Survey of the Least and Crested Auklet colony near Sugarloaf Head, Semisopochnoi Island, Aleutian Islands, Alaska, in 2004

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Abstract: The large Least and Crested Auklet colony near Sugarloaf Head, Semisopochnoi Island, Rat Islands, Aleutian Islands, Alaska (51° 53'N 179° 37' E) is one of the largest among the nine auklet colonies in the Aleutian Islands. In order to provide information necessary to evaluate the significance of this colony compared to other Alaskan auklet colonies and to evaluate survey techniques, we carried out a survey designed to precisely map its geographical limits and assess relative density of breeding birds within the colony site. We recorded presence or absence and density of auklets and vegetation cover at 314 20 m^2 survey plots, most randomly located within 100 m by 100 m cells on a grid overlying the colony site. After we were familiar with the colony site, we used a GPS receiver to create track lines along the colony boundary, defined by its outermost crevices. Our survey data provide a quantitative delineation of the extent and density of the entire colony that will be useful for comparison with future surveys. Our assessment of survey methodology suggested that regular spacing of survey plots is preferable to random placement of survey plots within grid cells. The boundaries of the colony delineated by us differed substantially from previously mapped boundaries, likely due to errors in the previous mapping. Apart from a small (c. 1 Ha) subcolony in beach boulders in Nuclear Cove, the Semisopochnoi colony site had close to 100% vegetation cover (grasses), with evidence of ongoing encroachment of vegetation. Openings into underlying rock crevices were maintained only by continuous use and resulting wear due to auklet activity, in many cases these entrances resembled burrows. There is apparently little opportunity for colony expansion, due to lack of suitable breeding habitat. We found 250 pairs of Glaucous-winged Gulls nesting on the auklet colony, apparently recent colonists following removal of foxes from the island in 1997. Least Auklets comprised more than 90% of gull diet, based on the composition of gull pellets examined. Although the colony is large, the apparent overgrowth of the site by vegetation and colonization of the site by Glaucous-winged Gulls suggested that it may be decreasing in size and numbers. Our survey results underline the need to complete surveys of poorly known colonies such as those at Segula and Gareloi, and especially to remove rats from Kiska Island, which has the largest remaining patch of ideal auklet breeding habitat in the western Aleutian Islands.

Least and Crested Auklets apparently breed at only nine colonies in the Aleutian Islands (Buldir, Kiska, Segula, Semisopochnoi, Gareloi, Kasatochi, and Koniuji Islands, with small Crested Auklet colonies reported from Chagulak and Seguam Islands). Intensive studies of auklet biology and populations have been carried out at Buldir, Kiska and Kasaotchi Islands, and these colonies are well known, but the other colonies have only been roughly surveyed and remain relatively poorly known. Renner et al. (ms. In preparation) proposed that for management and conservation purposes, Alaskan auklet colonies should be mapped following a protocol designed to be repeatable and quantitative, allowing for detection of decadal changes in colony area and density. The survey protocol, still in the developmental stage (Renner et al., ms in preparation), aims to precisely delineate colony boundaries using hand held GPS equipment, and to quantify auklet density and vegetation cover at representative points within the colony.

Why survey Least and Crested Auklet colonies? For management purposes, it is crucial to have quantitative information on the distribution and abundance of these species, which are two of the most abundant seabirds in Alaska. Because they nest in concealed breeding sites in rock crevices, auklets are difficult to count and their populations remain relatively poorly understood compared to cliff-nesting seabirds. Population monitoring has been attempted using surface counts, but these vary inconsistently from day to day, within seasons, and among years irrespective of population changes and immature and non-breeding birds are inordinately represented in surface counts, making this a questionable approach to population monitoring (Jones 1992). Nevertheless, some auklet colonies have changed in geographical area or disappeared entirely during historical time – leading to the suggestion that an approach that emphasizes mapping and photographic documentation of auklet colony locations and boundaries would be useful (Arthur L. Sowls, personal communication). We urgently require such documentation of auklet colonies in order to be able to interpret the effects of climate change on auklet breeding habitat and food supplies, the effect of plant succession on the availability of breeding crevices, the effects of non-indigenous predators (e.g., rats) that may be accidentally introduced to auklet nesting islands, and the severity of catastrophes such as oil spills. In the western Aleutian Islands, most

Least and Crested Auklets bred at Sirius Point, Kiska Island, but this colony has suffered breeding failure in recent years due to introduced Norway rats *Rattus norvegicus*, underlining the need to quantify auklet populations and breeding habitat available on nearby rat-free islands.

Semisopochnoi Island (52° N 179°E) is the easternmost of the Rat Islands, with dimensions of about 20 km by 17.5 km, and is part of the Alaska Maritime National Wildlife Refuge. Semisopochnoi has no native land mammals. Arctic foxes (*Alopex lagopus*) were introduced to the island during the 19th century for 'fur farming' and removed by the Refuge in 1997 (Ebberts 1997) to restore a naturally functioning ecosystem free of non-indigenous species. Semisopochnoi Island in 2004 is an island in the early stages of recovery from introduced Arctic foxes, with Aleutian Canada Goose (*Branta canadensis leucoparea*), Rock Ptarmigan (*Lagopus mutus*) and most burrow-nesting seabirds (storm-petrels, Ancient Murrelets, Cassin's Auklets, Tufted Puffins) extirpated. However, Semisopochnoi did not suffer the ravages of WWII relative to some other Aleutian Islands and remained free of introduced Norway rats (*Rattus norvegicus*) and other harmful war debris. Some debris remains from a monitoring station on Semisopochnoi related to the nuclear weapons testing program based on nearby Amchitka Island during 1971-73 (Thomson 1997).

Auklets breed in one colony at Semisopochnoi island, located on the south facing slopes of Sugarloaf Peak volcano and its associated cinder cones near Sugarloaf Head (51° 53' N 179° 37' E). Sugarloaf Peak is a recent volcano with basaltic lava flows that emanated perhaps 150 – 250 years bp from a parasitic cone with its 500 m asl summit 1.4 km from the coastline at Sugarloaf Head (Coats 1947). Preliminary surveys of this colony were made in 1976 and results included a rough map of the colony boundaries (Fig. 1) and estimates of population size Least Auklet (363,000), Crested Auklet (20,000) (Early et al. 1978). Surface counts and other information on the auklet colony were obtained twenty years later during the fox eradication project (Thomson 1997). Prior to the present study, it was apparent that Semisopochnoi was the site of a very large auklet colony, perhaps second in size only to that located at Sirius Point, Kiska Island. Given the apparent status of Kiska as an auklet colony gravely threatened by introduced Norway rats, assessment of the status of other large auklet colonies in the

Rat Islands, especially those at Semisopochnoi and Gareloi, is an urgent conservation priority.

In summary, the primary aims of our project were to: 1) precisely and accurately delineate the geographical boundaries of the Least and Crested Auklet colony near Sugarloaf Head, Semisopochnoi Island; 2) quantify relative auklet breeding-site density and vegetation cover throughout the colony site using representative survey plots; and 3) use the data collected to evaluate the status of the Semisopochnoi auklet colony and its significance and relationship to other Aleutian island auklet colonies.

Methods

Mapping

Prior to fieldwork, we looked for maps of Semisopochnoi Island suitable for georeferencing for use in the colony survey. Topographic maps (1:25,000 scale, prepared for the US military in 1943) of Semisopochnoi are archived in the Library of Congress but were not available to us by the time of the survey, although they were received in October 2004 (courtesy of Janet Schaefer, Alaska Volcano Observatory). However, before the survey we were able to obtain a geological map of Semisopochnoi that was based on these topographic maps (Coats 1947). The geological map is of smaller scale (c. 1" = 1 mile) than the topographic maps and lacks a datum and overlying UTM grid, but provided the only available outline of the coastline and elevation contours (interval 100') of features of Sugarloaf Peak and associated lava flows and cinder cones. Prior to fieldwork we georeferenced a scanned version of this map using GPSy Pro (Macintosh software) based on the scant latitude and longitude tick marks available on the map.

Survey Grid

We used the NAD27 Alaska datum and the UTM grid (zone 60 U) for the survey grid although the geological map has no recorded datum. Our survey grid was based on 100 m by 100 m cells; each survey plot was located at a randomly derived point within each cell so the mean distance between points was 100 m. We considered using a 100 m by 100 m grid and locating each survey plot at regular intervals on the grid line intersection points, but this option was rejected in favor of the random grid

recommended by Renner et al. (ms in preparation). The initial survey grid and list of position fixes for each survey plot was obtained by overlying the random grid (Microsoft Excel for Macintosh, spreadsheet, tab-delimited text format) on Coat's georeferenced geological map of Semisopochnoi using the GPSy Pro (Macintosh software) mapping application. We deleted plots that fell in the ocean and other boundary areas thought to be well outside the auklet colony, based on the 1977 colony map (Early et al. 1978, Fig 1). To generate a convenient order for visiting the survey points, the plot positions were ranked by their UTM Northings and numbered in 100 m (N-S) by c. 2 km (E-W) swaths that spanned the colony east to west. The resulting list of 281 survey points was uploaded to our 12-channel GPS receivers (Garmin GPS12XL and Garmin GPSmap 76S) for use in the field.

Groundtruthing Survey Map

Upon arrival at Semisopochnoi we collected position fixes at conspicuous landmarks (e.g., the outlet of Fenner Creek into the sea near our camp, the outlet of Fenner Lake into Fenner Creek c. 5 km N of camp, and the edges of Nuclear cove c. 5 km W of camp) and used these to again georeference Coat's geological map. When the initial random grid was overlaid on the newly georeferenced map it was apparent that Coat's map is hundreds of meters off its supposed position as indicated by its latitude and longitude tick marks. Furthermore, landmarks in the vicinity of the auklet colony for which position fixes were obtained did not display properly on Coat's map, suggesting that the geological map has errors and does not entirely accurately represent the terrain.

To solve the off-datum issue with Coats' geological map we used the map georeferencing calibration based on the three landmarks mentioned above, and we corrected each survey grid point Northing and Easting so the revised random grid overlaid the colony site as depicted in the 1977 map (Early et al. 1978). We resolved to complete the survey using this revised grid and the imperfect geological map, and later overlay the survey data on the better 1:25,000 topographic maps when these become available, with the assumption that the new revised grid overlaid the colony site and beyond the colony boundaries. Later in the season we obtained position fixes at Tuman Cove on the west side of Semisopochnoi and used these in the final and best calibration of Coats' geological map.

