Seabird Research and Monitoring on Machias Seal Island

RESEARCH PROTOCOLS

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April 2013
Preface

The Atlantic Laboratory of Avian Research (ALAR – then known as ACWERN), at the University of New Brunswick (UNB) began a long-term seabird monitoring and research program on Machias Seal Island (MSI), New Brunswick, in the spring of 1995. Initially, as part of the research for K.D. Amey’s M.Sc. at UNB (Amey 1998), field methods were employed that were acquired from a variety of sources, such as previous work experience on other seabird projects, personal communications with seabird authorities, colleagues in the Gulf of Maine Seabird Working Group (GOMSWG) and the literature. These methods have been refined subsequently to increase efficiency and minimize disturbance to the birds (Paquet and Diamond, 1998b). For the sake of year-to-year comparisons, it is important that a long-term monitoring program use the same methods each year (Diamond 1997). Therefore the primary purpose of this document is to provide details of the methods which have been developed for this specific field site and its seabirds.

This document provides the research protocols that will be followed while collecting data on MSI. The protocols are subdivided according to species. This document also includes additional sections which deal with collecting environmental data and other research activities.

Large sections of this document were incorporated from previous versions of the MSI protocol and future versions will likely draw heavily on this one. Although not listed here, numerous individuals have contributed over the years to establishing appropriate guidelines for the research on MSI and have spent many hours documenting proper methods. Their hard work is greatly appreciated. The current version is particularly indebted to extensive revisions by Travis Clarke, Kirsten Bowser, Kevin Kelly, and Lauren Scopel.
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In 1830, the St. Andrews, N.B., Chamber of Commerce petitioned the New Brunswick provincial government to build a light station on Machias Seal Island (MSI). Following two years of persuasion, one was finally built in 1832 (MacKinnon and Smith 1985a).

The jurisdictional dispute in the Gulf of Maine centres on MSI and who is sovereign over it. MSI is spatially within Canada’s and the United States’s 12-mile territorial waters, yet the boundary in this part of the Gulf of Maine is undefined because of this dispute. This makes for one of the more unusual boundary issues between the United States and Canada (Schmidt 1991).

Canada claims that it has been sovereign over MSI since the 1782 Treaty of Peace. The Canadian government claims it has manifested its sovereignty over the island in several ways but mainly through the lighthouse it built on the island and has maintained since 1832 (Schmidt 1991). Similarly, the United States claims that MSI has been in its possession according to the Treaty of Paris in 1783, which they say gave it control over the island (Schmidt 1991).

MSI is also a Federal Migratory Bird Sanctuary. On July 21st 1933, the Chief Migratory Bird Officer, Robie Tufts, visited MSI. Eleven years later, on April 17th 1944, MSI was established as a migratory bird sanctuary by Order in Council. The Sanctuary officially includes the island and the waters within one mile around it (MacKinnon and Smith 1985a).
Research Protocols
General Research Procedures and Objectives

The research protocols described here have been developed after careful thought and several seasons’ experience. Not only may the research be jeopardized by changes of protocol, but the protocols have been subject to both Animal Care and Environmental Impact Assessments (Paquet and Diamond 1998a, b) and the permission to carry out the research assumes that the protocols specified will be adhered to. They may not be perfect, and unexpected events in any particular season may require changes; but changes should not be made without full discussion among the whole crew and approved by the Principal Investigator (Tony Diamond).

Be sure to note that all research conducted on Machias Seal Island is subject to the following CWS guidelines (CWS 1994):

- Research must not interfere with normal activities of the island (including operation of the lighthouse), or visitors who may be present;

Make sure to vacate any area where you may disturb tourists or working individuals. The tourists and tour operators have priority over the use of Visitor Blinds 1, 2, 3 and 4. Make sure to vacate the area around these blinds at least 30 minutes before the arrival of tourists to allow the birds time to settle. It is best to restrict your activities at these times to the northern half of the island or the southeast corner.

- Research within the tern colony must be conducted only under good weather conditions i.e. (once the tern chicks have hatched) warm temperatures (≥ 11°C) and dry vegetation;

You will not be permitted to conduct most research activities under poor weather conditions. You may conduct re-sighting stints or feeding watches as long as you are concealed in a blind. Wandering through the colony under poor conditions can have a negative effect on breeding terns.

- All research activity must relate to the needs for management or monitoring of seabirds or provide a clear improvement to our present understanding.

Any investigation you plan to undertake should be approved by the principal investigator, Tony Diamond, and permits obtained beforehand.

UNB’s research program on MSI is directed toward the overall objective of understanding seabird responses to long-term changes in their marine ecosystem. This requires annual monitoring of the demographics (population size, productivity and survival) and feeding behaviour (feeding rate, and quantity and quality of diet species) of each species, so far as possible within the logistic and practical constraints of working on a small remote island managed as a Migratory Bird Sanctuary and visited daily by the public.

The demographic component of the program involves routine monitoring that is essential for the effective management of the seabirds. The feeding component has less obvious implications for management but is likely to provide information essential for interpreting changes detected by monitoring. The distinction between “monitoring” and
“research” seems particularly artificial on Machias Seal Island, and the difference between the two is not recognized in this document, which treats all activities as “research”.

**Demographic Studies**

There are several reasons for wanting to capture adult seabirds. At MSI we are primarily concerned with banding, re-banding and obtaining morphological measurements that will be used in current and future studies. But capturing adult seabirds also allows us to colour mark individuals, attach transmitters or data loggers and take blood samples or toenail clippings for stable isotope analysis.

Adult survival and recruitment are monitored by re-sighting banded birds. Seabirds are characteristically ‘k-selected’ birds with a high annual adult survival and low productivity. As such, long-term population trends are more sensitive to changes in survival than productivity. Thus, effective population monitoring must include measures of survival as well as productivity. Adult survival tracking programs such as MARK require a sample of at least 200 breeding adults of each species be maintained at any given time.

Recaptured birds are especially important. By measuring the same individuals from year to year we can gain insight into a number of things including the transition from chick to adult, how adults grow and develop and how individuals relocate around the colony.

**Productivity Studies**

Productivity monitoring of terns is generally conducted within a chicken-wire enclosure. Monitoring alcid productivity involves visiting individual nests and recording their status. Our productivity study contributes to a regional cooperative program by the Gulf of Maine Seabird Working Group (GOMSWG) to monitor and restore seabird breeding populations throughout the Gulf of Maine and Bay of Fundy (Kress 1998).

Monitoring productivity allows us to identify long-term trends and changes in the population from year to year. It also allows us to compare different species within a single year. This is an important source of information regarding how seabirds respond to changes in the environment.

Nest checking, a critical component of productivity studies, also increases our sample of banded chicks, which are all of known age (year hatched) at the time of banding.

**Feeding Studies**

Seabird diet is the third aspect of seabird ecology that we can measure effectively at MSI. Although we cannot monitor what seabird adults themselves are eating, we can observe what they bring back to the colony and feed their chicks. Changing trends in seabird diet may indicate larger scale changes in the marine system around MSI and prove to be an important way of monitoring changes in local fish stocks.

Seabird productivity can often be linked to diet quality as well. Monitoring changing trends in the food supply allows us to interpret our productivity and demographic data and enhances our overall understanding of the seabirds at MSI.
The Island Layout

As a manned lighthouse station, seabird study site and tourist destination, Machias Seal Island has had a number of structures built on it, primarily by the Canadian Coast Guard. Most of these structures are concentrated at the centre of the island and are surrounded by a maintained lawn area. We conduct the bulk of our research from the bird blinds around the island. With the exception of the Visitor Blinds, these blinds are UNB property. The locations and names of the blinds at MSI are shown in Figure 2. Take note that portable blinds are locations, not structures like the other blinds. Portable blinds require you to take one of the small tents out to the rocks and set them up. These tents can be set up in any location that you observe birds congregating but the three portable blind locations are used for Razorbill feeding observations and will be discussed later.

Machias Seal Island is also mapped in 30-meter grid squares. Each grid corner is assigned a letter-number combination. Researchers have driven stakes (“grid posts/markers”) into the ground on MSI and painted each marker with the appropriate label (Figure 3).

In some cases where bare rock is concerned, the designation is painted on the rock. The grid markers have traditionally been red numbers and letters painted on white backgrounds. These grids are used primarily for the Tern Census but are also used throughout the year as reference markers for various data that are collected.

Several grid squares are located on the edge of the island and although they are over land they are not painted on the rocks because wave action over the winter constantly removes these markers. They are not really used for the Tern Census but if for some reason they are needed you will have to map and paint them.

Maintaining grid markers is an important early-season activity.
Figure 2: Map of the blinds used for research at Machias Seal Island
Figure 3: Map of Machias Seal Island mapped by 30m grid squares
Atlantic Puffin  
(*Fratercula arctica*)

The Atlantic Puffin (*Fratercula arctica*) was observed on Machias Seal Island (MSI) as early as the 1880’s. The first recorded observation was in 1883 and consisted of only 60 individual birds. No indication of breeding status was given at that time but over the course of the next hundred years, the puffin population grew to approximately 1,450 birds (MacKinnon and Smith 1985b).

The Atlantic Puffin is the most abundant alcid on MSI and is the focal point of the tourism activities on the island. Machias Seal Island is the largest puffin colony in the Gulf of Maine (Gaston *et al.* 2009) and their sheer abundance on the island seems to dilute the numbers of other alcid species. During the breeding season, approximately 10,000 puffins can be found on or around Machias Seal Island.

The standard code for the Atlantic Puffin as defined by the Bird Banding Lab (BBL) is ATPU. When recording data, enter the species code ATPU as opposed to Atlantic Puffin.

All the records of both puffin banding and re-sighting are entered in the Seabird Finder database which is found on the island computer. This program involves using numerous codes that are summarized at the end of the Atlantic Puffin section. Make sure to review the Seabird Finder manual on how to operate this program.

**Banding and Processing Puffins**

The bulk of ATPU trapping stints should always occur at the beginning of the season shortly after researchers arrive at the island. The objective is to band puffins before the terns start laying eggs. Researchers walking back and forth to the traps can cause significant disturbance to nesting terns. Later in the season, if disturbance to terns is not an issue, puffin-trapping stints can be worked into the schedule again. Researchers should attempt to band a minimum of 200 puffins.

There are currently six wooden drop-boxes, which are equipped with a swiveling lid. Birds walking on these boxes will tumble into the box and be trapped.

Drop-boxes should be placed, well supported, in the nesting colony. The preferred locations are visitor blinds 3 & 4 and Northwest Notch. They can remain there for the season. Make sure that the boxes are the highest point in the
vicinity. This will ensure that the puffins will get used to using the boxes as “take-off points” and “look-outs”.

The sides of the drop-boxes are steep and it is generally helpful, to the puffins, if the boxes are placed in locations where nearby rocks will act as steps to help the puffins climb onto the drop-box. Also, leaning a log against the drop box will often serve as a ramp for puffins to climb. Visitor Blinds 3 and 4 are preferred locations, when tourists are not on the island.

Drop-box trapping generally begins early in the morning and traps should be open at about 5:30 or 6:00 just before the puffins leave their burrows for their morning activities. Researchers can remain in the house and walk out to check the boxes at half-hour intervals.

After the trapping stint is finished, make sure to close the lids and open the lower access hole on the boxes so that birds are not accidentally captured. The short drop boxes should be turned upside down.

Any puffins captured should be placed in a bird bag, brought to the blind or house and processed. However, if more birds are caught than can be processed in a reasonable amount of time, use your judgment and either release some birds or take abbreviated measurements. If releasing birds unprocessed, give priority to processing recaptures (birds already banded).

Puffins receive two size 5 bands (Appendix I). Puffin bands, especially the BBL’s, can be difficult to close. It is important to make sure that the two ends of the band butt together. If you can easily fit your fingernail into the gap, there is a danger that the band will become entangled in fishing line while the puffin is diving (Figure 5).

In Figure 5, closing the band by example A will result in a fairly large gap. After closing the band by method A, follow up by squeezing the ends of the band inward as shown by example B and C.

In the past, each island in the Gulf of Maine attached a different colour plastic field readable band to puffins based on which island the bird was banded. This custom has been abandoned in favour of metal field-readable bands, which have a longer lifespan and give resightings unbiased by band colour. These have been in use since 1999. You will likely still see some puffins wearing these worn plastic bands. Puffins with green plastic field readable bands were banded on MSI.
Birds with brown (and sometimes blue) field readable bands were banded at Matinicus Rock. Other colours are rarely seen. Plastic bands do not last long and are rarely in good enough condition to read. If a puffin wearing a plastic band is captured, always remove and replace the band with a metal one. Worn plastic bands will have white patches where the outer covering has been worn away (Figure 6). Many puffins wearing plastic bands occur near the Visitor Blinds.

There are also some puffins wearing a field-readable band but have no BBL band. If captured, make sure to equip the bird with a BBL. **Note:** There is some amount of overlap between the field-readable alphanumeric codes of different band types. Make sure to record as many details about a band (ridged, twice or thrice repeated, engraving colour, parts of the BBL sequence) to ensure you are seeing/have captured the correct bird.

In recent years on MSI, researchers have been banding puffins with ridged field-readable bands. Prior to that, non-ridged bands were used. It is not necessary to replace them, unless they are well worn. See Figure 6 for an example of the different types of bands deployed on puffins at MSI.

When replacing a worn BBL band from any seabird, make sure to record the BBL number of the removed band as well as the new BBL band number. Once that information is recorded, the old BBL band can be destroyed. However if the old BBL band cannot be properly read (certain numbers are unreadable), the band needs to be sent for etching (see Removed/Recovered Bands on pg 80 – not in this document). This applies only to BBL bands, not field-readable bands.

While puffins are being banded we also take a number of anatomical measurements, the first of which is mass. Weigh the bird while it is in the bird bag and then weigh the empty bag after the bird is released.

The wing chord (WC) is measured on the right wing from the bird’s “wrist” to the tip of its feathers. Do not flex the feathers, but let them lie in their natural state along the ruler. This is referred to as the “Natural Wing chord” (see Figure 25).

The brood patch (BP) is generally either present or it is not and can be recorded as yes or no. Puffins have two brood patches, which are generally found a little anterior of the “knee”. If it cannot be located check both sides to be sure. It is not obvious when holding the bird and will require some digging around in the feathers to find it.

Pluck at least five breast feathers from puffins and put them in a small bag (whirlpac). Label each bag with the following data:
- MSI
- UNB
- ATPU
- The field-readable band number
- The BBL band number
- The date
- The age of the bird

Put all whirlpacs containing feathers in a large freezer bag (marked with the year and the species) and keep them in the sample freezer. Don’t let feathers sit around at room temperature for a long time.

There are several head measurements that need to be taken on the puffins. Be careful when handling the puffins’ head. If they bite, they can deliver a pretty hard pinch.

