

BREEDING BIOLOGY OF THE RHINOCEROS AUKLET ON PROTECTION ISLAND, WASHINGTON

By FRANK RICHARDSON

It is not surprising that little information can be found in the literature on the breeding cycle of the Rhinoceros Auklet (*Cerorhinca monocerata*), for this species is entirely nocturnal on its breeding islands, the young birds or incubating adults staying far within their generally deep and tortuous burrows in the daytime. This auklet, with the puffins, is structurally one of the most fossorial of the alcids (see Storer, 1945) and it is as strictly nocturnal in breeding habits as the Marbled Murrelet (*Brachyramphus marmoratum*) and Cassin Auklet (*Ptychoramphus aleutica*).

Rhinoceros Auklets have an extensive breeding range (see A.O.U. Check-list, 1957) on widely scattered islands along both shores of the North Pacific, but their southernmost breeding islands in North America, and apparently the only ones in the United States other than Alaska, are Destruction and Protection islands off the Olympic Peninsula in Washington. They once (before 1865) bred as far south as the Farallon Islands off San Francisco (Grinnell and Miller, 1944) and they have bred on Smith and Whidbey islands near Puget Sound in Washington. It was from Whidbey Island that the species and its egg were originally described, but Suckley (1859) referred to Protection Island as "a favorite breeding ground of the species where they breed in holes dug in the steep banks."

METHODS

Eighteen trips of from one to four days each were made to Protection Island in the course of four breeding seasons from 1956 to 1959. Breeding activities of auklets were observed on several parts of the island but a restricted area was chosen for more detailed study and 76 burrows were marked with posts and metal tags.

Because of the impossibility of observing much auklet activity at night—except with field glasses in moonlight—an important technique was to smooth the dirt around and in burrows and study the usually clear and numerous tracks of the auklets the next morning (fig. 4). Lights of any color frightened auklets away at night. Infrared lighting was not attempted. Flash pictures with a stroboscopic light were fairly successful.

Some 71 auklets were trapped or banded. A mousetrap fitted to a number 10 can, with loose netting at the inner end, proved most successful. Traps placed inside burrow entrances were set off by the entering auklets pushing a metal tubing roller over the end of a trigger wire. A wooden catch operated by a rubberband held the trap door shut.

Some burrows were completely opened, thus precluding future study. To allow monthly observations eight burrows were entered from behind the nest cavity and the excavations then covered. Temperatures of auklets were taken cloacally with a portable potentiometer, which instrument was also used in obtaining temperatures of burrows. A blind set up at the top of the study area was helpful in making night pictures and observations.

ACKNOWLEDGMENTS

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SURVEY OF PROTECTION ISLAND

Protection Island is at the eastern end of the Strait of Juan de Fuca and is about 85 miles from the open ocean. It lies at the mouth of Discovery Bay, two miles from the mainland and at 48° 08' N latitude and 122° 55' W longitude. The island has an area of 394 acres composed, according to Einarsen (1945), of the following land types: tillable fields, 120 acres; dense mixed coniferous woods, 82 acres; sea level sandspits, 48 acres; barren sand dunes or gravel, 44 acres; and turfed grass or pasture lands, 100 acres. The pasture land extends up the steep south and east slopes onto a plateau about 100 to 220 feet high which constitutes approximately four-fifths of the island. Roughly 30 to 35 acres of so-called pasture land that lies on steep slopes and extends back on the plateau rarely farther than 50 yards is used in varying degrees of intensity by the auklets for their burrows (fig. 1).

The coniferous woods with their associated thickets, form the chief areas of native vegetation remaining on the island. The dominant plant of the pasture land along the top of the bluff is the large perennial beach grass *Ammophila arenaria*, little grazed by domestic animals and providing much protection for auklets and their burrows. The steep slopes where over half of the auklet population breeds are largely covered with annual grasses (*Bromus rigidus* primarily, but also other *Bromus* and *Aspris* grasses). Mustard (*Brassica nigra*) is fairly common on the slopes as are also *Lepidium densiflorum*, and the gumplant (*Grindelia integrifolia*). Alfalfa plants (*Medicago sativa*) were scattered over the slopes in 1956 but are now mostly eaten down and killed by sheep. Much of Protection Island has been burned over at least twice in recent decades. Possibly this has been to the advantage of the auklets if it did not occur during their breeding season, for a dense mat of dead vegetation may form on the slopes making less ground accessible for burrowing.

Protection Island is in the rain shadow of the Olympic Mountains and, judging from data from nearby Sequim on the peninsula, averages about 16 inches of rain per year. The covering of low annual plants on slopes favored by auklets and the fairly barren spots chosen for most of their digging are attributable to the low rainfall. The slopes become very dry and brown by July.

Various land birds and a few species of sea birds breed on Protection Island but few have significant ecologic relationships with the auklets. Glaucous-winged Gulls (*Larus glaucescens*) breed chiefly on the low eastern point of the island but they are also found in fair numbers on parts of the bluffs used by auklets. Pigeon Guillemots (*Cepphus columba*) nest under rocks or logs on the beaches close below some auklets, and they occasionally nest in the cliffs. Tufted Puffins (*Lunda cirrhata*) nest on some of the same steep slopes used by auklets but select the cliff-like sections not used by the auklets for their burrows. Only the gulls may compete with the auklets for breeding space and this competition seems unimportant because of the burrowing and nocturnal habits of the auklets. The auklets hurtle close by or run around the gulls that are standing on the bluff or incubating, but apparently neither species is bothered by the other. The only instance of competition with a land bird was the taking over and enlarging of a hole of a Violet-green Swallow (*Tachycineta thalassina*) by the auklets.