Survey Methodology

After one exploratory hike through the colony on June 10, during which 32 plots on the initial random grid were visited, we surveyed the colony by visiting plots in the revised random grid on a complete lower outbound swath and a returning higher swath. Thus the colony was surveyed systematically in narrow east to west swaths from the southern coastline to the highest and most northerly points in the colony. This proved to be the best possible method of visiting and surveying the randomly-placed points, because the swaths followed elevation contours approximately, except in the northwest part of the colony.

After four of the lowest elevation swaths were completed, it was apparent that the colony extended hundreds of meters beyond the previously mapped colony boundaries (Fig. 1) and beyond the revised random grid along the entire western side of the colony and in a small area in the extreme southeast corner, because the 1977 map (Fig. 1) used to determine the grid size underestimated the extent of the colony on the west side. Therefore, additional plot locations were generated at 100 m intervals starting 100 m W or E of the outermost plot in the revised random grid. Plots were added as required to extend at least 100 m outside the colony as recommended by Renner et al. (ms in preparation), as much as possible given time available for surveys. These additional plots were not randomly located within grid cells and were manually generated in the field by traveling 100m directly east or west of the outermost random grid point. Following the draft protocol (Renner et al., ms. in preparation) we only checked areas with potential auklet breeding habitat (i.e., areas of short grass meadows on a continuous fine substrate to the west of the colony site were not surveyed).

At each survey plot (circular area with 2.5 m radius around each point, 20 m^2 area) we recorded the date and time of our visit, whether occupied auklet breeding crevices were present or absent, auklet density based on sign (0, L, M or H; following Renner et al. ms in preparation), auklet density based on ILJ's method (0, 1-10, 11-100, >100 active crevices per 100 m^2), and the proportion of vegetation and rock cover to the nearest 5% for the following categories: bare rock, water, grass, moss, *Empetrum*, willow and herb (any of *Anemone narcissiflora, Lupinus nootkatensis, Angelica lucida*, and other broad-

leaved plants). We did not count droppings et c. within each survey plot, as these counts are likely to vary unpredictably with habitat type, date, time since previous heavy rain, and observer biases. We recorded the presence of gull nests within plot boundaries. In order to further document habitat characteristics including vegetation cover, we took a 6 megapixel digital photograph of each plot when weather conditions at the time of our visit permitted. When the survey plots were nearly completed and we had become familiar with the colony site, we walked the colony boundaries (lying along outermost active breeding sites) while recording track lines on the handheld GPS receiver.

Glaucous-winged Gull Diet

We examined the contents of pellets of Glaucous-winged Gulls found near roost and nesting sites within the auklet colony boundaries to assess gull diet. No more than one pellet was examined (at random) from groups of pellets within a 100 m^2 area, to avoid repeatedly sampling the pellets of individual gulls or pairs. We recorded the presence or absence of the following prey categories in each pellet examined: Least Auklet, Crested Auklet, passerine, fish (bones), limpet, and urchin.

Results

Between June 12 and July 19, 2004 we recorded presence or absence and density of auklets and vegetation cover at 285 20 m^2 survey plots on Semisopochnoi, including 248 on the revised random grid and an additional 37 plots added later. We also recorded data for 29 additional plots on the original grid on June 10, for a total of 314 plots surveyed (Fig. 2). The extent of the Least and Crested Auklet colony at Semisopochnoi closely overlapped the area of the most recent lava flows from the Parasitic Cone at the base of Sugarloaf Peak volcano (mapped by Coats 1947), with two areas of high density centered on the points of origin of the lava in these flows on the southeast and southwest sides of the Parasitic Cone at about 200 m asl (Figs. 3-4). Breeding auklets occupied crevices in the above mentioned lava flows, including crevices in shoreline cliffs. Breeding auklets were absent from lava areas near Nuclear Cove and from old lava flows between the eastern colony boundary and Sugarloaf Knob (Figs. 3-4). We found one isolated patch of auklet colony on an area of rounded beach boulders in Nuclear Cove (Figs. 3-4). This patch was separated from the main colony by c. 500 m of

unoccupied lava flow adjacent to Nuclear Cove. The maximum straight-line width of the colony at the shoreline (from the easternmost Least Auklets breeding in cliff crevices to the westernmost in beach boulders in Nuclear Cove) was 2.8 km. At its highest point c. 390 m asl, the innermost crevices were 1.5 km (straight line distance) from the shoreline. The area of the colony site, as determined from the mapped boundaries and not taking into account slope or unevenness of the terrain, was estimated to be 1.9 km^2. Of the 314 survey plots visited, 192 (62%) were later determined to be within the colony boundaries and of these 123 (64% of the plots within the colony boundaries) had active auklet breeding sites present (Fig. 2). Among the plots within the colony boundaries, 14 (7%) were high density, 41 (21%) medium density, 69 (36%) low density and 68 (35%) had no active breeding crevices (Fig. 2). We estimated that the colony site may support about 1 million nesting auklets, 90% of them Least Auklets and 10% Crested Auklets.

Colony boundaries mapped by us differed significantly from those inferred from the previous map (Early et al. 1978) (Fig. 5). The previous map appears to show the colony extending eastwards in meadows as far as the slopes of Sugarloaf Volcano above Sugarloaf Knob (c. 1 km east of the present boundary). The previous map also appears to show the western colony boundary on the southern slopes of the Parasitic Cone, while our survey indicated the boundary another c. 950 m west. The previous map also appears to show the colony extending onto parts of the Parasitic Cone that were continuous fine cinder substrate (unsuitable for auklet breeding) at the time of the present survey.

The colony site was nearly completely covered in vegetation, with bare rock (lava) comprising less than 0.1 % of the surface area. Only 4 (2%) of the 192 survey plots within the colony boundaries had any bare rock present. Similarly, only 2 (2%) of the 123 plots with active breeding crevices present had any bare rock present. The only areas of bare rock near the auklet colony site other than the beach boulders at Nuclear Cove were areas of unvegetated fine cinder on the Parasitic Cone and its secondary cinder cone and these were not used by auklets. Vegetation cover on the entire colony site averaged 99.9% on study plots and consisted of grasses (*Calamagrostis* sp., *Elymus* sp. and *Puccinnellia* sp. [collected for identification]) (mean of 70% of the area of survey plots), mosses (12%), *Empetrum* (11%) and herbs (7%). Vegetation cover on survey plots

with medium and high density auklet breeding crevices consisted of grasses (77%), mosses (11%), *Empetrum* (5%) and herbs (7%). Vegetation cover in the densest areas of the colony was predominantly *Puccinnellia* sp. grass. Openings in the vegetation through which auklets gained access to underlying blocky lava were typically small (5 – 20 cm diameter) and appeared to be maintained by birds forcing themselves through the dense vegetation cover (usually grass or moss). Herbs (broad-leaved vegetation) for the most part consisted of *Anemone narcissiflora*, *Angelica lucida* and *Lupinus nootkatensis*.

Glaucous-winged Gull biology and diet

We found active Glaucous-winged Gull *nests* on three of our 314 survey plots. Hatchlings were observed by mid-June and fledglings by mid-July. Gull nests were found throughout the colony site, on the auklet-unoccupied lava flow between the auklet colony and Sugarloaf Knob, and adjacent to Nuclear Cove. We estimated that 200 – 250 pairs of Glaucous-winged Gulls were nesting on the auklet colony and nearby lava flows. We observed Glaucous-winged Gulls hunting and killing auklets throughout the auklet colony. Among 100 Glaucous-winged Gull pellets examined, each at a different site within the colony, 92% contained Least Auklet remains, 2% Crested Auklet remains, 2% fish remains, 2% limpet, and 1% sea urchin.

Discussion

Size and significance of the Least and Crested Auklet colony at Semisopochnoi

The auklet colony at Semisopochnoi is unusual among Aleutian auklet colonies for its spectacularly large geographical size (2.8 km across and covering more than 2 km^2 area without accounting for its accordian-like surface) and for its nearly complete vegetation cover. Apart from two areas of high density in the most porous of the available vegetated blocky lava, much of the colony site consists of widely scattered active crevices in small patches of grass-covered lava in otherwise meadow-like habitat. We believe this colony supported in the neighborhood of one million breeding auklets in 2004. The future viability of this colony appears to face two challenges, one uncertain and one inevitable.

The Semisopochoi colony site has undoubtedly been colonized by Glaucous-winged Gulls after the removal of Arctic foxes from Semisopochnoi in 1997. The generally low

density of auklets on the colony site relative to other auklet colonies may make them vulnerable to gull predation. Gull diet consisted of more than 90% Least Auklets by occurrence, suggesting that gulls specialize on this species at Semisopochnoi. The potential population impact of the gulls is underlined by the rough calculation that 500 gulls taking 4 adult auklets each day for the 90 day auklet breeding season would take 180,000 auklets each year, 18% of the estimated population. This speculative rate of predation is higher than observed at other auklet colonies. However, without quantitative research on auklet demography and gull predation at Semisopochnoi the true impact of gulls on the colony will remain uncertain.

The second issue facing the future viability of the Least and Crested Auklet colony at Semisopochnoi is the steady natural advance of plant succession. The colony site is located on 150-250 year old lava flows that have been entirely colonized by vegetation, consisting mostly of grasses. Much of the area of the lava flows has been rendered useless to auklets because crevice entrances have been filled in. The colony site is therefore in a late stage of plant succession. Most (perhaps as high as 90% of) presently active auklet crevices are currently nearly blocked by encroaching vegetation and kept open only by the continual passage of birds forcing themselves through narrow openings. If the rate of plant encroachment at Semisopochnoi is similar to that observed at Bob's Plateau at the Sirius Point, Kiska Island between 1987 and 2001, most of the colony site at Semisopochnoi will be unsuitable habitat within a few decades. We speculate that regardless of any impact of gulls, the auklet colony at Semisopochnoi will be limited to a small remnant of suitable breeding habitat on coastal cliffs and boulder beaches within 50 – 100 years.

