

Wildlife Inventory Plan
Alaska Maritime National Wildlife Refuge
Protocol #1

Version 1.4

Parameter: Productivity, phenology, and chick growth

Species: Fork-tailed and Leach's storm-petrel

PURPOSE

To estimate annual productivity, phenology, and chick growth rates of storm-petrels and to track variation among years. Seabird reproductive parameters can serve as indicators of change in the marine ecosystem (Cairns 1987, Montevecchi 1993). Storm-petrel reproductive success, timing of breeding, and chick growth rates are all responsive to varying marine foraging conditions (e.g., Boersma et al. 1980, Boersma and Parrish 1998) and they are considered valuable indicator species in the northern Pacific Ocean (Piatt et al. 2006).

BREEDING BIOLOGY

Fork-tailed (*Oceanodroma furcata*) and Leach's (*O. leucorhoa*) storm-petrels are small burrow-nesting seabirds that breed on remote oceanic islands. Like other storm-petrel species, fork-tailed and Leach's storm-petrels are highly attracted to calls of conspecifics and often nest in large colonies. The only two storm-petrel species to breed in Alaska, both fork-tailed and Leach's storm-petrels breed on islands from southeastern Alaska west through the Aleutian Islands; Alaskan colonies often consist of both species. Both species are normally nocturnal, foraging at sea during the day and only returning to the colony at night (Huntington et al. 1996, Boersma and Silva 2001).

Storm-petrels usually use soil burrows but also opportunistically use nesting spaces formed by rock crevices, cracks in cliffs, or spaces underneath boulders or roots (e.g., Harris 1974, Quinlan 1979, Huntington et al. 1996, Drummond and Leonard 2010). Burrow entrances may be shared with other burrow nesting species. Depending on substrate, burrows can be more than a meter in depth. The nesting chamber is usually lined with a small amount of vegetation (Huntington et al. 1996, Boersma and Silva 2001).

Members of both species lay a single egg. Relaying can occur if eggs are lost early in incubation but is probably uncommon. Incubation periods are highly variable due to periods of egg "neglect", during which adults leave the egg in the burrow for days at a time with no damage to the developing embryo. As a result, incubation length varies widely (from 33-68 days in fork-tailed storm-petrels and 35-50 days in Leach's storm-petrels) and hatching at a colony is usually highly asynchronous. Both sexes share incubation duties, with shifts lasting 1-5 days. Once chicks hatch, adults brood chicks for an average of 5-6 days, after which chicks are left alone in the burrow for the duration of the nestling period, with adults returning only at night to feed chicks. Nestling periods range from 51-65 days for fork-tailed and 63-75 days for Leach's storm-petrels (Huntington et al. 1996, Boersma and Silva 2001).

Timing of breeding varies across sites but in general for Alaskan colonies, burrow selection and construction occurs from April to late June. Peak egg laying for fork-tailed storm petrels occurs from May to early June; Leach's storm-petrels are usually several weeks later. Fork-tailed storm-petrel chicks hatch from June to August and fledge mainly in September. Leach's storm-petrel chicks generally hatch from July through early September and fledge in September and October (Huntington et al. 1996, Boersma and Silva 2001, Drummond and Leonard 2009, Bechaver and Gehrig 2011, Drummond and Slater 2012).

Fork-tailed and Leach's storm-petrels are surface-feeders that feed on a mix of fish and zooplankton. Adults are central-based foragers during the breeding season and can travel more than 100 km from colonies (e.g., Vermeer and Devito 1988, Steele and Montevecchi 1994, Drummond and Leonard 2009). Prey supply is typically patchy and variation in availability and distribution can be reflected in productivity, phenology and chick growth rates (Boersma and Parrish 1998, Boersma and

Silva 2001). Predation and climatic conditions are also important factors influencing storm-petrel reproductive success and survival (Boersma et al. 1980, Huntington et al. 1996, Boersma and Silva 2001).

PROCEDURE – PRODUCTIVITY AND PHENOLOGY

Data collection.—Storm-petrel reproductive performance is monitored by following nest statuses of individually numbered burrows throughout the breeding season. Depending on the site, nests are visited at intervals from 5 to 30 days (5- to 14-day intervals are considered regular nest monitoring whereas 30-day intervals are considered Boom-or-Bust monitoring; see island-specific attachments for details). At each visit, nest status is determined by reaching an arm into a burrow (called “grubbing”) and gently feeling nest contents.

Storm-petrels burrows are organized into plots. When surveying each plot, it is helpful to have a single dedicated data recorder and one or more grubbers to survey nests and report data back to the recorder. All burrows are marked with flags (usually in a standardized location) and should be located on a plot map (maps at some sites show locations of entrances only [Figure 1], maps at other sites show tunnel directions and chamber locations [Figure 2]). Use the same burrow numbers every year; new burrows should be given the next-highest consecutive number in that plot.

On the first visit of the season, use the previous year’s plot maps as a guide to find all burrows in each plot. A hole must be at least 20 cm deep to be considered a burrow; if in question, use a “burrow board” (Figure 3) to determine length (a hole is deep enough to be considered a burrow if you can insert the full length of the narrow end of the burrow board into the hole). Keep in mind that some entrances may have collapsed since last year or new entrances may have been dug, so you may need to update maps. Mark burrows with new flags and remove any old flags that have lost their flagging over the winter (if old flags are still in good shape, there is no reason to remove them - later in the season when vegetation overgrows the plot and burrows are difficult to find, it can be helpful to have multiple flags marking an entrance. However, try not to keep more than three flags marking a single burrow, as it begins to get unwieldy). It doesn’t matter if two or three entrances join up to become a single burrow further in, or if a single entrance branches off into two or three nesting chambers - just flag and map every entrance visible from the outside. Storm-petrel burrows are often close together and curve around at funny angles, so be careful to check that flags do not go through the soil to skewer another burrow.

It is difficult to write on flags when they are damp, so it may be helpful to number most of your flags before heading out to the plots using the previous year’s maps as a guide, and bring a few extra blank flags for any new burrows you find. When numbering flags, use a thick, black permanent marker and write the number both on the main flag itself and also on the small flange of plastic attached to the back of the flag. Over the winter, the main flag often gets ripped off in the wind, but the smaller section usually remains.

After all burrows are marked and mapped, grub burrows to determine an initial status. For most sites, this will occur on the first visit; Buldir may wait until the second visit (see island-specific attachments for details). When grubbing each burrow **the first time**, record:

- (1) Entrance size (Small, Medium, or Large)
- (2) Presence of a chamber (Yes or No)
- (3) If you can reach the end of the burrow (Yes or No)
- (4) Nest status (using standardized codes)
- (5) Species, if previously unknown (fork-tailed = FTSP, Leach’s = LHSP, unknown storm-petrel = UNST)
- (6) Multiple chambers, multiple entrances, burrows that connect, etc.

When grubbing each burrow on **all future checks**, record:

- (1) Nest status (using standardized codes)
- (2) Species, if previously unknown (fork-tailed = FTSP, Leach’s = LHSP, unknown storm-petrel = UNST)

To survey each nest, carefully reach an arm into each entrance and slowly attempt to feel the contents of the nest. Be gentle when reaching your arm into a burrow, *walking your fingers slowly down*

the burrow floor rather than stabbing blindly with fingers extended. Storm-petrel adults are sensitive to disturbance and storm-petrel eggs are very thin and easily broken by human fingers, especially when you have been grubbing for a while and your fingers are cold and wet and have lost dexterity and feeling. Feel for the nest chamber, which will feel like a slight widening of the tunnel (you can usually spread your fingers a bit). There is often a slight depression (there may be a lip at the entrance followed by a dip as you enter the chamber) and occasionally small amounts of nesting material. The chamber is often rounded and defined all around (if you can feel the entire chamber). If no adult is present, carefully feel around in the nest material to search for an egg or chick (it may be somewhat nestled among the nest material). If a bird is present, carefully slide your fingers underneath to check for an egg or chick.

Record only what you feel and be sure to use the standardized codes (see pages 1-8 to 1-10; Figures 4 and 5) exactly as instructed. Lengthy text explanations and comments tend to cause confusion later and cannot be interpreted by the database used to summarize the data in the future. Choose a code then and there and stick with it - as the field biologist, you are the only person who can make a decision about what you saw that day. If you absolutely must record additional information about a nest, you can enter text in the comments section of the data spreadsheet, but keep in mind that this text is not used in any data summary so it should not contain any information pertinent to how the reproductive success data should be interpreted.

If a nest contains an egg or a chick, there are a few cases when you will need to record additional modifiers that provide more detailed information about the nest status (list of standardized code modifiers). For eggs, record if you find an old egg clearly from last year (Ely), a broken, crushed, or otherwise dead egg (Ed), an egg ejected from the nest (Ej), or an egg pipping just before hatch (Ep). Similarly, for chicks, record if you find a chick in the actual act of hatching (Co), a chick still wet from having recently hatched (Cw), or dead chick (Cd).

Although you should aim to record a “known” status egg, chick, or nothing for each nest each visit, there will be times when you cannot determine a certain status. For instance, you may be able to reach the front lip of the nest chamber but not down inside the nest, or you can just barely feel a bird’s tail feathers at the farthest reach of your fingers but you cannot feel underneath the bird. If there is a grubber in the group with slightly longer arms, it may be helpful to have that person give the nest a try. Otherwise, record an unknown code (Unknown “U” if you cannot feel anything but cannot reach to the end of the burrow, Bird Unknown “BU” you can feel an adult bird but cannot determine if it has an egg or chick) and make a concerted effort to confirm the status of that nest on the next visit.

If a nest is active, attempt to identify the species. This only has to be done once. If an adult is present, with luck the bird will vocalize so you can determine species without removing the bird (a scratchy, harsh, or squawky call, sometimes sounding “asthmatic” = fork-tailed; a more burble-ly or flute-like call = Leach’s). If the bird doesn’t call, try to extract it by clasping your fingers softly but firmly over the bill and gently leading it out of the burrow. If the adult attempts to bite your fingers in defense, this is a good opportunity to gently grasp both mandibles to extract the bird. In wider burrows, you may also be able to grasp the entire bird to remove it; try to situate it within your hand so that its head is pointed elbow-wards (towards the entrance) and you can protect its head/eyes as you gently pull your hand out of the burrow. Always try to hold the bird’s wings to its body to keep the feathers from getting damaged and dirty. Never try to remove a bird from a burrow backwards (tail-first), as its wings will get mangled. After you identify the bird in hand, release the bird back into the burrow head-first. Most birds will scamper immediately back to their nests but some may turn to try and bite you – make sure the bird does not escape from the nest or from your grasp during the daytime, as they will almost certainly be gobbled up by hungry gulls.

If you cannot identify the species from a vocalization and you cannot extract the bird, record the species as unknown and make it a top priority for your next check. If you find a chick in a burrow that has not yet been identified to species, carefully extract it for identification (fork-tailed chicks are gray with lighter gray down around the butt of the chick, Leach’s chicks are uniformly dark grayish-brown; see Figure 6). Avoid removing adults or chicks from nests on excessively wet or stormy day and never remove an adult or a chick if the adult is brooding the chick.

Be aware that some burrows may have more than one entrance and some entrances may branch off into more than one burrow. To complicate things further, burrows may have a single nesting chamber at the end, or they may lead to a nesting chamber that you can reach but then continue winding their way through the earth. When multiple entrances lead to a single chamber, assign the chamber to just one of the entrances and designate the other entrance(s) as lacking a chamber and containing nothing; on

subsequent checks, make sure that you record burrow status only for the “main” entrance. When a single entrance branches off into multiple chambers, record burrow status for each chamber separately as if they were separate burrows (which in a practical sense they are) and make sure to clearly indicate which is which for subsequent checks (e.g. label them as “left” and “right”, perhaps). It may be helpful to mark connected nests on your plot map.

Finally, burrow entrance size is recorded to distinguish between storm-petrel burrows and those of larger burrow-nesting seabirds such as tufted puffin burrows. Size is categorized simply as small, medium, or large (small: <9.5 cm, medium: 9.5-14.5 cm, large: >14.5 cm) and measured using a “burrow board” (Figure 3). Measure each entrance horizontally at the widest spot: if the smallest end of the board does not slide in to the entrance, but the burrow is at least 20 cm deep, it is assigned to the “small” category; if the small end will slide in at least 20 cm, it is assigned to the “medium” category; if the largest section slides in at least 20 cm, it is assigned to the “large” category. Note that at sites where burrows have been grubbed for many years, small burrows are usually enlarged by grubbing arms so small and medium burrows are often lumped.

Many storm-petrel nests will still be active when you leave the island at the end of the season, so it is important to conduct a final nest check as close as possible to when you depart in order to get the best data on nest fate. Please keep this in mind when scheduling your nest checks towards the end of the season, and if you need to shorten the last check interval to get a final check completed, definitely do so!