The only native mammals on the island appear to be the Townsend chipmunk (*Eutamias townsendii*) and a shrew (*Sorex* sp.). Neither rats nor cats have become

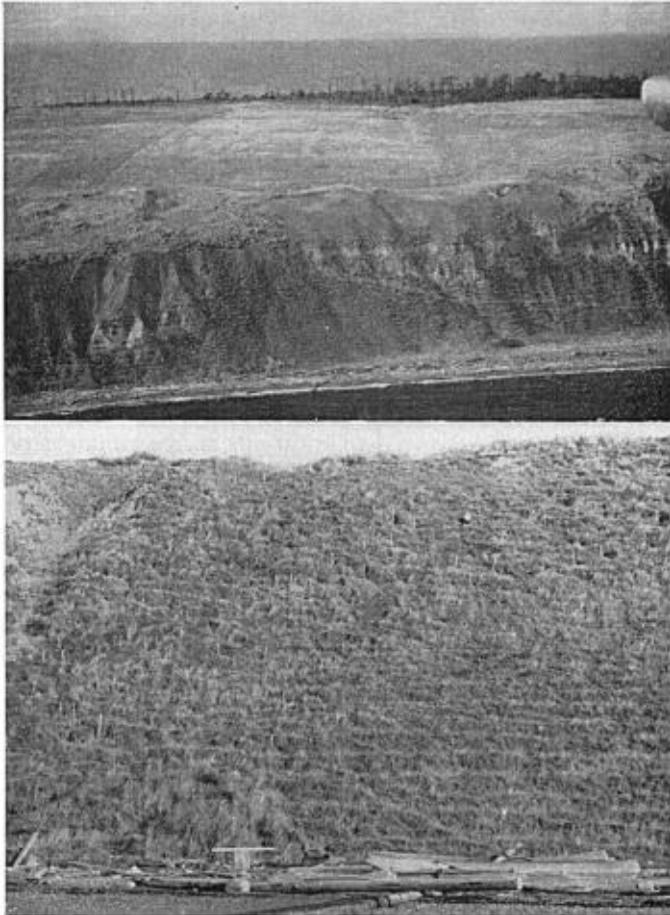


Fig. 1. Above: Oblique aerial view of center of Protection Island from the south. The study area was on the uniform steep slope in the left center foreground of the picture and in the clumps of beach grass on the dunes above. Tufted Puffins nested in some of the light-colored cliff areas. Photograph by William Calder.

Fig. 2. Below: Chief part of study area from beach. The person seated on the slope at the upper right gives an idea of the scale. Auklet burrows show up as dark spots with some of them marked by stakes. Sheep trails appear as numerous rough contour lines. Photograph by Karl Kenyon.

established but domestic ungulates have periodically been present. Since early in 1958 some 100 to 300 sheep have grazed freely over the island and are seriously affecting the breeding slopes of the auklets. Grazing, chiefly of annual grasses and what alfalfa is left, followed by frequent trampling of certain parts of the slopes as they become dry in early summer, has led to the formation of many slide areas of loose sand and soil. Auklet burrows have thus been buried in some regions and the slopes made unusable, or auklets in less severely affected areas must persistently dig out partly filled-in burrows. The seriousness of the situation is indicated by the fact that of the 76 marked burrows in the

study area, approximately 35, or 46 per cent, were buried by slides during the summers of 1958 and 1959. It was not possible to measure the mortality or re-nesting involved.

Sheep caved in some auklet burrows, chiefly on more level areas above the slopes. Fortunately, sheep did not graze on *Ammophila* and the many auklets nesting in this grass were not molested. After the four breeding seasons of this study, the auklet population did not seem noticeably depleted by the presence of sheep, and the auklets did not seem inclined to desert their ancestral breeding grounds. However, conditions on some slopes have become progressively worse. Increasing the number of sheep, dry years with lack of revegetation of slopes, or runoff from heavy rains, could destroy much of the best breeding areas of the auklets.

LOCATION OF AUKLET BURROWS

The auklet population on Protection Island is chiefly on or just above the steep earth slopes that extend for about 1.2 miles along the south side of the island. Burrows are scattered in the deep grass and along small hillocks as far as 75 yards back from the bluff (fig. 1). On the closely-cropped, gentle slopes at the high, west end of the island auklets breed in moderate numbers from 100 to 200 yards back from the bluffs.

Slopes under 35° were seldom used for burrows; the chief slopes used were 37° to 45°. Burrows were often located along the bases of small vertical banks but with suitable landing and takeoff slopes below them. For the nests on nearly level ground above the top of the main bluff, the auklets made use of adjacent steep slopes when taking to the wing.

Auklets usually drop a good many feet in taking off and burrows were accordingly usually 30 or more feet above the level of the beach or low-lying spits even where suitable slopes extended all the way to the bottom. However, in the study area scattered burrows were as low as six feet above and 12 feet back from the mass of logs and other flotsam marking the limit of highest water. Auklets liberated at these lowest burrows scrambled through the flotsam to take off from the water. Auklets with burrows above the spits did not nest this low down. There are fewer burrows on the southeast slope, and auklets apparently return to them later in the year. This may occur because much of this slope is above a wide spit and not directly over water.

Soil conditions and vegetation are important in determining the auklet population and its distribution on Protection Island. Although auklets are powerful diggers, soil can neither be too loose and sandy nor too hard or rocky. A rather firm, sandy soil with some roots holding it together near the surface is favored. When burrows are being started or enlarged in late winter and early spring, the ground is usually moist and easier to dig than later when it becomes dry. The problem of dry, sliding earth and sand is rarely present early in the year. Steep breeding slopes, or burrowing at the base of a small bank in a flatter area, make it possible for burrows to be dug almost horizontally and for dirt to be readily pushed out.

