Wildlife Inventory Plan
Alaska Maritime National Wildlife Refuge
Protocol #2

Version 1.5

Parameter: Productivity and phenology

Species: Red-faced, pelagic, and double-crested cormorants

PURPOSE

To estimate annual productivity and examine trends in productivity across years and sites. Cormorants may serve as indicators of changes in nearshore forage fish communities.

In addition, to collect data and develop a long-term dataset on phenology and other breeding parameters of red-faced cormorants. Most of the world's known red-faced cormorant breeding sites occur on the Alaska Maritime National Wildlife Refuge; the species is listed as a U.S. Fish and Wildlife Service "species of concern" and basic breeding biology information is lacking.

BREEDING BIOLOGY

Red-faced, pelagic, and double-crested cormorants (*Phalacrocorax urile, P. pelagicus, and P. auritus*) are long-lived piscivorous seabirds that nest on cliffs in loose colonies during the summer breeding season. Throughout the year they are primarily found within a few kilometers of rock-bottom coastlines, where they typically forage. Red-faced cormorants are distributed along a narrow region across the Aleutian and Pribilof Islands, from the Gulf of Alaska to Kamchatka. The majority of the world's population breeds within the Alaska Maritime National Wildlife Refuge, particularly the Near Islands and the Pribilofs (Causey 2002). Pelagic cormorants are more widespread along the west coast of North America, found breeding from northern Alaska to the Baja peninsula in Mexico (Hobson 1997). Double-crested cormorants span much of North America, with Alaskan breeding populations representing the northern-most reach of their distribution. In the Bering Sea, double-crested cormorants are restricted to the eastern Aleutian Islands and the southeastern part of the Bering Sea (Hatch and Weseloh 1999).

On islands in the AMNWR, all species primarily build nests on sea cliffs. At sites where species coexist, pelagic cormorant nests are generally located lower on the cliff face (in some places pelagic cormorants nest on steeper cliffs, narrower ledges, and closer to the sea than red-faced cormorants). Nests are constructed of grass, moss, and other plant material that may be gathered and carried considerable distances. Birds occasionally build "trial" nests lasting only a few days in peripheral breeding areas. Double-crested cormorants usually have larger nests than the other two species. Red-faced and pelagic cormorants exhibit low nest site fidelity and frequently move nest locations among years; therefore, numbers at breeding colonies can vary dramatically from year to year. Double-crested cormorants may show higher fidelity to nesting location (Hobson 1997, Hatch and Weseloh 1999, Causey 2002).

Red-faced cormorant breeding biology is poorly described; more information exists for pelagic and double-crested cormorants. At AMNWR sites, all species generally begin laying eggs in May, although phenology can vary substantially between years and sites. On St. Paul in the Pribilofs, where nesting phenology may be best known, most hatching occurs between from mid-June to mid-July, and fledging from late July through August (Causey 2002, McClintock et al. 2010, Wright unpubl. data).

Cormorants have large clutches (see Table 1) and usually lay eggs at intervals of about 2 days apart. If all eggs are lost, a smaller replacement clutch may be laid (Hobson 1997, Hatch and Weseloh 1999, Causey 2002, Wright unpubl. data). Incubation may start immediately after the first egg (Hatch and Weseloh 1999) but is often delayed until more eggs have been laid (Wright unpubl. data). Unlike most seabirds, chicks are altricial and therefore naked at hatch. Adults share brooding and feeding duties until chicks fledge at about 40 to 60 days. Red-faced cormorant chicks begin to make short flights around 40 days after hatch. Pelagic chicks will begin wandering on nesting ledges at about 3 weeks of age, and can

make short flights at about 5 weeks. Double-crested cormorants can walk from nests 3 to 4 weeks after hatch, and can fly at about 6 to 8 weeks. Fledglings may return to the nest site for several weeks post-fledging; little is known about movement of young after fledgling or recruitment behavior once they attain breeding age (Hobson 1997, Hatch and Weseloh 1999, Causey 2002, Wright unpubl. data).

Table 1. Ranges in clutch size and incubation length for red-faced, pelagic, and double-crested cormorants.

Species	Clutch size	Incubation length (days)
Red-faced cormorant	1-5	28-35
Pelagic cormorant	1-8	25-33
Double-crested cormorant	1-7	25-28

Literature Cited

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Seddon, P.J. and Y. van Heezik. 1991. Effects of hatching order, sibling asymmetries, and nest site on survival analysis of jackass penguin chicks. Auk 108: 548-555.

PROCEDURES – INDIVIDUAL NEST MONITORING FROM CLIFF TOPS ABOVE (ST. PAUL, sometimes AIKTAK)

Individual cormorant nests can be monitored for productivity where cormorant nests are viewable from above, making nest contents are visible. For nests that are viewed from below only (i.e., nest contents are not visible until chicks are large), or at locations where time restraints make intensive monitoring of individual nests impossible, see protocol for boom/bust estimates below.

Data collection.—Similar to kittiwake and murre productivity, cormorant reproductive performance is monitored by viewing individually numbered nests and sites at 3-4 day intervals (inclement weather and variation in workloads across sites may necessitate longer intervals between visits). Each observer is assigned a set of plots and then monitors the same plots throughout the season to avoid any confusion (i.e., a misinterpretation of nest site locations) between observers. Plots are usually close to the observation point (i.e., within 50 m) and viewable from above so that nest contents can be determined. Photographs are used to document plot locations and close-up photographs and/or drawings of plots to track individually numbered nest sites throughout the season (Figure 1). Do not worry about using the same numbering sequence for nests each year because cliff topography and nest site use can change from year to year. If possible, visit plots early in the season to take current plot photos, then print photos back at camp and weather-proof them using a laminator or plastic sheet protectors (with the top taped shut); this way your plot photos will be ready to go for your first productivity check.

Cormorant nests may be monitored within existing kittiwake and murre productivity plots or on separate cormorant-only plots, depending on nesting distribution in a given year. Cormorants are less site-faithful than other ledge-nesting seabird species, so locations of visible nests can vary substantially from year to year. Check areas where cormorants were monitored previously but also look for new locations.

Although cormorants often occur in clusters (plots) like kittiwakes and murres, we are typically not able to follow enough nests in distinct groups to make cluster analysis statistically feasible. Aim for 30-50 nests each year, although this will likely only be possible given time constraints if many of them are grouped together and can be monitored from a single site. If you cannot find at least 10 nests of a species visible from atop the cliffs, just do the Boom-or-Bust method instead (see Boom-or-Bust protocol below). Each observer should be assigned a set of nests and then monitor the same nests throughout the season to avoid any confusion (i.e., a misinterpretation of nest site locations) between observers. Nests are usually close to the observation point (i.e., within 50 m) and viewable from above so that nest contents can be determined.

Use 10x40 binoculars or zoomable (15-45x or 15-60x) spotting scopes to assess the status of each nest site (i.e., the presence of eggs or chicks) from cliff top vantage points. On each visit to plots, attempt to determine the status of all nest sites, recording each nest status in a field notebook using the appropriate standardized code (see pages 2-6 to 2-8). Due to the large clutch size and the larger, tightly sitting birds, status of every egg and chick can be more difficult to obtain than kittiwakes. Record only what you saw and be sure to use the standardized codes *exactly* as instructed. Weird and unpredictable things can happen during observations (e.g., a chick falling from one nest to another, another species stealing a nest and brooding the “stolen” chick) and you may want to describe every detail and feel limited by the standardized list of codes and modifiers available. However, lengthy text explanations and comments tend to cause confusion later and cannot be interpreted by the database used to summarize the data. 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 you see eggs or chicks, 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 see 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 see a chick in the actual act of hatching (Co), a chick still wet from having recently hatched (Cw), or dead chick (Cd).