Special considerations for grubbing in storm-petrel colonies:

Storm-petrels often nest in dense colonies where soil is honeycombed with numerous burrows. Burrows may be fragile and collapse if tread upon. In areas of high burrow density, substrate can be especially delicate. Use caution when traversing any area with burrows and avoid stepping above any burrow entrances. When monitoring a plot, it may be helpful to crawl on hands and knees. If a plot is on a slope, it is usually easiest to work uphill from the bottom to the top. If you do collapse a burrow, carefully dig out the entrance, ensure you have not crushed a bird, egg, or chick, and makes repairs as best as you can. Also take care when grubbing burrows to watch out for the tips of flags, especially old ones that may have lost their flagging - it is easy to poke yourself in the face.

Burrow can be narrow and take snaky turns. To maximize the distance you can reach into a burrow and thus your chances of getting known nest statuses, grubbers should minimize the number of shirt layers they wear, as multiple layers will add bulk to arms and make it more difficult to access burrows. In general, wear just a single, thin layer (such as a polypropylene top) and a pair of tight sleeves called “grubbing gauntlets” (Figure 7). Vests and/or extra pants layers may help grubbers stay warm on cold, wet days. If available at your camp, sleeveless rain jackets (called “grubbing vests”) are useful for staying dry without adding extra bulk to the arms. Some crew members prefer to wear disposable gloves with the fingertips cut off.

Data analysis.—Calculations for phenology and productivity parameters for storm-petrels have not yet been automated in an Access database, so analysis needs to be conducted by field crews.

Phenology: Storm-petrel phenology is only calculated at sites where nests are checked at 5 or 7 day intervals. As frequent checks may cause disturbance to storm-petrels, plots designated as “phenology plots” and checked at these more frequent intervals are usually kept separate from productivity analysis, which uses plots checked less frequently (i.e., every 14 days).

For phenology plots, dates for chick hatching and fledging are calculated using the Julian midpoint dates between applicable nest checks (*in leap years, be sure to use a leap year-specific Julian date calendar!*). The hatch date is the midpoint between the last time an egg was confirmed to be present and the first time a chick was confirmed to be present. Similarly, the fledge date is the midpoint between the last time a chick was confirmed to be present and the first time a nest was confirmed empty. If the midpoint falls between two days, by convention we use the EVEN Julian date.

Occasionally, you may record data that gives more exact information on hatching and fledging dates. If you observe an event occurring (e.g., the actual hatching and fledging) during your visit, we use the day of the observation as the date the event occurred and not the midpoint between observations. Similarly, if a piped egg is observed, we assume it will hatch the following day; if a wet chick is seen, we assume it hatched that day.

Not all nest sites in phenology plots are included in phenology calculations; we require confirmed visualization of the empty nest site, egg, or chick less than or equal to 7 days apart for that site to be used.

From your nests, calculate mean, first, and last hatch dates and first fledge dates for each species. If no chicks fledged by your last check at the end of the season, report the first fledge date as > the date of the last nest check.

Productivity: Reproductive success is calculated as the number of known fate nest sites that fledged a chick. A chick is considered “fledged” if it disappears from the nest when at least 50 days old; chicks that disappear from the nest when younger than 50 days are deemed failed. Because the storm-petrel breeding season extends later than many other species monitored, most chicks are too young to fledge by the time of the last visit. Therefore, we calculate maximum potential reproductive success measures, based on the assumption that any chick still present at last check could potentially fledge. While this undoubtedly overestimates actual success to some extent (albeit minimally, as most storm-petrel chick mortality occurs early in chick-rearing), it provides a useful index for examining storm-petrel breeding success across time and sites.

Productivity is only calculated from nests that were active and you can determine the fate all the way through the season.

(1) Begin by eliminating any nests that were not active in the current year. To be considered an active nest, a nest must have contained one of the following:

- a bird incubating an egg (BE) on *at least one* check
- a chick with or without an adult (BC or C) on *at least one* check
- a bird with unknown (BU) on *at least two consecutive* checks

The following are *not* active nests in the current year:

- an egg that was never incubated (cannot be sure it was from the current year)
- a bird with unknown (BU) just once, or on multiple but unconsecutive checks, where an egg or chick was never subsequently found
- a nest that had only empty (N) or unknown (U) codes
- a nest that is a duplicate of another nest (two entrances lead to the same chamber)

(2) Next eliminate any nests with an unknown fate. These are nests that, for one reason or another, have some question as to what happened to the egg or chick, and might include:

- an egg or a chick disappeared but you could not reach the end of the burrow so you cannot tell what happened (i.e., was the chick dead or hiding beyond your reach?). This includes all nests with status histories that look like:
 BE BE BE E E E U U U or BE BE BE BE BC BC U U U (for 14 day intervals)
 BE U U or BE C U (for 30-day intervals)
- a nest with wonky data that doesn't make sense (goes from egg to chick and then back to egg)
- a nest that was lost and could not be refound

(3) Then determine if any eggs are still potentially viable. In rare cases, an egg laid especially late in the season may not have hatched by last check but could still hatch after field crews leave the island. Incubation periods range from 33-68 days for fork-tailed storm-petrels and 33-50 days for Leach's storm-petrels, so we use 68 and 50 days as the cut-off for egg viability for each species, respectively. If an egg is still present at the last check, is not broken or dead, and is younger than the cut-off for the appropriate species, it should be considered “still potentially viable”. These nests should be removed from the sample, as we will never know if eggs hatch or not. Record the number of viable eggs for your data table but do not include it in your sample size for analysis.

(4) Once you have your sample of active, known-fate nests, for each nest determine whether the egg hatched and then whether the chick survived to fledge (or was still alive at last check). To be considered a successful hatch, a chick must be recorded on a subsequent check (an egg that disappears is considered egg failure). By convention, if an egg dies while pipping, the egg did not hatch (egg failure). If

a chick is partially out of the shell when it dies (or if it dies immediately after hatching), it is considered a successful hatch but a chick death.

For chicks still in the burrow at the end of the season, consider all chicks “potentially fledged” as long as they appear healthy at last check. For chicks that disappear from the burrow (this will likely be a very few chicks only), you must calculate chick age at disappearance to determine if the chick fledged or failed. How you do this will vary depending on whether you monitored nests regularly every 14 days, or whether you monitored nests infrequently every 30 days.

Regular nest monitoring – 14-day interval (Aiktak, St. Lazaria, Buldir)

Chicks disappearing at >50 days of age should be considered fledged; chicks disappearing at <50 days of age should be considered failed. As with phenology calculations, use the Julian midpoint between successive checks as the estimated date on which events occurred. For example, a hatch date is the midpoint between the last date an egg was recorded and the first date that a chick was recorded; a disappearance date is the midpoint between the last date that a chick was recorded and the first date an empty burrow was recorded. Chick age at disappearance is calculated as the difference between the disappearance date and the hatch date. For example:

Julian Date	150	156	163	170	177	183	190	197	204	210	217	224
Nest 1	BE	C	C	C	C	N						
Nest 2	BE	BE	C	C	C	C	C	C	C	C	C	N

Nest 1: Hatch date = midpoint between 150 and 156 = 153
 Disappearance date = midpoint between 177 and 183 = 180
 Chick age at disappearance = 180 - 153 = 27 d → Chick failed

Nest 2: Hatch date = midpoint between 156 and 163 = 160
 Disappearance date = midpoint between 217 and 224 = 220
 Chick age at disappearance = 220-160 = 60 d → Chick fledged

Boom or Bust monitoring - 30-day interval (Ulak, Buldir historically)

For nests monitored on a 30-day interval, it is impossible to accurately calculate chick age. Therefore, we determine if the chick *could have possibly fledged* by using wing chord as a proxy for age and extrapolating how large a chick would have been if it disappeared right before the final check. To do this, we use:

- the wing chord measurement at the last check a chick was present
- a standard average growth rate of 3.0mm/day (average at Ulak Island)
- the number of days between the last check a chick was present and the check a chick was gone

If this extrapolated value is at least 140mm, we say the chick could have fledged; if it is less than 140mm, the chick failed.

For example:

Nest #1	Nest status	Wing chord (mm)
10 June	BE	-
15 July	C	35
15 August	N	-

Last wing chord measurement = 35mm; Interval between second and final check = 30 days
 $35\text{mm} + (3.0\text{mm/day} \times 30 \text{ days}) = 125\text{mm}$ *This chick failed*

Nest #2	Nest status	Wing chord (mm)
10 June	BE	-
15 July	C	65
15 August	N	-

Last wing chord measurement = 65mm; Interval between second and final check = 30 days
 $65\text{mm} + (3.0\text{mm/day} \times 30 \text{ days}) = 155\text{mm}$ *This chick could have fledged*

Note that this method calculates the *maximum* size a chick *could have been*, had it fledged the day before the final empty visit. We obviously have no way of determining when a chick left the nest, but this provides us an index for maximum potential success in a Boom-or-Bust sense when nest visits are so infrequent. As such, it is not immediately comparable with success values determined by more regular monitoring with 14-day intervals.

After determining a fate of each nest (whether from 14- or 30-day intervals), calculate the following parameters. Do calculations separately for each plot and each species:

- Maximum nest sites with eggs (B+H) – maximum number of nest sites containing any eggs
- Maximum nest sites with chick (D+H) – maximum number of nest sites containing any chicks
- Maximum nest sites with chicks fledged (F+H) – maximum potential number of nest sites that fledged chicks (includes both chicks that fledge [disappeared from nest >50 days old] and all chicks still present at last check, regardless of age)

From the above values, calculate the following summary parameters:

- Maximum potential nesting success $[(D+H)/(B+H)]$
- Maximum potential fledging success $[(F+H)/(D+H)]$
- Maximum potential reproductive success $[(F+H)/(B+H)]$

Finally, calculate standard deviations of summary parameters based on cluster sampling by plot using ratio estimator spreadsheets.

Standardized Productivity Codes: List of Productivity Codes (STORM-PETRELS)

Always use CAPITAL LETTERS for productivity codes

See list of "Important Rules to Follow" for more details on correct use

B Bird	Adult bird occupying a nest site, with no egg or chick present. Used when the observer is <u>sure</u> the bird has no egg or chick (this code means a site is confirmed empty other than the adult bird, there is no need to combine B and N codes into BN). For kittiwakes, used between the time a nest is constructed and the first egg is laid, or after egg(s) or chick(s) is lost.
BU Bird w/ Unknown	Adult bird occupying a site, with no egg or chick visible . Used when the observer cannot see the entire nest contents to be sure whether there is an egg, a chick, or nothing.
BE Bird w/ Egg	Adult bird with an egg.
E Egg	Egg present, with no adult. Use numbers and/or "+" to indicate more than one (e.g., E2+ = at least two eggs) Use standardized modifiers to describe special egg status (e.g., Ed = dead egg)
BC Bird w/ Chick	Adult bird with chick.
C Chick	Chick present, with no adult. Use numbers and/or "+" to indicate more than one (e.g., C2+ = at least two chicks) Use standardized modifiers to describe special egg status (e.g., Cd = dead chick)
U Unknown	Nest site with nothing clearly visible. Seldom used - only when the observer is not sure of the nest contents (e.g., cliff nest site obscured by fog or other birds, crevice nest site offering a poor, incomplete view, etc.). If an observer records "U" many times, especially at crucial times (hatch and fledge), the nest site may not be included in analysis.
N Nest	Empty nest site. Used when an egg or chick that was in the nest has been lost and no adult is present. For kittiwakes, this code indicates that a nest structure from the current year is physically present, either before eggs are laid or after the nest fails.
NC Not Checked	Used between the previous and current check, when a site was not checked (e.g., it was skipped on purpose) or could not be found on that date. This code does not have to be used at the very beginning or end of the season before checks begin or after checks end for a particular nest.

Standardized Productivity Codes: List of Modifiers

Always use lowercase letters for modifiers!

See list of “Important Rules to Follow” for more details on correct use

Modifiers to egg status codes

- Eo Egg lay observed** Observer sees egg being laid; used only when event was actually observed, not simply suspected lay

- Ep Egg pipped** Hole in egg, sometimes chick bill poking through; hatch date determined to be following day. Note: do **not** use for eggs just starred (localized cracks in shell resulting from chick’s chipping action, often occurs before egg is pipped)

- Ed Egg dead** Egg is obviously damaged or broken (this includes eggs that have become partially buried in chamber/tunnel bottom)

- Ej Egg ejected** Egg once in a nest ejected outside the nest cup

- Ely Egg last year** Egg assumed to be from last year from appearance or other evidence

Modifiers to chick status codes

- Co Chick hatch** Observer sees chick hatch; used only when event was actually observed, not for pipping **observed** eggs, observations of newly-hatched wet chicks, or other reasons leading to suspected “probable” hatch. Do not combine Co modifier with Cw (see below) if you observe a hatching event that results in a wet chick; simply use Co to indicate hatch and not Cow/Cwo

- Cw Chick wet** Newly-hatched wet chick observed; indicates chick hatched that day but hatching event was not actually observed

- Cd Chick dead** Chick actually observed dead (not simply disappeared from nest)

- Cf Chick fledged** Chick actually observed in the act of flying (or jumping for murre) from the nest; very rare!