Early in the breeding season burrows are typically quite exposed with little vegetation around them and that mostly dead. Annual plants, chiefly *Bromus* grass, grow thickly around the burrow entrances during the spring, often partly or largely obscuring the openings. Auklets do not remove this vegetation although it may be partly buried by further removal of dirt from burrows. Most of the vegetation dies down or is grazed off during the late spring and early summer, and burrows again become exposed.

In contrast to the exposed burrows on slopes are the several hundred burrows in the *Ammophila* above the bluffs (fig. 3). Auklets make runways in this dense, high (2 to 3 feet) grass, the runways usually leading from open takeoff and landing areas on top of the bluffs.

The study area was a strip from beach to bluff-top near the center of the south side of the island (fig. 2). The area measured approximately 208 feet long and 58 to 87 feet wide, the shortest measurement being the width at the top. Seventy burrows were marked in the area. On July 13, 1957, 62 additional burrows were found in active use in the area



Fig. 3. Auklet burrow entrance in dense beach grass above bluff. Tunnels sometimes proceeded many feet in the grass before entering the subterranean burrow.

making a total of about 132 pairs of auklets in 14,040 square feet, or approximately in one-third of an acre. Heath (1915) records a much greater nesting density of up to 400 burrows in 600 square feet in dense spruce forest with little undergrowth, on Forrester Island, Alaska. Much of my study area had a maximum density of burrows, their entrances being one to three feet apart but irregularly scattered. Other parts of the area, such as the lowest part or the slightly more gently sloping (30° to 35°) central eastern part, had very few burrows. Judging from the concentration of auklets in the study area and observation of the other breeding areas, I estimated there were between 3000 and 4000 breeding pairs of auklets on the island. In addition there are indications that many nonbreeding birds are present. Thus, on Protection Island the total auklet population, including the young-of-the-year, may be well over 10,000 birds in July and early August.

NESTING

Return of adults.—The breeding grounds on Protection Island are deserted during the fall and most of the winter but by early March some auklets return and begin exca-



Fig. 4. Above: Entrance to a typical burrow on a steep slope. Note the tracks of two auklets that have left the burrow in the night. Dead *Bromus* grass is at the sides of the burrow. Photograph by Karl Kenyon.

Fig. 5. Below: Burrow entrance showing upper notch area excavated with bill. The burrow is seven inches high. Note claw scratches on surrounding hard earth. Photograph by Karl Kenyon.

vations. On March 2, 1958, the earliest visit made to the island, relatively few birds had returned and only 13 of 63 old burrows were being visited or re-excavated. On March 29, 60 of the 63 burrows were being entered. The many new burrows that were being started in late March indicated this was the time of the beginning of breeding activity for most of the auklets. Trips were not frequent enough to compare the yearly arrival time of auklets, but the comparable degree of activity of auklets in late March of three years suggests that the time does not vary greatly. Dawson and Bowles (1909) and Bent (1919) give, I think mistakenly, much later arrival dates (such as late April for De-

struction Island). Koslova (1957), however, records the return of Rhinoceros Auklets to Monyeron Island (46°N latitude, north of Hokkaido, Japan) during late March and early April.

Digging of burrows.—Digging is at its height from late March through April but it continues through July. Digging after early May cannot indicate successful nesting, for time then becomes too short for completion of the cycle. Late digging is generally for the enlargement of burrows or clearing of caved in or filled in entrances. Nevertheless, some new burrows are started, but not finished, even through July, suggesting digging as a displacement activity possibly of unmated individuals.

The auklets are very strong diggers, using both the sharply clawed, powerful feet, and the powerful bill. Initial excavations typically show a channel dug by each foot and an upper notch dug by the bill (fig. 5). Observations of digging and listening to birds digging indicate that the feet are strongly kicked backward to remove dirt from burrows. The horn on the bill is neither sharp nor stiff enough to serve in digging but it becomes partly worn down from digging with the bill.

The rate of digging, although varying with season, soil, and other factors, is somewhat predictable. Of 10 burrows started or worked on the night of March 25, 1957, and measured before and after the next night, the average increase in length was 7.6 inches (maximum 13 inches and minimum 2 inches). Two barely started burrows in the same area were not returned to this night, but observations indicate that most auklets work nightly to complete a burrow once it is started. The visits to the island were not long enough to judge accurately the time needed to complete a burrow, but I estimate that one to two weeks suffice to excavate a burrow of the usual length of six to eight feet. No visible differences between the two sexes of Rhinoceros Auklets were noted, but the worn condition of the bills and horns of most birds trapped or dug out indicates that both sexes take part in excavation of burrows.

Nature of the burrows.—Auklet burrows have been described and illustrated by Heath (1915) and Young (1929). Heath recorded burrows on Forrester Island of from eight feet to 20 feet in length, and Young states that burrows on Pine Island in Queen Charlotte Sound were six to 25 feet long but averaged 10 to 15 feet in length. On Protection Island burrows were generally shorter, perhaps because of deep compact soil, with extremes of four to 15 feet and an average of from six to eight feet in length. Some burrows did not have the blind side passage described as usually present, but the nest cavity or wide parts of the burrow would still allow mates to pass.

Occasional young Glaucous-winged Gulls seeking refuge in burrow entrances were the only other vertebrates found in auklet burrows. The most common invertebrate found, abundant even in the innermost ends of many burrows, was the camel-cricket (*Ceuthophilus agassizii*). Other invertebrates found a number of times in burrows were earwigs (*Forficula* sp.), carrion beetles (*Nicrophorus* sp.), carabid beetles, ants, spiders, and isopods (sow bugs). Generally these occurrences seemed incidental but the crickets and sow bugs appeared to live regularly in the auklet burrows.