Considered as a metapopulation, the viability of the entire auklet population in the western Aleutian Islands (Buldir, Kiska, Segula and Semisopochnoi) will depend on the availability of newly created habitat, the product of either marine erosion and the formation of talus slopes, or of volcanic activity producing suitable blocky lava flows and dome in coastal areas. At present the largest and newest area of suitable auklet breeding habitat is located at Sirius Point, Kiska Island (1964-69 lava dome). Sirius Point supports the largest auklet colony in the Aleutian Islands, but its future is undoubtedly threatened by introduced Norway rats that regularly invade the colony

site and reduce productivity to low levels (Major et al. IN PRESS). Buldir has auklet populations that are an order of magnitude less than Kiska's, has limited auklet breeding habitat that is in the mid- to late-plant-successional stage, and parts of that island's colony have disappeared over the last decade (ILJ personal observations). Segula's auklet colony at Gula Point has not been thoroughly surveyed but appears to be in a late stage of plant succession similar to Semisopochnoi. Gareloi island in the Delarof Islands 100 km east of Semisopochnoi has large Least and Crested Auklet populations but the locations and boundaries of this island's colonies and the state of the breeding habitat there are unknown. Surveys of the Least and Crested Auklet colonies at Segula and Gareloi would therefore be useful. Our work on Semisiopochnoi underlines the importance of Sirius Point, Kiska Island as the site of both the largest remaining auklet populations and the largest area of breeding habitat that will persist decades into the future. Our results therefore underline the need to remove Norway rats from Kiska Island.

Assessment of survey methodology

Because we used state-of-the-art GPS equipment for obtaining position fixes, our survey methodology undoubtedly produced an improved ordination of the Least and Crested Auklet colony site at Semisopochnoi. Our resulting map differed considerably from the previous maps, which showed auklet colony on areas with no suitable breeding habitat (meadows with fine substrate). We believe the difference between the present and previous mapped areas was due to improved accuracy of survey techniques rather than a change in auklet distribution on the ground.

We discovered some problems with the implementation and interpretation of the random plot placement methodology suggested by Renner et al. (ms in preparation). First, without an accurate knowledge of colony location in advance, the placement of survey points on a UTM grid is perilous. Either the colony location must be well known prior to fieldwork, or the area of the grid must be set to be very large in order to not miss the colony. If the area of the 100 point grid with randomly positioned plots within cells (hereafter 'random grid') recommended by Renner et al. (ms in preparation) is set very large, the grid will cover the colony site but resolution of colony boundaries will be very poor and the survey will fail in its primary objective (to usefully delineate

the boundaries and density of the colony). In our survey the lack of a topographic map and a misleading preexisting map of the colony made the advance placement of the random grid highly problematic.

Second, fieldwork in a large colony with difficult terrain (such as Semisopochnoi) is rendered more difficult and time-consuming by the random grid because there is no logical order in which the points should be checked and walking between the randomly-placed plots triples or more the zig-zag distance that has to be covered on the ground by the survey crew. Given the variation in readout of the GPS receiver and the random placement of plots, we often found it necessary to walk in circles up and down steep heavily vegetated slopes to find survey points, greatly increasing the time and effort to visit survey plots. At Semisopochnoi, with the span of the colony more than two kilometers, we found we had to walk five or six kilometers to check the approximately 20 points in one swath across the colony. By comparison, checking 20 evenly spaced survey plots 100 m apart on a straight grid line would have involved ground travel of little more than 2 km. We found the additional points we added on the west side of the colony, which were set 100 m apart along straight grid lines, extremely easy to visit and check compared to the randomly placed plots. For auklet colonies at remote locations being visited briefly by a vessel, survey plots on a regular grid could quickly be checked by fieldworkers walking parallel grid lines, making even moderate to large colonies surveyable in one day of work by two to four fieldworkers.

Third, the random grid disoriented us in the large colony at Semisopochnoi, especially when visibility was poor such as in foggy conditions, causing confusion about our current location in the colony and hampering the formation of an impression of colony limits and areas of high and low density. The resulting confusion delayed our ability to realize that the pre-existing colony map was off by hundreds of meters on both the east and west sides of the colony site, delaying and preventing us from using an appropriate survey grid.

Fourth, if during survey fieldwork it is determined that more plots must be added to cover a colony boundary (as occurred in this study), there is no easy way to add randomly placed points while in the field. In a regular grid additional points can easily be added on to cover unexpected areas of habitat occupied by birds. The regular grid also can be modified in future studies decades in the future to account for colony expansion into newly available habitat.

Fifth, the graphical product of random plot placement methodology is a mish-mash of randomly placed survey plots, some very close together and thus redundant and in other cases with wide gaps with no information, producing a map that is difficult to interpret because trends in density and colony boundary locations are obscured by the uneven sampling (Figs. 2-4). We believe the usefulness of graphical illustration of extent of, and variation in density within a colony is significantly reduced by the random grid methodology.

Sixth, a survey using a preset number (100) of survey plots regardless of colony size makes no logical sense because it completely disregards the need to quantify the colonies boundaries with a resolution sufficient to detect changes. The survey protocol under development (Renner et al. ms in preparation) recommends the same number of plots (100) for a tiny 100 m by 30 m colony in the Pribilof Islands as for a survey of geographically very large colonies such as Kiska and Semisopochnoi. Colony survey grid size should be set to one of a small number of options (e.g., 10, 30 or 100 m grids) that apply given colony size and time available. The number of survey plots should be determined by the geographic size of the colony site and necessity to cover a surrounding unoccupied area.

Finally, the random plot placement methodology offers no or at most highly dubious advantages for statistical analysis over a regular grid. As long as the first point is placed randomly within a 100 m square area, all generated plot locations in a resulting 100 m regular grid will be in effect random and no less representative of an auklet colony (or statistically analyzable) that a grid with plots placed randomly within grid cells. The only problem with a regular grid would result if the terrain in an auklet colony varied in a regular manner that was an exact multiple of the grid size – highly unlikely given the chaotic structure of the talus slopes and lava flows that form auklet habitat.

Therefore, we believe the survey approach using random placement of 100 (or more) survey plots in within grid cells has numerous problems and should be abandoned in favor of an approach using a regular grid. We believe the random grid poses numerous difficulties in both implementation during fieldwork and with interpretable graphical mapping of the colony boundaries and density. In comparison, the regular grid is easy to check and add to during fieldwork and in future surveys and produces maps with clear and easy to interpret results. The grid size should be set according to colony size

and time available for the survey. For large colonies such as Kiska and Semisopochnoi, a 100 m grid should be both feasible to check in a single field season as well as providing sufficient resolution to detect changes in colony boundary and density. For smaller colonies, such as Main Talus at Buldir or Thundering Talus at Kasatochi Island a 30 m grid may be more appropriate. For some small colonies a 10 m grid may be appropriate if sufficient GPS receiver resolution permits (e.g., using a base station or broadcast correction signal). For many auklet colonies, such as those located on a long narrow strip of beach boulders, a grid pattern of survey plots is entirely inappropriate. For these strip colonies, such as Village Cove Beach on St. Paul Island, a strait or curving transect line with survey plots set at regular intervals will best delineate auklet colony boundaries and density. Notwithstanding our concerns about grid types, we believe the most valuable kind of information that can be collected during colony surveys is the GPS-derived track lines that mark the outermost active crevices of the auklet colony – these provide the most concrete record of where the colony is located and will be the most sensitive measurements for detecting changes in colony size and shape.

Conclusions and Recommendations

• Semisopochnoi Island supports a large Least and Crested Auklet colony of about one million birds occupying 150-250 year old lava flows that are completely covered by vegetation.

• The geographic area of the colony site at Semisopochnoi is greater than 2 km^2, making it the largest measured colony in the Aleutian Islands, but recently colonized Glaucous-winged Gulls and advancing plant succession represent possible threats to its future viability.

• Colony mapping using a 100 m survey grid and hand-held GPS receivers provided an accurate and precise delineation of the auklet colony. Our experience suggested to us that for a number of reasons placement of regularly spaced survey plots is preferable to random placement of survey plots within grid cells.

• Our Semisopochnoi colony survey needs to be followed up with similar surveys of auklet colonies at Segula and Gareloi, completing the mapping of western Aleutian Island Auklet colonies. Ideally, surveys and mapping of each colony should be undertaken once every ten years.

• The Semisopochnoi colony survey results underline the need to remove rats from Kiska Island, which has the largest remaining patch of ideal auklet breeding habitat in the western Aleutian Islands.

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Figure Captions

Figure 1 Extent of the auklet colony on Semisopochnoi Island as inferred from previous mapping: a) map from Early et al. (1978) showing colony boundary; b) approximate colony boundary based on Early et al. (1978), superimposed on Coat's (1947) geological map.

Figure 2 Raw 2004 survey data displayed on UTM grid (no datum used). Heavy black line indicates boundary track line, red dots indicate plots with high density, orange medium density, yellow low density and green birds absent from survey plot.

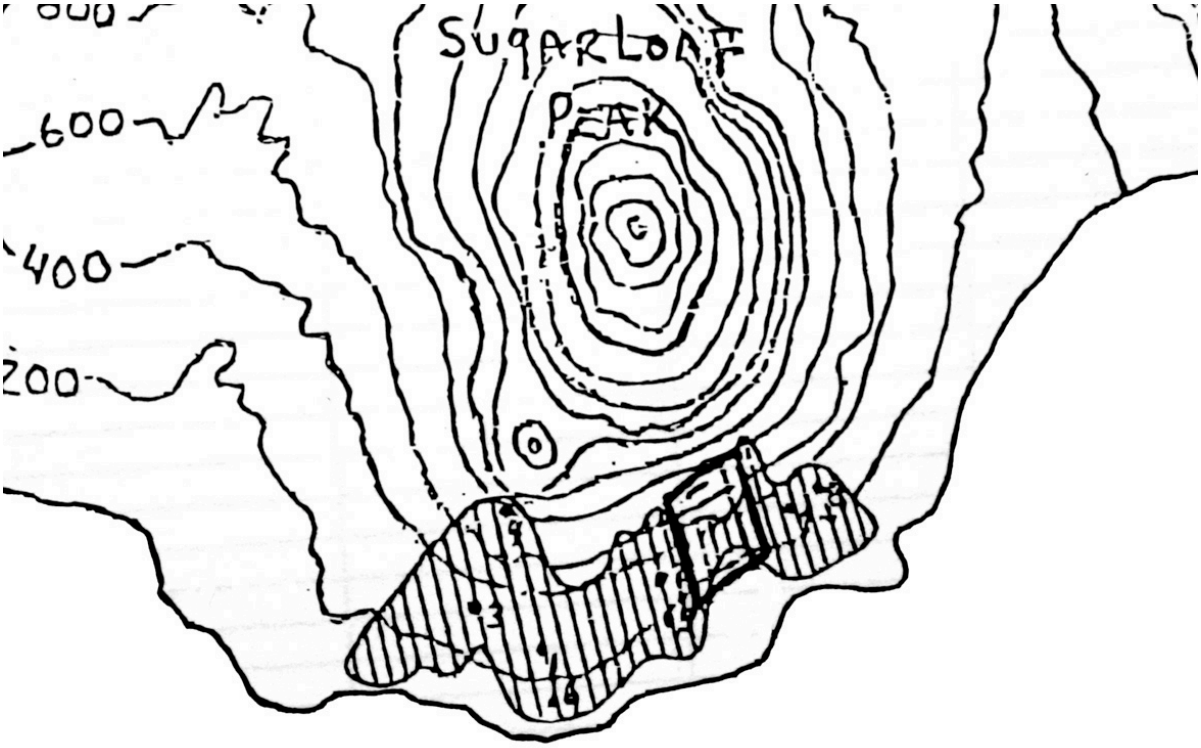
Figure 3 Survey results map showing overlay of data on nearby geographical features of Semisopochnoi Island as shown by Coats' geological map (no datum, main grid is 1000 yard army grid, second grid is UTM grid). Purple indicates entire extent of colony, red dots indicate plots with high density, orange medium density, yellow low density and green birds absent from survey plot.