Additional clues to nest fate

- sh eggshells** Presence of fresh eggshell fragments in the nest. Used ONLY with Bird Unknown or Unknown status codes (BUsh or Ush) to give more information about potential hatch; there is no need to use with known status codes (such as C or N)

- poop poop** Presence of fresh poop in or at the entrance of the nest. Used ONLY with Unknown status code (Upoop) to give more information about potential presence of a chick; there is no need to use with known-status codes (such as C or N)

- call chick calling** Chick heard calling but not actually observed. Used ONLY with Bird Unknown or Unknown status codes (BUcall or Ucall) to give more information about potential presence of a chick; not appropriate to use with known-status codes (such as C or N)

Standardized Productivity Codes: Important Rules to Follow

Use capital letters for basic productivity codes and lowercase letters for modifiers. Do not use superscripts or subscripts for any modifiers. Do not put spaces between any characters.

Use numbers to indicate quantities of birds, eggs, or chicks greater than one (do NOT use 1 to indicate single numbers). Numbers should always go AFTER the code that the number describes.

e.g., B2E means two adult birds with a single egg

BE2 means a single adult bird with two eggs

Use a plus sign (+) when you can see at least some but not all nest contents in multiple-egg clutches. As with numbers, the plus sign should always go AFTER the letter code (and when more than one, also after the number) that is being described.

e.g., BE+ means an adult bird and at least one egg were observed but entire nest contents could not be seen to determine if there was anything more

BE2+ means an adult bird and at least two eggs were observed but entire nest contents could not be seen to determine if there was anything more

Some codes and modifiers can be combined when appropriate as long as order (see below) is maintained. For instance, with multiple-egg species, if one egg hatches before another so that there is an adult bird present with both an egg and a chick, enter BEC.

The specific order in which these codes and modifiers are used is VERY IMPORTANT. The codes BEC and BCE, or BE2+ and BE+2, may mean the same thing to us but they are NOT the same to the computer database. Follow these rules for the correct order of codes and modifiers:

(1) Always write codes in the order of adult - egg - chick.

e.g., BE and not EB

(2) When adding modifiers (numbers, letters, or symbols that give more information), always follow the order of: main productivity code - letter modifier - number - plus sign

e.g., BEp2+ for adult bird with at least two pipped eggs

BE2Cd for adult bird with two eggs and one dead chick

B2E+Cd for two adult birds with at least one egg and one dead chick

****NOTE**** These standardized codes and modifiers should be used for ALL species, even those that we are still summarizing by hand this year (e.g., storm-petrels, cormorants, oystercatchers, gulls, ancient murrelets). The ultimate goal in future years is to use the database to summarize productivity data for all species and the more consistent we can make the data now, the easier it will be to make that transition.

PROCEDURE – CHICK GROWTH

Data collection.—Storm-petrel chick growth is usually done in conjunction with monitoring for productivity or phenology (see island-specific attachments for details on plots and measurement intervals used at each site). Chicks are removed from nests and measured several times during the linear period of growth to calculate linear growth rates.

While chicks are small, they are usually fairly easy to extract from the burrow, although care should be taken to protect the head. As the chicks grow, they may run away or put up a fight, and they may be harder to fit out the narrow burrow entrance. On larger chicks, it may be possible to extract chicks using a “chick grabber”, a piece of bent wire or copper tubing with a small hook at the end like a shepherd’s crook that can slide around a chick’s tarsus and gently drag a chick to the nest entrance. Be careful that the wings and/or the other foot do not become bent at an uncomfortable angle during extraction. **Never remove chicks from nests for measurements if an adult is present or when it is excessively wet or stormy days**, particularly when chicks are small and may have more trouble thermoregulating.

During each measurement session, measure the following (see Figures 8 and 9):

- **Mass:** Weigh chicks (g) in bird bags (or the toe of a pantyhose) using Pesola® spring scales. Be sure to weigh the empty bag after each chick weighing, because its weight can change due to moisture or chick feces.
- **Wing chord:** Measure the right wing from the bend in the wing to longest tip (pin feather or longest primary, depending on chick age; ignore any downy tufts stuck to the end of wings or feathers – these tufts are black on Leach’s) using a wing rule. With the right wing resting naturally against the chick’s body, slide the wing ruler under the wing and press the vertical stop gently against the wrist joint. Measure this distance to the nearest 0.5 mm. Wing should be relaxed, not flattened.
Only begin measuring wing chord once pin feathers erupt. Take care: pin feathers are very sensitive and will bleed if broken, which can lead to chick death; and over-zealous handling can maim the developing wing.
- **Diagonal tarsus:** Hold chick's right leg so both the foot and tarsal joints are bent at right angles. Place the inner jaw of the calipers into the notch at the tarsal joint and slide the outer jaw until it contacts the end of the tarsus just where the foot bends. Measure this distance to the nearest 0.1 mm.

Be sure the scale has been calibrated and zeroed prior to using it and recheck that it’s zeroed before weighing each chick. Similarly ensure calipers are zeroed before use.

Ideally, aim for at least three measurements per chick during the linear growth period (see Table 1). Because storm-petrel mass measurements can be troublesome (see data analysis section), it is usually best to play it safe and simply continue measuring the chick until it fledges or you leave the island, as measurements outside the linear growth phase can always be truncated later.

Table 1. Guidelines for linear growth period for fork-tailed and Leach’s storm-petrels.

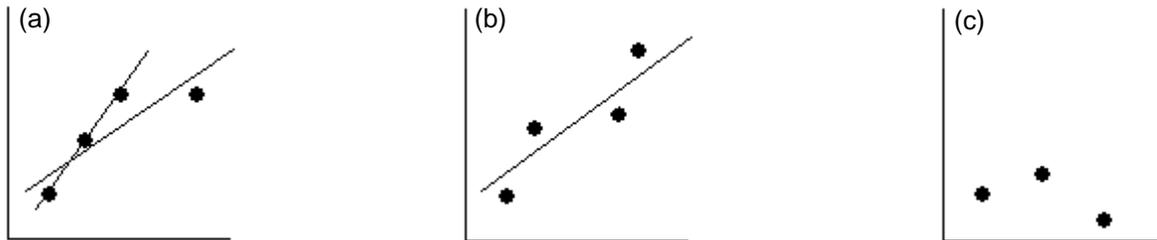
Species	Mass	Wing chord
	Lower - Upper Limit	Lower - Upper Limit
Fork-tailed storm-petrel	0 - 80 g	20 - 140 mm
Leach’s storm-petrel	0 - 60 g	20 - 140 mm

Additional safety considerations for handling birds

Monitor the condition of birds you are handling at all times and look for signs of injury or stress (e.g., panting, droopy eyelids, appearing dazed, shivering). If a bird starts having problems, release it immediately. If you encounter a bird that appears diseased (e.g., avian pox), take care to prevent spreading to other birds at the colony. Destroy the bird bag used with that bird (do not reuse with other birds) and clean all measuring and banding instruments with 70% ethanol.

Data analysis.—Chick growth is summarized during the linear growth period only (see Table 1); at about 40-50 days, wing chord measurements asymptote, while mass measurements reach a peak and eventually decrease before fledging (Boersma et al. 1980, Ricklefs et al. 1980, Huntington et al. 1996, Drummond and Leonard 2009). Truncate any data points that appear to be outside the linear growth window. To this end, use the linear growth phase limits (Table 1) as a rough guide, and plot the data for each chick to visually inspect graphs for any leveling off towards the end of measurements.

It may be helpful to use the r^2 value of the linear regression line as a guide to how close to linear your data points are. There is no concrete rule about how “good” a fit must be to be considered linear growth and thus included in analysis but as a rule of thumb, take an extra look at any chicks in which the r^2 value is <0.80 . If the poorness of fit is due to an early or late data point and the fit can be improved markedly by removing it (see “a” below), consider that point outside of the linear growth period and remove it. If the poorness of fit seems to be due simply to variability in measurements (see “b” below), consider keeping all data points. If the poorness of fit is because the chick just didn’t seem to exhibit any linear growth at all (this can happen with dying chicks, for instance; see “c” below), consider removing the entire chick from the sample, as we are only interested in chicks for which we can calculate a rate of linear growth.



Storm-petrel wing chord measurements typically exhibit good, consistent growth rates during the linear growth phase and bounds for wing chord measurements (20-140 mm) are generally a good fit. Avoid using measurements under 20 mm, as these are usually before any wing feathers erupt and are more difficult to measure accurately.

Mass is trickier, however, because chicks are adapted to binge-feeding: chicks are fed only once every few nights, so they can gain and lose a substantial amount of mass overnight, depending on whether or not they are fed (Boersma 1986). Therefore, mass measurements can fluctuate wildly on a day-to-day basis and does not always fit the linear growth model. This problem is compounded when chick measurements are taken at infrequent intervals. Thus, calculating a linear growth rate for storm-petrel mass can be frustrating. It is often helpful to include all mass measurements up to a peak mass, and then crop any subsequent post-peak measurements.

Once all data have been inspected and truncated to include only those measurements occurring during the linear growth period, calculate the growth rate for each chick by running a simple linear regression for each parameter (mass and wing chord). The slope of each regression line represents the growth rate. Present the average annual growth rate for each species as the mean slope (and standard deviation) of all chicks. Include chicks that have been measured at least three times during the linear growth phase. If a chick dies after three measurements, it can be included in the dataset. Consult with unit biologists regarding including chicks with only two measurements.

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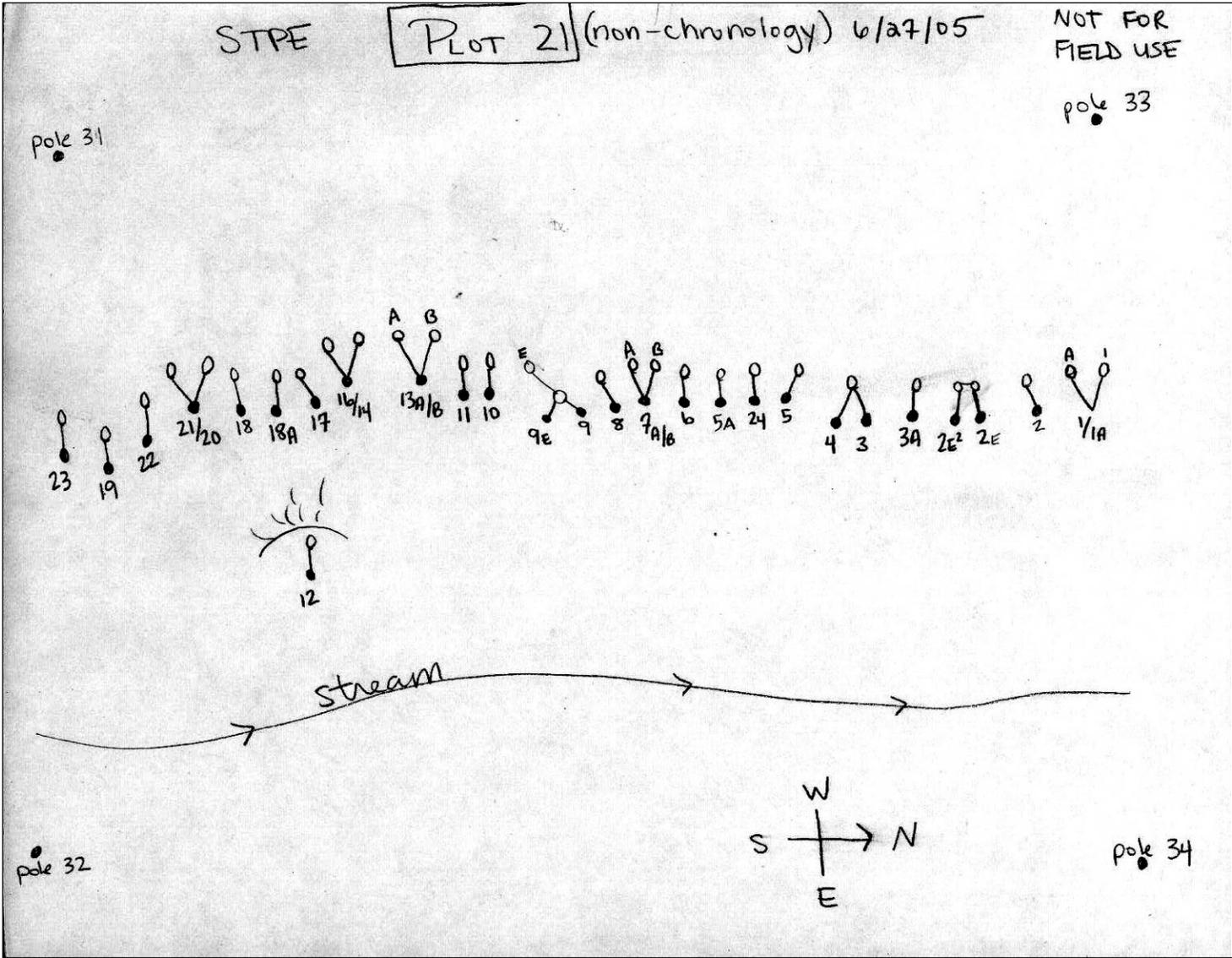


Figure 2. Example storm-petrel plot map showing locations of burrow entrances and chambers.

