Caribbean Seabirds Monitoring Manual

Promoting Conservation of Seabirds and their Marine Habitats Through Monitoring

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Promoting Conservation of Breeding Seabirds and their Marine Habitats in the Wider Caribbean Through Systematic Monitoring

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With funding and support from:
National Fish and Wildlife Foundation
Defenders of Wildlife
Clemson University
US Fish and Wildlife Service, Division of International Conservation
Royal Society for the Protection of Birds
Cornell Laboratory of Ornithology
Optics for the Tropics
National Environment and Planning Agency
The Nature Conservancy
Waterbird Council for the Americas
U.S. Geological Survey

Published by BirdsCaribbean (formerly the Society for the Conservation and Study of Caribbean Birds, SCSCB), 841 Worcester St. #130, Natick, MA 01760-2076, USA. Website: www.birdscaribbean.org Email: info@birdscaribbean.org.

Recommended citation: Haynes-Sutton, A.M., Sorenson, L.G., Mackin, W.A., Haney, C. & Wheeler, J. 2018. Caribbean Seabird Monitoring Manual: Promoting Conservation of Breeding Seabirds and their Habitats in the Wider Caribbean Through Systematic Monitoring. Caribbean Birdwatch Series, Volume 2. BirdsCaribbean, www.birdscaribbean.org, 85 pp.

French and Spanish versions of this manual are also available at www.birdscaribbean.org.

Disclaimer: This book is intended to be a starting resource for monitoring Caribbean Seabirds. The statistical methodologies for monitoring animal populations are complex and above the level of this manual. Powerful, new computer software (often free) is already available and more algorithms are being developed, such as the tools within Program Mark and in the packages (Unmarked, secr, etc.) of R statistical analysis software, all of which have detailed instruction manuals. We recommend that anyone supervising important seabird colonies learn to use these tools and consult continually with experts in wildlife management to revise and improve your monitoring efforts.

"One good tern deserves another"

"My soul is full of longing for the secrets of the sea, and the heart of the great ocean sends a thrilling pulse through me."
– Henry Wadsworth Longfellow

"The oceans deserve our respect and care, but you have to know something before you can care about it."
– Sylvia Earle

"People ask: Why should I care about the ocean? Because the ocean is the cornerstone of earth's life support system, it shapes climate and weather. It holds most of life on earth. 97% of earth's water is there. It's the blue heart of the planet-we should take care of our heart. It's what makes life possible for us. We still have a really good chance to make things better than they are. They won't get better unless we take the action and inspire others to do the same thing. No one is without power. Everybody has the capacity to do something."
– Sylvia Earle

Dedication

This seabird manual is dedicated to the memory of David S. Lee (March 22, 1943-July 19, 2014). Dave was a pioneering Zoologist and Conservationist and a founding member of BirdsCaribbean (then "the Society of Caribbean Ornithology"). He spent thousands of hours off the East and Gulf Coasts of the United States documenting the many seabirds that depend on these waters. He was a prolific writer and published his research in hundreds of peer-reviewed scientific papers, articles, and chapters in books. Because many of the seabirds he observed were declining and known to breed primarily in the Caribbean, Dave helped organize the Seabird Working Group of BirdsCaribbean and made several trips to the Caribbean Region to document breeding sites. He collaborated with other scientists as co-editor of "Status and Conservation of West Indian Seabirds (2000)," which summarized everything known at the time about these populations and highlighted needed conservation actions. His work helped to inspire much of the seabird conservation underway today in the Caribbean and Bahamas. We can honor David's legacy by continuing to study and conserve the natural world and communicating our results to other scientists, naturalists, and the public.

Foreword - The Purpose of this Manual

The Caribbean is one of the most important regions in the world for seabirds, and one of the most threatened. Despite this, until recently, it was also one of the least studied. The information that BirdsCaribbean and our partners have gathered over the last twenty years shows that numbers of Caribbean seabirds at many breeding colonies are declining catastrophically and rapidly, with some species reduced to scattered relict populations. Systematic, standardized inventories of colonies and long-term monitoring are essential to identify the need for conservation programmes and to assess their effectiveness. The purpose of this manual is to provide guidance to government agencies, protected area managers, researchers and citizen scientists who are interested in conserving and monitoring seabird populations.

Acknowledgements

Many people and organizations provided support for this manual and the work that supported its development. We gratefully acknowledge our funders and partners – principally the National Fish and Wildlife Foundation, Clemson University, U.S. Geological Survey, and Defenders of Wildlife. The following organizations have also contributed to this programme: US Fish and Wildlife Service, Royal Society for the Protection of Birds, Cornell Laboratory of Ornithology, Optics for the Tropics, Waterbirds Conservation for the Americas, National Environment and Planning Agency (Jamaica), and The Nature Conservancy.

We thank all the persons who contributed their time, resources and enthusiasm to make this project a success, especially Patrick Jodice and David Lee. We also thank the workshop participants for asking tough questions and steadfastly supporting our efforts. We greatly appreciate the copy-editing and translation of Yvan Satgé, Juan Carlos Fernández-Ordóñez and Régis Gomès.

Abbreviations used in the text

CWC	Caribbean Waterbird Census
EPIC	Environmental Protection in the Caribbean
GPS	Global Positioning System
IBA	Important Bird Area
IUCN	International Union for Conservation of Nature
NFWF	National Fish and Wildlife Foundation
NGO	Non-governmental Organization
SCSCB	Society for the Conservation and Study of Caribbean Birds
SWG	Seabird Working Group
UNEP	United Nations Environment Program
WCR	Wider Caribbean Region

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Introduction

Seabird conservation in the Caribbean

Seabird populations generally have large geographic ranges that cross international boundaries. This complicates conservation planning and implementation (Jodice and Suryan 2010), especially in the Caribbean basin, where there are 30 territories comprising more than 700 islands. High levels of terrestrial endemism often lead countries to focus their conservation efforts on single island endemic species and pay less attention to trans-boundary species, such as seabirds. Thus, despite including some of the most endangered regional endemic seabird species, and experiencing massive declines since the arrival of humans (van Halewyn and Norton 1984), seabirds were the most neglected element of the Caribbean region's avifauna until, in 1984, informed by the work of van Halewyn and Norton (1984), BirdsCaribbean (then the Society for Caribbean Ornithology)[1] formed its Seabird Working Group (SWG) and began to engage its members in seabird conservation. In 2000, the publication of "*Status and Conservation of West Indian Seabirds*" (Schreiber and Lee 2000) drew attention to the plight of seabird species in the region (Figure 1).

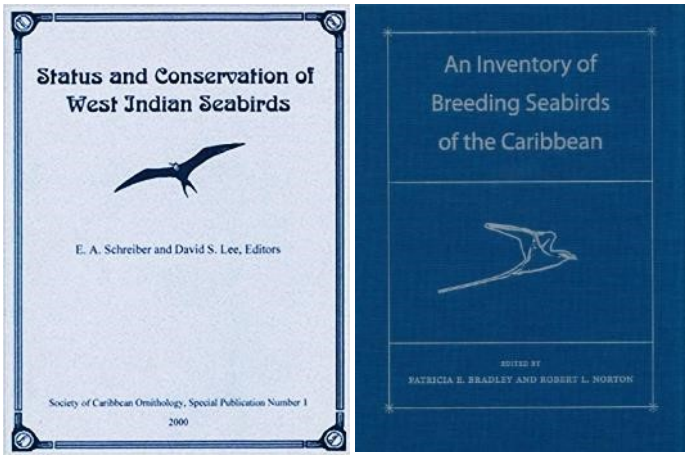


Figure 1: Books on Caribbean seabirds produced by BirdsCaribbean

The companion volume "*An Inventory of Breeding Seabirds in the Caribbean*" (Bradley and Norton 2009) assessed the conservation needs for seabirds and their habitats on each island or group of islands. Meanwhile, the SWG (led by Will Mackin and Dave Lee) were establishing a GIS-based atlas of seabird colonies across the region (West Indian Breeding Seabird Atlas, www.wicbirds.net, see below). The programme also included production of seabird outreach materials, including an identification card (Figure 2)

Figure 2: Identification card of Caribbean seabirds produced by BirdsCaribbean

and poster (Figure 3). These efforts made the SWG aware of the overall lack of consistent long-term data sets and the gaps in coverage of colonies and species. To address these issues, BirdsCaribbean began the task of building local capacity for inventories and monitoring by holding training workshops and developing the Caribbean Waterbird Census (CWC) (which also includes seabirds).

Figure 3: Poster on Caribbean seabirds produced by BirdsCaribbean

The work of the SWG was complemented by the publication in 2012 of the "*Seabird Breeding Atlas for the Lesser Antilles*" (Lowrie *et al*. 2012) by Environmental Protection in the Caribbean (EPIC) (Figure 4).

[1] See Appendix 1.

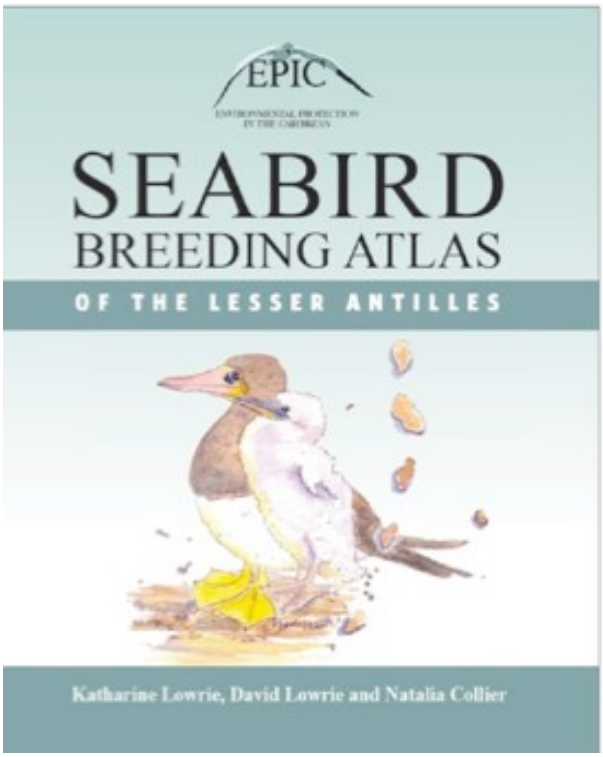


Figure 4: Seabird breeding atlas of the Lesser Antilles, produced by EPIC

In 2011, BirdsCaribbean, Clemson University and Defenders of Wildlife, were awarded a grant by National Fish and Wildlife Foundation (NFWF) for the project "Building International Capacity for Seabird Conservation" funded through the Recovered Oil Fund for Wildlife. Activities under this grant included: a seabird summit meeting in Grand Bahama in 2011(at which seabird experts from across the region met to determine conservation priorities); the preparation of a prioritization paper (Mackin *et al.* 2013); four training workshops, two in Jamaica in 2012 one in San Salvador, Bahamas in 2012; and one in Grenada in 2013; a small grant programme; and the production of this manual.

Using this manual

The purpose of this manual is to provide specific guidance for people who are planning and implementing seabird surveys in the Caribbean. It offers a flexible, multi-tiered approach to monitoring, designed to help the user to choose the protocol and extent of participation in the programme that is best suited to their objectives, available resources and capacity, so that they can improve knowledge of local seabird populations in feasible increments. It can be used to promote site conservation, assess impacts of threats to seabirds and their habitats, (for example rising sea levels, invasive species and loss of habitats) and design programs to protect, manage and restore seabird populations.

This first version of the BirdsCaribbean Seabirds Monitoring Manual is intended as a pilot version. Based on feedback and further review, revisions and updates will be made to future editions. It is not intended to be a comprehensive guide to designing and implementing monitoring programs. Many other manuals, such as "*Expedition Field Techniques – Bird Surveys*" (Bibby *et al.* 1998) and "*The Northeast Bird Monitoring Handbook*" (Lambert *et al.* 2009) provide excellent advice.

BirdsCaribbean expects that this manual will encourage people to participate in seabird surveys. Whether you are an interested volunteer, birder, or a natural resource professional working in government or a non-government organization your contribution is important. Please collect data and publish or share your results locally, nationally and internationally. You can help BirdsCaribbean to update the regional estimates for species and colonies. This manual includes instructions for contributing records of surveys to the West Indian Breeding Seabird Atlas – the database that tracks breeding populations of seabirds in the Caribbean (www.wicbirds.net). You can also share your data through eBird Caribbean and the Avian Knowledge Network (www.avianknowledge.net). Additional baseline information can be used to refine the focus of management activities and funding, and to provide important information to support applications for funding from international conservation organizations. It may also be used to increase public knowledge and appreciation for seabirds and the important roles they play in Caribbean marine ecosystems and economies.

Scope of the BirdsCaribbean Seabird Monitoring Manual

This version of the manual focuses on methods for assessing populations of the commoner seabird species that breed in colonies in the insular Caribbean. Rare nocturnal species that breed inland (such as the Black-capped Petrel *Pterodroma hasitata*) require specialized techniques and are not included[2].

The manual focuses on breeding species at the nesting colony because:

a. It is easier to find and survey seabirds while they are at their breeding colonies,
b. Seabirds are particularly vulnerable[3] during this phase of their life cycle, and
c. It is easier to identify and implement management actions at the colonies.

Seabirds spend most of their lives at sea and face many challenges there but it is only recently, with the advent of satellite tags, radio and GPS tracking, that it has become possible to get detailed information on seabirds at sea. Such work has only just started in the Caribbean. Detailed descriptions and applications for these and other at-sea techniques are beyond the scope of this version of the manual. eBirds has developed protocols for surveying seabirds on pelagic trips, and these are described in Appendix 7. Concentrations of seabirds at sea should always be reported, with numbers, species and geographic coordinates, if possible.

[2] Contact the Diablotin Working Group for assistance with surveys for this species.
[3] Seabirds at the nesting colony are vulnerable to threats that they do not face at sea, including predators and disturbance. Disturbance from people entering the nesting colony for whatever purpose, whether for tourism, research or exploitation of eggs, chicks and adults rapidly results in mortality, due to exposure to the sun and increased predation.

Background

What are Caribbean seabirds?

The term 'seabird' is generally applied to birds that forage at sea. Twenty-two seabird species breed in the insular Caribbean region[4] (Table 1, Figure 5). Families of seabirds that nest in, migrate through, or winter in the Caribbean include petrels, shearwaters, tropicbirds, frigatebirds, boobies, cormorants, pelicans, phalaropes, gulls, terns, skimmers, skuas and jaegers. All are highly adapted to the special challenges of life at sea. In general, they are long-lived; breed in colonies in coastal or island areas that were historically free of terrestrial predators; and have low reproductive rates. Most tropical species lay 1-2 egg clutches and generally produce 1 chick at most per year. Additional information about these species is provided in the species accounts below[5].

Table 1: List of seabird species that breed in the Caribbean (Bradley and Norton 2009)

Family	Common name	Scientific name	Range (Caribbean)	Status
Petrels	Bermuda Petrel	*Pterodroma cahow*	Bermuda	Endemic to Bermuda, Globally endangered, AZE species
	Black-capped Petrel	*Pterodroma hasitata*	Hispaniola	Endemic to Greater Antilles and Lesser Antilles. Extirpated from Guadeloupe may still nest in Martinique and Dominica. Globally endangered, AZE species
	Jamaica Petrel	*Pterodroma caribbea*	Jamaica	Endemic to Jamaica, globally critically endangered or extinct
Shearwaters	Audubon's Shearwater	*Puffinus l. lherminieri*	Caribbean	Caribbean endemic sub-species CARS
Tropicbirds	White-tailed Tropicbird	*Phaethon lepturus catesbyi*	Caribbean	Caribbean endemic sub-species CARS
	Red-billed Tropicbird	*Phaethon aethereys mesonauta*	Pantropical	CNIC
Boobies	Masked Booby	*Sula d. dactylatra*	Caribbean and SW Atlantic	CARS
	Brown Booby	*Sula l. leucogaster*	Caribbean and tropical Atlantic	CARS
	Red-footed Booby	*Sula s. sula*	Caribbean and SW Atlantic	CNIC
Pelicans	Brown Pelican	*Pelecanus o. occidentalis*	Caribbean	Caribbean endemic sub-species CARS
Frigatebirds	Magnificent Frigatebird	*Fregata m. magnificens*	Tropical Americas	CARS
Gulls and Terns	Laughing Gull	*Larus a. atricilla*	Caribbean	CNIC
	Brown Noddy	*Anous s. stolidus*	Pantropical	CNIC
	Black Noddy	*Anous minutus americanus*	Caribbean and S. Atlantic	CARS
	Sooty Tern	*Onychprion f. fuscatus*	Pantropical	CARS
	Bridled Tern	*Onychoprion anaethetus melanoptera*	Caribbean and E. Atlantic	CARS
	Least Tern	*Sternula a. antillarum*	US, Caribbean and Venezuela	CARS
	Gull-billed Tern	*Gelochelidon nilotica aranea*	E. US and northern Caribbean	CARS
	Roseate Tern	*Sterna d. dougallii*	Cosmopolitan	CARS
	Common Tern	*Sterna h. hirundo*	Cosmopolitan	CARS
	Royal Tern	*Thalasseus m. maximus*	Caribbean	CARS
	Sandwich Tern	*Thalasseus sandvincensis acuflavidus*	E US, Gulf coasts and Caribbean	CARS
	Cayenne Tern	*Thalasseus sandvincensis eurygnatha*	S. America and Caribbean	CARS

AZE = Alliance for Zero Extinction; CARS= Caribbean At Risk Species; CNIC Caribbean Seabird of No Immediate Concern.

[4] For the purposes of this manual, the Caribbean region is defined from a seabird perspective rather than a geopolitical one. It stretches from Bermuda to the Bahamas and south to Venezuela, and includes all the islands and cays off Florida, the Gulf of Mexico, Central America and northern South America.

[5] Readers who are planning surveys should refer to www.wicbirds.net to get up-to-date information about on-going surveys and data gaps. They should also plan to provide updated notes on observations of breeding seabirds to willmackin@gmail.com who maintains this database as well as the eBird Caribbean.

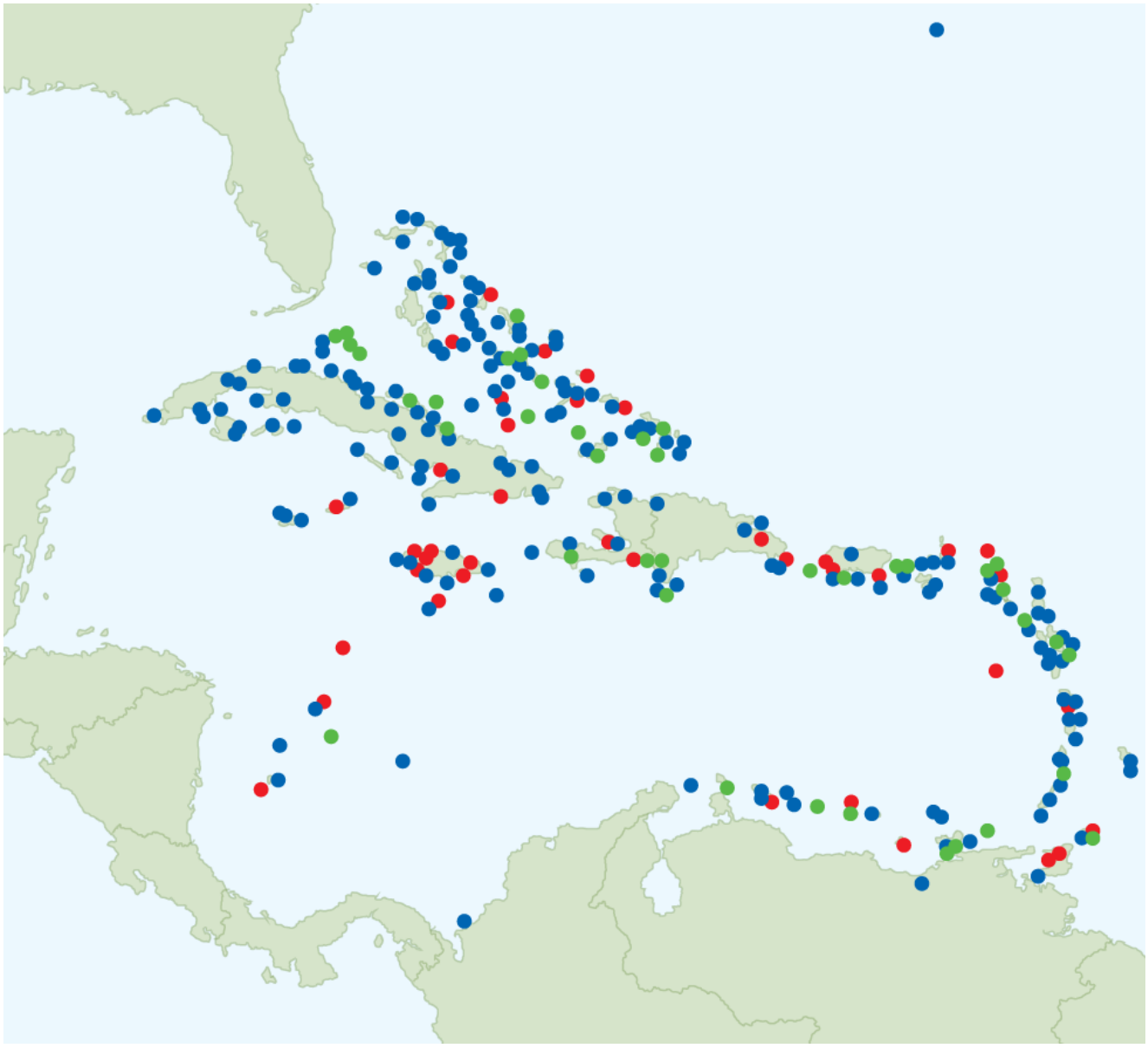


Figure 5: Seabird breeding sites in the insular Caribbean (not including the Gulf of Mexico)
(Source www.wicbirds.net)

Why is it important to monitor seabirds in the Caribbean?