On the bird’s head we measure the culmen (NOT including the cere), bill depth, head bill, rosette length, rosette width and number of bill grooves. Measuring head-bill should have the calipers positioned directly over the head, in the vertical plane, so you are sure you have the back end of the caliper at the furthest part of the bird’s head.

The correct way to measure each of these features is shown in Figure 7. The number of bill grooves will vary from puffin to puffin as it is an indicator of age. These grooves are prominent and can be easily identified by running your thumbnail along them. Also, remember that a complete groove will run through both the upper and lower portion of the bill. In many instances the groove closest to the tip of the bill will be incomplete because it will run through only half of the puffin bill. In cases like this you will have a bill groove score such as 2.5. Also, make sure that you do not count the innermost groove on the bill.

Rosettes are the small fleshy orange structures at the sides of the puffin’s beak. They may be used in sexual selection and be an important visual display that helps the puffin secure a mate.

![Figure 7: Guide to puffin head measurements](image)

**Ageing Puffins**

The general life stages of the puffin are illustrated in Figure 8. Puffins cannot be aged beyond “adult” (ATY – After Third Year in banding terminology) and in most cases the age of an adult puffin will be unknown. The abbreviations that correspond with various age classes are detailed below.

Puffin fledgers are young puffins that have left the burrow to go to sea for the first time. Puffin chicks are young puffins that have not yet left the burrow. Their age is classified as L. This stands for “Local” (that is, fledged right here).

Sub-Adult puffins look similar to adult puffins but with a noticeably shallower bill with a distinct notch at the base of the upper mandible. Sub-adult puffins usually have no bill grooves.
Other age classifications are ASY (after second year), ATY (after third year) and AHY (after hatch year). ATY is the most common designation you’ll use for adult puffins. Any adult bird with a brood patch or bill grooves will fall into this category.
- L = chick
- R = recapture
- AHY = after hatch year
- ASY = after second year
- ATY = after third year

**Sexing Puffins**

In the vast majority of cases the sex of a captured puffin will be unknown. The reason for this is that male and female puffins are nearly identical in appearance.

Puffins can be sexed (with 83% and 78% accuracy for females and males) using this equation (Friars and Diamond 2011):

\[ D(0.168) = 0.33(Culmen) + 0.20(Billdepth) + 0.14(Headbill) – 35.03 \]

A second, two-variable equation with graph (Friars and Diamond 2011) is included in Appendix II. It is occasionally possible to identify the sex of a puffin by observing copulations or copulation attempts. This is a rare occurrence because puffins generally copulate on the water (Lowther et al. 2002). Puffin copulation may be observed as one puffin stands on the back of another (Figure 9).

The bird standing on top is a male. The bird on the bottom is, in most cases, a female. In some cases, however, the bird on the bottom can also be a male (Figure 9).

**Recording Banding and Measurement Data**

For every puffin that is captured, banded and processed, make sure to record all the required information on the puffin-banding sheet (Figure 10) and enter each record in the *Seabird Finder* computer program. This also applies to recaptured birds that are processed and re-banded.

Make sure you read the *Seabird Finder user’s manual* before you head
into the field, to familiarize yourself with it.

In terms of how the banding sheet or capture sheet is used, we’ll run through a few examples. The puffin-banding sheet in Figure 10 is intended as an example to highlight some of the items that were discussed in this section. The tables are generally found on different sides of the page but have been shortened to fit on the same page here. As mentioned before, the Seabird Finder program and the puffin data sheets rely on several codes. While looking at these examples, you may have to refer to the later section in this protocol that briefly discusses *Seabird Finder* and its codes.

**Stint Box** – The first step is to fill out the stint box (see Figure 10). Each datasheet can accommodate up to six different stints. Fill in the appropriate Stint box located on the bottom or back of the datasheet. A “stint” is simply a period of time spent doing something. For each stint, fill in the following information in the stint box:

- The location of the trapping effort can be a grid square number or an area of the island such as North West Notch or Lawn.
- Stint type is trapping
- The trap type will be whatever type of trap was used. Use a different row for each trap type.
- Type/# refers to the number of traps that were set. In the case of grubbing or when pursuing birds on foot, enter the number of people that are involved.
- Time is the time that trapping started and stopped. **Do not** forget to enter both times. They are important when calculating effort.

Figure 10: Example banding sheet for the Atlantic Puffin
The example of the ATPU banding sheet (Figure 10) contains definitions in the bottom left corner for most of the abbreviations found in the columns. Note that on MSI we do not currently measure the tarsus on puffins so this column can be ignored.

Stint 2 was a typical adult puffin banding stint with two drop boxes open at Northwest Notch and two boxes open at Visitor Blind 4.

Note that the first bird that was caught was a new bird and thus, only the section titled “New Bands” was filled out.

The second bird captured in stint 2 was a recaptured bird. It did not require new bands so the field readable band was written in the box titled “Recapture Reference” and the appropriate information was filled out on the back of the page.

The third bird was also a recaptured bird so the “Recapture Reference” box was filled out. In addition, the bands on this bird were worn so they were replaced. Thus the “New Bands” box was also filled out.

The third stint was a grubbing stint. The location in the stint box was “MSI General” because researchers generally move all over the island for grubbing stints. The “loc” for each bird is a burrow number.

Also note that in stint three an adult was found in one burrow and a chick was found in the other. Puffin chicks are described in greater detail later in the productivity section and the chick banding section but it is worth mentioning here that when processing puffin chicks, measure only mass, wing chord, culmen, head-bill and feather score.

**Demography**

Researchers will spend numerous hours in the blinds reading puffin bands with a scope. It should be easy to re-sight several hundred per field season but researchers should attain a minimum of two hundred. Take note that we do not do band-reading stints for only Razorbills or only puffins or only terns. Try to read every band from every species that you can. Bring datasheets for multiple species when you go to the blinds.

Band reading should be conducted constantly throughout the season up until the research crew departs. Younger, non-breeding adult puffins tend to appear later in the season and breeding birds will spend more time on the water so the birds being sighted from a particular blind will change throughout the season. Be sure to record in notes a “young” looking puffin – observed either on the water or on the rocks – to confirm SY puffins.

** It is a very good idea to record at least a few numbers of the BBL to confirm you have the read the correct field-readable combination.

An example of the resighting datasheet is shown in Figure 11. Puffin re-sights, like banding records, are entered in the Seabird Finder database. As such, all of the codes and abbreviations for band type (Btype), band colour (BClr), engraving colour (EClr), etc used in the re-sight datasheet (Figure 11) are the same as those from the banding sheet (Figure 10). These codes are summarized later in this protocol at the end of the Atlantic Puffin section. The only addition is the column for behaviours (NOTE: behavioural data are not currently collected on MSI). If a banded puffin is observed behaving in a particular way, record the appropriate
code from the following behavior list. It helps to have these codes printed and taped to all the clipboards that are used during the summer.

- **A** - Allopreening
- **BG** - Billing
- **BW** - Bowing
- **CNM** - Carrying Nest Material
- **CP** - Copulation
- **CA** - Copulation Attempt
- **FE** - Feeding
- **FG** - Fighting
- **G** - Gaping
- **HJ** - Head Jerking
- **HS** - Head Shaking
- **LG** - Loafing
- **LPW** - Low Profile Walking
- **PW** - Pelican Walk
- **PNG** - Preening
- **PPG** - Prospecting
- **RW** - Rise up/Wing Shake
- **SS** - Spot Stomp
- **EE** - Enter/Exit (burrow)

You may have to look up the definitions of these behaviors if they are unfamiliar to you. *The Puffin* (Harris and Wanless 2011) is a good source of information on puffin behaviour.

Re-sighting stints are generally a minimum of two hours long. They can, most often, be done in most types of weather although wind and rain will generally reduce effectiveness.

**Recording Demography/Re-sight Data**

All puffin bands that are re-sighted must be entered on a datasheet found in Figure 11. Take one to the blind every time you go re-sighting.

In addition, *always* be sure that all re-sighting records are entered in the Seabird Finder database.

**Productivity**

In this protocol, puffin productivity and puffin chick growth have been separated into two different sections for the sake of length and readability. In reality, when chicks hatch, both are inseparable and it is important to note that both performed at the same time.

Assessing the productivity of puffins involves regular trips to marked burrows around the island. By reaching
down into the burrow, generally referred to as “grubbing”, we can monitor whether the burrow is empty, has an egg, has a chick, etc. This provides our data on puffin reproduction and chick growth and development each year.

There should be 100-120 marked puffin burrows around various locations on MSI. The coordinates of each burrow are in an Excel file called “Burrow Locations” in each yearly MSI folder on the laptop. The “Burrow Locations” file should be updated yearly, as some are dropped and new ones added. On the first burrow check of the year, bring out a printed copy of the most recent “Burrow Locations” spreadsheet, and a measuring tape, compass, and hammer to locate burrows with fallen markers.

Burrows are assigned a number and are marked by wooden posts with the number painted on the post. It is important to note that some burrows are identified with a number while some, such as burrow 64A, have a letter included. Always make sure the letter is included when identifying the burrow. Burrow 64, for example, is different than burrow 64A. The purpose of including letters was to indicate that the previous nest was no longer in use. For example, the presence of 64A on the island would indicate that burrow 64 was no longer in use. Make sure to pull obsolete nest markers out of the ground; they can cause serious confusion.

Keep a record of each visit made to marked burrows. This will be in the form of either Burrow Check or Chick Check datasheet (see below). Record the date the nest was checked and what was located in the nest.

The first check of all the burrows should be carried out within a few days of arriving at the island (early May). This is to facilitate determination of the date of clutch initiation. Visit every burrow on the list and reach in to the end of the burrow. Record what you find there. The following are examples:
- E = Egg
- EC = Cold Egg
- X = Empty
- A = Adult
- DE = Dead Egg
- C = Chick
- NC = New Chick (known age!)
- CNF = Chick no find
- ? = don’t know

![Figure 12: Example timeline of ATPU burrow checks for productivity and chick growth.](image-url)
### Figure 13: Burrow Check Datasheet

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### Figure 14: Chick Check Datasheet

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Remain at the nest only long enough to determine its status. If an adult and an egg are present do not remove the adult from the nest – they are often particularly sensitive at this stage of the breeding cycle (Harris and Wanless 2011; Rodway et al., 1996), although we have found this not to be so on MSI. Mark the date on the egg with a sharpie marker.

Occasionally a burrow may be too deep to grub. If the end of the burrow cannot be reached, then it is too deep to be accurately monitored and should be dropped from the list of burrows. Pull up the post and be sure to make a list of all the dropped burrows for the season. If you can reach the end of the burrow but are not sure of its status, use the video-probe to look into it…

The second check should be scheduled a week after the first (Figure 12). On the second check grub only those burrows that were empty on the first check. Burrows that contained eggs on the first check should be left until ‘chick checks’ start (after the incubation period).

The third check should take place a week after the second. For this check, grub burrows that were empty on the second visit. Burrows that are still empty on the third visit can be recorded as inactive and ignored for the remainder of the season.

After the first three checks, schedule each burrow to be revisited at the end of a full incubation period. For puffins this is about 37 days. However, if most of the burrows have eggs on the first round of burrow checks, assume a few days of incubation have already passed and visit the burrows earlier (33 days).

If an egg has not hatched after the 37-day period, continue to check it every week until it does, or has been cold on two successive checks. After the incubation period, every time a marked burrow is checked, it is considered a part of the puffin chick check.

**Recording Productivity Data**

All visits to burrows in May should be recorded on “Burrow Check” datasheet (see above)) and the corresponding portion of the “Productivity and Growth” Excel file. For all visits to burrows after the incubation period, use the “Chick Check” datasheet (see above) and the corresponding portion of the “Productivity and Growth” Excel file. Both datasheets are available to print as a tab within the “Productivity and Growth” Excel file.

**Chick Growth**

When a puffin chick is found in a marked burrow, it should be taken out and measured. If present, first remove the adult, or adults, from the burrow. Remove the chick last. Process the chick first and return it to its nest.

![Figure 15: Growth trend for Atlantic Puffin chicks](image-url)
removing the chick last and returning it first, the adult will not be aware that the chick was disturbed. If you encounter a banded adult in the burrow, make sure that you record its band numbers on the chick check datasheet in the spot for adult bands. If you find an unbanded adult in the burrow, band it then write the new band numbers on the chick check datasheet. Always bring an ATPU banding sheet (Figure 10) with you on chick/growth checks for when you find new or previously banded adults in burrows. It happens very often! Take all necessary measurements.

Always make a special note when encountering a newly hatched puffin chick. Chicks of known age are very important elements for calculating the age of other chicks. Newly hatched chicks are generally unable to use their legs, may have eggshell stuck to their feathers, be slightly wet or have their eyes closed. Record the date that the chick hatched in the “Known Hatch Date” column of the chick check datasheet. Always bring a chick growth datasheet with you when you are checking puffin burrows for chicks. All chicks need to be measured within their first 5 days after hatching.

Known-age chicks need to be measured twice within their first 5 days after hatching. If you find a newly hatched (known age) chick, make a note on the chick check datasheet to remind yourself that you need to come back to this burrow in a few days.

Puffin chicks enter linear growth after the 10th day after hatching and finish linear growth after the 30th day after hatching (Figure 15). Make sure to visit the chick twice within this time frame and take the appropriate measurements. See the next page for an example of the puffin growth datasheet. Notice that we take fewer anatomical

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**Figure 16:** Example feather scores (FS) for seabird chicks. Top, COMU chick with feather on wingtips (FS = 9). Middle, RAZO chick with feathers on wings, sides and some on head (FS = 4). Bottom, ATPU chick with feathers on wings and belly (FS = 5). FS 10 and 1 can be seen in Figure 8.
measurements on the chicks when compared to the adults.

The measurements taken during this linear growth phase are what will be used to calculate the puffin growth rates. The linear growth phase, as far as we are concerned, applies to bird mass, culmen length and, especially, wing chord.

It is important to make note of the feather score (FS) of puffin chicks. Puffin chicks are covered with fluffy down when they hatch and slowly lose it while they grow. By the time they fledge after approximately 40 days, they’ve generally lost all their down and replaced it with feathers. Feather score is recorded as a number from 0 to 10. These numbers correspond to how much down covers the bird’s body. A score of 0 means there is no down on the chick (0% of body covered in down), a score of 10 means that the chick is covered with down, a score of 5 would mean the chick was half covered with down, etc (Figure 16).