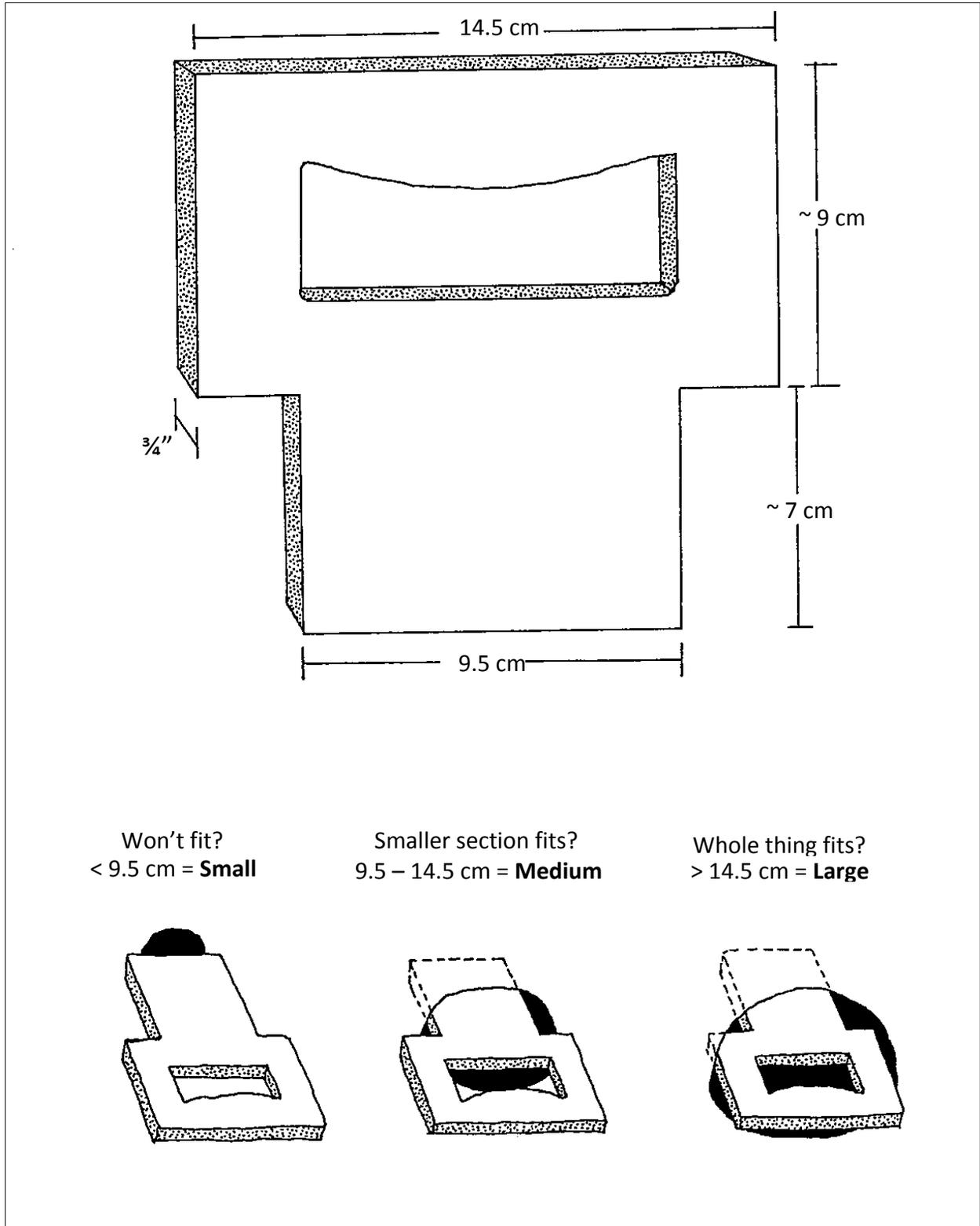


Figure 3. Diagram of burrow-measuring device and examples of burrows with entrances of different sizes.

Aikak 2009		Storm-petrel Productivity												
Nest	Plot	Spp	Ch?	Reach End?	5/21	6/10	6/24	7/7	7/21	8/6	8/20	9/7	Comments	
3	22	FTSP	Y	Y	BE	BE	BE	BC	C	C	C	C		
4			Y	N	U	U	U	U	U	U				
5		LHSP	Y	Y	N	BE	NC	BE	BC	C	C	C		
6		FTSP	Y	N	BE	BE	E	BE	E	E	E	E	Connects to 7B	
7B			N	Y	N								Connects to 6 as funnel, no chamb.	
8		FTSP	Y	N	BE	BE	BE	BC	C	C	C	C	Veers up + to right	
1		UNST	Y	N	BV	BV	V	U	U	U	U	U		
2		LHSP	Y	N	BE	BE	E	BE	E	C	C	C		
10			N	Y	N									
11			Y	N	U	U	U	U	U	U				
12			Y	N	U	V	V	U	U	U				
13		FTSP	Y	Y	BE	E	E	Ed	N					
14		LHSP	Y	N	E	E	BE	BE	CW	BC	C	C		
15		FTSP	Y	Y	BE	BE	BE	C	C	C	C	N		

Figure 4. Example of data notebook page for recording storm-petrel productivity data when checked frequently (7 or 14-day intervals) throughout the breeding season.

Storm-petrel Productivity															ISLAND: <u>WAK</u>		PLOT: <u>2</u>		YEAR: <u>2005</u>		Total pages: <u>5</u>	
Codes: Spp = species (L-Leach's storm-petrel, F-fork-tailed storm-petrel, C-Cassin's auklet, A-ancient murrelet). Size = burrow entrance size, measured horizontally (S-small <9.5 cm, M-medium 9.5-14.5 cm, L-large >14.5 cm). Chamb = chamber present? (Y=yes, N=no). A nest chamber is defined as a slight widening in the burrow, sometimes with bits of vegetation or a slight depression. If N, don't re-check. Occ = occupied. On final visit, check LARGE (i.e. tufted puffin) burrow entrances for evidence of occupancy (egg, chick, eggshells, membranes, shit, or feathers). Cont = contents (B-bird, E-egg, C-chick, M-membrane, N-nothing, U-unknown).															Date: <u>11 June</u> <i>Scott Widensaw</i>		Date: <u>15 July</u> <i>B. Drummond, D. Rehder</i>		Date: <u>24 Aug</u> <i>B. Drummond, D. Rehder</i>		Connected in 2004	
															Observers: <i>B. Drummond, D. Rehder</i>		Observers: <i>J. Williams, H. Rauer</i>		Observers: <i>Judy Adersson</i>			
Bur. no.	Spp.	Size	Chamb.	Last visit Occ.	Reach end?	Cont.	chick mass (g)	wing chord (mm)	Reach end?	Cont.	chick mass (g)	wing chord (mm)	Reach end?	Cont.	chick mass (g)	wing chord (mm)						
1			N		N	L U			N	U			N	U								
2			Y		Y	R N			Y	N			L=Y R=N	N/U								
3	MAU		Y		N	E			N	E			N	U								
4	F		Y		N	BE			N	C	48		N	C	No down 86	141						
5	F		Y		N	BE			Y	N			Y	N								
6	F		Y		N	BE			Y	BE			N	U								
7	F		Y		Y	N			Y	BE			Y	C	46	Too Small						
8	F		Y		Y	BE			Y	BC	<i>chick hatched very recently</i>		Y	C	103	106						
9	?		Y		N	E			N	U			N	U								
10			N		N	U																
11	F		Y		N	BE			N	BC	<i>chick tiny, just hatched</i>		N	U								
12	F		Y		N	U			N	BE			N	E								
13	F		Y		Y	BE			Y	Bad			Y	N								
14			N		N	U																
15			Y		N	U			N	U												
16	F		Y		N	BE			N	BE			N	C	89	83						
17			Y		Y	N			N	U			Y	N								
18	MAU		Y		N	BE			Y	C	<i>big, some down on left</i>		N	U								
19			N		N	U																
20			N		Y	N			Y	N												
21			N		N	U																

Figure 5. Example of data notebook page for recording storm-petrel productivity data when checked three times (about 30-day intervals) during the breeding season.

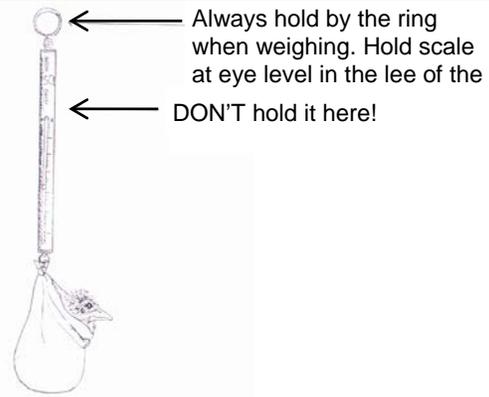


Figure 6. Storm-petrel species identification for downy chicks. Fork-tailed storm-petrel chicks (on right in both photos) are light gray with a circular patch of lighter down around the butt; Leach's storm-petrel chicks (on left in both photos) are uniformly darker gray/brown.

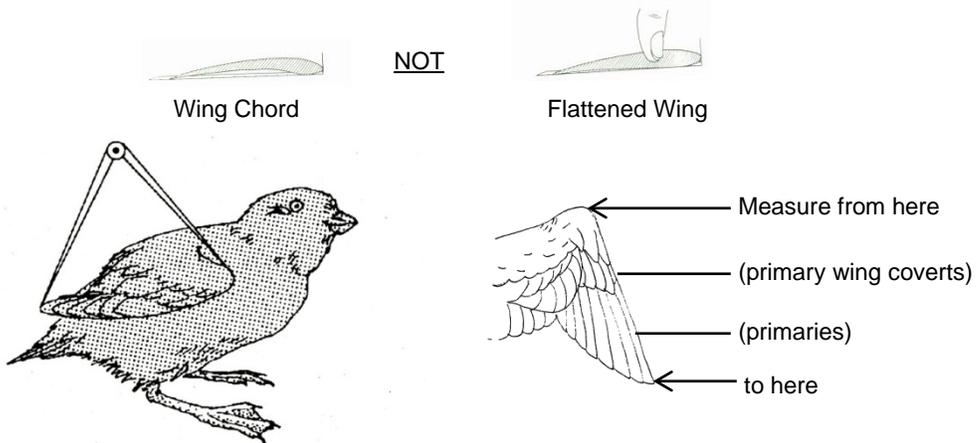


Figure 7. Storm-petrel grubbing attire of “grubbing gauntlets” (tight sleeves) and “grubbing vest” (sleeveless rain jacket).

Mass - Weigh birds using a Pesola® scale. Weigh the bag and bird and then the bag separately at end. Check bag occasionally for dryness.



Wing chord - holding the wing next to the body and using a metal ruler with a stop, measure to the furthest feather tip possible. Always measure the right wing.



Diagonal tarsus - length between the intertarsal joint and the distal end of the last leg scale before the toes emerge. Always measure the right leg.

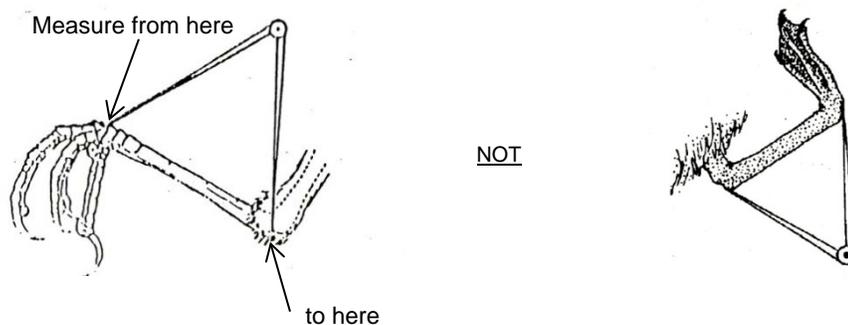


Figure 8. Diagram of storm-petrel chick measurements taken on the Alaska Maritime National Wildlife Refuge.