Declining numbers

In the past, seabirds were very abundant in the region. The fossil record indicates that the Caribbean once teamed with millions of breeding seabirds; but their populations declined substantially as human populations expanded (van Halewyn and Norton 1984; Schreiber and Lee 2000; Bradley and Norton 2009, Lowrie *et al.* 2012). Colonies shrank or disappeared due to loss or damage of habitat (from development and disturbance, hurricanes and storms, and invasive alien plants such as Australian Pine *Casuarina equisetifolia*), disturbance of nesting sites (startled adults leave eggs and chicks subject to harm), the harvest of eggs and chicks for food, and the introduction of exotic predators (especially invasive mammals including rats, cats, dogs, pigs, goats, mice, and mongoose). All these threats are increasing rapidly, as human populations increase and are being exacerbated by climate change.

Caribbean seabirds are also subject to diverse threats at sea, including by-catch, contamination, and changes to or loss of prey. Such threats may occur far from breeding colonies because many seabirds travel great distances to forage during both the breeding and non-breeding seasons. Today seabirds are among the most threatened groups of birds in the region. Two species are globally endangered and one may be extinct. Fourteen species are at risk (Table 1).

The value of Caribbean seabirds

Caribbean seabirds are an intrinsically valuable part of the Caribbean's rich biodiversity. They serve as guides for fishermen and attractions for tourists and contribute to nutrient cycling in the marine environment. Additionally, birds in general, and seabirds in particular, are recognized to be very good indicators of the productivity and quality of habitats (e.g. Gregory *et al.* 2005; Parsons *et al.* 2008). Conservation of seabirds is therefore of great importance (e.g. Bradley and Norton 2009).

Need for seabird conservation

Tropical seabirds pursue life-history strategies that are not generally compatible with human-altered ecosystems. They are long-lived and most species lay only one egg per year. Until the last 10,000 years, they could avoid most predators simply by nesting on islands that lacked predatory mammals. They are extremely sensitive to disturbance of their nesting sites, harvesting of eggs and chicks for food, and predation by invasive mammalian predators (including man). To persist as a relevant part of the natural ecosystem and human economies, most Caribbean seabirds now require direct, coordinated, and long-term intervention by conservationists. These interventions must be informed by current, accurate information on the status and distribution of seabirds.

While naturalists can only dream of the days when the West Indies supported millions of breeding pairs of seabirds, our generation could represent a turning point where the declines are halted and no more species are lost from the region. The first steps have begun. Partners in the region have identified, shared and stored data on most of the remaining breeding sites for Caribbean seabirds in the West Indian Breeding Seabird Atlas (www.wicbirds.net) and in the Seabird Breeding Atlas of the Lesser Antilles. The quality and quantity of data pertaining to significant threats (such as introduced predators, disturbance, fishing interactions) is increasing. Most importantly, a network of interested local biologists and naturalists is poised to take ownership of local populations, monitor and report on their health, and intervene where possible to decrease threats.

International support for seabird conservation - the Ramsar Convention

The Ramsar Convention is an international treaty that promotes conservation of Wetlands of International Importance that are designated on the basis of criteria including if they regularly hold 1% or more of a population of waterbirds or 20,000 or more individual waterbirds. The definition of waterbirds includes seabirds. Many Caribbean seabird colony sites qualify as potential Ramsar sites - although few have been declared, partly due to lack of information. Wetlands International publishes Waterbird Population Estimates at regular intervals. The latest version and other key publications on the world's waterbirds are available for download on the Wetlands International website.

Regional support for seabird conservation – the SPAW Protocol of the Cartagena Convention

The Specially Protected Areas and Wildlife (SPAW) is part of the Protocol of the Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (WCR), which includes a legal commitment by Contracting Parties to protect, and manage their common coastal and marine resources individually, jointly, and in a sustainable manner. The Protocol protects rare and fragile ecosystems and habitats, thereby also

protecting their endangered and threatened species. Several seabirds are identified for conservation under the annexes of the Convention and the sites of important seabird colonies (including the SeaFlower Biosphere Reserve, San Andres, Colombia; Pedro Bank, Jamaica) have been identified as pilot sites for the Caribbean Large Marine Ecosystems project.

BirdsCaribbean's Seabirds Programme

BirdsCaribbean's Seabirds Programme is in the forefront of efforts to conserve Caribbean seabirds. It is one of BirdsCaribbean's core programmes. Led by the SWG the programme's goals are to increase awareness and capacity to conserve seabirds and their habitats through training, small grants and this manual. Notable achievements include the development of two books on Caribbean seabirds (Schreiber and Lee 2000 and Bradley and Norton 2009) and the development of the West Indian Breeding Seabird Atlas (www.wicbirds.net). The Seabirds Programme has as its scope the metapopulations of seabirds in the wider Caribbean basin, including the insular Caribbean plus islands in the Gulf of Mexico and Caribbean coast of Central America, plus Bermuda, San Andres and Trinidad and Tobago (Figure 6).

Figure 6: Islands covered by the BirdsCaribbean Seabirds Programme

Seabird Monitoring and Caribbean Birdwatch

The monitoring component of the BirdsCaribbean Seabirds Programme is part of BirdsCaribbean's draft comprehensive monitoring initiative for the Caribbean called Caribbean Birdwatch. It includes a basic introduction to monitoring in a manual "*Caribbean Birdwatch – How to Design and Implement Bird Monitoring in the Caribbean*" (BirdsCaribbean in prep.), which includes information about designing a monitoring program, training, selecting equipment, assessing habitats and analyzing data, as well as a broad range of protocols. The core manual will be supplemented by more detailed manuals for specific groups (Figure 7).

The Caribbean Waterbird Census (CWC) Manual (Sorenson *et al.* 2012) and Seabirds Monitoring Manual are the first two manuals in the series. A manual for monitoring West Indian Whistling Ducks is also in an advanced stage of preparation.

Figure 7: Protocols included in Caribbean Birdwatch

How to get involved in monitoring Caribbean seabirds

BirdsCaribbean is encouraging interested people and organizations to get involved in monitoring seabird colonies by undertaking to monitor specific colonies, groups of colonies or even whole countries, as well as by sending reports on observations of seabirds. Persons who are interested in getting involved should contact BirdsCaribbean's Seabird Working Group's co-chairs (Will Mackin willmackin@gmail.com or Ann Sutton ahaynessutton@gmail.com). Data on colonies may be sent to Will Mackin so that he can add them to the atlas on www.wicbirds.net. There is also an active yahoo group Carib-Seabird-WG@yahoogroups.com through which it should be possible to contact the majority of people who are working on seabirds in the region. Information will also be posted on the seabirds page of the BirdsCaribbean website, www.birdscaribbean.org.

Why get involved in the seabird monitoring?

There are many reasons why government agencies, NGOs, educators, academic researchers and other persons should choose to get involved in seabird monitoring. These include:

- To determine which species of seabirds occur at one or more important sites in your country and how their numbers are changing over time,
- To assess the national and international importance of a seabird colony (for example, does it hold an important proportion of a larger population) to inform the prioritization of its protection and management,
- To assess the effectiveness of management of a specific seabird colony by assessing the response of species (for example, increased diversity or numbers of birds) to management actions (for example, removal of exotic predators, education to reduce disturbance, enforcement to reduce illegal harvest),
- As a tool to monitor changes in bird populations and their associated habitats over time from the effects of climate change (e.g., sea level rise, increase storm frequency and severity, changes in prey base),
- To increase awareness and willingness amongst decision makers, natural resource and wildlife managers, community leaders, educators, and the general public, especially youth, to take action to conserve seabirds,
- To learn more about seabirds, their marine habitats and the marine ecosystems that support them.

Partners are encouraged to use standard or compatible protocols and to coordinate monitoring with other islands in terms of timing. This coordination can improve our understanding of regional changes in numbers and distribution at the regional level given that seabirds often move across boundaries between countries.

Designing your monitoring program

As mentioned above, there are many good sources of information on designing monitoring programs. The Caribbean Birdwatch manual will be an important resource once it is published.

The main things to consider in designing any monitoring program are:

- Establishing your goals and objectives. Why are you setting up the program?
- Defining your site. Where are you going to survey? How will you select survey area and survey points? How will you define the boundaries?
- Defining your time frame. How long do you anticipate running the survey (e.g. 2 years, 5 years)? Do you have sufficient resources for the period?
- Getting information. Who do you need to contact before starting? Is there any pre-existing information?
- Defining your audience. Who will use the information and how will they use it?
- Deciding your methods.
    - If you have not surveyed the area before it may be necessary to do a one-year preliminary pilot study or reconnaissance to plan your surveys, train your observers and refine your methods.
    - What level of monitoring is appropriate? What protocol will you use?
    - Who are the appropriate contacts in the area?
    - How will you reduce and account for sources of bias in your monitoring?
- Preparing for the surveys. What preparations will be needed? Include the equipment you will need, transportation, human resources, training, funding, permits, etc.
- Using the data. How will it be entered, stored, analyzed and presented? How will it be used to answer your questions, for adaptive management in conservation programs, and to plan and improve monitoring in future?

Establishing goals and objectives – What is the question?

Establishing clearly defined goals and objectives is essential to the design of an effective monitoring program. The **goal** is the general statement of what the program is designed to achieve in relation to a specific problem. **The objectives** identify the specific measurable actions that will be carried out to implement the program and evaluate its success. Goals and objectives are essential parts of every program, whether at the site or national levels. They answer the question "Why monitor?" and lead to the answers to "What? Where? When? And How?"

For many actual or prospective managers of seabird colonies the basic questions are:

- What species of seabirds are present at the site(s)?
- How many pairs of each species are present?
- How are their numbers changing over time?
- How to define the colony site?
- How important is a colony site nationally, regionally and globally?
- What environmental factors (natural or human-induced) are linked to these changes?
- What conservation measures are needed?

These questions may lead to more refined investigations, such as:

- Determining which species of seabirds are present and their distribution and relative abundance throughout the year
- Measuring population sizes and trends—changes in numbers and density over time in seabird populations/colonies in response to changes in the environment (e.g., management, variation in site conditions, site-based threats, external threats such as climate change, or other factors)
- Assessing breeding success
- Assessing the status of a threatened species (this may require special protocols)
- Justifying conservation action (e.g. declaration of the site as a Ramsar site or as a protected area)
- Assessing the need for specific management or conservation measures to improve the site for seabirds
- Assessing the effectiveness of management or conservation measures in improving the site for seabirds
- Engaging the local community in citizen science and conservation of seabirds and their habitats
- Assessing the potential for nature-based tourism.

Designing your seabird survey

It is very tempting to be overly ambitious in designing a study and to try to do too much with limited capacity and time**.** Sometimes it is better to set and achieve modest objectives than to set your sights too high and fall short (Bibby *et al.* 1998).

In designing your survey and sustaining it over the long-term, be sure to consider the amount of time and funding it will take to get permission and permits, carry out site reconnaissance and pilot surveys, plan your monitoring program and decide on protocols, assemble equipment and supplies, recruit and train volunteers, travel to the site and conduct the surveys, enter and analyze data, prepare reports and communicate the results to decision-makers, managers, the local community, etc. as needed. Often the preliminary and follow-up activities take much longer than the survey itself. Think about how you can make your surveys sustainable in the long-term by integrating them into existing national and site programs, seeking ways to make the surveys maximally cost effective, seeking sponsorship to continue the program, and by training participants to prepare funding proposals for future work.

Of course the level of effort in preparation depends on the size and importance of a colony. For example, a colony might consist of just 25-30 pairs of Royal Terns nesting on a sandy spit. Just a good count would be valuable and the results should be reported but this would not need a team of trained researchers.

At a glance - Ten Steps to Successful Seabird Conservation Through Improved Monitoring

Step 1: Establish a clear purpose

- Define the problem
- Identify and consult stakeholders
- Set a conservation goal
- Develop monitoring objectives that are linked to the conservation goal

Step 2: Determine whether an existing program or protocol meets your need

- Consult with BirdsCaribbean on Caribbean Birdwatch protocols
- Build on monitoring programs that have worked elsewhere

Step 3: Assemble a team of collaborators with complementary interests and skills

- Form or participate in a monitoring partnership
- Engage people with the necessary expertise (e.g. bird identification, use of protocols, survey design, data analysis, data presentation)
- Define roles and responsibilities of team members.

Step 4: Summarize the relationship of target populations to other ecosystem elements, processes and stressors

- Summarize life history information for the species or species group of interest
- Build a conceptual model
- Identify important responses to monitor
- Revisit conservation and monitoring objectives

Step 5: Develop a statistically robust approach to sampling and data analysis

- Identify appropriate analytical procedures
- Delineate the sample frame
- Determine method for selecting sample sites

Step 6: Design and pilot standard field protocols that minimize error and bias

- Screen and train observers
- Simplify survey methods
- Consider stratifying among habitat types to minimize site effects
- Use standard methods to control survey effects
- Determine if variation in detection rates exists among species or habitat types (if called for by monitoring objectives)
- Obtain peer review of protocols
- Test protocols and solicit feedback from observers
- Use pilot data to establish quantifiable objectives and determine sample size

Step 7: Identify or develop a data management system

- Develop project metadata
- Design and manage the database
- Archive and exchange your data with BirdsCaribbean, www.wicbirds.net and eBird Caribbean
- Provide access to data according to legal requirements and project agreements

Step 8: Implement the monitoring program

- Prepare for the field season
- Perform the survey
- Enter and check the data for errors
- Explore and analyze the data

Step 9: Present results in a format that supports sound management and conservation decisions

- Interpret results and prepare reports with audience in mind
- Provide tools that inform management/conservation decisions

Step 10: Evaluate and adjust management and monitoring to make better bird conservation decisions.

- Evaluate the conceptual model
- Adapt management if necessary
- Adjust monitoring, if necessary
- Assess the cost effectiveness of the chosen management and monitoring strategies.

AMERICAN BIRD CONSERVANCY

Abstracted and adapted from:
The Northeast Bird Monitoring Handbook
(Lambert *et al.* 2009)

Preparing for Seabird Monitoring - determining the resources that will be needed

Investing time in carefully planning your project pays dividends in the long run. Procuring equipment and funding, and ensuring that you have all of the relevant background and reference information—on species, habitats, methodology, logistics, etc.—is essential for fieldwork, but it is also important to consider whether you need to run training courses for fieldworkers in advance so that everyone fully understands what is required. Observers may need training in bird identification by sight and sound, and pilot counts should be conducted to practice counting birds, filling in the count forms, and learning the protocol. For projects in remote or little known areas or involving large numbers of observers, planning may take a year or more and for complex projects it may be necessary to have one or more seasons of field trials of methodologies, including data recording forms, to ensure that everything works as planned (Haynes-Sutton and Sorenson in prep.). It is recommended that you plan on one pilot season to learn the protocols, fine-tune your methods, and make sure that field persons are well trained.

Considering accuracy, precision and efficiency

It is important to consider accuracy, precision and efficiency in designing a survey**. Accuracy** refers to how close the measurements are to the actual numbers (e.g. how close the estimate or count of the number of breeding pairs is to the actual number). **Precision** is a statistical measure of the amount of variation between samples. In simpler language, accuracy is how close an estimate is to the true value while precision is the spread around the estimate when different surveys are conducted. Accuracy is increased by avoiding bias in sampling design (random location of plots, use of quality base maps, well-trained observers, etc). Precision is usually increased by increasing the number of samples and using the best available methodology. However increasing accuracy and precision also increases the cost of the surveys. Often both money and time are very limited and it is therefore very important to consider the **efficiency** as well. The costs of increasing precision have to be balanced with costs and the time taken.

Determining your audience - Who will use your results and how will they be applied?

It is very important to consider how your data will be used and by whom. The data should meet the requirements of the users but not greatly exceed them, otherwise effort may be wasted. The type and level of information needed will vary with how the information will be used. For example a site manager in a protected area may require very detailed information on the distribution and numbers of a target species, whereas a national environment plan may only need general information about which sites are most important for seabirds.

Assembling your team, equipment and resources

Consultation: When developing any type of monitoring plan, it is important to make sure it is based on up-to-date information, follows accepted best practices where they are available, and builds on previous or complements ongoing work. Therefore you should decide whom you should consult in order to help ensure your work is useful, progresses smoothly and that the results are relevant and useful. Such consultation can help with program design, logistics, and obtaining permissions and funding.

Permits and permission letters (e.g. research permits, permission to work on private lands; in some countries these can take several months to obtain so start early.

Consultation and involvement of **decision makers** from the outset of planning can be extremely useful as they will be aware of your work and what you are hoping to achieve. Ultimately this increases the likelihood that the data you collect will be used appropriately, effectively, and wisely.

- **Local contacts** are likely to be able to assist with detailed knowledge of the study area, anecdotal information on past management of an area or changes in bird numbers. In many cases, ensuring that local communities are aware of your work can be valuable both for assistance with fieldwork and implementation of future conservation action.
- Involving **community members** in a project helps make them feel valued, gives them a sense of 'ownership' of the area or species you are working on and provides an opportunity for increasing local skills and knowledge.
- Many of the seabird species of interest in the Caribbean nest throughput the tropics and therefore **expertise** on a given species may be available in the Pacific or Indian Ocean as well. Like the seabirds you are studying, your network needs to become far-reaching.

Resources that will be needed will include:

- **Personnel** including trained observers and people who can assist with data entry, analysis, presentation, interpretation and statistics
- **Transportation:** Vehicles and boats and the funds to operate them
- **Field equipment** (e.g. binoculars, spotting scopes, tripods, rangefinders, GPS units, playback systems, cameras, game cameras, 25 m waterproof measuring tapes, etc.)
- **Field clothes** (suitable footwear, hats, pants, raincoats, etc.)
- **Field guides**
- **General field supplies** (e.g. field forms, notebooks, pencils, mosquito repellent, first aid kits, Ziploc bags for samples, string for doing circular plots, etc.)
- **Supplies for marking nests** such as flagging tape and markers or metal tags.

As well as your team, you will need to assess what other resources you will need to implement your program on the basis of past experience or from the reconnaissance visits.

Training for seabird surveys

In many cases, seabird surveys will be implemented using people who have no prior training or experience in seabird monitoring. Training observers is a very important part of preparations. It is very important to ensure that observers are fully competent in field identification and understand the protocols. A training session at the beginning of the field season that includes practice counts is highly recommended. Training resources are available for download at the BirdsCaribbean website www.birdscaribbean.org. Other useful resources and references such as bird monitoring manuals and key papers on monitoring theory, strategy and studies are also available on the BirdsCaribbean website.

Special considerations in designing surveys for Caribbean seabirds

The most commonly asked questions about a seabird colony include:

- Which species are present?
- Which species are breeding at the site?
- How many breeding pairs are at the site?
- What proportion of the regional population does this colony represent?, and
- Are the numbers of nests at the site increasing, stable or decreasing[6]?

