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## THE MARINE PEREGRINES OF THE NORTHWEST PACIFIC COAST

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### INTRODUCTION

It has long been known that a population of the Peregrine Falcon (*Falco peregrinus*) achieves densities along the northwest coast of North America that are far in excess of those considered usual for the species. This population has been described as consisting of a distinct subspecies, *Falco peregrinus pealei*. In the past ten years I have had opportunity to collect data from much of the Canadian portion of the range of this subspecies, and my life-history observations are reported here. These are supplemented by notes of other observers, particularly those who have had experience along the outer coast of British Columbia and Alaska and have visited certain islands and areas that are not yet known to me. Due to the rather limited range of the subspecies in Canada, this paper may well suggest more questions than it answers, questions that must await final solution by field workers in Alaska. Observations on details of range and subspecific characters stop just at the point where they become most interesting, and in this regard certain inferences may be drawn and some areas for further investigation suggested.

While most of the observations have been made on wild birds, reference will be made to behavior, molt, and hunting techniques of so-called "captive" birds that were taken for observation as fledglings and eventually trained and flown as hunting falcons. Lest the validity of observations of such birds be questioned, any data relating to them are clearly stated as such. It is my opinion, however, that the behavior of such birds is probably as natural as that of wild birds when they are aware of the presence of an observer.

*Field work and expeditions.*—This account is based on field work begun in 1949 and extending to 1958. In that time many points along the northwestern coast were visited. Attempts have been made in this time to ascertain not only the places along the coast where falcons do occur but also to collect information and determine why the birds do not occur in certain areas that appear to be favorable. The following is a list of the various field trips: Triangle Island, outermost of the Scott Islands, Queen Charlotte Sound, June 24 to July 4, 1949; Scott Islands (Lanz, Cox, Beresford, and Sartine), Queen Charlotte Sound, June 16 to 22, 1950; Langara Island, Queen Charlotte Islands, April 13 to June 12, 1952, June 1 to 11, 1955, June 19 and 20, 1956, June 20 to July 5, 1957, and June 16 to 22, 1958; Solander Island, Cape Cook, west coast of Vancouver Island, June 29 to July 3, 1954; Cape Flattery and Neah Bay, state of Washington, June 7 to 9, 1957; Carrol Island, state of Washington, June 15 and 16, 1957. These and other localities along the British Columbian coast mentioned in the text are shown in figure 1.

In addition to the foregoing, one-day flights and ground trips were made to all known high cliffs that might conceivably be used by peregrines in the Puget Sound area in both 1957 and 1958. Short trips were also made to the outer coast of Vancouver Island covering the more accessible coastline from Jordan River to Port Renfrew, Barkley Sound and Tofino.

Observations and notes have been made on a number of wild falcons wintering in the Puget Sound region. In all, somewhat over 30 young, subadult, and adult birds have

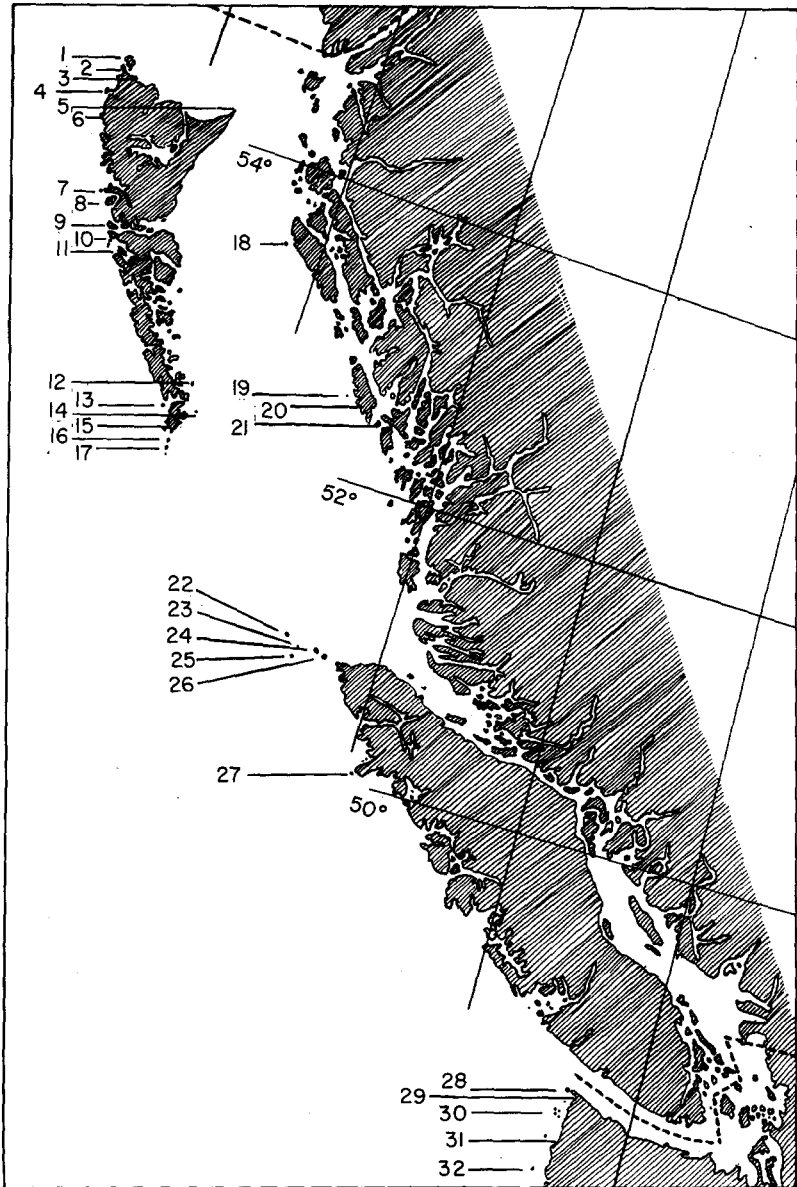


Fig. 1. The coast of northern Washington and British Columbia showing known (K), probable (P), recently reported (R), and old (O) reports of falcon aeries. 1, Langara Island, K; 2, Cape Knox, K; 3, Pillar Bay, K; 4, Frederick Island, K; 5, Tow Hill, K; 6, Tian Hd., R; 7, Nesto Is., P; 8, Hippa Is., R; 9, Chaatl Is., P; 10, Marble Is., R; 11, Hibben Is., P; 12, Rankin Is., P; 13, Anthony Is., P; 14, High Is., P; 15, Kunghit Is., K; 16, St. James Is., P; 17, Kerquart Is., P; 18, Bonville Is., P; 19, Moore Is., R; 20, Aristizabal Is., P; 21, Lady Douglas Is., P; 22, Triangle Is., K; 23, Sartine Is., K; 24, Lanz Is., K; 25, Beresford Is., K; 26, Cox Is., K; 27, Solander Is., K; 28, Tatoosh Is., O; 29, Cape Flattery, O; 30, Olympiades, O; 31, La Push, O; 32, Carrol Is., O.

been handled alive, in addition to a smaller number of freshly killed specimens. Three trained birds have been under constant observation for periods of one, two, and three years, respectively. A series of over 25 aeries or aerie sites has been visited and observed, of which ten, on Langara Island, have been re-visited and observed in five different years.

*Acknowledgments.*—This study was made possible by the cooperation and direction of Dr. G. Clifford Carl, Director, Provincial Museum, Victoria, B.C., and Charles Guiguet, Biologist of that institution. The museum expeditions to the outer islands of the Pacific coast, undertaken primarily as a long-term research project to study the mammalian fauna, provided the opportunity to make many of the observations and were the initial stimulus to the undertaking of this study. I have also had free access to Mr. Guiguet's unpublished field notes from Langara Island and, more importantly, from Frederick, Hippa, and Kunghit islands on the outer coast of the Queen Charlotte Islands, and from the Goose Islands. Much of the material presented from these areas is taken directly from his observations. To Wilson Duff and Michael Kew, anthropologists at the Provincial Museum, I am indebted for observations from Anthony Island. I would like to thank Tom J. Cade at the Museum of Vertebrate Zoology, Berkeley, California, for the opportunity to check my material with his work on the arctic peregrines before publication and to refer as freely to his findings as I have done. Both he and Frank A. Pitelka have helped in editing the manuscript. My thanks are also given to Harold M. Webster, Jr., of Denver, Colorado, for use of photographs and weight records.

Finally, and most importantly, I must acknowledge my deep appreciation for the help so generously given by those people to whom the work was of no particular importance, the employees of the Atlin Fish Company of Prince Rupert and the Fishermen's Cooperative of Prince Rupert, who maintain the fish-camps on Langara Island and who provided transportation on packers and accommodations in camps. Much of the work on the outer coast would have been impossible without the help of these people.

#### VALIDITY OF THE SUBSPECIES

Brooks (1926:78) gives an accurate description of the adult Peale Falcon. To his statements I would add that the Peale Falcon averages somewhat heavier than other peregrines, and that it is markedly heavier and larger than peregrines from the North American arctic (table 1). Harold M. Webster, Jr., has gathered weight data on peregrines and sends me the following average weights: *F. p. pealei*, females, 40 oz., males, 24 oz.; *F. p. anatum*, females, 32 oz., males, 18 oz.; and for arctic peregrines, females, 28 oz., males, 15 oz. The difference in size between the birds from the outer coast and

Table 1  
Weights of Certain North American Peregrines<sup>1</sup>

Race	Number of specimens	Mean	Range
<i>F. p. pealei</i> (British Columbia)			
Males	6	954 gms.	810-1058
Females	7	1398	1244-1597
Arctic peregrine (Alaska and N.W. Canada)			
Males	8	625	575- 706
Females	11	994	851-1129

<sup>1</sup> Weights for immature individuals and for adults do not differ significantly, hence they are pooled above.

typical *anatum* is not as marked as between the coastal birds and arctic peregrines. Between these latter, there is actually no overlap in the weights of the respective sexes. The arctic falcon shown in figure 2, an immature female, weighed 32 oz.; the Peale Falcon, an adult female, was a 40-oz. bird.

As pointed out by Brooks, the suppression of the tendency to a pinkish or rufous tinting of the under surfaces, so characteristic of most other adult peregrines, is a

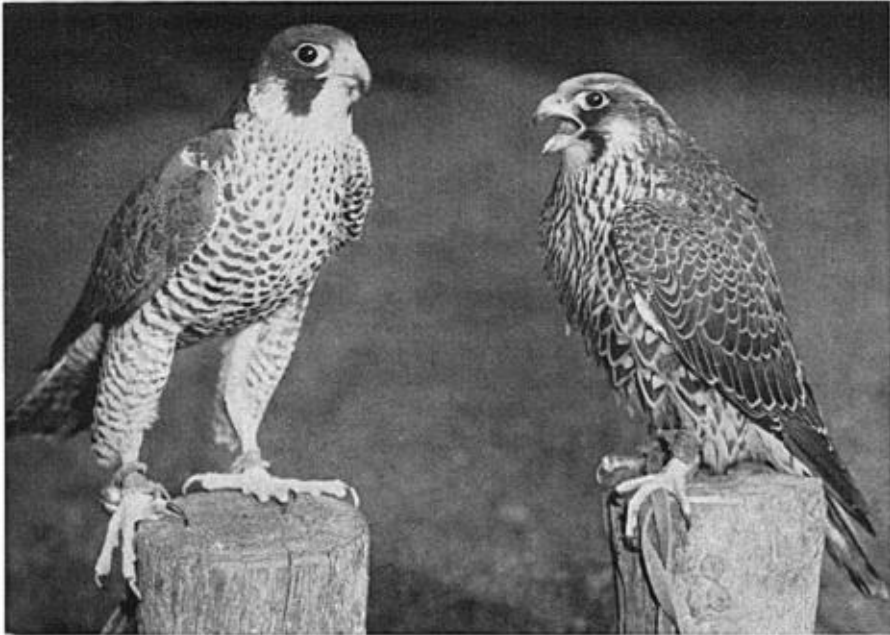


Fig. 2. An adult female Peale Falcon from Langara Island and an immature female arctic peregrine from Banks Island, Canadian arctic, showing difference in size. Note pale crown, broken malar stripe, and small feet of the arctic peregrine.

marked character of the adult plumage of the Peale Falcon, as is also the breadth of the cross-barring and other characters listed. In addition the upper parts are singularly uniform in color; the cross-barring of all the large feathers of the dorsal surface are broader than the ground color and but slightly darker. The crown and broad malar stripe are only slightly darker than the back and mantle and are never black. Males are less clearly characterized than females, and some individuals are indistinguishable in the field from adult continental peregrines. In the hand, however, the dusting of gray over the entire under parts, as mentioned by Brooks, is distinctive, as are also the black shaft-lines on the feathers of the upper breast. In *anatum* and in arctic peregrines, the breast of the males is immaculate. The dorsal surface of adult male *pealei* is much like that of the female, that is, rather uniform in color with ill-defined dark cross-barring dominating the slightly paler ground color, the crown and broad, sharply defined malar stripe being only slightly darker than the back and mantle (fig. 3).