Note that for cormorants, unlike other ledgenesting species, we also use codes to describe chick ages when possible (see page 2-6). These are important in determining whether or not chicks fledge. See Figure 2 for photographic examples of known-age chicks to help you classify chick sizes. We are working to better define these codes; in the meantime just do the best you can with the current definitions.

Although you should aim to see and record a "known" status egg, chick, or nothing for each nest each visit, in general do not spend more than 1.5 hours per plot each visit (this will depend on the distribution of your birds each year and your workload). Because you are limited to indirect observation and because some birds remain motionless for long periods of time, you will occasionally have sites where you cannot see the contents of the nest site during your entire visit (this is particularly true for cormorants during incubation!). If nest contents remain unknown after 1.5 hours, record an unknown status (BU or U), move to the next plot, and make a concerted effort to confirm the status of that nest on the next visit (during laying and early chick-rearing stages, cormorants tend to stick particularly tightly to the nests even when shifting around, so it is unlikely that all nests will have exact egg counts). It is particularly important to minimize unknown nest status codes around expected hatching or fledging dates. In other words, **it is important to see the nest contents the check before and after a chick hatches and fledges.**

Before leaving the site, check to see that your recorded status makes sense based on what you saw last time (e.g., if you had a chick last visit, you shouldn't have an egg this visit). Data strings that don't make sense will have to be discarded. If you decide a particular nest site is problematic and should be tossed (e.g., grass grew during the season and obscured your view, or you aren't certain what species the nest was), don't erase the data from your field notebook and electronic data file but simply mark it as "exclude from analysis" in the electronic spreadsheet and indicate your reasons in the comments section (see separate data entry protocol).

At the end of the day (or at the very least, before you take your data notebook into the field again), enter the day's plot data in the electronic data file provided.

***Data analysis*.—**Calculations for productivity and phenology parameters for cormorants are not yet performed within the AMNWR productivity database but must be done manually.

Phenology: Chick hatch dates are estimated to be the Julian date midpoint between the last time an egg was confirmed to be present and the first time a chick was confirmed to be present (*in leap years, be sure to use a leap year-specific Julian date calendar!)*. If there was no midpoint (i.e., an even number of days between visits), we use the even Julian date closest to the midpoint. Not all nest sites are included in phenology calculations; we require a confirmed egg and then a confirmed chick less than or equal to 7 days apart for that site to be used. Therefore, nests you can use to calculate phenology will likely be a subset of the known-fate nests you use to calculate productivity. In calculating midpoints, some people find it helpful to use a calendar to record when checks occurred to make it easier to visualize how many days were between checks.

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

Hatch dates are calculated for only the *first* egg to hatch per nest (if multiple eggs hatch across different days, do not record hatch dates for all eggs or average hatch dates across eggs in a nest). Similarly, hatch dates should be calculated for only the first clutch; do not include known relays in phenology calculations.

Report the first and last hatch dates (across all nests), mean hatch date, and standard deviation around the mean.

Productivity: Reproductive success is calculated as the number of known fate nest sites that fledged a chick. If a nest "fails", we keep track of what stage this happens (egg or chick period). Obtaining precise counts of cormorant eggs or young chicks can be difficult. Therefore, egg and chick numbers are considered a minimum estimate of productivity, as not all eggs or chicks may have been seen in every nest.

Beginning in 2011, analysis of cormorant productivity data was simplified by changing how fledglings are defined: we use the chick size codes to indicate if chicks were old enough to be considered successful. Fledglings are counted simply as the maximum number of large, huge, or fledgling-sized chicks (see chick size codes on page 2-6) ever observed in each nest. We include large and huge and not just fledgling-sized chicks as "fledglings" because once cormorant chicks become large and mobile, it can be difficult to keep track of them and assign them to specific nests if nesting density is high. For instance, cormorant chicks often begin wandering from nest sites once they become mobile, and most fledglings periodically leave and return to their nests for one to two weeks after first "fledging" (S. Wright, unpubl. data). If a nest has chicks but all are still present and *smaller than* large-sized at the last check, then nest fate cannot be determined. Such nests should be excluded from analysis.

To calculate cormorant productivity, calculate the following from your raw data:

- Total nest starts (A) – number of known-fate nest sites monitored (do not include any poor-quality nests that you discarded during the season
- Nest sites with eggs (B) – number of nest sites containing *any* eggs
- Total eggs (C) – *maximum* number of eggs seen, calculated by summing the *highest* egg count from every nest
- Nest sites with chick (D) – number of nest sites containing *any* chicks
- Total chicks (E) – *maximum* number of chicks seen, calculated by summing the *highest* chick count from every nest
- Nest sites with chicks fledged (F) – number of nest sites containing *any* "fledglings", which are defined as chicks described with the size code large (C_L), huge (C_H), or fledgling (C_F).
- Total chicks fledged (G) – *maximum* number of fledglings, calculated by summing the *highest* fledgling count from every nest; again, "fledgling" is defined as a chick described with the size code large (C_L), huge (C_H), or fledgling (C_F).

From the above values, calculate the following summary parameters:

- Laying success (B/A)
- Mean clutch size (C/B)
- Nesting success (D/B)
- Hatching success (E/C)
- Chick success (G/E)
- Egg success (G/C)
- Fledging success (F/D)
- Reproductive success (F/B)
- Fledglings per nest start (G/A)
- Productivity (F/A)

We are typically not able to follow enough nests in distinct groups to make cluster analysis statistically feasible, so we treat individual nests as sample units and do not estimate variance around reproductive parameters with ratio estimator spreadsheets.

Note: historically we calculated success of cormorant by calculating ages of all chicks at disappearance, based on estimated hatch dates. However, because cormorants have large clutch sizes, keeping track of when multiple chicks hatch and disappear is difficult, and making assumptions as to which chicks disappear when based on hatch order is harder to justify biologically. The new analysis described above is simpler.

Standardized Productivity Codes: List of Productivity Codes (CORMORANTS)
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 sure 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.
NN	**No Nest**	(**Kittiwakes, gulls, cormorants only**) Used when a kittiwake nest that had been active in the current year disappears. Use this code when no nest material is present, regardless of the presence of an adult bird (if a bird is standing at the old site and no nest material remains, use NN and not B). Do not use this code at the beginning of the season before a nest is built at a site.
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.

***Chick codes** -- whenever chicks are observed, use a subscript to indicate the approximate age:

N	**Naked**	No down, <7 days old
T	**Tiny**	Barely visible above the nest wall, downy little fluff balls, 7-14 days old
M	**Medium**	Big enough to stand up and move around, 14-28 days old
L	**Large**	Tall and lanky but still gawky and mostly downy, ??? days old?
H	**Huge**	Half to full flight feathers (not necessarily fully feathered), might start sitting beside rather than in the nest, ???-45 days old
F	**Fledgling**	Fully feathered (juvenile plumage completed) as big as adults. May no longer be associated with the nest, capable of short flights, 46+ days old

E.g., a nest with an adult red-faced cormorant and at least 3 (possibly more) medium chicks is recorded as: $BC3+_M$

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

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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
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 murres) 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 check, 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.