Retention of burrows; pair bonds.—The same burrows may be used year after year or new ones may be dug nearby. Of 76 burrows in use in 1957, at least 57 were used in 1958 and 32 in 1959. Much of this reduction in use was due to burrows being caved in or buried by sheep. Banding returns of six birds showed that three returned to the same burrow a year later. Two of the six birds returned a year later, and one two years later, to adjacent burrows, the original burrows having been caved in or buried. One bird occupied three different burrows in three years; the third burrow was adjacent to the first. Other returns showed that one auklet moved from a disturbed burrow to a new one some 50 feet away and was still there the third year.

Banding returns, although few, indicated that auklets maintain the same pairs year after year. Direct evidence of pair formation early in the breeding season and indirect evidence of both members working on the burrows was afforded by observations of birds arriving at or leaving the breeding grounds. For instance, between 4:45 and 5:10 a.m., March 27, 1957, 75 auklets were counted leaving the study area and of these 68 were paired, each pair flying away close together. On this same date one auklet was seen to leave a burrow in which its mate remained.

Nest and egg.—The nest chamber, although variable, is typically an enlarged cavity at the end of the burrow. It has been described as seven to eight inches high and a foot or more across by Dawson and Bowles (1909). The last few feet of the burrow tend to slope down toward the chamber and there is often a drop-off of an inch or two from the end of the burrow into the chamber.

The nest varies from a depression in the dirt with or without a little dry grass (Young, 1929) to a shallow accumulation of available plant material such as spruce twigs, salmonberry branchlets, moss, or fern (Heath, 1915). On Protection Island only dry or green grass was found to make up nests. During the nestling period, dry grass was often added to the nest or was found in the burrows.

The single egg of the Rhinoceros Auklet has been described by Dawson and Bowles (*op. cit.*). Apparently a second egg may be laid if the first is destroyed; this probably accounts for fresh eggs found as late as June 7 by Young (*op. cit.*). The start of egg laying off southern Alaska is given as June 1 by Heath (*op. cit.*) and the last week in May by Willett (1915). Young (*op. cit.*) gives the period of May 10 to 21 for egg laying just north of Vancouver Island, and Dawson and Bowles (*op. cit.*) record egg laying on May 1 for Destruction Island. Thus there appears to be some correlation between lower latitude and earlier laying. However, on more southerly Monyeron Island north of Japan, Koslova (1957) found the first auklet eggs in early May, and on Protection Island I found eggs as early as April 21 although most are probably laid about the second week in May. On May 19, 1957, for instance, of six burrows opened, all had an egg, whereas on May 3, 1958, only one of four occupied burrows had an egg. A fresh egg was found as late as May 31.

Incubation.—The incubation period is given as about three weeks by Heath (1915) and about a month by Young (1929). Three records of eggs in the present study showed the incubation period to be over 31 days, and the nearly successful artificial incubation of one egg indicated a period of about 31 days. Occasionally eggs may hatch in late May but usually the time of hatching is in the second and third week in June. A few birds were still incubating on June 20, 1957.

There is little doubt that both males and females incubate. In several instances pairs were banded in burrows known to contain eggs. Also, there was a great deal of nightly activity of adults during the weeks of incubation. Large numbers of auklets came in at dark, many staying on the slopes during the night but many others coming or going. Almost all burrows were entered nightly and tracks in the morning almost invariably showed a bird had left the burrow. The dawn flight of auklets leaving the study area on May 19, 1957, consisted of only 22 birds, none in pairs. Such flights suggested that many birds were incubating and that the time of changing of mates was irregular.

Heath (1915) speaks of incubating auklets changing places at about 10:00 p.m. and again early in the morning, the relieved birds thus being free to go to sea to feed during the night. My studies did not indicate any such regular shift. Instead, large numbers of auklets were present on the breeding slopes throughout the night. A check of 23 traps on each of two nights during the incubation season disclosed that traps were entered

at irregular times chiefly between 10:00 p.m. and 3:00 a.m. An average of only 30 per cent of the traps were entered, suggesting that mates do not change places every night. However, the fact that most burrows without traps were entered indicates that traps often deter birds. No fish were brought into burrows in April and May, indicating that incubation was still continuing and that auklets were not bringing food to their mates.

Temperatures of birds and burrows.—A limited number of temperatures of auklets, taken cloacally with the same potentiometer and electrodes, were recorded. Two readings of adult, incubating birds were 102° and 103.5° F., low temperatures compared to most species of birds. Temperatures of young birds showed considerable variation but also indicated well-established temperature control at hatching or soon thereafter. The temperature of one young (1 to 3 days old) was 103.5° F. and of another young (4 to 6 days old) was 104.0° F. Young auklets are thus precocial in acquiring temperature control although their behavior is nidicolous during growth.

The temperature within burrows, near or in the nest chamber, remains nearly constant in spite of fluctuations outside. For instance, the temperature within one burrow was 63.5° F. when the temperature outside was 62.5° F. and the temperature within another burrow was 64.0° F. when the temperature outside was 74.0° F. The importance of the deep burrow in protecting young birds or incubating adult auklets from excess cold or heat is thus suggested. Apparently there is little or no brooding of the nestling, a fact which can be correlated both with the uniform mild temperature of the burrow and with the early establishment of temperature control in the young.

Growth of young.—The two most readily detectable signs of hatching of young are the parents bringing in fish and the frequent appearance of egg shells or membranes, presumably brought out by a parent, near entrances of burrows.

The growth of the young from hatching to fledging apparently takes five to six weeks. During that time the completely downy nestling of about 50 grams becomes a fully feathered fledgling of over 400 grams. Too few repeated weights of young birds were obtained to give an adequate idea of the growth rate, but the data in table 1 give some indication.