In order to understand these questions (and the challenges of answering them) it is necessary to understand the breeding biology of tropical seabirds. A summary of the most important aspects is provided below.

Breeding biology of Caribbean seabirds

Caribbean seabirds have not been well studied and there is little detailed information about their ecology. The West Indian Breeding Seabird Atlas www.wicbirds.net summarizes much of the available information. A summary of some of the most pertinent information to designing surveys and analysing the results is included the species accounts below. Much information about Caribbean seabirds is inferred from studies of the same species that have been conducted in other parts of the world. While these data should be considered and can provide useful insights, there remains an urgent need to confirm the utility of these inferences through studies within the Caribbean.

Life span: Most seabirds are long-lived. For example, even smaller birds like Sooty Terns are known to live 28 or more years, and the generation time (=the average age of reproductive females in the population) for seabirds is often 15-20 years, in a similar range to humans. The demographics of seabirds are influenced greatly by their long life spans. Factors that increase adult mortality tend to have stronger negative effects on population size and dynamics than factors that decrease survival of nestlings, all other things being equal (e.g. Hunter and Caswell 2005). For example, many seabird populations can withstand a few years of poor breeding success without experiencing a long-term population decline. This is not to suggest that nestling mortality is unimportant but rather that adult mortality typically affects population trends more quickly, more severely, and more permanently.

Age at first breeding: Seabirds take at least 3-5 years to begin breeding and it is important to know the difference in this age among species. Variability in age at first breeding within a species (e.g. breeding sooner or later than average) may be related to habitat condition, prey availability, colony dynamics, or population trends among other factors. Thus, for example, an abundance of 'young' breeding birds may signal a growing colony with good resources, while an abundance of non-breeding adults may signal some limit to breeding opportunities, such as a shortage of quality mates or nest sites. It can be difficult to assess the numbers of non-breeding birds, which is one reason why population surveys often focus on estimates of breeding pairs rather than counts of all individuals.

Breeding seasons – colony: Most Caribbean colonies have an annual cycle with a clear peak in laying of eggs in the northern spring or late winter, but some boobies, pelicans and terns may have peaks every 9 months or breed asynchronously (i.e., within a colony not all pairs are in the same breeding stage), and breeding individuals can be observed all year round. In most Caribbean species, there is little breeding in the early fall at the peak of the hurricane season. Many colonies are used by several species of seabirds whose breeding seasons also may not coincide. Breeding chronology for seabirds in the Caribbean is complex and still not well studied (see species accounts below and www.wicbirds.net).

If possible, reconnaissance surveys should be conducted at regular intervals over at least a year in order to determine nesting species and their approximate peak laying dates, and the timing of each major stage of reproduction (e.g., colony arrival, peak laying, peak chick-rearing, colony

[6] Colony managers may wish for information on changes in populations, but this is very difficult to measure. Most studies actually measure the number of nests (nest count).

departure) before setting dates for a long-term monitoring programme (see protocol for Level 1 surveys below).

Breeding frequency – individual: Individual birds at a colony may breed annually, but some alternate years or attempt to nest in most years but abandon nesting quickly if conditions are not favourable. Some individuals may attempt to re-nest following nest failure depending on when in the breeding season or breeding cycle nest failure occurs. Monitoring regimes should account for inter-annual variability and replacement nesting by basing population estimates on multiple years of data and multiple samples within years.

Metapopulations: Studies have shown that seabird populations in regions such as the Caribbean function as a metapopulation, or a population of populations. There is immigration and emigration among colonies. Dispersal to other colonies is more common for first-time breeders compared to experienced breeders. Nonetheless, it is ultimately our goal to understand the health of the regional population, which includes all interacting colonies. To do so we need to understand success across all breeding sites. In addition, some colonies can act as **source populations** where high levels of reproductive success often lead to positive population growth rates, while others act as **sinks** where low levels of reproductive success can lead to negative population growth rates. Importantly, management of any species of seabird in the Caribbean requires a broader view than just a single colony because population trends in one island can affect populations in others. Hence, cooperation and sharing of information among natural resource managers from multiple island nations is essential.

Planning seabird surveys

Surveys of seabird colonies often occur by good fortune and are only possible when the weather permits. The best strategy for a naturalist trying to make a difference for seabirds is to be prepared for good fortune. Plan long-term monitoring for sites that you can easily visit, but be prepared to tag along with friends for trips to survey remote locations. See the Level 1 protocols for suggestions.

Factors to consider when planning seabird surveys

Inaccessibility of nesting colonies: Inaccessibility is an overarching challenge to seabird surveys and monitoring. Most important seabird populations are on remote islands that have not been settled by humans and are difficult or expensive to reach because they are distant from the mainland or because landing on them is difficult and dangerous. Others are on main islands on precipitous cliffs that protect the birds from cats, rats, and other predators. Such difficult-to-reach colonies require complex expeditions to sample, but they can hold large proportions of the Caribbean populations for particular species (e.g., Cay Sal Bank, Bahamas, Los Roques, Venezuela, La Selle Ridge, Haiti).
Due to inaccessibility, there is a lack of baseline information for many species across much of the region and this makes it challenging to plan effective surveys. In some locations, several preliminary visits may be needed just to establish the timing of breeding seasons and subsequently the timing of surveys and data collection.

Detection: Gulls, terns, pelicans, boobies and frigatebirds often nest in the open and are fairly easy to detect. Some tern species are difficult to identify when they nest among similar looking species (e.g. Black Noddies nesting with Brown Noddies). Less common species may be overlooked in large colonies where they constitute tiny proportions of the breeding individuals. Tropicbirds and petrels nest in cavities, crevices, or burrows. They require special census techniques. Petrels are particularly difficult to detect and monitor since they are only active at the colony at night. Even large colonies are sometimes not noticed for many years. Special strategies are needed for finding populations of petrels and shearwaters and estimating their size.

Movements among colonies: Types of movements among colonies include:

- movements of individuals from one colony to another,
- movements of entire colonies, and
- movements of individuals among sites in the same colony.

Most young seabirds tend to return to their natal sites to breed but some individuals may make large-scale geographic movements. For example a juvenile Masked Booby, banded at Pedro Cays in October 2012, was seen at a colony in the Campeche Bank in October 2013. Some species show high levels of site fidelity - returning to the same site to breed for many years. Others move their colony or nesting sites between seasons, especially if they are subject to intense disturbance. Roseate and Least Terns tend to move their colonies frequently, even following years when nesting success was apparently high and there was little obvious evidence of disturbance. Thus, it is important to catalogue the locations of nesting sites in multiple years and plan for the fact that population of these terns may move between sites.

Disturbance: Seabirds eggs and young chicks are vulnerable to exposure to heat, cold and predation. Any disturbance of the colony, even one of a short duration, can therefore reduce reproductive success if parents flush and leave eggs or young chicks unattended. For example, exposure to direct sun at midday for as little as 15 minutes can kill an embryo within an egg and an absent parent can allow an avian predator to seize a young chick (Haynes-Sutton, pers. obs.). Therefore, time your surveys for cooler parts of the day and take care to minimize the time you spend in the colony. Move as quickly as you can through the colony. If you flush birds from their nests, quickly leave the area so they can return.

Unit of measurement: Seabird populations at a colony consist of two main components -breeding adults and non-breeding individuals (including non-breeding adults and sub-adults, juveniles and chicks). Generally it is easiest to count breeding pairs or occupied nest sites and in this case the unit of measure is the **number of breeding pairs**. For hole-nesting species the stage of breeding cannot easily be assessed, and the simplest unit of measure is the **apparently occupied nest site**.

Sampling and reducing bias

"The basic idea which underpins sampling is that because we cannot count a whole population or bird community, we take samples and extrapolate our results to provide estimates of the true population sizes or species diversities. In the same way, we might sample a variety of habitats to try to build up a true picture of what a species' habitat requirements really are. The problem with any sort of sampling is that there are many ways in which the sampling regime could be biased. For example, many birds are more active and vocal early in the morning, so if two forest areas are censuses, one between 0600 and 0800h and the other between 1300 and 1500h, the results cannot be compared; the first area may seem to have more birds but is this because of a real difference in the bird populations, or just because the birds were easier to see and hear? The sampling regime was obviously biased, and there are many other ways in which bias can affect the outcome of any bird counting exercise. Another example of bias is comparing results from a noisy environment (e.g. riparian forest) with a 'quiet' habitat. Understanding the causes of bias and dealing with it in the appropriate way is the most important part of study design" (Bibby *et al*. 1998).

Unappreciated bias is one of the biggest problems undermining the value and credibility of survey and monitoring work. Some recommended ways to reduce bias include:

- Ensuring that key parts of a site or key habitats are sampled,
- Standardizing surveys according to observers, time of day, weather conditions, state of the tide (in the northern Caribbean), area covered, and the amount of time spent counting
- Using standardized methodologies
- Ensuring that there are no major differences in the abilities of observers working on the same project.

Bibby *et al.* (1998) contains more detailed discussions of bias and how to reduce it.

Detection probability/detectability
In any survey, it may be difficult to be sure that the observer carrying out the survey has counted all the birds present during the survey. With seabirds, some species are easier to observe generally and some habitats conceal some birds more than others.

Data based on an incomplete count cannot be used to estimate density or population numbers or to compare sites. Thus valid survey protocols measure the likelihood that all birds have been seen, which is called detection probability or detectability. This can be used to adjust the counts to produce an estimate of the actual numbers that were present in a given area. There are several ways to do this, including comparing the numbers counted by two independent observers at the same time (double observer), repeating the counts over a very short period of a few days (repeated counts), dividing the count into time intervals and seeing how many new individuals are seen in the count periods (removal counts), or measuring the distance to each individual or flock when it is first seen (distance sampling). All these techniques have their challenges but they can greatly increase the usefulness of the data that are collected. For most seabird colony surveys, the most practical approaches for assessing detectability is repeated counts (e.g. Kerry *et al.* 2005).

Selecting sites for surveys
Where will your surveys be carried out? Defining the study area and selecting where exactly you will work is one of the most important and challenging aspects of the design of your monitoring program. It is closely linked to the goals of the program. The overall area from which you will select your study sites is called the sampling frame. If the objective of the survey is to identify the most important sites for seabirds on an entire island, the sampling frame must include a full range of sites representing all seabird nesting habitats in the island. If the objective is to survey seabirds in a particular group of islands, the sampling frame should include representative sites from across the group. If the proposed study site is small and/or open, it may be possible to do a complete count (census) of all the birds in the study area. If the study site is large and partly or wholly inaccessible or involves multiple colonies in an area or island, conducting a complete census will be impossible.

In reality, site selection will depend in large part on access and logistics; however, one should systematically explore the options and decide on a monitoring scheme according to sampling capacity while following as much as possible the principles of sampling design. More details on defining your sampling frame and selecting your sites and survey points for monitoring can be found below and in other monitoring manuals or scientific papers (e.g., Bibby *et al.* 1998). You can also contact experts directly from the information in scientific papers, post your query of the SWG listserve, contact the members of the SWG directly - most will be happy to provide guidance.

Other criteria for selecting a monitoring site might include its regional importance, its international status (e.g. as a Ramsar site or IBA) and its local status (e.g. as a protected area).

Defining the site

It is important to define the site clearly and where possible to survey the whole colony. It is not always easy to decide where the boundaries of the site lie, e.g. is it a cay or the whole group of cays in an area? How should small outlying colonies on isolated rocks or cays be treated? There is no simple recipe for this. Consult www.wicbirds.net to see what others before you have done. However you choose to define the site, it is important to record the definition you used for your sample frame and, if possible, use your GPS to map the boundaries.

Selecting dates for surveys
The complexity of tropical seabird nesting cycles makes it very difficult to answer even the most basic questions about a colony such as the species present, the size of a population and trends. Single annual counts generally only yield an estimate of the minimum number of breeding pairs. Repeated visits are needed throughout the year but the number and timing of visits depends on the colony and the species present. There is no simple recipe for determining the sampling schedule. Many colonies are difficult and expensive to get to and the schedule can be disrupted by external factors such as the weather, availability of suitable boats, and free time for researchers. It is important to plan in stages and accomplish high priority objectives on initial visits with more technical or complex objectives on subsequent visits. Differences in survey dates among years are a common source of bias (see above) in survey data.

For species that nest more or less synchronously like shearwaters or terns, a visit in the egg stage and later in the near-fledging stage can provide a good estimate for the number of pairs attempting and succeeding at nesting in a single year. Depending on the number of species at the colony the ideal number of visits may be three or more:

a. During the peak laying period for the species of greatest concern,

b. When most eggs have just hatched, and
c. Before most chicks have fledged. Try to avoid doing counts when there are large numbers mobile chicks in the colony because the risk of disturbance is great and the accuracy of counting low.

If estimates of survival are needed visits may have to be even more frequent (e.g., daily, weekly or biweekly).

For species that breed all year round (some colonies of pelicans, frigatebirds, and boobies) or in extended breeding seasons (some colonies of tropicbirds and terns) the situation is more complicated. For larger colonies, at least 2 or 3 counts will give a better estimate of the total number of breeding pairs using the site. For example, a visit in winter and another in summer would provide two good counts of nesting attempts that could be added together to estimate the population.

If it is only possible to make one visit to a colony, it should be timed around the end of laying of the species of greatest interest – just before hatching starts. This minimizes that risk of missing nests and also is the period when the impacts of disturbance to the colony are lowest if precautions are taken. However many colonies support several species of seabirds whose peak breeding seasons do not coincide. The number and timing of surveys conducted in a year depends on local monitoring objectives, available resources, and the timing of breeding at each colony.

Using the data

Entering the data

Data entry should be done as soon as possible after the field trip, preferably the same evening.

Sharing data

Count data should be entered on the computer using spreadsheets and/or eBird Caribbean (see Appendix 6). They should also be shared with www.wicbirds.net by going onto the "Contribute" page on the website, and completing the form.

Analyzing the data

For site purposes a species list should be compiled, including the species present and their numbers by season, which can be compared annually with previous years. Also look for changes on maps and photographs and take action if any major changes due to human interference are noted. eBird Caribbean can be used to view maps and graphs of frequency and abundance of bird species. Exploratory data analyses can also be conducted in Excel. Once you have several years' data you should use simple statistics to analyze nest counts and changes. Some simple analyses can be performed on Excel and there are many statistical packages available to do basic statistics. If you are unfamiliar with statistics, consider seeking help via the seabirds listserve Carib-Seabird-WG@yahoogroups.com.

Some basic questions to consider in the analysis include:

- Which species were present at the time of the surveys?
- What is the species richness and numbers of each species at the site and how does it compare with other sites?
- Are there any threatened, endangered or rare species or other species of special conservation interest? Any species of special interest to birders or ecotourists?
- What are the most common species and how large are their populations?
- Are there any changes in species composition or numbers?
- If yes, how can this be related to changes in habitats, conservation management or threats (e.g. climate change)?

Understanding the results

Habitat use away from the breeding colony: The fate of a colony may depend on factors far distant, such as mortality of juveniles or adults at sea or contamination of prey brought back to chicks. Until recently there was very little information about where Caribbean seabirds go when they leave the colony. Recent studies using satellite transmitters, geolocators and GPS trackers have provided new and sometimes surprising information. These data are demonstrating that the geographic range in which threats may occur for seabirds breeding in the Caribbean is vast and hence management and conservation for these species should consider factors from far beyond the region.

Longevity and nest site fidelity: Many species of seabirds live for more than thirty years. They also have high levels of nest site fidelity. Therefore the presence of large numbers of nesting adults at a colony is not necessarily an indicator that the colony is sustainably reproducing. Hence it is important to document when possible not just egg-laying and incubation but also hatching and fledging.

Long-term trends: In analysing data it is important to consider that large-scale and sometimes distant factors like the El Nino (ENSO), the North Atlantic Oscillation, and climate change may influence nesting success and seabird populations at your colony in ways that are totally unrelated to local conditions at the colony itself. The relationship between some of these large-scale ocean-climate patterns and seabird popuatlion dynamics are poorly understood in the Caribbean.

Ideally, focus resources on monitoring the most important colonies for each species to maximize the information gained per unit effort. Such strategic, regional thinking is difficult in a fragmented political environment such as the Caribbean, but it will be important to continue to collaborate and communicate with experts and conservationists around the region to make sure that important colonies are protected and monitored properly.

Storing the data

Make sure that electronic data are backed-up in at least two places (e.g. on an external hard drive and on a CD, which should ideally be kept in different physical locations (in case fire or hurricane destroys one of them). Also make sure that original field notes are safely stored.

Presenting the results

Using and reporting the data are as important as collecting it – a fact that is often forgotten. Unless the results of your study are made available, especially to those who control or influence the conservation and management of the species, habitats or sites that you are working on, then the value of the data are minimized. BirdsCaribbean suggests that you present and share data in appropriate ways. Formats for national and site reports are being developed and will be circulated.

It is important to think about the format of how your results are presented – publication in a scientific journal will be very different from a popular magazine or newspaper and many decision makers will not have the time or inclination to read a long, detailed technical report, so consider producing a short, easily readable summary if this is your target audience. A technical report can, however, provide detail to support such a summary.

How you disseminate the results will determine whether your results are applied effectively to conservation or not. The first step is to define your message, then your audience. Based on this you can determine what materials are best suited to communicate to your audiences. Some options include:

- **For supporters, volunteers and tourists** – provide a checklist of your site on the web and in newsletters, email alerts of rarities, or a blog of your activities, e.g. on eBird Caribbean
- **For Protected Area managers:** Provide a summary of major findings, focusing on management implications and need for action
- **For politicians** – Prepare a one page summary interpreting results (include simple graphs and photos) with reference to their concerns (such as seabird nesting habitat health, functions and the values of ecological services, nature tourism/education value of the site, threatened and rare species using the site, conservation problems/successes)
- **For the scientific community** – peer reviewed scientific paper (e.g., *Journal of Caribbean Ornithology*), Avian Knowledge Network (www.avianknowledge.net), local bird bulletins.

More advanced studies - Understanding trends in survival, distribution and abundance

A detailed assessment of reproductive effort and success may be used to provide detail needed to better understand the mechanisms underlying trends you may be observing in nest counts or populations. More detailed studies could include measurements of survival at different stages (incubation, fledging, first year), collection and identification of prey items, or measurements of provisioning rates and growth rates of chicks.

Measuring breeding success is an important aspect of seabird management and it is critical to understand the biases and pitfalls in attempting to do so. For example, when assessing nesting success some nesting attempts are almost inevitably not detected. Birds may initiate nesting but fail before the research team arrives or between research visits. Additionally, some nests will have unknown fates and it is not clear how to classify such nests. One common method used to measure nest success that accounts for some of the above-mentioned challenges is to use the Mayfield Method. In short, this approach tracks daily survival of a nest and estimates a probability of success for each nest. There are several guides available to conducting Mayfield surveys as well as spreadsheets that incorporate the appropriate formulas. A spreadsheet guide to using the Mayfield method can be downloaded from www.birdscaribbean.org.

Long-term studies using banding can provide information about age at first breeding, rate of recapture, adult survival, movements among nest cavities and between colonies, and long-term trajectory and contribution of particular colonies to the regional population. In the case of seabirds, most of which are long-lived long-term refers to multiple decades. Initiating a long-term study using banding requires a commitment of several years with large numbers of birds banded (~hundreds) to provide useful estimates using Mark-recapture analysis, and such studies can be developed after a population is protected and any immediate conservation concerns are addressed. Where some populations are more accessible for study, such detailed investigations can provide a baseline for comparison to understand and model the behavior of the inaccessible populations where in-depth analysis is not feasible.