Figure 4 Survey results map of area covered by survey plots and boundary tracklines overlaid on the US Army topo (UTM grid, datum is NAD 27 Alaska. Red dots indicate plots with high density, orange medium density, yellow low density and black birds absent from survey plot. Red line indicates colony boundary.

Figure 5 Comparison of previously mapped (black) to our mapped colony boundaries mapped with the aid of the GPS (red).

Figure 1 Extent of the auklet colony on Semisopochnoi Island inferred from previous mapping: a) map from Early et al. (1978) showing colony boundary; b) approximate boundary based on Early et al. (1978), superimposed on Coat's (1947) geological map.

a)



b)

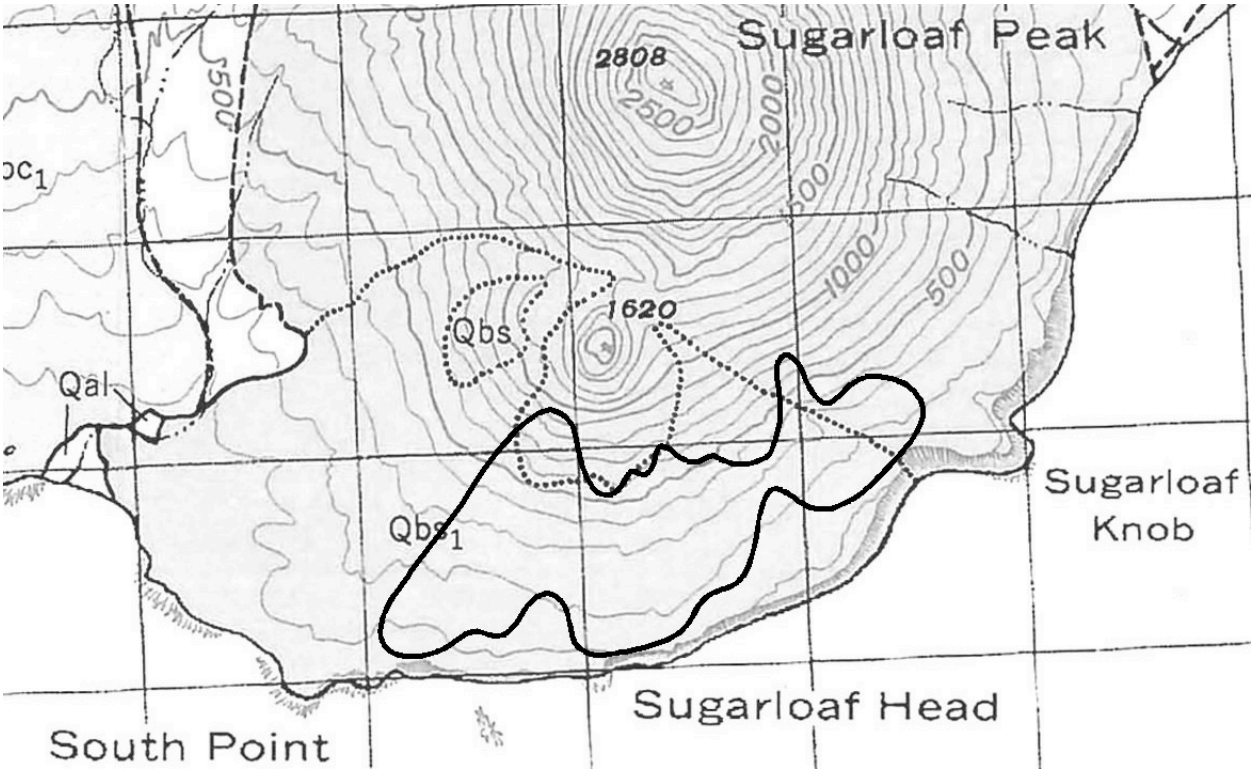


Figure 2 Raw survey data displayed on 1000 m UTM grid (no datum used). Heavy black line indicates boundary track line, red dots indicate plots with high density, orange medium density, yellow low density and green birds absent from survey plot.

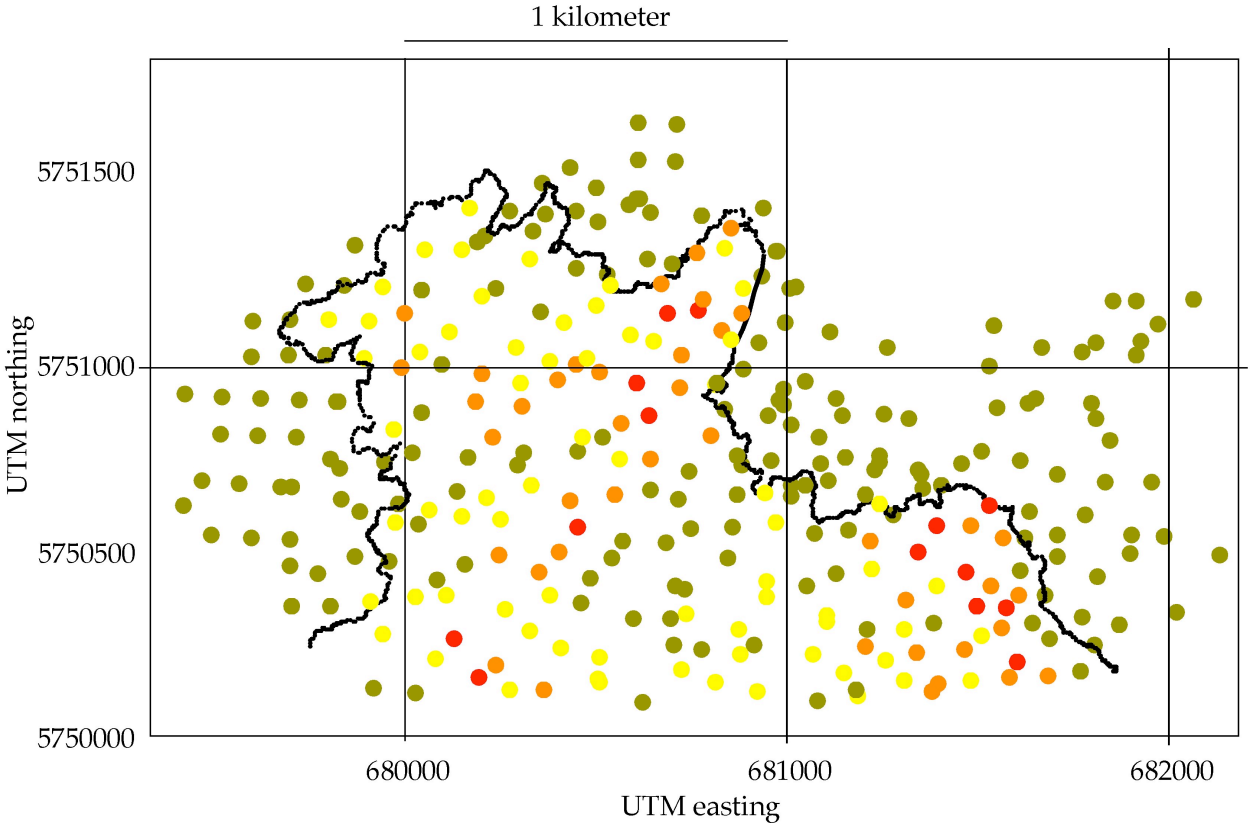


Figure 3 Survey results map showing overlay of data on nearby geographical features of Semisopochnoi Island as shown by Coats' geological map (no datum, main grid is 1000 yard army grid, second grid is UTM grid). Purple indicates entire extent of colony, red dots indicate plots with high density, orange medium density, yellow low density and green birds absent from survey plot.