Record whether each chick has an egg tooth or not. This will be observed as a white bump on the tip of a young chick’s upper mandible. As the chick grows it will lose this structure.
## Figure 17: Puffin Ageing Datasheet (Day 1-5) and Linear Growth Datasheet (Day 10-30)

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<td>147</td>
<td>40</td>
<td>21</td>
<td>45</td>
<td>52</td>
<td>9</td>
<td>N</td>
<td>EMT</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>124</td>
<td>G00F</td>
<td>24-Jun</td>
<td>24-Jun</td>
<td>24-Jun</td>
<td>24-Jun</td>
<td>AM</td>
<td>165</td>
<td>35</td>
<td>36</td>
<td>24</td>
<td>54</td>
<td>10</td>
<td>N</td>
<td>RWH</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>27</td>
<td>G00F</td>
<td>9-Jul</td>
<td>29-Jul</td>
<td>9-Jul</td>
<td>9-Jul</td>
<td>AM</td>
<td>126</td>
<td>20</td>
<td>33</td>
<td>21</td>
<td>51</td>
<td>9</td>
<td>Y</td>
<td>EMT</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>433</td>
<td>G00F</td>
<td>28-Jun</td>
<td>18-Jun</td>
<td>18-Jun</td>
<td>18-Jun</td>
<td>AM</td>
<td>172</td>
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<td>4</td>
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<td>EMT</td>
</tr>
<tr>
<td>12</td>
<td>406</td>
<td>G00F</td>
<td>15-Jul</td>
<td>26-Jun</td>
<td>26-Jun</td>
<td>26-Jun</td>
<td>AM</td>
<td>172</td>
<td>20</td>
<td>44</td>
<td>22</td>
<td>53</td>
<td>13</td>
<td>4</td>
<td>N</td>
<td>EMT</td>
</tr>
<tr>
<td>13</td>
<td>403</td>
<td>G00F</td>
<td>16-Jul</td>
<td>16-Jul</td>
<td>24-Jun</td>
<td>24-Jun</td>
<td>AM</td>
<td>162</td>
<td>35</td>
<td>37</td>
<td>20</td>
<td>51</td>
<td>10</td>
<td>N</td>
<td>RWH</td>
<td></td>
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<tr>
<td>14</td>
<td>76</td>
<td>G00F</td>
<td>29-Jul</td>
<td>29-Jul</td>
<td>29-Jul</td>
<td>29-Jul</td>
<td>AM</td>
<td>162</td>
<td>20</td>
<td>44</td>
<td>23</td>
<td>54</td>
<td>8</td>
<td>N</td>
<td>EMT</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>401</td>
<td>G00F</td>
<td>23-Jun</td>
<td>24-Jun</td>
<td>24-Jun</td>
<td>24-Jun</td>
<td>AM</td>
<td>162</td>
<td>35</td>
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<td>22</td>
<td>52</td>
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<td>Y</td>
<td>RWH</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>176</td>
<td>NWN</td>
<td>27-Jun</td>
<td>27-Jun</td>
<td>27-Jun</td>
<td>27-Jun</td>
<td>AM</td>
<td>142</td>
<td>21</td>
<td>34</td>
<td>22</td>
<td>52</td>
<td>10</td>
<td>Y</td>
<td>AKB</td>
<td></td>
</tr>
</tbody>
</table>
**Ageing Chicks**

As previously mentioned, locating chicks of known age is **very important**. These chicks are very valuable, because their wing chord and age can be used to calculate the age of unknown chicks. Figure 18 below shows how:

**Figure 18**: primer on how to age chicks using chicks of known age.

### 1. Using known-age chicks

<table>
<thead>
<tr>
<th>DAY 1-5 (aging) measurements</th>
<th>WING CHORD 1</th>
<th>WING CHORD 2</th>
<th>AGE 1</th>
<th>AGE 2</th>
<th>WING 1</th>
<th>WING 2</th>
<th>SLOPE</th>
<th>INTERCEPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chick 1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>14</td>
<td>0</td>
<td>2</td>
<td>1.000</td>
<td>12.000</td>
</tr>
<tr>
<td>Chick 2</td>
<td>1</td>
<td>2</td>
<td>15</td>
<td>16</td>
<td>1</td>
<td>2</td>
<td>1.000</td>
<td>14.000</td>
</tr>
<tr>
<td>Chick 3</td>
<td>2</td>
<td>4</td>
<td>18</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>1.000</td>
<td>14.000</td>
</tr>
<tr>
<td>Chick 4</td>
<td>0</td>
<td>3</td>
<td>17</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>1.333</td>
<td>13.000</td>
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<tr>
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<td>1</td>
<td>15</td>
<td>14</td>
<td>0.500</td>
<td>13.500</td>
</tr>
</tbody>
</table>

**NOTE:**
You do not have to calculate ages or growth rates manually; formulas within the “Productivity and Growth” Excel file do this for you.

### 2. Estimating ages of unknown chicks

![Table with calculations](image)

**Figure 18**: primer on how to age chicks using chicks of known age.

### 3. Growth Measurements

<table>
<thead>
<tr>
<th>DAY 5-15 Growth Measurements</th>
<th>WING CHORD 1</th>
<th>WING CHORD 2</th>
<th>AGE 1</th>
<th>AGE 2</th>
<th>WING 1</th>
<th>WING 2</th>
<th>SLOPE</th>
<th>INTERCEPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chick 1</td>
<td>6</td>
<td>14</td>
<td>28</td>
<td>26</td>
<td>6</td>
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<td>26</td>
</tr>
<tr>
<td>Chick 2</td>
<td>7</td>
<td>13</td>
<td>27</td>
<td>27</td>
<td>7</td>
<td>5</td>
<td>22</td>
<td>27</td>
</tr>
<tr>
<td>Chick 3</td>
<td>5</td>
<td>14</td>
<td>25</td>
<td>25</td>
<td>5</td>
<td>7</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Chick 4</td>
<td>6</td>
<td>18</td>
<td>26</td>
<td>26</td>
<td>6</td>
<td>15</td>
<td>18</td>
<td>26</td>
</tr>
<tr>
<td>Chick 5</td>
<td>8</td>
<td>25</td>
<td>27</td>
<td>27</td>
<td>8</td>
<td>13</td>
<td>25</td>
<td>27</td>
</tr>
<tr>
<td>Chick 6</td>
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<td>22</td>
<td>28</td>
<td>28</td>
<td>6</td>
<td>12</td>
<td>22</td>
<td>28</td>
</tr>
<tr>
<td>Chick 7</td>
<td>5</td>
<td>23</td>
<td>28</td>
<td>28</td>
<td>5</td>
<td>11</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td>Chick 8</td>
<td>7</td>
<td>24</td>
<td>27</td>
<td>27</td>
<td>7</td>
<td>14</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>Chick 9</td>
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<td>25</td>
<td>27</td>
<td>27</td>
<td>8</td>
<td>15</td>
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<tr>
<td>Chick 10</td>
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<td>29</td>
<td>29</td>
<td>7</td>
<td>13</td>
<td>22</td>
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<tr>
<td>Chick 11</td>
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<td>22</td>
<td>30</td>
<td>30</td>
<td>6</td>
<td>14</td>
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<tr>
<td>Chick 12</td>
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<td>28</td>
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<td>32</td>
<td>7</td>
<td>14</td>
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<tr>
<td>Chick 13</td>
<td>8</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>8</td>
<td>13</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

**NOTE:**
These chicks have an average WING growth rate of 0.735 (mm/day) with a 0.32 standard deviation.
NOTE: Sometimes things can get messy in Excel. Be vigilant with moving data around and erasing rows, etc.

**Scheduling Burrow Checks**

It is important to enter data from the datasheets into the “Productivity and Growth” file often. Since ages are calculated automatically, these datasheets will self-update. You will need to print out several copies of the same datasheet over the course of the summer to update the data for each burrow. A good rule of thumb is to make sure data from all datasheets are entered into the computer every other day. The Chick Check and Ageing (Growth Day 1-5) datasheets need to be printed only once – but if they get really dirty, it might be a good idea to reprint them. However, the Growth (day 10-30) datasheet needs to be printed out several times in the season because this datasheet tells you when you need to visit each chick within its linear growth period. Print yourself a new Growth (day 10-30) datasheet about once a week.

The Chick Check datasheet will help you schedule which burrows need to be checked (for checks to see if an egg has hatched and for burrow visits to get ageing or linear growth measurement). Always refer to the electronic data to determine which burrows need to be visited. Do this daily (it doesn’t take long!). Use highlighters to identify which burrows need visiting on any particular day. Using different coloured highlighters can help you keep track of the purpose of your visit to each burrow (eg: yellow = chick check, green = ageing measurement, blue = growth measurement). A highlighted cell means, “this burrow needs to be checked on this date.”

NOTE: Reprinting datasheets also makes life easier. You can easily sort the data to keep all the active burrows at the top or the sheet.

**Banding**

After measuring the chick twice during its linear growth phase, visit it again on about day 35. The chick should be out of linear growth phase at this point but the purpose of this visit is primarily to band the chick (Figure 12); take measurements as well.

Puffin chicks generally have to be fairly large before they can hold a band as puffin bands tend to slip off the leg of smaller chicks. Usually, when the wing chord of the chick is about 115 mm, the chick is large enough to band but there is a lot of variation with this rule. Always remember to bring the “Burrow Banding” datasheet (available to print from a tab of the “Productivity and Growth” Excel file) on growth/productivity checks when chicks become old enough to band.

After banding the chick, return to the nest approximately every seven or so days until it has fledged and always verify if a chick has left the nest by doing a follow up check a few days later (Figure 12). You may have missed it the first time. Be sure to take measurements.

**Datasheets and Data Entry**

The ‘Burrow Banding’ datasheet should be printed out often (like the linear growth (day 10 -30) datasheets). If you keep reprinting them, the “day 35” value assigned to each chick will stay current and you will decrease your chances of missing your banding opportunity for that chick.
Once you put a band on a chick, it needs to be entered in *Seabird Finder*. The easiest way to do this is to keep a designated banding sheet for productivity chicks, and enter the relevant stint soon after each round of banding. You may also want to keep a Bander’s Field Datasheet regularly updated with bands that are deployed or destroyed as you band chicks; you will quickly forget what you did in the field! Chicks that die during the season still need to be entered; enter them as a new bird in *Seabird Finder* on the banding date, and additionally as a recovery on the date that you found them dead.

**Feeding**

Puffins begin bringing in food to feed their chicks after they hatch. Our goal is to observe what kind of food the parents are supplying.

Feeding-observation stints are much like band-reading stints. The researcher goes to the blind and records all the adult puffins that bring in food to a specified plot and identifies, if possible, what items the adult brings in.

There are three plots used for puffin feeding watches. The blinds used to observe the plots are Visitor Blind 3, Visitor Blind 1 and Goofapuff Blind. The boundaries of the plots are marked by blue dots spray-painted on the rocks.

Observation stints last for 3 hours and should begin as soon as enough chicks have hatched to warrant a full stint. During band reading stints, keep an eye on whether the puffins are bringing in food or not. When you notice that there are 1 to 2 feedings per hour, it is time to start doing feeding watches. The starting date of feeding watches will be different for each species. New observers need to be trained in identifying prey by paired observation with an experienced observer once feedings begin, by using photos from previous years, or by using the reference collection in the hall closet. Since observers may differ in their identification skills, it is very important to rotate observers among blinds and target species, and to compare each set of observations at the end of each day.

It is also important to rotate the times of day that each species is observed to decrease any biases in observations. Try to schedule observations of a tern species and an alcid species on the same day (and if possible at the same time using two different observers). This will be useful when making comparisons between foraging guilds such as surface-feeding terns and diving alcids. If terns are not breeding, schedule stints of puffins and razorbills on the same day if possible.

An example of the feeding watch data sheet is shown in Figure 19. Fill in
the date, species and appropriate times.

Each time a puffin brings food into one of the nests on the plot, count the number of prey items in its bill, the size of the prey items (see below) and the species of the prey items.

The size of the prey item is defined by how it compares to the culmen length of the bird (Figure 7). If, for example, the prey item is the same length as the culmen, then the length is 1.

The codes used for each prey item are found in Appendix III. On the external hard drive and printed out, there are reference materials to help you learn how to identify different species of fish. Use them!

All ATPU feeding watch data must not only be recorded on the datasheets, but must also entered in the Seabird Provisioner database.

**Trapping Puffin Chicks**

Banding puffin chicks is especially important because they are of known age. When trapping and banding adults we do not know their age, but banding chicks increases the number of known-age birds we have in our banded population. Naturally, knowing the age of a bird is an important aspect of a demographic study so make every effort to band as many chicks as possible.

Puffin chicks on MSI fledge at night beginning in late July and continue into August. In fact, they are usually still fledging when researchers leave the island.

Fledging puffin chicks are commonly found on the lawn around the lighthouse area after dark.

There are several chicken-wire fences, which should be set up near the lighthouse at night to act as a corral for fledging chicks (Figure 20). Researchers should check the corral and lawn area from the house to the helipad at least every half hour. Capture any chicks by hand or with a net and bring them back to the house to be banded and measured. Fledger-bandng stints can run as late as 3 in the morning especially if the fledgers are abundant.

**Make sure** to use the ATPU Fledger Banding Sheets (a slightly modified version of the adult datasheet) for fledger catching stints. When processing ATPU chicks, measure the head bill length, culmen, wing chord and mass. Don’t forget to take breast feathers (see the banding section).

After the chicks are processed, they can be released on the landing down near the water. From there they will find their way out to sea.

Speculation as to why fledging puffins are attracted to the lighthouse includes light from the lighthouse lamp, vibrations from the generator located inside the lighthouse and the loud noise of the generator. The attraction of fledgers to the lighthouse area seems to
be reduced under a full moon.

Although this phenomenon has never been studied experimentally, observers have reported that fewer puffin chicks are captured on nights when the generator is not running.

The increasing dependence of the island infrastructure on solar panels and wind power has reduced the use of the generator. Several of the lighthouse keepers have been very accommodating and have made an effort to run the generator for us on nights when we trap puffin fledgers. This occurrence is a privilege, which may vary from keeper to keeper.

A second method for banding puffin chicks is to move through the colony, grub multiple burrows and band any chicks large enough to hold a band. You can estimate when to begin grubbing for chicks by referring to the sizes of the chicks that are in the marked burrows. Make sure that only chicks that are close to fledging are banded, otherwise the bands may fall off.

**Abbreviations for Seabird Finder, Puffin Banding sheets and Puffin Re-sight sheets**

*Seabird Finder*, the ATPU banding datasheet, and the ATPU band reading datasheet usually require various observations about puffin bands and will occasionally require that the colour of bands, the colour of engravings and any special features be entered.

**Band Type**

Each different type of band used on puffins in the Gulf of Maine has been assigned a particular code. Codes with an asterisk next to them are most frequently used.