Seabird Survey Protocols

Selecting your survey methods or protocol

BirdsCaribbean has identified four levels of monitoring (Table 2). Which one you choose will depend on the amount of time, resources and money you have to devote to seabird surveys. **Level 1** is a reconnaissance visit to document the species, and describe the location of the seabird colony. If a reconnaissance survey indicates an important population of small to moderate size, it should be documented with a **Level 2** survey, which will provide a total count of the number of birds at the colony as well as notes on the stage in the nesting cycle. **Level 3** is designed for estimating numbers of breeding pairs at very large colonies, for which a total colony count cannot be done. Once you have information on breeding species and their numbers at a colony, you may want to get a better understanding of population dynamics, through measuring reproductive success and gathering life history information. Some approaches are suggested in **Level 4.**

Table 2: Summary of Levels of Monitoring and Seabird Nesting Survey Protocols

LEVEL OF MONITORING	APPLICABILITY
Level 1 - Reconnaissance survey	Explore and get basic information (including mapping and habitat assessment) for undescribed sites or sites that have not been recently visited. Depending on the size and complexity of a colony it may be necessary to do several reconnaissance surveys over the course of a year. It may also be necessary to visit during the day and at night at several times of year.
Level 2 – Total colony counts	Estimate number of nests at small to medium-sized colonies (<500 pairs)
Level 2a – Total colony count (or census)	Nest counts in small to medium-sized colonies (<500 pairs) of species. Make notes on the stage in the nesting cycle.
Level 2b – Remote counts	Count numbers of nests in inaccessible colonies (e.g. on cliffs)
Level 3 – Sampling	Sampling is necessary to estimate the number of nests at large colonies (>500 pairs).
Level 3a – Circular plots	Appropriate for large colonies, including those with widely dispersed or concealed nests. This method can be used in combination with playback for Audubon's Shearwater colonies at night.
Level 3b –Line transects	Appropriate for large colonies, including those with widely dispersed or concealed nests and those with linear features. Also used for counting seabirds at sea.
Level 4 – Reproductive success and life history	Information on reproductive success is necessary to understand the dynamics of seabird populations at a site.
Chick growth rates	Assess conditions (including stress) and survival at nesting colony
Provisioning rates for chicks	Assess food availability
Life history parameters	Use banding and colour marking to determine age at first breeding, longevity etc.
Foraging patterns	Use tracking devices to determine where birds go to feed
Prey species	Collect and examine regurgitated fish to identify prey items which are being fed to chicks
Alien invasive species	Use nest cameras and other observations to assess presence or absence of predators and the threats they pose to nesting seabirds
Other methods for estimating numbers in difficult circumstances	These methods may be used as a last resort when entry into a nesting colony is not possible or time is limited. They mostly do not allow for counts of the number of breeding pairs or nests and so are not comparable with methods above.
Flush counts	Estimate numbers of nesting pairs from the numbers that fly up from a colony following disturbance
Roost counts	Estimate numbers at non-breeding sites.
Fly-by counts	Estimate numbers of birds flying from or to inaccessible colonies or roost sites.

Level 1 – Reconnaissance survey

If you have never visited the area before it will be necessary to conduct a preliminary site assessment (also called a reconnaissance survey). Ideally a reconnaissance survey includes identifying the location of the breeding birds at a colony, the state of nesting (roosting/courting, incubation, feeding of chicks, etc.) at the time of the survey, and (if possible) the number of nesting pairs.
The basic approach is simple:

- Do a literature search to determine whether there are any existing data from the site (published or unpublished)
- Get a map and image(s) of the location (e.g., from Google Earth, local Lands and Survey Department) or make a map when you get there
- Plan your visit to coincide with the maximum likelihood of seeing the maximum numbers and variety of birds (i.e. early in the day, during peak breeding season, etc.)

Special approaches will be needed for nocturnal species and species that nest in holes. For **shearwaters or petrels**, reconnaissance requires visits at night, playback of calls from a boat at night near islands that are difficult to access, or thorough ground searches during the day reaching into cavities and looking for evidence of nesting. For **tropicbirds**, reconnaissance requires documenting sites where the birds are flying and entering cavities, usually on cliffs or offshore islands.

Box 1: Stages in the seabird nesting cycle
- Pre-nesting – prospecting for nests, no eggs or chicks
- Early laying – some eggs present, not all nests have eggs
- Peak laying – most nests have eggs, some newly-hatched chicks
- Early hatching – most nests have small newly-hatched chicks
- Pre-fledging – most nests have large chicks
- Fledging – chicks are ready to fledge
- Are nesting stages synchronous or asynchronous?

Before visiting a site for the first time, if possible acquire a good map or aerial photograph of the site and review it to determine accessibility of the site, general habitat and access routes. If the site has been surveyed previously, helpful information on site accessibility and habitat may be gleaned from publications or unpublished observations and notes. Additionally previous surveys can also give you an idea of the species composition of the site (at least at the time of these surveys). Timing of the initial visit should be tailored towards species of interest (if the presences of these species are known or suspected from previous surveys). Always determine land ownership and acquire written permission to enter and survey any private land.

Once you have determined how you can access the site, do your reconnaissance survey. This will help you to get the information you will need to design your monitoring program.

Determine an initial species list for the site. The goal for the initial survey is to determine which species are at the site. Therefore, you should consider ways of maximizing detection of species. You should always be aware that disturbance may negatively impact the birds at the site, especially when they are on nests. Follow the ABA Principles for Birding Ethics www.aba.org/about/ethics.html).

If possible, start with an overview of the colony, by selecting a vantage point from which you can assess breeding activity in a large proportion of the site while causing minimal disturbance.

It is important to make a thorough description of the site on the first occasion that you visit. Sketch a map or draw on a photograph (see section on mapping the colony, below). Make notes on distribution of nests, vegetation, human activities and other features. Remember that the reconnaissance survey will serve as a baseline and enable you to assess changes in the future. Detailed notes will make your survey more valuable, especially if you are contributing to a coordinated national or international monitoring program (such as www.wicbirds.net). If you have time, use the Seabirds Site Description Form to describe the area (Appendix 4).
On such visits, keep your methods simple but make detailed notes of what you observe. Take many photographs, including panoramic shots and videos if your camera has this capacity, and be sure to save the images with your report on the colony, perhaps in the same folder on your hard drive.

Detecting invasive species

Invasive species (including cats, rats, mice, dogs, raccoons and goats) are one of the most important threats to nesting seabirds. Their presence is not always obvious, therefore active searches for their presence should be an important component of seabird surveys at all levels of monitoring. Search for signs of the presence of invasive mammals, such as chew marks on the bark of vegetation, fecal pellets, and

mammalian urine trails. The latter can be detected using a UV light at night. If you suspect invasive species are present, consider setting up Sherman rat traps or a game/wildlife camera (such as a RECONYX or similar brand) to confirm their presence.

For colonies where there are no large crabs, a cheap way to verify the presence or absence of rats and mice is to use wooden popsicle sticks or tongue depressors. You should soak them in vegetable oil for several days or smear them with peanut butter. Place them around the colony and when you come back in a week or so, you will see characteristic tooth marks if mice and rats have chewed them. Hermit crabs will work them over too but the marks are different. However larger crabs will draw them away.

It is also very important to note the presence of alien invasive plant species (such as Casuarinas). They can adversely affect the availability and quality of nesting habitats.

Level 2 – Monitoring: the Census or Total Colony Count (with notes on nesting cycle)

A census is a total count; in this case a count of all active nests or nesting pairs. It is a basic approach to collecting data on seabird abundance at a colony or nesting area. A census works well in small to medium colonies (<500 pairs), or when you have a large number of people to do the count. The census will provide information on the number of species present, numbers of breeding pairs and stage in the breeding cycle (see Box 1). If conducted in combination with mapping and habitat descriptions, it can also provide information on the distribution of nests in the colony.

How to conduct a census

The aim is to count every nest and record the stage in the nesting cycle of each nest in as much detail as possible. Table 3 includes suggested codes for these data. A data form is included in Appendix 3.

- As noted throughout this manual, for diurnal species, conduct counts in the morning or late afternoon and avoid the heat of the day.
- Approach the colony with caution. Use binoculars or a spotting scope to scan the area from a distance to get an idea of the distribution of birds and plan how you can minimize disturbance.
- Mark and number each nest as you count it. This may not be as simple as it sounds. Box 2 includes some recommendations for marking nests.
- If time and resources are limited, (or because of the stage in the nesting cycle, number of predators or the heat of the day means that the time spent in the colony needs to be minimized) you can do a basic census and simply count the number of incubating pairs. This allows the survey team to be less intrusive (e.g. all we can do is walk around the colony and count nests, or walk through it but birds sit tight and you don't want to push them).
- If you have time and resources (and the colony you are working is less vulnerable to disturbance) you may be able to walk through the colony and look into the nests) you may do a more advanced census. This involves describing the contents of each nest, as well as the number of incubating pairs of adults, the number of eggs, downy chicks, and the number of large chicks that are covered in feathers in each nest.
    - If you have time, also count the number of courting pairs or males defending a nest site, any dead adults or chicks. This may provide important supplemental information.

Box 2: How to mark seabird nests

When counting in a colony, (especially a hot and noisy one) it is very important to mark nests to ensure all nests are counted and to avoid double counting. In the harsh environment of most seabird colonies something as simple as marking nests can be harder than expected. Options include numbered flagging tape, spray paint, popsicle sticks painted orange and flags. Metal tags can also be attached to rocks or trees. Unfortunately bad weather, seabirds and visitors to seabird colonies can remove most types of markers so permanent marking is difficult. If you are doing more than one census in a year, you will need to remove markers after your census or use different colours or types of markers for each visit.

Second and subsequent visits:

Repeat the first survey as closely as possible using the same methods and spending about the same amount of time in the colony.

For each nest note whether it was previously marked (and mark it if necessary). Note the nest number, nest contents and stage in the nesting cycle.

Suggested codes are included in Table 3. The codes can be combined to make a complete description, e.g.. A2 + E1 = Two adults on a nest with one egg.

Table 3: Codes for describing seabird nests and the stage in the nesting cycle

CODE	DESCRIPTION
A1	Adult single
A2	Adult pair
Disp	Displaying bird/pair
E1	Nest with one egg
EP1	Nest with one damaged or spoiled egg (record type of predator if known)
C	Nest with chick, no other details
N1	Nest with one small, newly hatched unfeathered chick
D1	Nest with one small downy chick
P1	Nest with one partially feathered chick
F1	Nest with one fully feathered chick
U1	Fully feathered juvenile, still dependent on parents
CD1	Nest with one dead chick
Kemp	Empty cavity
Kocc	Cavity occupied
Kpot	Cavity possibly occupied
Ku	Cavity – contents unknown
Ne	Active nest (no other information)
Na	Nest complete – adult sitting on it (no information on contents)
Nc	Nest complete but not apparently active
Np	Nest partially built
Nu	Nest complete but not apparently active
Nx	Nest not active, fallen or broken
Adapted from Burger and Lawrence 2003	

Censusing large colonies

If the colony is large, you may need to survey it in sections, using obvious and permanent landmarks (if there are any) so that each section can be counted separately. This will make counting more efficient and allow you to share the effort between team members. If there are several team members they can be assigned to different sectors. By having the same team survey the same section on subsequent visits, you can reduce or eliminate bias in your census associated with different observers.

Describing the habitat

You should also make a detailed description of the habitat including the species of plants and threats, if any, to seabirds using a site description form. The site inventory approach and forms can be used, on the first visit (Appendix 2) and photographs and notes on changes made on subsequent ones.

Entering, sharing and analyzing data from censuses

Data should be entered on a spreadsheet, for example in Excel. Data from censuses can be entered on the eBird Caribbean site and the totals shared with www.wicbirds.net.

Detection Rates: In surveys of seabirds where pairs of ground-nesting species are counted in the total colony or within plots, the rate of detection may be expected to be 100% (especially if two observers work together to ensure no nests are missed). The survey is thus a total census and does not require the use of a correction for rate of detection (Gregory *et al.* 2004). You can check this using repeated counts.

Repeated counts: The same observers recount the whole colony marking any additional nests or do a recount in a known proportion of the colony (e.g. 5%-10%) on the same day or on the following day.

Calculating the detection rate

The detection rate (D) is calculated as
$D=n_1 / N^{\wedge}$.
Where n_1 = the number counted in the first count, and $N^{\wedge}$ = the total number of nests found in the plot after all searches. For example, if the first observation in the sub-sample area was 73 nests and the total found in all searches was 78 nests, D = 73/78 = 0.936. To adjust the counts for the remaining area (which was not re-sampled) you would divide the raw counts from that area by D. If you were adjusting counts of a number of separate plots to account for missed pairs, you could adjust each count individually by dividing by D and then estimate your population based on the adjusted counts.

The nests of some species (e.g. Audubon's Shearwaters, Bridled Terns, and White-tailed Tropicbirds) are concealed in under dense vegetation or in holes or crevices. In such cases, you may have to watch the adults visiting the nests or use playback at night to find nests. However it will be nearly impossible to detect 100% of the nests because the adults may be away from the colony during the count or they may not respond to playback. You should determine the detection rate (e.g., using repeated counts over several days or nights or the double observer method) and correct your counts accordingly.

Trimm and Hayes (2005) repeatedly searched areas for Audubon's Shearwaters at colonies around San Salvador using playback on multiple nights and found 79% of the total number of nests ultimately detected on the first search. They corrected their estimates by a factor of 1.21 to account for birds missed on the first search.

In all cases both the raw counts and the corrected counts should be reported, along with the correction factors calculation, to allow for later review of the interpretation of the data.

Error rates for observers

You can use the same approach to calculate an error rate for each observer. This will give you more confidence in the

accuracy of your census, and encourage observers to improve their observational skills and hence their detection rates.

Estimating the number of nests using a mark-recapture approach

If nests found on each search can be marked using a different mark (e.g. flagging + paint), you can use a simple mark-recapture approach to estimate the total number of nests for species that are hard to census. Two independent counts of the number of nests are made.

You can estimate the total number of nests (N_t) using the following formula:

$N_t = N_2(M_1/M_2)$

Where

N_t = the total number of nests

M_1 = number of nests marked on the first visit, M_2 = number of already marked nests found on the second visit

N_2 = the total number of nests counted on the second visit.

Censusing inaccessible colonies - remote counts

When to do a remote count

Remote counts may be the only option for inaccessible colonies (e.g. on cliffs or small rocks in rough weather).

How to do a remote count

Choose a vantage point or series of points from which the colony can be seen and use a GPS to mark the point so you can repeat the count on subsequent visits. Count the total number of nests, nests with chicks or juveniles or nesting pairs by species.

Using multiple counts from the same location in a short time frame with consistent methodology would allow an estimate of detectability to be made.

Level 3 – Protocols: Sampling nesting colonies using Circular Plots

In large colonies (>500 pairs) or where the habitat is difficult to penetrate (mangroves, dense sea grape, cactus thickets, etc.), it will be impractical or impossible to count all the breeding pairs. In such cases, it is necessary to use a sampling method to estimate the number of nesting pairs in the colony. Through sampling, which involves counting birds in a known proportion of the colony and extending that information to portions of the colony that were not surveyed, you can determine upper and lower estimates by measuring the density of pairs nesting at the site and using the 95% confidence interval of the density estimate to estimate the population. There are two main methods for sampling densities of nesting seabirds. These are circular plots and transects. This manual does not include a detailed description of the use of transects.

Level 3a – Sampling a nesting colony using Circular Plots

Using two observers and a length of rope or measuring tape, the observer walks in a circle around the fixed point (or the first observer holds the rope), and counts and describes the nests in the circle. The counts can be used to calculate density of pairs in the plots, which can then be applied to the total area of the colony. The total area can be measured with simple mapping tools (Google Earth, ArcGIS Explorer, etc.) on a computer or, if good maps are available, on a map by hand.

Objectives for circular plots

The simplest objective is to estimate nest density within plots and thus estimate the number of pairs in a colony. Circular plots (or any count that is not a total census) also can be used to monitor trends over time (does the density within plots increase or decrease) without necessarily estimated total colony size. If the centres of the plots can be permanently marked for sampling in future years, then by re-sampling the plots in the future, you can use statistical tests (paired counts) to assess whether the population has changed.

Method for doing circular plots

Number of people: Ideally 2 or 3 (a recorder and a one or two searchers). The second searcher can help particularly where there are several species in the same colony. In a team of 2, the first searcher should search the plot thoroughly and flag each nest. The second searcher should repeat the count following the first searcher and mark any additional nests he/she finds. Even for cryptic species like shearwaters, which must be surveyed at night when they are at the nest, searchers should miss very few birds that are available to detect on a given night. Resampling of all or a portion of the plots will be necessary on subsequent nights because some birds may be away from the nest at the time of the count. Measure the detection rate and adjust your counts as described above.

Equipment needed: Each team should have:

- data sheets preferably printed on waterproof paper (see example below),
- field notebooks
- several pencils
- several markers
- a 10-m measuring tape or suitable length of rope,
- at least 1 GPS unit (and a spare one if possible),
- compass,
- flagging or other means of marking the nests,
- ample drinking water,
- playback equipment and flashlights (if you are surveying Audubon's Shearwater nests at night)
- suitable lengths of rebar to mark the centre of plots
- bit and brace to drill holes in limestone to mark the centres of permanent plots (if necessary).
- sharpened machete and clippers (marked with flagging).

Number and size of sample plots: Often the number and size of plots is determined by the time and personnel available. Ideally, however, tests should be done to determine the optimal size of plots needed to obtain precise population estimates. The optimal size of the plots depends on nest density (Table 4).

As described below, the number of birds in the plots will have a Poisson distribution. The variance in the Poisson distribution is very high when there are large numbers of plots with 0 nests or pairs. You can improve the precision of your estimate by increasing the size of plots to an area until they are large enough that there are two or more pairs per plot on average. However remember that when plots are too large or have too many pairs, they become cumbersome to census and mistakes in counting will increase.

To find the right size of plots for your colony, try a small number of plots of large (~7 m) size and measure the distance from the plot centre to the 4th pair of each species. If you are in a colony with multiple species, you can use differently sized plots for different species with the same plot centres. Adjust the size for the rest of your plots to the distance just greater than the average distance to the 4th pair. When possible, use a whole number for the radius (e.g. 3 m, 5 m, 7m, etc.), as simple numbers help minimize mistakes in the field (See Table 4).

It can be difficult to decide just how many plots you will need and there is little guidance in the literature. The most important goal is to complete the survey with minimal bias in the time you have available. Densities of 2-4 pairs per plot provide more precise estimates, but you should balance plot size with survey time.

Table 4: Plot size and radius that would provide an average of 4 nests per plot for various densities of seabirds (pairs per m^2).

Pairs per m^2	Ideal Plot Area	Ideal Plot Radius (rounded to the nearest whole number)	Example of Species Population that may nest at this density
0.01	400	11	Shearwaters, tropicbirds, noddies
0.02	200	8	Shearwaters, tropicbirds, noddies
0.03	133.3	7	Terns, Boobies, tropicbirds
0.04	100	6	Terns, boobies, pelicans
0.05	80	5	Terns, boobies, pelicans
0.06	66.7	5	Terns, boobies, pelicans
0.07	57.1	4	Terns, boobies, pelicans
0.08	50	4	Terns, boobies, pelicans
0.09	44.4	4	Terns, boobies, pelicans
0.1	40	4	Terns, boobies, pelicans
0.2	20	3	Terns, boobies, pelicans
0.3	13.3	2.0	Terns, boobies, pelicans

The uncertainty of your estimate decreases with the square of the inverse of the number of plots (see formula below). This curve has an inflection point around 8 plots. Thus, the lowest number of plots you should use would be 8. At about 40 plots, your return in precision for adding additional plots begins to flatten out. This relationship is independent of the island size. As long as the habitat is uniform and randomly surveyed, 40 plots should give you excellent precision. If your reconnaissance survey indicated that the habitat is not uniform, it may be necessary to stratify your sampling by selecting the same number of plots in each major habitat type.

As mentioned above, you can use different plot sizes for different species in the same survey. Choose a size where the average count for that species is 2-4. At your first few plots, measure the distance to every nest from the centre point, and count all plots up to 7 m from the centre. After 8 plots, choose a plots size that gives you an average of 2-4 birds. For the rest of your plots, simply restrict the survey for each species to the plot size you worked out in your first few plots. As long as your positioning of plots is unbiased with respect to habitat gradients (elevation, distance from shoreline, etc.), these plot sizes should give you good estimates in the shortest amount of time.

Positioning the sample plots on your map:

a. Grid the survey area by using a fine-scaled transparent graph paper overlaid on your map (preferably a good, large-scale (1:24,000 or larger) map, an aerial photograph, or a computer with GIS software.

b. Use a random number generator (e.g. calculator, Microsoft Excel) to pick centre points for your plots by randomly choosing coordinates. You can use Table 5 below by choosing plot coordinates in a systematic way working through the table (e.g. choose every other number as your x and then y coordinates).

c. If the colony is large, break it into subunits of equal area and be sure an equal portion of the plots are placed in each subunit so that the entire area is covered by the survey. For example, you might put 8 plots each into 5 subsections of equal area.

d. Use a ruler and the printout of the map or mapping software to locate each of the points in the longitudinal and latitudinal directions.

e. Exclude any centre points that would produce plots that overlap with a previously chosen plot or are not in the sampled habitat.

f. If possible, print out a copy of the map with all the plots located. You should be able to get close to the plot's center using only your map and visible features and landmarks on the island.

g. Make sure that your GPS is using the same map datum as your mapping software (Google Earth and many other programs default to WGS 84).

h. Program your plots in to your GPS using the software for the device or manually by creating waypoints.