It is not in the adults, however, but in first year birds that the plumage characters of the race *pealei* are most clearly marked. As already noted, I have seen close at hand not less than 30 living first-year birds plus a large series of museum skins, and in this plumage descriptions based on the specimen skins alone are misleading. Brooks (1926:

78) states that "the young are very dark and may or may not have rufous edgings to the feathers of the mantle; they can be matched almost exactly by dark juveniles from the Atlantic coast." While I have not seen many specimens from the eastern areas of North America, I have seen several living immature birds and they are most strikingly different in appearance from living birds from the Pacific coast. The most pronounced feature about them is the beautiful reddish brown overwash of the entire plumage, both

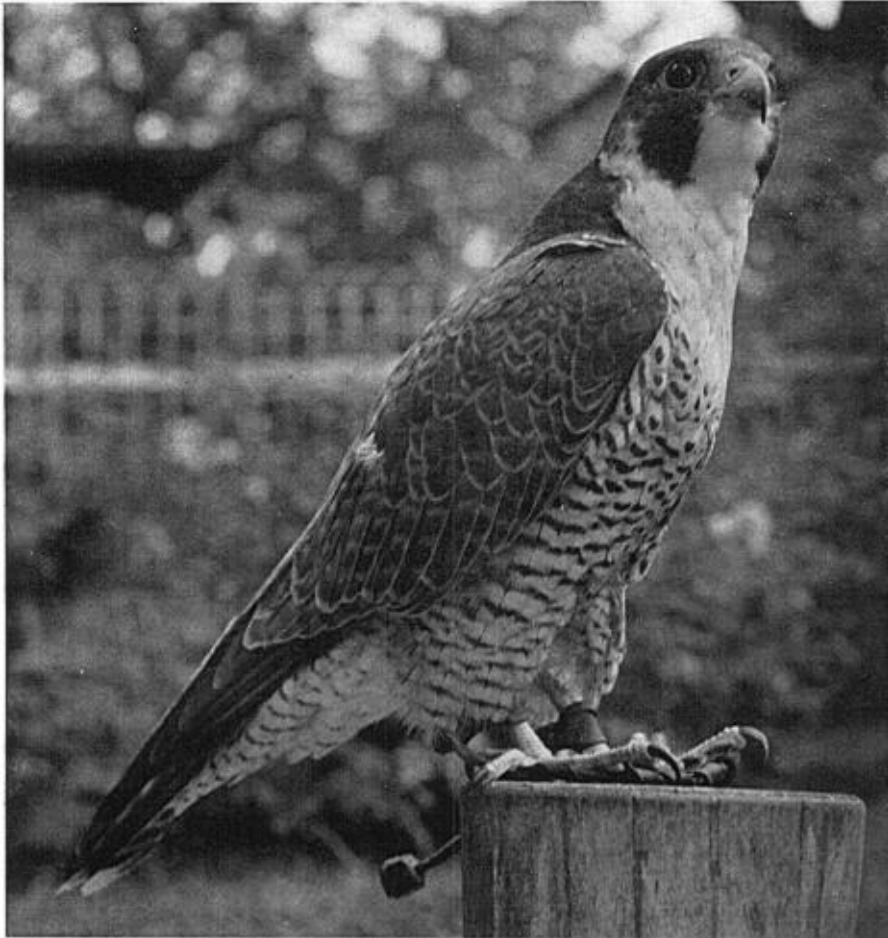


Fig. 3. Adult male Peale Falcon from Langara Island. Photograph by Harold M. Webster, Jr.

dorsally and ventrally, and the strikingly dark, almost black malar stripe and (usually) crown.

Skins of immature Peale Falcons are usually described as being some shade of brown. However, the most striking feature of the living birds is that they do not appear brown at all, but dark slate-gray, the only brown or rufous on the dorsal surface being the narrow, pale edgings to the feathers of some of the lightest colored individuals. In dark birds even this is utterly lacking. The palest birds show, in addition to the light feather-edges, a slightly narrower and less sharply defined malar stripe and sometimes a bit of light streaking on the crown, while the light grayish brown ground color of the under

parts may almost equal in breadth the dark longitudinal streaking. In darker, well-marked individuals the head, broad malar stripe, and the entire back are uniform dark slate-gray, so dark in some as to approach blue-black. In all plumages there is a marked glaucous bloom on the mantle and mid-back. The under parts of dark individuals are also so broadly streaked as to appear nearly uniform in color too, there being only narrow feather edgings of pale gray or grayish brown. These heavily marked immature

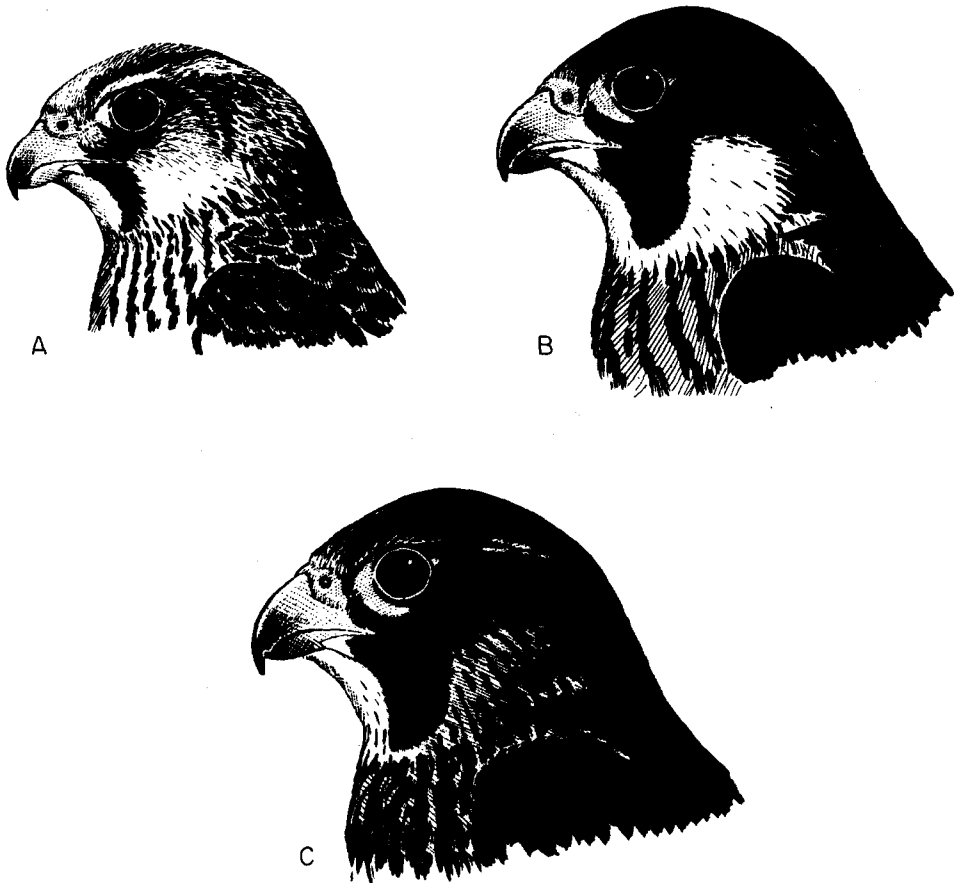


Fig. 4. Drawings of heads of North American peregrines showing main subspecific characters. (A) Arctic peregrine. Small size, pale general tone, light crown, narrow, black, broken malar stripe; (B) *F. p. anatum*. Medium size, contrastingly marked. Dark crown, black malar stripe, rufous overwash; (C) *F. p. pealei*. Large size, dark general tone, all colors grayed, crown and malar stripe dark gray. Illustrations by the author.

falcons are remarkable looking birds, and except for the broad malar stripe they look much like the dark phase of the Gyrfalcon (*Falco rusticolus*). At any distance, whether in flight or at rest, they look absolutely black, the only light patch of the entire plumage being the small buffy area on the throat under the beak.

I think in areas where the range of the Gyrfalcon overlaps that of the Peale Falcon it would be extremely difficult to separate the two in the field. This is emphasized by the fact that the first adult specimen of *pealei* collected at Kiska Harbor by Dall (1874) was misidentified as a Gyrfalcon by none other than Robert Ridgway.

The general grayness of living birds as contrasted with specimens which, while often a very dark brown, are nevertheless brown, deserves comment. The condition varies much with individuals and even varies in the same individual from day to day. The same bird will appear much more glaucous after a few days of fine weather than it does during, or immediately after, a rain. The glaucous effect results from a copious production of powder down that, in turn, seems to be linked to the excessively damp and rainy environment of the outer coast and which seems to act in some way as a waterproofing agent. At any rate, when one of these coastal birds bathes, a film of powder down can easily be seen afterward on the surface of the water. It comes off the plumage on the hands if the bird is handled and shows clearly if the bird is brushed with a dark cloth. Of course, it disappears entirely from specimen skins after a short time, and the color of such skins changes accordingly. This powder down modifies all the colors of the living bird, graying, or even blueing them. It is present, too, in the plumage of the adults but their plumage is already gray; and although it may tend to subdue and blend the markings, it has no noticeable effect on the color. I know of no other raptor that produces powder down to the same extent, although Bannerman (1956:231) makes note of this same character in European Goshawks (*Accipiter gentilis*). Whether this is the reason for the remarkable ability of the west coast falcons to shed rain, I do not know, but at any rate they are as waterproof as a duck, and the daylong drenching rains of the Pacific coast winters do not succeed in wetting them. I have had eastern and arctic peregrines, Prairie Falcons (*Falco mexicanus*), Gyrfalcons, and Goshawks that inadvertently were left out in soaking rains with a Peale Falcon and thus served as controls. All of these other species needed some shelter to keep from eventually becoming wet, bedraggled, and miserable. No amount of rain, however, seemed able to wet the feathers or dampen the spirits of the Pacific coast peregrines.

Altogether the Peale Falcon, at least that portion of the population that breeds in western Canada, seems to be a well-marked and recognizable form.

#### GENERAL DISTRIBUTION

The range of *pealei* as listed by Brooks (1926:78) is as follows: "North Pacific Islands between latitude 50° and 55°, from the Skeena River mouth (British Columbia) to the Commander [Kommandorski] Islands (and adjacent coast of Kamchatka?)." The A.O.U. Check-list (1957:119) lists a rather different range: "Breeds from the Aleutian Islands and islands off the coast of southern Alaska [Alexander Archipelago?], occasionally to St. George Island in the Pribilof group south to the Queen Charlotte Islands (Graham Island, Langara Island) and Moore Islands; reported also to breed in the Kurile Islands."

Of these two statements, the former is the more correct, although it is rather arbitrary in its use of 55°N. latitude for the northern limit. Both ignore Dawson and Bowles (1909:531) account of the Peale Falcon on the outer Washington coast and the recent check-list also ignores Bent's (1938:68) statement: "Duck hawks from interior and northern Alaska and from the Pacific coast south of latitude 50°N. are clearly referable to *anatum* as are also those from Admiralty Island and the Sitkan region." Here is evidence that many, perhaps most, of the falcons from the south coast of Alaska and the Alaska Peninsula are not clearly assignable to *pealei*.