TABLE 1
WEIGHTS OF YOUNG AUKLETS

Young	1st weight (gm.)	Age	2nd weight (gm.)	Days later	Gain in weight (gm.)
No. 1	69.5	1-3 days	355.5	24	286.0
No. 2	95.0	4-6	410.0	24	315.0
No. 3	208.0	8-11	401.0	27	193.0

Young no. 3 appeared nearly fledged at its last weighing.

Data from table 1 and other weights recorded indicate that the rate of increase in weight of nestlings averages over 10 grams a day during the first three or four weeks but decreases greatly during the last week or two when the juvenal plumage is being completed. The young at fledging weigh a little over 400 grams, which is markedly below adult weight; the average weight of 13 adults was 542 grams with a range from 490 to 610 grams.

The young as they grow apparently move about more and more freely in the burrows. Young are ambulatory on hatching but were not actually seen in the outer part of burrows until nearly fledged. There is a lack of excrement in nest chambers but it frequently occurs outside entrances, where its forceful expulsion has been heard at night. It may occur on the walls of burrows, indicating that both young and adults usually leave the nest chamber to defecate.

The nearly grown young (figs. 6, 7) still has some patches of down attached to its teleoptiles; the down occurs chiefly on the rump, neck, and on the breast. The horn on the bill is extremely small in very young birds, but it becomes more noticeable (about $\frac{1}{8}$ inch high) as the nestlings grow. The horn is rounded, slightly movable from side to side, and appears to be covered with skin.

Bent (1919) and others give details on plumage changes in the young but some data may be added here. The first visible changes from the completely downy plumage occur



Fig. 6. Ventral view of young auklet about four weeks old showing the large amount of down still attached to underlying contour feathers. Young were temporarily removed from burrows for photographing.

early in the fourth week when primaries and secondaries and their greater coverts are just emerging from their now conspicuous (13–18 mm.) periderm sheaths. Within two to four days of this time, areas of contour feathers appear around the bill and eye. Soon after this, at about four weeks of age, contour feathers previously developing, but hidden under down, cover most of the upper and underparts and appear in the tail (fig. 6). Primaries and other wing feathers are by now up to 65 mm. out of their sheaths. At or near the time of fledging the wing measurement (wrist to tip of primaries) of a young bird (fig. 7) was 155 mm. compared to an average of 182 mm. in adults.

Food and feeding of young.—The sand lance (*Ammodytes tobianus*) appears to form almost the exclusive diet of young auklets on Protection Island judging from hundreds of specimens of this small teleost fish dropped by parents entering traps. Only a single specimen of another fish, a smelt (Osmeridae, probably *Hypomesus pretiosus*), was found. Heath (1915) and others have found sand lances to be the only food of Rhinoceros Auklets, but Grinnell (1899) found a small crustacean to be the food of 10 auklets collected in winter off southern California, and Linton (1908) recorded small sardines as the food in several specimens taken off California in late fall. Koslova (1957),

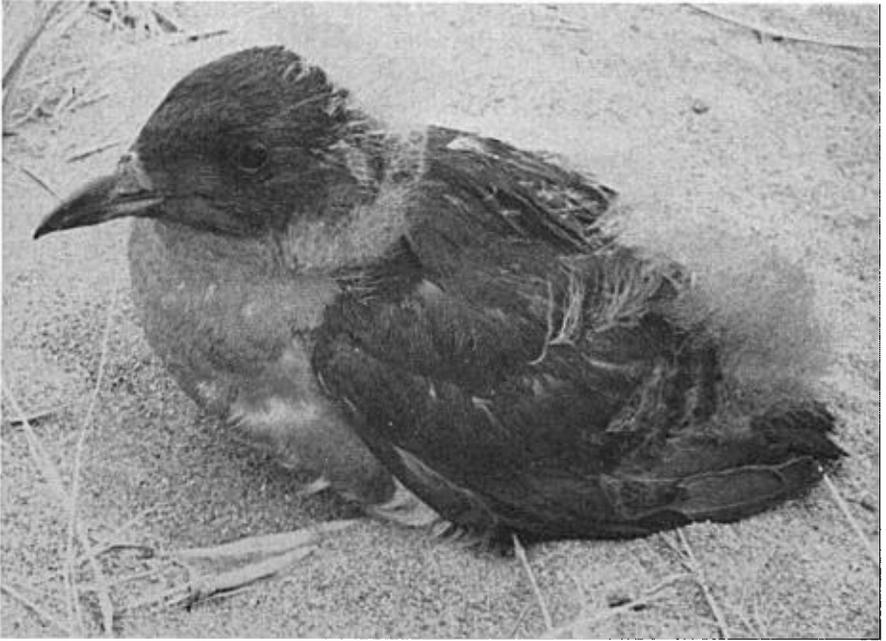


Fig. 7. Young auklet about five weeks old. The young leave their burrows to go to the ocean at about this stage or a few days later even though they are not full-grown. This bird weighed 401 grams compared to an average of 542 grams for adults.

reporting on records from the northwest Pacific, states that Rhinoceros Auklets eat mostly marine invertebrates but that the young are fed two kinds of smelt, young salmon, and other fish.

The number of sand lances carried at one time in the bill of a parent returning to its burrow was often impressive, being as many as 13. In 37 cases the average number of fish brought in was 6.4 with a minimum of one fish on two occasions. The fish were usually between four and six inches long, but occasionally they were as small as two or as large as seven inches. The weights of two billfuls of 10 and 12 fish were 29 and 30 grams, respectively. The ability of the auklets successively to catch and hold a large number of fish in the bill, rivaled by other birds such as White Terns (*Gygis alba*), can be explained by the structure and control of the tongue and bill.