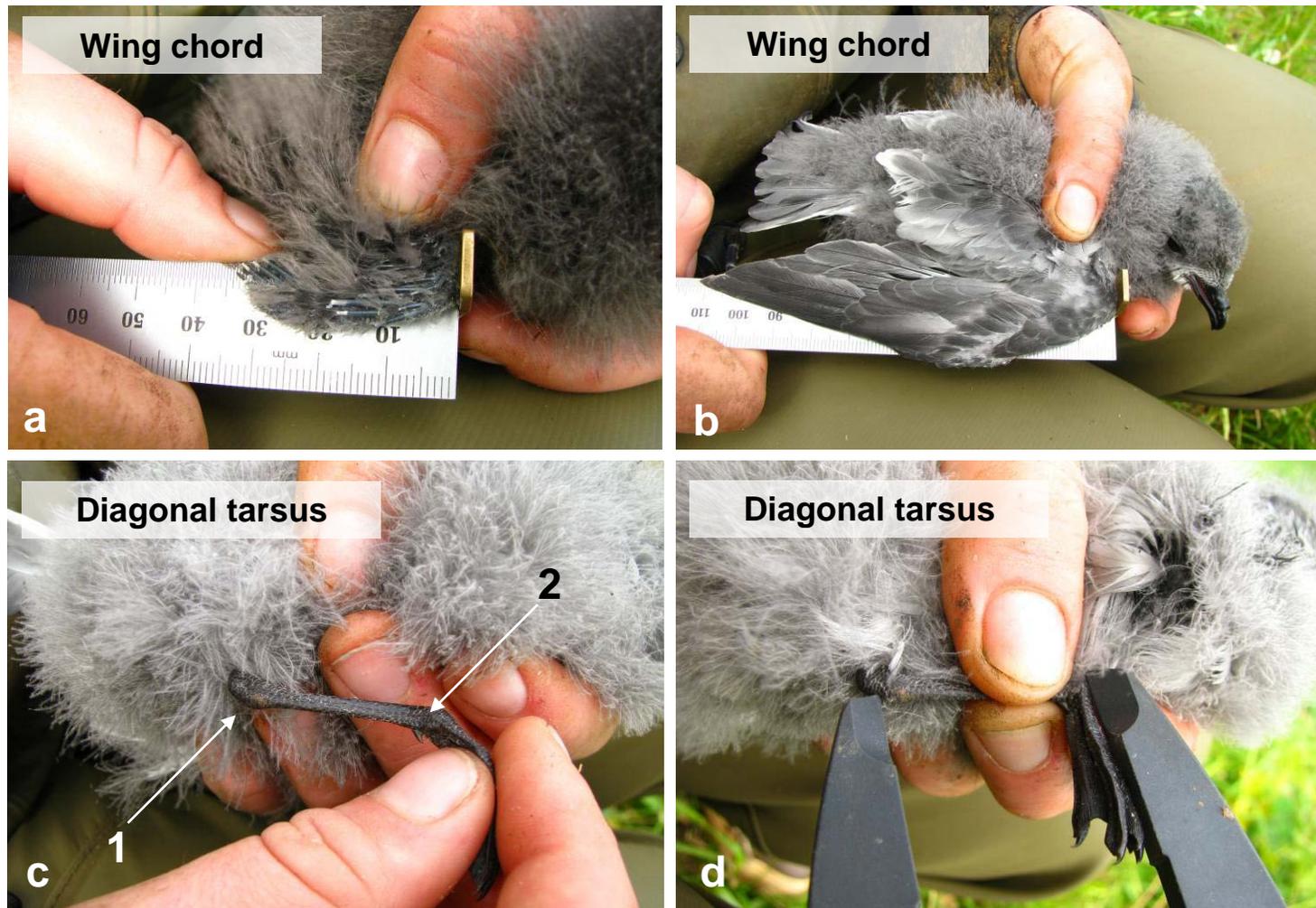


Figure 9. Photos showing storm-petrel chick measurements taken on the Alaska Maritime National Wildlife Refuge. Wing chord measurements are shown on (a) small and (b) large chicks; note that wing is relaxed, shoulder is bent, and for small chick, length is measured to the end of the erupting primary, not downy tuft. For tarsus (c & d), note that calipers rest in the groove of joint #1 rather than the far distal end.

Attachment A. Aiktak Island specifics (includes Figures A1-6 and Table A1)

PROCEDURE DETAILS SPECIFIC TO AIKTAK

Both fork-tailed and Leach's storm-petrels breed at Aiktak. Birds nest primarily in soil burrows in the banks of streams and drainages, although a few birds can be found in puffin burrows around the perimeter of the island and in rock crevices or under boulders on the beaches. On Aiktak, eggs are generally laid in May and June. Fork-tailed storm-petrel chicks typically hatch from late June to mid-August; Leach's storm-petrels hatch from mid-July to late August. A few early fork-tailed storm-petrel chicks may fledge in late August but most fork-tailed and all Leach's storm-petrels fledge later in September and October, after crews have left the island.

Storm-petrel productivity, phenology, and chick growth are monitored on 18 plots scattered around the island (Figure A1 and Table A1). Most plots are rectangular areas bounded by four poles (one at each corner); one plot is circular with a single pole at the center.

Early in the season before vegetation becomes rank (late May or early June), make an initial visit to all plots to reflag burrow entrances, map both entrances and chambers, and determine initial burrow contents. Also search the entire plot area for any new entrances within the plot boundaries, which are much easier to find when the vegetation height is lower (do NOT mark burrows that fall outside the plot, this will mess up the density/occupancy data); some plots are quite large and there is a lot of room for new potential burrows. When searching for new burrows it can be helpful to stretch a tape measure between plot poles to make boundary determination easier.

Some crews find it easiest to do all burrow flagging and mapping first, and then come back another day when fresh to grub burrows for the first time; some crews prefer to do it all at once. All burrows should be marked with a numbered flag at the **lower left corner** of the entrance. If you have to mark the entrance elsewhere due to the physical structure of the burrow, make a note of it on your map. There is no specific burrow numbering scheme on Aiktak. For new burrows, refer to the plot map and choose any number not already used in that plot (it is easiest and less confusing if you choose unique numbers rather than using alphanumeric combinations such as 46A and 46B, and if you start with the next lowest number available). For old burrows, try to use the same number as in previous years (if the number is worn off the old flag, you can often figure out the number using the maps). Once nests are flagged, measure and record entrance size of all burrows (lump small and medium entrances together for all plots because most plots were used for productivity at some point in the past), and reach an arm in to record presence of a chamber, nest status, species (if occupied), whether the end is reachable, and any connections to neighboring burrows. It can take a long time (sometimes many days) to get through the initial check; don't get discouraged, future checks will go faster. To stream-line data collection, after the first check it may be helpful to reorder your notebook to coincide with the order you will be checking nests and clearly identify nests with chambers to be checked again in the data notebook and even in the field [e.g., use an additional flag of a different color flag to identify these nests].

Storm-petrel plots on Aiktak are divided into two groups, chronology and productivity (non-chronology) plots (see Figure A1). These two groups differ with respect to visitation frequency and level of disturbance. Chronology plots are visited every 7 days and used for phenology and chick growth data, while productivity plots are visited every 14 days and used for productivity data. Field crews should check all storm-petrel plots together, with one person grubbing burrows while the other records data. For consistency, try to have the same person grub the same burrows throughout the season (e.g., assign a dedicated grubber and a data recorder to each plot, although be sure to switch up plots so one person doesn't grub the entire island!).

Chronology Plots: Plots 8, 12, 23, 25, and 27

Beginning 7 days after the initial check, check burrows every 7 days throughout the season (can adjust a day or so earlier for weather considerations; avoid going more than 7 days because a nest with a hatch date interval of more than 7 days will not be used in analysis). Once an egg is laid, you technically don't need to check the burrow again until close to expected hatch. Therefore, if you know when the egg was laid (e.g., went from empty to an egg on subsequent check), you can skip checking that burrow again for about 30 days, then resume checking every 7 days until the end of the season to get accurate hatch dates and chick fates. If you do not know when the egg was laid (e.g., burrows that contained eggs or incubating adults on your first visit), use the earliest hatch dates recorded in past years as a guide to

when to expect the earliest hatch and skip checks until just before that date before resuming 7-day checks.

Conduct chick growth measurements on all chicks that hatch in chronology plots. Beginning the **check after** you first encounter a chick, measure chicks every 7 days during regularly-scheduled checks of chronology plots until chicks fledge or you leave the island (you can truncate measurements for the linear growth period afterwards). It can be helpful to add a different color of flagging to chick growth burrows for ease of finding them.

Try to keep chicks as clean and dry as possible. If the person grubbing a plot is extremely muddy and wet, it may be helpful for the data recorder to handle chick measurements for that plot. **Do NOT remove chicks from burrows when adults are present or on wet days** when their down may become wet. If cannot measure a chick on a particular day for any reason (e.g., the chick ran out of reach, an adult was present, or inclement weather), you can try again the following day; if you fail twice in a row, wait until the next scheduled check in 7 days. For consistency in measurements, try to have the same person measure the same chick each time.

As chicks grow, they will become more mobile and can dash away out of your grasp surprisingly quickly. Know in advance which nests have chicks to measure so you can be ready to grab a chick as soon as you put your arm in a burrow. If possible, check plot map ahead of time to know if the burrow is a right- or left-handed tunnel to help grab the chick on the first try.

Chick growth sample size will be limited by the number of chicks that hatch in chronology plots. Do NOT measure chicks in productivity plots to make up for small sample sizes in chronology plots.

Productivity plots (non-chronology plots): Plots 9, 10, 11, 13, 16, 17, 18, 19, 20, 21, 22, 24 and 26

After the initial check in late May check plots every 14 days (+/- a day if necessary depending on weather) until the end of the season. Do not skip checks between egg laying and hatching, as done with chronology plots - less frequent check intervals make projecting hatch dates too inaccurate for this in productivity plots. Chicks are **not** measured on productivity plots; the only reason a chick should be removed from a burrow in productivity plots is to identify the species if that has not yet been determined.

There are also five artificial burrow plots (Figures A1-6 and Table A1) on Aiktak with 6-12 burrows each, all made of corrugated plastic tubing. Four plots are marked with a single pole, the other is within a productivity plot. At the beginning of the season, location and flag burrows and check nest statuses. (Because they are not used, they tend to get overgrown with vegetation so you may have to search around a bit and dig them out). If any burrows are occupied, you can monitor them throughout the season as you would productivity plots (every 14 days), if you have time or if your unit biologist asks you to. If burrows are not occupied by mid-June, you can stop checking them.

For both chronology and productivity plots, there is no need to continue to check any burrows that did not have a chamber on the first check. Do continue to check empty and unknown burrows until you can be sure that egg laying is complete (usually into August for Leach's storm-petrels). This can be determined most accurately using data from your chronology plots; when you go at least two checks in your chronology plots without new eggs, you can stop checking empty and unknown burrows in all plots.

For a number of nests, chambers will be difficult to reach and you may have BU/U statuses only (e.g., BU BU BU BU U U U U). Crews always want to know when they can stop checking these nests. For chronology plots, we use nest data for hatch dates, chick growth, and occupancy. If you have already confirmed the species for occupancy data and you determine that you will never get hatch dates or be able to access chicks, then you can stop checking the nest. For productivity plots, it is unfortunately important to check these nests until the end: if you happen to reach to a chick at the last check, when chicks are larger and more mobile, the nest will suddenly become a known-fate nest (a nest with a chick still present at the last check is deemed potentially successful).

For nests in which eggs appear abandoned later in the season, make sure to continue checking eggs until they are no longer potentially viable (68 days old for fork-tailed storm-petrels, 50 days old for Leach's storm-petrels).

Storm-petrels were banded on Aiktak in the past to estimate adult survival rates but this has been discontinued because of difficulty attaining an appropriate resighting effort. However, we continue to record observations of previously banded birds on an incidental basis. Record the band number of any banded birds that you encounter while monitoring productivity (i.e., adults extracted from burrows to identify species - never remove a bird from a burrow solely to see if it happens to be banded). Add a

resight page in storm-petrel field notebooks to record band numbers.

Specific Requirements for Aiktak

Dates: *Productivity/phenology:* initial visit/mapping of all plots in late May, then every 7 (for chronology plots) or 14 days (for productivity plots) throughout end of season.

Chick growth: late July through end August.

Optimal sample size: *Productivity/phenology:* All burrows in specified plots.

Chick growth: As many as possible in chronology plots.

Time of day: *Productivity/phenology:* Any time.

Chick growth: Any time.

Weather: *Productivity/phenology:* Any, but for your sake, try to avoid excessively wet and windy conditions if possible, given that grubbing requires minimal clothing.

Chick growth: Avoid wet and windy conditions.

Equipment needed: *Productivity/phenology:* Grubbing gauntlets and vests (disposable gloves with fingertips cut off optional), plot maps, Rite-in-the-Rain[®] notebook, two pencils, flags (for initial visit), burrow measuring board (for initial visit), two permanent markers (for initial visit).

Chick growth: Bird bag and/or pantyhose toes, Pesola[®] scales (100g and 300g), wing ruler (150mm), calipers, "chick grabber" device (optional), Rite-in-the-Rain[®] notebook, two pencils.