From a map it would appear that the Peale Falcon should logically be found in the entire Gulf of Alaska region, there being no present physiographic barriers to prevent free movement. This, however, may not always have been true, and typical *pealei* is found chiefly south of the arbitrary latitude 55°N. as stated by Brooks, a situation that deserves some comment.

First of all, Dawson and Bowles (1909:531) list the Peale Falcon as the form found breeding on the outer coast of Washington. Californian falconers, however, report that peregrines nesting on high sea cliffs along the northern coast of California are white-breasted and smaller than those I sent to them from Langara Island. There seems little doubt that the Californian birds are, if not typical *anatum*, only slightly different from continental peregrines. It would appear that originally there was a simple cline, the birds becoming progressively darker and more heavily marked northward.

If the Canadian population was at one time so linked to the more southern populations, it has certainly become less so within historic times. The sites listed by Dawson and Bowles were definitely not occupied in 1957 and the population of the Washington coast is, if present at all, much smaller and more scattered than it used to be. It should be pointed out here that the physiographic boundaries which might tend to isolate a coastal race are not well-marked in Washington and Oregon. The gorge of the Columbia River still has occupied peregrine aeries as have some of the lava cliffs of interior Washington. The Cascade Range is neither very high nor very wide, and the Columbia River cuts through to the coast. These conditions permit a relatively easy interchange between coastal and interior populations.

A search of the high cliffs on the islands of Puget Sound for peregrine aeries was completely unsuccessful and indicates that if the birds ever did occupy such places, they no longer do so. The breeding population of *pealei* in Canada is accordingly much more isolated from the continental population than is any residual population of the Washington and Oregon coast. Nevertheless, I would be inclined to postulate the original range of *pealei* as including the Washington coast at least as far south as the mouth of the Columbia. Northwestward from here, the axial ranges of the Cascades and Olympics, the Coast Range and the Vancouver Island Range, and the heavily timbered country associated with these mountain systems tend to separate by over two hundred miles the most western of the known aeries of the continental peregrines from those along the coast.

This isolation of the coastal peregrines while very well marked in Canada and most of southeastern Alaska breaks down again in the region of Cook Inlet and the Gulf of Alaska, but it is re-established in the Aleutians. This conforms fairly well with Brooks' latitude 55°N. as quoted by Bent (1938:68), who writes: "Young birds from the Aleutian Islands are much darker than those I have seen from the Queen Charlottes and very much darker than the darkest of our eastern birds." As indicated previously, this appears to be true but remains puzzling. Why should any easily recognizable subspecies terminate suddenly and be replaced by another in a region where no physical boundaries restrict movement and in an area of ample food supply, then re-express itself as the same subspecies 1500 miles farther west? The problem is one that will have to be left to field workers in Alaska, but I would like to offer the following suggestion. The present bipartite distribution of typical *pealei* can perhaps be accounted for by the fact that virtually the entire Gulf of Alaska region, from at least the vicinity of Cape Fairweather to the Alaska Peninsula and perhaps farther south to include a part of the Alexander Archipelago, has only recently emerged from the last ice age. The entire area was thus uninhabitable to peregrines until fairly recent times. It appears to be in the process of re-population from three directions: (1) by an eastward movement of Aleutian peregrines; (2) by a northwestward movement of Pacific coast peregrines; and (3) by a southwestward movement of highly migratory arctic peregrines.

The discussion here implies acceptance of a third, and thus far unrecognized, race of migratory peregrines inhabiting arctic and subarctic North America. Such a race has been suggested as probably valid and perhaps identical with the Siberian arctic form,



*F. p. leucogenys* (Manning, Höhn, and Macpherson, 1956:52), although Cade (in press) points out that the Russian workers consider *leucogenys* to be a large race while the tundra peregrines of the American arctic are markedly small. Although the A.O.U. Check-list gives *anatum* as the form breeding across the North American arctic, falconers have long insisted that peregrines trapped during migration on Assateague Island and at various other points along the east coast are paler in color, lighter in weight and markedly smaller than the breeding birds of the same area and have coined the name "tundra falcon" to identify them. The most noticeable features of these birds in addition to small size, pale coloration, and light weight are the very light colored crown, the narrow, pointed, and often irregular or broken malar stripe, and the suppression of the tendency to redness in the first-year plumage that is so typical of *anatum*. It is interesting to note that first-year peregrines of known origin from Alaska and the Canadian arctic match the birds trapped on Assateague Island almost exactly in every character just listed.

If one assumes the validity of the arctic race, this subspecies could be expected to reach Pacific tidewaters in those areas north of the coastal and boreal forests where the mountain barriers are discontinuous. Such a condition is met on the Alaska Peninsula and in the Cook Inlet region where the Susitna River forms an avenue from the interior. A small pale subspecies interbreeding with a large dark subspecies (*pealei*) would result in a certain number of birds showing intermediate characters of both size and plumage. Such hybrids would be about the size of *anatum* and might look very much like it, but they should still show the marked suppression of ochre or rufous tints in the plumage, because neither *pealei* nor the tundra peregrine possess that trait. Typical *anatum* probably does not occur in Alaska. I suspect that specimens taken on or near the Gulf of Alaska and appearing to be *anatum* will turn out to be arctic-*pealei* intergrades.

Once the foregoing hypothesis is assumed, the range of the Peale Falcon at once makes sense. Originally inhabiting the entire Gulf of Alaska they were forced to a bipartite coastal distribution by the ice sheets. Langara Island and much of the Queen Charlotte Islands escaped glaciation. The birds thus most clearly marked as *pealei* do occur very closely within the boundaries postulated by Brooks. South of latitude 50°N., the only breeding birds known are those of the Washington coast, and they could well have shown some intergradation with *anatum* to the east and south. North of 55°, in a region only recently again habitable to peregrines, increasing interbreeding with arctic peregrines may be expected. West and south of the Alaska Peninsula, maritime conditions, increasing isolation and probably a long-established population, plus a climate sufficiently mild to permit year-round residence, occur again. It is significant, perhaps, that Bent (1938) notes that young birds from the Aleutians are darker than those from the Queen Charlotte Islands. Friedmann (1950) suggests they represent a different race.

#### BREEDING RANGE AND LOCAL NUMBERS

*Southern limits.*—As mentioned previously, a search for breeding peregrines south of latitude 50°N., both in Puget Sound and along the outer coast, was not successful. The impression given by Jewett *et al.* (1953:186) that the Peale Falcon is still common in Washington State is incorrect. Changes wrought in recent years seem to have had a serious effect on the population. The country looks very much like some of the outer coast of the Charlottes and has a very similar climate. There could well be a few pairs of falcons still inhabiting the less accessible parts of this rugged coastline. Yet I cannot think that they were ever as common here as they are farther north. Two things suggest this conclusion. One is the paucity of seabirds, especially the smaller alcids, and the

other is the comparative poverty of the sea itself that shows all along the shorelines. The variety and richness of life of the intertidal zone, so characteristic of the outer coast of northern British Columbia, is lacking here. This would indicate a lack of a rich planktonic life in these waters, and it is to this source, in the final analysis, that one must look to explain the abundance of peregrines farther north. Carrol Island, by far the most promising of the old sites on the Washington coast, was deserted in 1958 and no other signs of recent occupancy could be found.

There are high cliffs overlooking water on Saltspring Island and near Cowichan Bay on the east side of Vancouver Island that, according to Hickey's (1942) classification, should be first-class peregrine cliffs. Those on Saltspring Island (Mount Maxwell) are nearly vertical and very high, 200 to 500 feet. This area of associated cliffs and those bordering Sansum Narrows were worked thoroughly both from the air with a light sports plane and from the ground. One male peregrine was seen high over the cliffs of Mount Maxwell but it did not stay in the area. These cliffs were definitely not occupied in 1958, nor was there any sign of previous occupancy.

Except in winter, I do not think the Puget Sound region is sufficiently rich in marine bird life of a size suitable to the needs of peregrines, although the region is in many ways singularly like that of the northeastern United States where peregrines do breed.

*The outer coast.*—For comparative purposes the region of the outer coast extending from just north of Cape Flattery (48.5°N.) north to the British Columbia-Alaska boundary between Langara and Forrester islands (54.5°N.) is divided into three subregions: (1) the west coast of Vancouver Island north to and including the Scott Islands, comprising the southern subregion; (2) the islands of Queen Charlotte Sound; and (3) the Queen Charlotte Islands.

Climatically, the three subregions are alike, being characterized by a cool, moist summer climate with winters only slightly colder but with more rain and less fog. Shore-

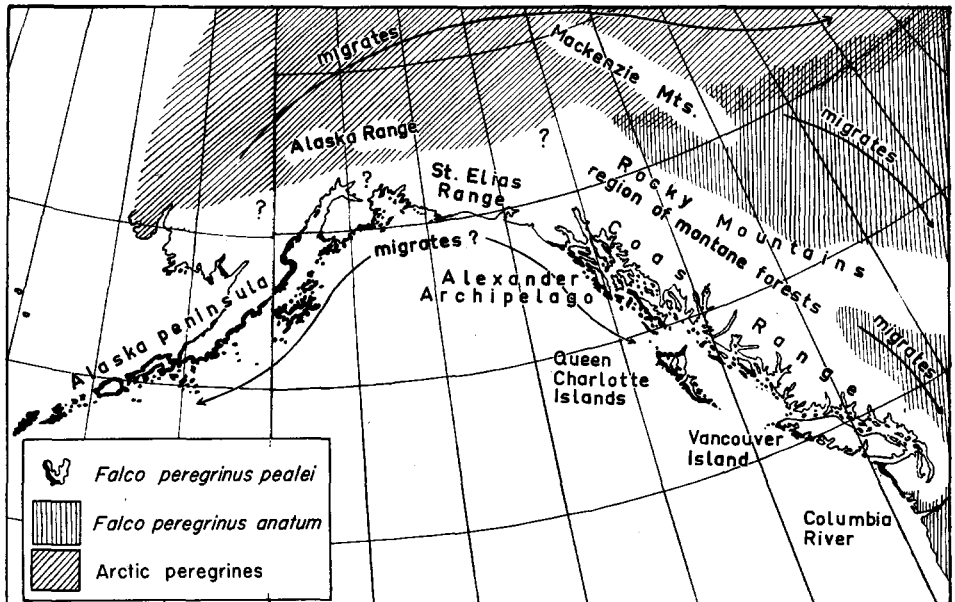


Fig. 5. Postulated breeding range of the Peale Falcon exclusive of the Aleutian and Komandorski islands and of Kamchatka.

line fog is the most marked characteristic of the summer climate, but rainfall is relatively high even during May and June. Temperatures are always cool, averaging between 48° and 54° F. for daytime maxima and seldom going much above 60°. To the human visitor the climate seems unpleasantly cold, and coupled with the rain, fog, and chill winds off the sea, it is usually downright miserable. The comparatively low islands in Queen Charlotte Sound, and perhaps the two outermost of the Scott Islands, may have a slightly better climate with more wind but rather less fog and rain than either the northern or southern subdivisions.

Of these three subregions, I know the southern and extreme northern best, the middle area scarcely at all. There are marked differences in the biology between the north and south that are significant.

1. The southern subregion.—From Jordan River some 40 miles northwest of Victoria northwestward to Cape Beale at the entrance to Barkley Sound, the shoreline of Vancouver Island is regular, and for many miles cliffs from 50 to 100 feet in height face the sea. There are no offshore islands along this stretch of coastline and, as far as is known, no seabird colonies. I cannot say that there are no peregrines along this stretch of coast as there are so many miles of cliffs that are utterly inaccessible, but the poverty of the region in marine bird life is most marked and precludes any high density of peregrines. There may nevertheless be occasional pairs here as every creek flowing to the sea cuts a short vertical-walled canyon for perhaps a quarter of a mile through the sea cliffs.

