEAMAP Programme) was agreed.
- BirdLife International offered, at least as an interim measure, to house and manage the database at its Secretariat headquarters in Cambridge, UK.
- The offer was accepted in principle. However the need to maintain and augment the data, to facilitate interactive and collaborative use, to link the albatross and petrel and tracking data to other, analogous, data sets and to the latest information on the physical and biological marine environment was recognised. Possibilities for linking, or possibly migrating, the Procellariiform Tracking Database from BirdLife to an organisation or institution specialising in the management and analysis of data on marine systems and biogeography should be investigated.

FUTURE WORK

Existing data

- All data submitted to the workshop should be re-submitted to the new database, managed by BirdLife, and subject to the agreed data access and use procedures.
- Other extant data, especially for Antipodean and Waved Albatrosses, and Westland Petrel *Procellaria westlandica*, should be requested from relevant dataholders and data owners.
- New data should be requested as it becomes available.

New data

Priorities are:

- For breeding birds, more data (and in most cases from more individuals) are needed for some stages of the breeding cycle (particularly incubation), for sexed birds and for sufficient years to assess the consistency of basic distribution patterns, for additional populations (island groups) and from more colonies within populations.
- For most species, data on the distribution of adults when not breeding.
- For almost every species, data on the distribution of immatures and early life-history stages.

Methods

- Evaluation of the potential biases of using the different types (and where appropriate different duty cycling) of existing data (e.g. PTT, GLS) in different kinds of analysis and on the use of appropriate spatial statistics to create density distributions from the different kinds of tracking data.

Environment

- Need to facilitate easy access to appropriate data sets on the physical and biological environment at appropriate scales, including detailed bathymetry, sea surface temperature, marine productivity, sea-ice etc.

Links to other tracking/sighting data on pelagic marine taxa

- Facilitate links to analogous sets of data on other petrels, penguins, marine mammals, sea turtles and migratory fish.
- Encourage and support links with initiatives like the Marine Mammal Tracking Database and programmes like the Census of Marine Life's Tagging Of Pacific Pelagics which are trying to assemble similar data on a collaborative basis.
- Investigate the feasibility and utility of combining remote tracking and survey data sets. Prime candidate areas for pilot studies to do this with seabird data would include the north-east Pacific, tropical east Pacific, south-west Atlantic and parts of the Indian Ocean.

Links to data from fisheries

Compare and analyse the distribution data for albatrosses/petrels and fishing effort to:

- Identify times and places where potential exists for adverse interactions between fisheries and albatrosses/petrels. This would enable:
  - i. Specification of mitigation measures appropriate to these circumstances;
  - ii. Approaches to RFMOs with appropriate jurisdictions, singly or in combination, to seek to develop the necessary regulations to apply the mitigation measures.
- Estimate bycatch rates of albatrosses/petrels for appropriate areas and at appropriate scales and for extrapolation to areas where bycatch data from fisheries are currently lacking.
- Assist modelling of seabird-fishery interactions with implications for fisheries (taking financial losses through bycatch into account in cost-benefit analyses) and for seabird populations.

IBAs and Marine Protected Areas

- Identify and relate areas of core habitat to population estimates and threatened status to evaluate in detail the implications of different criteria for helping define marine IBAs.
- Develop this approach further by choosing suitable systems/areas in which to link to remote-tracking data on other seabirds (especially penguins) and to at-sea survey data. This is especially relevant for coastal and shelf systems (i.e. within EEZs).
- Develop this further relative to Marine Protected Areas in conjunction with data on other marine taxa (e.g. marine mammals, sea turtles) and on resource use (e.g. fisheries, hydrocarbons). This is relevant both to EEZs and to high seas.

Agreement on the Conservation of Albatrosses and Petrels (ACAP)

- The applications envisaged of the albatross and petrel tracking database are highly relevant to the conservation aims of ACAP. The database is likely to be a key tool for furthering the work of ACAP.

RESUMEN EJECUTIVO

ANTECEDENTES E INTRODUCCIÓN

Las aves pertenecientes al orden Procellariiformes (albatros y petreles) se encuentran entre las más pelágicas de las aves marinas y están presentes en todos los mares del mundo. Potencialmente son, por lo tanto, unos excelentes indicadores del estado de los ecosistemas marinos, sobre todo en alta mar.

Existe buena información sobre el estado y la tendencia de las poblaciones reproductoras de albatros. 19 de las 21 especies de albatros se encuentran amenazadas en la actualidad y el resto están en situación de casi amenaza (‘Near Threatened’) (BirdLife International 2004a). Por ello, la familia Diomedeidae se ha convertido en la familia de aves con mayor riesgo de extinción. Muchas especies de petreles y pardelas se encuentran también globalmente amenazadas. Aunque las especies de albatros y petreles sufren muchas amenazas en sus lugares de cría, sus problemas más importantes tienen lugar en el medio marino, sobre todo los que se derivan de las interacciones con pesquerías, especialmente los cientos de miles de aves que mueren cada año como consecuencia de la pesca de palangre.

Muchas de las soluciones a estos problemas requieren un conocimiento adecuado de las distribuciones de los albatros y los petreles a lo largo de sus ciclos anuales y vitales. Esa información resulta muy valiosa también para poder comprender muchos aspectos de la ecología y la demografía de dichas especies, así como su papel en el funcionamiento de los ecosistemas – incluida su susceptibilidad a los cambios potenciales en los ecosistemas.

En el aspecto del seguimiento a distancia para revelar cómo se distribuyen en el mar (un elemento clave para comprender cuál es su función dentro de los ecosistemas marinos), los albatros (y los petreles gigantes) se encuentran entre las especies marinas mejor estudiadas. Dado el potencial de estos datos para los objetivos de conservación, que se extiende al equivalente marino de las Áreas Importantes para las Aves (IBA), impulsadas por BirdLife International desde la década de los años 1980, BirdLife organizó un taller de evaluación para explorar los datos y los conceptos emanados con los principales proveedores de esos datos. Este informe presenta los resultados del taller

OBJETIVOS

Los principales objetivos estratégicos del taller fueron:

1. Evaluar de qué forma los datos de distribución en el mar obtenidos mediante seguimiento a distancia pueden contribuir a:
   i. la elaboración de criterios para definir Áreas Importantes para las Aves (IBAs) en el medio marino;
   ii. iniciativas actualmente ya en marcha de cara a establecer Áreas Marinas Protegidas en alta mar (MPAs) especialmente por parte de la UICN.
2. Analizar hasta qué punto esos datos pueden ser útiles para cuantificar el grado de coincidencia entre las áreas marinas que utilizan los albatros y la localización del esfuerzo pesquero, especialmente de palangre:
   i. para identificar las áreas de mayor riesgo, especialmente de cara a desarrollar medidas correctoras adecuadas para las pesquerías en cuestión;
   ii. para identificar las Organizaciones Regionales de Pesca (RFMOs) que tienen la responsabilidad principal en la gestión de las pesquerías con riesgo significativo de capturas accidentales de especies no objetivo mundialmente amenazadas, especialmente albatros y petreles.
3. Crear una base de datos de Sistemas de Información Geográfica (GIS) para almacenar información detallada sobre los movimientos y la distribución de las aves marinas obtenida a través del seguimiento a distancia, como una herramienta de conservación internacional.

RESULTADOS

Datos y métodos

- Se aportaron al taller más del 90% de todos los datos existentes de seguimiento de albatros y petreles, representativos de16 especies de albatros, las dos especies de petreles gigantes y Pardela Gorgiblanca Se desarrolló una base de datos GIS para facilitar el análisis, la visualización y la interpretación de los datos.
- Se desarrollaron procedimientos analíticos estándar, y se aplicaron los mismos a los datos de seguimiento por satélite (PTT) a partir de los datos en bruto aportados por los participantes.
- Se elaboraron procedimientos coherentes para la presentación de los datos de seguimiento por geolocalizador (GLS) – la principal fuente de información para la distribución de aves fuera de las temporadas de cría.
- Se convinieron unos procedimientos analíticos adecuados para transformar los datos de localizaciones en densidades de distribución, un paso esencial de cara a la visualización, análisis e interpretación de múltiples series de datos.
- Se acordaron protocolos para el uso y acceso a los datos, teniendo en cuenta la necesidad de facilitar información a la comunidad conservacionista internacional mientras al mismo tiempo se tienen que salvaguardar los derechos de propiedad de los titulares que aportaron los datos y de los usuarios de los mismos.

Análisis y casos ilustrativos

Los datos disponibles hicieron posible la demostración de varias propiedades relativas a la ecología y la distribución de los albatros y petreles, incluyendo:

- La naturaleza y la variación en el área y en la distribución, para las aves reproductoras, en relación con la fase de la temporada de cría, con el género (sexo) y el año (es decir, variación interanual).
- Diferencias en el área y en la distribución de las aves reproductoras pertenecientes a distintas colonias dentro de una misma población (grupo de islas).

- Semejanzas y diferencias en el área y en la distribución de aves reproductoras pertenecientes a distintas poblaciones de una misma especie, utilizando los datos de las dos especies con mayor información disponible (albatros viajero y albatros ojeroso), lo cual ha aportado pruebas ilustrativas de los resultados que pueden obtenerse si se aplican los mismos enfoques coherentes a datos obtenidos en distintos estudios y procedentes de distintos lugares.
- Síntesis regionales para aportar indicaciones claras del potencial (y los retos) de usar datos sobre diversas especies de albatros y petreles para identificar áreas comunes de hábitat esencial para las distintas especies.
- Semejanzas y diferencias en el área y la distribución de aves reproductoras y no reproductoras en la misma época del año.
- Los impresionantes viajes y los destinos lejanos (incluyendo las rutas migratorias, las áreas de reposo y las áreas de invernada) de algunas especies de albatros y petreles fuera de la época de reproducción.

Estos resultados representan unos avances muy importantes: algunos son indicativos de aspectos interesantes y abren nuevas líneas de investigación, otros identifican posibles sesgos y preocupaciones relativas al análisis y a la interpretación de los datos, e incluso otros revelan lagunas importantes en nuestro conocimiento. No obstante, todos indican el potencial de esos datos para hacer frente a las cuestiones importantes en la ecología y la conservación de albatros y petreles.

Objetivos y aplicaciones estratégicas

Definición de Áreas Importantes para las Aves (IBA) y contribución a las Áreas Marinas Protegidas en alta mar

- Los datos de seguimiento de albatros y petreles van a suponer una contribución esencial a los esfuerzos para identificar áreas de hábitat primordial para los organismos marinos y los núcleos de biodiversidad en los ecosistemas marinos costeros y pelágicos.
- Algunos de los enfoques fundamentales para los taxones marinos consistirán en caracterizar las distribuciones de densidades y combinar (sopesar) éstas con las estimas de tamaño de la población de origen.
- El grado con el que las actuales definiciones de IBA, desarrolladas para las especies y los ecosistemas terrestres, puedan extenderse al contexto marino requerirá de mucha investigación futura, para la cual los albatros y petreles están perfectamente situados; no obstante, es muy probable que los enfoques que combinan datos relativos a distintas clases de animales (p.ej., peces, aves marinas, mamíferos marinos) se conviertan en esenciales para la conservación a largo plazo de los hábitats marinos.
- La información relativa a los albatros y petreles representa una serie de datos amplia, única y coherente que se extiende sobre grandes áreas de hábitat marino; resulta por tanto especialmente adecuada para la investigación futura, posiblemente de modo especial para el contexto de alta mar.

Interacciones con pesquerías y organizaciones de gestión pesquera

- Los ejemplos de coincidencia entre la distribución de albatros (tanto en época de cría como fuera de ella) y el esfuerzo pesquero demuestran la gran importancia y el potencial de relacionar datos sobre la distribución (y abundancia) de albatros y petreles con los datos sobre esfuerzo de pesca, especialmente en el caso de las pesquerías de palangre.
- Los resultados pueden verse afectados por las dificultades en obtener datos en escalas y tiempo adecuados, especialmente por lo que respecta a los análisis tendentes a estimar la proporción de capturas accidentales y/o al impacto de éstas sobre las poblaciones de origen de los albatros.
- No obstante, los datos actualmente disponibles resultan apropiados, incluso, para caracterizar burdamente la localización (y la temporalidad) de las interacciones potenciales entre las especies de albatros y las distintas pesquerías de palangre; esta es una actuación altamente prioritaria.

  Estos datos sirven para realizar una identificación preliminar de las responsabilidades de los Organismos Regionales de Pesca (RFMOs) de cara a una gestión ambientalmente sensible de los albatros y su hábitat basada en la superposición de las áreas y las jurisdicciones. En el hemisferio Sur, esto aporta indicaciones muy claras del papel fundamental de los siguientes ORP, situados por orden preliminar de prioridad: Comisión para la conservación del atún de aleta azul (CCSBT), Comisión pesquera del Pacífico occidental y central, (WCPFC), Comisión del atún del Océano Índico (IOTC), Comisión internacional para la conservación del atún atlántico (ICCAT), y Comisión para la conservación de los recursos vivos marinos antárticos (CCAMLR). (N*ota: siglas en inglés*).
- Se elabora de forma preliminar también una revisión similar para las Zonas Económicas Exclusivas (EEZ).
- Combinada con los datos de superposición con la actividad pesquera, esta información permitirá identificar de forma preliminar las épocas, los lugares y las pesquerías en las que las interacciones perjudiciales son más probables y, por lo tanto, permitirá identificar medidas correctoras apropiadas a las circunstancias.