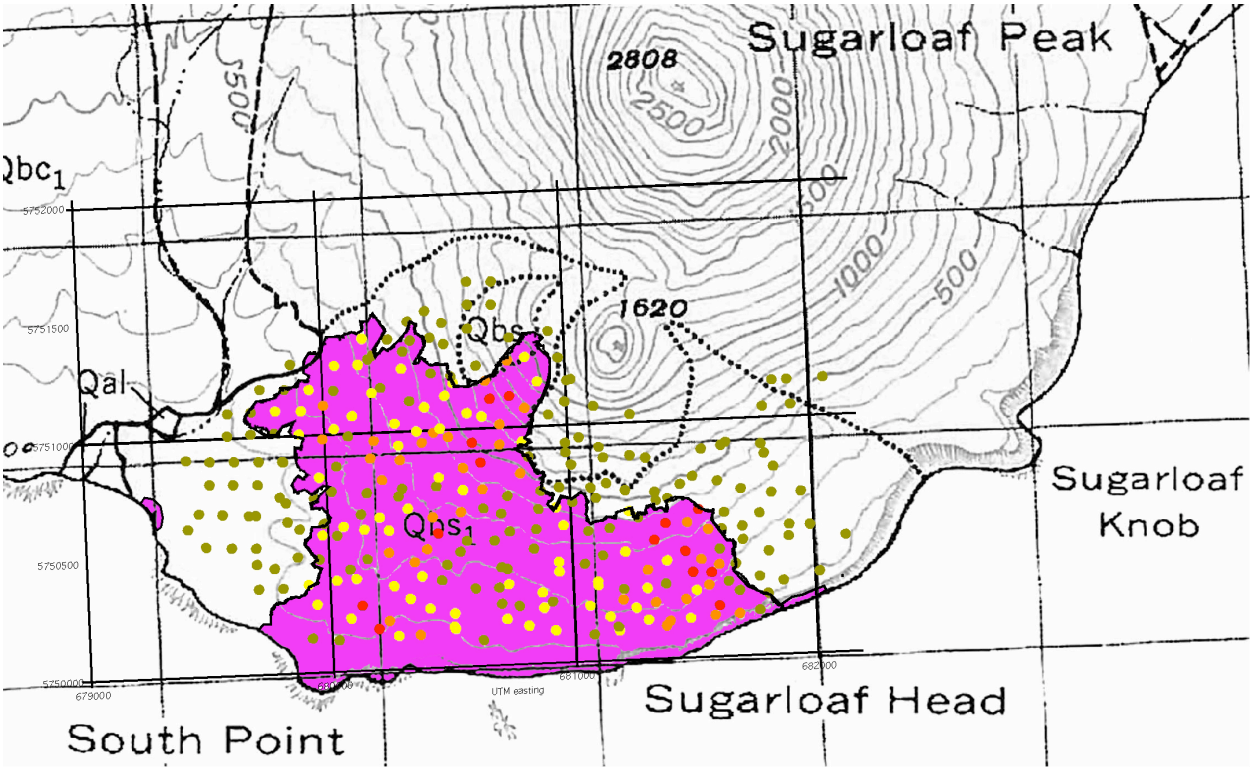


Figure 4 Survey results map of area covered by survey plots and boundary tracklines overlaid on the US Army topo (UTM grid, datum is NAD 27 Alaska). Red dots indicate plots with high density, orange medium density, yellow low density and black birds absent from survey plot. Red line indicates colony boundary.

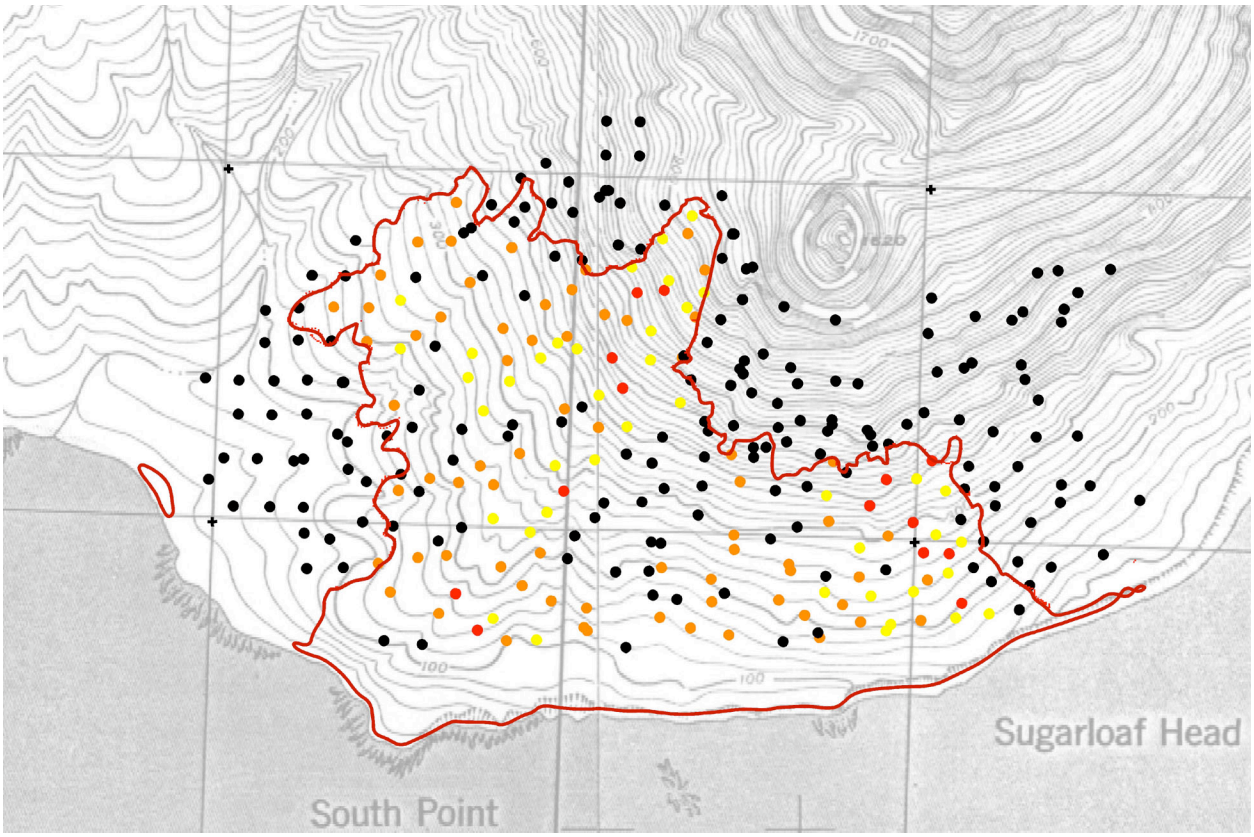
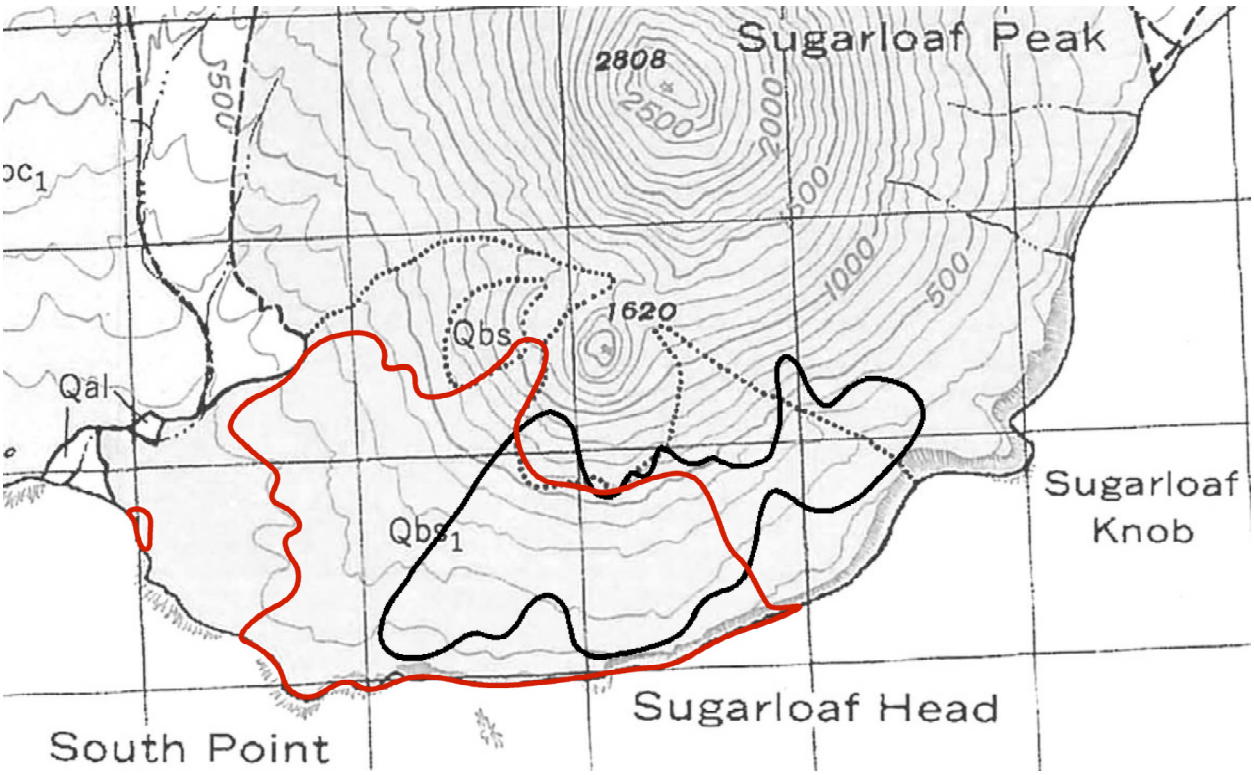


Figure 5 Comparison of previously mapped (black) to our inferred colony boundaries mapped with the aid of the GPS (red)



Appendix 1 Data summary for 314 survey plots in the vicinity of the auklet colony near Sugarloaf Head, Semisopochnoi Island, 2004 (all plots in UTM zone 60 U).

Plot	UTM north	UTM east	Date	Time	P/A	density	% cover					substrate
							rock	grass	moss	*Empetrum*	herb	water	
r-001	5750173	681577	June 17	12:32	P	M		85	10		5		blocky lava
r-002	5750166	681477	June 17	12:39	P	L		80	10		10		blocky lava
r-003	5750156	681389	June 17	12:46	P	M		90	5		5		blocky lava
r-004	5750138	681375	June 17	12:49	P	M	5	75	15		5		blocky lava
r-005	5750165	681300	June 17	13:43	P	L		85	5		10		blocky lava
r-006	5750124	681181	June 17	13:54	P	L		90	5		5		blocky lava
r-007	5750141	681176	June 17	13:58	A	0		85		10	5		filled blocky lava
r-008	5750188	681141	June 17	14:03	P	L		30	20	40	10		filled blocky lava
r-009	5750115	681076	June 17	14:11	A	0		80	10		10		filled blocky lava
r-010	5750138	680916	June 17	14:19	P	L		90	5		5		mostly filled blocky lava
r-011	5750164	680806	June 17	14:25	P	L		45	5	40	10		mostly filled blocky lava
r-012	5750195	680719	June 17	14:30	P	L		40	5	50	5		mostly filled blocky lava
r-013	5750111	680618	June 17	14:36	A	0		40	5	50	5		mostly filled blocky lava
r-014	5750163	680503	June 17	14:41	P	L		50	10	10	20		partly filled blocky lava
r-015	5750171	680497	June 17	14:45	P	L		50	5	20	25		partly filled blocky lava
r-016	5750140	680356	June 17	14:53	P	M		70			30		blocky lava
r-017	5750140	680267	June 17	15:00	P	L		80			20		partly filled blocky lava
r-018	5750173	680185	June 17	15:06	P	H		80			20		porous blocky lava
r-019	5750134	680022	June 17	15:15	A	0		85	5		10		filled blocky lava
r-020	5750146	679911	June 17	15:21	A	0		40	10	40	10		filled blocky lava
r-021	5750261	681798	June 17	18:12	A	0		95			5		unknown
r-022	5750275	681683	June 17	18:01	A	0		90	5		5		filled blocky lava
r-023	5750213	681596	June 17	17:55	P	H		90	5		5		blocky lava
r-024	5750282	681502	June 17	17:46	P	L		90	5		5		blocky lava
r-025	5750248	681460	June 17	17:39	P	M		80	15		5		blocky lava
r-026	5750241	681335	June 17	17:31	P	M		95			5		blocky lava
r-027	5750298	681299	June 17	17:26	P	L		85	5		10		blocky lava
r-028	5750217	681252	June 17	17:20	P	L		85	5		10		blocky lava
r-029	5750255	681199	June 17	17:14	P	M		80	5		15		blocky lava
r-030	5750236	681063	June 17	17:07	P	L		85	10		5		blocky lava
r-031	5750260	680907	June 17	17:00	A	0		60	5	30	5		filled blocky lava
r-032	5750234	680870	June 17	16:54	P	L		40	15	40	5		mostly filled blocky lava
r-033	5750246	680769	June 17	16:49	A	0		85	5		10		filled blocky lava
r-034	5750260	680698	June 17	16:38	A	0		75	10	5	10		filled blocky lava
r-035	5750226	680503	June 17	16:28	P	L		90	5		5		mostly filled blocky lava
r-036	5750252	680402	June 17	16:22	P	L		70	5		25		blocky lava
r-037	5750295	680319	June 17	16:13	P	L		75	10	5	10		blocky lava
r-038	5750206	680231	June 17	16:07	P	M		90	5		5		blocky lava
r-039	5750277	680123	June 17	15:57	P	H		95			5		blocky lava