Table 5: Sample of random numbers

Sample of random numbers						
399	033	159	806	287	342	857
044	250	283	072	226	940	741
935	311	231	680	007	449	984
428	966	105	207	353	344	106
559	539	585	948	763	441	386
790	107	261	815	100	554	548
102	282	674	112	486	075	281
Reproduced from Burger and Lawrence (2000)						

Positioning the sample plots on the ground:
If you are using a GPS unit to find the centre points, note that most GPS devices are only accurate to between 3 and 5 m. Thus, there will be some error when you are finding centre points at the colony.
It is important to avoid bias in positioning your plots by using a standard rule for your procedure in marking the centre point. Use the point where the GPS, after being on for several minutes and finding at least 3 satellites, indicates you are on the programmed location. Then, use the closest point possible where a permanent marker can be installed. You might be able to mark it by drilling a hole in the rock with a masonry bit. The centre of the plot should always be less than the margin of error (3-5 m) from the point that was indicated by the GPS. You should also have a backup plan in case your GPS does not work or is inaccurate during your survey. If possible, carry a backup GPS. If all else fails, a 25-100 m measuring tape or a range finder and compass can be used to find distances and bearings from visible landmarks such as island centerlines or the location of particular points that can be easily found on the map. You can use a compass to find your angle from the point of reference to your location.

Marking the sample plots:
Ideally this should be done before nesting starts to reduce disturbance. If you are going to be surveying a colony in the long-term you should try to permanently mark the plots, if possible. In sand or soil, plots can be permanently marked (assuming there is no human interference and cays are not over-washed by the sea) using a short length of rebar, driven into the ground and sheathed with a piece of plastic conduit pipe on which a number can be written. If you have the resources you can make these markers more permanent by cementing them in place. The piece of rebar will be the centre point of the plot so the length and design should be adjusted depending on the height and density of vegetation.

In the Caribbean, the ground may be limestone rock that makes it impossible to use such markers. Instead, use a numbered aluminum tag attached to the rock with galvanized wire. These can last several years or longer depending on how much salt spray impacts the area. Use coloured flagging and reflective tape to make your centre points more visible.

Time needed to establish and survey plots: The first survey at an island will be the most difficult because locating and marking the plots is the most time consuming step. Subsequent trips should be straightforward and much faster if you set up the survey well and mark your plots clearly on paper, in a GPS, and with a visual marker in the field. The number of plots that can be surveyed in a single day or night varies depending on the terrain, the size of the island, and the size and experience of the team. If sites can be located, marked, and surveyed simultaneously, it can take 15-30 minutes for each plot.

Counting nests:

1. Mark the centre point,
2. Attach a rope whose length is the desired radius to it using a ring or loop or ask a field assistant to stand in the middle and hold one end of the rope,
3. Walk around the circumference of the plot counting all pairs nesting within, calling out the number and contents of nests while the scribe records the data (see below)
4. If necessary lay down the rope and walk into the plot to check for nests and mark them.

If the plot is in thick vegetation, you may need a machete or brush clippers so that you can access the whole plot. Take time to look at trees from several angles and move outside the plot as necessary to ensure that you see all the nests. Also check under boulders and logs for ground nesting species. Many species will use thickets of coppice

or brush. In these cases, alter the vegetation as little as possible while allowing yourself access to all parts of the plot.

Recording the data:
Record the data in the same way as for complete counts of a colony using the standard data forms (Appendix 3). At each site, note the species, the status (egg, downy chick, feathered chick, etc.), and the number of adults. If possible, note the bearing from north and distance to the centre point. This information would allow adjustments to plot sizes and relocation of old nests in future surveys.

Note any dead adults or chicks, types of vegetation, the slope, and anything else relevant about the plot. It is better to record data in too much detail than not enough. Take lots of photos, if possible with a numbered piece of paper or flagging in the photo to identify the plot. Covariates including % cover, substrate type, species of vegetation, and slope should be recorded for each plot and updated during each subsequent survey.

Analyzing data
Detection error: For surface nesting species, this method is a complete census of each plot because detection error should be approaching zero if plots are thoroughly searched by two observers.

Calculating the density of nests/plot
a. ***Calculate the mean number of nests/plot***
First calculate the mean number of nests in the plots (lambda λ), which is both the mean and variance. λ is the arithmetic mean density of pairs found in each of the plots divided by the number of plots (n). It is calculated as: the number of pairs detected in all plots/number of plots. If your repeated samples indicate missed detections, correct your counts by dividing each count by the detection rate (D) (see above).

b. ***Calculate confidence intervals for λ:***
By calculating the 95% confidence limits of your pairs per plot (λ) you will be able to determine the upper and lower limits of your estimates.
Calculate the 95% confidence intervals as follows:

Lower Limit = $\lambda - 1.96(\sqrt{(\lambda/n)})$

Upper Limit = $\lambda + 1.96(\sqrt{(\lambda/n)}$,

where n = the number of plots searched. If the range covered by the intervals you calculate is larger than you would like, consult a statistician to help you improve the design of your survey.

c. ***Measure the area of the colony***
You may already have used the maps you prepared of the colony to calculate the area of the colony (or each habitat type if you stratified your sample). See "Mapping the Colony" below for instructions about calculating the area.

d. ***Estimate the number of nesting pairs***
To estimate the number of nesting pairs, you divide your 95% confidence values for the number of pairs per plot by the area of each plot ($A=\pi r^2$) and multiply by the total area of the colony to obtain the upper and lower estimates of the number of nesting pairs. For example, if your 95% interval indicated a low and high of 2 to 4 pairs per plot respectively, your plots were 50.3 m^2 , and the habitat for nesting was 10 ha (100,000 m^2), then your estimate would be 3976 to 7952 breeding pairs.

Measuring nesting success (see also Level 4)

The standard measures to determine whether nests were successful are:

- **nesting success** (1 or more eggs hatch per nest),
- **brood success** (1 or more chicks survive to fledge per nest) or
- **fledge success** (the number of chicks that fledge per nest).

If you make repeated visits during the nesting season, you should be able to estimate nest success and the fecundity of birds within the colony (i.e. how many fledglings are produced per nesting attempt for each species.)
It is important to remember that there is no way to detect the number of nests that were started but failed before you arrived or in between your visits. Therefore measuring fecundity as the proportion of detected eggs that result in fledged chick will overestimate reproductive success. Instead, use the spreadsheet provided (available for download at www.birdscaribbean.org). It contains step by step instructions for entering and calculating nest success. Each nest is represented by a single row of data in which you summarize its fate over time. By keeping track of the number of days each nest was active (referred to as exposure days) and its fate (survived and hatched at least 1 egg) you can calculate the daily survival rate for your population and the probability that a nest will survive and hatch at least 1 egg. The concept can easily be extended to tracking the survival of broods or individual chicks. Spreadsheets and detailed instructions for doing the calculations are also available on www.birdscaribbean.org.

Level 3b – Sampling a nesting colony using line transects

Transects are linear bands that are laid out across a colony. They may provide a faster method of sampling than sample plots, but it can be difficult to lay plots out to avoid bias from features such as elevation, vegetation and geology. Therefore BirdsCaribbean does not recommend using line transects as a method of sampling, except in situations in which circular plots are inappropriate (e.g. in a linear geological feature such as a narrow ravine) (Lowrie *et al.* 2012).

Other ways to estimate seabird numbers

These methods are included because in certain circumstances they may provide the best available option.

Flush Counts

When to do a flush count

You can do a flush count in an incubating colony of seabirds (such as terns). Many of these species will all leave the nest together ("panic") if they are threatened. Only do a flush count when time or access is very limited or you are very concerned about the impacts of disturbing the colony by doing more detailed counts (e.g. because there are young chicks, who might be disturbed or exposed to predators). It is very important to not conduct flush counts during bad weather (heat, cold, rain, wind) or if it is obvious that avian predators are abundant.

How to do a flush count

Adults may "panic" when an observer approaches the colony. A bird of prey may also cause a panic. A second observer can count the adults while they are off the nest (or take photographs or video for later counting)

Limitations

Flush counts provide only a very rough estimate of the number of breeding pairs. The calculation relies on a ratio of nests to adult birds in an area. By counting birds that flush and dividing by the ratio of individuals to nests for a species, your flush count can be converted to an estimate of breeding pairs. The method can be calibrated by carefully counting all the nests in an area (preferably several areas) in which a flush count is made.

Kites

Some researchers have had success using kites with cameras attached to count colonies. This method is only suitable for species that nest in the open, and colonies where the wind conditions allow kites to be used. It requires a great deal of practice but could be employed over a season if one invests time to learn to use the kite and camera system effectively.

Drones

As drone technology improves and the prices become more affordable, the options for using drones to survey colonies are rapidly increasing. Drones are particularly suitable for surveying species that nest in the open in inaccessible sites. Limiting factors may include access to a suitable place from which to launch the device, wind speeds, range and the technical expertise needed to select and operate the devices. Note that local rules may apply. More information is available from www.conservationdrones.org.

Roost counts and fly-by counts

These counts have limited use, and should only be done when there are no other options, or when the site is very convenient and the activity has important educational value.

When to do roost and fly-by counts?

If seabirds regularly roost at a non-breeding site or fly-by a point at which it is easy to count them (e.g. on the way to a foraging area), then the results of the counts may provide an index of feeding habitat use, and if the counts are repeated they may indicate qualitative changes in feeding habitat and, if age and sex can be determined from plumage, an indirect measure of breeding success.

How to do roost and fly-by counts

It is very important to always do the counts at the same time of day, usually around sunset. The best time should be determined through reconnaissance surveys and field-testing. Once determined, the time of day, the length of the

count and the time of year should be standardized for future counts. Make separate counts of perched birds, birds flying in and birds flying out.

Counting foraging seabirds

There is very little information about the distribution of foraging seabirds. Such information is particularly difficult to obtain for the Caribbean because of the generally low productivity of Caribbean waters and the lack of information about the location of oceanic features that might predict concentrations of foraging seabirds.

When making observations of seabirds at sea, try to record surface water temperatures (most boats have gauges that spell this out). This will help you to identify when you are crossing current edges and upwelling areas, which is very important because that is a major factor in attracting mixed seabird foraging flocks. If possible also note the presence or absence of Sargassum lines and other things that collect along currents.

Even if you are not doing formal at sea surveys, always note locations of mixed species feeding flocks when you encounter them. This information can be used to identify parts of the Caribbean basin that need protection from offshore development and over-fishing.

There are two main methods for observing foraging seabirds. These are sea watches and marine transects.

Sea watches

A sea watch is a qualitative method for determining which seabirds are present in coastal waters. The observer selects a good vantage point and spends a standard amount of time looking out to sea, recording all the observations he/she makes of seabirds. Points, peninsulas, and headlands are particularly good vantage points from which to conduct sea watches using assistance of high power optics such as spotting scopes.

For example, Bransby Point off western Montserrat provides excellent viewing even for pelagic, deep-water species such as Red-footed Boobies and Black-capped Petrels (JCH, pers. comm.). Sea watches have greatest value if they are used in a standardized monitoring program over time. They are sadly under-used in the Caribbean, but the geography and topography of this region make them particularly feasible and cost-effective. In Guadeloupe, the Pointe aux Châteaux is a good vantage point from which to observe shearwaters, petrels and skuas, etc.

Marine transects

Marine transects are carried out from moving ship or place on a known course and speed. One or more observers look for seabirds from the boat and summarize their observations in standard time intervals, the size of which depends on the frequency of seabird encounters. They may count all the birds they see to infinity, use distance bands from the ship or measure the distance to the seabirds. Marine transects can be carried out on pelagic trips, voyages to and from seabird colonies or on standard grids. Details for establishing a marine transect programme are beyond the scope of this present manual. Ronconi and Burger 2009 discuss many of the most important methodological considerations). Contact an expert if you are planning this type of survey. See also: Nomani *et al.* 2012 and www.fws.gov/birds/waterbirds/monitoring/monitoring_papers/Survey_Manual.pdf).

Level 4 – Measuring the success of nesting and describing life history

While information about numbers of nesting birds is useful, it is difficult to assess how the seabird population in your colony is doing without information about breeding success. Most seabirds are long-lived and some have high site fidelity. Thus a colony of Masked Boobies (whose life span can be more than 50 years) might persist for a very long time even if their reproductive success is very low before the colony finally collapses. If you are just counting breeding pairs, your data may indicate that the population is stable, but if you are also collecting data on nesting success, you will have much greater knowledge of the long-term health of your nesting population.

If time and resources allow, the best way to estimate success in a colony is to use the Mayfield Method (see above), which tracks the daily survival rate of each nest encountered and estimates fledging success for each nest attempted as the rate of survival to the time of fledging for that species.

Calculating the ratio of adults to juveniles
The ratio of adults to juveniles is another index of how successful a breeding season has been. To do this, count adults and juveniles near the end of breeding season and calculate the ratio. This only works well for species that have synchronized breeding.

Monitoring chick growth
Chick growth rates often respond to the quality or quantity of available food, parental quality, or some type of stress such as disease or parasite infestation. The weight of the chick and length of wing, culmen, and tarsus measured at regular intervals can be used to estimate rates of chick growth generally reported as growth in grams/day or growth in mm/day (e.g., wing). Be aware, however, that handling chicks can be much more disruptive than simply walking through a colony and therefore an efficient data collection protocol must be established if growth rates are to be measured. If you are interested in measuring chick growth rates you contact a researcher who has experience with such methods to determine if this is an appropriate approach and what the best sampling strategy might be. Lastly, the statistics required to estimate and compare chick growth rates are more complex than those discussed for nest survival and hence some additional support may be needed.

Monitoring survival and feeding rates
Game/wildlife cameras can be a useful tool for this type of study. The rate of feeding and the size and species of the food provided can provide useful information on food availability (the latter in species where food is passed externally from parent to chick). Cameras only work well for species that stay at the nest after hatching. Wildlife cameras are also useful to documenting the presence and impact of invasive predators such as rats or cats. The information can be used to raise awareness and support for management actions, like eradication of invasive species. Be aware that game cameras can produce thousands of images in a day and so an efficient process for reviewing and storing photos needs to be established.

Determining foraging locations and patterns
Tracking devices can provide substantial data on foraging habits of parent birds, dispersal patterns, migration routes, or wintering areas over either short (e.g. 1 week) or long (e.g. 2+ years) timespans. They are potentially particularly useful for studying highly-dispersed, low-density seabirds in

the Caribbean as they are much more cost-effective than at sea surveys. There are several types of tracking devices or tags available for marine birds and they differ substantially in size, cost, durability, and operation. A detailed description of each is beyond the scope of this text. Given the range of products available and the rate at which the technology is improving, it is likely that there is a suitable tracking alternative available for most taxa and questions. Seek expert advice or a partnership if you are planning a tracking study.

Diet Studies
Collecting prey samples and establishing a prey database can be an effective way to track short- or long-term changes in marine conditions. The easiest way to do so is to collect prey items that are dropped in the colony. Chicks also may regurgitate if they are handled and these samples can be identified as well. In species that pass prey from adult to chick externally (e.g. many terns) you may be able to identify visually fish during this interaction.

Life history
Long-term studies using banding can provide information about age at first breeding, rate of recapture, adult survival, movements among nest cavities and between colonies, contribution of particular colonies to the regional population. Banding studies require long-term commitment, licenses to handle birds and a supply of bands.

Monitoring Seabird Nesting Habitats

The current condition of the nesting habitat (including factors such water level, vegetative cover, weather and human activities and their impacts, e.g. egg collection, pollution, dredging, invasive species, etc.) influences the number and diversity of seabirds at the site and your ability to count them. In addition, understanding the relationship between birds and habitat and what constitutes good nesting habitat is one of the basic objectives of monitoring. Thus, it is very important to record information on site-specific variables (known as covariates) before starting your monitoring program and at the time of each survey.

Seabird nesting habitats may be monitored in order to:

- Understand the relationship between seabirds and their environment, for example, why are birds in some habitats and not others, what constitutes good quality habitat?
- Measure changes in the habitat (e.g. as a result of climate change or invasive species) that might be correlated with observed changes in populations.
- Assess the effectiveness of a management action on habitat, bird diversity and abundance, e.g., removal of rats or cats.
- Measure changes in habitat quality and availability following a natural or human-caused event.
- Detect and act on threats in good time. Monitoring provides information for advocacy and for planning interventions.
- Assess the effectiveness of conservation efforts. Is investment in conservation actually bringing about an improvement in the habitat or greater availability of preferred habitats? Are 'sustainable use' approaches really proving sustainable?

Using BirdsCaribbean Seabird Habitat Monitoring Form

The amount of data that you need to collect about habitats depends on your objectives and resources. Generally it is better to collect too much information than too little so long as data collection does not become onerous or detract from collecting other data considered higher priority. As with all types of data collection it is important to consider analysis and use in the design phase.

Monitoring habitat in IBAs

If you are monitoring an Important Bird Area (IBA), Birds Caribbean recommends that you follow the monitoring guidelines in *Monitoring Important Bird Areas: A Global Framework, Version 1.2* – this is an excellent system for monitoring threats to IBAs ('Pressure'), the condition of IBAs ('State'), and conservation actions taken at IBAs ('Response').

Habitat Covariates for monitoring

The conditions of seabird nesting habitats change over time in ways that greatly affect the numbers and distribution of birds; therefore it is important to collect data on habitat conditions at the time of the survey.

The definition of good or poor quality habitat is challenging because it will depend on the site and the species of seabirds using the site. Species with different life histories use different kinds/parts of the habitat thus good habitat for terns will not necessarily be good habitat for pelicans.

Although it may be difficult, consider developing an index of habitat quality that is based on well-defined quantitative or qualitative data and is species-specific. Doing so will likely require a considerable investment of time and should include a thorough literature search and/or consultation with others who have experiences with the species of interest. Measuring the type and extent of vegetative cover may provide a useful indication of nesting habitat availability/quality or it may contribute to the development of a composite index (i.e., several variables combined). A number of variables are included in the seabird habitat assessment forms; you can revise these forms to include others or delete any variables you think are not applicable to your site.

Mapping the colony

Mapping is best done using tools like Google Earth or more sophisticated GIS software. If not, a sketch map in concert with a handheld GPS will have to suffice. Carefully locate areas where birds occur and those where birds are absent. If density changes based on some factor (e.g. elevation), note that and note on your map each area where density of birds is roughly uniform. You can use different methods and plot sizes to reflect the habitat changes you have discovered. The approximate distribution of nests should be drawn on the map. Before you plan your survey, be sure to consult the Caribbean Regional Seabird Colony Register (www.wicbirds.net), Bradley and Norton (2009), and the Lesser Antilles Breeding Seabird Atlas (Lowrie *et al.* 2012) to know what has been done previously at the colony you are studying. If possible, phone or email the last person to collect and submit data on that colony. Once you arrive, locate the birds and use your GPS to identify the boundary lines and points for the colony. Upload those data to your computer and project them using Google Earth or other software onto a base map of the colony.

Frequently, nests will be denser in a strip of habitat of varying width that circles or runs along one side of an island. In such cases, the challenge is to accurately map the locations of the appropriate habitat and exclude or use fewer, larger circular plots (see above) in the less-densely populated habitat.

To map that habitat, use the map, GPS, and a measuring tape to document the dimensions of the habitat. Include waypoints in your GPS that you can then use to measure the area of each stratum of the colony. These area measurements can best be completed on a computer. Examine the map. Are the birds spread relatively evenly across the island? If so you should sample the area as a whole. If the birds occur in patches related to particular habitats, you can improve your survey by using a technique called stratification, which involves dividing your study area into sub-plots or strata. For example you may notice a gradient that affects the distribution of nests e.g. you may find that plots within one type of area (e.g. a vegetation type) have no birds and take ten times longer to survey, then you can exclude the entire stratum from your survey and from the area of the colony to which you apply your density estimate as long as you have placed enough plots in the colony so that losing a few does not greatly affect your precision. If birds are sparsely populated in one stratum, you can use fewer, larger plots in those habitats. You would then estimate the density of the birds and the area of each stratum separately and add those estimates together to estimate the population size.