One notable exception is cormorants, which use standardized size codes for chicks at some sites - we have not yet developed these for the database so continue to use old chick codes for cormorants outlined in the Big Green Protocol Book (Williams et al. 2002).

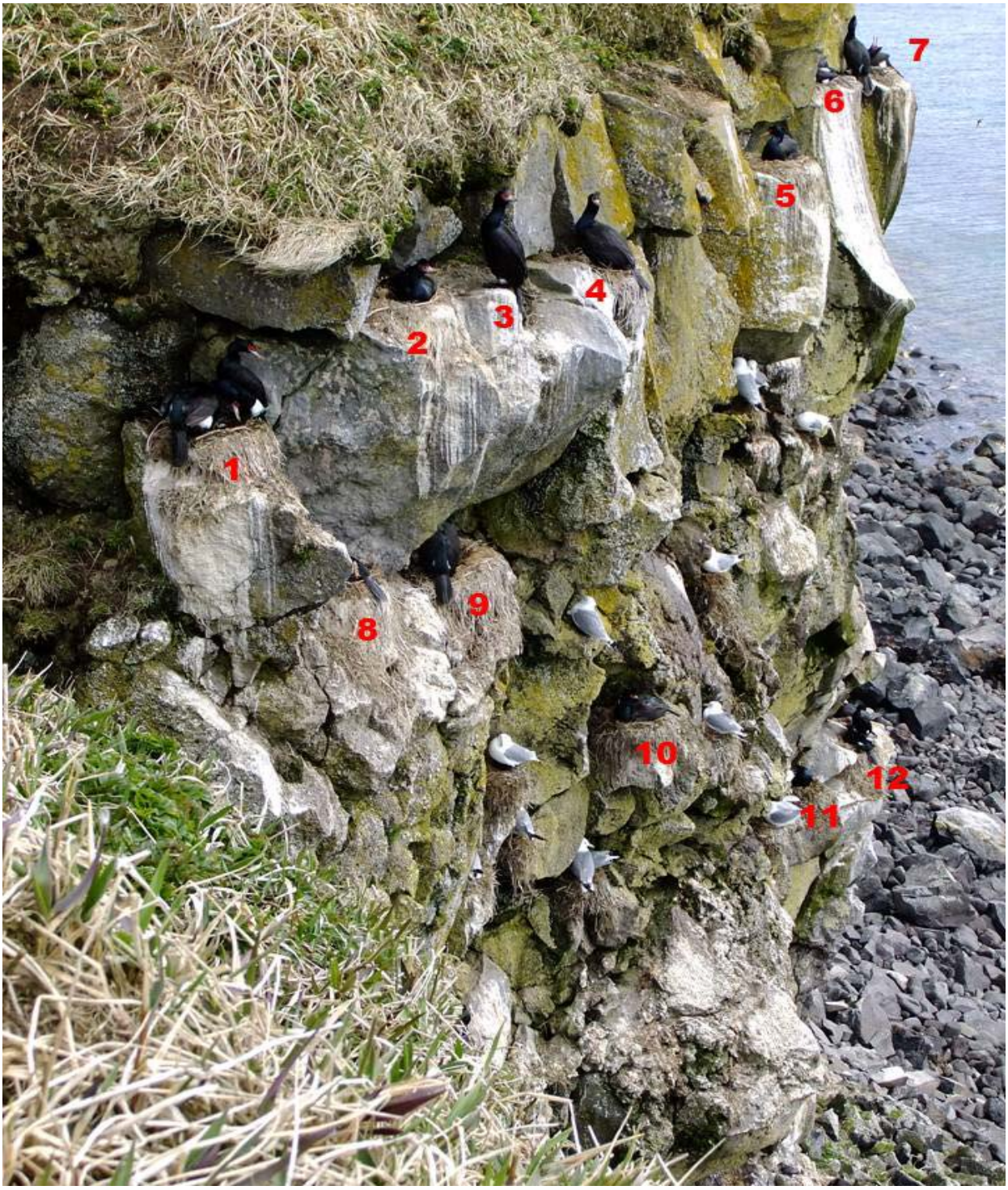

Figure 1. Example close-up plot photo for cormorant productivity by individual nest monitoring with numbered nest sites (note: nests shown here are numbered using a computer; most crews prefer to write directly on the plot photo in the field with a permanent marker).

Figure 2. Example photos of known-age red-faced cormorant chicks form St. Paul Island (all photos from G. Thompson).

PROCEDURES – BOOM-OR-BUST MONITORING (ST. GEORGE, ST. PAUL, AIKTAK, BULDIR, CHOWIET, ST. LAZARIA)

At locations where nests are viewed from the beach below (i.e., nest contents are not visible until chicks are large and thus egg data are rarely available) or where time restraints make intensive monitoring of individual nests impossible, cormorant productivity is estimated using a Boom-or-Bust procedure. This method generates success parameters from counts of nests conducted early in the nesting period (representing initial reproductive effort), and then counts of visible large chicks conducted late in the nesting period (representing success). Boom-or-Bust monitoring is quicker and less detailed than monitoring of individual nests (described above) but still provides a rough index of cormorant success that can be compared across years and sites. Data on nesting phenology cannot be collected using this method.

***Data collection*.—**Early in the cormorant nesting period (ideally when nest building is complete but before nests begin to fail; generally in June), conduct 1-3 counts of all nests along a given stretch of beach(es) or cliff(s) where cormorants are nesting. Count all nests, defined as structures to which vegetation or material have been added in the current year, regardless of the presence of a bird. It is not necessary to record nest contents (i.e., eggs, brooding adults, etc.). If more than one species nests at your colony, identify nests to species based on the attending adult; unattended nests should be recorded as unknown species. Depending on the site, nests may be viewed from a single observation point or may be spread along a stretch of beach observers walk along. Cormorants typically move among nesting locations from year to year, so you may have to scout for cormorant nesting locations early in the season (see island-specific details for information on where to search for nests at each site). It may be helpful to use a GPS to record colony locations both to facilitate relocating colonies later in the year and to document locations used through time at your island.

Timing of nest counts ideally should occur after all nests are built but before any nests are lost, capturing the maximum reproductive effort that year. Practically, however, not all birds build nests at the same time, and some nests may be lost before all are built. It is also difficult to optimize the date to count if cormorant colonies are far from camp or normal work locations where you don't see them often (i.e, requires hiking to cormorant colony locations specifically for this purpose). Conducting multiple nest counts (up to 3), each 7-10 days apart, will provide a larger window to capture the true maximum nest number. Ideal dates for nest counts vary among sites; see island-specific details.

If nests are few and difficult to find, it may be helpful to number and/or photograph or map nest locations to streamline finding them later in the season. If multiple species nest at your site, mapping, numbering and identifying species of nests early in the season when adults are present may help you determine species of chicks later when adults are no longer present. Do not worry about using the same numbering sequence for nests each year, because the cliff topography and nesting locations can change annually. Sample size can vary dramatically from year to year based on movement of nesting birds, but aim for at least 30-50 total nests. If you are unable to find at least 10 nests, consult with the Unit Biologist, who will consider skipping cormorant monitoring that year.