The islands in Barkley Sound are low, and from Ucuelet to north of Kyuquot the coastline is relatively low and much indented with deep inlets; the offshore islands are low and tree-covered, with very low sea cliffs or none at all.

Northwest of Kyuquot, the mountain mass of Brooks Peninsula juts outward to the southwest at right-angles to the trend of the coastline, and off its point there is a spectacular, jagged, fog-bound rock, Solander Island, the first of the high islands of the outer British Columbia coast. Although separated by a channel less than half a mile in width from the heavily forested tip of Brooks Peninsula, Solander Island is treeless. Ground cover in the form of beachgrass and salmonberry scrub nevertheless dominates all but vertical slopes. The deep, peaty turf is honeycombed with the burrows of seabirds, this being the most southern of the large seabird colonies of the British Columbia coast. The chief species of burrowing alcids are the Tufted Puffin (*Lunda cirrhata*) and the much smaller Cassin Auklet (*Ptychoramphus aleutica*). We found no murrelets, no murrelets. Conditions on this island and the general appearance of the place are strikingly like Triangle Island.

At the time of our visit (June 29 to July 3) there was only one adult falcon in residence, a female in molt, but there was plenty of evidence of recent occupancy by a breeding pair—detached wings of auklets, dead auklets, plucking perches and an empty, but recently occupied aerie site. Inasmuch as young birds are well on the wing by this time, it is pretty certain that a pair raised young on the island in 1954. The isolation and undisturbed nature of this rock are such that the island is likely occupied by one or more pairs annually. It is interesting to note that Solander Island is just north of Brooks' arbitrary 50°N. and is separated by about 200 airline miles from the nearest known, previously occupied (but now deserted), aeries to the south of Cape Flattery and Flattery Rocks. Solander Island, at 50°N., may now mark the southern limit of breeding by *pealei*.

The outer coast from Cape Cook northwestward to Cape Scott, a distance of about 50 miles, has not been investigated. From the sea there appear to be no high islands, certainly none like Solander. There are two small islands off the north side of Cape Cook that may, or may not, have seabird colonies.

The five islands of the Scott Island group form an interesting study in contrasts and present some puzzles. The chain runs westward off the tip of Cape Scott. The two largest islands, Lanz and Cox, are nearest the cape, the two smallest (the "haycocks"), Beresford and Sartine, are next in line, while Triangle, in many ways the most interesting, is outermost. Triangle Island was visited in 1949; Lanz, Cox, Beresford and Sartine were visited in 1950.

An account of the biology of the Scott Island group was published by Carl, Guiguet and Hardy (1951). Lanz and Cox islands are high (695 feet and 1025 feet, respectively), heavily timbered, but with bold cliffs and steep grassy headlands rising from the sea. The two islands are very nearly the same size, roughly  $2\frac{1}{2}$  miles long by about a mile wide and nearly rectangular. They are separated by a deep tide-swept channel only about a half mile wide.

These islands should be the sites of large colonies of seabirds and their attendant falcons, and there is ample evidence that this was once the case. Carl *et al.* (1951:50) report: "Mink were introduced on Lanz Island about 1938 or 1939 . . . . At the time of our visit the mink population appeared to be large. The effect of these mammals upon sea-bird nesting was forcibly brought to our attention, since this unauthorized introduction of a carnivorous mammal has apparently eliminated the island as a nesting-site for pelagic birds." Notwithstanding the apparent total destruction of the marine bird colonies, there was at least one pair of falcons resident on Lanz Island as noted in the same report; but there can be little doubt that the destruction of their major food supply has reduced the number of nesting falcons on this island.

A similar situation was found on Cox Island. Here raccoons were introduced at about the same time as were mink on Lanz. In addition minks are present also, apparently having invaded from Lanz. We were ashore here for only a short time and the one bird colony found was deserted. The first mate of the fisheries patrol vessel "Howay" told us later that he had landed on a point on the southwest side of the island the year before and that there his dog had uncovered nesting seabirds. The picture is therefore still not entirely clear, and there may yet be occupied colonies on one or both of these islands.

The evidence certainly indicates that introductions of mammalian predators constitutes a definite hazard to falcons of the outer coast. Of the two species present on the Scott Islands, the mink appear to be the most destructive, not directly to the falcons, but to their food supply. Raccoons, however, are reported by Hagar (*cf.* Cade, 1954) to be a factor in the low reproductive yield of some eastern peregrine aeries by direct night predation on the young.

Beresford and Sartine are very small islands rising steeply from the sea. Beresford is almost circular in shape, with high sea cliffs, rounded on top with a cap of short, wind-pruned timber. Sartine is a narrow, precipitous, treeless ridge but covered with deep soil and high grass, as is Solander. Both islands have large colonies of burrowing alcids (puffins and auklets), and both had one pair each of breeding peregrines at the time of our visit. An occupied nest of a Bald Eagle (*Haliaeetus leucocephalus*) was also present on the top of Beresford.

Triangle Island, outermost of the Scott Islands, is the most truly marine in character of the islands of the British Columbian coast. It has an interesting history and a rugged climate that is recorded in some detail by Carl, Guiguet and Hardy (1951). The Provincial Museum party visited the island in 1949 from June 24 to July 1. At that time there were four pairs of falcons resident, all with flying young. As the island, roughly triangular, measures only about three-quarters of a mile to the side, this is a high density and much the highest encountered in the southern third of the range of *pealei* in Canada.

Even assuming there are several pairs on Lanz and Cox islands, and three or four pairs between Cape Scott and Cape Cook, the total population from this subregion is not large. The known population totals exactly eight pairs, one each for Solander, Beresford and Sartine, one for Lanz and the four on Triangle. It is probably somewhat higher than this, especially if some of the seabird colonies on Lanz and Cox are still producing; but even doubling the number would give only sixteen pairs. I do not think there are that many.

There are some significant differences in the food species available to these southern falcons and those breeding farther north, and after studying both groups the observer is forced to conclude that the southern aeries, favorable as they appear at first, are in reality marginal.

The burrowing alcids of the Scott Islands and of Solander Island are confined to three species: Pigeon Guillemot (*Cepphus columba*), Tufted Puffin, and Cassin Auklet. The islands seem to lie south of the range of the Ancient Murrelet (*Synthliboramphus antiquus*). The two Pacific coast petrels, although recorded, are not common. The food of the breeding peregrines on all these islands seems confined to the Cassin Auklet. Although thousands of birds of other species flew under and around the falcons, peregrines were never observed to molest them in any way; but the wings of the little Cassin Auklet littered their plucking perches and the platforms of the aerie sites. Moreover, Cassin Auklets taken from the nesting burrows and thrown out in free flight in sight of passing falcons were in almost every case singled out from the milling throng of other seabirds, attacked, and taken.

On the three islands that are free of mammalian predators, the numbers of this alcid are so large that I doubt if estimates of their numbers could be accurate. There is scarcely a square foot of turf-covered land surface that does not have one or more burrows. The bird is small, weighing only four or five ounces, and nondescript gray in color. The flight is very swift but the wings are surprisingly small. Although not strictly nocturnal, since they may be seen at sea in daylight, they are so in their flights to and from nest burrows, and it is puzzling how the falcons take as many of them as they clearly do. There are some observations to be mentioned from Langara Island which indicate that most of these auklets are taken either very early in the morning or very late in the evening. They are also very likely to be taken from the water by the same techniques observed to be used with similar species farther north. Carl *et al.* (1951:45) lists the food of the Cassin Auklet as "primarily . . . the shrimp-like . . . [euphausiid] *Thysanoessa spinifera*."

Although this small population of *pealei* may be marginal in that the members seem entirely dependent on a single food species, they do occupy habitat optimal in most other respects. With the exception of Lanz and Cox, the islands are entirely free of land predators and almost equally free of disturbance by man. I doubt that a single bird or egg has been taken or destroyed on these islands by human agency since the abandonment of the weather station and lighthouse on Triangle Island in 1921.

On all these islands, the falcon aeries were not on cliffs. In fact, except for Beresford and a small detached fragment of Triangle, cliffs are not characteristic of these islands. The aerie sites were located here near the top of very steep, grass-covered slopes. Approach to these sites was not difficult if made with care from above; the slopes beneath the aeries, although clad in vegetation, were nearly vertical and far too steep to climb. The site on Beresford was under an overhang of rock; the sites on Triangle, Solander and Sartine were completely exposed. Considering the wind velocities known to buffet these islands, the exposure of young to such conditions seems remarkable. Despite this apparent hazard, brood success appeared high. We saw no young on Solander Island,

nor on Sartine, although adult birds and nest sites were present on both. Beresford had two flying young in addition to the adults; and broods of two, two, and three were observed at three of the four sites on Triangle. No young were observed at the fourth site.

Eagles were not observed on Solander nor on Sartine, but they must certainly occur on both islands. There was a nesting pair on Beresford, and they were extremely numerous on Triangle. One unoccupied nest was found, built on the ground near the summit of the island. There were certainly in excess of 50 eagles present on Triangle Island all the time we were there, and clashes between them and the falcons were so frequent that they soon ceased to be interesting. Detailed observations of the interrelationships of these two species were made on Langara Island (see beyond).

2. The middle subregion.—The same general conditions as described for the Scott Islands prevail along nearly 100 airline miles of the outer coastal islands of Queen Charlotte Sound and along 200 airline miles of the outer coast of the Queen Charlotte Islands. I have so far had no opportunity to do any observation except from the air in either of these areas.

Some information, however, is available. Guignet (1953) spent three months (May to August, 1948) on the Goose Islands about midway between Cape Cook and Cape St. James. In his report he notes only one small colony of the Fork-tailed Petrel (*Oceanodroma furcata*) from Fingal Island, just north of the Goose Islands. No other burrowing marine bird was found except the ubiquitous Pigeon Guillemot. One falcon was seen on the Goose Islands, but there was no evidence of breeding birds. There are unconfirmed reports of "seabird rookeries" at two points on Aristazabal Island and on Lady Douglas Island, but neither the size of the colonies nor the component species is known, nor whether these colonies are attended by breeding falcons. However, the A.O.U. Checklist (1957:119) cites the Moore Islands (off Aristazabal) as a breeding site for *pealei*.

From the air most of the outer islands of Queen Charlotte Sound appear to agree with Guignet's description of the Goose Islands—low, with a heavy fringe of large timber, opening to scrub or semi-open muskeg in the interior. Most of them do not look like the type of island that is either suitable for large seabird colonies or for falcons. It should be noted here, however, as pointed out by Bond (1946:105), that high cliffs are not a prerequisite to breeding by peregrines in an undisturbed insular habitat. They are perfectly adaptable to any reasonably steep, open slope with a ledge or sheltered area near the top. Further, that slope need be of no great height. Guignet (unpublished field notes) found a pair with young in the nest a scant 20 feet above the high tide line on Graham Island opposite Frederick in 1946, and I found one aerie on Langara in 1956 with three well-grown young no more than 15 feet above the water.

3. The northern subregion.—The outer coast of the Queen Charlotte Islands appears to be, in many respects, the most favorable habitat in British Columbia for both breeding seabirds and for falcons, and it is tempting to expect a high density of peregrines along this entire two hundred miles of outer coast. Such an expectation would be based on the belief that conditions and densities occurring on Langara Island and certain other islands extend south to Cape St. James. The available evidence, however, is not consistent. The facts are not to be found easily, and there are factors of man-induced change and disturbance that could easily and unfavorably alter the biology of the region.

Much of what is known of the outer coast of the Queen Charlotte Islands is based on work done on Langara Island, and to a lesser extent on that done on Frederick and Hippa islands to the south. The reason for this is very simple. Langara Island is reasonably accessible, it has a sheltered, all-weather harbor, and in the summer fishing season there are certain amenities available to the visitor there that make living reasonably secure and comfortable in what is otherwise a cold, wet, and hostile environment.