Measuring the area of the colony: Use area-measuring tools in a GIS program such as Google Earth, ArcView, ArcInfo, or Grass (e.g. www.acme.com/planimeter/), otherwise it can be done simply by overlaying a transparent grid on the map, and counting the number of squares, but this method is less accurate and less repeatable and correctable than using GIS.

Fixed-point photography

Photographs are a good way of documenting changes to a site though generally at the broad, rather than fine, scale and therefore are a very useful and simple tool for monitoring habitat changes. Many habitats change relatively slowly and a series of photographs may show changes imperceptible to protected area staff, especially when staff change. Photographs are also an effective and efficient way of illustrating changes and problems.

To be truly useful, care needs to be taken when setting up a fixed-point photograph program, with equal consideration given to designing and implementing the programme and establishing an accurate and secure storage and documentation system so that photographs can be linked to locations. A good archiving system requires time and money so if this is unlikely to be possible and sustainable, it is probably better not to start. With the increasing use of digital cameras, some of which either have in-built or at least are compatible with, Global Positioning System (GPS) technology, archiving and referencing images and supporting information is becoming much easier. The frequency at which photographs need to be repeated will depend on the objectives of your monitoring and the anticipated rate of change of the habitat that you are monitoring.

A strategy for establishing a habitat monitoring using fixed-point photography is outlined below:

- Walk the site and select potential fixed points which are either likely to be recognizable well into the future or record their positions using a GPS.
- Use a fixed rather than zoom lens as this will ensure that the field of view is consistent between photographs.
- Always use a tripod.
- Either photograph a panoramic arc from left to right, with 10-30% overlap between images, or take photographs at fixed compass bearings.
- Mark tripod locations and bearings of photographs on a map. It may also be useful to photograph tripod locations.
- Record the date, time and focal length of the lens used, plus any other information that may be useful such as the name and contact details of the photographer, used etc.
- Ensure that all details are carefully documented and that information and images are cross-referenced. Developing a standard recording sheet can help with this.
- Consider making archival quality prints to ensure the images do not deteriorate. Black and white prints last longer than colour but may show less detail.
- Make two copies of everything and store them in separate locations for added, long term security

Breeding Seabird Species in the Caribbean

This section includes a summary of basic information about conservation status, distribution, data gaps and life history and conservation needs. Readers should find it helpful for planning seabird monitoring. Information in this section is taken primarily from www.wicbirds.net[7] and the reader is strongly advised to refer to this website to get the latest information about life histories and population estimates. After the surveys remember to submit your findings to willmackin@gmail.com so that the database can be updated

Petrels

Petrels are pelagic seabirds that have very large feeding ranges. Black-capped Petrels from Hispaniola are known to feed off the Carolinas. The three most endangered seabirds in the Caribbean are petrels - Bermuda Petrel *Pterodroma cahow,* Black- capped Petrel *Pterodroma hasistata* and the Jamaica Petrel *Pterodroma caribbaea.* These species require special survey techniques that are beyond the scope of this manual.

Black-capped Petrel

[7] We note with appreciation the contribution of Dave Lee in the preparation of the text for the website, which we have used in many of these accounts.

Shearwaters

Only one species of shearwater breeds in the Caribbean – the Audubon's Shearwater. It feeds on small fish that are brought to the surface by predatory fish such as tuna and ranges over wide areas of sea in its search for food. Nesting shearwaters are often overlooked because they are nocturnally active at colonies and breed in holes and under rocks. Their breeding seasons may not coincide with other seabirds at a colony.

Audubon's Shearwater *Puffinus lherminieri lherminieri* AUSH

Known distribution in the Caribbean:

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Audubon's Shearwater (Photo by D. Lee)

Audubon's Shearwater Chick (Photo by W. Mackin)

Conservation status: CARS, 1600-3800 pairs at 26 sites in the Caribbean
Breeding season: Typically, in the Bahamas, laying occurs in late spring (March-May).
Nest sites: Nest sites may be in cavities under rocks, in piles of rocks, burrows, caves or under dense vegetation. The shearwaters usually come and go from their nests at night.
Incubation: C. 48 days. 1 egg.
Fledging: 62-100 days
Longevity: >12 years

Surveying a typical colony: Surveys should be carried out at night otherwise shearwater colonies can easily be overlooked. The best time to visits to conduct surveys is when nights are darkest +/- 1 week of the new moon, late winter-August. Playing back the duetting call (available on www.wicbirds.net) is a very useful way to increase detection. For larger colonies it may be necessary to use circular plots to sample habitats (see below).
Conservation needs: Protection of colonies from human predation and invasive species. Possible reintroduction to Bermuda.

Tropicbirds

Two species of tropicbirds occur in the Caribbean; White-tailed Tropicbird and Red-billed Tropicbird. They usually feed singly, off-shore; plunge-diving for flying fish, squid and other small fish. They nest in holes in rocks and cliffs. The Dutch Caribbean Nature Alliance has produced a handbook "Monitoring Tropicbirds – an introductory guide" (DNCA 2012). For both species, the presence of pairs conducting courtship flights is a good indicator that nesting is occurring nearby.

White-tailed Tropicbird *Phaethon lepturus catesbyi* WTTR

Known distribution in the Caribbean

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

White-tailed Tropicbird (Photo by A. Sutton)

Conservation status: CARS, 3300-5300 pairs at about 200 sites.
Breeding season: There is variation in breeding season between Caribbean colonies e.g. in Cayman Islands they breed October-December while in Jamaica it is December to April. In the Bahamas they lay in March and fledge by September.
Nest sites: They nest in holes in cliffs and in rocky areas.
Incubation: 40-42 days. 1 egg.
Fledging: 70-80 days
Foraging: They feed offshore, usually singly, by plunge diving, mainly on flying fish and squid. They often forage along lines of *Sargassum*. When nesting they may forage more than 100 km from the nest site. When they are feeding chicks, their feeding trips may last 1-3 days.

Surveying a typical colony: Some colonies are accessible and can be counted from the land, others from vantage points or from a boat at sea. Some are totally inaccessible and the best that can be done is to count the number of flying birds by age category and use an index developed elsewhere to estimate numbers. Multiplying the maximum count of tropicbirds seen in flight by seven produces a good approximation of the number of breeding pairs in a colony (David Wingate, pers. comm. to Dave Lee).
Accessible tropicbird colonies can make very good subjects for more detailed studies of breeding success.
Conservation needs: Reassessment of global status of threatened species, increased monitoring and protection of larger colonies (including control of alien invasive predators and plants), provision of artificial nest boxes, increased education and awareness, and development control.

Red-billed Tropicbird *Phaethon aethereus mesonauta* RBTR

Known distribution in the Caribbean

- Extirpated or Threatened
- Small or not surveyed
- > 1% of Caribbean population

Red-billed Tropicbird (Photo by D. Brandon Hay)

Conservation status: CARS, 1,800-3,400 pairs in the Caribbean, rare and declining, probably should be ranked as globally threatened.
Breeding season: ?
Nest sites: Nest in cavities and rocky overhangs. A pair will use the same site each year.
Incubation: 1 egg.
Fledging: ?
Foraging: Feed on small fish at the surface, by plunge diving.

Surveying a typical colony: See White-tailed Tropicbird account
Conservation needs: Protection from human visits and control of alien invasive species (including goats). Information on this species is incomplete – more studies are needed.

Red-billed Tropicbird chick (Photo by D. Brandon Hay)

Boobies

Three species of boobies occur in the West Indies.

Masked Booby *Sula dactylatra dactylatra* *MABO*

Known distribution in the Caribbean

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CARS, 580-650 pairs in 26 colonies in the Caribbean (3863 pairs on the Campeche Bank) "one of the rarest birds in the Atlantic"
Breeding season: There is little information about peak egg-laying seasons for Caribbean birds. In the northern Caribbean the birds may lay eggs at any time of year but most are laid from September to April (Schrieber 2000). Adults are present at the colony year round.
Nest sites: They nest on the ground in flat areas generally with little or no vegetation.
Incubation: 38-49 days. One or two eggs are laid but only one chick survives.
Fledging: 109-151 days, young fed by adults at nest until 139-180 days old.
Longevity: c. 30 years.
Diet and foraging ecology: They forage on flying fish and squid. New studies of satellite-tagged birds are providing information on foraging ranges and it appears that parents may forage locally during incubation and chick-rearing.

Masked Booby, adult & chick (Photo by Ann Sutton)

Masked Booby, breeding colony (Photo by Ann Sutton)

Surveying a typical colony: Most colonies in the Caribbean are small. The birds are large and conspicuous and nests are not concealed. Thus a census can be carried out (see Level 1). Ideally the censuses should be repeated 3-4 times a year at the same time annually.
Conservation needs: Protection and removal of cats, dogs and pigs from major colonies.

Brown Booby *Sula leucogaster leucogaster* BRBO

Known distribution in the Caribbean:

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Brown Booby (Photo by A. Haynes Sutton)

Conservation status: CARS, 9784 pairs in the Caribbean
Breeding season: Asynchronous – nest year round.
Nest sites: Generally nest on the ground in areas with little or no vegetation, sometimes with Masked Boobies.
Incubation: 40-44 days. 1 to 2 eggs
Fledging and parental care: 95-120 days depending in food availability. Parents may continue to feed juveniles after fledging. Recently fledged juveniles often stay at the colony in groups ("crèches").
Longevity: 30-50 years
Diet and foraging ecology: Feed closer to shore than other boobies and are more often seen from the mainland. Often in mixed species flocks following schools of predatory fish (jacks or tuna).

Surveying a typical colony: Most Caribbean colonies are small enough for censusing. There is no simple method for estimating the total population of a colony of asynchronously nesting seabirds.
Conservation needs: All colonies should be protected. Studies of breeding phenology and dispersal in the Caribbean are needed.

Red-footed Booby *Sula sula sula* RFBO

Known distribution in the Caribbean:

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CARS, 12,710 pairs
Breeding season: Generally October-May
Nest sites: Red-footed Boobies may build nests of sticks on small to medium-sized trees or even on cliffs or on the ground where there are no trees.
Incubation: 42-46 days.
Fledging: 91-112 days. Young return to the natal colony to be fed for 1-4 months.
Longevity: >20 years
Diet and foraging ecology: Feed on fish and squid, mainly by plunge diving.

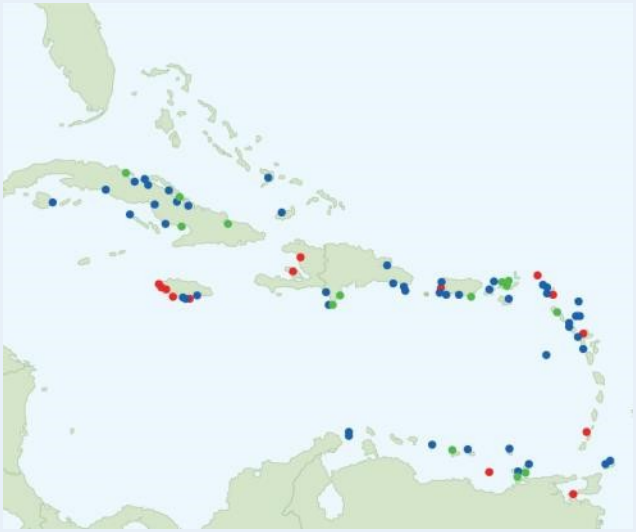
Surveying a typical colony: When censuring colonies from a distance be aware that the lighter colored morph are more conspicuous and tend to be over represented in final tally. Many birds are not perched in the crowns of the vegetation and may be difficult to detect. Check for nests as groups of tree roosting birds do not always signify breeding sites.
Conservation needs: Protection of larger colonies. Removal of alien invasive species.

Red-footed Booby (Photo by Ann Sutton)

Red-footed Booby adult with chick (Photo by D.Brandon Hay)

Brown Pelican *Pelicanus occidentalis occidentalis* BRPE

Known distribution in the Caribbean for the Caribbean endemic sub-species *P.o. occidentalis*. (*P.o. carolinensis* breeds on islands off Central America.)



- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: P.o. occidentalis c. 1500 pairs on Caribbean islands, >3,000 on islands off C. America (c. 30% of the regional population depends on Venezualan islands). CARS.
P.o. carolinensis c. 500 pairs in region (out of 18,000 pairs total). US Species of Concern.
Breeding season: Breeding cycle takes about 6 months. Peak laying dates differ among islands.
Nest sites: Nests colonially in platform nests made out of loosely woven twigs in mangrove trees, sometimes on cays, usually close to the sea.
Incubation: 30-35 days, 2-4 eggs are laid per nest but usually only one survives.
Fledging and parental care: Juveniles leave nest 11-12 weeks after hatching and form "crèches" on the ground where parents continue to feed them.
Longevity: Up to at least 43 years (in captivity).

Brown Pelican juveniles (Photo by D. Brandon Hay)

Brown Pelican chicks (Photo by D. Brandon Hay)

Diet and foraging ecology: Usually feed within sight of land, on small fish (e.g. sardines), also follow boats to feed on discarded by-catch.
Surveying a typical colony: Access to colonies can be very difficult if the mangroves are in standing water. Assessing nesting status can also be difficult. Wherever possible, censuses or total counts should be attempted.
Conservation needs: All colonies should be protected from human disturbance and alien invasive species. Species is very sensitive to organochlorines and exposure can cause severe population declines. Damage to populations following oil spills should be monitored and mitigation considered.

Frigatebirds

Magnificent Frigatebird *Fregata magnificens* MFBR

Known distribution in the Caribbean:

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: 6,300-9,700 pairs at 103 breeding sites. CARS.
Breeding season: Usually breeds in summer, but timing of egg laying varies from colony to colony.
Nest sites: Nests are usually located so that birds can land on them into the prevailing wind. Nests are platforms of twigs consolidated with chalky faeces in coastal trees of shrubs (usually mangroves) or on the ground.
Incubation: 53-61 days. 1 egg.
Fledging: 159-185 days, juvenile remains near nest for 5-13 months, while being fed by female.
Roost sites: May form non-breeding roosts near feeding grounds.
Longevity: 15-30 years.
Diet and foraging ecology: They feed by scooping waste fish and scraps from fishing boats from the surface of the sea. They kleptoparisitize terns and tropicbirds. They also take young chicks of other seabirds, especially Sooty Terns.
Surveying a typical colony: Great care is needed when counting frigatebird nests as eggs can easily be dislodged or damaged and young chicks knocked out of the nest. Once out of their nests they cannot get back and will die. **Research teams make every effort to avoid disturbing chicks, and should try to recover any displaced chicks and put them back in their nests.**

Magnificent Frigatebird, nesting colony (Photo by Ann Sutton)

Juvenile Magnificent Frigatebirds (Photo by Ann Sutton)

Where possible they should be counted from a distance using binoculars and a counter. Colonies may be too large for censusing, in which case a sample area or areas can be selected at random and the result(s) used to estimate the total population. It is important to count separately:

- breeding males (with pouches),
- males (all black with no pouches),
- females (with black heads and white band on chests)
- juveniles (all white heads, chests and bellies).

Continued overleaf…

In order to minimize disruption it may be necessary to use a very simplified classification of nests

- Nest empty or being built
- Nest with sitting adult (assume egg or young chick), (note age and sex of adult)
- Nest with downy chick (not being brooded)
- Nest with near fledged chick
- Nearly fledged chick off the nest.

Conservation needs:

- Updated inventory of nesting colonies
- Protection of known colonies and potential breeding sites from uncontrolled visits and alien invasive predators
- Signage and control of visitors at sites visited by tourists.

Magnificent Frigatebirds feeding on scraps (Photo by Ann Sutton)

Gulls

There is only one resident gull species in the region. Laughing Gulls are voracious predators on tern eggs. They are (or were in the 1980s-1990s), expanding their range in the Caribbean region. It would therefore be very useful to collect information from locals to determine how long the gulls have been nesting at a specific site. It is also important to get accurate counts and maps of colonies, to find out whether the number of colonies is increasing, whether particular colonies are growing in extent or numbers, and whether these changes are affecting other nesting seabird species.

Laughing Gull *Larus atricilla atricilla* LAGU

Known distribution in the Caribbean: Widespread in insular Caribbean.

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CNIC – Caribbean Not Immediately at Risk species. *L.a. atricilla* breeds in the Caribbean and S. America (5,000-10,000 pairs). *L.a. megalopterus* breeds in N. America and winters in the Caribbean. Total global population is 168,000-173,000 pairs.
Breeding season: Eggs laid April to May.
Nest sites: Makes small nests of woven grass on the ground in or near tern colonies.
Incubation: 22-25 days. Lays 3-4 eggs per nest.
Fledging: 60 days. Disperse 2-3 weeks after fledging.
Longevity: c. 20 years.
Foraging areas: Mostly scavenge in coastal areas and beaches. Follow ships and boats.

Laughing Gull, adults (Photo by A Haynes-Sutton)

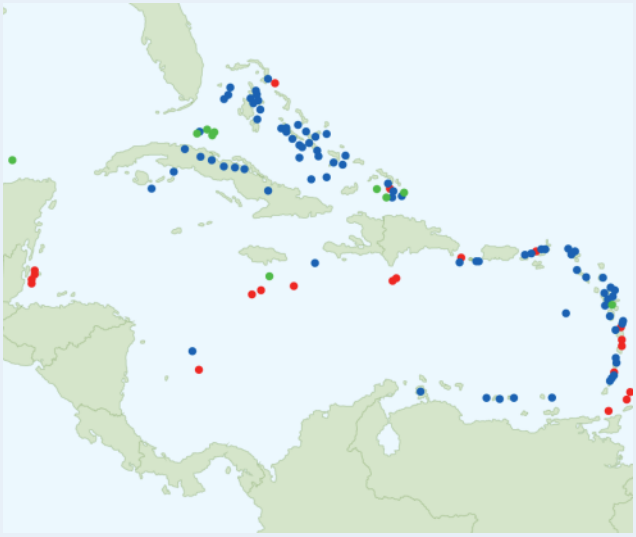
Laughing Gull nest (Photo by W Mackin)

Surveying a typical colony: Colonies are generally small and can be censused.

Terns

Brown Noddy *Anous stolidus stolidus* BRNO

Known distribution in the Caribbean:



- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CNIC, Total population in W. Atlantic 143,000-149,000.
Breeding season: Typically eggs are laid in May-July but laying dates are variable and can shift over time.
Nest sites: Usually build a nest of twig, seaweed, plastics, on the ground, in shrubs or on trees or cliffs
Incubation: 33-36 days. 1 egg.
Fledging and parental care: 43-49 days, parents continue to feed young for at least 100 days.
Longevity: Up to 25 years
Diet and foraging ecology: Feeds by dipping or seizing small fishes and squid from surface, usually within 50 km of the shore.

Brown Noddy adult & egg (Photo by Ann Sutton)

Brown Noddy chick, white morph (Photo by Ann Sutton)

Surveying a typical colony: Colonies are small and nests conspicuous, in most cases colonies can be censused.
Conservation needs: Update of status of Caribbean colonies Protection of nest sites from egg collection and alien invasive predators (especially cats and rats) and the alien invasive plant *Casuarina* (Australian Pine), which can rapidly exclude noddies and other seabirds from nesting areas.

Black Noddy *Anous minutus americanus* BLNO

Known distribution in the Caribbean

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CNIC. Total N. Atlantic population probably 100-300 pairs.
Breeding season: Typically nests with Brown Noddies.
Incubation: 1 egg
Fledging: ?
Longevity: >25 years.
Diet and foraging ecology: Populations stay at nesting colonies year round. They feed on small fish, crustaceans and squid, in coastal lagoons or within 10km of the coast.

Surveying a typical colony: Numbers are small so they can be censused. Their similarity to Brown Noddies mean that they could easily be overlooked, so surveys should include searches for this species.

Black Noddy adults, with Sooty Tern

Black Noddy adult

Conservation needs:

- Update of status
- Protection of colonies

Sooty Tern *Onychoprion fuscatus fuscatus* SOTE

Known distribution in the Caribbean

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Sooty Tern adult (Photo by Ann Sutton)

Sooty Tern colony (Photo by Ann Sutton)

Conservation status: CARS. Global population 18-23 million pairs of which 230,000-500,000 pairs nest in the greater Caribbean, the majority in 13 colonies with >1,000 pairs.
Breeding season: In most colonies Sooty Terns breed on a 12-month cycle, but in a few they reportedly breed every nine months. In many colonies the peak laying season is in late April-May.
Nest sites: Sooty Terns generally nest on the ground in open areas or under vegetation.
Incubation: 28-30 days. Usually one egg.
Fledging: About 8 weeks (depending on food availability). Remain in colony for 2 weeks after fledging, being fed by adults, who continue to feed them for a further 2-3 months at sea. Age at first breeding 4-10 years.
Longevity: c. 28 years
Diet and foraging ecology: Sooty Terns are nearly commensal with large fish such as tuna, that force small fish to the surface. They feed on small squid, jacks and other small fish at the surface.