*BBL – Bird Banding Lab (service band)*

*NMFR – Non-ridged metal field-readable*

*RMFR – Ridged metal field-readable*

PFR – Plastic field-readable

BC – Bicoloured

CC – Coloured coiled

**Band Colour**

The colour of puffin bands is required for *Seabird Finder* and must be recorded for each band that is read on a bird or applied to a bird. Most commonly used on MSI will be metal bands with a metal engraving. Beware: ridged bands may be metal bands with black engraving. Sometimes the black engraving wears off which gives the appearance of a metal band with a metal engraving. The codes assigned to the various band colours are listed below. On MSI almost all puffin bands, with the exception of a few plastic bands, will be metal.

- M – Metal
- W – White
- BLK – Black
- Y – Yellow
- BLU – Blue
- BRW – Brown (looks brick-red)
- R – Red
- G – Green
- LG – Light Green
- Or – Orange
- BrB – Blue/Red/Blue Stripes
- ObO – Orange/Black/Orange Stripes

**Engraving Colour**

The engraving colour on the band is just as important as the band itself. The engraving colour refers to the colour of the letters/numbers that appear on the band. The codes assigned to the various engraving colours are listed below. On MSI metal will apply to BBL bands and non-ridged field readable bands. Black will apply to ridged field
readable bands. It is unlikely that the others will be used.

- M - Metal
- W - White
- BLK - Black
- BLU - Blue
- BRW - Brown
- R - Red
- Y - Yellow
- None – No engraving

**Special Features**

Although there are many special features that have to be assigned to bands in the Seabird Finder program, most are no longer in the population. A special feature basically refers to how many times a code appears on the band. The three codes that will be used over 99% of the time are as follows:

- HNR – Horizontal Not Repeated. This is when the number code occurs only once on the band such as with the BBL bands.
- HR – Horizontal Twice Repeated. Older non-ridged field readable bands have the alphanumeric code printed on them twice.
- HTR – Horizontal Thrice Repeated. Recently deployed non-ridged field readable bands and ridged field readable bands have the alphanumeric code on them three times.

Due to potential code overlap between different types of bands, it is critically important to record at least part of the BBL to verify your resight. Also be sure to specify whether a metal band is ridged or non-ridged (see Figure 6).

**Band Wear**

These data are no longer recorded on MSI. Record band wear on bands from recaptured birds and any birds seen during resighting stints in which you have seen the entire band. It may be difficult to obtain during resighting stints because the bird will have to turn in a full circle but be vigilant. This applies to both field readable bands and BBL bands. The band scoring scheme is as follows (see also Figure 21).

1 – No wear on band
2 – Light wear – Some wear but all characters easily read
3 – Moderate wear – One or more characters difficult to read
4 – Severe wear – One or more characters unreadable

![Figure 21: ATPU BBL bands showing various stages of wear](image)

**Age**

The column titled “Age/H” is an approximation on the age of the puffin being banded. The H refers to how the puffin was aged. The following codes can be used in this column for the age of the puffin. Transplant Chicks are not used on MSI so any chicks banded should be identified as a Local Chick.

- AHY – Adult Status Unknown (should not be necessary – “adults” are by definition ATY)
ASY – Subadult
ATY – Adult
L – Local Chick

As for how the puffin was aged, use the following codes in the same column:
1 – Known breeder
2 – Bill Grooves (ridges)/Bill size
3 – Adult (breeding status unknown)
4 – Brood patch present

Sex
The sex of a puffin will in most cases be recorded as U for unknown. If known, record M or F. On the banding sheet the H in Sex/H stands for how the bird was sexed. The following codes can be used for how the puffin was sexed.
1 - Compare bill measurements to mate
2 – Compare bill/body size to mate
3 – Copulation
4 – Copulation attempt

Proximity
Abbreviated to “Prox” - proximity is defined as the distance of the capture from whatever landmark was written in the “Loc” column. Simply write in the appropriate number found in the following list that corresponds to the approximate distance.
1 - Captured in Burrow
2 - Entering or Exiting the Burrow
3 - Within 2 metres
4 - Within 4 metres
5 - Within 6 metres
6 - Within 10 metres
7 - Within 20 metres
10 - Within 50 metres

Trap Method
Each trap method (TrM) has been assigned a number from the list below. Adult puffins are targeted primarily by using box traps, however several are captured throughout the year by other methods.
1 - Grubbed
2 - Box Trap
3 - Noose Mat
4 - Mist Net
5 - Pursue
6 - Transplant Chick
7 - Unknown

Puffin Behaviours
Record any of the following puffin behaviours that are carried out by a banded puffin (no longer recorded).
A - Allopreening
BG - Billing
BW - Bowing
CNM - Carrying Nest Material
CP - Copulation
CA - Copulation Attempt
FE - Feeding
FG - Fighting
G - Gaping
HJ - Head Jerking
HS - Head Shaking
LG - Loafing
LPW - Low Profile Walking
PW - Pelican Walk
PNG - Preening
PPG - Prospecting
RW - Rise up/Wing Shake
SS - Spot Stomp
EE - Enter/Exit
The Razorbills at Machias Seal Island have had a somewhat rocky history as detailed by MacKinnon and Smith (1985b). The earliest reference from MacKinnon and Smith (1985b) to Razorbills breeding on MSI comes from 1886 when a single Razorbill egg was collected for the New Brunswick museum. Numbers remained low, likely under 100 pairs, until the late 1940’s when, as nesters, the Razorbill disappeared from MSI. They began to return in the mid 1950’s and by 1985 had reached a population of approximately 75 to 100 pairs.

Although it is the least abundant auk in Atlantic Canada (Gaston and Jones 1998), today the Razorbill is the second most numerous auk species on Machias Seal Island. A census conducted by Grecian (2005) in the breeding season of 2001 calculated 600 breeding pairs of Razorbills at MSI.

The species code used for the Razorbill, as defined by the Bird Banding Lab, is RAZO. When recording data, enter the species code RAZO as opposed to Razorbill.

**Banding**

When researchers on MSI target Razorbills, they generally use a noose mat. Noose mats, generally made of some kind of rope or wire net, can be anchored to the rocks in a Razorbill loafing area. The mat is covered with nooses made out of monofilament line. When the Razorbills are shuffling around on the loafing areas, they will walk over the mat and the nooses will close around their legs.

Razorbills on MSI tend to loaf close to the water. As a result, Razorbills will generally loaf on different rocks at high tide than they will at low tide. Make sure to watch the tide if you are trapping close to the water.

Always make sure that the mat is securely anchored down by tying down the four corners to rocks. If two or more Razorbills become entangled on the same mat they may dislocate it.

Using noose mats to capture seabirds is always a two-person job.
This is especially true where Razorbills are concerned. One person is required to hold the Razorbill while the second person removes the nooses from around its leg. Razorbills are quite capable of drawing blood with an extremely hard pinch and it is very important that the person holding the Razorbill is wearing gloves. Take care to keep the bird oriented so that it cannot bite the exposed hands of the person who is removing the nooses.

Razorbills are given one triangular eight-digit BBL band (Figure 23) on their right leg, on which the last five digits can be read from a distance. Two sides of the band have the band number on them. The third side does not. Make sure when closing the band that the unmarked side is positioned against the back of the bird's tarsus. This way when the Razorbill is walking, the unmarked side will be in contact with the ground. These bands are designed such that they will not rotate after they are applied to the bird’s leg; if they are closed improperly the numbers will be upside-down and are likely to be misread. Close the Razorbill band as shown in Figure 24 – either leave the long end tucked in as in letter A, or continue to letter B by “popping” the long end out so that both ends butt together. Improper closure of a triangular band may result in band deformation over time, allowing it to open and fall off or close too tightly around the bird’s tarsus – whichever method you choose, be certain you have closed the band well!

**Razorbill Measurements and Banding Sheet**

Take the mass of the bird while it is still in the bag. Weigh the empty bag after you release the bird. Most researchers prefer to leave the bird in the bag during the processing and just let the portion of the bird they are working on stick out. Apply the band to the bird by
pulling its right leg out of the bag. After you’ve banded the bird, pull the bird’s right wing out and measure the wing chord (Figure 25). Let the birds wing lie along the ruler in its natural state. Don’t straighten it out.

Figure 26: Guide to Razo head measurements.

Be careful while taking head measurements on the Razorbills. Unlike puffins they will twist their head while trying to free themselves from your grip. This manoeuvre is very effective at freeing their bill so be sure to keep a firm, but not too firm, grip on it.

Take the head-bill, culmen, gape and depth measurement. The measurements are summarized in Figure 26. In addition, it is important to measure the width and the depth of the white line on the Razorbill face. Be very careful while using the calipers near the bird's eyes. Don’t put them any closer than necessary.

Make sure to check for a brood patch. Razorbills have two brood patches, which are generally found a little anterior of the “knee”. If it cannot be located check both sides to be sure. It is not a highly visible feature and it will usually require some digging around to find.

Similar to the puffins, Razorbills also have bill grooves which increase in number as the bird ages. Make sure to record how many there are. Razorbills can have anywhere from zero grooves up to 2.5 or 3 grooves. Do not count the groove in the white bill line.

Pluck at least five breast feathers from Razorbills and put them in a small bag. Label each bag with the following items.

- MSI
- UNB
- RAZO
- The BBL number
- The date the feathers were collected
- Age (L or AHY)
- The letter “R” if the Razorbill was a recaptured bird.

Razorbills are difficult to identify to sex for many of the same reasons that were discussed in the puffin section. One important difference is that Razorbills copulate primarily on the land (Figure 27). Thus, you’ll have more opportunities to identify the sex of a banded Razorbill, especially towards the beginning of the season when mating is
more frequent.

If head measurements are obtained, Razorbills can also be sexed using the following discriminant function from Grecian et al. (2005 – see graph in Appendix II). This function has an 80% success rate for the Razorbills at Machias Seal Island.

\[
D = 0.25(\text{HB}) + 0.73(\text{DEP}) - 40.84
\]

HB = the head to bill measurement  
DEP = the bill depth measurement  
If \( D \) is greater than \(-0.04 \) it has an 80% probability of being a male  
If \( D \) is less than \(-0.04 \) it has an 80% probability of being female

The Razorbill banding sheet is much less complex than the puffin sheet. Make sure that each Razorbill that is banded is entered on the datasheet (Figure 28). The Razorbill banding computer spreadsheet looks the same as the banding sheet.

There are two main formats for recording the Razorbill measurement and banding data. Each time a Razorbill is banded, enter the information in the following:

- Banding datasheet (Figure 28)  
- Banding spreadsheet (Figure 28)

**Demography**

It is important to note that band reading from any one blind can bring you in contact with bands from several species of bird. When going to the blinds to read bands, it will be necessary to bring band-reading sheets for numerous species. On MSI we do not do band reading stints for only Razorbills or only puffins. Try to read every band from every species that you can. Because the number of banded birds in a population increases each year, it should be easy to re-sight several hundred Razorbill bands per field season.

 Attempt to read Razorbill bands constantly throughout the season up until the research crew departs. Younger, non-breeding adult Razorbills tend to loaf on the rocks later in the season and breeding birds will spend more time on the water, so the birds being sighted from a particular blind will change throughout the season.

Take note of any banded birds that you observe copulating (Figure 27). You may be able to identify what sex it is in the comments section.

Every time you read a Razorbill band, it should be entered on:

- Razorbill resight datasheet  
- Razorbill resight spreadsheet

Both the band reading sheet and the computer spreadsheet follow that same format. Figure 29 is an example of the datasheet you will take to the blind. The computer spreadsheet follows the same format and will contain all the resights from the field season.
Razorbill productivity is estimated the same way as puffin productivity. There are several differences that will be covered here, but for the most part the methods from the Atlantic Puffin Productivity section can be applied to the Razorbill.

Assessing the productivity of Razorbills will involve regular trips to marked nests. The Razorbills nest amongst the rocks and boulders around MSI. They nest in crevices, under rocks (Figure 30) and, occasionally, on ledges. As a result, the majority of Razorbill nests are difficult to reach but several are still accessible.

By reaching into the Razorbill’s nest we can monitor whether the burrow is empty, has an egg, has a chick, etc. This provides the data on Razorbill reproduction and chick growth and development each year.

There should be between 75 and 85 marked Razorbill burrows around various locations on MSI. Razorbill nests are assigned a number and these numbers are painted on the rocks at the entrance of the nest or on the rock covering the nest. These numbers are black and are painted on a white square.

The first check of all the marked Razorbill nests should be carried out within a few days after arriving on the island (early May). This is to facilitate determination of the date of clutch initiation.

At the beginning of the season it is best to check Razorbill nests on a different day of the week than puffins. For example, check Razorbills on Monday and puffins on Wednesday.

Make sure that the first check of the marked Razorbill nests is carried out within the first few days after arriving on the island in early May. Record what is found in each nest. Mark the date on the egg with a sharpie marker.

The second check should take place one week after the first. On the second check, visit only nests that were

<table>
<thead>
<tr>
<th>Ad</th>
<th>w.</th>
<th>Time Ob Start</th>
<th>Time Ob End</th>
<th>Total</th>
<th>Time Read</th>
<th>Location</th>
<th>RBL Band #</th>
<th>Leg (RL)</th>
<th>Field-readable band #</th>
<th>Colour type</th>
<th>Leg (RL)</th>
<th>Breeding</th>
<th>Init.</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>09</td>
<td>07</td>
<td>11:10</td>
<td>14:10</td>
<td>1</td>
<td>12:15</td>
<td>Stock</td>
<td>895-45637</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>07</td>
<td>09:00</td>
<td>12:00</td>
<td>3</td>
<td>9:30</td>
<td>NWN</td>
<td>895-27767</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
<td>GMB</td>
</tr>
<tr>
<td></td>
<td>07</td>
<td>10:15</td>
<td>NWN</td>
<td>895-21963</td>
<td>R</td>
<td>Trane Plastic</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GMB</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>07</td>
<td>10:45</td>
<td>NWN</td>
<td>895-54541</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The third Razorbill on the list was seen with a transmitter. The second bird was observed mating on top. It must be male.

Figure 29: Example of a Razorbill resighting datasheet. Note that the excel computer spreadsheet follows this same format.

**Productivity**

Razorbill productivity is estimated the same way as puffin productivity. There are several differences that will be covered here, but for the most part the methods from the Atlantic Puffin Productivity section can be applied to the Razorbill.

Assessing the productivity of Razorbills will involve regular trips to marked nests. The Razorbills nest amongst the rocks and boulders around MSI. They nest in crevices, under rocks (Figure 30) and, occasionally, on ledges. As a result, the majority of Razorbill nests are difficult to reach but several are still accessible.

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Make sure that the first check of the marked Razorbill nests is carried out within the first few days after arriving on the island in early May. Record what is found in each nest. Mark the date on the egg with a sharpie marker.