The continental shelf west of the Queen Charlotte Islands and the waters of Dixon Entrance are the richest in western Canada, and commercial fishing for salmon and halibut is the most important industry in the region. Safe harbors adjacent to open water are none too numerous, and Henslung Bay at the extreme south tip of Langara Island is the best in the entire area.

The expeditions to Langara were therefore planned to take advantage of these facilities, the fishing season coinciding very nicely with the time when the falcons are raising young. The total time spent on the island in any one season was not particularly long. Nevertheless, a good amount of comparative data has been accumulated. The revisiting each year of a number of aeries and aerie areas as large as the series on Langara is productive of information that is not apparent from a single visit of much longer duration.

The population of peregrines on Langara has long been known to be one of very high density, so much so as to contradict certain concepts regarding the biology of these birds (Green, 1916; Brooks, 1926:77). Thus, on North Island (Langara) in the breeding season, according to Brooks (*loc. cit.*), "one is never out of hearing of the birds. Sometimes three broods of fledglings can be heard calling from one vantage point, and probably thirty-five pairs nest on the twenty-five miles of coast-line of this small island alone."

Seabird burrows are everywhere on the slopes facing the sea and the sight and smell of them are as much a part of the island as the trees, gullies, down timber and the endless roar of the surf.

It is interesting to note that both Green and Brooks infer that conditions along the entire outer coast of the Charlottes are very like those they found on Langara; they both further infer a population density along the entire coastline of Langara comparable to the sector they worked. It is fairly certain that they worked the same aerie sites and coastline that were covered by our expeditions in much greater detail over the recent five-year period, the reason being that we worked nearly all the coastline that is accessible. My own estimate of the population of falcons on Langara after my first visit in 1952 was very like that of Brooks. Now, six years later, I am convinced that this estimate is too high.

I have personal knowledge of 16 aerie areas on Langara Island, and I have definite information on two more. These 18 areas cover all suitable shoreline of Langara Island with the exception of the extreme west side from Langara Point to Lacey Island and the south side from Lacey Island to Rhodes Point. Not all these areas have been occupied every year, and two of them only once each in five years. Such areas must, therefore, be considered marginal, even though the reasons for their being so are not clear. Assuming four more such areas on the unexplored south and west coastline, the total population at maximum density would be 20 pairs. This is still 16 short of Brooks' estimate of 35 pairs, and I am sure that even the former figure is higher than the average over a number of years.

Aerie areas are well marked, the better ones being occupied regularly year after year, although the actual nest location (aerie site) may be shifted to one or another of a number of alternates. Only one aerie site has been occupied continuously at every visit. Aerie areas are shown in figure 8. For each a distinctive place name is given.

Beginning at Henslung Bay and working around the island to the east and thence along the north side to Langara Point, the first aerie area is about half a mile east of camp on a high point overlooking the semi-permanent native village of Dadens. The favored site is on the cliff above the village directly over the sea, but two alternate sites on cliffs farther back from the sea are sometimes used.

Beyond Egeria Bay to the north is Cohoe Point, a marginal area, the site at the point being occupied in 1955 and an alternate site on timber-hidden cliffs in Dibrell Bay occupied in 1952. Andrews

Point is generally occupied, although the highest cliffs are only 20 feet from base to summit. There are three alternate sites in 200 yards of cliff face. Between Andrews and McPherson points in Explorer Bay, on low 30-foot cliffs entirely hidden by timber, is another marginal site occupied in 1955. McPherson Point has been continuously occupied and must be considered a preferred area. There are three known sites, the favorite at the top of a 40-foot cliff some distance from the sea, and two alternates, one of which is on a little 20-foot cliff with the site no more than 15 feet above high-tide line. West of McPherson Point about a mile is an abandoned radar post, and right below it is an aerie area. This area of cliffs, although very small, has three known aerie sites and has been continuously occupied at least since the radar post was abandoned, and must be considered a preferred area. Guignet (unpublished field notes) reports three areas west of this one. The first, immediately west of the radar post is possibly but not probably an alternate site to the one just listed. Another area is at a flat-topped rock about a half-mile east of the light at Langara Point; the third is directly below the lighthouse on Langara Point.

The aerie areas on the east and north sides of Langara conform in one important respect to the usual pattern of peregrine nest areas in that they are spaced from half a mile to about two miles apart. Aside from this spacing, they violate nearly every other popular concept relating to peregrine aeries. All of them are on very low cliffs; all are surrounded by heavy timber. They do not face the sea or overlook the water (even the low site previously mentioned faces inland across a narrow inlet). The ocean is, of course, in all cases, no great distance away. Yet three of these are evidently good areas, and two of them have been occupied every season that I have been on the island.

Immediately west of Henslung Bay, above an old Indian burial cave, is a marginal site that has been occupied twice in the five-year interval. Less than half a mile farther west on a 100-foot cliff of a deep gully cutting in from the south is one of the best areas on the island. Here there seem to be no alternate nest sites, and the same place has been occupied every season. The site gives every appearance of having been occupied for centuries. This is the first of a remarkable series of six aerie areas that may mark the highest local density of peregrines anywhere in the world.

Just around the point from this site that we shall call the "cleft" area, is Cloak Bay with its weird and wild scenery of detached rock pinnacles standing clear of the sea, and with the high vertical cliffs and attendant pinnacles of Cox Island just offshore. Here, in a linear distance of somewhat over a mile, but in less than two square miles of land and sea surface, are concentrated never less than five, usually six and sometimes eight breeding pairs of peregrines. In this area the spatial requirements of peregrines are, in comparison with other areas, unbelievably small, and evidence of territorialism and intolerance, if present at all, is not easy to observe. It is certainly to the area of Cloak Bay that Brooks referred when he mentions being able to hear three broods calling at one time, and it is here also that even an experienced observer visiting the outer coast for the first time is very likely to be carried away in gross overestimates of the total population.

The aerie areas are associated with the pinnacles, and there are five of these. The first is just across the ridge from the site in the cleft, in air distance much less than a quarter of a mile. It has three known alternate sites all on the pinnacle. The pinnacle itself is about 200 feet high; the sites vary from one under a root scarcely 20 feet from the top, and in no sense on a cliff, to a very difficult site about half way down on the west side just at the top of an overhanging cliff but still about 100 feet above the beach. A scant quarter of a mile farther along the beach to the north are two more pinnacles standing very close together and referred to here as the twin pinnacles. The area of these is always occupied. There is a site on each of the pinnacles and two more alternate sites on the ancient shore cliffs back from them. There seems to be no preferred site in this series.

A little over a quarter of a mile farther north along the beach rises yet another pinnacle, referred to here as the third pinnacle. The area of this pinnacle is again regularly occupied by a breeding pair of peregrines. This is a small pinnacle, a scant 100 feet high and sheer on all sides except the knife-edged north ridge. There is a much favored but rather inadequate site on the pinnacle itself and an alternate on the rather low ancient shore cliffs back from it.

The fourth and last pinnacle of the series, almost a mile north of the third, is magnificent. It rises in sheer grand cliffs over 200 feet above the old beaches and is much the largest of the series. Oddly enough the area of this great rock is the most marginal of all and it is not always occupied.

The presence of a well-marked series of intermittently occupied areas is one of the more puzzling



aspects of the falcon population of the island. These marginal areas are at Cohoe Point on the east side, above the burial cave just west of Henslung Bay, and at the fourth pinnacle in Cloak Bay. In these areas the successful rearing of a brood by a mature pair does not indicate that the area will be reoccupied the next season. This is in contrast to the permanent areas where even the shooting of both adults is followed by immediate reoccupation the next season. There is no reason, visible to the human eye, why these areas should not be permanent. The fact remains that they are not. The fourth pinnacle, occupied in 1952 and again in 1957, appears to be a far better area than that about any of the other pinnacles. It is well removed from the rest, has higher, longer cliffs and plenty of large nesting ledges, yet it is seldom occupied. Cohoe Point has higher cliffs than either Andrews or McPherson points and is much less subject to human disturbance, yet to my knowledge it was occupied only in



Fig. 6. Falcon aerie site on Cox Island, Queen Charlotte Islands. Note vegetation growing on and overhanging the cliff; dead tree directly over the aerie site (outlined) is about six feet in diameter. Photograph by G. C. Carl.

1955. The area immediately to the west of the camp at Henslung Bay is the only one of the series where the reason for the lack of favor is discernible. Here there is only one possible spot for the actual aerie. The nest platform is none too large and slants outward slightly instead of being perfectly flat. It has no overhanging tree or tree roots and is completely exposed. This site was successfully occupied in 1957 and three young were fledged. In other years it has been occupied by a lone, apparently unmated female.

Out on the bay Cox Island rises in sheer, 300-foot cliffs from the old sea beaches at its base. This small island is regularly occupied by a pair of falcons, and I would suspect it to be the most attractive area of the entire group. To the north of Cox Island the cliffs extend westward fronted by a beach that can be walked at low tide. This beach was walked out to Rhodes Point at Fury Bay in 1955, and two unoccupied aerie sites were found on the cliffs there. We did not go beyond Rhodes Point; although there are very high cliffs extending on to the westward, it was apparent we were already out of the very high density of falcons that for some reason are packed into this one small area of pinnacles facing Cox Island.

Green's observations would indicate that there may be a comparable density on Knox Peninsula on Graham Island. In 1952, the museum party crossed the peninsula by way of the old Indian trail that runs from the ruins of the Haida town of Kiusta on the north shore of Graham Island through the woods to Lepass Bay. On the cliffs to the north of Lepass Bay two aeries were noted but they have not been visited since.

#### BIOLOGY OF THE FALCONS ON LANGARA ISLAND

*Onset of breeding.*—I have no notes on arrival dates of falcons at their nesting areas on Langara. When we arrived on the islands on April 13, 1952, the breeding areas we visited had falcons in residence. We saw no flight displays or any other pre-nesting behavior such as mate selection or territorial aggressiveness. The pair on Cox Island and the pair above the native village at Dadens were both definitely on eggs. The aerie site nearest to camp was not occupied by a pair but was being used by a lone female as a lookout point and plucking perch. This bird was under daily observation from camp for long periods of time. Bannerman (1956:35) states that falcons on the coast of Wales (about the same latitude as Langara) start to incubate about April 15, which would put egg laying into the first two weeks of April and any display activity into the latter weeks of March. This timing seems to match very closely that of the earlier birds nesting on Langara; in fact, I suspect that nearly all the favored areas are occupied by that time. Yet, on Langara there are either falcons raising two broods, or some areas are occupied in succession by two different pairs, or else (and most likely) there is a marked staggering of the time of hatching due to predation of some kind on eggs, young, or both. At any rate, I have been to Langara only one time, in 1957, when there were not both fresh eggs and flying young at different aeries on the same date.

Green (1916:475) visiting the islands specifically for the purpose of collecting eggs, notes: "Peale's falcon lays, of course, four eggs . . . . When the completed clutch is taken, before incubation begins, the bird begins her fresh set close by the first in about ten days, but if incubation is advanced it will be more like three weeks before the new set is laid." This is observed evidence of capacity for renesting. Bannerman (1956:37), quoting Nethersole-Thompson and Col. Ryves, lists British peregrines as laying eggs at two-day, rarely three-day intervals, incubation starting with the second-to-last or last egg and continuing for 28 to 30 days. I have no such detailed data for the northwest coast birds, but there is no reason to expect much difference.

Observations of British peregrines (Bannerman, 1956) indicate that incubation of the eggs does not begin until the clutch is complete or nearly so. I have seen several nests on Langara in which the young were only, at most, two days out of the egg, and in all instances the brood seemed to be very much the same age. Peregrines in a maritime habitat at this latitude do not seem to begin incubation with the first egg and then continue to lay as is the case with some of the arctic raptors, a situation that makes for a marked difference in the size of the nestlings.

It is worth noting at this point that all birds observed in breeding pairs were fully mature individuals. In no instance were birds observed either in immature plumage, or even in plumage showing traces of immaturity.