Surveying a typical colony: Colonies may be very large, in which case it may be necessary to use a sampling method, either randomly positioned circular plots (e.g. with radius of 10 m) or transects (see Level 1). Sooty Terns use a variety of vegetation types and it may be necessary to stratify the survey (e.g. by dividing the colony into sectors) to ensure that all vegetation types are fully surveyed. Colonies should be surveyed at least twice per year.
Conservation needs: Protection of the largest colonies from exploitation, disturbance, development and alien invasive species. Public education.

Bridled Tern *Onychoprion anaethetus melanopterus* BRTE

Known distribution in the Caribbean

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CARS, 8900 pairs in the Caribbean[8]
Breeding season: Similar to Sooty Terns.
Nest sites: Nests under ledges or dense vegetation on cays and rocks often in mixed colonies with Sooty Terns. Move sites annually.
Incubation: 26-33 days. Single egg.
Fledging: 55-62 days. After fledging individuals from northern colonies disperse to the Gulf Stream off the Carolinas.
Longevity: c.14 years
Diet and foraging ecology: Feeds along oceanic fronts over lines of *Sargassum,* mostly on small fish and crustaceans

Surveying a typical colony: Surveys should be carried out at the peak of laying but before hatching starts. Due to their low density it may be best to count them on transects. Nests (especially nests with chicks) under vegetation or in rock piles can be very difficult to find and plenty of time should be allowed for searches, if possible. Propensity to move nest sites each year makes it difficult to assess populations. Inexperienced surveyors should remember to look (and listen) for this species among the much more common Sooty Terns.

Bridled Tern (Photo by Ann Sutton)

Juvenile Bridled Tern (Photo by Ann Sutton)

Conservation needs: Colonies should be protected from disturbance and predators.

[8] This may be an over-estimate due to over-sampling because they move nest sites each year.

Roseate Tern *Sterna dougallii dougallii* ROST

Known distribution in the Caribbean

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CARS. Caribbean population 4,000-6,000 pairs out of a total Atlantic population of <8,000 pairs. US Threatened species.

Identification: Roseate Terns in the Caribbean may have predominantly red bills, even in breeding plumage. This leads to confusion with Common Terns and Arctic Terns. Most reports of Common Terns nesting in the Caribbean are actually of Roseate Terns (David Lee, in litt.). Some diagnostic features to look for include:

- Roseate Terns have pale under-wings, which lack any dark margins on the trailing edges
- The outer tail feathers (tail streamers) of perched Roseate Terns in breeding plumage extend well beyond the tip of the folded wings.

Breeding season: Adults usually return to breeding sites in late April and early May, and start to lay eggs about 3 weeks later.

Nest sites: Barren or sparsely vegetated rocks or densely vegetated areas. Nests have little or no nest material.

Incubation: 23 days, 2 eggs.

Fledging: 22-30 days.

Longevity: Up to 17 years.

Diet and foraging ecology: Feeds in mixed species flocks e.g. with Brown Noddies, close to shore on small fish. Does not hover.

Roseate Tern in breeding plumage (Photo by Y-J Rey-Millet)

Roseate Tern adult (Photo by Y-J Rey-Millet)

Surveying a typical colony: Numbers are small and can usually be censused. Often on small inaccessible rocks so counts must be done from the sea. Can be confused with the similar Common Tern, so care should be taken in identification. Very sensitive to disturbance early in the breeding cycle and may desert the site, so special care is needed in surveys by counting without getting close to the nests (e.g. using binoculars). Colony sites may move from year to year, even following successful nesting, so assessment of populations is particularly difficult.

Conservation needs: Nesting colonies should be protected from exploitation and alien invasive species. Levels of heavy metals should be monitored if possible.

Common Tern *Sterna hirundo hirundo* COTE

Known distribution in the Caribbean

Common Tern adult

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CARS. West Indies and Bermuda <100 pairs of total regional population of 300 pairs.
Identification: Often confused with Roseate or Arctic Terns (see above).
Breeding season: Late spring.
Nest sites: A simple scrape in sand or soil.
Incubation: 21-23 days. 3-4 eggs.
Fledging: 22-29 days.
Longevity: 26 years
Diet and foraging ecology: Feed in mixed species flocks on small fish, crustaceans and insects.

Surveying a typical colony: Colony numbers are small and can be censused. Great care is needed to ensure correct identification as they can easily be confused with the similar Roseate Terns.
Conservation needs: Protection of colonies, control of predators including Laughing Gulls, and management of vegetation.

Royal Tern *Thalasseus maximus maximus* ROYT

Known distribution in the Caribbean: In much of the Caribbean Royal Terns are the most common seabird. They are often seen singly or in pairs foraging close to shore. In winter the population includes large numbers of migrants (mostly from the Carolinas).

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CARS
Breeding season: Breeding activity may start in April, but nests with eggs have been seen in June-July at some colonies.
Nest sites: They breed in tightly packed colonies in low vegetation *(*such as *Sesuvium portulacastrum)* close to other tern colonies, sometimes near to a beach.
Incubation: 30-31 days. 1 egg. Young leave the nest to form crèches after 1 week.
Fledging: 28-35 days but parents continue to feed young after fledging.
Longevity: Up to 17 years.
Diet and foraging ecology: Usually feed close to shore, over schools of coastal and pelagic fish. They eat larger fish than other terns, also shrimp and squid.

Royal Terns (Photo by A. Sutton)

Royal Tern Colony (Photo by A. Sutton)

Surveying a typical colony: Colonies are small and densely packed. It is generally feasible to count the total number of nests. Surveys should be carried out before hatching, if possible.
Conservation needs: Colonies need protection from visitors, dogs, exploitation and Laughing Gulls.

Sandwich Tern *Thalasseus sandvincensis acuflavidus* SATE

Known distribution in the Caribbean: Nest in the Bahamas, Pedro Cays (Jamaica), Cuba, Culebra (Puerto Rico), British Virgin Islands and US Virgin Islands.

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Conservation status: CARS. Only observed in the Caribbean since 1965.
Breeding season: Breeding colonies form in late April-early May and are abandoned by late August or early September.
Nest sites: Nest can be a simple scrape on sand or rocks.
Incubation: 21-29 days. Chicks move from nest in 2-3 weeks to form crèche.
Fledging: 25-28 days.
Longevity: > 21 years.
Diet and foraging ecology: Feeds (usually along coasts) on fish, squid and crustaceans.

Sandwich Tern and chicks (Photo by A. Sutton)

Sandwich Terns (Photo by A. Sutton)

Surveying a typical colony: Colonies are small so can be censused, but this must be done before hatching as young are easily scattered.
Conservation needs: Protection of colonies from exploitation, disturbance and introduced predators. Genetic studies needed to determine relationship to Cayenne Terns.

Cayenne Tern *Thalasseus sandvincensis eurygnatha* AYT

Known distribution in the Caribbean: They occur along the Caribbean and Atlantic coasts of central and south America, Puerto Rico, the Virgin Islands, Las Aves, Los Roques, off Trinidad, off Guyana, and south America.

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Cayenne Tern

Conservation status: CARS. First reported in the Caribbean in 1962, but may have been overlooked previously. Critically endangered in the West Indies. Total population in wider Caribbean is 5200-6800 pairs, mostly in the Caribbean rim islands and countries.
Breeding season: Eggs laid in second week of May, colonies abandoned by late August or early September.
Nest sites: Colonial, often nesting with other terns (but not in colonies with Laughing Gulls). Nests are scrapes in fine sand.
Incubation: ?
Fledging: ?
Longevity: ?
Diet and foraging ecology: Similar to Sandwich Tern.

Surveying a typical colony: See Sandwich Tern. All surveys of seabirds should include specific searches for this species.
Conservation needs: All sites need full protection, including control of Laughing Gulls.

Least Tern *Sterna antillarum antillarum* LETE

Known distribution in the Caribbean: Widespread in the Greater and Lesser Antilles and present on most islands.

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Least Tern (Photo by Y.J Rey-Millet)

Conservation status: CARS. Bahamas and the West Indies 1,500-3,000 pairs out of a total population of 32,000 pairs.
Breeding season: Nesting begins between mid-April and mid-May.
Nest sites: Usually colonial, nesting in scrapes on sand or soil on beaches, sand banks or near saline ponds. Rarely associated with colonies of other seabirds.
Incubation: 21-23 days. 2-3 eggs/nest.
Fledging: 20 days. Disperse from colony after about 3 weeks. Parents feed young up to 8 weeks after fledging.
Longevity: 24 years.
Diet and foraging ecology: Feed inshore or in coastal ponds, often hovering, mainly on small fish and shrimp.

Surveying a typical colony: Colonies are very small and can be censused. They are not usually found in mixed colonies with other species, so surveys of this species will require targeted searches of beaches, sand banks and pond margins.
Conservation needs: Colonies should be generally protected from development and recreation. If they are in areas subject to human disturbance they might need to be fenced and signed during the nesting season.

Gull-billed Tern *Gelochelidon nicolita aranea* GBTE

Known distribution in the Caribbean:

- Extirpated
- <1% of Caribbean population
- >1% of the Caribbean population

Gull-billed Tern (Photo by Y.J Rey-Millet)

Conservation status: CARS. Bahamas and West Indies 100-300 pairs of total for N. Atlantic 3,100-3,500 pairs.
Breeding season: Not determined
Nest sites: Nest on open flats, between dunes, open sandy washes. Ground nesting, nest simple sparsely lined with vegetation or marine mollusk shell fragments. Rarely associated with other species of nesting seabirds.
Incubation: 22-23 days. 3 eggs.
Fledging: 28-35 days and depart from colony shortly after fledging. Young remain with adults for an additional 2-3 months.
Longevity: First breeds at 5 years. Lifespan 16 years.
Diet and foraging ecology: Not primarily a marine species. Feeds over salt flats, marshes and freshwater and brackish lagoons on insects, small crabs, lizards and seabird chicks. Migrates at sea, but mainly inshore.

Surveying a typical colony: Colonies are small and can be censused if found in accessible areas. Sites can be inaccessible and sometimes the only available measure is the number of birds in flight. They do not nest with other terns, so specific surveys may be needed. Will abandon sites if disturbed.
Conservation needs:
Surveys needed especially in the Caribbean.
Protection of colonies (including signage, control of access during the breeding season, removal of alien predators, control of Laughing Gulls, and management of vegetation).

Important resources for Caribbean seabird studies

West Indian Breeding Seabird Atlas
The West Indian Breeding Seabird Atlas is a Caribbean regional seabird colony register that stores and allows access to information about seabirds breeding sites and even data on invasive species in Bermuda, the West Indies, and the Caribbean. It will be part of the World Seabird Colony Register, which is being developed to track the health of seabirds around the globe. The atlas can be reached through its website (www.wicbirds.net)

The atlas manager Will Mackin (willmackin@gmail.com) is available to answer queries (for example comparison of nesting data between areas and years). Access to this database is free to conservationists, scientists, and governments, and contributors are permanently honored for their service to the birds. The breeding sites documented in the atlas appear in Figure 1.

Seabird Breeding Atlas of the Lesser Antilles (2012) by Lowrie, K, Lowrie D and N. Collier, EPIC, St Martin."The Seabird Breeding Atlas of the Lesser Antilles makes available data and narrative related to Environmental Protection in the Caribbean's (EPIC) census of breeding seabirds in the Lesser Antilles. The book provides information on methodology, species profiles and distribution maps and tables by species and country/territory, and site specific threats. The Atlas reports key individual islands for breeding seabirds in the Lesser Antilles, nations or territories supporting the greatest number of globally and regionally important populations and clarifies the significance of the region in relation to Caribbean-wide populations. Species with restricted breeding ranges are also identified. The study covered 3,162 nautical miles and over 200 islands between 2009 and 2010. Every island, islet, or cay above the high-tide level capable of supporting seabirds was surveyed by land and/or sea. Surveys were conducted over a two-year period to account for variations in breeding cycles. The only islands not surveyed by EPIC were locations for which colleagues contributed recent data. A full seabird population survey for this region had never previously been undertaken. Existing records varied greatly from areas of intense research, to sites where data were based on anecdotal notes, sometimes dating back to the early 19th century."[9]

An inventory of Breeding Seabirds of the Caribbean. (2009) Edited by Patricia E. Bradley and Robert L. Norton. University Press of Florida, Gainesville, USA.

Status and Conservation of West Indian Seabirds (2000). Edited by B-A. Schrieber and D. Lee. Society of Caribbean Ornithology, Special Publication Number 1.

The World Seabird Union/Seabirds.net
The World Seabird Union is an association of seabird-focused conservation groups from around the globe. Its mission is to place seabird research, management, and conservation into a worldwide perspective, while its vision is to aid in creating global partnerships that will continue into the future by sharing research, knowledge, and ideas on a global level BirdsCaribbean is a member of the World Seabird Union. Seabirds.net is a global forum for discussing seabirds and a clearinghouse for databases, and as mentioned above, will provide a portal to Caribbean information.

BirdsCaribbean online resources
BirdsCaribbean has a wide range of seabirds materials available on its website www.birdscaribbean.org, including training materials, videos, powerpoint presentations and reports on workshops and meetings.

[9] Text from listing on Amazon.com.

Further Reading[10]

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[10] Many useful resources, reports, manuals, papers, and Powerpoint presentations are available for download from BirdsCaribbean's website.

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Glossary of Some Terms Related to Counting Birds

Abundance – The average density of selected species in places where they are present and sampled (or occupied patches).

Census – A total count of the number of individuals of birds at a site by species. Note that the term is widely used in manuals and monitoring literature to refer to methods/all types of incomplete counts (e.g., point counts) to estimate population size and trends. Many people use the word *census* interchangeably with count and survey. However, the word census is also used to mean a complete count, a total number without any error or uncertainty.

Colony – "A bird colony is a large congregation of individuals of one or more species of bird that nest or roost in proximity at a particular location. Many kinds of birds are known to congregate in groups of varying size; a congregation of nesting birds is called a breeding colony." (en.wikipedia.org/wiki/Seabird_colony).

Covariate - A variable that is possibly predictive of the outcome under study. A covariate may be of direct interest or it may be a confounding or interacting variable.

Crèche – A group of mobile chicks at the nesting colony

Density – Number of birds per unit area.

Detection probability or detectability – A measure of the likelihood that an individual will be seen in a count.

Index, as in "index of abundance" – A measurement that is related to the actual total number, for example, the number of nests counted in a breeding colony (as an index to the number of breeding pairs)

Occupancy – A measure of number of patches in a habitat that are occupied by the species or group of species that are being studied.

Metapopulation – A population of populations.

Nest success – A nest is considered successful if at least 1 egg hatches

Point Count – A method of counting birds while standing at a predetermined geographic location or point for a set period of time.

Point count station – Fixed location from which to count birds using the point count method.

Poisson distribution – Probability distribution. See en.wikipedia.org/wiki/Poisson_distribution

Population size – Number of birds in a survey region

Sampling Bias – Factors that affect the accuracy of counts in a systematic way.

Sampling Frame – The geographic area or group of similar habitats within a geographic area from which sample points will be selected.

Site Inventory – A complete list of the species present at a site.

Survey – A way to estimate numbers or relative abundances of species or groups of species at a site based on sampling.

Trend – Changes in numbers over time.

Appendices

Appendix 1 - About BirdsCaribbean/Society for the Conservation and Study of Caribbean Birds

BirdsCaribbean, formerly Society for the Conservation and Study of Caribbean Birds (SCSCB) is a nonprofit 501 c (3) membership organization working to conserve the birds of the Caribbean and their habitats through capacity building, research, conservation action, education, outreach and communication. Founded in 1988, BirdsCaribbean is the largest single bird conservation organization in the Greater Caribbean region, including Bermuda, the Bahamas and all islands within the Caribbean basin.

The overarching goal of the BirdsCaribbean is to increase the capacity of Caribbean ornithologists, resource managers, conservation organizations, institutions, and local citizens to conserve the birds of the Caribbean and their habitats. BirdsCaribbean aims to achieve this by 1) developing regional conservation projects, activities, and materials that facilitate local research, management, conservation, education and outreach, and 2) Building networks and partnerships with local, national and international organizations and institutions that share our bird conservation goals.

What we do

BirdsCaribbean holds a week-long biennial meeting, has a number of active Working Groups and publishes *The Journal of Caribbean Ornithology*. With assistance from the US Fish and Wildlife Service, BirdsCaribbean also sponsored the publication of local bird field guides. The organization works to raise public awareness, knowledge and appreciation of the value of the region's many endemic bird species and their habitats through two flagship programs: the *Caribbean Endemic Bird Festival* (CEBF) and the *West Indian Whistling-Duck (WIWD) and Wetlands Conservation Project*. BirdsCaribbean also raises awareness about migratory birds through celebration of *International Migratory Bird Day*.

The organization works through projects, which are developed through its working groups. Current working groups include: West Indian Whistling-Duck and Wetlands, Threatened Birds, Seabirds, Bird Monitoring, Caribbean Wildlife Art, Media, Invasive Species, White-crowned Pigeons, and Caribbean Parrots. The CWC is part of a program that was initiated by the Monitoring Working Group.

Educational materials

As well as this manual, BirdsCaribbean has developed various materials that would be useful in the development of seabird conservation programs. These include waterproof plastic field identification cards in English, Spanish and French including:
- Wetland Birds of the Caribbean
- Seabirds of the Caribbean
- Resident and Migratory Ducks of the West Indies

There are also identification cards for the common landbirds of Bahamas, Grenada, Cayman Islands, Jamaica, St. Vincent and the Grenadines, Guadeloupe and Puerto Rico, and others are in production.
We have also produced an identification booklet on *Mangroves of the Caribbean*, *Migratory Birds of the West Indies Colouring Book*, *Save Our Seabirds* poster, and *Wondrous West Indian Wetlands: Teachers' Resource Book*. Several of these items are available for purchase on www.birdday.org, or contact Lisa Sorenson (Lisa.Sorenson@birdscaribbean.org).

How you can help

Become a member today

Show your support for the organization by becoming a member. Categories of membership include ordinary member, life member and institutional member. We also have a sponsorship program.

Get involved

BirdsCaribbean works primarily through volunteers. There are many opportunities to use any or all of your skills. From monitoring your favourite birding locality to development of regional projects, we can use your help or the support of your organization.

Provide funding

Funding to support our general activities and specific projects is always much appreciated and every dollar goes directly to putting conservation on the ground.

BirdsCaribbean is a registered 501 c (3) organization in the U.S.A thus US donations are tax-deductible. Check our website for more information about projects and programs that would benefit from your support.

Find out more

To find out more about BirdsCaribbean including how to join, visit www.birdscaribbean.org.