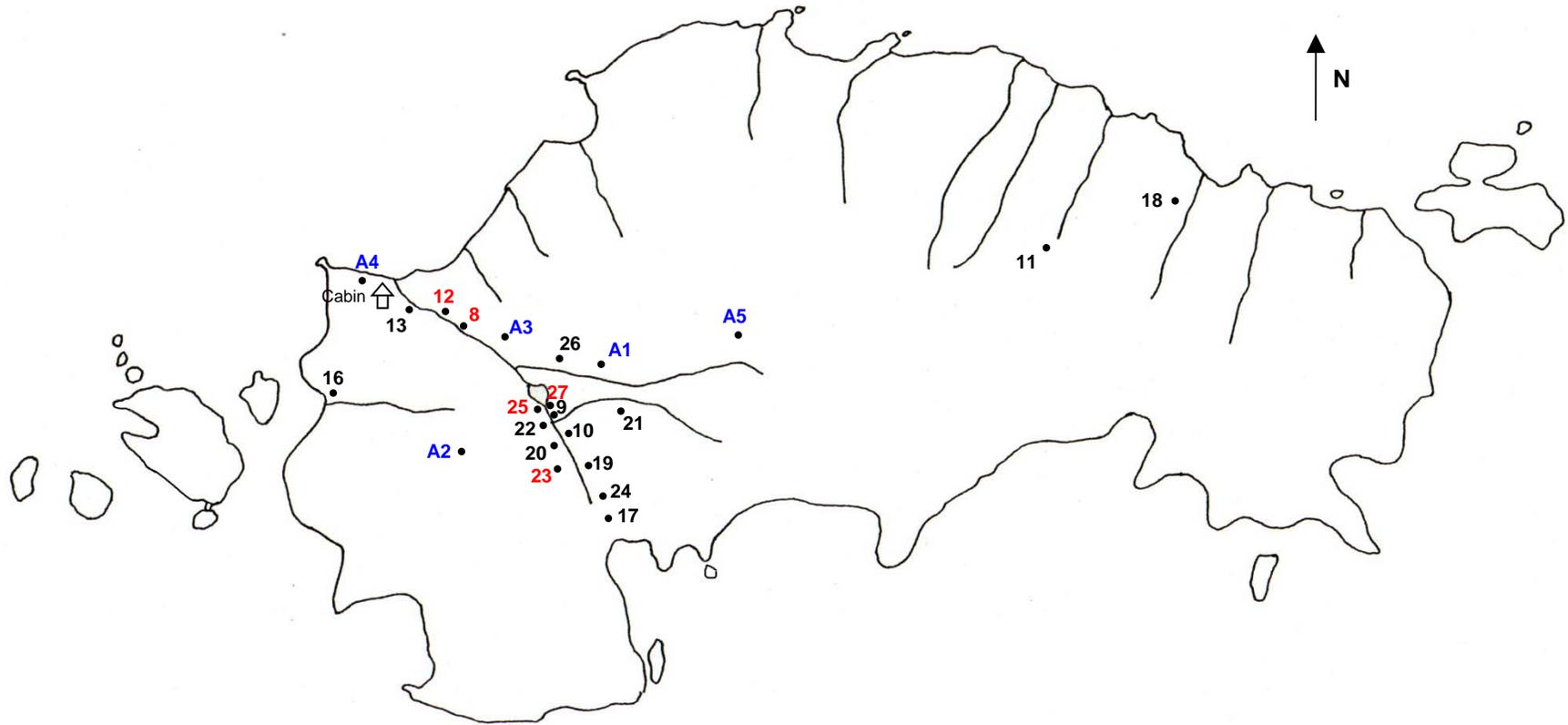


Figure A1. Location of storm-petrel plots at Aiktak Island. Chronology plots are shown in red, productivity plots in black, and artificial nest box plots in blue.

Plot A1
Storm-Petrel artificial burrows
Inside Plot 26 Burrows A1-A6
N 54°11.033' W 164°50.409'

6 burrows, numbered A1-A6. Located within STPE productivity plot 26. Photo taken from Pole 264 as point of reference but no pole located directly above burrows. Use plot 26 burrow maps to locate burrows.



Figure A2. Artificial storm-petrel plot A-1 at Aiktak Island.

Plot A2
Storm-Petrel artificial burrows
Pole 602 Burrows A7-A12
N 54°10.996' W 164°50.544'

6 burrows, numbered A7-A12. Located in the drainage the sits due west of plots 25 and 22. In 2009, most of these artificial burrows had storm-petrel tenants. The surrounding area is also good for picking up a few extra birds in natural burrows if needed to boost your sample sizes.



Figure A3. Artificial storm-petrel plot A-2 at Aiktak Island.



Figure A4. Artificial storm-petrel plot A-3 at Aiktak Island.



Figure A5. Artificial storm-petrel plot A-4 at Aiktak Island.

Plot A5
Storm-Petrel artificial burrows
Pole 605 Burrows A31-A42
N 54°11.001' W 164°50.263'

Plot A5 12 burrows, numbered A31-A42. Located up the drainage from plot 21. Can get thickly covered in *Heracleum lanatum*.



Figure A6. Artificial storm-petrel plot A-5 at Aiktak Island.

Table A1. Description of storm-petrel plots at Aiktak Island. Most plots are rectangular areas bounded by four poles (one at each corner); plot 16 is a circular plot with a single pole at the center. Artificial plots are marked by a single pole (A2-A5) or nothing (A1).

Plot	Pole #	Pole type	Plot shape	Area (m ²)
Chronology Plots				
8	8, 7, 1, 3	Pipe w/ embossed #	Rectangular	100
12	4, 3, 1, 2	Crimped poles	Rectangular	50
23	231, 232, 233, 234	Rebar with caps	Rectangular	455
25	251, 252, 253, 254	Rebar with caps	Rectangular	1219
27	271, 272, 273, 27	Rebar with caps	Rectangular	340
Productivity Plots				
9	20, 12, 15, 21	Pipe w/ embossed #	Rectangular	200
10	18, 24, 23, 10	Pipe w/ embossed #	Rectangular	150
11	11, 28, 30, 26	Rebar with caps	Rectangular	50
13	8, 7, 5, 6	Crimped poles	Rectangular	50
16	16	Rebar with caps	Circular	100
17	17, 72, 73, 74	Rebar with caps	Rectangular	50
18	18, 82, 83, 84	Rebar with caps	Rectangular	494
19	19, 92, 93, 94	Rebar with caps	Rectangular	125
20	68, 62, 63, 64	Rebar with caps	Rectangular	75
21	31, 32, 33, 34	Rebar with caps	Rectangular	119
22	85, 86, 87, 88	Rebar with caps	Rectangular	288
24	241, 242, 243, 244	Rebar with caps	Rectangular	52
26	261, 262, 263, 263	Rebar with caps	Rectangular	-
Artificial Plots				
A1	within STPE plot 26	-	-	-
A2	602	Rebar with caps	-	-
A3	603	Rebar with caps	-	-
A4	604	Rebar with caps	-	-
A5	605	Rebar with caps	-	-

Attachment B. Buldir Island specifics (includes Figure B1 and Table B1)

PROCEDURE DETAILS SPECIFIC TO BULDIR

There are six plots (1-4, 7 and 9) that are currently used for monitoring productivity and chronology of storm-petrels on Buldir Island (Figure B1). Historically, there were a total of 10 plots but plots 5 and 8 were dropped due to the difficulty in working within them; plot 11 was formerly a control plot that is now surveyed only for population indices; and plot 26 was an experimental, artificial burrow plot. Detailed descriptions and directions to each plot can be found in the booklet entitled “Burrow nesting seabird plot locations and descriptions: Buldir Island, Alaska” which can be found in the “Auklets, Puffins, Petrels Maps” binder.

Storm-petrel productivity at Buldir was historically (1974-2014) monitored in a Boom-or-Bust fashion with a 30-day check interval (three or four visits – often one initial visit to mark and count burrows, then three main visits to determine nest contents). Beginning in 2015, storm-petrel productivity at Buldir followed a more frequent 14-day check interval. Monitoring plot 9 for chronology was started in 2016.

Conduct an initial visit to all six plots between late May and early June, before the vegetation becomes too deep. On this visit you will flag and map burrow entrances and determine initial nest contents. Some crews find it easiest to do all burrow flagging and mapping first, and then come back another day when fresh to grub burrows for the first time; some crews prefer to do it all at once. Whatever you do, *make sure to thoroughly search, map and flag burrows in all plots as early in the season as possible, before vegetation begins to take over.*

On the first check, find the coordinates of each corner stake for each plot and search for all burrows within the plot boundaries (maps from the previous year will greatly help!). Each burrow should have a numbered flag and a small, numbered, plastic stake that are usually located on the *lower left* side of the entrance. Previous years' flags do not overwinter well and will likely be reduced to a stick with a flimsy bit of orange plastic. Mark all burrows with new flags (it may help to label flags ahead of time using previous years' plot maps). Also search carefully for any new burrows that have not yet been marked and mapped - it is critical that you do a good job of marking and recording burrow locations on this first visit so that you can relocate them during later checks when the vegetation is very dense. To ensure you cover the entire plot, place a check mark over burrows completed on your plot map as you proceed through the plot (if you have the plot map in a plastic sheet protector, use a permanent marker to write directly on the plastic). Once nests are flagged, measure and record entrance size of all burrows (lump small and medium entrances together for all plots because most plots were used for productivity at some point in the past), and reach an arm in to record presence of a chamber, nest status, species (if occupied), whether the end is reachable, and any connections to neighboring burrows. It can take a long time (sometimes more than one day) to get through the initial check; don't get discouraged, future checks will go faster. With three or four field crew members, it is best to have two people grubbing burrows while one person records data. To stream-line data collection it helps to mark burrows with reachable chambers with a flag of a different color. If you use a flag with a metal shaft make sure to remove it at the end of the season as it will likely lose the flag overwinter and become a hazard for eyeballs and other soft squishy body parts.

Note that these plots are also used for tufted puffin density and occupancy surveys which occur every other year. In those years, the initial count for puffin burrow density in these plots can take place concurrently with your first storm-petrel visit (see Burrow-nester Population Protocol).

Chronology Plot: Plot 9

Beginning 7 days after the initial check, check burrows every 7 days throughout the season (can adjust a day or so earlier for weather considerations and trips to Spike; avoid going more than 7 days because a nest with a hatch date interval of more than 7 days will not be used in analysis). Once an egg is laid, you technically don't need to check the burrow again until close to expected hatch. Therefore, if you know when the egg was laid (e.g., went from empty to an egg on subsequent check), you can skip checking that burrow again for about 30 days, then resume checking every 7 days until the end of the season to get accurate hatch dates and chick fates. If you do not know when the egg was laid (e.g., burrows that contained eggs or incubating adults on your first visit), use the earliest hatch dates recorded in past years as a guide to when to expect the earliest hatch and skip checks until just before that date before resuming 7-day checks.

Conduct chick growth measurements on all chicks that hatch in chronology plots. Beginning the **check after** you first encounter a chick, measure chicks every 7 days during regularly-scheduled checks of chronology plots until chicks fledge or you leave the island (you can truncate measurements for the linear growth period afterwards).

Try to keep chicks as clean and dry as possible. If the person grubbing a plot is extremely muddy and wet, it may be helpful for the data recorder to handle chick measurements for that plot. **Do NOT remove chicks from burrows when adults are present or on wet days** when their down may become wet. If cannot measure a chick on a particular day for any reason (e.g., the chick ran out of reach, an adult was present, or inclement weather), you can try again the following day; if you fail twice in a row, wait until the next scheduled check in 7 days. For consistency in measurements, try to have the same person measure the same chick each time.

As chicks grow, they will become more mobile and can dash away out of your grasp surprisingly quickly. Know in advance which nests have chicks to measure so you can be ready to grab a chick as soon as you put your arm in a burrow. If possible, check plot map ahead of time to know if the burrow is a right- or left-handed tunnel to help grab the chick on the first try.

Chick growth sample size will be limited by the number of chicks that hatch in chronology plots. Because they nest so late you may end up with only two measurements for several Leach's storm-petrel chicks; that is OK. Do NOT measure chicks in productivity plots to make up for small sample sizes in chronology plots.

Productivity plots (non-chronology plots): Plots 1-4 and 7

After the initial check, continue to check plots every 14 days (+/- a day if necessary depending on weather) until the end of the season. There is no need to continue to check any burrows that did not have a chamber on the first check. Do continue to check empty and unknown burrows until you can be sure that egg laying is complete (usually into August for Leach's storm-petrels). To stream-line data collection, after the first check it may be helpful to reorder your notebook to coincide with the order you will be checking nests and clearly identify nests with chambers to be checked again in the data notebook and even in the field [e.g., use an additional flag of a different color flag to identify these nests]). For nests in which eggs appear abandoned later in the season, make sure to continue checking eggs until they are no longer potentially viable (68 days old for fork-tailed storm-petrels, 50 days old for Leach's storm-petrels).

Chicks are **not** measured on productivity plots; the only reason a chick should be removed from a burrow in productivity plots is to identify the species if that has not yet been determined. If you must remove a chick to determine species, avoid doing so in wet conditions.

Storm-petrels were banded on Buldir in the past to estimate adult survival rates but this has been discontinued because of difficulty attaining an appropriate resighting effort. However, we continue to record observations of previously banded birds on an incidental basis. Record the band number of any banded birds that you encounter while monitoring productivity (i.e., adults extracted from burrows to identify species – never remove a bird from a burrow solely to see if it happens to be banded).

Special considerations for working in the storm-petrel plots at Buldir: These plots and the areas around them are extremely fragile and it is easy to accidentally crush a burrow as you walk. Use caution and try to step in front of and below burrow entrances rather than above them and try to avoid areas of bare dirt. Be aware of your surroundings as you reach into burrows. When you do crush a burrow, excavate the area with your hands and check to make sure that any bird occupying that burrow is able to get out. Once the dirt is removed, cover the resulting hole with a piece of wood and a layer of dirt over the top. All crew members should carry some material for repairing burrows. If you don't have any wood with you to make a repair, you can make a lattice with the stalks of vegetation and then cover the new "roof" with a layer of dirt. However, you should avoid using Putchki for this as it will result in a very uncomfortable rash. If you accidentally damage the burrow of a bird that is being monitored for productivity, record this in the data and exclude it from your final analysis.