*Nest sites.*—Green (1916:474–475) further notes that most of the sites he investigated were located at "the very top of the cliff under the roots of a spruce-tree growing on the edge . . . which gives shelter to the sitting bird in rainy weather." A good many, I think most, of the Langara aeries do fit this description, although they are not all actually at the top of a cliff. The amount of shelter afforded by the roots of the big trees is remarkable, and the flat, sheltered area often extends in under the roots six feet or so as a sort of shallow cave. Such places are, considering the climate, remarkably dry, as Green notes. In contrast to the sheltered sites on Langara are the utterly exposed situ-

ations selected by the Triangle Island birds. It appears that shelter, however desirable, is not as much a prerequisite to selection of a nest site and brood success as examination of the Langara sites alone would tend to indicate.

Hickey (1942:180) states that "the peregrine appears to possess an absolute requirement in that the eggs must be laid in a hollow which is scraped out of dirt, gravel, or similar material." This is not particularly true of the Pacific coast peregrines. In aeries showing long-continued use, this is true, but in those places—and they are rather frequent—where the birds are reoccupying an alternate site that has been unused for a period of two or three years, the eggs are laid on the fresh green moss. Two sets of fresh eggs were found in such situations.

*Territorial behavior.*—The apparent lack of aggressive behavior of mated pairs toward other peregrines is one of the most puzzling observations made on Langara Island, especially when compared to the observed actions of mated pairs in other areas. Cade (in press), writing of arctic peregrines, notes that in an area generously supplied with cliffs the average distance between aeries was seven to eight miles and the least distance was about one-quarter of a mile. He considers territorial aggressiveness between mated pairs as being the most likely reason for lack of a higher population density. The situation in the vicinity of Cloak Bay would seem to indicate that territorial behavior is markedly modified by the abundance of food and may not be, by itself, as much of a limiting factor as has been assumed.

The pairs occupying the pinnacle areas are nearest together and, with the pair in the cleft and the pair on Cox Island form a tight grouping of five pairs that can, at times, all be seen in the air at once. In this close grouping I have observed no hostility between pairs; yet deep invasion of one another's "territory" is commonplace. The pair occupying the cleft, for instance, has been observed harrying eagles as far east as the aerie area at Dadens. Similarly the pair at Dadens has been observed (from Henslung Bay) to cross over the areas at the burial cave and the cleft and go out of sight over the point toward Cloak Bay. Any eagle passing close along the shore around the corner from Parry Passage to Cloak Bay is passed from pair to pair, and its progress can be followed by the sound of screaming falcons from east of the cleft right around past the third pinnacle. Here, again, despite the penetration of the territory of one pair by one or both birds of an adjacent pair, there are apparently no clashes between the peregrines.

Green made no observations on aggressiveness between pairs, nor did Brooks or Guiguet. Nevertheless, despite the lack of observable intraspecific intolerance, certain inferences do indicate that territorialism, although markedly modified, is still a factor of some importance. The presence of clearly delimitable aerie areas is itself an indication of territorialism. In every one of these areas, there are plenty of cliffs and ledges that could provide nest sites for additional pairs of peregrines. The presence in most of the areas of from one to three alternate nest sites is sufficient proof of that. There is also nothing even approaching full utilization of the food supply. Cox Island, for instance, is annually occupied by only one pair of falcons, yet on this one small island alone there are cliffs and ledges, and certainly food, for all the falcons in Cloak Bay. Observations during early courtship and nest-selection stage are totally lacking, and it is at this time that territorialism is likely to be most observable and rigidly enforced. Later, with eggs or young in the nest and food always immediately at hand, a tolerance could easily be developed that might not be present at all in March and early April.

*Aggressiveness at the aerie.*—The reaction of breeding falcons to interference or near approach by man is singularly like their reactions to eagles; that is, the man seems to be recognized as a potential menace to the eggs or young and the birds become excited and noisy. Incubating birds are considerably less demonstrative, and some are so quiet

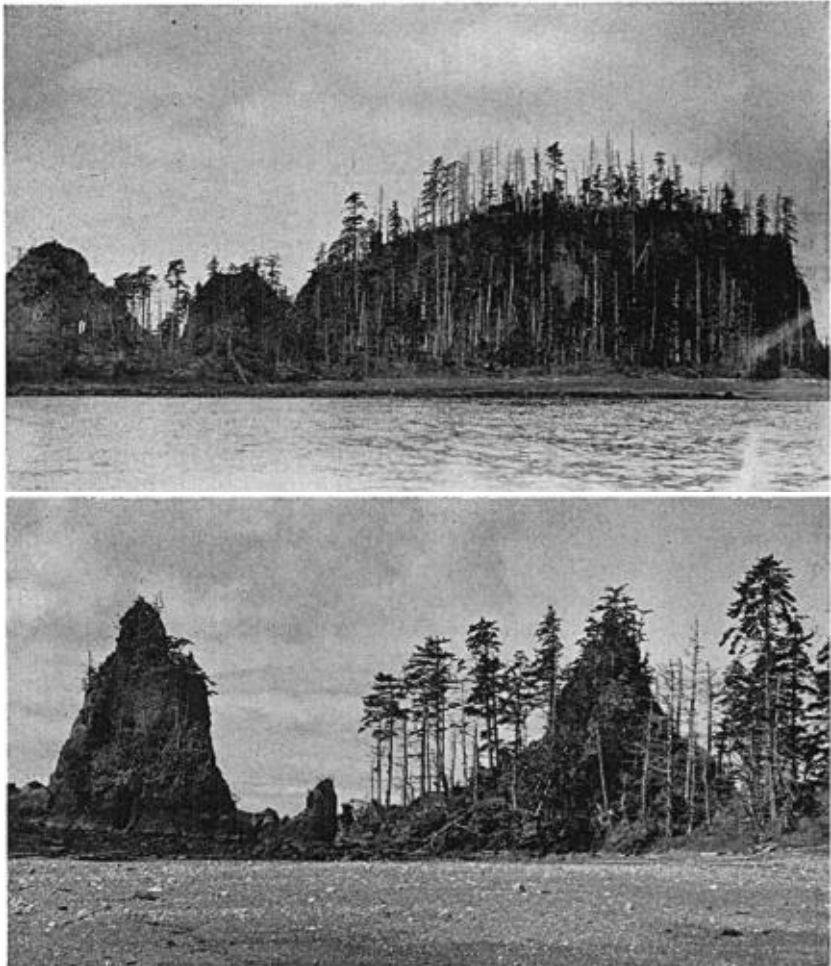


Fig. 7. Cox Island, Queen Charlotte Islands.

Above, from Cloak Bay; the highest cliffs are about 300 feet high.

Below, pinnacles and old beaches lifted clear of the sea by recent geological uplift.

that they escape notice. As the young develop, so too does the interest of the parent birds in their welfare, as long as they remain in the aerie; but as soon as they fly, the adult birds quickly become much less apprehensive. Within this pattern are wide variations. Some adults are very aggressive; others are just as noisy but much less intimidating. The most aggressive single individual was the male at Cox Island in 1955. While I was on the nest platform, this bird repeatedly whipped past so close that the wind of his passing was distinctly felt, yet he never actually struck. An interesting aspect of this bird's behavior was its awareness of being watched. As long as I kept my eyes on him, he would circle and scream; but the instant I gave my attention to something else, I would feel the rush of his slipstream as he zipped past. The pair at the cleft the same year were almost as bold, both birds making some spectacular stoops but pulling out just short of actual contact. By contrast, the pair at McPherson Point stayed high in the

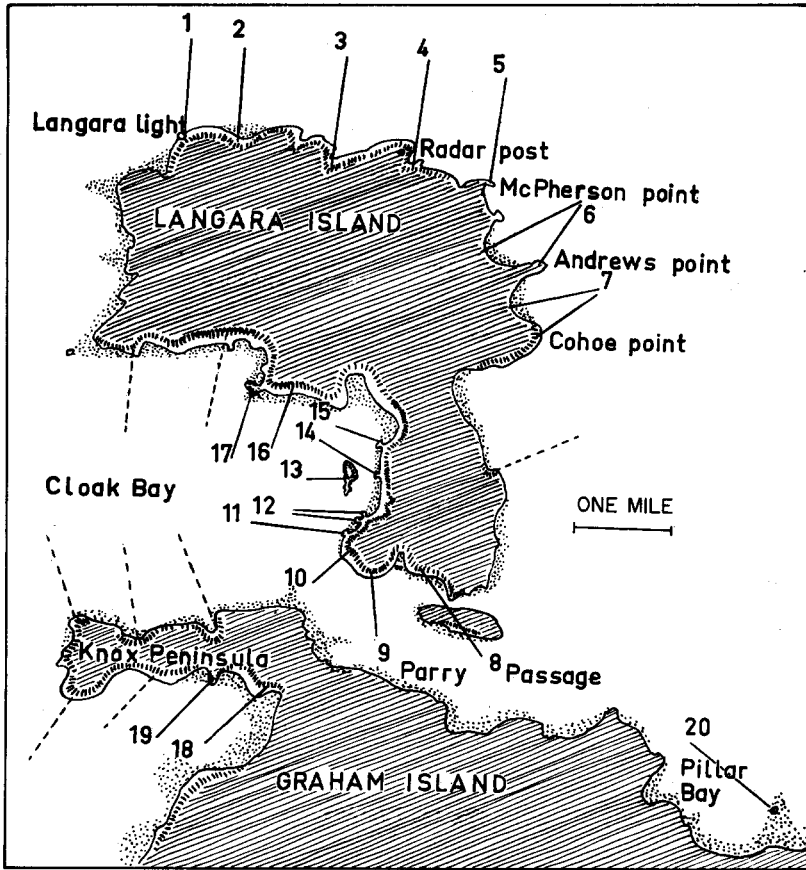


Fig. 8. Langara Island and the northwest corner of Graham Island, Queen Charlotte Islands, showing aerie areas of the Peale Falcon mentioned in text; dashed lines indicate areas of cliffs where unrecorded pairs might be found. 1, Langara light; 2, known, no data; 3, known, no data; 4, radar post; 5, McPherson Point; 6, Andrews Point; 7, Cohoe Point; 8, Dadens; 9, Burial Cave; 10, cleft; 11, first pinnacle; 12, twin pinnacles; 13, Cox Island; 14, third pinnacle; 15, fourth pinnacle; 16, Fury Bay site; 17, Fury Bay site; 18, Knox Peninsula; 19, Knox Peninsula; 20, Pillar Bay.

air, or perched in trees screaming continuously (see frontispiece), but never carrying through a single maneuver that could be considered in the least intimidating.

A marked characteristic of breeding birds is that they are much more sensitive to persons approaching along the beach from below the aerie than to persons approaching from above. This same behavior is also noted in their relationship to eagles. Birds may thus show apprehension to persons walking the beach below the aerie when they are as much as half a mile away, yet they show no particular interest in invaders from above until the actual descent to the aerie site is begun. Territoriality, as expressed by aggression, thus takes the form of a spatial hemisphere of varying size in front of and below the aerie, but it extends very little above it and (apparently) behind it not at all. The direction in which nearby aeries face may thus be fully as important as the actual distance from one another. In this regard it is worth noting that none of the closely spaced aeries in Cloak Bay face one another.

*Relationships with eagles.*—Statements just made are confirmed by observations of relationships between falcons and eagles. The Bald Eagle is extremely abundant on Langara Island both as a breeding and nonbreeding species, there being large numbers of the first- and second-year individuals. Eagles far outnumber the falcons, and groups of 10 to 20 individuals are not at all uncommon anywhere around the coast of the island. The breeding population is also very large, considerably larger than that of the breeding falcons. Brief mention has already been made of the frequency of clashes between these species on Triangle Island. The same conditions obtain on Langara. It is in the relationships of these two species that observations of territoriality and aggressiveness are most easily observed.