Later in the nesting period, when chicks are large enough to be clearly visible from the beach below nests (or your best viewing location), but before any chicks could have fledged, return to the same locations to count all visible chicks in nests. Record the number of chicks you see in each nest to attain information on clutch sizes, as opposed to simply recording the overall total (simply record how many chicks you see, regardless of whether you can see all the nest contents or not; you do not need to use the plus (+) codes for uncertain numbers of chicks as done for individual nest monitoring). It is not necessary to record any nest statuses other than chicks (e.g., eggs or brooding birds) or chick sizes (as used in monitoring individual nests). Note that weather can make a big difference in your ability to see chicks in nests. On warm, sunny days chicks are more active and easier to see. Try to avoid counting chicks on cold, wet, windy days when even large-sized chicks may be hunkered down in the nest out of view. To account for differences in chick timing, conduct up to 3 chick counts at intervals of about 7-10 days. Recommended dates for chick counts vary among sites; see island-specific details and adjust for the phenology in your season.

Data analysis.—Calculate the following from your raw data:

- Total nest starts (A) – *maximum* number of nests counted during early surveys
- The number of nests w/ x chicks – *maximum* number of nests containing 1, 2, 3, 4, etc. chicks
- Nest sites with chick (D) – *maximum* number of nest sites containing *any* chicks
- Total chicks (E) – *maximum* number of chicks seen, calculated by summing the *highest* chick count from every nest

If you made multiple counts, use the *maximum* value (not the average) recorded for any parameter. This should be the *single day* that yielded the maximum total nest starts (A) for early counts and total chick (E) count for late counts. For example, if you made 2 early nest counts and 3 chick counts along one stretch of beach or plot, and your data looks like this:

Date	Total nest starts (A)	Number of nests w/ x chicks:				Nest sites w/ chicks (D)	Total chicks (E)
		1	2	3	4		
3 Jun	15	0	0	0	0	0	0
10 Jun	18	0	0	0	0	0	0
1 Aug	12	6	2	2	1	11	20
7 Aug	13	6	4	2	1	13	24
14 Aug	12	1	4	3	4	12	34

The day with the maximum total nest starts (A) is 10 June and the day with the maximum total chick count (E) is 14 August; therefore report your maximum values as those highlighted in yellow above. (Note that the maximum nest site w/ chicks (D) falls on a different day (7 Aug) – that may happen in rare instances but by convention we use the date of maximum total chicks (E).

If your counts are made in distinctly separate plots, take the single day that yielded the maximum total chick (E) count *in each plot* and sum across all plots. For example, if you made 2 early nest counts and 3 chick counts along 2 different stretches of beach or plots, and your data looks like this:

PLOT 1 Date	Total nest starts (A)	Number of nests w/ x chicks:				Nest sites w/ chicks (D)	Total chicks (E)
		1	2	3	4		
3 Jun	15	0	0	0	0	0	0
10 Jun	14	0	0	0	0	0	0
1 Aug	13	6	2	2	1	11	20
7 Aug	13	6	4	2	1	13	24
14 Aug	13	5	4	2	1	12	23

PLOT 2 Date	Total nest starts (A)	Number of nests w/ x chicks:				Nest sites w/ chicks (D)	Total chicks (E)
		1	2	3	4		
3 Jun	15	0	0	0	0	0	0
10 Jun	18	0	0	0	0	0	0
1 Aug	14	6	2	2	1	11	20
8 Aug	14	6	4	2	1	13	24
14 Aug	14	1	4	3	4	12	34

Report your maximum total nest starts and chick counts as *the sum* as the daily maximum total nest starts (A) and total chick count (E) *at each plot independently*, highlighted in yellow above. Therefore, your total values would be:

	Total nest starts	Number of nests w/ x chicks:				Nest sites w/ chicks	Total chicks
	(A)	1	2	3	4	(D)	(E)
All plots	23	7	8	5	5	25	58

Finally, from the above values, calculate the following summary parameters:

- Mean brood size (E/D)
- Proportion of nest sites with chicks (D/A)
- Chicks per nest start (E/A)

These measures of reproductive success [proportion of nest sites with chicks (D/A) and chicks per nest start (E/A)] may be considered maximum potential values of productivity (F/A) and fledglings per nest start (G/A), respectively. Our inherent assumption is all chicks remaining late in the season survived to fledge.

Attachment A. Aiktak Island Specifics (includes Figure A1)

PROCEDURE DETAILS SPECIFIC TO AIKTAK

Cormorant productivity at Aiktak Island is monitored for red-faced, pelagic, and double-crested cormorants using the Boom-or-Bust procedure (in 2010, nests were monitored using individual nest monitoring procedures – consult with the unit biologist whether this should be done in current year and if so, try to follow individual nest monitoring protocol above). The presence and abundance of all species varies among years, and in some years no cormorants have nested. Locations of breeding areas have varied among years, ranging from cliff faces on the southeast to southwest sides of the island (Figure A1). Nests at Aiktak are usually viewed from the cliff tops above. Cormorants also nest on nearby Ugamak Island and nests have been monitored there in the past, but this has been discontinued.

For Boom-or-Bust productivity, survey the island in late May to determine if/where cormorants are nesting can be monitored. Record colony locations (lat/long) using a GPS (in decimal degrees and WGS 84 datum). Count (and map if helpful) nests 1-3 times, beginning in mid-June (for multiple counts, aim for 7-10 day intervals from mid- to late June; for a single count, try to schedule it for the middle of the count window). Then count large chicks 1-3 times beginning in mid-August. Whether you do one or three counts each period will depend on your workload at the time. Timing is based on past phenology data from Aiktak. If you pass by cormorant nests throughout the course of other work and observe that timing appears to be earlier or later than in other years, you can refine the exact timing of your counts in the current year accordingly.

Specific Requirements for Aiktak – Individual nest monitoring

Dates: *Late May*: Survey island for cormorant colonies and determine if nesting is occurring in location that will allow individual nest monitoring, if so, obtain the status of nests.
1 Jun-end of season: Check status of nests every 3-4 days (optimal; up to 5-6 if dictated by bad weather or workload), most frequently during the peak of hatching (mid-June to mid-July).

Optimal sample size: At least 30-50 nests (this will depend on distribution of nests and may be lower; less than 10 may not be worth monitoring).

Time of day: Daylight hours.

Weather: Good visibility (minimal fog). Wind and rain do not preclude work but do tend to make birds sit tighter and can make observations through optics problematic.

Equipment needed: Binoculars, spotting scope, tripod, Rite-in-the-Rain® notebook, two pencils, plot photos, ultra-fine tipped Sharpies for writing nest numbers on photos, clear plastic photo protectors (to protect plot photos).

Equipment suggested: Crazy creek chair, clipboard, large rubber bands to keep items from flying off the clipboard, safety equipment for tying into plots, thermos of hot drink, lots of snacks, lens cleaning cloths, complete change of clothes, camera.

Specific Requirements for Aiktak – Boom-or-Bust monitoring

Dates: *Late May*: Survey island for cormorant colonies.
Mid- to late June: Count/map nests 1-3 times.
Mid- to late August: Count chicks 1-3 times.

Optimal sample size: At least 30-50 nests (this will depend on distribution of nests and may be lower; less than 10 may not be worth monitoring).

Time of day: Daylight hours.

Weather: Clear visibility if nests are high on cliffs; avoid wet, windy days when doing chick counts as chicks may be huddled down in nests and difficult to see.

Equipment needed: Binoculars (or spotting scope), tally counters, paint pens or spray paint (if numbering nests), maps or photos of nest locations for chick counts (if maps/photos were done during nest counts), Rite-in-the-Rain® notebook, two pencils, GPS.