Although the frequency of feeding of young appears to decrease markedly during the week or so before fledging, when the young may gain little or no weight, young are fed nightly or twice nightly before this period. Eighteen records were obtained of two visits to single burrows in one night. In eight cases fish were brought in both times. In two instances catching of banded birds proved that both parents were feeding the young. Two records of three visits to a burrow in a night, and a banded bird returning the same night, show that a parent may make two visits a night presumably to feed the young. In these latter cases, however, trapping could have disrupted the normal feeding schedule.

The regularity of visits to the young is indicated by the fact that of 223 nightly checks of burrows during late June and July, 213, or about 95 per cent, showed that burrows had been entered. Very likely at least a few of the burrows checked were not in use even though appearing to be, so the nightly visitation was even closer to 100 per

cent. However, considering the records in late June and July of burrows with traps in them, 69 of 83 burrows, or about 83 per cent, were entered or visited. Only 60 of the 83 traps, or about 72 per cent, were actually entered, further emphasizing the deterring effect of traps.

Of the 60 times traps were entered and set off, mouthfuls of fish were disgorged 35 times. Apparently parents were entering burrows without food for young in the other 25 instances for I think an auklet's surprise at finding its head in a net, and the push and clatter of the trap door shutting behind it, would always cause it to drop fish.

Observations of traps and burrows appear to show a regular decrease in frequency of feeding but not of visitation after the early growth of the young (table 2). It appears,

TABLE 2
VISITATION OF BURROWS FROM BEFORE HATCHING TO FLEDGING OF YOUNG

Date	Open burrows		Burrows with traps		Mouthfuls of fish dropped
	Checked	Entered	Checked	Entered	
June 1, 1958	33	30	23	8	0
June 18, 1957	50	47	12	10	9
July 4, 1958	34	33	12	10	4
July 13, 1957	64	61	12	7	4
August 1, 1958	29	27	23	11	0

too, that the greatest urge to enter burrows, in spite of the presence of traps, is when the young are small and being fed the most frequently. Fewer birds entered traps on June 1, when incubation was still in progress, or on August 1, when young were nearly fledged, although the visitation of open burrows on these dates was still almost 100 per cent.

The feeding of young does not appear to occur at any definite time during the night. The records for some nights show a preponderance of fish brought in soon after dark but the records for other nights show about equal visitation of the parent birds before or after midnight or more frequent feeding of young in the hour or two before dawn. It was difficult to obtain adequate data on feeding times of young because the auklets were easily disturbed when one walked around the breeding slopes or showed a light.

The need for intensive feeding of the young during their early growth is emphasized by the fact that in late June there are only about six hours (9:15 p.m. to 3:15 a.m.) of darkness each night. The young must thus be adapted to going without food for at least three-quarters of the diurnal cycle. During the later growth, they, like the young of various sea birds such as shearwaters and fulmars, seem adjusted to not eating for a number of days.

The source of the sand lances brought to the young was not determined, but the extreme freshness of the fish, one of which was found still alive, indicated not too distant fishing grounds. Daytime fishing was observed within 10 miles of Protection Island which suggests that the auklets do not go to distant feeding grounds, as to the open ocean some 80 miles away, to obtain food for their young.

Fledging of young.—Apparently all or nearly all the young auklets were fledged by early August. Koslova (1957) indicates a similar date (August 1 to 10) for the appearance of young auklets on the Bay of Taba near Sakhalin Island, northwest of Japan. A number of nearly fledged young, one apparently just taking off, were found in burrows on Protection Island on August 1, 1959, and some fish were being brought in to them. Fewer young were present on this date in 1958 and no fish were known to be brought in. On August 20, 1957, no young were found. The young leave their burrows to fly down

to the water when they still have patches of down and are substantially smaller than adults. Coues (1868) pointed out the marked size difference, particularly of the bill, in fledged young and adults. Koslova (1957) noted young auklets with subadult wing lengths on the water. Limited flight thus appears to develop precociously to enable young to get to the water and undertake a more independent existence. This is in contrast to the Ancient Murrelet (*Synthliboramphus antiquus*) whose few-day-old chicks walk from their shallow burrows to the sea. The behavior of young auklets suggests murrelets whose half-grown young fly down to the water.

Nocturnal activities of adults.—A consistent relationship to the amount of daylight was shown in the arrival and departure of adults. Auklets started coming to the island about 45 minutes after sunset when it was almost completely dark and when, if clear, numerous stars were out. In the morning, however, the last birds left about 20 minutes before sunrise when it was about half light, or occasionally as on May 3, at 8:15 a.m., in full daylight. Consequently, adults were on the breeding grounds from about 8:00 p.m. to 5:10 a.m. in late March, from 9:15 p.m. to 3:15 a.m. in late June, and from 8:55 p.m. to 4:00 a.m. in early August. These times are approximate since there is no mass arrival or departure of birds. Usually it was 15 minutes or so after the arrival of the first auklets that large numbers started coming in, and the birds continued to arrive in numbers for the next half hour or more. A reverse pattern occurred in the early morning. In either evening or morning there could be so many birds both coming and going during the hour after first arrivals or the hour before last departures that a particular time of arrival or departure could not be designated.

Although auklets started coming in to the slopes at dark throughout the season, usually many more came in after midnight while digging of burrows or incubation were going on than during the weeks when young were being fed. Heavily overcast skies sped the general arrival time or delayed departure for about 15 minutes. No instance of delayed departure of an hour or so due to cloudiness or fog, as cited by Heath (1915), was observed.