The second check should take place one week after the first. On the second check, visit only nests that were

Figure 30: Life stages of the Razorbill. Clockwise from top left: RAZO egg in nest site, young chick less than 24 hours (note presence of eggshell on down), adult, young chick with egg tooth.
empty on the first check. Nests that contained eggs on the first check can be ignored until it is time to check for chicks.

The third check should take place a week after the second. For this check, grub nests that were empty on the second visit. Nests that are still empty on the third visit can be recorded as inactive and ignored for the remained of the season.

All the Razorbill nests should fall into one of two categories. If an egg is not found within the first three checks, that nest will be inactive for the season. For nests where an egg is found, schedule that nest to be checked at the end of the Razorbill incubation period.

Razorbills have a slightly shorter incubation period than puffins (35-37 days, Lavers et al 2009). Schedule the nests where eggs were located to be checked in 35 days (or earlier if most nests had eggs on the first burrow check).

If an egg has not hatched after this period, continue to check it every week until it does.

After chicks hatch, Razorbill chick growth is incorporated into the Razorbill nest check. Every time a marked nest is checked, it is considered a part of the Razorbill nest check.

Growth

Razorbill chick growth is measured in the same manner as puffin chick growth. This section highlights some of the differences but make sure you refer to the puffin growth section for a more complete description.

When a Razorbill chick is found in a marked burrow, it should be taken out and measured. In most cases Razorbill adults will flee the area when a researcher approaches but if present, first remove the adult, or adults, from the burrow. Remove the chick last. Process the chick first and return it to its nest. Process and return any adults last. Record adult band numbers (bring an adult RAZO banding sheet!) on the chick check datasheet.

Always make a special note when encountering a newly hatched Razorbill chick (Figure 30). Record the hatch date on the chick check datasheet.

Visit chicks of known age twice in the first 5 days after hatch. Make sure to visit all chicks once between 1-5 days and twice between day 5 and 15 and take the appropriate measurements. Measuring Razorbill chicks is done in the same manner as measuring puffin chicks. In fact, they use the same datasheet.

New in 2013: for the second growth measurement, include whether or not the chick is growing basic or alternate plumage. Alternate plumage looks like that of the breeding adults (see fledger in Figure 31); basic plumage is like that of wintering adults, featuring white throat and cheeks.

Razorbill chicks grow much faster than puffin chicks. They enter linear growth after the 5th day of
hatching and finish linear growth after the 15th day after hatching (Figure 31).

When the chick is eventually banded make sure to record the BBL number on the chick banding datasheet. Razorbill chicks have large feet when compared to puffin chicks. As such the Razorbill chicks can hold bands at a much earlier age. Try not to band the chick when it is too young but wait until the chick is towards the end of linear growth. However, do not wait too long, as chicks can fledge as early as day 16. Be especially vigilant with timing of checks for Razorbills, as the margin for error is much smaller than with puffins.

Data sheets and Spreadsheets

The datasheets and spreadsheet for the razorbills are similar to the puffin’s with these three differences: 1) Incubation is shorter, so “Predicted Hatch Dates” are calculated in Excel with 35 days instead of 37. 2) The linear growth period for razorbills is between day 5-15, so there is a greater rush to get the razorbills measured. 3) Razorbills fledge earlier (16-22d), so banding should occur at the same time as the second growth measurement.

There is no “Razorbill Finder” database, so all banding information needs to be entered on the RAZOBanding spreadsheet in Excel.

Feeding

Make sure to review the feeding section in the Atlantic Puffin chapter. Razorbill feeding watches are conducted in the same manner as the puffin feeding watches and to avoid repetition only the few differences between the two are covered here.

Razorbill feeding watches are conducted from three locations. They are all portable blind locations and are named Portable Blind (PB) 1, PB2 and PB3. You will find the tent-like portable blinds in the basement of the house and you can carry the blind and a stool to the feeding watch location. The locations are marked with a large, blue circle with an arrow pointing from it. The arrow indicates the direction of the feeding plot. The plot is marked by blue dots painted on the rocks. The locations of

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**Figure 32**: Example timeline for Razorbill nest productivity and growth checks. Note that these intervals and dates are variable. This is intended as a guide only.
the portable blinds are shown in Figure 2.

Unlike puffins, Razorbills have a tendency to stand around on the rocks with their catch of food for a while before entering the burrow to feed chicks. This display period increases the chances of correctly identifying the species, quantity and size of the food items that the Razorbill is bringing in for its chick.

Razorbill feeding watch data are recorded in two formats. Razorbill feeding watch datasheets look the same as the puffin datasheets (Figure 19). Make sure you indicate at the top of the feeding watch datasheet which species is being watched.

All feeding watch data are also entered in the Seabird Provisioner database. Watch for “kleptoparasitism” in which Razorbills try to take food from each other; this behavior may increase when the food supply is inadequate.

**Trapping Razorbill Chicks**

Special effort should be made to move through the colony and band any Razorbill chicks that are found. You should be able to determine when to begin these Razorbill chick-banding stints according to the stage of the Razorbill chicks in the marked burrows.

Do these checks as frequently as possible and band as many Razorbill chicks as possible. Don’t forget to take breast feathers and record plumage type (basic or alternate). Use the “garbage picker uppers” as a tool to catch chicks deep under rocks and out of arm’s reach.

When banding Razorbill chicks make sure to fill out the Razorbill banding sheet (Figure 28) and spreadsheet.
The Common Murre is a relatively new breeder at Machias Seal Island. In 1994, two Common Murre eggs were found at the south end of MSI. These were the first confirmed nesting attempts of Common Murres on MSI; unfortunately both were unsuccessful (Amey, unpublished data). In 2001 increased numbers of murres were observed loafing on the ledges (up to 300 individuals) and exploring sites around the visitor blinds.

In 2003 they established a breeding colony (Charette et al. 2004) which continues to this day.

The murres are concentrated in the southwest area of the island, primarily under large boulders in the form of three to four miniature caves. The murres are very gregarious and are highly concentrated in these nesting areas.

Due to its recent establishment at MSI, the Common Murre is traditionally not one of the primary species of focus on MSI. This is however changing and if the murre population continues to increase, they will likely require a more significant portion of our time.

The species code for the Common Murre is COMU.

**Banding**

The primary method for catching murres is by pursuit. The best tools for the job are either a noose pole or a net on a pole.

In some cases, the pole can be inserted into one of the cave entrances and the murres can be pulled out. In other cases one or two of the more slender researchers will be able to crawl part way into the cave with a noose pole or net and hand the birds out. Both adults and chicks can be captured by this method.

Beware, murre caves are extremely smelly, dirty and cramped so dress accordingly. Also, murres become very vocal when stressed out and the enclosed rocky space amplifies this noise considerably. Make sure there is water available for bathing before someone enters a cave.

Adult murres become easily panicked when humans are nearby, especially if the caves are invaded. Early in the breeding season, it is likely that the adults will destroy their eggs in an attempt to escape. There can be large concentrations of murre eggs in these areas and murres do not provide their
eggs with soft nest material. Remember that these eggs are resting on bare rock.

Later in the season when murre chicks are large enough to band is the best time to band both the adults and chicks. Researchers can make periodic visits to the murre nesting sites to see how big the chicks are. When the chicks have lost much of their down, schedule some banding time for the murres.

It is not necessary to spend a large number of stints banding murres. One or two stints of up to an hour each should be sufficient for the season. Crawling in murre caves can be highly invasive and may contribute to abandonment.

Common Murres receive only one band, a BBL, on their right leg. Murre bands look much like the Razorbill bands (Figure 34) but there are two important differences. First, the murre bands are noticeably larger than the Razorbill bands. Second, the murre bands have the band number printed on them three times as opposed to only twice in the Razorbill bands. Murre bands are closed in the same way as Razorbill bands (Figure 24).

The murre banding sheet looks like the Razorbill banding sheet (Figure 28). The only difference is that there are fewer measurements. For murres there is no white line to measure or bill grooves to count.

**Egg Counts**

**Murres no longer nest outside of the caves, so these data are no longer collected.** A few individuals do not nest in the miniature caves with the majority of the murres, but have in the past laid in two exposed areas in the colony “Murre Hole” and “Stone Hen”. There used to be blinds in both of these locations (Figure 2).

When passing these two areas record how many murre eggs are present in each. Since gull predation on eggs laid in the open has increased, since 2007 the murres have made no attempt to nest in these areas. Also take note
that murre eggs come in a wide variety of shapes and patterns (Figure 35). Various island activities will take you past these two areas, so it is not usually necessary to make a special trip there. There is no set interval for when this observation should be taken but twice a week should be sufficient.

These data, although not applicable to the cave-nesting murres, will give us an indication of how productive the open-area nesting murres are. It can also provide insight into the activities of marauding gulls.

Egg counts are recorded on a simple datasheet (Figure 36). This datasheet is usually kept on the corkboard in the living room of the CWS house. As usual, a copy of the data is kept in a spreadsheet on the island computer.

<table>
<thead>
<tr>
<th>DATE</th>
<th>Time</th>
<th>Location</th>
<th>Total Eggs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/06/07</td>
<td>9:30</td>
<td>Stone Hen</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>20/06/07</td>
<td>14:35</td>
<td>Stone Hen</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>28/06/07</td>
<td>11:00</td>
<td>Stone Hen</td>
<td>5</td>
<td>5 eggs broken - Gull pred</td>
</tr>
<tr>
<td>5/07/07</td>
<td>12:15</td>
<td>Stone Hen</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Figure 36: Example of the murre egg count datasheet
The Common Eiders are a popular sight on and around Machias Seal Island throughout the breeding season. Nesting numbers are variable, between (e.g.) 139 nests in 2004 (the highest on record) and 52 in 2006 (Bond et al. 2007).

The eiders nest in thick vegetation (see Figure 38), usually within two or three meters of the boundary between the vegetation and the bare rock that surrounds the island. These nests can be very difficult to detect, even when the drab females are on them. With the exception of nesting females, eiders are generally seen rafting in groups on the water or sitting on the rocks near the water’s edge.

While the Common Eiders do not receive much special attention in terms of our long term monitoring efforts, it is important not to ignore the species. You should make a weekly tour of the island counting eiders on the rocks and the water, and noting the sex ratio; when males outnumber females, it is because females are ashore incubating.

You should do a nest count every season before the eggs hatch. Eider ducklings do not remain in the nest long after hatching. Do the count a week or so after you notice eider nests. If you think that you are early and not all the eiders have laid yet (because clutches are <5-6 eggs), you can do a second count later. The count essentially involves an organized sweep of the island during which each eider nest, its clutch size and its location (grid square) is recorded.

Special banding effort directed towards the Common Eider is not as necessary as it is with alcids and terns. Nonetheless, if the opportunity arises, or if researchers are keen, they can make an effort to capture and band some Common Eiders. Take note that male eiders rarely venture on land further than a few metres from the water’s edge so any eiders captured will likely be females.

The primary method for capturing females is to simply pick them up while they are sitting on their eggs.
Female eiders can be extremely docile while they are sitting on their nest, especially late in incubation, and it is possible for a quiet, patient researcher moving with the right balance of speed and stealth to approach the nest and pick up the incubating female.

Obviously this method requires locating the nests on one visit and returning to them at a later date to attempt to catch the birds. Planting a flag near the nest is a good idea. This method can also take some practice and it’s usually a good idea to have a second researcher with a net positioned between the nest and the water in case the female panics and flees towards the ocean, as is often the case.

When processing and banding the eiders it usually helps to cover the head. We are not equipped with bird bags that are large enough to hold eiders, but when their heads are covered and they cannot see the procedure, they seem to become completely docile.

Common Eider bands are the largest used on the island (Appendix I) and can take a bit of muscle to close.

The eiders require only one BBL band on their right leg and it is applied in the same manner as the puffin bands (Figure 5).

An example of the eider banding sheet is shown in Figure 39. Note that we do not take anatomical measurements of the eiders. Make sure that you keep an electronic copy of this banding sheet on the island computer.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>Grid</th>
<th>Age</th>
<th>Sex</th>
<th>Initials</th>
<th>Method of Capture</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-06-06</td>
<td>1800</td>
<td>N</td>
<td>2587-1273</td>
<td>M</td>
<td>Y</td>
<td>ALX</td>
<td>Nest</td>
<td>Female, Blood Taken</td>
</tr>
<tr>
<td>1976-06-14</td>
<td>1830</td>
<td>N</td>
<td>2587-1273</td>
<td>M</td>
<td>Y</td>
<td>AWB</td>
<td>Nest</td>
<td>Female, Blood Taken</td>
</tr>
</tbody>
</table>

Figure 39: Example of the Common Eider banding sheet
Gulls
(Larus sp.)

The general consensus is that gulls are not welcome at Machias Seal Island. However, throughout the breeding season, the island is home to both the Herring Gull (Larus argentatus) and Great Black-backed Gull (Larus marinus). The Great Black-backed Gull is noticeably larger than the Herring Gull and in its adult plumage, has black wings and back, where the Herring Gull has grey.

Both species will establish nests on nearby Gull Rock and, more recently, on MSI itself. In 2012 a Bald Eagle consistently loafed on Gull Rock, encouraging gulls to nest on MSI instead: 24 nests were located on Gull Rock and 37 on MSI proper.

In addition to breeding gulls, loafing gulls of both species can often be observed on Gull Rock in large groups of several hundred individuals. On MSI, groups of up to 100 individuals can be observed loafing at the north and south ends of the island.

As far as nesting seabirds at MSI are concerned, gulls are one of the primary sources of egg and chick mortality. Gulls can often be observed searching through the vegetation and rocks and the remains of depredated eggs can usually be found scattered along the outskirts of the island. In 2006, the abandonment of the tern colony was attributed partly to heavy gull predation (Bond et al. 2007).

Gull Count
See daily data collection.

Gull Scaring
Attempts to deter gulls from landing on Machias Seal Island have not been successful. The most popular method employed thus far has been through the use of a scare pistol. This pistol shoots very loud crackers and bangers, which scare the gulls (and the auks and terns).
Upon shooting one of these bangers at a group of gulls, they may move some distance away, but they generally return within an hour or so.

The CWS Observer has generally used the scare pistol as part of their duties during the two months they are on the island. It is worth noting that attempts by UNB researchers in 2006 to deter gulls did not prevent abandonment of the tern colony that year.

In 2007, we began using a spring-powered pellet gun to deter gull predation. It is most effective when brought to a blind during resighting stints. It is very difficult to walk up to a gull and get within shooting range. Years of scare pistol use have made them wary of humans, but not to the point that they will abandon the island. Researchers have also tried using a slingshot, but accuracy tends to be low. As of 2013, we are adding a paintball gun as a potential gull scaring method.

**Trips to Gull Rock**

When the opportunity allows, Captain Patterson will transport the research crew over to Gull Rock for a few hours. Try to arrange a trip in early to mid June for a few hours at a time when it is convenient for him. Make sure to pack lots of ziplock bags, some nest flags (with pin), and maybe a garbage bag for the trip.