Mantener la base de datos como una herramienta de conservación internacional

Los participantes acordaron mantener una base de datos de seguimiento a distancia, reunida con motivo de este taller, más allá de la reunión y la elaboración de este informe.

- Dicha base de datos debería mantenerse y restaurarse mediante el envío de nuevo de los datos siguiendo los acuerdos alcanzados referentes al acceso y al uso de los datos.
- Se acordaron unos criterios y unas instrucciones para el acceso y el uso de los datos (basados en los principios desarrollados para el Programa *Census of Marine Life Ocean Biogeographic Information Service* (OBIS) – SEAMAP).
- BirdLife International ofreció albergar y gestionar, por lo menos como medida provisional, dicha base de datos en las oficinas centrales de su Secretariado en Cambridge, Reino Unido.
- La oferta se aceptó en principio. Sin embargo, se reconoció la necesidad de mantener y aumentar los datos, de facilitar un uso interactivo y compartido de los mismos, y de vincular los datos de seguimiento de albatros y petreles con otras series de datos análogas y con la última información disponible sobre los elementos físicos y biológicos del medio marino. Deberían investigarse las posibilidades de vincular, o

incluso de migrar, la Base de Datos de Seguimiento de Procellariiformes de BirdLife a otra organización o institución especializada en la gestión y el análisis de datos sobre sistemas y biogeografía marinos.

ORIENTACIONES DE CARA AL FUTURO

Datos existentes

- Todos los datos presentados en el taller deberían volver a enviarse a la nueva base de datos, gestionada por BirdLife, y deberían de someterse a los procedimientos acordados sobre acceso y uso de los datos.
- Deberían de solicitarse, de sus correspondientes depositarios o dueños, otros datos que se conoce que existen, particularmente para el Albatros de las Antípodas, para el Albatros de Galápagos, y para la Pardela de Westland (*Procellaria westlandica*).
- Deberían solicitarse nuevos datos a medida que estén disponibles.

Nuevos datos

Las prioridades son:

- Entre las aves reproductoras, se necesitan más datos (y en muchos casos sobre más ejemplares) para algunas fases del ciclo reproductor (especialmente la incubación), para aves de sexo conocido y para un número de años suficiente que permita evaluar la coherencia de los patrones básicos de distribución, para otras poblaciones (grupos de islas) y para más colonias dentro de las poblaciones.
- Para la mayoría de especies, datos sobre la distribución de los adultos cuando no se están reproduciendo.
- Para casi todas las especies, datos sobre la distribución de inmaduros y de las primeras fase de su ciclo vital.

Métodos

- Evaluar los posibles sesgos derivados de utilizar distintos tipos (y en su caso distintos ciclos de tareas) de datos existentes (p.ej. PTT, GLS) en distintos tipos de análisis y del uso de la adecuada estadística espacial para generar densidades de distribución a partir de los distintos tipos de datos de seguimiento.

Medio

- Facilitar de modo prioritario un acceso fácil a las series de datos adecuadas sobre el medio físico y biológico, en una escala adecuada, incluyendo batimetría detallada, temperatura de la superficie del agua, productividad marina, hielo en el mar, etc.

Vínculos con otros datos de seguimiento/avistamiento sobre otros taxones pelágicos

- Facilitar vínculos con otras series de datos análogas sobre otros petreles, pingüinos, mamíferos marinos, tortugas marinas y peces migratorios.
- Fomentar y apoyar los vínculos con iniciativas como la Base de Datos de Seguimiento de Mamíferos Marinos y programas como el Censo de Marcaje de la Vida Marina del Pacífico Pelágico que buscan reunir datos similares sobre la base de la colaboración.
- Indagar sobre la versatilidad y la utilidad de combinar series de datos de seguimiento a distancia y de censos. Las áreas ideales como candidatas para estudios piloto de este tipo con datos sobre aves marinas son el Pacífico NE, el Pacífico E tropical, el Atlántico SO y partes del océano Índico.

Vínculos con datos sobre pesquerías

Comparar y analizar los datos de distribución de albatros/petreles y de esfuerzo de pesca para:

- Identificar épocas y lugares con potencial para dar lugar a interacciones nocivas entre las pesquerías y los albatros/petreles. Eso permitiría:
  - i. Especificar las medidas correctoras apropiadas para esas circunstancias;
  - ii. Contactos con las ORP con jurisdicción, de forma individual o combinada, de cara a intentar desarrollar la regulación necesaria para que se apliquen las medidas correctoras.
- Estimar la proporción de capturas accidentales de albatros/petreles en determinadas áreas y en la escala apropiada y extrapolarla a las áreas en las que no se dispone de datos de capturas accidentales en sus pesquerías.
- Ayudar a modelizar las interacciones aves marinas-pesquerías con implicaciones para las pesquerías (teniendo en cuenta las pérdidas financieras causadas por las capturas accidentales en los análisis coste-beneficio) y para las poblaciones de aves marinas.

IBA y Áreas Marinas Protegidas

- Identificar y relacionar las áreas de hábitat primordial con las estimas de población y el grado de amenaza, de cara a evaluar con detalle las implicaciones de los distintos
criterios, con el fin de ayudar a definir las IBA marinas.
- Desarrollar aún más ese enfoque a través de la selección de sistemas/áreas adecuados con el objetivo de vincularlos con los datos de seguimiento a distancia de otras aves marinas (especialmente pingüinos) y de censos en el mar. Esto es especialmente importante para los sistemas costeros y de plataforma continental (p.ej. dentro de las ZEE).
- Desarrollar aún más este enfoque en relación con las Áreas Marinas Protegidas de forma combinada con los datos de otros taxones marinos (p.ej. mamíferos marinos, tortugas marinas) y con el uso de los recursos (p.ej. pesquerías, hidrocarburos). Esto es importante tanto para las ZEE como para alta mar.

Acuerdo para la conservación de albatros y petreles

- Las aplicaciones futuras previstas para las base de datos de seguimiento de albatros y petreles son altamente relevantes para los objetivos de conservacion de la ACAP. Es probable que la base de datos acabe siendo una herramienta clave para los futuros trabajos de la ACAP.

1 INTRODUCTION

Seabirds belonging to the order Procellariiformes (albatrosses and petrels) are amongst the most pelagic of seabirds and occur in all of the world's oceans. They are, therefore, excellent potential indicators of the state of high seas marine ecosystems, increasingly recognised as amongst the least known, yet most imperilled, of marine systems and habitats.

The status and trends of albatross and petrel breeding populations are reasonably well documented. These data contributed to the recognition that albatrosses, with 19 of 21 species now globally threatened and the remainder Near Threatened (BirdLife International 2004a; see Table 1.1), have become the bird family most threatened with extinction.

However the crux of their problem derives from their relationship with the marine environment, particularly involving interactions with fisheries, notably the hundreds of thousands of birds killed annually by longline fishing.

In terms of remote-tracking to reveal their at-sea distribution (a key to understanding how they function in marine ecosystems), albatrosses (and giant-petrels) are the most studied of all marine species.

Such data are potentially invaluable contributions to current BirdLife International initiatives, seeking to complement their pioneering work in the 1980s in defining terrestrial Important Bird Area networks (priority sites for land based conservation) with the first steps towards similar approaches for marine habitats. Until now attempts to characterise the at-sea distribution of threatened seabird species (e.g. Figure 1.1) have been derived from distribution maps in field guides and regional handbooks.

Against this background, BirdLife International, with generous support from the Wallace Research Foundation, invited all holders of remote-tracking data for albatrosses

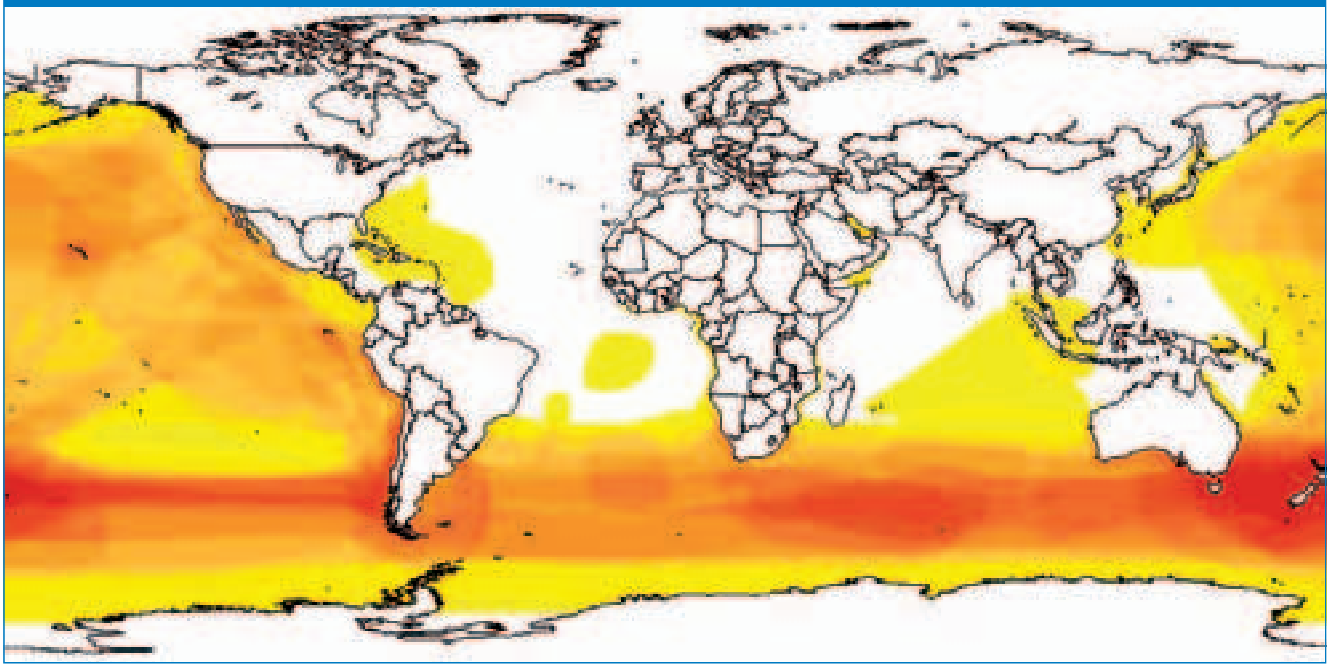
Table 1.1. Global conservation status of all albatross and selected petrel species, according to BirdLife International (2004a).

Common name	Scientific name	Status
Amsterdam Albatross	*Diomedea amsterdamensis*	CR
Antipodean Albatross[1]	*Diomedea antipodensis*	VU
Black-browed Albatross	*Thalassarche melanophrys*	EN
Black-footed Albatross	*Phoebastria nigripes*	EN
Buller's Albatross	*Thalassarche bulleri*	VU
Campbell Albatross	*Thalassarche impavida*	VU
Chatham Albatross	*Thalassarche eremita*	CR
Grey-headed Albatross	*Thalassarche chrysostoma*	VU
Laysan Albatross	*Phoebastria immutabilis*	VU
Light-mantled Albatross	*Phoebetria palpebrata*	NT
Northern Royal Albatross	*Diomedea sanfordi*	EN
Southern Royal Albatross	*Diomedea epomophora*	VU
Salvin's Albatross	*Thalassarche salvini*	VU
Short-tailed Albatross	*Phoebastria albatrus*	VU
Shy Albatross	*Thalassarche cauta*	NT
Sooty Albatross	*Phoebetria fusca*	EN
Tristan Albatross	*Diomedea dabbenena*	EN
Wandering Albatross	*Diomedea exulans*	VU
Waved Albatross	*Phoebastria irrorata*	VU
Atlantic Yellow-nosed Albatross	*Thalassarche chlororhynchos*	EN
Indian Yellow-nosed Albatross	*Thalassarche carteri*	EN
Northern Giant-petrel	*Macronectes halli*	NT
Southern Giant-petrel	*Macronectes giganteus*	VU
White-chinned Petrel	*Procellaria aequinoctialis*	VU

[1] Including Gibson's Albatross *D. (antipodensis) gibsoni*

CR Critically Endangered; EN Endangered; VU Vulnerable; NT Near Threatened

Figure 1.1. Distribution of threatened seabirds of the world (after BirdLife International 2004b).



and petrels to a Global Procellariiform Tracking Workshop. This was held at Gordon's Bay, South Africa from 1–5 September 2003. It was co-convened by Dr Deon Nel (BirdLife Seabird Programme) and Prof John Croxall (British Antarctic Survey and Chairman of RSPB, the BirdLife Partner in the UK). The technical coordinator was Frances Taylor (BirdLife Seabird Programme) supported by Janet Silk (British Antarctic Survey) and Samantha Petersen (BirdLife South Africa). The workshop was attended by 28 scientists from 8 countries (listed in full at Annex 1).