Specific Requirements for Buldir

Dates: *Productivity/phenology:* initial visit/mapping in late May, then every 7 (for chronology plots) or 14 days (for productivity plots) throughout end of season.

Chick growth: mid-July through end August.

Optimal sample size: *Productivity/phenology:* All burrows in specified plots.

Chick growth: As many as possible in chronology plot.

Time of day: *Productivity/phenology:* Any time.

Chick growth: Any time.

Weather: *Productivity/phenology:* Any, but for your sake, try to avoid excessively wet and windy conditions if possible, given that grubbing requires minimal clothing.

Chick growth: Avoid wet and windy conditions.

Equipment needed: *Productivity/phenology:* GPS with waypoints entered, plot maps with sheet protectors, datasheets, clipboard, flags (initial visit: pre-labeled for existing burrows, blank for new ones), plastic stakes (if necessary), measuring tape (initial visit), burrow measuring board (initial visit), grubbing gauntlets (disposable gloves with fingers cut off optional), multiple pencils, permanent markers (fine tip for marking maps, fat for making flags), foot-sized sections of plywood to repair damaged burrows.

Chick growth: Bird bag and/or pantyhose toes, Pesola[®] scales (100g and 300g), wing ruler (150mm), calipers, “chick grabber” device (optional), Rite-in-the-Rain[®] notebook, two pencils.

Equipment suggested: Binder clips or large rubber bands to keep datasheets from blowing off of clipboard. Flags of a different color for differentiating between burrows you should grub and ones you should not.

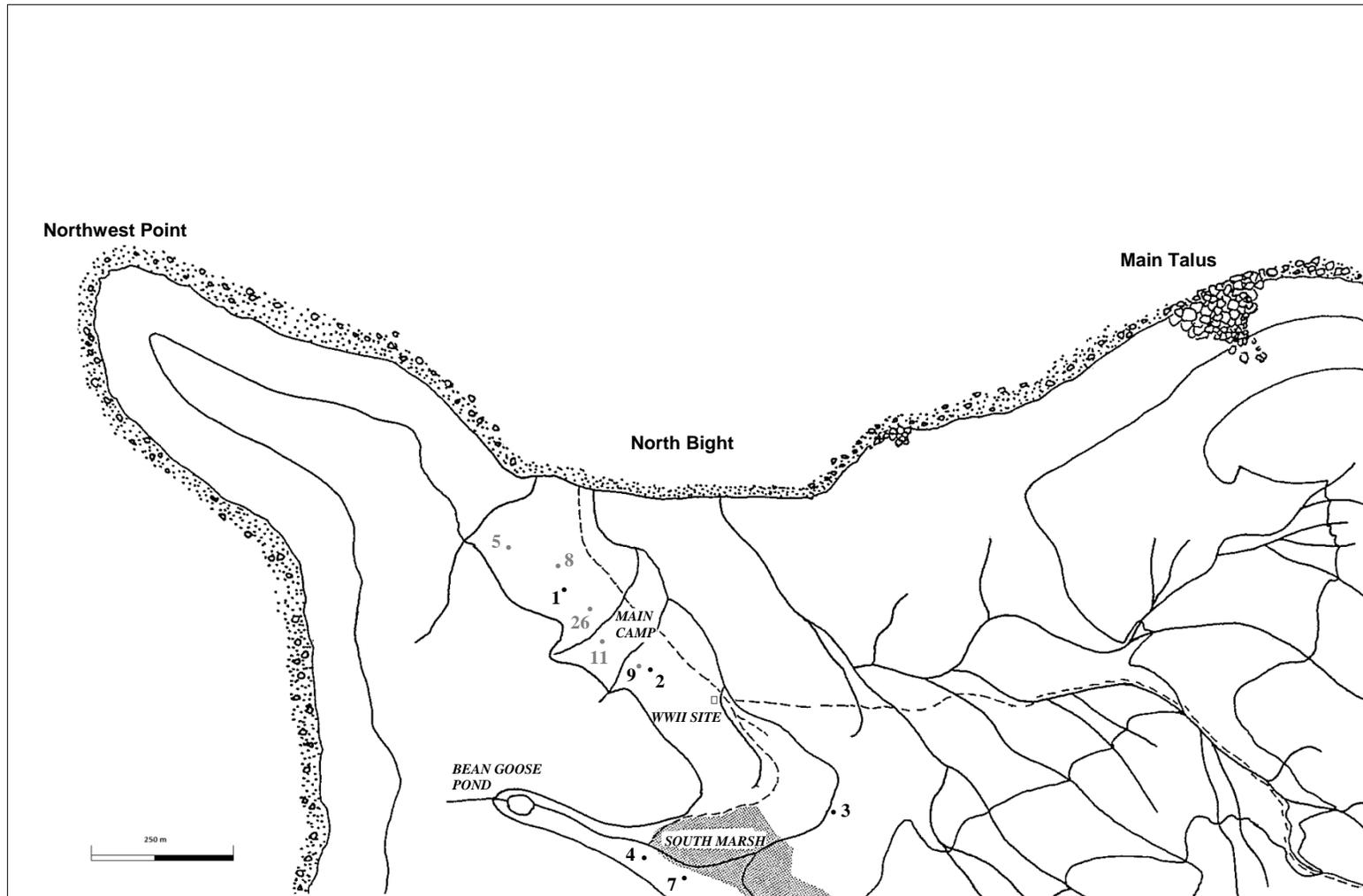


Figure B1. Locations of storm-petrel plots on Buldir Island. Plot numbers in black indicate those used for occupancy, productivity, and/or chronology. Those in gray indicate plots used only for burrow density surveys (excluding plot 26, shown just for reference).

Attachment C. St. Lazaria Island specifics (includes Figure C1 and Table C1)

PROCEDURE DETAILS SPECIFIC TO ST. LAZARIA

Storm-petrel plots on St. Lazaria are divided into three different groups: phenology, productivity and population plots (Figure C1 and Table C1). Phenology plots (BN2, BN7, Random 6, Random 12, Chinup and Random Bridge) are the most data intensive and are used to calculate egg lay dates, egg hatch dates, fledging dates, and chick growth. These plots are visited every 5 days. Productivity plots (BN1, BN4, BN8, BN10, BN12, BN13, BN15, BN16) are used to calculate reproductive success and are visited every two weeks. Only species and burrow status data are obtained from productivity plots; chicks should never be measured on productivity plots. (For information on population plots, see Burrow-nester Population Protocol).

All plots are circular in shape with a rebar and/or Carsonite or wooden stake in the center with an identifying number. Most plots have a 3-meter radius, except plots 6, 7, 10, 11, 13 and 16 that have a 2-meter radius. During the initial visits at the beginning of the field season, measure each plot and delineate the boundary with pin flags. All burrow entrances within a plot are marked with flags placed to the **right** of the entrance (working from bottom to top, looking uphill). Flags should not only be uniquely numbered and but also indicate whether an excavation accompanies the burrow. Some burrows may have more than one entrance and/or excavation and should be noted on the entrance flag. Excavation flags are placed uphill, just above the excavation site, and should have the same number as its burrow entrance. Use permanent markers (i.e., Sharpies), to write on all flags. Keep in mind that winter weather can destroy or move flags between seasons. On St. Lazaria, the following pin flag color system is used on all storm-petrel plots:

White flags - used to designate the outer perimeter of each plot. These should be used when measuring plots to ensure accuracy at the beginning of the season.

Pink, red or yellow flags – used to identify burrow entrances.

Orange flags – used to identify excavation sites.

Begin visiting all monitoring plots on or before June 10; then proceed with checks throughout the end of the season following the appropriate interval for each plot type. At each visit, record nest status information not only in a notebook or on a PDA, but also on the flag with the appropriate date. If a burrow has an excavation, write the data on the excavation flag; if not, write the data on the burrow entrance flag. At St. Lazaria, also be sure to record any band numbers you encounter, the number of ticks, and presence of pox.

Once chicks hatch in phenology plots, measure chicks during the first six visits post-hatch. For most chicks, this allows us to get six mass measurements and three wing chord measurements within the linear phase of growth. Thereafter, take all measurements every other visit (i.e., 10 days apart) until plumage development (e.g., having just wisps of down, a "topknot" of down on the crown, and/or a "necklace" [an indentation ringing the base of the neck]) indicates imminent fledging. Then resume measuring chicks on a 5-day interval check to capture fledging data.

Take care measuring chicks in adverse conditions. Protect the chick from wind, rain, and the observant eyes of predators by using an umbrella when needed. Wind will also affect the accuracy of the scale.

Specific Requirements for St. Lazaria

Dates: *Productivity/phenology:* 10 June through the end of the season (every 5 days for phenology plots, every 14 days for productivity plots).

Chick growth: late July through end August.

Optimal sample size: *Productivity/phenology:* All burrows in plots.

Chick growth: As many as possible in phenology plots.

Time of day: *Productivity/phenology:* Any time.

Chick growth: Any time.

Weather: *Productivity/phenology:* Any weather, but for your sake, try to avoid excessively wet and windy conditions if possible, given that grubbing requires minimal clothing.

Chick growth: Avoid wet and windy conditions.

Equipment needed: *Productivity/phenology:* Grubbing gauntlets and vests, disposable gloves with the finger tips cut off to about the first knuckle, raincoat with sleeves cut off, plot maps, PDA data recorder and/or Rite-in-the-Rain[®] notebook, flags (for initial visit; white, pink/red/yellow, and orange), burrow measuring board (for initial visit), two permanent markers, pencils, paper towels.

Chick growth: Bird bag and/or Ziplock bag, Pesola[®] scales (60g and 100g), wing ruler (150mm), calipers, umbrella, PDA data recorder, and/or Rite-in-the-Rain[®] notebook, pencils, paper towels.

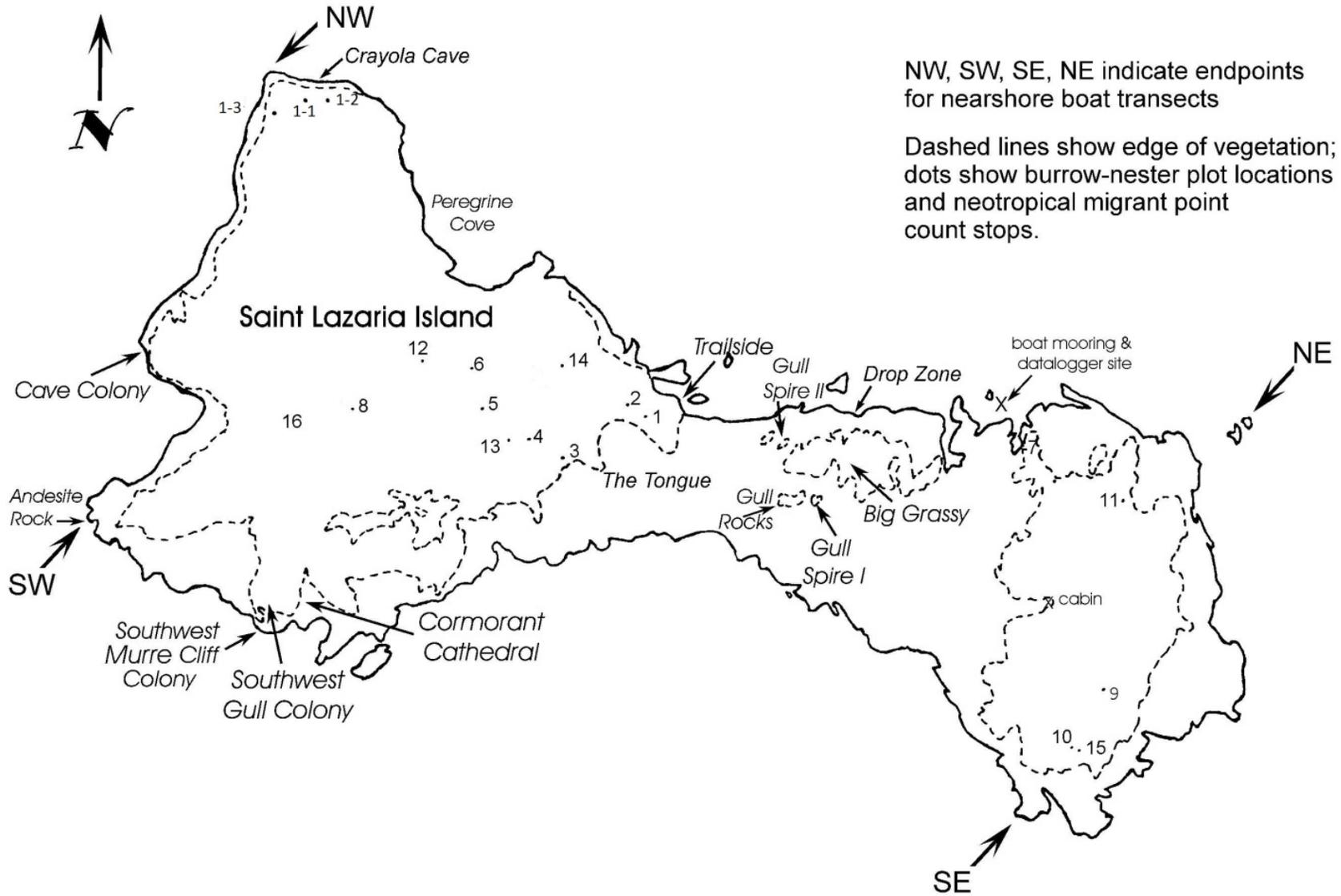


Figure C1. Location of storm-petrel plots at St. Lazaria Island.