While at Gull Rock make a search of the island for gull nests (Figure 41) and other interesting items. When you find a gull nest, shake the eggs and puncture them at their widest breadth (this is easily accomplished with a flag – be sure to puncture both halves of the shell). This will make the eggs inviable, but may not disrupt the adults; this prevents re-nesting. Use this technique for nests on MSI as well.

You’ll have to measure each egg, so it is important to give each egg an identity. Mark a large number on the egg with a sharpie.

Make sure you measure the length and width (Figure 54) of each egg as well; these are used to determine to which species they likely belong. Record them in a spreadsheet with the date and location where the egg was found and the number that you wrote on the egg. You should also indicate somehow which eggs belonged to the same clutch.

Quite often gulls and raptors will bring their prey back to Gull Rock. If you find any bird carcasses be sure to take note of them, and search them for bird bands.
The Leach’s Storm-Petrel is a historic breeder at Machias Seal Island. They live in burrows much like the puffins. Storm-petrel burrows are generally much smaller in diameter than puffin burrows and, on MSI, are usually found more inland than puffin burrows. Like the puffins, however, they have a tendency to burrow under rocks and discarded piles of wood. One popular piece of MSI history is Brown (1911)’s report that a dog owned by a lighthouse keeper would often dig up storm-petrels.

The Leach’s Storm-Petrel is a nocturnal bird and can often be heard after dark on MSI. They can also be seen around the lighthouse on most nights. Often the light will stun them and they can be picked up on the lawn. If you are handling a storm-petrel for the first time make sure you take a moment to smell the bird. They emit a very unique smell, which is very likely the only pleasing bird-based aroma that you will encounter on MSI.

The petrels are not one of the species that we monitor but they are banded when the opportunity arises. We also conduct a petrel census every few years.

In the 2006 census, 85 storm-petrel nests were found on MSI, with the largest concentrations in grids 33, 52, 25, 80 and 114 (Bond et al. 2007).

**Banding and Processing Petrels**

The easiest method of catching petrels on MSI is to grub them from their burrows. The diameter of a petrel burrow is smaller than a puffin burrow and you may have some difficulty getting your arm down them.

When you remove the storm-petrel from the burrow, keep it in a cloth bird bag as you do with all other birds. Be extra careful when banding the petrels. Their legs are very delicate. Close the bands with the rounding pliers shown in Figure 48.

Take the standard measurements for mass, head-bill, culmen and wing chord (see Figures 25 and 26). Also record the presence or absence of a brood patch. Storm-petrels have only one brood patch about the size of a dollar coin and it is located below the sternum in the belly area. You will have to search under the feathers to find it.

Take feathers and record the grid where the bird was grubbed/found.

A storm-petrel banding sheet will look like the Razorbill banding sheet without columns for gape grooves and white line (Figure 28).

Release the bird into its burrow if it was grubbed. Do not release it into the air; storm-petrels are easy prey for gulls in the daylight. If the bird was found on the lawn after dark you can release it off the boardwalk or front step.
Arctic and Common Tern
(*Sterna paradisaeae + Sterna hirundo*)

According to MacKinnon and Smith (1985b) terns have been reported on Machias Seal Island as early as 1873. In the early 1900’s between 1,000 and 1,700 pairs of terns, most of them Arctic, were present.

In the early 1900’s most of them actually nested on nearby Gull Rock as opposed to Machias Seal Island itself. Over the years, an influx of gulls to Gull Rock restricted the terns to Machias Seal Island.

In addition to the marauding gulls, both species of terns faced numerous challenges on MSI. Resident lighthouse keepers routinely shot terns or scared them away. The keepers also raised sheep and cattle on the island, which would frequently trample eggs and chicks. Pet dogs and cats were kept on the island as well and would commonly kill tern chicks. Another frequent occurrence on MSI was visitation of people from the mainland for the purpose of collecting tern eggs. These practices ceased with the establishment of the Migratory Bird Sanctuary in 1944.

In 2004 the tern population reached 3,032 pairs but failed almost completely then and in 2005. Up until 2006 Machias Seal Island was the largest tern colony in the Gulf of Maine. Abandonment in 2006 was attributed to a combination of bad weather, poor food, and severe predation by gulls (Bond et al. 2007). The cause of the 2007 and subsequent abandonments is unknown.

The species codes for the Arctic and Common Tern as defined by the Bird Banding Lab are ARTE and COTE respectively.

Arctic Terns breeding in the Gulf of Maine were the focus of Kate Devlin’s Ph.D. study (Devlin 2005, Devlin et al. 2008). Some of the birds banded during her study are still visiting MSI, so we need to put serious effort into re-sighting ARTE bands whenever possible.

**Flagging Tern Nests**

Several people including researchers, lighthouse keepers and tourists make use of the lawn area on MSI. Because tern nests are so difficult to see, it is important to place a flag close, but not too close, to each tern nest on the lawn and along the main trails. Do this before
tourists arrive and before the lighthouse keepers mow the lawn! Make sure that each time a new nest is discovered on the lawn or along the main trails, that a flag and numbered Popsicle stick (see Banding section) is planted near it. Do a daily nest check around the lawn and main trails before the tourists arrive to mark new nests.

Keep in mind that the lighthouse keepers routinely mow the lawn and the main trails, and tourists have a tendency to wander into places where they are not supposed to be, so flagging the nests will help reduce any possible accidents.

**Banding**

The primary method for catching terns on MSI is by using modified Weller treadle traps (Weller 1957; Figure 45). These traps are square wire cages that are placed over the tern nests. When the tern walks in the opening and step on the floor trigger, the door drops and traps the tern inside. There is a small opening in the roof of the trap where the bird can be extracted.

Trapping of adults on nests should *not* be conducted any sooner than 7 days into incubation of a particular nest. This is approximately 8-10 days after the first egg in a clutch has been laid. Preferably one should wait until the second week of incubation before attempting to trap individuals. If the lay date of a nest is known, then the timing of the nest can be planned specifically. If the lay date of a specific nest is not known, then trapping should begin at the start of the second week of incubation following peak egg laying. This is determined by monitoring the phenology of nests in the study plots, which samples nests from different parts of the island and colony (more on this later).

The time spent observing the nest initiation and identifying the species is also used to determine the difference in the laying times of the different species. On Machias Seal Island the Arctic Terns generally begin laying eggs a week *before* the Common Terns (Diamond and Devlin 2003). This phenology has also been observed on other islands (Devlin, *personal observation*, Scott Hall, National Audubon Society, *pers. comm*...).

Tern trapping can take place almost anywhere on the island where vegetation does not restrict the functioning of the treadle trap. Flat areas such as the lawn, path and rocky edge of the island work best.

Choose several nests that are not too close together to place traps on. Make sure to remove the real eggs from the nest and replace them with fake eggs (found in the upstairs hall closet) of a comparable size and colour. If the real eggs are left in the nest, the adult may damage them if it panics and thrashes around the cage. Make sure to keep the real eggs in a cotton padded egg carton. Tern eggs are resistant to chilling; however, during trapping one should be sensitive to the amount of time the adult terns are kept from their nests due to the disturbance this may cause (Nesbit...
and Welton 1984). During 2001, on MSI, the average time to capture an adult Arctic Tern at the nest was 47 minutes (SD = 21.3). In the future, if the terns become reluctant to being captured by the treadle traps, it may be necessary to modify or alter the method of capture. Trap any particular nest for no more than 50 minutes.

Make sure to label each real egg that is taken out of the nest with magic marker. Give each egg a letter. Eggs inside monitored tern areas will have already been labeled (more on this later). Eggs outside the plot will need to be labeled with some sort of letter or number system. Label the nest as well by putting a number on a Popsicle stick and sticking it in the ground next to the nest, always in the direction of Gull Rock. Again, nests inside the monitored plots will already have one. It is very important to keep track of which egg belongs in each nest. Tern eggs have a wide variety of colours and patterns (Figure 46) and adults can recognize which eggs belong to them based on these patterns, so they will likely know that something is amiss if you have returned the wrong egg(s) to the nest.

The terns have a tendency to approach the nest from a particular side. You may want to watch the tern you are targeting before you set the trap. If the entrance of the treadle trap is not facing the direction that the tern approaches from, it is unlikely that it will find its way inside.

Make sure you choose an observation location where you can see all the tern cages that were set.

Arctic Terns receive two bands (Figure 47). The first is a Bird Banding Lab band (BBL) and the second is an alpha numeric field-readable band. Common Terns receive only a BBL. They do not get a field-readable band.

The tern bands are small and do not require much pressure to close. Don’t use vice-grips like you use on the alcid bands. Use the rounding pliers found in the banding kit (Figure 48).

**Tern Measurements and Banding Sheet**

The first thing to do after capturing a tern is to identify which species it is. The easiest way to identify them is based on the bill colour. Common Terns have a noticeable black tip on their otherwise red bill. Arctic Terns may have slight darkening at the tip of their red bill but it is not nearly as distinct as that of the Common Tern. There are several other slight differences in colour and anatomy, which will be highlighted in any bird field guide.

After banding the bird, measure the

Figure 46: Three tern eggs showing variation in colour and pattern

Figure 47: Tern field readable band (Arctic Tern only; left) and BBL (right). The scale is in millimeters.
wing chord (Figure 25) and look for a brood patch. Terns have only one brood patch about the size of a dollar coin and it is located below the sternum in the belly area. You will have to search under the feathers to find it.

When processing terns, we take a number of head and tail measurements, which are summarized in Figure 49.

Pluck at least five breast feathers from each tern and put them in a small bag. Label each bag with the following items.

- MSI
- UNB
- ARTE or COTE
- The BBL number
- The date the feathers were collected
- Age (L or AHY)
- The letter “R” if the tern was a recaptured bird.

Remember to put all feather bags in the freezer.

There are two main formats for recording the tern measurements and banding data. An example of the Arctic Tern banding datasheet is shown in Figure 50. The Common Tern sheet looks the same except for the absence of the field-readable band columns highlighted in red. Make sure you also fill out the tern trapping effort banding sheet as well.

Also note that for ARTE, this info gets entered into Sterna Finder. Each time a tern is banded, enter the information in the following:

- ARTE/COTE banding datasheet
- Sterna Finder (if ARTE)
Figure 50: Example of the Arctic Tern banding sheet. Note: Removing the columns in the red box will be representative of the Common Tern banding sheet. Also, the excel computer spreadsheet for both species follows the same format.

**Remember** that even though they are described together in this protocol, the Arctic and Common Terns are different species. When recording banding data for these birds, do not forget to identify which species each individual belongs to.

**Demography**

Arctic Tern band re-sighting can take place from a number of locations on the island. Band-reading stints are most efficient when conducted at Northwest Notch, Tern Blind, Oceanspray, Gully and Foundation blinds. In addition, the portable tent blinds can be carried to any other locations on the island where terns are found. Such areas include the rocks south of the jetty, the main trails and much of the interior of the island.

It can be difficult to read the leg bands of a tern that is nesting in the vegetated area of the island. You’ll notice that terns nesting in these vegetated areas tend to perch on grid posts and other sticks and poles that rise above the vegetation. Take advantage of this behaviour if you suspect that a banded bird is nesting in the vegetation. Drive wooden stakes in the ground not far from the nests of the bird you suspect of carrying a band and this may entice it to perch there when you return with the portable blind.

The tern re-sighting datasheet is shown in Figure 51. Make sure you write which species the datasheet is for at the top and carry one for both COTE and ARTE. As usual, band reading from any one blind will likely bring you in contact with bands.
from several species of bird so you should bring ATPU and RAZO sheets as well. Try to read every band from every species that you can.

Attempt to read tern bands constantly throughout the season up until the research crew departs or the terns do. Currently, terns are present at the colony for only a few weeks early in the season, so band-reading stints should be started as soon as the birds start landing. If they continue to abandon later, as they have done each year since 2006, the opportunity to resight bands will soon be lost. Terns may only be landing around dawn, so prepare to wake up early!

Identifying a pair of terns copulating is not as easily done as with the alcids. It is common to see one tern standing or sitting on another tern’s back (Figure 52). Take note that this “mounting” behaviour is not always an act of copulation.

Terns also engage in courtship feedings, which may be helpful in identifying which sex the bird is. Males typically bring in prey items and display them as a method of attracting a mate. However, it is not uncommon for a second male, instead of a female, to take the prey item from the first male. The datasheet requires you to say only if you observed the tern breeding at all; yes or no (Figure 51).

Every time you read a tern band, it should be entered in:
- Either the COTE or ARTE band reading sheet (Figure 51)
- COTE re-sight computer spreadsheet. The spreadsheet follows the same format as the datasheet.
- Sterna Finder (ARTE)
  Note that tern band resighting focuses on Arctic Terns; Common Terns should not carry field-readable bands.

Productivity
Measuring tern productivity is much different than alcid productivity. Terns build new nests every breeding season, which means we have to mark them every year. Thus, unlike the alcids, we do not monitor the same nests from year to year. We do however monitor the same areas from year to year.

Productivity is monitored in several areas across the island. These areas are the maintained lawn at the centre of the island, the trail running down to the north end of the island, the old foundation area which currently has scrap metal and garbage dumped (east of our house) and the small fenced-in enclosures surrounding Foundation, Oceanspray and Gully blinds. You can see these areas in Figure 2.

The chicken wire fencing around Foundation is left up year-round. You may have to conduct a few minor repairs. The chicken wire fencing around Oceanspray and Gully will have to be erected within the first few days of arriving at the island. Have a look at the fencing around foundation to see how it is constructed. There are rolls of chicken wire fencing in the basement and you’ll need wire or zip-ties (found in the upstairs closet) to attach them to the poles. There are also some stakes cemented in paint cans that you can fasten the fencing to.
3) **Measure the first 50 eggs you come across**

4) **Identify new nests to species**

We generally call these activities Tern Nest Check or TNC for short. Make sure you bring some calipers, an electronic scale and some spare tongue depressors (popsicle sticks). Be extremely careful when walking amongst tern nests. Tern eggs are a variety of colours and patterns (Figure 46) and blend into the ground easily. If you don’t watch your step, you are likely to crush eggs.

1) **Label new nests**

Move through each of the monitored areas and look at every nest within the plots. For every new nest that is found, insert a tongue depressor in the grass, peat or a rock crack near the nest and write a number in black marker on the stick.

These numbers are **not** species specific. A COTE can be 28 and an ARTE can be 29. **Do not** use the same number twice for different tern species. At the end of the TNC, record each individual nest number, lay date and location on the nest check summary datasheets (Figure 57), which will be located in a binder in the house.

After you get the fence up, make sure you use rocks to block up any holes that tern chicks can run through. They can get highly mobile and will try to hide from you.