Aims

The main strategic aims of the workshop were:

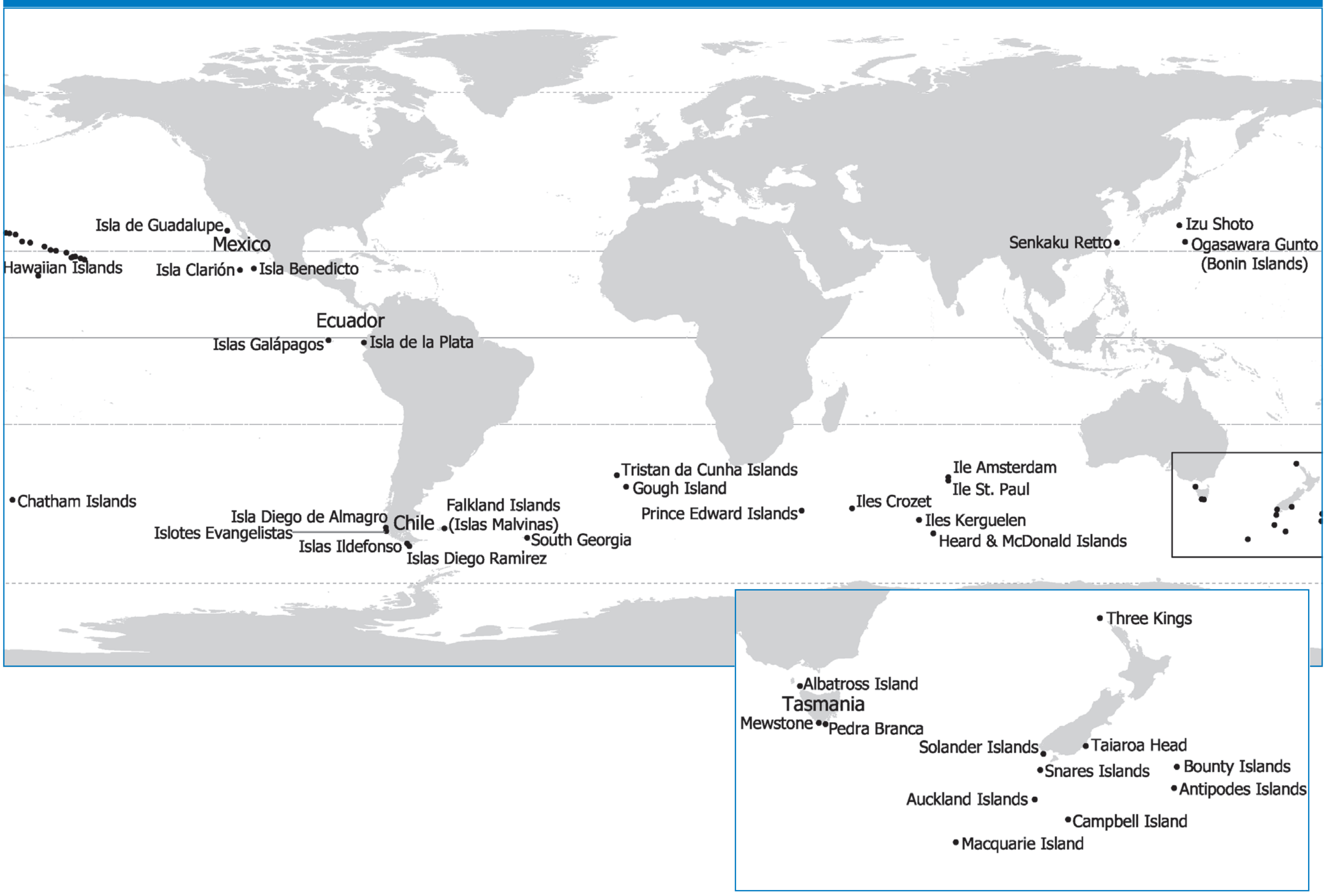
1. To assess how at-sea distribution data from remote-tracking studies of seabirds can contribute to:
   i. the development of criteria for defining Important Bird Areas (IBAs) in the marine environment;
   ii. current initiatives for the establishment of high seas Marine Protected Areas (especially by IUCN).

2. To scope the extent to which these data can be used to quantify overlap between marine areas used by albatrosses and the location of fishing effort, especially longline:
   i. to identify areas of higher risk, especially for the development of appropriate mitigation measures for the fisheries involved;
   ii. to identify the Regional Fishery Management Organisations (RFMOs) with prime responsibility for the management of fisheries with significant risk of incidental bycatch of albatrosses (and petrels).

3. To establish a Geographic Information System (GIS) database to maintain detailed information on remote-recorded range and distribution of seabirds, as an international conservation tool.

John Croxall, Frances Taylor and Deon Nel

Figure 1.2. Location of main breeding sites of albatrosses.



2 METHODS

2.1 TRACKING METHODS

Currently there are two methods employed for tracking albatrosses and petrels, satellite or platform terminal transmitters (PTT) and geolocators (GLS). Both have advantages and disadvantages: the former providing more accurate and numerous fixes at greater cost and shorter battery life, while the latter are cheaper and lighter with a potentially much longer deployment period, but require retrieval of the device and more complex data processing.

Both types of data were submitted. PTT data were primarily provided for birds tracked during the breeding season. PTT data submitted to the database were in unvalidated form to ensure that standard validation routines were used during processing. The GLS data consisted primarily of dispersal and over-wintering tracks. GLS data were submitted in post-processed form as the processing is extremely time-consuming. Although this meant that processing and validation were non-standard, contributors submitted details of the methods they used, and these were entered as metadata. In the event, all submitted GLS data had been subjected to almost identical post-processing routines.

2.2 METHODS FOR ANALYSING PTT DATA

2.2.1 Standardisation and validation of data

PTT Tracking data were submitted in a variety of formats, which were standardised to the format given in Table 2.1.

Separation of deployments and trips was usually done by the data contributors. A 'deployment' refers to the period between attaching a PTT device to an individual and the removal of the device from the individual, or the cessation of uplinks from the device indicating battery failure or loss of the device. A 'trip' refers to the period between an individual leaving the colony—either identified by the data contributor, or where this information was not provided, by examining the distance from the central point of the colony—and the subsequent return to the colony. As many birds will roost at sea in close proximity to the colony, intervals of less than 12 hours were not considered to be separate trips. In the few cases where deployments were not separated by the contributor, the return of the bird to the general area of the colony and a gap of more than 24 hours between successive uplinks were assumed to indicate the start of a new deployment. The individual was identified as the main statistical unit, with data separated on a biological basis where that information was available (see Table 2.1). An attempt was made to differentiate between individuals foraging from a breeding colony and those that had dispersed as part of non-breeding migration.

In order to ensure standard validation, PTT data contributors were asked to submit unvalidated datasets. Each dataset was then passed through a filter which coded points according to their location quality and the velocity of the bird. An iterative forward/backward averaging filter, based on that used by McConnell *et al.* (1992) for validating Southern Elephant Seal *Mirounga leonina* tracking data, was applied to calculate the bird's velocity at each uplink (Figure 2.1). If this velocity was over the maximum velocity v_{max}, and the alternative lat/long was provided, the filter substituted the alternative point. Once all the velocities were calculated the filter removed the point with the maximum velocity over v_{max}. However, if the Advanced Research Global Observation Satellite (Argos) location quality was provided, a point was not removed if it had location class 1, 2 or 3, because these locations have an accuracy of up to 1 km (Argos 1989, 1996). The velocities for the 4 points adjacent to the removed point were then recalculated, and the process repeated, until no low-quality point had a velocity over v_{max}. No assumptions were made about points on land and these were therefore not discarded if they passed the filter's criteria. The validation/filtering methodology was explicitly documented within the dataset's metadata and excluded points were coded with the reason for exclusion, so that alternative filtering criteria can be used in the future.

v_{max} was set at 100 km.hr^{-1} for all species. This resulted in an overall 2.4% of points being rejected. For species whose maximum velocity is likely to be over 100 km.hr^{-1}, such as the Wandering, Northern Royal, Black-browed and Grey-headed Albatrosses, the percentage of points rejected was 1.8%, 2.7%, 1.2% and 4.3% respectively. For species such as the giant-petrels, whose maximum velocity is likely to be lower, the rejection rates were 1.9% and 0.4% for Southern and Northern Giant-petrels respectively.

Figure 2.1. Method used to calculate the average velocity of the bird at a particular point.

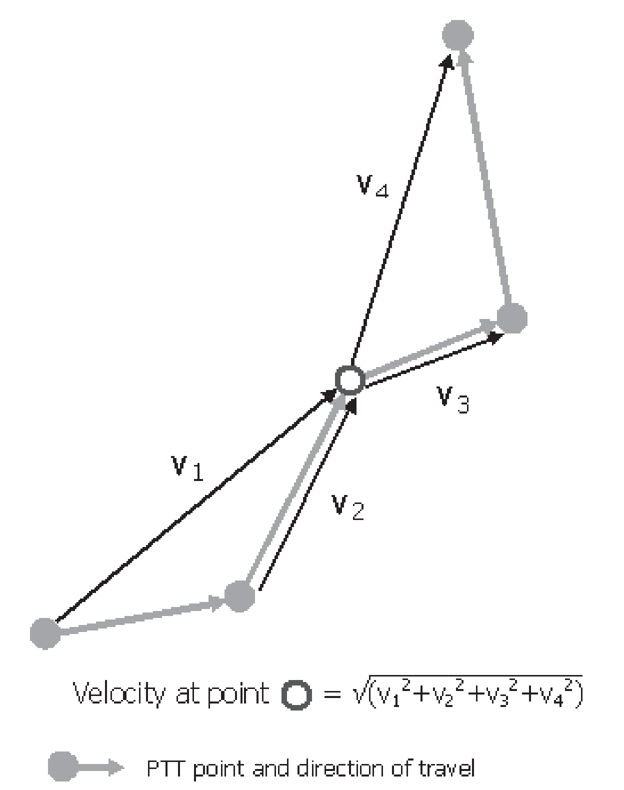


Table 2.1. Format of the standardised PTT tracking data.

Name	Type	Length	Description
Species	string	3	links to Species table
Site	string	3	links to Site table
Colony	string	3	links to Colony table, which in turn has links to Site
TrackID	string	10	unique track identifier, usually device ID + trip number, depending on what was provided
PointID	integer		sequential number to identify uplinks within a trip
DeviceID	string	10	unique PTT identifier
DeviceType	string	20	PTT type, usually blank
DutyCycle	string	15	if blank, assume continuous
RepRate	string	5	repetition rate, usually blank
TripID	integer		Sequential number to identify trips within a deployment. A trip is defined as time at sea lasting more than 12 hours, and ends upon the bird's return to the colony, as defined by the data contributor (see Location).
TripStart	datetime		used for validation
TripEnd	datetime		used for validation
BirdID	string	10	ring number or other label to uniquely identify an individual
Age	string	1	A: adult, J: subadult / juvenile / prebreeder, U: unknown
Sex	string	1	M: male, F: female, U: unknown
Status	String	1	R: resident, M: migratory – assigned by examining track. If bird moved off from colony in a consistent direction then defined as migratory.
BreedStatus	string	1	B: breeder; N: non-breeder; U: unknown
BreedStage	string	2	PE: pre-egg EB: early breeding (includes incubation and brood stages) IN: incubation CK: chick (includes brood, guard and post-guard stages) BG: brood guard (includes brood and guard stages, also referred to as 'small chick') BD: brood stage (also referred to as 'early chick') GD: guard stage PG: post-guard stage (also referred to as 'large chick') FM: failed breeder / migration after breeding UN: unknown
Latitude	float	8.4	
Longitude	float	8.4	
AltLat	float	8.4	alternative latitude provided by Argos
AltLon	float	8.4	alternative longitude provided by Argos
DateGMT	date		
TimeGMT	time		
DateLocal	date		
TimeLocal	time		
TimeZone	string	6	
Quality	string	1	Argos location quality code (0-3, A, B, Z) (Argos 1989, 1996)
Code	integer		-9: invalidated by user 9: validated by user -1: invalid as average velocity over v_{max} 1: valid as velocity under v_{max} -2: invalid as low quality 2: valid as high quality (Argos location code = 1, 2 or 3) 3: alternate point invalid as average velocity over v_{max} 3: alternate point valid as velocity under v_{max} 4: alternate point valid as high quality (Argos location code = 1, 2 or 3) 0: not validated
Location	string	1	C: colony, S: at sea – provided by data contributor, else calculated using a set radius from the colony. Used to demarcate trips
Comments	memo		
Contributor	memo		
Reference	memo		
VelFilt	float	8.4	average velocity calculated by the velocity filter
Elapsed	float	8.4	time in hours elapsed since the previous uplink
Distance	float	8.4	great circle distance in km from the previous uplink
Velocity	float	8.4	velocity in $km.hr^{-1}$ from previous to current uplink
ColDist	float	8.4	great circle distance in km from the colony
Sunrise	string	20	time of sunrise(s) at current latitude/longitude and date
Sunset	string	20	time of sunset(s) at current latitude/longitude and date
DayNight	string	1	D: daytime uplink, N: night-time uplink

italics: unique identifier for each uplink underline: calculated fields **bold**: mandatory fields required from data holder

2.2.2 Deriving density distribution maps

In order to identify areas which are highly utilised by albatrosses and petrels, some indication of density needs to be derived from the PTT tracking data. However the sampling regime of these data is dependent on several factors: the speed at which the bird is travelling, its latitude (Georges *et al.* 1997), and the performance of the device itself. In order to provide a more regular sampling regime it was assumed that a bird flew in a straight line at constant velocity between two successive uplinks, where these uplinks were less than 24 hours apart. The path of the bird was then resampled at hourly intervals, any remaining time being added to the first segment of the next path between successive uplinks. If the interval between uplinks was more than 24 hours, no assumptions were made about the bird's behaviour and these paths were not resampled. In this way devices with long duty cycles were also catered for as no assumptions were made about the bird's location during 'OFF' cycles. The resampling method also ensured that each trip was weighted by its duration when calculating density distributions. The process produced locations for the individual at hourly intervals, and thus density distribution maps derived from these locations were indicative of time spent ('bird hours') in a particular area.