Eagles are sometimes "attacked" by one or more falcons when they are well out over the sea at considerable distance from any aerie. The stoops of the falcon in these instances are cut off well short of the eagle and do not seem to worry the larger bird much, as it often ignores the cries of the falcons and continues to circle and soar. Eagles are also attacked, and in a very different manner, when they pass close to the cliffs at a level with, or somewhat below, that of the aerie site. At beach level or well above the aerie they may be allowed to pass unmolested, particularly when above. When the flight course of an eagle is such that it will pass close to the aerie, both members of a pair usually take part in attack. The initial attack is launched with the apparent intention of doing no more than turning the eagle to make it change its course; but should this fail and the larger bird by accident or design continues on toward the aerie, the falcons then attack in earnest. The screams of the falcons increase in pitch and frequency, caution is cast aside, and the falcons pitch headlong in terrific stoops at the eagle. They carry through these attacks, aiming alternate attacks at the "blind spot" between the wings in the center of the back. The eagle puts on speed, twists and turns, and shows a marvelous ability to roll over on its back and present outstretched talons toward the plunging falcons. The latter in turn show an equally amazing ability to pull out of a stoop just short of the clutching feet. Occasionally an eagle is hit. This occurs only when the eagle is under attack by two falcons and is unable to recover from a roll fast enough to present the same defense to the second falcon. The presence of the observer is not a factor in these clashes. They are of repeated occurrence all day long anywhere about the island.

An interesting encounter of a very different nature was observed at the aerie on the first pinnacle in 1957. Here a pair of eagles had its nest in a large dead spruce no more than 100 yards behind, and perhaps 300 feet above, the falcon aerie. I was approaching from above, and the falcons were as yet either unaware or unconcerned about my presence although I was, in fact, quite close to the aerie. My course down the very steep slope took me past the base of the eagle's tree and the eagles were distinctly disturbed. As I worked on down below the tree, the female falcon appeared suddenly from behind the pinnacle, crossing parallel to the coastline, from left to right. At her appearance the male eagle left the nest in a straight, swift, downhill rush at the falcon. In this case the falcon, despite her vaunted power of flight, was hard-pressed to escape. She seemed to sense her peril almost the moment the eagle started his rush, for she changed course and, diving for speed, headed out to sea. The eagle overtook her and for an instant there was an intense moment of twisting and turning, the feet of the eagle came down, struck, and missed. The falcon broke clear, veering off to the left, and the eagle continued a straight course out to sea. The entire incident took less than five seconds and both birds were completely silent; the falcon made no attempt at retaliation. The presence of the observer in this instance was almost certainly the disturbing factor that caused the eagle to attack the falcon by way of substitute. Nevertheless, the incident

points up the very edgy nature of anything resembling tolerance between these two species. These same eagles were attacked by the falcons on occasions when, on leaving the nest, the former dropped steeply down the gully and came out in the clear below the level of the falcon aerie.

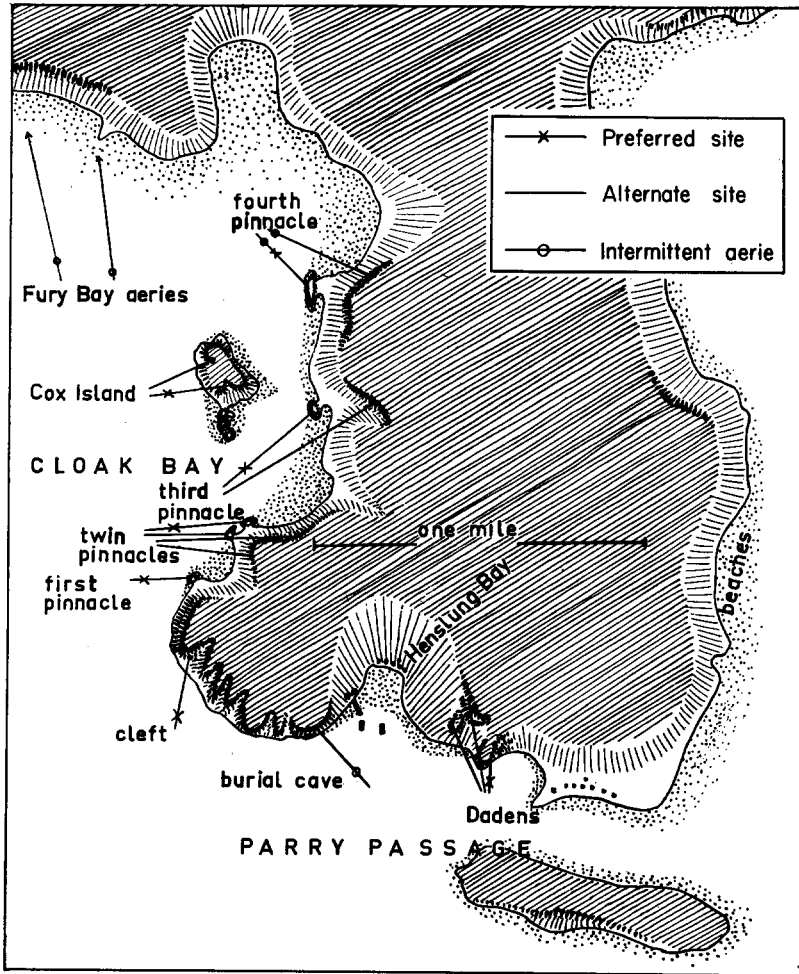


Fig. 9. Cloak Bay and Parry Passage, Langara Island, showing high density of breeding peregrine population and location of aerie sites.

*Food.*—While walking through the fringe forest above the aerie site at the burial cave in 1957, I watched a lone Glaucous-winged Gull (*Larus glaucescens*) fly past below the aerie site. Both adult birds suddenly left the nest ledge and set upon this gull. It was quickly forced to the water, and, after swimming a short distance, it took to the air again and went its way. The incident is mentioned because it is so unusual. Except for the attacks on eagles, this is the only time I have seen the breeding falcons of the outer coast attack anything except the four food species.

Before dealing with food species, it might be well to list the birds common on the islands that are not attacked. Of these, the larger ones—gulls, ravens, cormorants and

puffins—might be considered somewhat immune due to size alone, although the puffin is normal prey for peregrines in some other areas. On the other hand, the abundant Northwestern Crow (*Corvus caurinus*) and the Pigeon Guillemot are certainly easily within the ability of the big Peale Falcon both to kill and to carry, but these are never molested, nor are their remains found in or about nest sites. Even more interesting, two species of passerines are both abundant and, it would appear, available to falcons. These are the Fox Sparrow (*Passerella iliaca*) and the Hermit Thrush (*Hylocichla guttata*). Both of these species habitually frequent the beaches and foreshore around the islands and are often out on open beaches far from cover. The falcons pay no attention to them, and their remains are never found among the numerous falcon kills.

The high density of falcons on Langara, especially in the vicinity of Cloak Bay, and on certain other islands along the outer coast appears to be nothing more than a very marked contraction of the space requirements normal to the species in response to the easy availability of certain food species present in astronomical numbers and located so close at hand that both sexes can do most of their hunting right from the aerie site. The efficiency of peregrines in obtaining food for themselves and their young has long been assumed to be high. Even Cade (1954:15) remarks: "I am inclined to doubt that there are many regions which support such a low total bird population that a pair of peregrines could not make a living off it." I think the matter is not quite so simple. Falcons have long been observed to show very strong preferences for certain types of prey, but the exact reasons for these preferences are not too clear. The breeding falcons of the outer coast are apparently completely "fixed" to four, occasionally five, prey species and the conditions and reasons for this are remarkably easy to observe.

A "good" prey species must have certain characteristics. It should be palatable, sufficiently numerous to provide many opportunities for the predator to make kills, and small enough for either sex to carry. Finally, and perhaps most important, it must be in some particular way, or at some particular time, vulnerable to attack; that is, it must have some biological peculiarity that the predator can regularly and repeatedly exploit. All four species utilized by the west coast peregrines meet these requirements.

The incredible number of Cassin Auklets breeding on Triangle Island has already been noted. Langara, Frederick and Hippa islands and Forrester Island (in Alaska) have what must be, in the aggregate, a much higher population of a similar and closely allied species, the Ancient Murrelet. There are somewhat smaller colonies of the Cassin Auklet at various points on Langara, too, and one large colony of two species of petrels (*Oceanodroma furcata* and *O. leucorhoa*). These four species, but especially the Ancient Murrelet, are the chief food species of the breeding falcons. One other species may at times be taken; this is the Marbled Murrelet (*Brachyramphus marmoratus*), but it cannot be very important, being neither as numerous nor, by its habits, as exposed to attack by the falcons. It is, however, within the size range of the species regularly taken. In the five years that I have visited the islands, I have examined thousands of kill remains both in and around the aeries and scattered over the forest floor. Every one was one of the four favored species.

The Cassin Auklet is about the same size and weight as the Mourning Dove (*Zenaidura macroura*), but it appears much smaller because of its tiny wings. The Ancient Murrelet is somewhat larger, weighing between eight and ten ounces, and having a body size comparable to that of the common domestic pigeon but with wings scarcely larger than those of a swallow. The flight is very like that of the Cassin Auklet, very swift and straight, with little maneuverability.

The nest burrows of the Ancient Murrelet are dug into the moss and soil of the steep slopes of the fringe forest, but they are not found higher up in the scrub. They inhabit



certain grassy slopes and headlands with the Cassin Auklet, most noticeably the steep slopes behind Cloak Bay and in the grassy parkland at McPherson Point, and they are found with Cassin Auklets and the two species of petrels on Cox Island. The entire fringe forest seems to be one continuous colony, extending to all parts of the island that I know, from Cloak Bay around to Langara Light. The numbers can only be described as astronomical.

This murrelet is a most interesting species and worth considerable study in its own right. Most of the smaller alcids are burrowing birds. Except for this one species, all lay one egg and the young are raised to flying age in the burrow. The Ancient Murrelet lays two eggs, and the young are precocial, following the adults down the steep hillsides and out to sea the first night after hatching. Were it not for a considerable spread in the time of egg laying, these birds would be ashore for a very brief time indeed. However, nesting is known to extend from May until mid-July, with downy young coming down to the sea every night from about the first of June onward. It appears that the breeding population is actually so high as to exceed the onshore facilities, and that favored burrows are used by successive pairs.

The two petrels are very much the same size and have almost identical nesting requirements. They tend to colonize the tops of small islands, and the top of Cox Island is typical. They are different from the alcids, being very small and light and agile in flight. They resemble the familiar Nighthawk (*Chordeiles minor*) in size, wing-loading and manner of flight. They are heavily utilized by falcons where they are near at hand, but they are not as important as the small alcids.

If large colonies of auklets, murrelets, and petrels are a characteristic of the entire west coast of the Queen Charlotte Islands, then the assumption of a very high population of peregrines, comparable to that of Langara, is warranted. If, however, such colonies are entirely restricted to the offshore islands, then the estimates must be revised sharply downward, for the number of such islands on the west side of the Queen Charlotte Island group is not large, consisting mainly of Langara, Frederick, Hippa, Marble, Anthony and Kunghit islands, with a few additional associated rocks and islets.

Every active falcon aerie that I have visited is located in the immediate vicinity of a colony of one or more of these favored food species. There are, however, a few authenticated aerie areas that are not so associated. The aeries at Tow Hill and Pillar Bay on Graham Island are examples. The aerie on the pillar was not occupied when I checked it in 1958, but the site was well marked and had been occupied recently. I have not visited the well-known aerie at Tow Hill east of Massett. Neither of these are in close proximity to seabird colonies. The aeries listed by Green on Knox Peninsula may also be in this category. If so, there would appear to be an unknown number of aeries in the general area whose occupants have hunting habits more in keeping with those normally observed for the species; that is, nestlings at these aeries would appear to be supported primarily by the male bringing in food from a considerable distance, instead of by both parents hunting directly from the aerie site as seems to be the case at most of the aeries on Langara. Whether these pairs take a wider range of food species than is observed for those located in the midst of seabird colonies would be interesting to know.

*Habits of predation.*—The limitation of the west coast falcons mostly to one, and to not more than four, prey species during the nesting season is a most singular characteristic. The sheer abundance of these four species would seem at first glance to be ample reason for such heavy utilization, but there are some curious aspects to this that are not very clear.