Keep a sharp watch for when terns have begun to nest (usually late May to early June). When nesting is confirmed you will conduct the four following activities on a daily basis.

1) Label new nests
2) Label new eggs
3) Measure the first 50 eggs you come across
4) Identify new nests to species

Figure 53: Example of a tern nest check summary datasheet. Note that you will need a row for each egg in each nest in the monitored plots.

Figure 54: Guide to egg measurements using a Razorbill egg for example

2) **Label new eggs**

As you find new eggs being laid, make sure you label each one with a black sharpie marker. The first egg laid in each nest should be labelled “A”, the second
“B” and the third “C”. It is unlikely that you’ll have to go beyond “C” because the terns will rarely lay more than 3 eggs. It is important to label the eggs properly because you’ll need to refer to each specific egg when filling out datasheets like Figure 53 and Figure 55 and other Excel spreadsheets.

3) *Measuring eggs*

Every year, we aim to measure (length, width; Figure 54) 50 eggs. In years where the terns might abandon, measure the first 50 eggs you see (can be done during TNC) otherwise, measure new eggs found in nests (also done during TNC). Measurements should be taken within one day of laying. Record the measurements with the egg and nest ID in the egg measurement datasheet (Figure 55).

4) *Identify new nests to species*

One of the more difficult aspects of monitoring tern productivity is determining which species laid each nest in the monitored areas.

The mowed lawn area and the path running down to the north end of the island are dominated by Arctic Terns (Bond *et al.* 2007, Diamond 2007) and it is pretty safe to assume that any tern eggs you see there are from Arctic Terns. You should however keep an eye out for any changes in this trend.

At the south end of the island, in the Gully and Oceanspray enclosures, it is a different story. The Common and Arctic Terns will both establish nests in these areas which can make things a little confusing. Luckily, there are ways to identify which nest belongs to which species of tern.

When you first notice an egg within the Gully or Oceanspray enclosure, you’ll need to draw a map of each enclosure from your position in the corresponding blind. Choose the best artist in the crew for this job because you’ll all need to be able to read the map. Include tufts of grass, puddles, cracks in the rock and other landmarks in the enclosure to make the map easy to navigate.

As nests are established in the enclosures, indicate their location and the nest number you assigned them on the map. Next, you’ll need to spend a couple of hours in the blind watching to see what species of adult is incubating at each nest. Use the opportunity to do some resighting.

When you identify an incubating adult, record the species on the map with the nest ID. Now you can fill in the species of that nest in the appropriate

<table>
<thead>
<tr>
<th>Date</th>
<th>Nest #</th>
<th>Egg # / Total Clutch Size</th>
<th>Length (mm)</th>
<th>Breadth (mm)</th>
<th>Mass (g)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 05 06</td>
<td>1 A</td>
<td>42.9</td>
<td>30.6</td>
<td>20.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 05 06</td>
<td>2 A</td>
<td>41.0</td>
<td>29.9</td>
<td>19.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 05 06</td>
<td>3 A</td>
<td>43.4</td>
<td>29.4</td>
<td>18.9</td>
<td></td>
<td>Cold egg</td>
</tr>
<tr>
<td>4 06 06</td>
<td>1 B</td>
<td>44.1</td>
<td>29.8</td>
<td>19.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 55: Example of an egg measurement datasheet
Chick growth

Tern chick growth is a little different than alcid chick growth. The tern chicks have a much better chance of escaping researchers than the alcid chicks. Puffin and Razorbill chicks can hide within the burrow, but seldom leave the burrow and attempt to escape. Tern chicks, on the other hand, will leave the nest, run away and attempt to hide in the tall grass, in rock cracks or under the boardwalk. This can be a problem for several reasons:

1) It will be difficult to identify which species of chick it is if you do not know which nest it came from.
2) If you scare a chick too much or too far away from its nest, it may never return. This will greatly bias your productivity and survival estimates. This is especially important within the tern enclosures at Gully and Oceanspray. If a tern chick climbs over or under the fence or squeezes through a crack, they will be unable to return to their nest. Make sure the fence is secure.

Ultimately, it is impossible to completely remove all human disturbances but you should be conscious of the impact you are having on the terns. Researchers should stick together and move as a group. Loud noise and excessive movement should be minimized. Small nets may be useful for catching running tern chicks or fetching them from under boardwalks.

Terns incubate their eggs for approximately 21 days (Walsh et al. 1995). Using this information you can be sure to do a check on the predicted hatch day. Remember that a chick’s hatch day (usually the chick will still be wet) is considered to be day zero. Do not band wet chicks. Return in the next day or two and band them. Apply only the BBL band at this stage. Field-readable bands are applied to chicks that are 10 days or older. Giving the chick a BBL band as early as possible will help you identify which species and nest the chick belong to when they become mobile and will help you distinguish between A, B and C chicks within a single nest. Remember: field-readable bands go on ARTE only, not COTE.

One aspect of tern chick growth that is easier than alcid chick growth is that the tern chicks should all be of known age. This is because you conduct tern nest checks (TNC) every day (except in bad weather).

The necessary data that you need to collect when you encounter a chick are shown on the example chick growth datasheet in Figure 56.

Figure 56: Example of a tern chick growth datasheet
Linear growth in terns occurs between days 5 and 15 so make sure you obtain two measurements between these days for as many chicks in the monitored plots as possible.

**Nest summary datasheet**

The nest summary datasheet (Figure 57) is a useful datasheet for keeping track of the fate of each tern chick/egg. Fill in the appropriate info for each egg/chick as it becomes available and be sure to indicate if the chick was seen alive at days 15 and 20. Keeping the sheet up to date will help make your life easier when you need to interpret the results.

<table>
<thead>
<tr>
<th>Plot</th>
<th>Species</th>
<th>Nest #</th>
<th>Chick (A.B.C)</th>
<th>Band</th>
<th>Leg</th>
<th>Lay Date</th>
<th>Hatch Date</th>
<th>Alive Day 15</th>
<th>Alive Day 20</th>
<th>Age Last seen</th>
<th>Date found dead</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>ARTE</td>
<td>1</td>
<td>A</td>
<td></td>
<td></td>
<td>29/05</td>
<td>29/05</td>
<td></td>
<td></td>
<td></td>
<td>30/05</td>
</tr>
<tr>
<td>F</td>
<td>ARTE</td>
<td>2</td>
<td>A</td>
<td>802-12117</td>
<td>R</td>
<td>29/05</td>
<td>23/06</td>
<td>5</td>
<td>29/06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OS</td>
<td>COTE</td>
<td>3</td>
<td>A</td>
<td></td>
<td></td>
<td>29/05</td>
<td>01/06</td>
<td>1</td>
<td>26/06</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

L - Lawn, F - Foundation, OS - Oceanspray

Leave space in case other eggs are laid in the same nest

The age of the chick the last time it was seen

If, heaven forbid, a chick is found dead or an egg is cracked or disappeared, record the date here

---

**Feeding**

The tern diet monitoring follows the same basic procedure as the alcids so be sure to familiarize yourself with the information covered in the ATPU section of the protocol. Tern feeding watches are conducted from the following three blinds. As indicated below, each species of tern is monitored from two of the three blinds.

- Gully = COTE
- Oceanspray = COTE and ARTE
- Foundation = ARTE

**Tern Blind:** ARTE and COTE

All three of these plots are defined by the fencing erected for the productivity and growth study. In addition, all three sites have a blind, which looks over the plot.

Choose five to seven nests to monitor for the three-hour stint. Select nests that are close to the blind and easily visible. You may have to trim vegetation around the nest that would obstruct your view. In addition, you should select nests that have been identified to species. Hopefully by the time the terns begin feeding, enough nests will have been identified to species during the band reading or productivity efforts to give you
a reasonable sample size. Otherwise, part of your feeding watch responsibilities will be to identify more nests to species.

It is important not to make assumptions when watching terns in the Gully and Foundation plots. Although these plots are used for diet studies, this does not necessarily mean that all the terns in that plot are the same species.

For each feeding watch, record the time that observations began and ended. For each delivery, record the arrival and departure time of the parent, the number of food items, the size of the food item (relative to culmen length) and prey type on the feeding watch datasheet for each species (Figure 19).

For each feeding watch enter all data on the following:

- ARTE or COTE datasheet
- Seabird Provisioner

Both of these methods follow the same format. Make sure to differentiate between both tern species.
Daily Data Collection

Aside from the long term monitoring of the seabirds at Machias Seal Island, we collect a plethora of other biological, ecological and environmental data that are used to enhance our observations and interpretations each season.

Environmental data

Several environmental variables are measured on MSI every day and at three specific times. Environmental data play an important part in interpretation of our results so make sure they are collected every day at the appropriate time. If for some reason they were not collected, do not guess or use data from another time of day. The daily weather conditions datasheet should be placed in an accessible location such as on the fridge or corkboard. At 09:00 each day, researchers are required to record:

- General Conditions
- Presence of fog
- Wind Speed and Direction
- Visibility
- Cloud Cover
- Current Temperature

General conditions are simply a one or two word description such as “sunny”, “windy” or “foggy/rainy”. Wind speed and direction are measured in knots and can be obtained from the lighthouse keepers’ house. If the anemometer stops working, the Beaufort scale (Appendix V) can be used until it is fixed.

Prevailing visibility is measured in kilometres and can be estimated by using landmarks of known distance. The following features are most prominent when it comes to this and it is useful to keep a copy of them next to the datasheet.

- Gull Rock 0.25km
- North Rock 4.0km
- Grand Manan 18.75km
- Gannet Rock 25.0km

Estimate the amount of cloud cover by looking at the sky, and recording 0, 25, 50, 75, or 100%. If it is too foggy to assess cloud cover, record “obscured” in the appropriate column of the data sheet. Current temperature (°C) is obtained by viewing the display on the digital thermometer. This thermometer should be set up at the beginning of the season and the probe should be positioned in the shade under the front doorstep of the CWS house with the reading unit in the front porch.

At 21:00 every day, researchers should record the same variables that were recorded at 09:00. In addition, the following variables should be recorded.

- Min and max temperature
- Rainfall

Min and max temperatures are obtained from the digital thermometer and the amount of rainfall (mm) can be obtained by checking the standard rain
gauge located on the lawn. Once the gauge is checked make sure to empty it. In cases of excessive rainfall, it may be necessary to check and empty the gauge several times per day. In such cases, make sure to keep a tally of each visit and record the sum at 21:00. The rain gauge should be far enough away from the house to be out of its rain shadow.

At 12 noon, when conditions allow, sea-surface temperature (SST) (°C) should be taken. This is achieved by tossing a standard SST bucket into the water from the landing on the east side of the island. Two tosses should be performed; the first is simply to acclimate the bucket, the second is to obtain the water to be measured. Following the second toss place the thermometer in the water and after approximately 2 minutes, read and record the temperature on the weather data sheet. The SST bucket can be obtained from the light-keepers at the beginning of the field season and stored at the CWS house for the field season but should be returned to the light-keepers before leaving the island at the end of the field season.

Gull Count
After taking weather readings at 09:00 and 21:00, count the number of gulls loafing on Gull Rock and around the island. Counting gulls on Gull Rock requires the use of the scope (and some patience). Stand out on the front porch and count all the gulls you can see on the island. To count the gulls on MSI, take your binoculars, and look out every window of the house, looking for gulls loafing on the rocks. You can also stand on the front and back porches for better counting ability, but there is no need to wander down the boardwalk – this is just a sample. The Gull Count datasheet should be kept with the weather datasheet, on either the fridge or the corkboard.

Daily Bird List
Numerous birds representing a variety of taxa will be seen on or around MSI throughout the summer. Many species migrate through the area during early May and June and individuals of certain species may hang around the island for weeks at a time. Occasionally large fallouts will occur (Figure 59) or intense weather patterns will drive unusual species into the area.

Figure 59: Blackburnian Warbler (*Setophaga fusca*), Baltimore Oriole (*Icterus galbula*) and Common Yellowthroat (*Geothlypis trichas*)

At the end of each day, researchers should recount every species of bird they have seen and how many of each species were present and record this
in the daily bird list datasheets (Figure 60); this should become a part of the end-of-day routine. It is not necessary to record the breeding seabird species such as Razorbill, Common Murre and Common Eider (a checkmark will suffice for these) but other species should be documented.

<table>
<thead>
<tr>
<th>Daily Bird List</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>2-Jul</td>
</tr>
<tr>
<td>Horned lark</td>
</tr>
<tr>
<td>Water pipit</td>
</tr>
<tr>
<td>Brown thrasher</td>
</tr>
<tr>
<td>Gray catbird</td>
</tr>
<tr>
<td>Northern mockingbird</td>
</tr>
<tr>
<td>Eastern bluebird</td>
</tr>
<tr>
<td>American robin</td>
</tr>
</tbody>
</table>

Figure 60: Example of the bird list datasheet

The Bird List data sheet lists all the notable species that have been observed on MSI and is several pages long. All that is required is to place the date at the top of the column and then place the number of each bird observed in the corresponding box as shown below. It is not necessary to record zero if no birds are observed. Birds not on the bird list can be listed in the daily journal. Do not add new birds to the list!

**Aggressive Tern Activity**

This is a continuation of a study conducted by Morrison (1996) on the aggressive behaviour of the terns nesting in the “high traffic” area of the island. We continue monitoring the behaviour as a potential indicator of for the health of the tern colony.

The “high traffic” area is defined as the area of the island which is travelled by researchers, the CWS personnel, lighthouse keepers (lawn mowers), boat captains, helicopters and tourists. The number of actual physical hits made by terns on researchers and the CWS personnel should be recorded daily.

These hits should be recorded on a data sheet (Figure 61) posted in a highly visible location. The reasons for recording hits include:

- Investigating whether or not the behaviour will habituate as the terns become accustomed to human presence
- The possible use of the behaviour as an indicator of the physical condition of the terns (in 1996, when feeding conditions were poor, the 'hit rate' declined markedly).

<table>
<thead>
<tr>
<th>Tern Aggression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>dd</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>8</td>
</tr>
</tbody>
</table>

Figure 61: Example of the tern hit datasheet

**Recording Depredated Eggs**

It is quite common to find broken eggs that have been preyed on or broken by species such as gulls or turnstones. If any such eggs are found, it is important to make note of what species the egg is, the grid square where the egg was found and the date and time when it was found.

After recording the relevant data, make sure to crush the egg so that it will not be counted a second time.

A data sheet for recording depredated eggs should be printed out and posted on one of the corkboards.

Due to the high rate of depredation of tern eggs, please compile a proportion of depredated, broken, or missing productivity eggs relative to the monitored total; making this distinction in the field is of critical importance.
Recording and Collecting Carcasses

Whenever a bird carcass is located on the island it is important to identify it if possible.