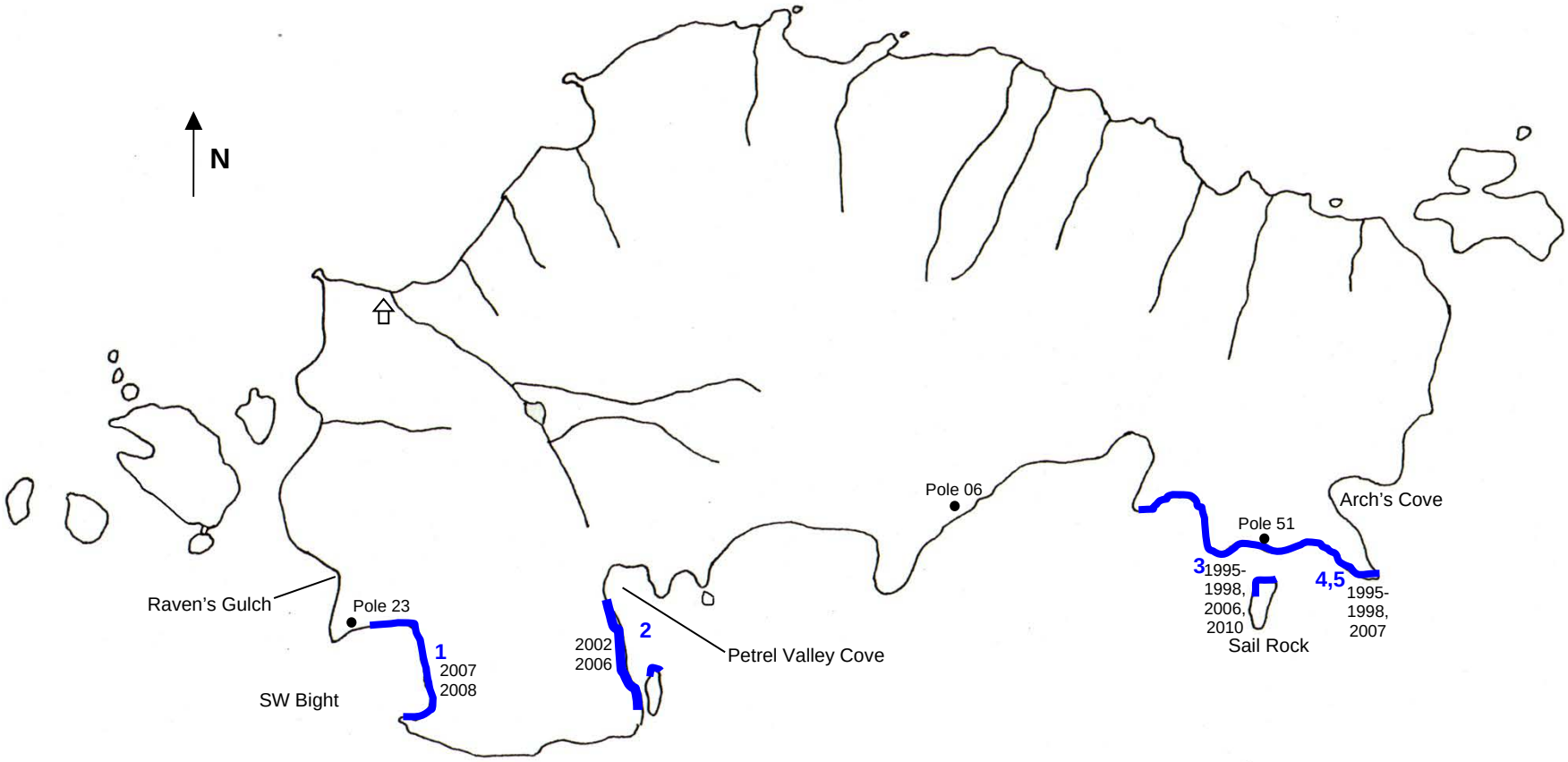

Figure A1. Locations of past cormorant nesting locations at Aiktak Island.

Attachment B. Buldir Island Specifics (includes Figure B1)

PROCEDURE DETAILS SPECIFIC TO BULDIR

Cormorant productivity at Buldir Island is monitored for red-faced and pelagic cormorants using the Boom-or-Bust procedure. Nests are viewed from the beach in five coastline sections along the northern coast between camp and Kittiwake Lane (Figure B1):

- Main Talus to North Rocks
- North Rocks to Petrel Valley Creek
- Petrel Valley Creek to West Gull Slide
- West Gull Slide to East Gull Slide
- East Gull Slide through Kittiwake Lane (KWL)

Keep track of the number of nests in each section. Counts can be conducted while hiking to Kittiwake Lane for resighting, diet sampling, or productivity monitoring.

Count and map/individually mark nests 1-3 times, beginning in early June (for multiple counts, aim for 7-10 day intervals from early to mid/late June; for a single count, try to schedule it for the middle of the count window). Look carefully at the cliff face because nests are often tucked into cracks and easy to miss. Then count large chicks 1-3 times beginning in early August. Whether you do one or three counts each period will depend on your workload at the time (because surveys are conducted while walking to Kittiwake Lane for other work, you should be able to accomplish 3 counts during each period at Buldir). Timing is based on past phenology data from Buldir. If you pass by cormorant nests throughout the course of other work and observe that timing appears to be earlier or later than in other years, you can refine the exact timing of your counts in the current year accordingly.

In order to keep track of nests through the season, assign a number to each nest found and mark it with spray paint on a rock below the nest. In areas where nests are clustered, it is helpful to paint the numbers in a layout representative of that of the nests and/or draw a map with nest numbers in your notebook. Alternately, you can write the nest numbers on a photograph as is done with murre and kittiwake plots (see Ledgenester Productivity Protocol). Since individual nests are not followed across years, disregard any numbers that were previously painted on the rocks and just number nests as you find them. The cliffs of Buldir are comprised of rocks embedded in dirt and are very susceptible to erosion and rockfalls. It is possible that nests may be obliterated or lost throughout the season and an area can look very different in August than it did in June so it's important to do a good job of keeping track of nest locations. It is also very important to always wear a hard hat and stay alert whenever walking or working between Main Talus and Kittiwake Lane.

Specific Requirements for Buldir

Dates: *Early to mid/late June*: Count/map nests 1-3 times.
Early to mid-August: Count chicks 1-3 times.

Optimal sample size: At least 30-50 nests (this will depend on distribution of nests and may be lower; less than 10 may not be worth monitoring).

Time of day: Daylight hours.

Weather: Clear visibility if nests are high on cliffs; avoid wet, windy days when doing chick counts as chicks may be huddled down in nests and difficult to see.

Equipment needed: Binoculars (or spotting scope), tally counters, two cans of spray paint, maps or photos of nest locations for chick counts (if maps/photos were done during nest counts), Rite-in-the-Rain® notebook, two pencils, hard hat, GPS.