Albatrosses and petrels are central place foragers when breeding, so in any density distribution map the uplinks around the colony could potentially outweigh any more distant foraging area. If the commuting points to and from foraging areas are removed, this high density around the colony should be reduced. However this requires making assumptions about the bird's activity based solely on the tracking data. In addition, commuting birds could still be at risk from fisheries interactions if they encounter a fishing vessel and stop to forage. To assess the effect of excluding commuting data, foraging points for Wandering Albatrosses were assumed to be those resampled points occurring between sunrise and sunset where the velocity was less than 20 km/hr. By excluding all other points, a density distribution of foraging locations was produced. This did not noticeably reduce the density around the colony, and there was little difference in areas of importance (Figure 2.2). Therefore foraging and commuting points were not separated out in the final maps. It is thus recognised that not all 'hot spots' identified by the kernel analysis will be foraging areas, but they still represent areas of risk.

Kernel density estimators have been successfully used in several tracking studies to quantify habitat use and identify home ranges (e.g. Wood *et al.* 2000). The single most important step when using these estimators is the selection of the smoothing (or h) parameter. This can greatly influence the home range size and can also highlight or smooth over areas of high density (Annex 3), so it is necessary to explicitly report the methods used to ensure transparency and objectivity. Care needs to be taken when comparing different datasets, but current experience and practice is encouraging (e.g. Matthiopoulos 2003).

As this study does not attempt to estimate range sizes, aiming instead to identify core areas of utilisation for conservation manage-ment, the selection of h was done by identifying the smallest practical unit of management on the high seas. For present purposes the workshop participants agreed this to be a 1 degree grid square. Although the use of 1 degree as a smoothing parameter means the shape of the kernel will vary with changes in latitude, it was agreed that the effects of this would be small in relation to the scales at which the data would be presented, and that this latitude-related distortion is widely understood.

Kernel density distribution maps were derived using the kernel function in ArcGIS 8.2. The grid size was set at one-tenth of the value of h i.e. 0.1 of a degree. If sample sizes were sufficiently large, separate kernel density distribution maps were produced for birds of different ages (juvenile, adult), breeding status, sex and breeding stage.

2.2.3 Combining density grids (weighting)

The density grids derived by kernel analysis of the resampled PTT locations for each part of the population were adjusted to reflect an index of 'seabird at sea hours' as follows: the kernel density estimate of each cell was divided by the number of resampled PTT locations for the dataset, and then weighted by the number of individuals at sea for that particular colony and breeding status/stage (e.g. Figure

Figure 2.2. Kernel density distribution contours of breeding Wandering Albatrosses tracked from Iles Crozet, showing density contours using all locations (A) and foraging locations only (B).

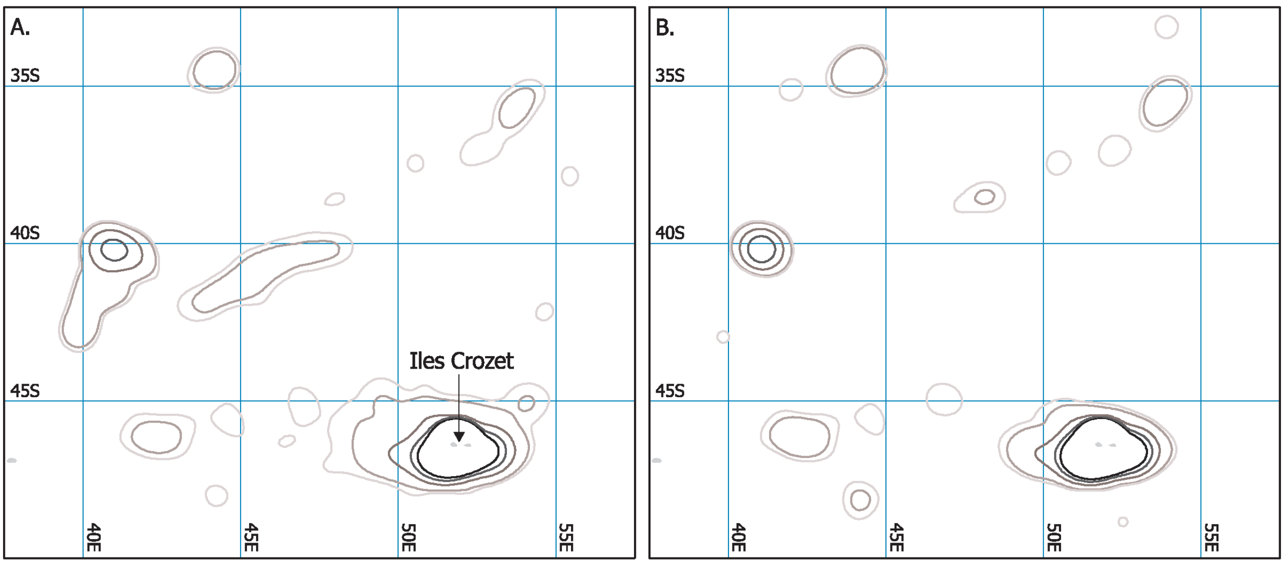
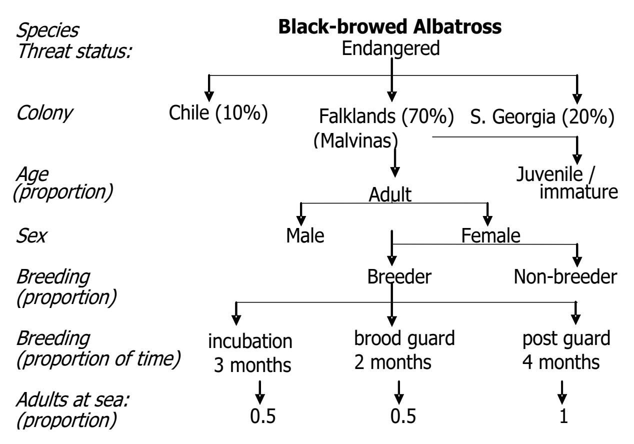


Figure 2.3. Example of how the species density distribution map for Black-browed Albatross *Thalassarche melanophrys* was compiled.



2.3). These grids were then summed to provide a density grid for the colony. However, because there are many more tracking data available for adult breeding birds than for non-breeding or juveniles/subadults, separate maps were produced for these categories. Species maps were generated by combining colony grids weighted according to colony size. Colony sizes, expressed as the number of breeding pairs, were drawn from several sources (Gales 1998, Tickell 2000, Arata *et al.* 2003, Lawton *et al.* 2003, Robertson, G. *et al.* 2003c, BirdLife International 2004b, Patterson *et al.* in press), which variously reported the number of breeding pairs, nests, eggs, chicks or fledglings censused at the colony. In each case the latest available census figure has been used to weight the colony, regardless of the census method used. The density distributions are represented on the maps by Utilisation Distributions (UDs), which provide probability contours indicating the relative time that birds spend in particular areas. For example, birds will spend 50% of their time within a 50% UD contour.

Frances Taylor

2.3 EFFECT OF SAMPLE SIZE ON KERNEL ANALYSIS

The sample sizes of the datasets submitted to the Global Procellariiform Tracking Workshop varied widely (see Annex 7), and some indication is needed of the reliability of utilisation distributions produced from small samples, particularly as most of the non-breeding data fell into this category. Two datasets with different characteristics were therefore examined in more detail. (1) Wandering Albatrosses breeding on Iles Crozet radiated out from the colony in a relatively uniform manner (Figure 2.4), with foraging hotspots identified in several locations at varying distances and directions from the colony. This dataset is very large, consisting of 205 tracks, and so the UDs produced from the full dataset should reliably reflect the actual foraging distribution of breeding birds from this colony. Although individuals were not identified in the dataset, it was assumed for the purposes of this exercise that each track was obtained from a unique individual. (2) Buller's Albatrosses breeding on the Snares Islands showed a more skewed distribution, with hotspots concentrated along the shelf-break of New Zealand's South Island, eastern Tasmania, and two discrete areas in the Tasman Sea (Figure 2.5). The dataset consists of 37 tracked individuals.

A series of random samples of increasing size (10 replicates of each) were extracted from each of the two datasets, and the areas of the resultant UDs plotted against sample size (Figures 2.6 and 2.7) (see also Annex 3). The areas of the UDs from the full datasets were plotted as the last point. The curves appeared to approach this asymptote with increasing sample size. The higher probability UDs approached the asymptote faster: in the case of the Crozet dataset a sample size of over 60 tracks produced no major increase in area for the 50% UD; whereas the 50% UD from the Snares dataset appears to plateau with a sample size of only four individuals. The area of the 75% UD reaches a plateau after 140 and 12 tracks for the Crozet and Snares datasets respectively. Conversely the 95% UD does not appear to have reached a maximum value even with the full dataset in the case of the Crozet tracks.

Figure 2.4. Utilisation distributions (UDs), range and resampled locations from PTT tracks for breeding Wandering Albatrosses from Iles Crozet. A UD provides a probability contour indicating the relative amount of time birds spend in a particular area i.e. they will spend 50% of their time within the 50% UD contour. The dotted line represents the range, or the 100% UD contour.

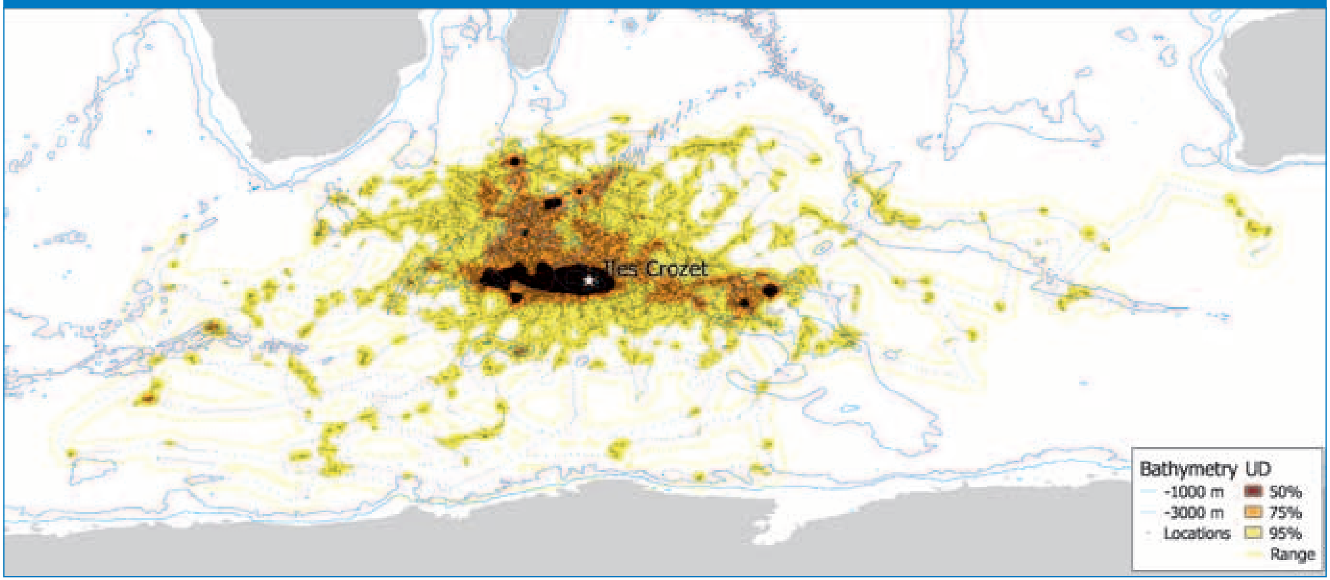
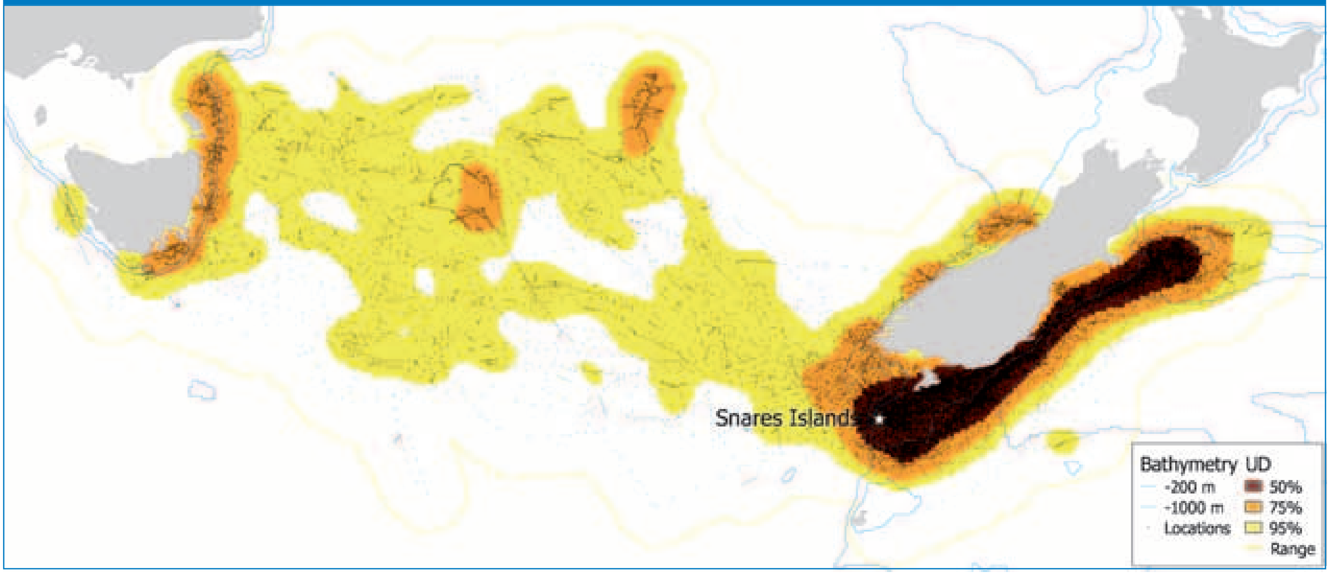