Table C1. Data collected on burrow-nester plots on St. Lazaria Island.

Plot	Population		Productivity	Phenology	
	Density	Occupancy		Chick growth	Hatch dates
BN1	-	-	X	-	-
BN2	-	-	-	X	X
BN3	X	-	-	-	-
BN4	-	-	X	-	-
BN5	X	-	-	-	-
BN6	X	X	-	-	-
BN7	-	-	-	X	X
BN8	-	-	X	-	-
BN9	X	X	-	-	-
BN10	-	-	X	-	-
BN11	X	X	-	-	-
BN12	-	-	X	-	-
BN13	-	-	X	-	-
BN14	X	X	-	-	-
BN15	-	-	X	-	-
BN16	-	-	X	-	-
Random 6	-	-	-	X	X
Random 12	-	-	-	X	X
Chinup	-	-	-	X	X
Random Bridge	-	-	-	X	X

Attachment D. Ulak Island specifics (includes Figure D1 and Table D1)

PROCEDURE DETAILS SPECIFIC TO ULAK

Storm-petrel productivity at Ulak is monitored in a Boom-or-Bust fashion with a 30-day check interval (usually three visits). There are four burrow-nester plots on Ulak Island, but only one (plot 2) is monitored for productivity (Figure D1). Plot 2 is a 100 m² circular plot, with a 5.6 m radius and marked at the center with a rebar stake. Three visits, roughly at 30-day intervals, are made throughout the season to monitor productivity (Table D1). A crew of 3-5 people is ideal: one person should be a data recorder, filling in the datasheet and checking burrows off on the map as two or three people grub burrows. If possible, work is streamlined if there is a dedicated person to distribute flags on the first visit or measure chicks on the second and third visits. Additional people on the plot cause too much disturbance, however, as the substrate is honeycombed with burrows and prone to collapse.

Before the first visit, label flags using the previous year's plot map and make Rite-in-the-Rain copies of the datasheet and plot maps (you will need enough maps for each person to have one each visit). Bundle flags numerically in groups of about 25 to facilitate distribution once on the plot. In recent years, grubbing work has been streamlined by eliminating burrows that have always been too deep to reach – these burrows are still marked with flags but do not need to be grubbed. It is helpful to cross these burrows off on the plot map and the datasheet (do so in a way that enables observers to still see numbers on the map for orientation).

Conduct an initial visit in mid- to late June, before the vegetation becomes too deep. Each burrow should have a numbered flag and a small, yellow plastic tag with the burrow number engraved, both usually located on the *lower left* side of the entrance unless otherwise noted on the plot map. (Note: yellow tags have not been installed in the past several years so recent burrows [the highest numbers] may not have tags. Mark all burrows with new flags and remove any old flags that are stripped of their plastic or no longer readable. If old flags are still in good shape, there is no reason to remove them; later in the season when vegetation overgrows the plot and burrows are difficult to find, it can be helpful to have multiple flags marking an entrance. However, try not to keep more than three flags marking a single burrow, as it begins to get unwieldy. Also search carefully for any new burrows that have not yet been marked and mapped - it is critical that you do a good job of marking and recording burrow locations on this first visit so that you can relocate them during later checks when the vegetation is very dense.

After marking a burrow, grubbers should reach an arm in to determine presence of a chamber, nest status, species if occupied, whether ends are reachable, and any connections to neighboring burrows. In addition to storm-petrels, ancient murrelets, Cassin's auklets, and tufted puffins have all been encountered nesting in the productivity plot on Ulak. If you find one of these species, record all the same data as you would for a storm-petrel burrow and use the data as incidental observations in an annotated list. Finally, if time allows on the first visit, record the size of the burrow entrance – most burrows on Ulak have been enlarged through annual grubbing so most burrows are lumped together as small/medium burrows and do not need to be measured; it is only necessary to record the number of large burrows you encounter.

After your initial visit, make two more visits over the season to grub burrows and determine nest status for productivity: in mid- to late July and in mid- to late August. With so few checks spread so far apart, it is possible to get a rough estimate of maximum productivity but not any phenology data. In July, *recheck all burrows that had chambers*, even if they were empty or had an unreachable end before; you do not need to check burrows that did not have chambers on the previous check. At the final check in August, *recheck only burrows with chambers and reachable ends*; you do not need to check burrows that did not have chambers OR those with unreachable ends the previous two checks. If eggs are still present, gently extract them and attempt to determine if they are abandoned/failed or still viable (check that they are still clean and intact with no cracks; (Leach's storm-petrel eggs will often hatch after your last visit).

When chicks are present (generally the July or August checks), remove chicks from burrows for chick growth measurements. Due to time constraints, only measure mass and wing chord (not diagonal tarsus). You will only get one or two growth measurements from each chick, but even having a single chick measurement can still provide a potentially index of timing. For chicks with two that fall within the linear growth period, you can calculate a rough growth rate estimate.

After each visit, transcribe data from the Rite-in-the-Rain datasheet onto a clean copy of the

datasheet or into the computer, as the waterproof copy will be used for all three visits and you need to have a back-up. At the end of the season, be sure to update all maps for the next year.

Data on burrow persistence were collected historically; these surveys are no longer done due to limited time constraints.

Special considerations for working in the storm-petrel plot at Ulak: Like many storm-petrel colonies, the plot at Ulak is fragile substrate honeycombed with burrows and prone to collapse. Move gingerly when working in the plot, especially more densely populated eastern half of the plot. In addition, most of the plot consists of *Leymus* vegetation, the tips of which can be surprisingly sharp – take caution when grubbing burrows to avoid poking yourself in the eye. This is can cause a serious injury (people have had to be evacuated from field camps for eye injuries from *Leymus*!) so consider wearing protective goggles, especially on windy days.

It can be extremely cold grubbing burrows on wet, windy days and due to time constraints of the ship, you may have to work in less-than-ideal conditions. Although grubbers need to minimize shirt layers to keep arms as skinny as possible, warm pants, vests, and hats can all help keep you warm. Wear as few layers as possible on the steep hike up to the plot to prevent getting sweaty and then pile the extra clothes on when you get there.

Finally, the storm-petrel productivity plot is a long way up the hill from the beach, so triple check your supplies before you leave the ship to make sure you have everything you need. It is a good idea to bring multiples of small, crucial items that may be easily lost in the vegetation (pencils, permanent markers, Pesola® scales and wing rulers).

Specific Requirements for Ulak

Dates: Three visits: mid- to late June, mid- to late July, and mid- to late August.

Optimal sample size: One productivity plot.

Time of day: Any time.

Weather: Avoid windy, wet weather for handling of adults or chicks.

Equipment needed: Rite-in-the-Rain® copies of plot map (one for each person) and datasheet, clipboard, flags (initial visit: pre-labeled for existing burrows, blank for new ones), burrow measuring board (initial visit), grubbing gauntlets and vests (disposable gloves with fingertips cut off optional), protective goggles (optional), bird bag and/or pantyhose toes, Pesola® scales (100g and 300g), wing ruler (150mm), multiple pencils, multiple permanent markers.

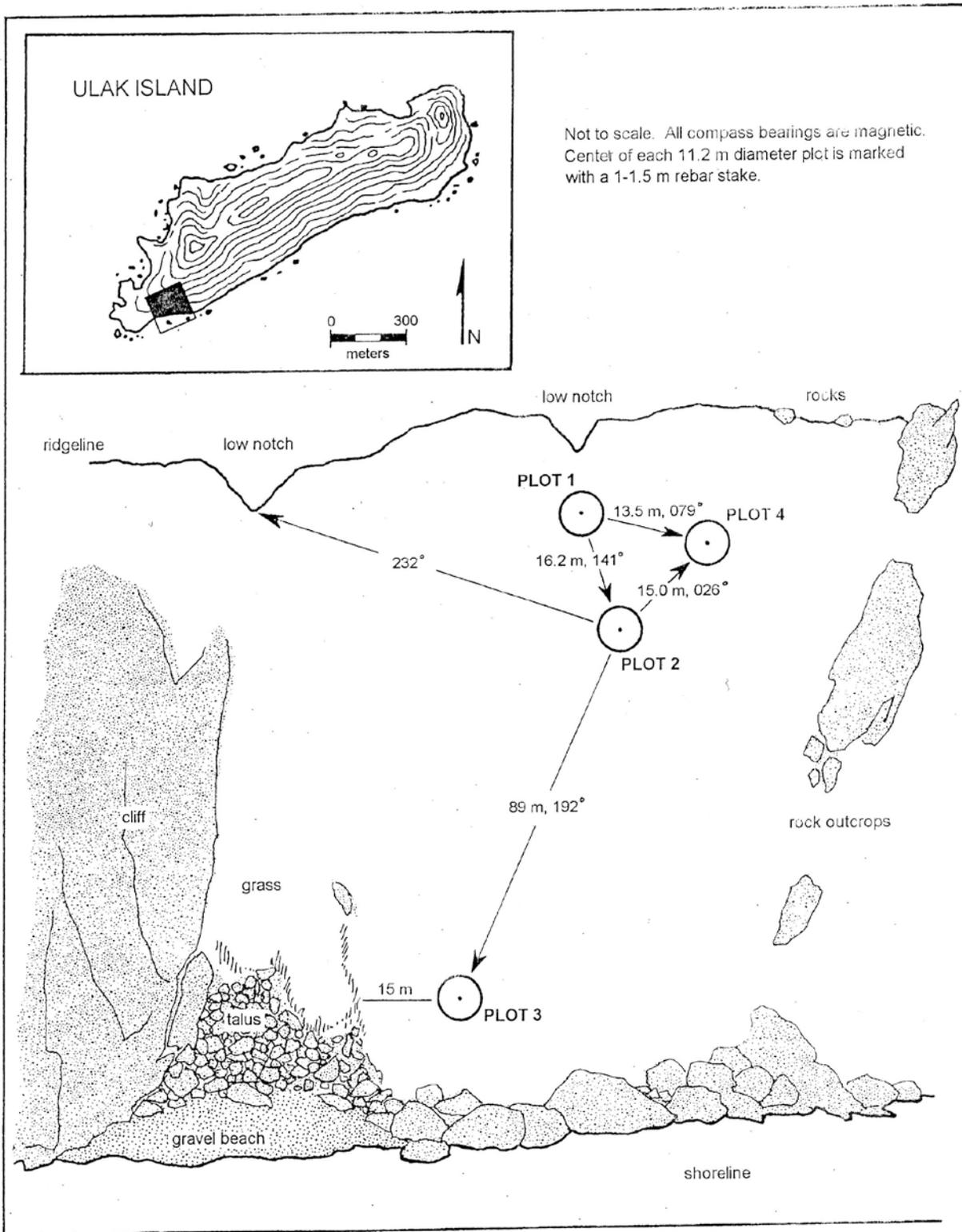


Figure D1. Location of storm-petrel plots used for productivity (plot 2) and population (plots 1-4) indices at Ulak Island.

Table D1. Summary of work conducted during three visits to storm-petrel productivity plot (plot 2) on Ulak Island.

Visit:	1	2	3
Dates:	Mid- to late June	Mid- to late July	Mid- to late Aug
Tasks:	Count and mark all burrows, measure large ones if time allows		
	Reach into all burrows	Reach into all burrows with chambers	Reach only into burrows with chambers and reachable ends
	Determine chamber, reachable end and contents	Determine reachable ends and contents	Determine contents and viability of remaining eggs
		Measure and weigh chicks	Measure and weigh chicks

Protocol Revision History Log

Revision Date	Changes made	New version #
April 2017	Specified that a leap year Julian date calendar should be used in leap years, clarified that for phenology calculations we require confirmed visualization of the empty nest site, egg, or chick less than or equal to 7 days apart for that site to be used, clarifications in Aiktak attachment, updates to Buldir attachment including addition of monitoring for chronology, corrected spelling typos	1.4
Sept 2015- Mar 2016	Changed names of reproductive success parameters to match other species (puffins), clarified Ed modifier to include eggs that get squashed into dirt, elaborated analysis of Boom-or-Bust 30-day-interval data, clarified some Aiktak, Buldir (updated Buldir section to reflect 14-day check) and St. Lazaria sections, clarified Ep modifier, specified getting a last check in before you leave the island, fixed page number references in text, added figure to help chick identification	1.3
April 2015	Fixed minor typos, added stress and disease details per IACUC	1.2
April 2014	Changed font to Arial, added revision history log, replaced revision date with version # on first page, added protocol # to first page, changed number format of table and figures in island attachments, changed page number format to include protocol #, made minor grammatical edits	1.1
May 2013	Protocol developed in standardized format from historic protocols, includes Aiktak, Buldir, St. Lazaria and Ulak attachments	1.0