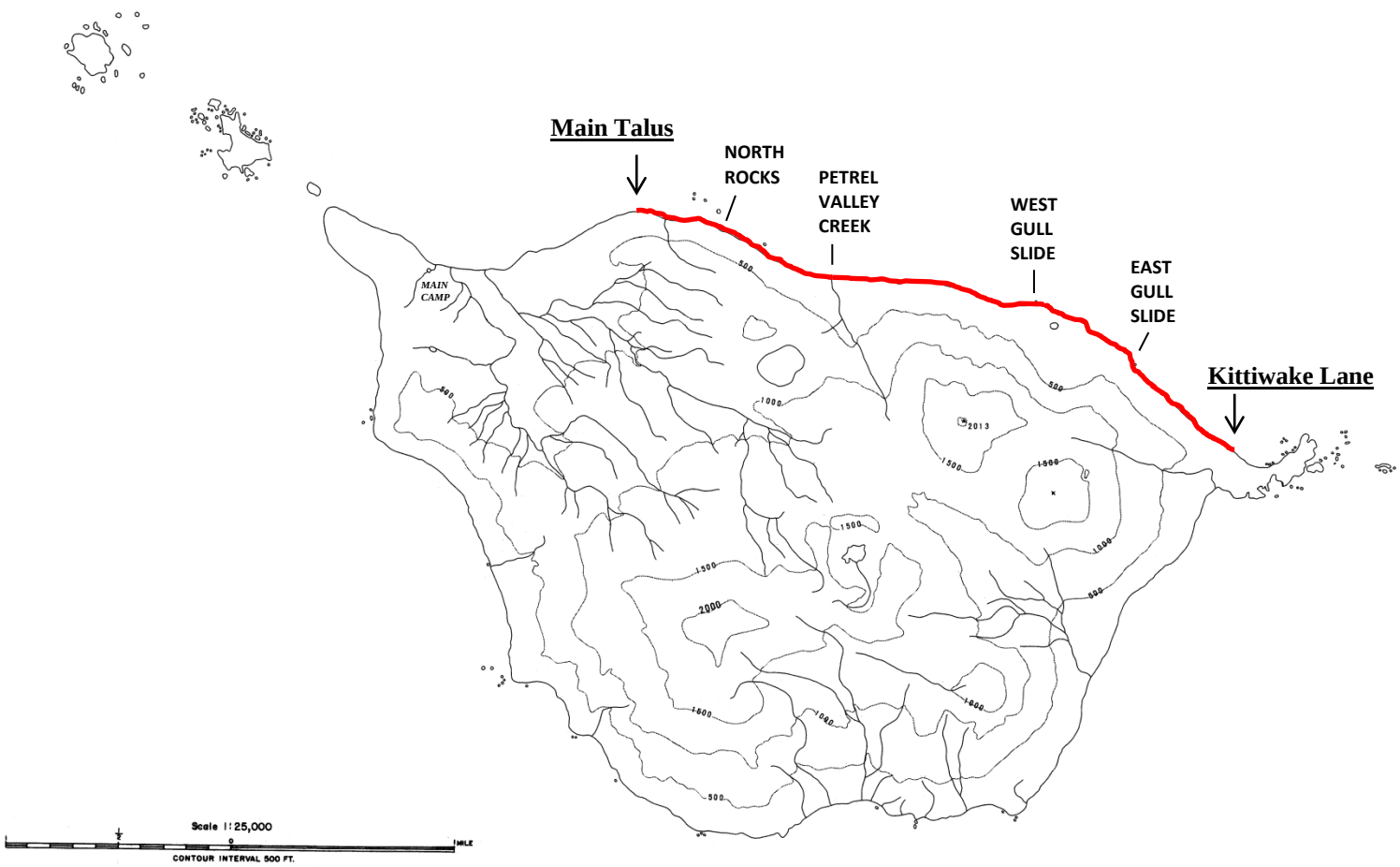

Figure B1. Location of cormorant productivity transect at Buldir Island showing the locations of each subsection.

Attachment C. Chowiet Island Specifics (includes Figure C1)

PROCEDURE DETAILS SPECIFIC TO CHOWIET

Cormorant productivity at Chowiet Island is monitored for red-faced and pelagic cormorants using the Boom-or-Bust procedure. The presence and abundance of all species varies among years, and in some years no cormorants have nested. Locations of breeding areas have varied among years, ranging from cliff faces on various parts of the island, including mixed cormorant colonies found at North Point, Puffin Point, and Castle Crags Cove (Figure C1). Review Figure 2 and annotated list descriptions in 2007, and 2009 - 2011 reports for past colony locations, which would be likely spots to check in the current season. Nests at Chowiet are usually viewed from the cliff tops above.

For Boom-or-Bust productivity, survey the island in late May to determine if cormorants are nesting and if so, if nests can be monitored in those locations. Record colony locations (lat/long) using a GPS (in decimal degrees and WGS 84 datum). Count nests 1-3 times and identify cormorant species, beginning in early June (for multiple counts, aim for 7-10 day intervals from early to mid/late June; for a single count, try to schedule it for the middle of the count window). It is helpful to map the nest locations to keep track of locations and identity of species. Then count large chicks 1-3 times beginning in late July. Whether you do one or three counts each period will depend on your workload at the time, however because we have limited data on cormorant breeding chronology at Chowiet, attempt to complete more than one count in each period. Timing is based on phenology data from Nysewander 1986 (mean initial laying 26 May, with range of 13 days in annual means; Gulf of Alaska egg-laying period begins mid-May or early June, hatching from late June to mid-July onward, fledging from mid-August or early September). If you pass by cormorant nests throughout the course of other work and observe that timing appears to be earlier or later than in other years, you can refine the exact timing of your counts in the current year accordingly.

Specific Requirements for Chowiet

Dates: *Late May to early June*: Survey island for cormorant colonies.
Early to mid/late June: Count/map nests 1-3 times.
Late July through mid-August: Count chicks 1-3 times.

Optimal sample size: At least 30-50 nests (this will depend on distribution of nests and may be lower; less than 10 may not be worth monitoring).

Time of day: Daylight hours.

Weather: Clear visibility if nests are high on cliffs; avoid wet, windy days when doing chick counts as chicks may be huddled down in nests and difficult to see.

Equipment needed: Binoculars (or spotting scope), tally counters, maps or photos of nest locations for chick counts (if maps/photos were done during nest counts), Rite-in-the-Rain® notebook, two pencils, GPS.