Appendix 2: Seabirds Survey Form for Level 2 - Seabird Colony Site Total Nest Count or census (with notes on breeding status)

Date _____ Area Name:_____ Area Code/# _____

GPS Latitude: _____ Longitude:_____

Observer _____ Recorder _____Trainees:_____

Start Time: _____ End Time: _____ Duration: _____Area surveyed (Hectares): _____

Temp. ____°C Sky code: _____ Wind code: _____ Wind direction: _____ Total # of spp:_____

Species Code or Name	Adult (#)	Nest #	(# eggs)	Newly hatched chicks (#)	Downy chicks (#)	Partly fledged chicks)	Identification, habitat or behavioral notes

ADDITIONAL NOTES

Sky codes: **0** = clear or a few clouds, **1** = partly cloudy/variable, **2** = cloudy/overcast, **3** = fog, **4** = drizzle, **5** = rain (do not survey)
Wind codes: **0** = calm; **1** = light air; **2** = leaves start to rustle; **3** = small branches start to sway; **4** = moderate breeze; **>4** Do not survey
Wind direction: N, S, E, W
Number in group #: indicate sex if known, **M** = Male, **F** = Female, and if the bird is an immature, **J** = Juvenile
Breeding Status (BS) (Occupied nest, unoccupied nest, nest with adults, nest with eggs, nest with chicks and eggs, nest with chicks, loafing juveniles)
Human disturbance near count site at time of survey: Fishers, Hunters, Tourists, other _____
Water level - % of colony covered with water: _____ 0=None, 1-25%, 26-50%, 51-75%, 76-100%
Vegetation - % of colony covered with plants (by species): _____ 0=None, 1-25%, 26-50%, 51-75%, 76-100%
Photograph taken of the site: Yes/No Unusual species: Yes/No _____

Species Code or Name	Adult (#)	Nest (#)	Eggs (#)	Newly hatched chicks (#)	Downy chicks (#)	Partly fledged chicks (#)	Loafers (# in group)	Identification or Behavioral notes

ADDITIONAL NOTES

Appendix 3: Seabird Circular Plot Data Sheet

Date:	**Start Time :**	**End Time:**	**Island Name:**
Team Members (First & Last names):			
Latitude:		**Longitude:**	
Plot Number:	**Habitat type:**		**Elevation:**
Plot radius (m):	**Photograph File #s or names:**		
Vegetation Present (% cover) or DAFOR rating:			
Notes (e.g. how to find plot):			

Species	Distance of nest from centre (m)	Bearing (degrees) (optional)	Nest Status (e.g. 2A, 1e)	Found on 1st pass (Y/N)	Found on second 2nd pass (Y/N)	Recorder Initials (1st/2nd pass)	Notes

Appendix 4: Monitoring habitats – Caribbean Seabird Site Description Form

The Caribbean Seabird Site Description Form is designed to provide a standard description of the site, in a format that will allow for comparison among sites, if necessary. It should be completed once, at the start of surveys, usually during the site reconnaissance visits. The form includes information on location, habitat type and condition, uses, and threats. It includes a site map, which may be drawn on a Google Earth image (see the section on Google Earth below), or on a topographic map, or provided as a hand-drawn sketch map. The site map should clearly indicate the survey locations (point count stations or area search locations).

Caribbean Seabird Site Description Form

COUNTRY:	**DATE:** DY:		MO:	YR:	**ALTITUDE (m):**
NAME OF SITE:			**SITE CODE:**		
PROVINCE/PARISH:					**AREA (ha):**
NEAREST LARGE TOWN:					
COORDINATES at centre of site	deg.	min.	sec.		N/S
	deg.	min.	sec.		E/W
NAME OF RECORDER:					
CONTACT INFORMATION	E-MAIL:		TELEPHONE:		

COLONY LOCATION		
Mainland (describe)		
Sand cay (note distance from nearest mainland)		
Rocky cay (note distance from mainland)		
NESTING HABITAT TYPES	**EXTENT/ AREA** (note units)	**NOTES** (Include notes on habitats, special features and use made of these habitats by seabird species)
Hyper-saline/ saline lagoon, or salt pond		
Sandy beach, berm, shoreline, sandy cay		
Salt flat, salina		
Sand bank		
Rocky cliff		
Rocky cay, strand, rock piles, flat rock (note presence or absence of crevices)		
Sand cay		
Other		

PROVIDE A BRIEF DESCRIPTION OF YOUR SITE (include main habitats, physical features and dominant plant species (if known).
% of colony area covered with plants (by species) or list with DAFOR[11] ratings Species 1 Species 2 Species 3 Species 4
Species 5
Species 6
Species 7
Species 8

[11] DAFOR SCALE– Donimanr A-Abundant F-Frequent O – Occasional R- Rare

Species 9
Species 10
NOTES:
PROTECTION STATUS (circle those that apply to your site)
Land Protection: protected site, partially protected site, no protection, unknown
If protected, state the type of protection: marine protected area, national park, reserve, conservation area, fish sanctuary, other (state which)
Land tenure: government owned, private owned, mix of government and private ownership
Name of organization(s) or agency(ies) responsible for management and conservation:
Organizations, agencies, or groups involved in conservation activities or projects (describe briefly):
OTHER IMPORTANT FAUNA AND FLORA E.G. SEA TURTLES, ENDEMIC LIZARDS, OTHER BIRDS (list)
HISTORICAL SITES AND CULTURAL SIGNIFICANCE (describe)

THREATS TO THE COLONY AREA **Rank all that apply 0 = None, 1 = Little, 2 = Moderate, 3 = Large-scale, 4 = Unknown**
RESIDENTIAL AND COMMERCIAL DEVELOPMENT
Housing [ ], commercial development [ ], industry [ ]. Hotels [ ], villas [ ], marina [ ], golf course [ ], fishing village [ ]. Fishing camp [ ], squatter settlement [ ], other (describe).
OVEREXPLOITATION AND PERSECUTION OF SEABIRDS
Egg collection – subsistence [ ]. Commercial [ ]
Harvest of eggs [ ]. Harvest of chicks [ ], harvest of adults [ ]
People walking through colony (describe)
MODIFICATION OF NATURAL ECOSYSTEMS
Fire [ ], fire control [ ]
Shoreline encroachment: housing [ ], roads [ ], agriculture [ ], industry [ ], tourism [ ], other [ ] (list)
Overgrowth by vegetation
INVASIVE SPECIES
FERAL ANIMALS: Cats [ ], dogs [ ], goats [ ], cattle [ ], pigs [ ]
Invasive mammals: rats [ ], raccoons [ ], mongoose [ ], monkeys [ ], donkeys [ ], other (list) [ ]
Overgrowth by invasive plants [ ]
Other (list)
POLLUTION
Domestic sewage [ ], solid waste [ ], industrial waste [ ], pesticides [ ], fertilizers [ ], oil [ ], agricultural wastes [ ], bathing [ ], washing [ ], siltation [ ], noise [ ], air-borne pollutants [ ], thermal pollution [ ], light pollution [ ], eutrophication [ ] Other (state) [ ]
GEOLOGICAL EVENTS
Volcanic eruptions [ ], earthquakes [ ], mudslides) [ ], tsunamis [ ]
CLIMATE CHANGE AND SEVERE WEATHER (include dates if known)
Hurricanes [ ], drought [ ], floods [ ], rising sea level [ ], high temperatures [ ], fire [ ], coral bleaching [ ], other (state) [ ]

PROVIDE A SKETCH MAP OF YOUR SITE SHOWING MAIN PHYSICAL AND NATURAL FEATURES (e.g. trails, nesting colonies) AND LOCATION OF AREA SEARCH ROUTE OR SURVEY POINTS, ON A TOPOGRAPHIC MAP OR GOOGLE EARTH IMAGE ON A SEPARATE SHEET or SKETCH IT BELOW

Appendix 5: Using A Computer Programme To Position The Sample Plots

GIS software is required for this exercise (Google Earth, ArcGIS Explorer, and QGIS are available for free; ArcMap, MapInfo require a paying subscription) together with spreadsheet software (such as Microsoft Excel, Open Office, Google Sheets).

a. Using a satellite image of the island, find the lowest and highest latitudes and longitudes. Set the software to produce estimates in decimal degrees with 6 (or more) decimal places (e.g. 24.623572 N, -78.475237 W, 24.427374 N, -78.421793). Record these 4 points in a spreadsheet. The smallest latitude and longitude will be named LatMin and LonMin, and the highest Latitude and Longitude will be named LatMax and LonMax.

b. Name "Latitude" and "Longitude" the two columns to the right of the cells just recorded from the satellite image. Fill in these two columns with random numbers, following this method:

1) In the second cell of the Latitude column, type " =randbetween(α,β) " where α is the decimal part of the lower LatMin or LatMax (here 427374) and β is the decimal part of the higher LatMin or LatMax (here 623572) ;
2) In the second cell of the Latitude column, type " =randbetween(α,β) " where α is the decimal part of the lower LonMin or LonMax (here 421793) and β is the decimal part of the higher LonMin or LonMax (here 475237).

c. Copy these cells and paste them into the next several hundred rows below them.

d. You should now have two columns (Latitude and Longitude) of random numbers that give random coordinates within a rectangle surrounding your island of interest.

e. These values will change every time you press return in another cell or "F4".

f. In the next two columns (Column E and Column F) you will reconstruct the latitudes and longitudes using the following

1) In cell E2, type: " = ε+C2/1000000 ", where ε is the whole fraction of LatMin (here 24). C2 is the first cell in column Latitude.
2) In cell E2, type: " = φ-D2/1000000 ", where φ is the whole fraction of LonMin (here -78). D2 is the first cell in column Longitude.

g. Copy these two cells and paste them down next to the values in columns Latitude and Longitude.

h. Now, copy columns E and F. Open a new spreadsheet (Open/New) and paste the values (using the command "Paste Special") into columns B and C of the new worksheet. Now you have a sheet of random points for your island.

i. Save this set of points as a delimited text file (.csv, .txt, or other).

j. Import this file into your GIS software and choose the points that are within the breeding habitat with sufficient space from the edge of the island to fit the entire circle.

k. Many points in the rectangle will not be on land. In google earth plus, you can rename each point that is in the proper habitat.

l. Program your GPS with correct points and print your map.

Appendix 6. eBird Caribbean and Seabird Monitoring (including protocols for monitoring pelagic species)

For many sites in the Caribbean there is very little information about the presence of bird species, thus reporting even a single incidental sighting of a bird has value for science, education and conservation. However, observations are much more useful when certain conditions are met. One of the most important considerations is to record and report all the species you see or hear. Another is to repeatedly visit the same location at the same time of day and cover the same area. The Caribbean seabird protocols include a variety of more structured and rigorous techniques to understand seabird distribution, but it is amazing how much can be learned when large quantities of data are gathered with relatively simple protocols that focus on complete, effort-based checklists gathered repeatedly from the same locations[12].

eBird Caribbean is a web-based database in which surveyors submit, save and explore their bird observations. Created from a partnership of BirdsCaribbean and the Cornell Lab of Ornithology, it is an invaluable tool for birders, scientists, natural resource managers, and conservationists. Entering your monitoring data into eBird Caribbean will allow you to keep track of local bird observations, view maps and graphs of frequency and abundance of bird species and at the same time contribute to expanding our knowledge of bird distribution and abundance throughout the Caribbean.

On land or on the sea, eBird thrives on data entered with specific and accurate locations. The ability to associate a complete checklist of birds with a specific and discrete location is essential for understanding the habitat associations and geographical patterns of occurrence, and is also helpful for eBird users to find birds and have their reports associated with the correct lists in My eBird.

Birding at sea is somewhat different from birding on land, since the marine habitats are much less obvious than those on land. Factors such as water depth, amount of upwelling, steepness of the ocean bottom, water temperature, salinity, and currents tend to be the most important determinants of where pelagic birds are likely to occur. And while a woodpecker may live its entire life within a territory of one square kilometer or less, all pelagic birds must move between feeding areas, so none are so uniquely tied to a certain habitat as are many landbirds.

eBird pelagic protocol: This protocol was designed mainly for the organized pelagic trips that leave from many ports around the USA. However it can also be adapted for use by scientists in the Caribbean. This protocol produces accurate species range maps, as seen in Figure 6.1 below.

[12] See also: Effort-based observations enable powerful data analysis, Sept. 24, 2010, http://ebird.org/content/ebird/news/effort_based_obs

Figure 6.1: eBird range maps for Audubon's Shearwater off the NE US coast

Cape Cod, Massachusetts, forms the northeasternmost point of land in Figure 6.1 and regular pelagic trips conducted there have used the eBird protocol. This accounts for the linear sets of Manx observations obvious in the left image. Those pelagic trips head to the edge of the continental shelf, and it is here that Audubon's Shearwaters are found. note the striking differences in occurrence of Manx (often seen from shore; when offshore, over the continental shelf and common north of Cape Cod) vs. Audubon's (seen from shore during hurricanes only; when offshore, mostly south of the continental shelf, and almost unknown north of Cape Cod). Several of the inshore points for Audubon's Shearwater are imprecisely plotted records that were actually found far offshore, which highlights the need for more accurate location plotting of pelagic observations.

Count protocol: For species at the dock or inside the harbor, make sure to conduct a checklist for the amount of time it takes to leave the nearshore area. Once you are sufficiently far offshore, begin your series of pelagic transects. Each pelagic transect should be 30 or 60 minutes in length. While 30-minute counts are always preferable, the important thing is to try to keep the locations closely tied to the birds seen. If you are on a slower moving vessel (e.g., a sailboat) or on a faster boat that is going slowly to look for birds, you may opt for a 60-minute count. A fast moving boat steaming out to offshore birding areas may go 20 knots or more (22+ mph), so even half-hour counts may cover 10 miles. Do your best to record (using a GPS) or estimate (using average ship speed) the distance traveled and try to account for potential backtracking or changes in speed. At the close of each count period, tally the birds and begin a new count.

Counting birds: Count all birds visible at one time. While some seabird counting protocols count birds that pass through a discrete pie slice of your view from the ship, or count birds only within limited distance bands, eBird protocols include all birds visible. Shearwaters that are too distant to be identified should be counted entered as shearwater sp. (likewise for tern sp., storm-petrel sp., etc.).

Stationary counting: When the boat is stationary for a long period (when chumming for example), we recommend conducting a single count to cover the time spent in that area, rather than continuing with the 30 or 60-minute increments. Rarely are these truly stationary counts, unless the boat is anchored, so it will probably still be appropriate to use traveling count protocol with a very short distance. Once the boat resumes normal speed, end that count and begin a new one. This will help to reduce the issues with double-counting birds across prolonged periods in one area or at a single chum slick.

Individuals seen repeatedly: Often a recognizable individual will be seen across multiple checklists. In such cases it is recommended that you include the bird in your count (which is really a survey of the birds in the area at that time) but that you

clearly mark it as a continuing bird. To simplify the process of recording a total count for the trip, some observers may prefer to mark the species with an X to record it as present and with notes to indicate that it continued from a previous count period. Please do not omit the bird entirely from that checklist period.

Final notes

Work as a team: Anytime you do a pelagic trip, try to find other eBirders aboard so that you can help one another in keeping track of the birds and submitting your lists appropriately. Ideally, you should chat with the leaders before departing to ask if there is an effort by the leadership team to keep eBird checklists. Finding and counting birds offshore is a challenge, so working as a team really helps!

States and counties offshore: Within eBird, we use a strict closest point of land (CPOL) rule to assign a country, state, and county to offshore observations that are within 200 nautical miles of land. As long as you plot your points accurately and keep your lists short, eBird will assign them automatically to the correct region. This standard matches U.S. Federal law, as well as listing guidelines of the American Birding Association and other similar bodies around the world. Nate Dias explains the policy and some of the nuances in the following blog www.blog.aba.org/2012/09/open-mic-on-east-coast-pelagic-boundaries.html. Within the United States, all states except New Hampshire, Rhode Island, Delaware, Mississippi, Oregon, Washington, and Alaska have adopted the closest-point-of-land for their avian records as well.

Plotting rarities: For extremely rare birds, it is very important to get specific information on the location. If you take a specific lat-long for a rare bird, please do enter that in the species comments so that it is always clear exactly where the rarity was seen. In such cases, recording the water depth and sea-surface temperature is also recommended.

Documentation, documentation, documentation: Many pelagic birds are poorly understood, so providing photos for your observations are very helpful, especially in record review. Even in well-covered pelagic areas there are new discoveries to be made, such as the regular occurrence of Hawaiian Petrels off California and the presence of late-summer Barolo Shearwaters off New England and Atlantic Canada, both of which have been demonstrated only in the past decade. When in areas with more poorly known pelagic avifauna, providing detailed notes and photos on anything unexpected is especially important.

Analysing data

eBird Caribbean has the ability to create frequency bar charts, which indicate the percentage of checklists where a species was seen during each week for a specific location or IBA or even an entire country. Wide bars indicate species that are commonly observed, narrow bars show species that are infrequently observed. For instance in the bar charts below for the US Virgin Islands, Brown Noddy is uncommonly observed in May, Short-billed Dowitcher is present year round, Laughing Gull is commonly seen May through September, and White-rumped Sandpiper is largely a fall migrant. While fairly simple, these charts show very well the details of the seasonal distribution of wetland birds. Additional charts and graphs display high counts and abundance of a species through the year. Such graphs can be very useful in understanding the dynamics of species composition at a site, group of sites, country or region.

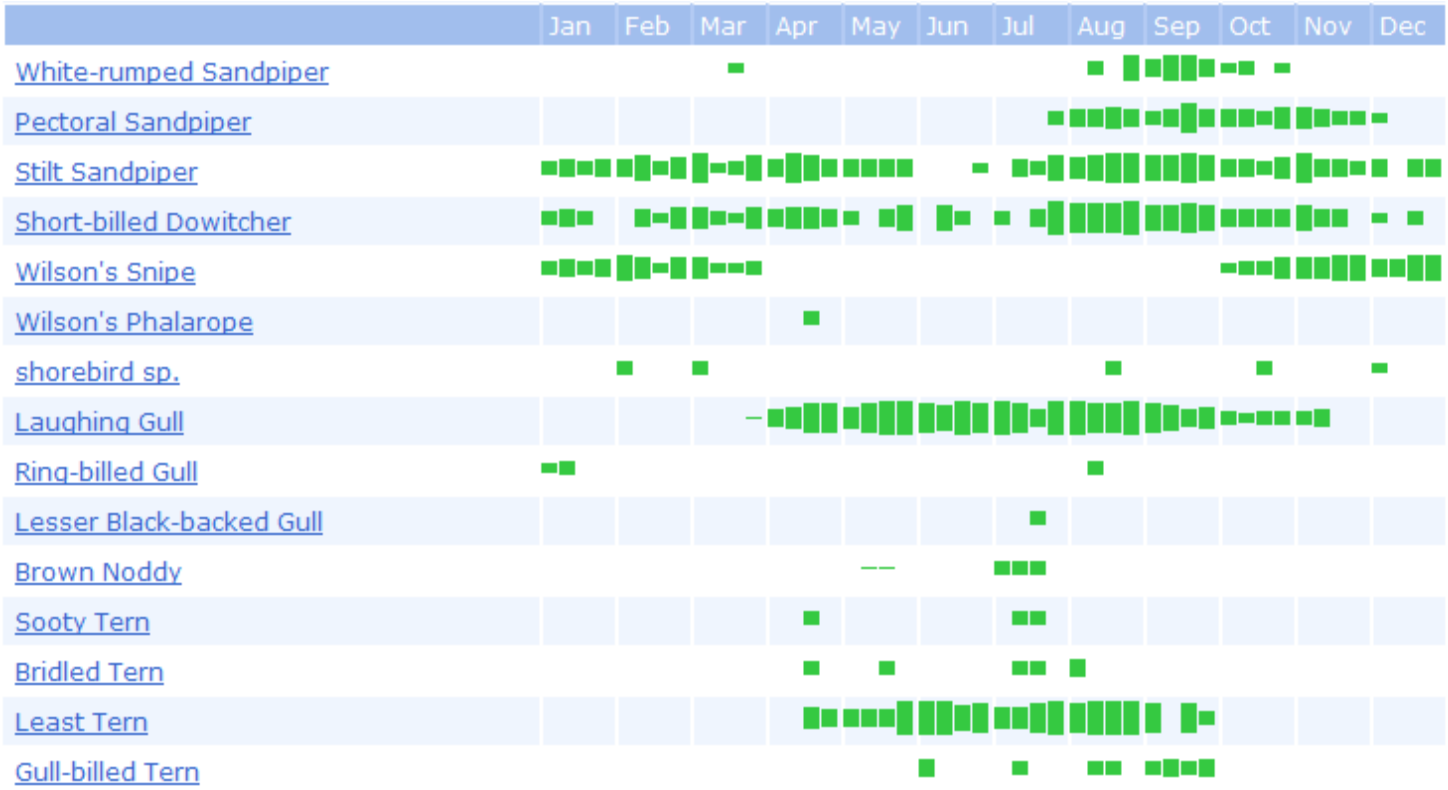

Figure 6.2. Graph showing the distribution of waterbird sightings for the U.S. Virgin Islands. Source: eBird Caribbean

It is also important to remember that with eBird your data do not exist in a vacuum. When you enter a checklist into eBird Caribbean and provide the date and exact location, we are able to link your observations with a variety of other datasets like habitat, population density and climate. In fact, each checklist is linked with *hundreds* of other variables that affect bird distribution and abundance. eBird can use these to develop models of bird distribution that predict where a species occurs. Their initial efforts have focused on the Lower 48 United States, but the long-term plan is to expand these analyses to the entire Western Hemisphere, including the Caribbean. Of course, this depends on the sufficiency of the data, among other factors.


YAMAHA