r-040	5750223	680074	June 17	15:45	P L	75	5	10	10	blocky lava
r-041	5750289	679935	June 17	15:43	P L	90	5		5	blocky lava
r-042	5750343	682014	June 17	18:25	A 0	95			5	unknown
r-043	5750311	681863	June 17	18:16	A 0	95			5	unknown
r-044	5750331	681765	June 21	11:38	A 0	95			5	unknown
r-045	5750388	681668	June 21	11:44	A 0	30	35	30	5	mostly filled blocky lava
r-046	5750317	681636	June 21	11:51	A 0	70	25		5	filled blocky lava
r-047	5750387	681601	June 21	11:57	P M	95			5	blocky lava
r-048	5750356	681567	June 21	12:05	P H	75	20		5	blocky lava
r-049	5750303	681558	June 21	12:12	P M	80	15		5	blocky lava
r-050	5750362	681490	June 21	12:22	P H	90	5		5	blocky lava
r-051	5750317	681379	June 21	12:30	A 0	95	5			gravel-like cinder?
r-052	5750378	681307	June 21	12:38	P M	95	5			blocky lava
r-053	5750301	681203	June 21	12:44	A 0	30	30	35	5	filled blocky lava
r-054	5750320	681100	June 21	12:52	P L	90	5		5	partly filled blocky lava
r-055	5750336	681099	June 21	12:57	P L	90	5		5	partly filled blocky lava
r-056	5750386	680941	June 21	13:04	P L	50	5	40	5	mostly filled blocky lava
r-057	5750301	680869	June 21	13:34	P L	50	5	40	5	mostly filled blocky lava
r-058	5750339	680729	June 21	13:43	P L	50	20	25	5	mostly filled blocky lava
r-059	5750328	680690	June 21	13:48	A 0	70	10	15	5	filled blocky lava
r-060	5750329	680593	June 21	13:54	A 0	85	5		10	filled blocky lava
r-061	5750370	680456	June 21	14:00	A 0	90	5		5	filled blocky lava
r-062	5750388	680375	June 21	14:08	P L	90	5		5	filled blocky lava
r-063	5750354	680257	June 21	14:17	P L	85	5	10		filled blocky lava
r-064	5750390	680100	June 21	14:25	P L	50	20	25	5	partly filled blocky lava
r-065	5750383	680019	June 21	14:30	P L	65	15	15	5	partly filled blocky lava
r-066	5750371	679902	June 21	14:37	P L	35	10	50	5	partly filled blocky lava
r-067	5750361	679800	June 21	14:45	A 0	50	5	40	5	filled blocky lava
r-068	5750495	682126	June 17	18:31	A 0	95			5	unknown
r-069	5750497	681893	June 21	11:23	A 0	90			10	unknown
r-070	5750439	681807	June 21	11:30	A 0	25	35	35	5	filled blocky lava
r-071	5750491	681703	June 17	11:48	A 0	45	45		10	unknown
r-072	5750452	681604	June 21	17:09	A 0	85	10		5	filled blocky lava
r-073	5750412	681526	June 21	17:01	P M	90	5		5	blocky lava
r-074	5750451	681461	June 21	16:55	P H	90	5		5	blocky lava
r-075	5750412	681387	June 21	16:48	P L	95			5	partly filled blocky lava
r-076	5750458	681217	June 21	16:37	P L	90	5		5	filled blocky lava
r-077	5750445	681124	June 21	16:31	A 0	90	5		5	unknown, fine material?
r-078	5750412	681044	June 21	16:26	A 0	85	10		5	filled blocky lava
r-079	5750424	680942	June 21	16:20	P L	85	10		5	mostly filled blocky lava
r-080	5750485	680838	June 21	16:14	A 0	90	5		5	filled blocky lava
r-081	5750406	680726	June 21	16:08	A 0	90	5		5	filled blocky lava
r-082	5750414	680700	June 21	16:04	A 0	90	5		5	filled blocky lava
r-083	5750488	680535	June 21	15:57	A 0	80	15		5	filled blocky lava

r-084	5750434	680478	June 21	15:52	A 0		90	5		5		filled blocky lava
r-085	5750450	680345	June 21	15:46	P M		70	25		5		blocky lava
r-086	5750493	680239	June 21	15:39	P M		40	15	40	5		blocky lava
r-087	5750469	680149	June 21	15:34	A 0		25	35	35	5		filled blocky lava
r-088	5750429	680079	June 21	15:28	A 0		45	5	45	5		filled blocky lava
r-089	5750478	679951	June 21	15:09	A 0		85	5		10		filled blocky lava
r-090	5750491	679861	June 21	15:03	A 0		35	60		5		filled blocky lava
r-091	5750445	679766	June 21	14:58	A 0		85	5	5	5		filled blocky lava
r-092	5750543	681982	June 21	11:16	A 0		95			5		filled blocky lava
r-093	5750546	681897	June 21	11:21	A 0		95			5		fine cinder
r-094	5750548	681703	June 21	17:32	A 0		90	5		5		filled blocky lava
r-095	5750540	681618	June 21	17:25	A 0		90	5		5		filled lava
r-096	5750539	681559	June 23	11:50	P M		90	5		5		blocky lava
r-097	5750573	681477	June 23	12:05	P M		90	5		5		blocky lava
r-098	5750573	681387	June 23	12:13	P H		80	10		10		blocky lava
r-099	5750501	681339	June 23	12:26	P H		90	5		5		blocky lava
r-100	5750599	681271	June 23	12:43	A 0		80	5		15		fine cinder?
r-101	5750558	681156	June 23	12:50	A 0		90	5		5		fine cinder
r-102	5750549	681064	June 23	12:55	A 0		85	5		10		fine cinder
r-103	5750579	680965	June 23	13:01	P L		80	10		10		partly filled blocky lava
r-104	5750569	680850	June 23	13:09	A 0		40	5	50	5		filled blocky lava
r-105	5750564	680742	June 23	13:37	A 0		45	30	20	5		filled blocky lava
r-106	5750527	680676	June 23	13:42	A 0		65	5	10	5	15	filled blocky lava
r-107	5750529	680564	June 23	13:48	A 0		75	20		5		filled blocky lava
r-108	5750566	680448	June 23	13:59	P H		80	5		15		blocky lava
r-109	5750503	680397	June 23	14:03	P M		85	5		10		blocky lava
r-110	5750589	680245	June 23	14:11	P L		85	5		10		blocky lava
r-111	5750597	680144	June 23	14:16	P L		80	15		5		blocky lava
r-112	5750574	680030	June 23	14:23	A 0		75	20		5		mostly filled blocky lava
r-113	5750581	679968	June 23	14:27	P L		70	20	5	5		blocky lava
r-114	5750535	679692	June 23	14:39	A 0		80	20				fine cinder?
r-115	5750685	681948	June 21	11:11	A 0		90			10		fine cinder?
r-116	5750683	681828	June 14	17:32	A 0		75	15	5	5		fine cinder?
r-117	5750600	681774	June 14	17:28	A 0		60	30	5	5		filled blocky lava
r-118	5750607	681631	June 14	17:21	A 0		90	5		5		filled blocky lava
r-119	5750623	681525	June 14	17:16	P H		85	10		5		porous blocky lava
r-120	5750678	681400	June 14	17:08	A 0	25	50	15		10		porous blocky lava
r-121	5750669	681351	June 14	17:05	A 0		55	30		15		unknown
r-122	5750629	681236	June 14	17:00	P L		75	15		10		unknown
r-123	5750690	681102	June 14	16:54	A 0	5	50	30		15		unknown, rocks visible
r-124	5750675	681004	June 14	16:50	A 0		70	20		10		unknown
r-125	5750658	680938	June 14	16:41	P L		85	5		10		porous blocky lava
r-126	5750653	680863	June 14	16:34	A 0		90			10		unknown
r-127	5750641	680710	June 14	16:28	A 0		55	40		5		unknown