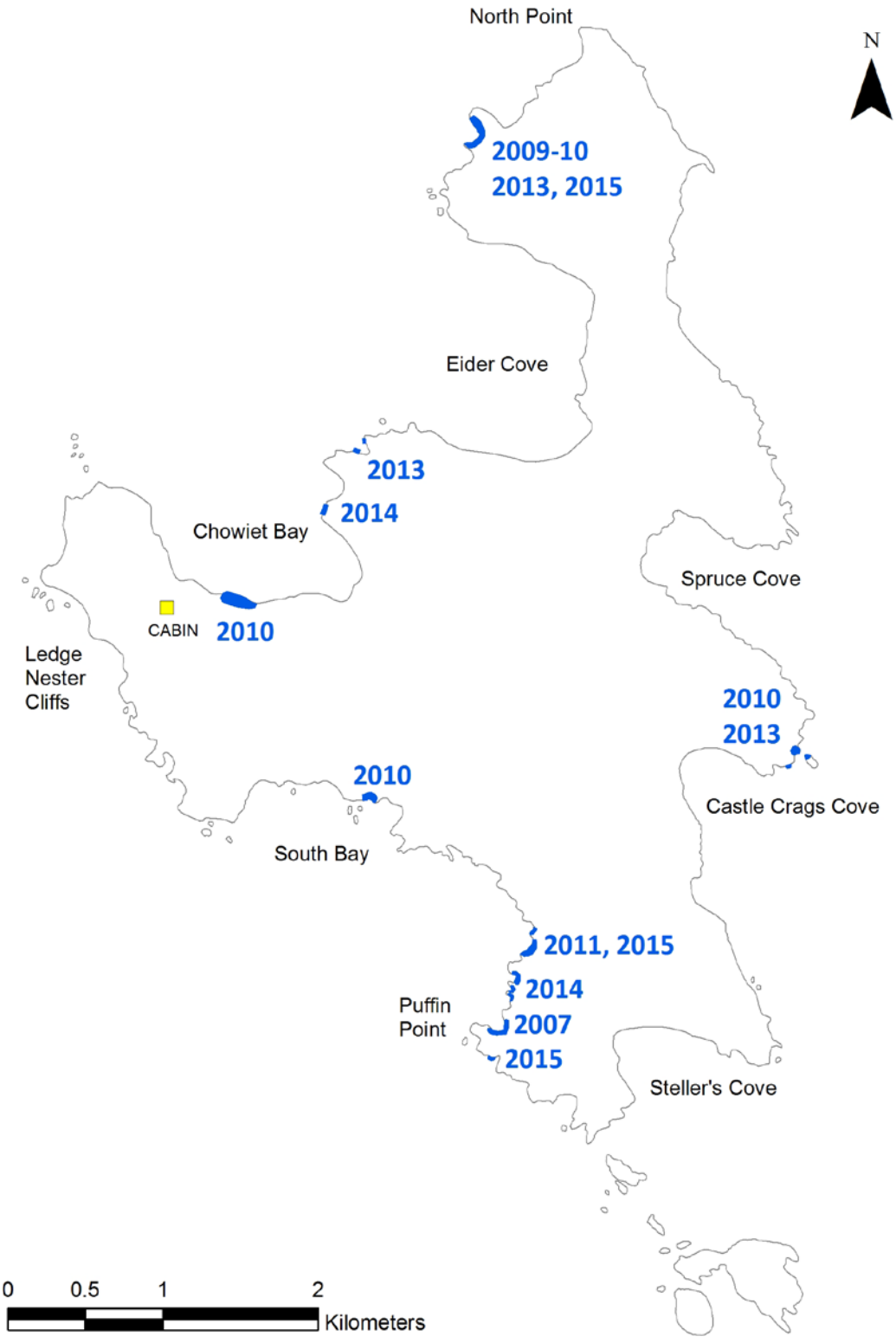

Figure C1. Locations of past cormorant colonies on Chowiet Island.

Figure C2. Locations of past cormorant colonies between South Bay and Puffin Point on Chowiet Island.

Attachment D. St. George Island Specifics

PROCEDURE DETAILS SPECIFIC TO ST. GEORGE

Cormorant productivity at St. George is monitored for red-faced cormorants using the Boom-or-Bust procedure. Count (and map/individually mark if helpful) nests 1-3 times, beginning in early June (for multiple counts, aim for 7-10 day intervals from early to mid/late June; for a single count, try to schedule it for the middle of the count window). Then count large chicks 1-3 times beginning in late July. Whether you do one or three counts each period will depend on your workload at the time. Timing is based on detailed phenology data from St. Paul (peak laying 18-31 May 2004 and 2005; mean hatch 13 June-11 July 1976-2010; earliest fledge 27-31 July 2004 and 2005).

Locations where cormorants have been found and monitored in past years include Village (both west and east sides), Rosy Finch, Tolstoi Beach, and Zapadni Beach. Some nests at Rosy Finch may viewable from the observation point for productivity plots 56/57 on clear days by using a scope; other areas need to be viewed from the beach. At Zapadni you may need to walk a ways down the beach: in recent years, large cormorant clusters were located several kilometers west of the beach access (N 56.58293°, W 169.70705° and N 56.58360°, W 169.70996° in WGS84).

When visiting Tolstoi, care should be taken to avoid disturbing the fur seals that congregate on the beach itself and along the access route. Tolstoi Beach is reached by way of a rope going down the lowest part of the cliff (N 56.59823°, W 169.48268° in WGS84), halfway between the seal rookery and Tolstoi Point. In the beginning of the season, it is fastest to walk along the cliff edge to the rope, but by late June, seals sometimes make their way onto the cliff edges and sleep there. Then it's best to cut far inland, avoiding the pootchki and the possibility of startling seals over the edge. Be very careful, as there can be both large groups of seals and hidden lone sleepers all the way out to Tolstoi Point. ***Note: Be sure to be sensitive to marine mammal harassment issues and discuss them with your supervisor before accessing Tolstoi Point. When getting down the rope and walking along Tolstoi Beach, male fur seals may be present. Avoid them as much as possible; you may gently persuade movement from male fur seals to access your plots. If females with pups are present, no disturbance is allowed – in this case, do not access Tolstoi for cormorant productivity that year.***

Specific Requirements for St. George

Dates: *Early to mid/late June*: Count/map nests 1-3 times.
Late July through mid-August: Count chicks 1-3 times.

Optimal sample size: At least 30-50 nests (this will depend on distribution of nests and may be lower; less than 10 may not be worth monitoring).

Time of day: Daylight hours.

Weather: Clear visibility if nests are high on cliffs; avoid wet, windy days when doing chick counts as chicks may be huddled down in nests and difficult to see.

Equipment needed: Binoculars (or spotting scope), tally counters, paint pens or spray paint (if numbering nests), maps or photos of nest locations for chick counts (if maps/photos were done during nest counts), Rite-in-the-Rain® notebook, two pencils.

Attachment E. St. Lazaria Island Specifics (includes Figure E1)

PROCEDURE DETAILS SPECIFIC TO ST. LAZARIA

Cormorant productivity at St. Lazaria Island is monitored for pelagic cormorants using the Boom-or-Bust procedure. The timing, presence and abundance of cormorants varies among years. Breeding areas include open cliff faces and caves. Locations where cormorants have been found and monitored in past years include the Drop Zone, Trailside, Crayola Cave, Cormorant Cathedral, Murre Cave Colony (nearby to the south), and Southwest Murre Cave (usually on the back side of the cliff; Figure E1). While not all of the locations will be used by cormorants every year, they will still need to be checked each field season. Some nests can be viewed from land, although most will require using the skiff for observations.

Check all potential breeding areas for nesting activity beginning in mid- to late June; from mid- to late June through mid- to late July, count (map and number on photograph) nests every 10-14 days (ideally at least three times). From mid- to late July through your departure from the island in September, count numbers of chicks present (again, ideally at least three time).

Specific Requirements for St. Lazaria – Boom-or-Bust

Dates: *mid/late June*: Count/map nests every 10-14 days (at least 3 times)
mid/late July through September: Count chicks nests (at least 3 times).

Optimal sample size: At least 30-50 nests (less than 10 may not be worth monitoring).

Time of day: Daylight hours.

Weather: Clear visibility if nests are high on cliffs; avoid wet, windy days when doing chick counts as chicks may be huddled down in nests and difficult to see. Calm winds and calm seas (winds less than 15 knots and seas less than 4-5 ft), clear visibility, light to moderate precipitation is acceptable.

Equipment needed: Binoculars, tally counters, camera, maps or photos of nest locations for chick counts (if maps/photos were done during nest counts), Rite-in-the-Rain® notebook, two pencils. inflatable skiff with all safety gear (don't forget to bring your safety equipment and VHF!).