Voice.—Dawson and Bowles (1909) speak of the "growls and barks and parrot-like shrieks" of Rhinoceros Auklets on their breeding grounds, but this variety of noises has not been confirmed. Heath (1915:33) describes the call as a "curious nasal cry of four short notes rapidly repeated," which is closer to descriptions of the call in my notes. I recorded the call as consisting of five to seven rather high-pitched, groaning notes with the accent and longest pause usually on the second or third note and the last one to three notes fainter and dying away. At close range a brief, guttural "chuck" was occasionally heard between groan notes. Late in the season a series of three or four low-pitched "chirps," presumably from young, was heard a number of times within burrows.

The calls of different individuals, although similar, showed marked variations in pitch, stress, and number of notes. Perhaps these variations function in helping birds to locate each other in the dark. Call notes were often given from inside burrows and these could help mates locate their burrows. Single, low notes were heard occasionally from inside burrows. Much more calling occurred after midnight, especially during the hour or two before departure of birds at dawn, and this may discount the possible role of calls in locating mates or burrows. In the evening, just before or when auklets were first coming in, and during departure in the morning, auklets were heard many times calling from well out on the water suggesting some gathering of auklets there. A single groan-like call note was occasionally heard, as was a rasping squeak. Vocalizations of Rhinoceros Auklets showed an interesting parallel, both in quality and variety, to those of the nocturnal, burrowing, Wedge-tailed Shearwater (*Puffinus pacificus*).

Mortality.—Two instances were seen of auklets killed by the caving in of burrows by sheep or humans. This cause of death, perhaps serious in some areas, is usually not discovered. Predation appears to be almost negligible as there are no mammal predators and the auklets are not exposed to any diurnal birds of prey. One cleanly picked partial skeleton of an auklet was found which could have been the work of a Horned Owl (*Bubo virginianus*), the only large owl seen occasionally on the island.

Auklets are sometimes killed by flying into obstructions. A wire sheep fence with a 5- to 10-inch mesh ran through the beach grass above the bluff of the study area, and departing auklets were heard to hit it forcefully many times. However, repeated search along this fence revealed only two dead birds which may have been thus killed. This may attest to the strength of the neck and short wings in auklets. Jewett, Taylor, Shaw, and Aldrich (1953) mention auklets being killed fairly often by flying into rocks below breeding slopes when taking off. Numerous searches of the jumble of logs and driftwood below the study area revealed only two dead auklets, so this cause of mortality also seems minor.

Diurnal and postbreeding distribution.—Very few auklets were seen in the daytime in waters near Protection Island, the maximum being 15 seen on July 5, 1948, about a mile out in the channel between the Olympic Peninsula and the island. However, on several occasions from early March to late May hundreds were recorded in Admiralty Inlet about 10 miles eastward from the island, toward Puget Sound. Sufficient data are not available to be sure of the daytime or nighttime distribution of the auklets of Protection Island, but it appears they stay in the more inland water, not going the long distance to the open ocean.

Many auklets continue to return to Protection Island even two or three weeks after the young are fledged. On August 20, 1957, for instance, 63 of 76 burrows had been visited within a few days, and on the night of August 21, 30 of the 76 burrows were entered. No young were found in a number of burrows that had been entered. The few birds caught, none bringing food, were unbanded adults and it could not be determined whether they were nonbreeding or recently breeding birds. Two, probably postbreeding adults, were caught in recently used burrows, but tracks in and out of three uncompleted burrows indicated some indiscriminate entering of burrows at this time. Recently fledged young can hardly be involved, for they are generally many miles from the island at this time and their power of flight is not great. On August 15, 1957, for instance, at least 200 adult and young auklets, presumably from Protection Island as it is the only breeding grounds in the whole region, were seen in the channel east of San Juan Island, some 25 miles to the north. These birds could not be made to fly when repeatedly approached by boat.

In early September of two years no auklets were returning to Protection Island. A few are present each year in the Puget Sound region from September to February but these may be migrants from the north. A maximum of 24 of these wintering auklets was seen off the west side of Bainbridge Island on February 2, 1958. Apparently nearly all auklets go to the open seas or coast during the winter. Some migrate as far south as Baja California.

BEHAVIOR

A somewhat miscellaneous group of observations is included in this section. Although related to the breeding activity in varying degree, they do not fall under the major headings discussed there.

Flight.—Auklets hurtle directly toward Protection Island at high speed and with rapid wing beats regardless of darkness. Normally they sweep somewhat upward on the

slopes before alighting, a fact that would seem to make low burrow sites less desirable. Although some observers have commented on auklets frequently landing with a crash, as in vegetation, I found they almost always landed rather lightly after a forceful flutter of wings. Occasionally auklets struck the ground rather hard or landed in the beach grass with much rustling, but these seemed to be atypical examples of poor judgment or poor visibility.

Fairly often, especially when first coming in after dusk, one or more auklets would swerve across the face of the slopes for a distance and head back out to sea. Birds thus seemed to determine that darkness was not yet complete enough for their safety on the ground, although their behavior may have been analogous to the "passing flights" often seen in Tufted Puffins.

Rhinoceros Auklets, perhaps especially the fledgling young, must launch themselves from a slope or bank when taking off from land. Auklets could not take flight from the deep beach grass or from burrows about 10 feet above the beach. Birds liberated at night generally took off very quickly but those liberated in the daytime often ran to escape. One, curiously, repeatedly swam back to shore when liberated into the water. Capture and subsequent liberation clearly disturbed the auklets. Instincts to run away or find shelter on or under the ground seemed to conflict with flight movements.