Carcasses of migrants are frequently found in the early and late season and, if in good condition, should be placed in a ziplock bag in the freezer to be returned to UNB. Write the species, location, date, sex if known, and any other useful information on the bag.

It is fairly common to find the carcass of puffins while in the colony. If the carcass of these or any other focal species is found, make sure to record the species, date, location and any other valuable information. Record the band number and keep band in separate bag as well if present.

A data sheet for recording carcasses should be printed out and posted in the house on one of the corkboards. If the carcass can be made into a study skin, make sure it is kept and frozen with the appropriate information. Otherwise, throw it in the ocean or pile rocks on it to avoid counting it a second time.

At the end of the season, notify Travis Clarke (UNB Biology) who is responsible for keeping records of bird bodies in the UNB collection under our federal Migratory Bird permit.

Journal

Every evening researchers should write an entry in the island journal summarizing the day’s activities. Feel free to be creative and have fun with it but also be sure that important events are documented each day. Examples include first feedings, first hatches, fledglings, unusual recaptures or resights, weather comments, predation attempts etc. Make your notes as quantitative as possible.

You should also note who did what, which blinds each individual used and what activities they performed there. This makes a useful backup if, for example, you forgot to write your location or the date on a banding sheet.

Prey Item Collection

Whenever you note a prey item that was dropped on the ground, make sure you collect it. Identify the item and record the prey species, date found, location found, fresh weight, length, the species of bird that dropped it (if known) and any other info that can be filled in on the data sheet.

There are appropriate datasheets for this information that can be printed out and left on the fridge or corkboard. Also store the prey item in a sample bag and freeze it for later reference. Make sure you write an ID on the bag so it will match up to the entry on the datasheet.

Weekly Reports

It is important to keep track of progress, in a written form so it can be transmitted to Tony at UNB regularly – ideally, at the end of every week. Keep it as quantitative as possible: lost x days to rain (yy mm), did a resighting stints seeing bb banded puffins and cc razorbills; checked dd puffin burrows, ee razorbill nests, ff % puffin burrows have eggs, gg% chicks, etc. The need to report often arises during the season and Tony needs information updated regularly so he can respond to such requests.

Season Permit Report

Our research on MSI is under a federal (CWS) permit, normally ending 31 August, on which a report is due within the next 30 days. This is another reason to prepare weekly report; these make it much easier to prepare the final permit report in a timely fashion.
# Appendix I
-Bird Band Sizes-

<table>
<thead>
<tr>
<th>Species</th>
<th>Band Size</th>
<th>Internal Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic Puffin</td>
<td>5</td>
<td>8.0</td>
</tr>
<tr>
<td>Razorbill</td>
<td>5R</td>
<td></td>
</tr>
<tr>
<td>Common Murre</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Arctic Tern</td>
<td>2, 1A</td>
<td>4.3</td>
</tr>
<tr>
<td>Common Tern</td>
<td>2</td>
<td>4.3</td>
</tr>
<tr>
<td>Leach’s Storm-petrel</td>
<td>1B</td>
<td>2.8</td>
</tr>
<tr>
<td>Common Eider</td>
<td>7A</td>
<td></td>
</tr>
</tbody>
</table>
Appendix II
Discriminant Functions and Graphs

ATPU:

From Friars and Diamond 2011:

Two-variable equation: \( D(0.174) = 0.31(Billdepth) + 0.26(headbill) - 32.28 \)

The discriminant function using bill depth and head-bill length to sex female (below line) and male (above line) Atlantic Puffins, including individuals with bill grooves >1.5 and a brood patch present. Incorrectly classified females were labelled as “x” and males as “+”. The solid line was set to the discriminant cut-off of 0.5 probability of being either female or male (Phillips and Furness 1997). Dashed lines are to set the discriminant cut-off for 25% and 75% posterior probabilities. Note: some data points overlap.
RAZO:

From Grecian *et al.* 2005:

\[ D(-0.04) = 0.25(\text{head-bill}) + 0.73(\text{bill depth}) - 40.84. \]

The relationship between bill depth and head+bill length for each bird in the sample. The line divides the cloud of points into predicted males (upper right) and predicted females (lower left) based on the above discriminant function and the observed value of \( D_{\text{crit}} \). The actual sex of each bird as determined genetically is shown.
ARTE:

From Devlin et al. 2004:

\[ D(0.043) = 1.22(\text{Bill depth}) + 0.362(\text{Head-bill}) - 34.222 \]

**Figure 2.** The discriminant function using head-bill length and bill depth to sex female (below line) and male (above line) Arctic Terns. Line is defined as DF Score 0.043 = bill depth(1.22) + head-bill (0.362) – 34.222. Note: some data points overlap.
## Appendix III
~Codes for Prey Items, Providers and Recipients~

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Amphipod</td>
<td>AA</td>
<td>Adult A</td>
</tr>
<tr>
<td>J</td>
<td>Ant</td>
<td>AB</td>
<td>Adult B</td>
</tr>
<tr>
<td>SY</td>
<td>Atlantic Saury</td>
<td>BA</td>
<td>Banded Adult</td>
</tr>
<tr>
<td>F</td>
<td>Bluefish</td>
<td>BMB</td>
<td>Breast marked bird</td>
</tr>
<tr>
<td>T</td>
<td>Butterfly</td>
<td>KF</td>
<td>Known Female</td>
</tr>
<tr>
<td>B</td>
<td>Click Beetle</td>
<td>KM</td>
<td>Known Male</td>
</tr>
<tr>
<td>C</td>
<td>Crustacean</td>
<td>S</td>
<td>Self</td>
</tr>
<tr>
<td>CU</td>
<td>Cunner</td>
<td>SMB</td>
<td>Shoulder marked bird</td>
</tr>
<tr>
<td>DR</td>
<td>Dragonfly</td>
<td>TA</td>
<td>Teaser adult</td>
</tr>
<tr>
<td>EW</td>
<td>Earthworm</td>
<td>UB</td>
<td>Unbanded adult</td>
</tr>
<tr>
<td>EEL</td>
<td>Eel</td>
<td>U</td>
<td>Unknown</td>
</tr>
<tr>
<td>EP</td>
<td>Eelpout</td>
<td>UA</td>
<td>Unknown adult</td>
</tr>
<tr>
<td>E</td>
<td>Euphausid</td>
<td>UC</td>
<td>Unknown Chick</td>
</tr>
<tr>
<td>#</td>
<td>Filefish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td>Fish Scrap (Bait)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BR</td>
<td>Four Bearded Rockling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Goosefish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Hake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H or R</td>
<td>Hake or Herring (DO NOT USE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>Herring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Insect (species unknown)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>Isopod</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KF</td>
<td>Killifish (mummichog)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA/H</td>
<td>Larval Hake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA/R</td>
<td>Larval Herring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA/S</td>
<td>Larval Sandlance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA/UF</td>
<td>Larval Unknown Fish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Lumpfish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>Mackerel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Moth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH</td>
<td>Perch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>Plant Seed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Pollock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Polychaeta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PUF</td>
<td>Puffer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Rock Eel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROS</td>
<td>Rosefish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Sandlance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Sculpin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>Shore or Sand Shrimp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH</td>
<td>Silver Hake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Silverside</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>Snipefish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Spider</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>Squid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>Stuckleback</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UF</td>
<td>Unknown Fish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UI</td>
<td>Unknown Invert</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Codes that are presented in bold text are the most popular codes used in feeding studies at MSI.
Appendix IV
-Machias Seal Island seabird studies-

Several studies have been conducted on the seabirds of Machias Seal Island. These studies will be outlined briefly here but for details of each study refer to actual works (see also References). See MacKinnon and Smith (1985b) for historical (pre-ACWERN) information on the seabirds of MSI.

- **Pettingill** (1939) examined the fledging success of 100 Arctic Tern (*Sterna paradisaea*) nests.
- **Hawksley** (1950) studied the behaviour and (1957) the ecology of the breeding population of Arctic Terns.
- **Reg Newell** (1985) conducted a 4-year study of the nesting ecology of Arctic Terns in relation to habitat.
- **Judah Bunin and Sherman Boates** (1994) investigated the effects of nesting location on the breeding success of Arctic Terns.
- **Tony Diamond** began ACWERN-UNB long-term research and monitoring program in 1995.
- In 1995, Bridget **Morrison** (1996) studied the effects of human disturbance on the behaviour of Arctic Terns.
- **Julie Paquet** investigated Arctic Tern activity budgets in 1997-98.
- **Dorothy McFarlane** (now Diamond) surveyed the island to assess the breeding population of Leach’s Storm-Petrel (*Oceanodroma leucorhoa*) in 1998 and 1999.
- **Catherine Devlin** studied the population dynamics of Arctic Terns from 2000 to 2005.
- **André Breton** studied demographic parameters of the Atlantic Puffin metapopulation from 2000 to 2005.
- **Dedreic Grecian** studied the biology and habitats of Razorbills in 2000 and 2001.
- **Chantal Gagnon** studied impacts of human disturbance on Arctic Tern breeding success in 2001.
- **Jenn Lavers** included MSI Razorbills in a MUN Ph.D. study of the Canadian Razorbill metapopulation, centred on Gannet Is, Labrador, 2003-5.
- **Mathieu Charette** compared breeding and feeding biology of nesting terns on Machias Seal Island to Country Island, NS from 2003 to 2005.
- **Laura Minich** studied the intra-seasonal and inter-seasonal variability in the feeding of seabirds in 2006.
- **Amie Black** studied feeding areas of Arctic Terns and Common Terns in 2004 and 2005.
- **Alex Bond** studied patterns of mercury burden and isotope-derived trophic levels in the seabirds of Machias Seal Island in 2005 and 2006.
- **Dorothy Diamond** surveyed the island to assess the breeding population of Leach’s Storm-Petrel in 2006.
- **Travis Clarke** studied behaviour and movements of Razorbill through the use of data loggers, satellite telemetry and radio telemetry.
- **Kevin Kelly** began study of physiological indicators of health of Atlantic Puffins, 2010.
- **Erin Whidden** began study of Atlantic Puffin recruitment to MSI, 2011.
- **Lauren Scopel** began study of Arctic Tern metapopulation dynamics post-abandonment of MSI, 2012.
Appendix V
- Beaufort Scale-
(from Lister 1956)

<table>
<thead>
<tr>
<th>Beaufort No.</th>
<th>Wind</th>
<th>Wind Speed Mph</th>
<th>Nauts</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Calm</td>
<td>Less than 1</td>
<td>&lt; 1</td>
<td>Sea like a mirror</td>
</tr>
<tr>
<td>1</td>
<td>Light air</td>
<td>1 – 3</td>
<td>1 – 2.5</td>
<td>Scale-like ripples</td>
</tr>
<tr>
<td>2</td>
<td>Light breeze</td>
<td>4 – 7</td>
<td>3.5 – 6</td>
<td>Small wavelets, glassy crests</td>
</tr>
<tr>
<td>3</td>
<td>Gentle breeze</td>
<td>8 – 12</td>
<td>7 – 10.5</td>
<td>Large wavelets; crests begin to break; a few “white horses”</td>
</tr>
<tr>
<td>4</td>
<td>Moderate breeze</td>
<td>13 – 18</td>
<td>11 – 15.5</td>
<td>Small waves become longer; “white horses” fairly common</td>
</tr>
<tr>
<td>5</td>
<td>Fresh breeze</td>
<td>19 – 24</td>
<td>16.5 – 21</td>
<td>Moderate waves with pronounced length; many “white horses”; some spray</td>
</tr>
<tr>
<td>6</td>
<td>Strong breeze</td>
<td>25 – 31</td>
<td>22 – 27</td>
<td>Large waves form; white foam crests more extensively everywhere</td>
</tr>
<tr>
<td>7</td>
<td>High wind/moderate gale</td>
<td>32 – 38</td>
<td>28 – 33</td>
<td>Sea heaps up; white foam from breaking waves is blown off</td>
</tr>
<tr>
<td>8</td>
<td>Fresh gale</td>
<td>39 – 46</td>
<td>34 – 40</td>
<td>Moderately high waves of greater length; edges of crests break into spindrift; foam blown in well marked streaks</td>
</tr>
<tr>
<td>9</td>
<td>Strong gale</td>
<td>47 – 54</td>
<td>41 – 47</td>
<td>High waves; dense streaks of foam along direction of wind; spray may affect visibility</td>
</tr>
<tr>
<td>10</td>
<td>Whole gale</td>
<td>55 – 63</td>
<td>48 – 55</td>
<td>Very high waves with long overhanging crests; foam in great patches, blown in dense white streaks; surface of sea becomes white; rolling of sea becomes heavy and shock-like; visibility affected</td>
</tr>
<tr>
<td>11</td>
<td>Storm</td>
<td>64 – 75</td>
<td>55.5 – 65</td>
<td>Exceptionally high waves; sea covered with foam; visibility affected</td>
</tr>
<tr>
<td>12</td>
<td>Hurricane</td>
<td>Over 75</td>
<td>Over 65</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix VI
- Band Sequences by Year -

<table>
<thead>
<tr>
<th>Species</th>
<th>Year</th>
<th>Band numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common &amp; Arctic Terns</td>
<td>1995</td>
<td>0802-05001 to 0802-05388</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-05401 to 0802-05434</td>
</tr>
<tr>
<td></td>
<td>1996</td>
<td>0802-05389 to 0802-05400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-05435 to 0802-05609</td>
</tr>
<tr>
<td></td>
<td>1997</td>
<td>0802-05610 to 0802-05893</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-05901 to 0802-06000</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>0802-07001 to 0802-07004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-07012 to 0802-07106</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-07283 to 0802-07307</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-07403 to 0802-07572</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-07601 to 0802-07700</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-07801 to 0802-07945</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>0802-69672 to 0802-69800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9802-80101 to 9802-80600</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>9802-80901 to 9802-81000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1182-61011 to 1182-61800</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>1182-61462 to 1182-61500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1182-61801 to 1182-62000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-56402 to 0802-56700</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-68001 to 0802-68168</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>1172-56001 to 1172-56614</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1172-57001 to 1172-57100</td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td>1172-55701 to 1172-55810</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1172-56576 to 1172-56600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1172-56615 to 1172-57399</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>0802-06214 to 0802-06220</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-06260 to 0802-06286</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1172-55811 to 1172-55900</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1172-57101 to 1172-57300</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>1172-57401 to 1172-57500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1172-77701 to 1172-77836</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>0802-06201 to 0802-06213</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-06221 to 0802-06259</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-09287 to 0802-06288</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0802-06301 to 0802-06319</td>
</tr>
<tr>
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**Leach’s Storm-Petrel**

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**Common Eider**

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**Common Murre**

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Appendix VII
- Timeline of routine activities in a “typical” year on Machias Seal Island –
References and MSI-Specific Literature