r-128	5750665	680636	June 14	16:23	A 0			85	10		5	porous blocky lava
r-129	5750652	680543	June 14	16:17	P M			75	20		5	porous blocky lava
r-130	5750637	680424	June 14	16:07	P M			45	45	5	5	porous blocky lava
r-131	5750676	680323	June 14	16:01	P L			85	10		5	porous blocky lava
r-132	5750643	680209	June 14	15:54	P L			60	25		15	porous blocky lava
r-133	5750661	680129	June 14	15:46	A 0			50	10	30	10	porous blocky lava
r-134	5750613	680059	June 14	15:40	P L			80	10		10	porous blocky lava
r-135	5750626	679975	June 14	15:34	A 0			70	5	20	5	unknown
r-136	5750642	679825	June 14	15:29	A 0			35	30	30	5	unknown
r-137	5750674	679695	June 14	15:22	A 0			70	15	5	10	filled blocky lava
r-138	5750673	679668	June 14	14:12	A 0			70	10	20		unknown
r-139	5750625	679415	June 14	14:22	A 0		20	70	5		5	basalt
r-141	5750792	681839	June 17	11:37	A 0			30	10	50	10	unknown
r-142	5750705	681702	June 21	17:43	A 0			50	45		5	filled lava
r-143	5750742	681605	July 2	11:33	A 0			30	60		10	filled blocky lava
r-144	5750766	681505	July 2	11:38	A 0			30	40	10	20	fine cinder with scattered rocks
r-145	5750733	681452	July 2	11:41	A 0			30	60	5	5	fine cinder with scattered rocks
r-146	5750706	681347	June 14	11:45	A 0		5	85	5		5	fine cinder
r-147	5750718	681223	June 14	11:50	A 0		5	35	50	5	5	fine cinder with scattered rocks
r-148	5750749	681145	June 14	11:55	A 0			40	40		20	fine cinder
r-149	5750732	681081	June 14	11:58	A 0		5	5	60	30		fine cinder
r-150	5750742	680951	July 2	11:57	A 0			50	25	5	20	fine cinder
r-151	5750729	680874	July 2	12:02	A 0			65	5	25	5	filled blocky lava
r-152	5750711	680739	July 2	12:15	A 0			90	5		5	cinder
r-153	5750746	680638	July 2	12:20	P M			90	5		5	blocky lava
r-154	5750746	680557	July 2	12:41	P L			90	5		5	blocky lava
r-155	5750766	680448	July 2	12:49	A 0			55	15	25	5	filled blocky lava
r-156	5750760	680305	July 2	12:55	A 0			95			5	filled blocky lava
r-157	5750729	680290	July 2		A 0			90	5		5	cinder
r-158	5750751	680157	June 14	13:44	A 0			95			5	unknown
r-159	5750760	680014	June 14	13:49	A 0			10	5	80	5	unknown
r-160	5750736	679938	June 14	13:58	A 0			30	30	30	5	5 unknown
r-161	5750720	679823	June 14	14:00	A 0			30	30	35	5	unknown
r-162	5750745	679797	June 14	14:04	A 0			20	10	60	10	unknown
r-164	5750851	681803	June 17	11:30	A 0			50	30		20	unknown
r-165	5750892	681790	June 17	11:24	A 0		5	55	30		10	filled blocky lava
r-166	5750891	681625	June 14	11:27	A 0		5		70	20	10	gravel-like cinder
r-167	5750880	681544	June 14	11:37	A 0		10	10	70		10	gravel-like cinder
r-169	5750852	681313	July 4	11:01	A 0		5	5	85		5	fine cinder with scattered rocks
r-170	5750863	681250	July 4	11:03	A 0		45		50		5	fine cinder with scattered rocks
r-171	5750858	681137	July 4	11:08	A 0		45	5	45		5	fine cinder with scattered rocks
r-172	5750834	681005	June 23	16:39	A 0		20	5	70		5	mixed rocks and cinder
r-173	5750889	680983	June 23	16:36	A 0		40	5	50		5	fine cinder with scattered rocks
r-174	5750874	680829	June 14	12:07	A 0		5	25	65		5	fine cinder with scattered rocks

r-175	5750808	680794	June 23	16:27	P M		95			5	blocky lava
r-176	5750857	680631	June 23	16:10	P H		95			5	blocky lava
r-177	5750840	680559	June 23	16:02	P M		95			5	blocky lava
r-178	5750801	680457	June 23	15:55	P L		85	10		5	blocky lava
r-179	5750882	680301	June 14	13:10	P M		30	50	15	5	porous blocky lava
r-180	5750801	680223	June 14	13:15	P M		10	40	40	10	porous blocky lava
r-181	5750897	680179	June 23	15:31	P M		90	5		5	blocky lava
r-182	5750867	680036	June 23	15:25	A 0		50	20	25	5	fine substrate
r-183	5750822	679964	June 23	15:15	P L		10	25	60	5	blocky lava
r-184	5750895	679818	June 23	14:59	A 0		5	10	80	5	filled blocky lava
r-185	5750895	679815	June 23	14:55	A 0		40	10	40	5	5 filled blocky lava
r-189	5750968	681798	June 17	11:20	A		30	50		20	unknown
r-190	5750902	681646	June 14	11:25	A 0		15	65	5	15	fine, scattered fist-sized cinders
r-195	5750903	681121	July 4	11:12	A 0	75	5	15		5	cinder
r-196	5750946	681041	July 4	11:18	A 0	75	5	15		5	cinder
r-197	5750926	680984	July 2	16:31	A 0	5		90		5	cinder
r-198	5750941	680807	July 2	16:25	P L			80		20	partly filled blocky lava
r-199	5750933	680712	June 14	12:17	P M		95			5	porous blocky lava
r-200	5750943	680601	June 14	12:30	P H		90			10	porous blocky lava
r-201	5750972	680502	June 14	12:42	P M		95			5	porous blocky lava
r-202	5750993	680443	June 14	12:51	P M		85	10		5	porous blocky lava
r-203	5750950	680393	June 14	12:50	P M		20	20	40	20	porous blocky lava
r-204	5750945	680298	June 14	13:05	P L		70	20	5	5	porous blocky lava
r-205	5750969	680194	July 2	12:55	P M		35	20	40	5	blocky lava
r-206	5750991	680090	July 2	13:00	A 0		55	5	35	5	filled blocky lava
r-207	5750984	679986	July 2	13:55	P M		35	20	40	5	blocky lava
r-210	5751053	681920	June 14	11:11	A 0	1	50	40		9	filled blocky lava
r-211	5751048	681803	June 14	11:19	A 0		40	25		35	fine cinder
r-217	5751039	681255	July 4	11:20	A 0	100					fine cinder
r-218	5751077	681106	July 4	11:20	A 0	100					fine cinder
r-220	5751048	680921	July 2	16:10	A 0	95		5			fine black cinder
r-221	5751083	680824	July 2	16:08	P M		90	5		5	blocky lava
r-222	5751017	680719	July 2	15:59	P M		90	10			blocky lava
r-223	5751053	680646	July 2	15:54	P L		90	5		5	partly filled blocky lava
r-224	5751071	680583	July 2	15:48	P L		90	5		5	partly filled blocky lava
r-225	5751008	680471	June 14	12:47	P L		90	5		5	porous blocky lava
r-226	5751000	680372	July 2	15:32	P L		90	5		5	partly filled blocky lava
r-227	5751038	680285	July 2	15:25	P L		45	5	45	5	partly filled blocky lava
r-228	5751076	680108	July 2	15:15	P L		5	5	85	5	blocky lava
r-229	5751023	680031	July 2	15:09	P L		10	5	80	5	blocky lava
r-230	5751162	682058	June 14	11:05	A 0		65	20		15	fine cinder
r-231	5751160	681908	June 14	11:09	A 0	5	40	50		5	filled blocky lava
r-232	5751157	681846	June 14	11:15	A 0	15	20	60		5	filled blocky lava
r-241	5751196	681018	July 4	11:20	A 0	100					fine cinder

r-242	5751189	681002	July 4	11:20	A 0	100					fine cinder
r-243	5751101	680988	July 4	11:39	A 0	100					fine cinder
r-244	5751189	680881	July 4	11:46	P L		95			5	blocky lava
r-245	5751134	680761	July 4	11:56	P H		90	5		5	blocky lava
r-246	5751128	680680	July 4	12:02	P H		90	5		5	blocky lava
r-247	5751199	680533	July 4	12:19	P L		60	30		10	blocky lava
r-248	5751145	680493	July 4	12:28	P L		75	20		5	partly filled blocky lava
r-249	5751103	680410	July 4	12:38	P L		25	70		5	partly filled blocky lava
r-250	5751129	680350	July 4	12:41	A 0		75	5	5	15	cinder?
r-251	5751191	680233	July 4	12:48	A 0		85	10		5	filled blocky lava
r-252	5751172	680194	July 4	12:52	P L		85	5	5	5	partly filled blocky lava
r-253	5751188	680039	July 4	13:03	A 0		45	5	45	5	filled blocky lava
r-254	5751127	679992	July 4	13:37	P M		10	10	75	5	blocky lava
r-259	5751290	680968	July 4	15:28	A 0	100					cinder
r-260	5751296	680833	July 4	15:10	P L		45	50		5	blocky lava
r-261	5751283	680760	July 4	15:04	P M		80	10		10	blocky lava
r-262	5751203	680666	July 4	14:56	P M		65	30		5	blocky lava
r-263	5751268	680629	July 4	14:47	A 0		10	80		10	cinder
r-264	5751226	680522	July 4	14:41	A 0		55	30		15	cinder
r-265	5751242	680444	July 4	14:38	A 0		50	30		20	cinder
r-266	5751268	680320	July 4	14:32	P L		90	5		5	blocky lava
r-270	5751380	680770	July 12	12:06	A 0	100					cinder
r-271	5751366	680498	July 12	12:47	A 0	25	30	40		5	cinder
r-272	5751392	680441	July 12	12:52	A 0	20	20	55		5	cinder
r-273	5751386	680362	July 12	13:20	A 0		30	65		5	filled blocky lava
r-274	5751341	680330	July 12	13:30	A 0		80	15		5	filled blocky lava
r-275	5751327	680203	July 4	14:27	A 0		75	15	5	5	filled blocky lava
r-276	5751314	680181	July 4	14:25	A 0		90	5		5	cinders?
r-277	5751403	680934	July 12	11:58	A 0	10		85		5	cinder
r-278	5751427	680599	July 12	12:43	A 0	100					cinder
r-279	5751455	680493	July 12	12:45	A 0	20	20	30		30	cinder
r-280	5751507	680424	July 12	12:55	A 0		40	50		10	
r-281	5751468	680354	July 12	12:58	A 0		40	55		5	filled blocky lava
x-001	5750192	681763	June 17	12:14	A 0		70	20		10	blocky lava
x-002	5750180	681677	June 17	12:20	P M		90			10	blocky lava
x-003	5750362	679695	June 21	14:50	A 0		90		5	5	filled blocky lava
x-004	5750464	679692	June 21	14:55	A 0		65		25	10	filled blocky lava
x-113	5750606	679873	June 23	14:33	A 0		25	30	40	5	filled blocky lava
x-114a	5750540	679591	July 12	14:58	A 0		95	5		5	filled blocky lava
x-114b	5750547	679487	July 12	14:53	A 0		65	10	30	5	filled blocky lava
x-138a	5750680	679561	July 12	14:42	A 0		65	5	25	5	filled blocky lava
x-138b	5750687	679461	July 12	14:47	A 0		55	10	30	5	blocky lava
x-162a	5750804	679707	July 12	14:29	A 0		65	5	25	5	filled blocky lava
x-162b	5750805	679607	July 12	14:33	A 0		45	5	45	5	filled blocky lava