Figure 2.5. Utilisation distributions (UDs), range and resampled locations from PTT tracks for breeding Buller's Albatrosses from Snares Islands.



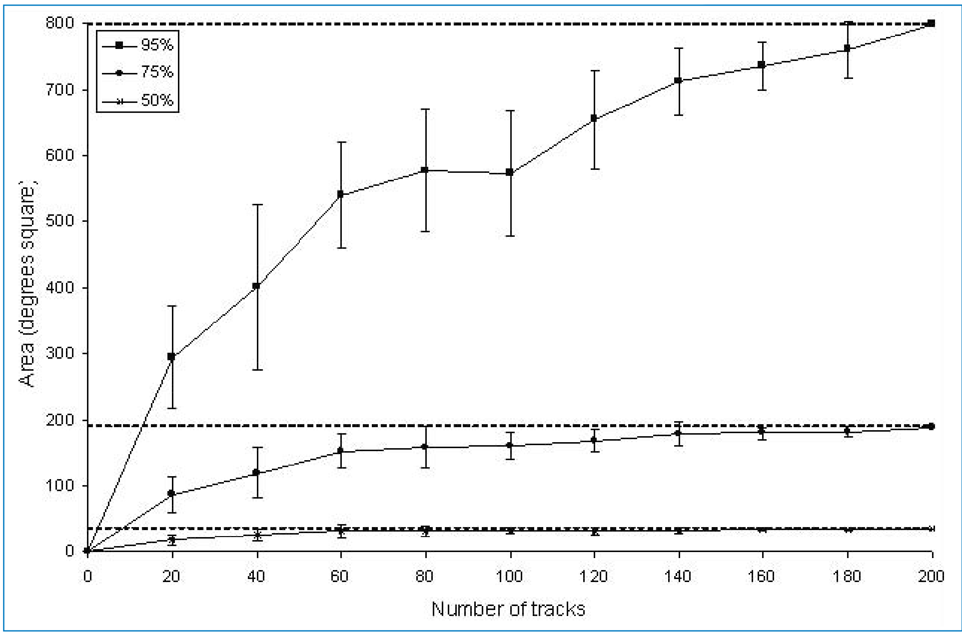


Figure 2.6. Mean UD areas (50%, 75% and 95%) and standard deviations in relation to sample size (number of tracks selected randomly from the dataset) for breeding Wandering Albatrosses tracked from Iles Crozet.

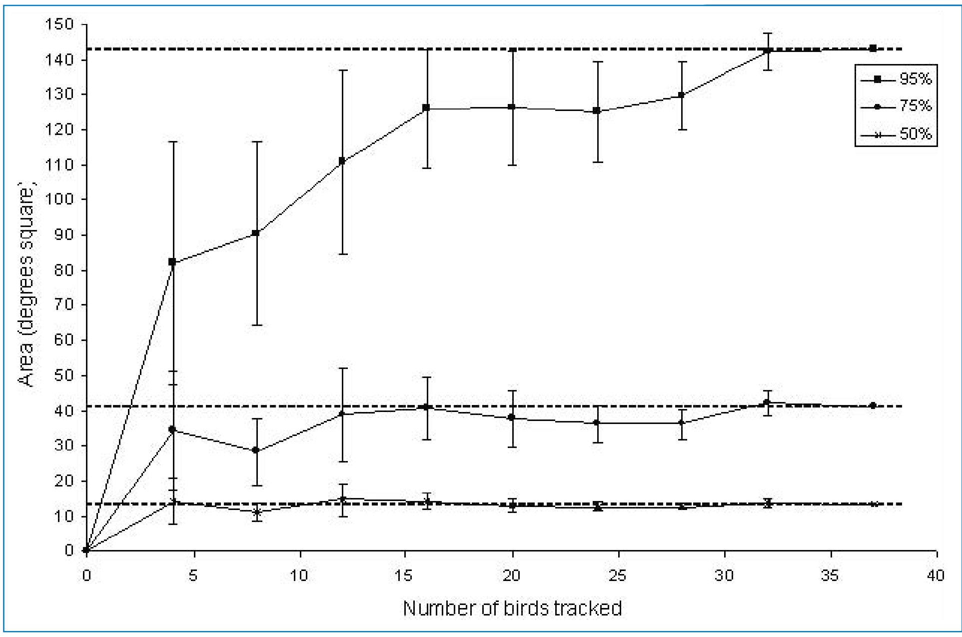


Figure 2.7. Mean UD areas (50%, 75% and 95%) and standard deviations in relation to sample size (number of individuals selected randomly from the dataset) for breeding Buller's Albatrosses tracked from Snares Islands.

Figure 2.8. Utilisation distributions (UDs) and range for breeding Buller's Albatrosses from Snares Islands. Each map was produced from the PTT tracks of four individuals selected at random from the complete dataset.

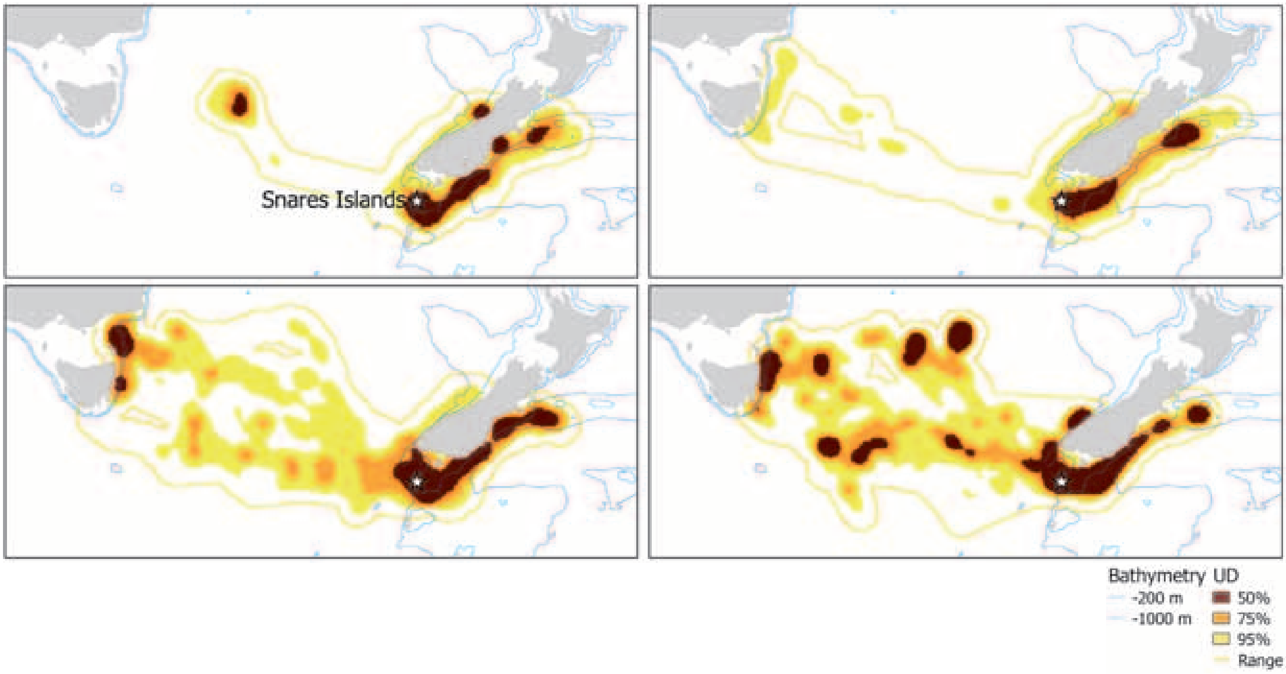
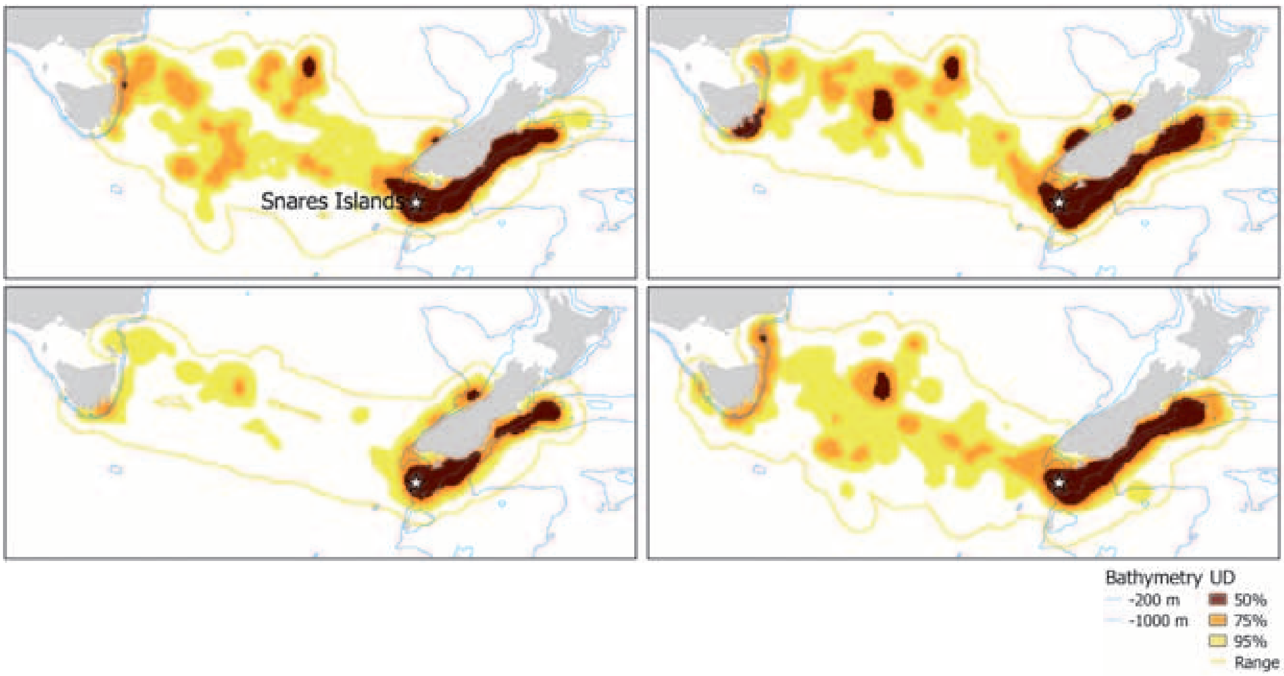


Figure 2.9. Utilisation distributions (UDs) and range for breeding Buller's Albatrosses from Snares Islands. Each map was produced from the PTT tracks of 12 individuals selected at random from the complete dataset.