Relation to burrows.—The highly developed fossorial habits of Rhinoceros Auklets are shown not only by their extensive digging and entering of breeding and accessory burrows both during and after the breeding season but also by the frequent attempts of both young and adults to escape into burrows when liberated. In one case an adult, liberated at night next to its destroyed burrow, quickly ran into another burrow about four feet away.

Auklets, although showing a high degree of specificity to their burrows, were several times noted to adopt new entrances where cave-ins destroyed the outer one to three feet of burrows. Several double entrances, never more than a foot or so apart, were seen. They appeared to result from excavation or small cave-ins, and only one entrance was regularly used. Although burrow entrances of separate pairs of birds were sometimes only 6 to 12 inches apart, in only one case were two pairs found to use a common entrance, the burrow then branching immediately into right and left passages.

Accessory burrows seemed usually to be manifestations of digging proclivities but one such burrow, not used for breeding, was about two feet deep and had feathers and nest material in it, suggesting it might be a dummy nest. In June and July of 1958, four burrows used for breeding in 1957 were found to have been entered numerous times even though they were not being used for breeding purposes. The opening and covering of these burrows from the back may have led to their desertion in 1958 although they were not deserted in 1957 when eggs and young were present.

Incubating adults would rarely leave their burrows when I attempted to dig them out in the daytime, but in one instance a bird came out when I was digging about four feet from its nest. Five incubating birds, taken by excavation from the backs of burrows, all returned quickly to their burrows and did not come out during the day. These and other observations indicate the auklet's aversion to being in the open on their breeding grounds in daylight.

Temperament.—Rhinoceros Auklets display a vicious temperament when captured and use the strong bill and sharp claws violently and effectively in efforts to escape. This temperament is slow to manifest itself in the young, but nearly fledged birds five weeks old were very aggressive although they could never have seen a human before. Adults when caught in traps or handled did not give any vocal notes except an occasional grunt

caused perhaps when they were tightly held. A nearly fledged young, however, sounded a high-pitched note when caught by hand.

Activities on slopes.—Nightly, during the whole breeding season, there were many auklets walking, running, or standing on the slopes. Many of the birds seemed to have no purposeful activity for they often stood in the same spot, not adjacent to burrows, for 20 or more minutes at a time. Others walked around, rather aimlessly it appeared, or more often ran, the body typically held nearly parallel to the ground and the neck low and outstretched. The birds thus seem to scoot low to the ground, a pose which must be approximated as they go through their burrows (fig. 8).



Fig. 8. Auklet resting in beach grass above bluff at night. The squat stance, resting on the tarsometatarsi, is typical. The head and neck are lowered when the bird runs.

My notes for 2:30 to 3:00 a.m. on July 4, 1958, give some further indication of auklet activities: "Some 10 birds were seen at one time from the bluff, all from 6 to 30 feet away. Birds intermingled without altercations. Two or three pairs were seen standing together but others were single, or three or more were together." Standing birds at night were several times seen to stretch and flutter their wings, perhaps drying their feathers.

There do not seem to be recognized territories around burrows and we can perhaps best think of the burrows themselves as constituting the territory of each pair of auklets. The very distribution of the burrows, ranging from close together to widely scattered, suggests that Rhinoceros Auklets are not a truly colonial breeding bird beyond the point of showing a selectivity for certain islands. On Protection Island their distribution is largely due to the suitability of slopes or soil; the frequently widely-scattered pairs of auklets show no attempt to congregate into a close-knit breeding colony.

SUMMARY

A portion of the long-established breeding grounds of the Rhinoceros Auklet on Protection Island, Washington, was studied on monthly trips in the course of four breeding

seasons. Seventy-six burrows were marked and followed; a total of 71 auklets were banded.

The return to the island of the population of an estimated 3000 to 4000 pairs of adult auklets starts in early March but is not complete until late in the month. The digging of burrows or reclamation of old ones begins at once.

Preferred burrowing sites are generally in firm, sandy soil on slopes of between 37° and 45° or in dense growths of beach grass (*Ammophila*) above steep slopes.

Both members of a pair of auklets excavate their burrow, using the bill and claws in digging. The rate of excavation averaged 7.6 inches a night.

Banding returns indicate that auklets typically maintain the same pairs each year and use the same burrows.

No consistent colonial or territorial behavior is exhibited and burrows may be from one to dozens of feet apart. The study area of about one-third of an acre contained about 132 active burrows.

The single eggs are laid as early as April 21 or as late as May 30 but generally about mid-May. Incubation is performed by both parents and apparently the young hatch in 31 days plus a day or two. No evidence was found of a regular evening and morning exchange of incubating birds, but most burrows are entered each night.

Temperature control is established in the young, densely down-covered auklets within a day or two after hatching. Correlated with this and the uniform, mild temperature of the burrows, the young are apparently not brooded.

The sand lance, *Ammodytes tobianus*, appears to form almost the exclusive diet of the young auklets in this study area. A parent may bring in as many as 13 of these four-to-six inch fish at once in its bill. Both parents bring fish to the young auklet, feeding taking place nightly at least during the early weeks of growth of the young.

Growth of the young from hatching to fledging takes approximately five to six weeks, but the fledgling is definitely of subadult size and just able to fly down to the water from its burrow. All young auklets are fledged and gone from the island by early August, but numerous adults continue to return to the breeding grounds at night until late August.

Whether in March or July, the auklets start coming to the breeding grounds about 45 minutes after sunset. There is much coming and going during the night, but virtually all auklets leave the island by 20 minutes before sunrise. Rain or overcast skies do not appear to change these limits by more than 15 minutes.

The chief cause of mortality of auklets on Protection Island appears to be the caving in, or burying through earth slides, of burrows by sheep or people. The denuding by sheep of slopes used by breeding auklets is seriously decreasing suitable nesting areas.

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