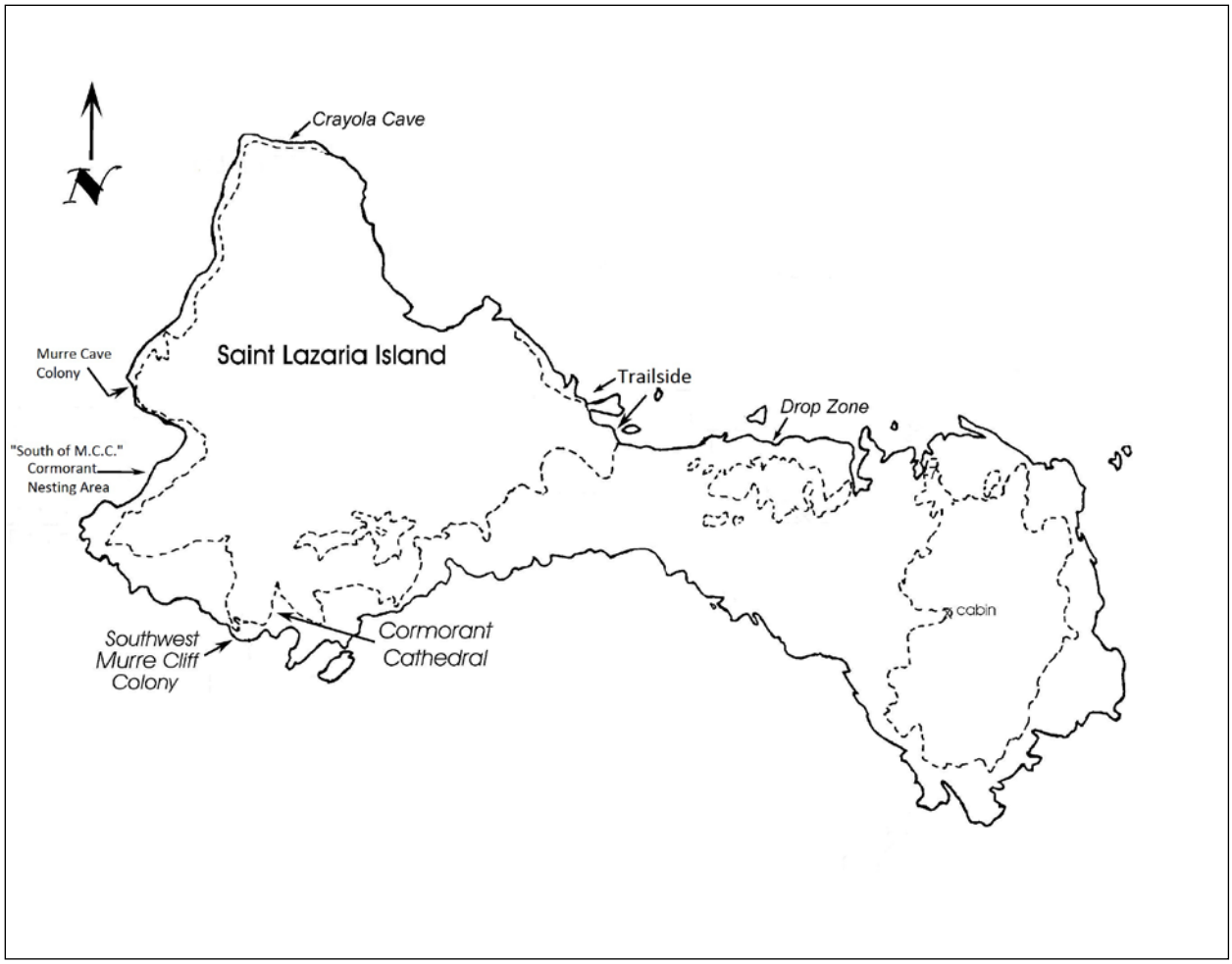

Figure E1. Locations of past cormorant colonies on St. Lazaria.

Attachment F. St. Paul Island Specifics

PROCEDURE DETAILS SPECIFIC TO ST. PAUL

Cormorant productivity at St. Paul is monitored for red-faced cormorants, using both individual nest monitoring and Boom-or-Bust procedures. For individually-monitored nests, cormorant nests that can be observed from above are followed every 3-4 days in conjunction with ledgenester productivity. Some cormorant nests are within kittiwake and murre productivity plots; in addition, since 2003, new plots for monitoring just red-faced cormorants have been monitored at Tolstoi (plots 111, 112, and 114) and Zapadni (plot 109). Any new nesting clusters found in future years can also be monitored.

A different sample of nests (not viewable from above) is used to generate Boom-or-Bust estimates of productivity. In past years, this has been done at Tolstoi and Northwest Point. Count (and map/individually mark if helpful) nests 1-3 times, beginning in early June (for multiple counts, aim for 7-10 day intervals from early to mid/late June; for a single count, try to schedule it for the middle of the count window). Then count large chicks 1-3 times beginning in late July. Whether you do one or three counts each period will depend on your workload at the time. Timing is based on detailed phenology data from St. Paul (peak laying 18-31 May 2004 and 2005; mean hatch 13 June-11 July 1976-2010; earliest fledge 27-31 July 2004 and 2005). You can refine the exact timing of your counts in the current year by using any data gathered during individual nest monitoring that year.

Specific Requirements for St. Paul – Individual nest monitoring

Dates: *25 May-1 Jun*: Conduct a thorough survey of all productivity plots, and obtain the status of nests on each plot.
1 Jun-end of season: Check status of nests every 3-4 days (optimal; up to 5-6 if dictated by bad weather or workload), most frequently during the peak of hatching (mid-June to mid-July).

Optimal sample size: At least 30-50 nests (this will depend on distribution of nests and may be lower; less than 10 may not be worth monitoring).

Time of day: Daylight hours.

Weather: Good visibility (minimal fog). Wind and rain do not preclude work but do tend to make birds sit tighter and can make observations through optics problematic.

Equipment needed: Binoculars, spotting scope, tripod, Rite-in-the-Rain® notebook, two pencils, plot photos, ultra-fine tipped Sharpies for writing nest numbers on photos, clear plastic photo protectors (to protect plot photos).

Equipment suggested: Crazy creek chair, clipboard, large rubber bands to keep items from flying off the clipboard, safety equipment for tying into plots, thermos of hot drink, lots of snacks, lens cleaning cloths, complete change of clothes, camera.

Specific Requirements for St. Paul – Boom-or-Bust

Dates: *Early to mid/late June*: Count/map nests 1-3 times.
Late July through mid-August: Count chicks nests 1-3 times.

Optimal sample size: At least 30-50 nests (this will depend on distribution of nests and may be lower; less than 10 may not be worth monitoring).

Time of day: Daylight hours.

Weather: Clear visibility if nests are high on cliffs; avoid wet, windy days when doing chick counts as chicks may be huddled down in nests and difficult to see.

Equipment needed: Binoculars (or spotting scopes), tally counters, paint pens or spray paint (if numbering nests), maps or photos of nest locations for chick counts (if maps/photos were done during nest counts), Rite-in-the-Rain® notebook, two pencils.

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, clarified Aiktak attachment	1.5
Dec 2015-Jan 2016	Update and addition to figures in Chowiet section, clarified Ep modifier, fixed page number references in text	1.4
April 2015	Clarified calculations of Boom-or-Bust by adding Total Nest Starts (A) to example calculations, made other minor clarifications. Updated map in Chowiet attachment.	1.3
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 tables and figures in island attachments, ordered island attachments alphabetically, changed page number format to include protocol #, made minor grammatical edits, removed reference to chick sizes in St. Lazaria Boom-or-Bust protocol	1.2
May 2013	Added St. Lazaria attachment	1.1
April 2012	Protocol developed in standardized format from historic protocols, includes St. George, St. Paul, Aiktak, Buldir, and Chowiet attachments	1.0