The area of the 50% UD requires fewer tracks to reach a stable maximum value, which is encouraging for the purpose of identifying marine Important Bird Areas as these will be located in areas of high-intensity use. However care is needed as the locations of these hotspots are not necessarily the same for each random sample: in Figure 2.8 four samples of the Buller's dataset are shown, using four tracks drawn at random from the complete dataset. Even though the total area of the 50% UD is similar to that of the complete dataset, different regions are highlighted and some apparent hotspots are missed completely. At sample sizes this small, the foraging behaviour of a single individual on a single trip can produce hotspots in regions not frequented by any other individuals in the dataset. If the random sample is increased to 12 the influence of a single individual is reduced and hotspots are found in similar areas to the complete dataset (Figure 2.9), although some are still missed. The possibility of missing hotspots should be borne in mind when interpreting maps irrespective of the sample size.

Frances Taylor, Aleks Terauds and David Nicholls

2.4 METHODS FOR ANALYSING GLS DATA

Geolocation (Global Location Sensing or GLS-logging) is an alternative to satellite-telemetry for determining animal location. GLS loggers record light levels and use the timing of local noon and midnight to estimate longitude, and day length to estimate latitude. Although not as accurate as satellite tags, their small size and longevity mean that they are ideally suited to long-term deployment, and are therefore highly effective for migration studies.

The GLS technique provides 2 locations per day (at local midday and midnight) except for a variable period around the equinox when it is impossible to estimate latitude. The accuracy of the technique varies but given the type of device, processing technique and study-species it is reasonable to assume, based on data collected between 30°S and 60°S, an average error of around 186 km for GLS datasets submitted to the workshop (Phillips *et al*. 2004a).

2.4.1 Standardisation of GLS data

A variety of GLS loggers are available, differing in both design and recording interval. Techniques for converting light levels to location estimates also vary (e.g. threshold methods compared with curve-fitting), as do approaches to subsequent post-processing to remove unrealistic locations. The latter is a particularly time-consuming part of the analysis. For these reasons it was deemed unrealistic to develop a standardised validation routine for the GLS component of the workshop tracking data.

Data contributors were therefore asked to submit post-processed GLS locations and provide brief metadata on the conversion methods and validation rules that had been applied. In fact, there was little difference in the proportion of points eliminated in each of the four GLS datasets submitted to the workshop (6.9%, 15.2%, 5.9% and 6.9% of locations excluded during June and July and 21.0%, 22.8%, 24.5% and 29.6% of locations excluded in August).

The GLS tracking data were standardised according to the format indicated in Table 2.2.

In order to separate breeding from non-breeding season data, if individual-specific data were not provided, the breeding season for a particular population was defined as the time from the mean copulation date to mean fledging date. All locations falling outside this date range were assigned a status of N (non-breeder) and a stage of NB (non-breeding).

2.4.2 Density distribution maps

As GLS locations are available from tracked birds at approximately 12-hour intervals and invalid locations are eliminated more or less randomly, there is no requirement to resample the data. For a variable period around the equinoxes, however, it is impossible to obtain location estimates and consequently sample sizes were consistently smaller during March and September and, to a lesser extent, during April and August. Histograms presented alongside each distribution map indicate the sample size (bird days) per month, highlighting the under-representation of ranges during certain periods.

The analysis of submitted GLS data was restricted to the non-breeding period as (better quality) satellite-tracking data were available for breeding birds for all species and sites concerned. Kernel density distribution maps were generated in ArcMap 8.1 using a smoothing factor of 2 degrees (the nominal resolution of the GLS data) and a cell size of 0.5 degrees (see PTT methods section for further details).

Janet Silk

Table 2.2. Format of the standardised GLS tracking data.

Name	Type	Length	Description
Species	string	3	links to Species table
Site	string	3	links to Site table
Colony	string	3	links to Colony table, which in turn has linksto Site
TrackID	string	10	unique track identifier, usually device ID + trip number, depending on what was provided
PointID	integer		sequential number to identify uplinks within a trip
DeviceID	string	10	GLS identifier
DeviceType	string	20	GLS device type
TripID	integer		sequential number to identify trips or stages within a deployment
BirdID	string	10	ring number or other label to uniquely identify an individual
Age	string	1	A: adult, J: subadult / juvenile / prebreeder, U: unknown
Sex	string	1	M: male, F: female, U: unknown
Status	string	1	B: breeder; N: non-breeder; U: unknown
Stage	string	2	PE: pre-egg IN: incubation CK: chick (includes brood, guard and post-guard stages) FM: failed breeder / migration after breeding UN: unknown
Latitude	float	8.4	
Longitude	float	8.4	
DateGMT	date		
TimeGMT	time		
Code	integer		-9: invalidated by user 9: validated by user
Comments	memo		
Contributor	memo		
Reference	memo		

2.5 METHOD FOR ANALYSING MIGRATION ROUTES

Migration locations were distinguished from resident locations based on consistent movement in an easterly or westerly direction at high velocities (>20 km/h). Resident locations only were used to calculate kernel density distributions maps of wintering areas.

An indication of the variation in the routes taken from one wintering area to the next was obtained by calculating the average latitude ± 1 SD of all migration points within 10 degree longitudinal bands (Figure 2.10).

Frances Taylor and Janet Silk

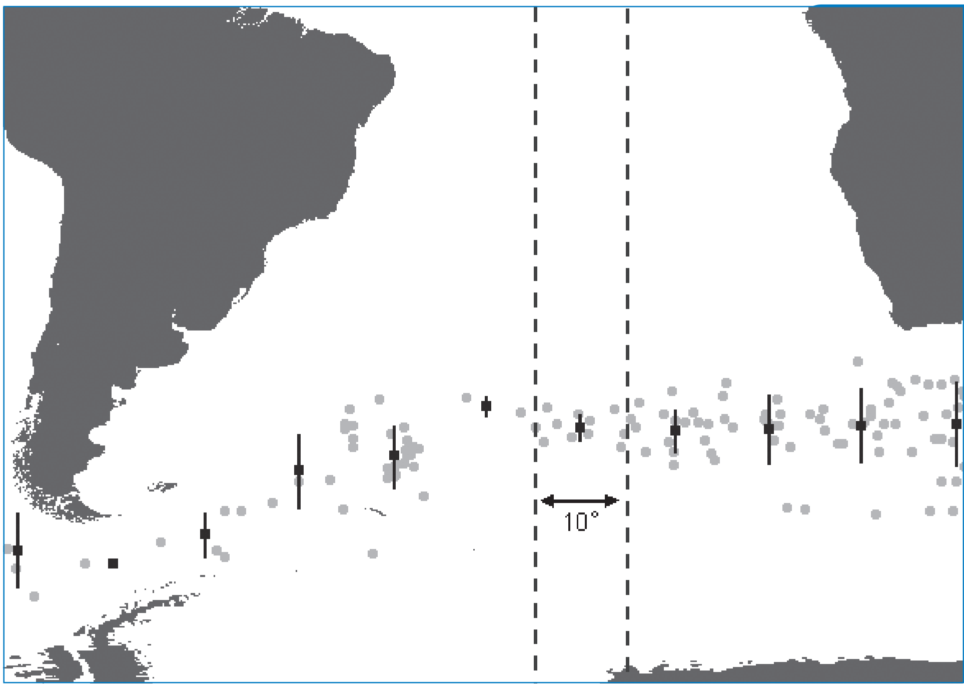


Figure 2.10. Example of a migration route. The grey points are the migration locations. The black squares and vertical bars indicate the mean latitude ± 1 SD within each 10° band.

3 RESULTS

Data were provided for 16 species of albatross, both species of giant-petrel and White-chinned Petrel; these are listed at Annex 2. A bibliography of published studies involving remote tracking of albatrosses, giant-petrels and *Procellaria* petrels is provided at Annex 4.

Figure 3.1 provides a map of locations from which PTT or GLS tracking data were obtained for the workshop.

The data submitted are summarised, for PTT and GLS tracking locations, in Figures 3.2 and 3.3.

The results of analysis undertaken during and after the workshop are divided into five main sections. These involve examples of:

1. Variation in foraging range and distribution of breeding birds in relation to: a. stage of breeding cycle; b. sex; c. year; d. colony.
2. Breeding season ranges for species where data are available from several different geographical (island group) populations.
3. Ranges and distributions of birds which are not breeding: a) whether adults or immatures during the breeding season; b) adults on migration and in staging and/or "wintering" areas.
4. Summaries of range and distribution data available for all species for different regions (comprising Southwest Atlantic and southern South America, Indian Ocean, Australasia and North Pacific).
5. Overlap between albatross ranges and distributions and the jurisdictions of fishery management organisations and of longline fishing effort.

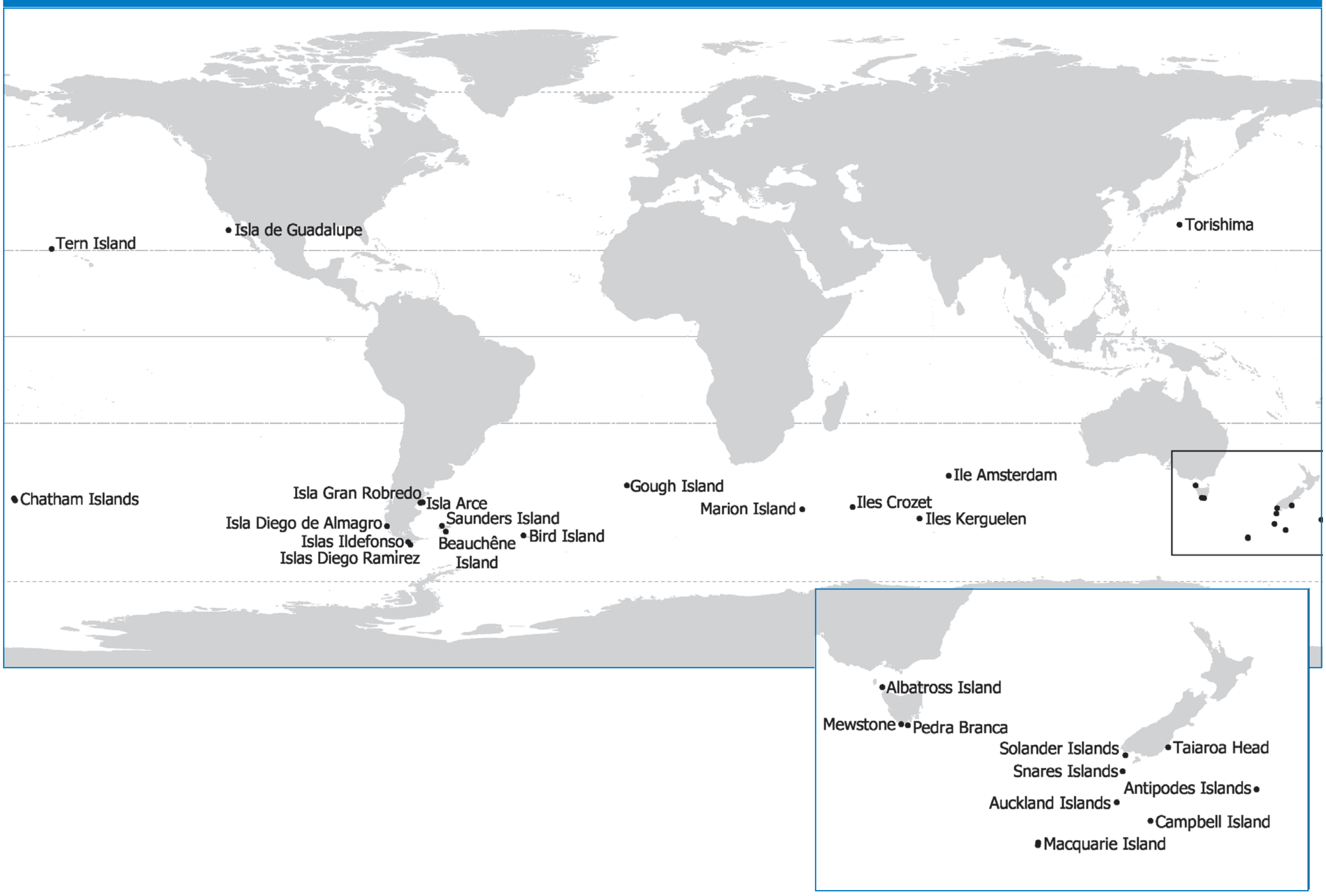
3.1 DISTRIBUTION OF BREEDING BIRDS

3.1.1 Distribution of breeding birds in relation to stage of breeding cycle

Wandering Albatross *Diomedea exulans* – Iles Crozet

The distribution at sea of foraging Wandering Albatrosses from Possession Island (Crozet Islands) differed greatly according to the stages of the breeding season (Figure 3.4). During incubation Wandering Albatrosses forage for foraging trips lasting on average 10 days, ranging from 2 to 22 days. They forage at long distances (up to 3,600 km) from Possession Island, from Antarctic waters along the Antarctic continent to sub-tropical waters, mainly using long looping movements stopping regularly en route for brief periods. At this time birds are foraging mainly over oceanic waters, visiting the Crozet shelf only during the week or so preceding hatching, i.e. during the longer trips over oceanic waters. They can also visit shelf areas around Kerguelen, or the seamounts located between the Crozet and Prince Edward Islands. As soon as the chick hatches,

Figure 3.1. Locations for which PTT or GLS tracking data were provided for the workshop.