x-162c	5750812	679509	July 12	14:33	A 0		40	5	50	5	filled blocky lava
x-184a	5750901	679715	July 12	14:26	A 0		20		75	5	blocky lava
x-184b	5750905	679616	July 12	14:21	A 0		90	5		5	blocky lava
x-184c	5750908	679516	July 12	14:10	A 0		90	5		5	blocky lava
x-184d	5750917	679416	July 12	14:00	A 0		65	10		25	blocky lava
x-19	5751293	680144	July 4	14:17	P L		90	5		5	partly filled blocky lava
x-20	5751303	679864	July 4	14:00	A 0		15	20	60	5	fine cinder
x-207a	5751007	679889	July 3	14:00	P L		10	10	80		blocky lava
x-207b	5751016	679786	July 4	14:10	A 0		65	30		5	filled blocky lava
x-207c	5751017	679690	July 5	14:19	A 0		30	5	60	5	filled blocky lava
x-207d	5751012	679591	July 6	14:28	A 0		80	15		5	filled blocky lava
x-229a	5751106	679899	July 2	14:58	P L		10	5	80	5	partly filled blocky lava
x-229b	5751110	679796	July 2	14:51	P L		5	5	85	5	partly filled blocky lava
x-229c	5751110	679694	July 2	14:45	A 0		5	5	85	5	filled blocky lava
x-229d	5751107	679595	July 2	14:37	A 0		95			5	fine cinder
x-253a	5751197	679935	July 4	13:42	P L		55	20	20	5	blocky lava
x-253b	5751200	679835	July 4	13:47	A 0		75	10		15	filled blocky lava
x-253c	5751203	679735	July 4	13:50	A 0		20	5	70	5	cinder?
x-270a	5751522	680701	July 12	12:12	A 0	100					cinders
x-273a	5751392	680266	July 12	13:35	A 0		5	5	85	5	blocky lava
x-273b	5751402	680164	July 12	13:40	P L		35	60		5	blocky lava
x-276a	5751293	680044	July 4	14:10	P L		10	10	75	5	blocky lava
x-278a	5751527	680603	July 12	12:34	A 0	100					cinders
x-278b	5751625	680605	July 12	12:34	A 0	75	10	5		10	cinders
x-278c	5751620	680705	July 12	12:34	A 0	100					cinders
f-012	5750531	681212	June 10		P M		95	2		3	blocky lava
f-023	5750650	681006	June 10	16:24	A 0		90	10			cinders
f-024	5750676	681043	June 10	16:29	A 0	5	80	10		5	cinders
f-025	5750652	681199	June 10	16:33	A 0		65	30		5	cinders
f-032	5750804	680511	June 10	16:16	A 0		95	4		1	cinders
f-036	5750755	680865	June 10		A 0		95	4		1	
f-038	5750802	681077	June 10	13:37	A 0						small cinders
f-039	5750752	681235	June 10	13:20	A 0						small cinders
f-040	5750736	681236	June 10	13:10	A 0						small cinders
f-041	5750717	681339	June 10	13:05	A 0						small cinders
f-054	5750901	680974	June 10	13:42	A 0	5		95			cinders
f-071	5750943	680812	June 10	16:07	A 0		60	35		5	cinders
f-072	5750980	680878	June 10	13:46	A 0		95	5			
f-078	5750989	681523	June 10	13:01	A 0						small cinders
f-091	5751057	680846	June 10	13:53	P L		95			5	blocky lava
f-098	5751094	681536	June 10	12:53	A 0						small cinders
f-099	5751039	681661	June 10	12:51	A 0						small cinders
f-100	5751023	681767	June 10	12:46	A 0						small cinders
f-101	5751016	681910	June 10	12:39	A 0						

f-102	5751099	681964	June 10	12:33	A 0						
f-110	5751162	680774	June 10		P M		95	5			blocky lava
f-111	5751127	680875	June 10	14:02	P M		95			5	blocky lava
f-130	5751256	680695	June 10		A 0		70	30			cinders
f-132	5751224	680930	June 10		A 0	90		10			cinders
f-133	5751290	680965	June 10		A 0	100					cinders
f-150	5751409	680579	June 10	15:20	A 0						cinders
f-151	5751388	680638	June 10		A 0	100					cinders
f-153	5751349	680848	June 10	14:39	P M	2	8	90			blocky lava
f-154	5750857	680943	June 10		A 0	100					cinders
f-172	5751424	680607	June 10		A 0	100					cinders

Appendix 2 Annotated list of birds seen on Semisopochnoi Island, June 8 – July 27, 2004 (breeding species in bold face)

Red-throated Loon *Gavia stellata* Two birds regularly seen and heard in Swell Bay near camp.

Fork-tailed Storm Petrel *Oceanodroma furcata* Birds heard calling at night on June 29 from crevices in cliffs on the inside of the Caldera at 400m asl near Three-quarter Cone (51º 57′N 179º 34′E) and on July 15 near Cerberus lava 150 m asl above Southwest Knob (51°54' N 179° 33′E). This suggests a breeding population may have survived foxes by using remote inaccessible interior cliffs. Flying birds were occasionally heard calling over our camp at night. A species likely to be rapidly recovering from the removal of foxes.

Leach's Storm Petrel *Oceanodroma leucorhoa* Birds heard flight calling at night on July 15 near Cerberus lava 150 m asl above Southwest Knob. Flying birds were occasionally heard calling over our camp at night. A species likely to be rapidly recovering from the removal of foxes.

Pelagic Cormorant *Phalacrocorax pelagicus* Common, breeds locally.

Red-faced Cormorant *Phalacrocorax urile* Common, breeds locally.

Canada Goose *Branta canadensis* Flocks flying by auklet colony regularly in June, with numerous droppings found near the auklet colony site in June. No birds were seen inland or after late June.

Mallard *Anas platyrhynchos* At least 20 birds on the Fenner River and associated wetlands on June 13, one female had a brood of six ducklings. One brood was observed July 14 on the ponds near Tuman Cove.

Green-winged Teal *Anas crecca* Common along the Fenner River and in associated wetlands. A female with a single small duckling was observed on a pond near Fenner Lake July 10.

Greater Scaup *Aythia marila* Nineteen at Triangle Pond on the Fenner River June 13, with courtship behaviour observed. One brood and six adults were present on the ponds near Tuman Cove July 14.

Common Eider *Somateria mollissima* Lone males seen a couple of times flying by Sirius Point.

Harlequin Duck *Histronicus histronicus* Uncommon near shore between camp and Nuclear Cove.

Common Merganser *Mergus mergansor* Uncommon near the mouth of the Fenner River at Swell Bay.

Semipalmated Plover *Charadrius semipalmatus* One at Sugar beach July 5.

Rock Sandpiper *Calidris ptilocnemis* Uncommon breeder in subalpine meadows and vegetated alpine areas, mostly between 100 and 400 m asl. A nest with four eggs was found at 200 m asl on the north slope of Sugarloaf Peak on May 16 (photographed). Perhaps 1000 pairs breed on the island.

Common Sandpiper *Actitis hypoleucos* One near camp June 11-13.

Terek Sandpiper *Xenus cinereus*. One on Sugar Beach near our camp June 10.

Glaucous-winged Gull *Larus glaucescens* Common breeder, especially at auklet colony where perhaps 150-200 pairs nest. Nests found throughout auklet colony, southern slopes of Sugarloaf volcano, and near camp. Birds seen near Fenner Lake may have been nesting locally. Presumably these birds have recolonized Semisopochnoi following the removal of foxes.

Pigeon Guillemot *Cepphus columba* Uncommon near rocky headlands on the south side of the island.

Ancient Murrelet *Synthliboramphus antiquus* One sighting: three birds were seen together July 22 off Sugar Beach. This bird was not heard at night anywhere we camped, but is a species likely to begin recovering from the removal of foxes.

Parakeet Auklet *Cyclorhynchus psittacula* Uncommon breeder on low cliffs adjacent to the Least and Crested Auklet colony near Sugarloaf Knob, Sugarloaf Head and Nuclear Cove.

Crested Auklet *Aethia cristatella* Abundant breeder.

Least Auklet *Aethia pusilla* Abundant breeder.

Horned Puffin *Fratercula corniculata* Uncommon along cliff-tops where lava flows from Sugarloaf Volcano reach the ocean. A species likely to be rapidly recovering from the removal of foxes.

Tufted Puffin *Fratercula cirrhata* Uncommon along grassy cliff-tops where lava flows from Sugarloaf Volcano reach the ocean. Also present on sea cliffs associated with Raggedtop Peak. A species likely to be rapidly recovering from the removal of foxes.

Bald Eagle *Haliaeetus leucocephalus* Remarkably rare on Semisopochnoi. Four sightings only: single adults were observed once each at Fenner Lake (June 12), twice in the auklet colony (June), and at Saltypepper Beach (July 10) and one immature near auklet colony June 10.

Peregrine Falcon *Falco peregrinus* Remarkably common breeder. Territorial pairs were observed at nine locations.

Northern Raven *Corvus corax* Up to four birds seen regularly together at auklet colony and near camp.

(Rock Ptarmigan *Lagopus mutus* Absent. No evidence of this species was detected anywhere on Semisopochnoi Island.)

Winter Wren *Troglodytes troglodytes* Uncommon along shoreline, in dense vegetation at auklet colony and along the Fenner River.

Yellow Wagtail *Motacilla flava* One at camp June 13.

Gray-spotted Flycatcher *Muscicapa griseisticta* One near the mouth of the Fenner River June 8-10.

Siberian Rubythroat *Luscinia calliope* One male (singing) near camp June 8-10.

Lapland Longspur *Calcarius lapponicus* Common to abundant in meadows. Four nests found on one colony survey hike June .

Snow Bunting *Plectrophenax nivalis* Common to abundant in stony habitat on mountains and lava flows, mostly above 200 m asl. Likely the most abundant passerine on Semisopochnoi.

Aleutian Song Sparrow *Melanospiza melodia* Common in well-vegetated areas along shorelines, in the auklet colony up to 300 m asl, along the Fenner River and shorelines of Fenner Lake, and in sheltered canyons associated with lava flows in the island's interior.

Gray-crowned Rosy Finch *Leucosticte arctoa* Uncommon nearly everywhere on island.