the foraging strategy completely changes. They make short foraging trips lasting 1–5 days (average 2 days) and forage mainly over the Crozet shelf, the shelf break and the neighbouring oceanic waters. They mostly concentrate on the shelf break, in sectors that are colony-specific. For Possession Island these sectors are mostly concentrated on the south-eastern shelf edge, at a distance of 20–50 km from the colonies. As soon as the chick is left alone on the

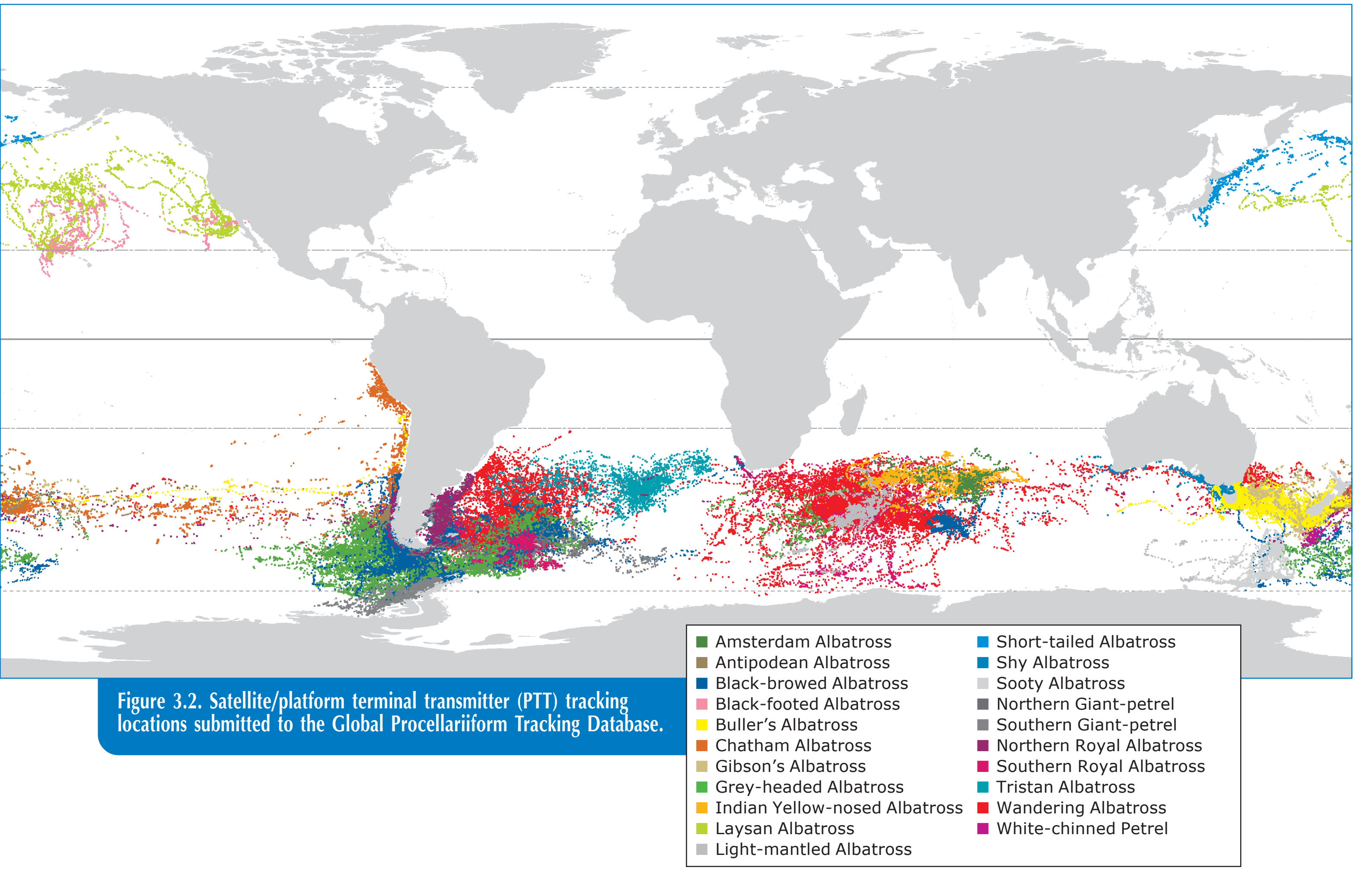


Figure 3.2. Satellite/platform terminal transmitter (PTT) tracking locations submitted to the Global Procellariiform Tracking Database.

Figure 3.3. Geolocator (GLS) tracking locations submitted to the Global Procellariiform Tracking Database.

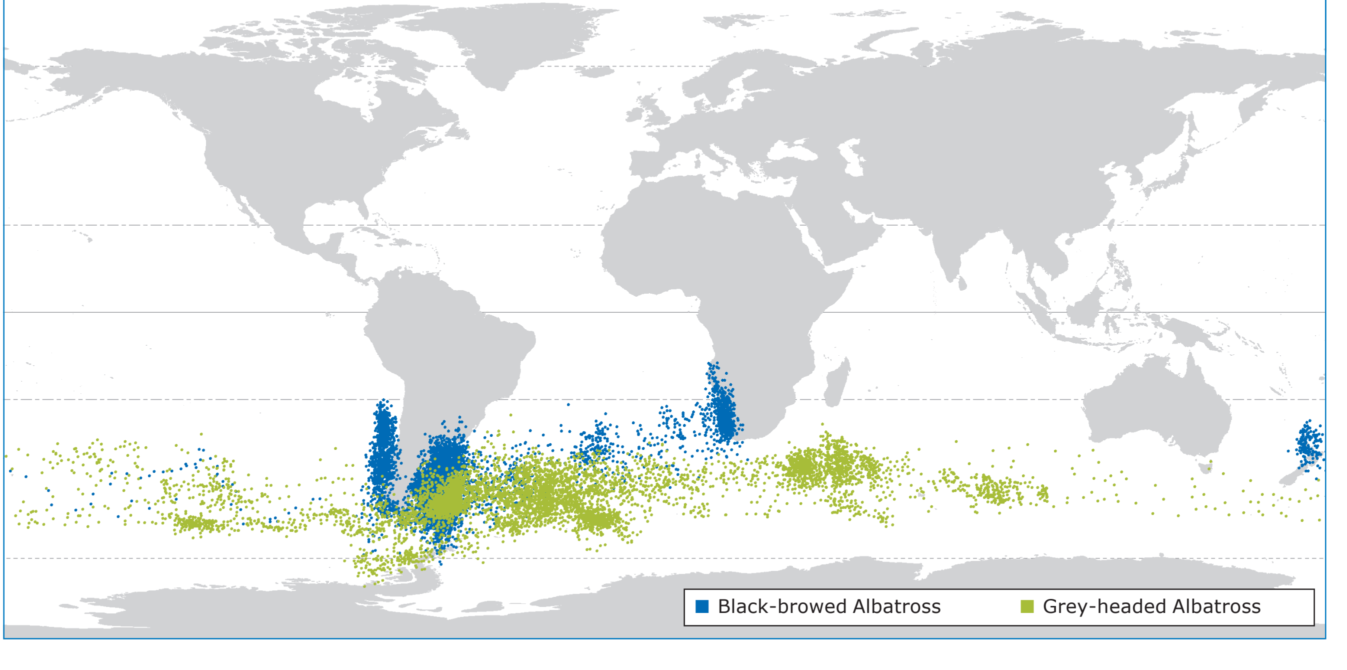
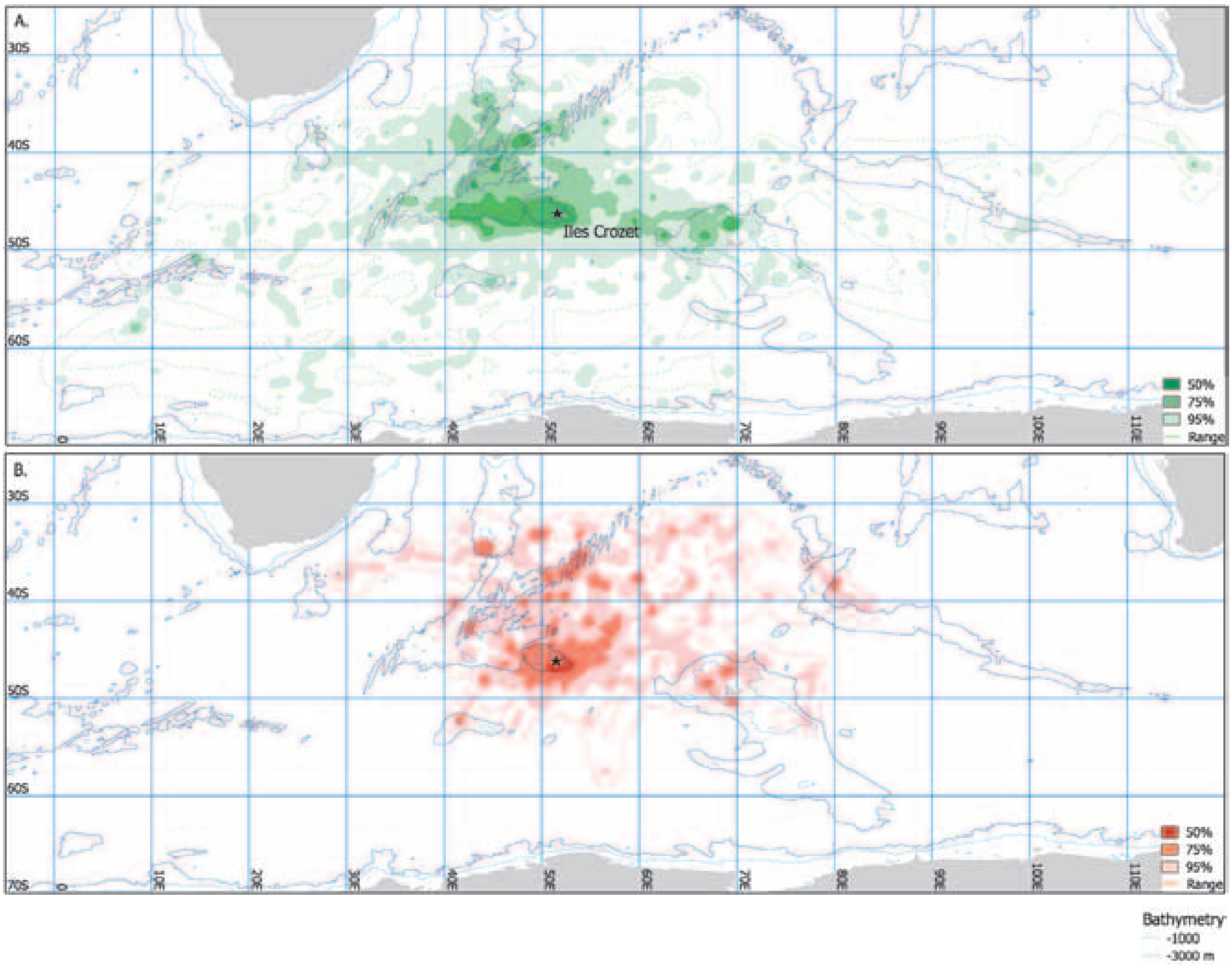


Figure 3.4. Utilisation distribution maps for breeding Wandering Albatrosses tracked from Iles Crozet at different stages in the breeding cycle. A. incubating birds (n=38,011 hrs); B. chick rearing (n=10,859 hrs). (Unable to determine number of individuals of each category from dataset, so sample sizes are given in number of hours tracked.)



nest, birds use a two-fold strategy, whereby they alternate long foraging trips in oceanic waters (similar to those of the incubation period) with a succession of short trips to the shelf edge and neighbouring oceanic waters (similar to the brooding period trips). Oceanic trips are mainly done to the north of the Crozet Islands, i.e. birds no longer go south to Antarctic waters.

These important changes in foraging habitats and duration of trips observed at Crozet at different stages of the breeding season (see also Figures 3.13 and 3.14) have been found at other breeding sites, e.g. South Georgia, Marion Island and also Kerguelen Island.

Henri Weimerskirch

Tristan Albatross *Diomedea dabbenena* – Gough

The utilisation distribution maps for the Tristan Albatross reveal substantial differences between the three major stages of the breeding cycle. During incubation most foraging is concentrated around Gough Island from 20°W to 0° of longitude and between 35–50°S, although some individuals also made trips to western areas of the South Atlantic moving as far as 50°W (Figure 3.5A). Foraging trips during incubation averaged 10 days (range 6–22 days) and with an average foraging range of 940 km. During the brood/guard stage foraging trips averaged 2 days (range 0.5–4 days) and are centred on Gough (Figure 3.5B), with an average range of 380 km. The sudden change from trips of long duration during incubation to short trips in the brood/guard stage is expected, as breeding adults are constrained to frequently feed small chicks at this time (Weimerskirch *et al.* 1993, Prince *et al.* 1998). During the post-guard stage the foraging distribution of breeding adults ranges across the South Atlantic from 50°W to 10°E and between latitudes 30–45°S. Trips during the post-guard stage averaged 5 days in duration (range 1 to 21 days) and varied greatly in range, with the maximum distance of trips varying from 110 to 3,500 km. The distribution of foraging locations indicates no clear pattern in relation to bathymetric features with most foraging locations concentrated over pelagic waters (>3,000 m depth) and within the sub-tropical zone and sub-tropical convergence zones. The distribution of the Tristan Albatross mainly between 30–45°S suggests that the species is at considerable risk from longline mortality as most pelagic fishing effort in the South Atlantic occurs within these latitudes (Tuck *et al.* 2003). However, variation between different stages of the breeding cycle and spatial variation in pelagic fishing effort over the year means that numbers of

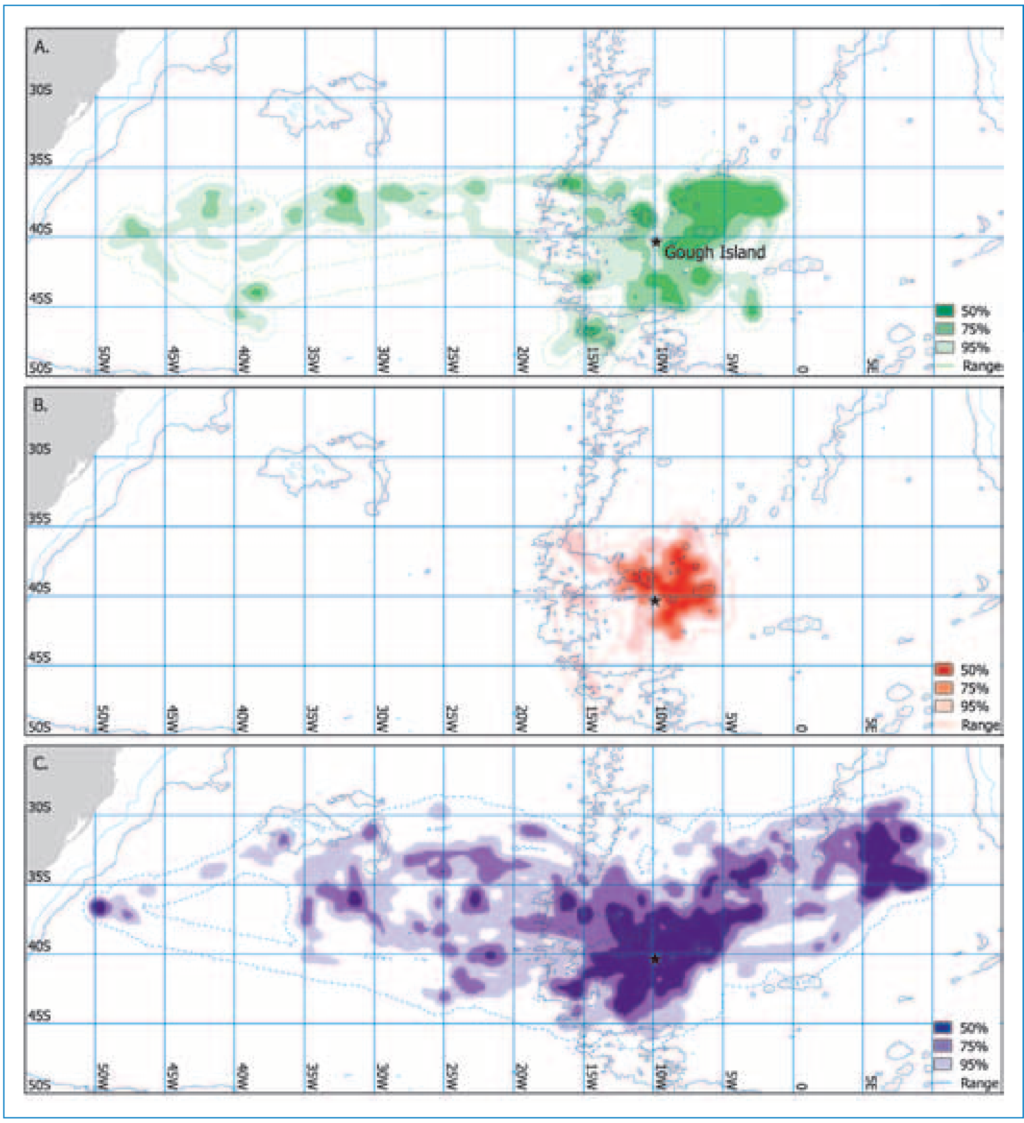


Figure 3.5. Utilisation distribution maps for breeding Tristan Albatrosses tracked from Gough Island at different stages during the breeding cycle. A. incubating birds (n=3,070 hrs, 17 indivs); B. brood-guard (n=1,017 hrs, 9 indivs); C. post guard (n=7,364 hrs, 12 indivs).

birds at risk from longline mortality is likely to vary greatly over the course of the year (Cuthbert *et al.* 2004).

Richard Cuthbert

Black-browed Albatross *Thalassarche melanophrys* – Falkland Islands (Malvinas)

During the incubation period birds from Saunders Island foraged almost exclusively on the Patagonian Shelf to the north of the Falkland Islands (Malvinas) and up to 41ºS (Figure 3.6C). Within this huge potential foraging area, the sites of most intense foraging, as represented by areas of higher density, were located in relatively discrete areas. Three such areas were located along the shelf break: one was between 49º and 50ºS, another around 48ºS and the third was between 45º and 46ºS. Another area of high density was located east and north-east of Peninsula Valdez between 41º and 43ºS. Two further areas were located close inshore to two fishing ports, Rawson and Camerones. Towards the end of the incubation period, birds reduced their foraging trips both in terms of duration and distance travelled and mostly stayed close to the north coast of the islands.

During the chick rearing period, the foraging area was much smaller and confined to the Falkland Islands (Malvinas) Inner Conservation Zone, apart from small areas on the shelf break between 46º and 48ºS (Figure 3.6F). The major area of foraging activity was situated close to the north west coast of the islands from the Jason Islands to the northern entrance of Falkland Sound. Another area of high activity was situated close to the shelf break to the north east of the islands at around 50ºS. As in the incubation period, almost all foraging was to the north of the islands.

During the incubation period birds from Beauchêne Island use the largest foraging area of all, with birds ranging from 41º to 56ºS (Figure 3.6B). Most of the area used was over the Patagonian Shelf, the only exception being the area of high activity inside the Southern Area of Cooperation (SAC) box (of concern, should this area open for oil exploration as planned). In the southern part of their distribution, areas of high foraging activity were situated on the shelf break south-west of the islands, east and west of Staten Island and south of Cape Horn. In the northern part areas of high activity were similar to those used by birds from Saunders Island during incubation. These are along the shelf break between 46º and 48ºS, on the Patagonian Shelf west of Peninsula Valdez between 41º and 43ºS and around the same two fishing ports. As at Saunders Island, birds reduced foraging distance towards the end of the incubation period and concentrated close to the islands, but in this case along the southern coasts.

During the chick rearing period birds from Beauchêne Island also had a restricted foraging range, being almost a mirror image of the one used by birds from Saunders Island at the same period (Figure 3.6E). Most activity was concentrated along the south coast of the islands, mainly west of Beaver Island, at the southern entrance of Falkland Sound, around Sea Lion Island and around Beauchêne Island itself. Areas of lower activity also existed along the shelf break, south-west of the islands, in the SAC box and on the Burdwood Bank.

Overall, these data clearly show the difference between a very restricted foraging range during chick-rearing (Figure 3.6D) and an incubation period range (Figure 3.6A) which is orders of magnitude larger, even though smaller favoured foraging areas can be identified.

This confinement to shelf waters and to the shelf break is in accordance with other studies at Kerguelen Island (Weimerskirch *et al.* 1997c) and South Georgia (Prince *et al.* 1998), but differs from some birds studied at Campbell Island (Waugh *et al.* 1999) which foraged over deeper waters.

Nic Huin

Black-browed Albatross *Thalassarche melanophrys* – Chile

Black-browed Albatross foraging distribution in Chile is known for all breeding stages only at the Diego Ramirez Islands (Figure 3.7). Although marked differences in the extension (both in time and distance) of the foraging trips between stages were found, breeding Black-browed Albatrosses from Diego Ramirez used mainly the continental shelf and slope of central (north to 35ºS) and southern Chile, with sporadic trips into deeper oceanic waters to the west of Chile, to the Antarctic Polar Frontal Zone and the Antarctic Peninsula. During incubation, albatrosses foraged along the Chilean coast, from 35–57ºS, concentrating their effort mostly off the Arauco Gulf (37ºS), Chiloé Island (43ºS) and southern Chile (52–57ºS). Trip duration and range were significantly reduced during brooding, when birds foraged mainly around the southern tip of the Chilean continental shelf, although a few birds prospected in Antarctic Polar Frontal Zone

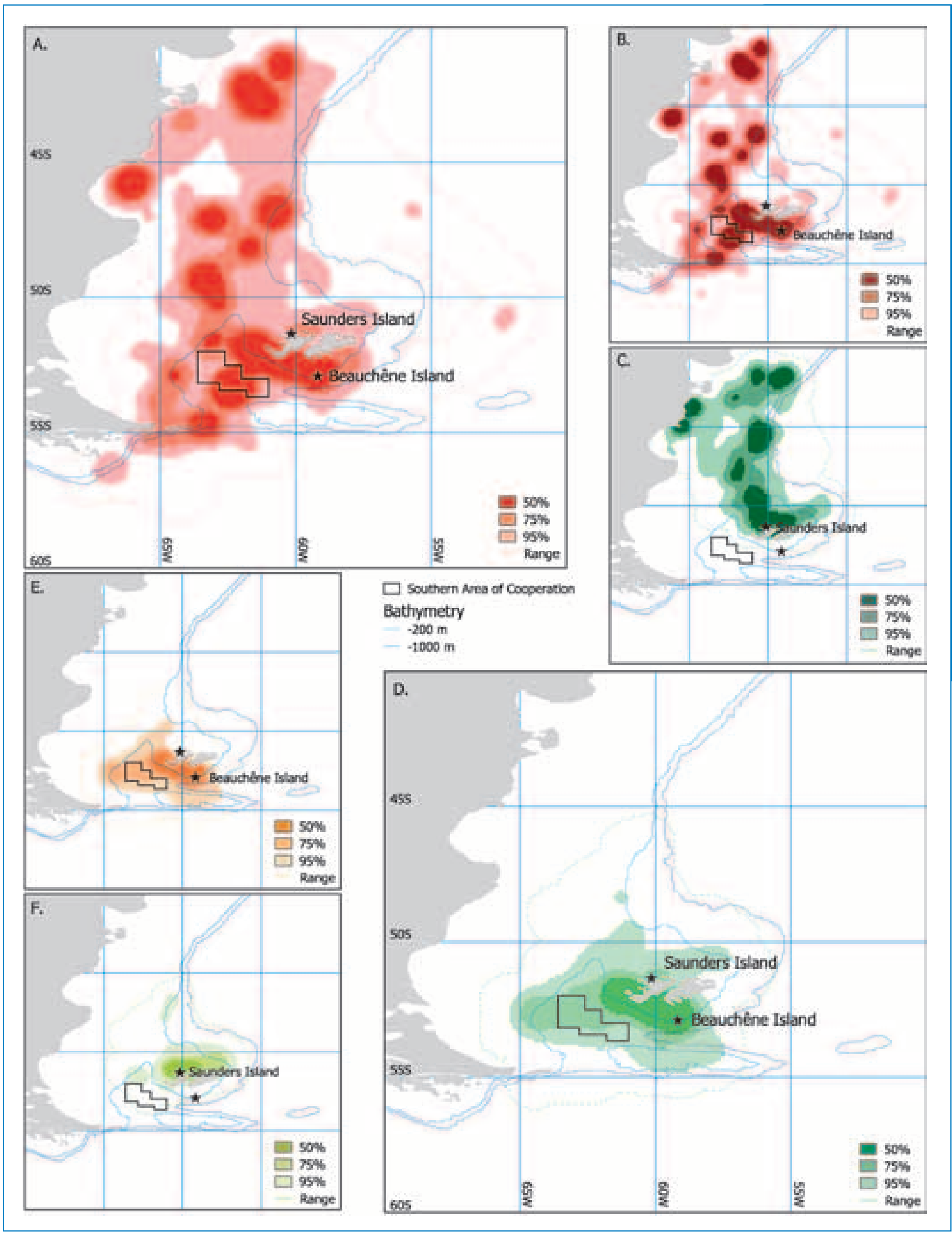


Figure 3.6. Utilisation distribution maps for breeding Black-browed Albatrosses tracked from the Falkland Islands (Malvinas) at different stages in the breeding cycle. A. incubating birds from the Beauchêne and Saunders colonies, weighted by colony size (n=5,412 hrs, n=11 indivs); B. incubating birds from Beauchêne (n=2,653 hrs, 4 indivs); C. incubating birds from Saunders (n=2,759 hrs, 7 indivs); D. post guard birds from the Beauchêne and Saunders colonies, weighted by colony size (n=7,984 hrs, n=12 indivs); E. post guard birds from Beauchêne (n=3,397 hrs, 4 indivs); F. post guard birds from Saunders (n=4,587 hrs, 8 indivs).