Bannerman (1956:30–31) records the food of British peregrines as including over 60 different species ranging in size from a Brent Goose (*Branta bernicla*) down

to small passerines, but including such various items as rooks, jackdaws and magpies, as well as ducks, shorebirds and puffins. The great seabird colonies of the Atlantic coast south of arctic latitudes have no burrowing alcids except puffins and guillemots and thus have no species comparable in size to the Cassin Auklet and Ancient Murrelet of the north Pacific islands. Similarly, the food of the eastern North American peregrines is listed by Bent (1938:54) as including jays, icterids, Mourning Doves, nighthawks, and killdeer-plover. Cade (in press) shows that arctic peregrines take a similarly wide range of species, shorebirds and passerines mostly, but with some utilization of ptarmigan and waterfowl. All of this only makes the specialization of the west coast peregrines the more remarkable.

The favored species, if appearing in flight anywhere near the falcons in daylight, are apparently taken at every opportunity, regardless of hunger. The reaction of the Triangle Island falcons to Cassin Auklets thrown out under them paralleled exactly the behavior of the Langara Island birds to Ancient Murrelets trying to make it out to sea from the top of Cox Island when so released in daylight. Guignet (unpublished field notes) records the same fate for all petrels released from the top of Cox Island when he was ashore there in mid-August of 1947. The birds I observed usually carried their prey to some favorite plucking perch and then just left it there. This hunting activity was interesting also because it took place when we were very near the aerie site and the birds were certainly disturbed and excited by our being there. As on Triangle, many other species of birds flew about and crossed around and below the falcons, yet none of these except the four prey species was ever subjected to attack, except of course the eagles; but any of the four food species was invariably pursued and usually taken.

Just when the falcons do most of their normal hunting is not easy to observe. They do at times hunt out over the water. While on a boat out in Parry Passage, I watched the male of the aerie on Dadens launch into the air and fly out over the water. He climbed for some distance, then tilted downward and began picking up speed, ending by flying at very high speed scarcely a foot above the water over the thousands of murrelets that sheeted the passage. Most of these dived underwater as he whizzed over them, but some panicked and attempted to fly. One of these was taken as it fluttered into the air. This is the only observation I have of the adult birds hunting out over the sea. As has already been noted, both adults of a pair seem to be in close attendance to their nest site at almost any time of day, and one comes away with the distinct impression that they do very little except guard the nest between sunrise and sunset.

I am convinced that at least those pairs that live in the midst of the seabird colonies do most of their hunting from, or over, the aerie site and that the tactics observed when birds are thrown out under them are close to what happens normally, except for the time of day. I think that most of the kills are made so late in the evening, or so early in the morning, as to be almost nocturnal. This inference is based on these observations: First, the regularly occupied aeries are in the midst of dense concentrations of burrowing nocturnal seabirds; second, the remains of kills at and near the aerie site are of the species occupying the burrows around the nesting falcons. At Dadens, for instance, there are neither petrels nor Cassin Auklets, the only species nesting nearby is the Ancient Murrelet; and only Ancient Murrelet remains are found at this site. At McPherson Point there is an open grassy headland occupied by a sizeable colony of Cassin Auklets, and here two species, Ancient Murrelet and Cassin Auklet, are found among the kill remains. Below the pinnacles in Cloak Bay and on the grassy slopes slanting up to the old shore cliffs are again Cassin Auklets and at the pinnacle sites remains of both species are found, but I found no petrel kills. Yet, over on Cox Island, the remains of petrel kills outnumber those of any other species. All three species nest on Cox Island, but petrels

are by far the most numerous. On the slopes below the pinnacles they nest hardly at all. If the falcons were ranging any significant distance for food one would expect to find the evidence in a slightly wider range of prey remains.

In 1952, the museum party camped overnight on top of Cox Island to study the incoming flights of petrels. Just before dark, I walked across the top of the island to the cliff where the falcon aerie was situated that year (fig. 7). A strong wind was blowing from the south, thrusting a powerful updraft aloft as it poured out of the cleft where the falcons were nesting. Above the cliff, riding the updraft, both falcons were in the air. They made no noise and seemed unaware of my presence. They were still flying, as though hung on strings, when it was so dark that they would appear and vanish as they shifted upward or dropped a little in the wind. My impression at the time was, and still is, that those birds were hunting—hanging there, waiting for the beginning of the great throngs of birds to leave the island. I think they wait thus and take the first outgoing birds from the great colonies, quite possibly making several kills each, and leaving them in certain favored places, just as we observed in daylight. I think they catch their quarry exactly as we observed, in swift headlong stoops as the prey species appear in silhouette against the sea. Certainly if this is the way most of the hunting is done, it would account for the very small range requirements of each individual pair.

It is also certain that this is the time when the prey species are most exposed to successful attack by a bird with the hunting habits of the peregrine. All these birds leave for the sea in much the same manner, dropping swiftly downhill as quickly as the land contour permits to pick up speed, then leveling off anywhere from two to 30 feet above the beaches or the sea. The alcids have no escape tactic whatsoever as far as aerial evasion is concerned, but they do have the ability to fly full tilt into the water. The light, graceful petrels do not fly with nearly the speed of the heavy-bodied alcids, but they are adept at dodging. Their weakness appears to be a total inability to get beneath the surface of the water without first landing in the water. There is a difference in the way the two species are taken: On the observed flights at alcids, the falcons always took them just as the smaller birds began to level off and just before, or just after they were out over the water; the flights at petrels were of longer duration and sometimes went some distance out to sea with the falcon making repeated short stoops at the shifty petrels. Success in capturing petrels was not as great as that in capturing alcids, and about half of the petrels subjected to attack were able to escape.

Experience with trained falcons tends to substantiate the evidence of very late crepuscular hunting activity on the part of falcons, as do certain other recorded observations. Emperor Frederick II, writing in the thirteenth century in his work on falconry, makes reference to it (Wood and Fyfe, 1943); and Cade, who has researched the literature on peregrines much more thoroughly than I, writes me that the same thing has been recorded by Stager (1941) on bats in Texas and by Dementiev (1951) for *F. p. babylonicus*, also on bats, in the Middle East. He adds that one of the peregrines trained in California would come in on a lure illuminated by the headlights of a car after dark.

One does not work with trained peregrines very long before becoming aware that they can see quite well in very dim light. On a number of occasions I have had trained falcons, lost in the field, return home very late in the evening. These birds would see and take a lure in the air from a low approach if the lure was thrown up against the sky. On these strikes they showed great accuracy and excellent judgment of distance even though it was far too dark for them to see the lure against the ground. As soon as they had the lure in their feet, they would come down and begin to feed. Every falconer knows that peregrines will eat by feel in total darkness and even when hooded. My point is that the onset of real darkness would have no effect on the feeding activity of the falcon once

prey was taken, and of course the situation is reversed if the hunting is also done very early in the morning. It is well worth observing, too, that the eagles, so much a factor in the life of the falcons in this environment, are strictly diurnal in their habits and disappear entirely from the air at sunset.

Whatever their methods, these falcons regularly kill in excess of their own needs and that of their brood. Eaten and partly eaten kills litter the forest floor all around the island but especially in the vicinity of occupied aeries. The habit of the adult birds of taking kills deep into the fringe forest is worth noting, as falcons are generally supposed to prefer open and exposed places and to avoid heavy forest. There are places in these woods where the remains of 50 and 60 kills, some eaten, some partly eaten, can be counted in a comparatively small area. These may mark the favorite feeding place of the male, although I have no direct observations to support this. The prey is eaten on the ground, the chosen places being open and moss-covered and clear of underbrush. Most of the remains are very characteristic, a circle of feathers and the two wings still joined together by the strong bone structure of sternum and shoulder-girdle. Dead, untouched kills are not usually found except in the near vicinity of the aerie, but they are not unusual there and sometimes are quite numerous—four, five or more. Such kills are intact, the heads not being removed as has been observed elsewhere.

Palatability is one factor in choice of prey. Tame falcons show marked preferences for some kinds of meat over others. Species such as duck or pheasant they will eat at any time, while others such as gulls or crows they will eat only when really hungry. The saying "to eat crow" refers to the observed distaste with which falcons eat this species and the humiliation implied when a trained bird is given nothing better. Falcons show a great fondness for the skin and adipose tissue of waterfowl and, if left to themselves, will carefully pluck a duck, then strip the carcass of skin and fat, eating every bit of it before beginning on the flesh. The palatability of the murrelets is attested by the fact that they were an important food item of the primitive human population of this area, a population accustomed to eating such excellent foods as salmon, halibut and abalone. Perhaps it is significant, certainly it is worth mentioning, that the small alcids and petrels do not feed on fish, but primarily on crustacea, of which the euphausiid shrimps are most important.

The primary condition near Langara Island that makes for the high density of peregrine population is upwelling along this northern coast of deep oceanic waters which bring to the surface the food constituents for a rich planktonic fauna, the food of the billions of shrimp-like animals. The secondary condition is a very large population of marine birds depending on this food supply—birds of a size that can be easily killed and carried by a falcon. The primary condition is not fully developed very much south of the fiftieth parallel. The same primary condition exists on the outer Atlantic coast—Labrador, Greenland and northern Europe—and to a much higher degree along the west coast of South America; but neither of these regions has developed the small shrimp-feeding avifauna to the same extent that it has been developed in the North Pacific region.

The high density of peregrines along the outer west coast of North America is therefore the result of specialized conditions found nowhere else in the world. These same conditions appear to extend northwestward along the outer islands of the Alexander Archipelago to the Fairweather, Yakutat Bay and Saint Elias regions, where, due to lack of insular breeding habitat for the burrowing seabirds, a considerable gap may be expected to occur. West and south of this, from Cape Saint Elias and the Cook Inlet region out to the Kamchatka Peninsula and the Kuriles, insular habitat is again developed and conditions should be as favorable as those along the outer coast of the Char-

lottes. Cade (1954) quotes O. Murie as saying that there is at least an average of one pair of falcons for every island and islet of the Aleutian chain.

*Brood size and breeding success.*—Hickey (1942:188) in an extensive study of peregrine aeries, mostly in the eastern United States, found the average clutch of eggs to be 3.72. The number of downy young averaged 3.0, but fledged young averaged only 0.7 to a high of 1.5. Cade (in press) further lists fledged young in a series of 20 aeries along the Yukon River in 1951 as 0.8 per pair, and at 25 aeries on the Colville River in arctic Alaska in 1952 as 1.4 per pair. By contrast, a series of 14 aeries along the upper Mississippi River produced only 0.64 in 1954 (Cade, 1954).

The marine falcons seem to do better. At one aerie only (and it consistently) have we found but one nestling. All the rest, every year (unless unoccupied or with eggs), had a minimum of two, usually three, and sometimes four young. The data are presented in table 2.

Table 2

## Summary of Reproductive Performance of Peregrines on Langara Island

Location	Date	Reproductive data	Location	Date	Reproductive data
Radar site	1952 June 2	2, fully fledged	Cleft	1952 June 2	Occupied, not checked
	1955 June 8	2, fully fledged		1955 June 8	4, fully fledged young
	1956	Not checked		1956 June 19	Occupied, not checked
	1957 June 20	3, flying		1957 June 20	3, flying
	1958 June 17	3 large downies		1958 June 17	3, flying
McPherson Point	1952 June 2	4 large downies	First pin-nacle	1952 June 2	Occupied, not checked
	1955 June 8	3 large downies		1955 June 8	3, flying
	1956 June 19	3, flying		1956 June 19	2, fully fledged
	1957 June 20	3, flying		1957 June 20	2, flying
	1958 June 17	Adults present, no eggs or young; apparently taken by natives		1958 June 17	2 large downy young
Andrews Point	1952 June 2	2 small downies	Twin pin-nacles	1952 June 2	Occupied, not checked
	1955 June 8	3 large downies		1955 June 8	2 eggs
	1956 June 19	3, flying		1956 June 19	3 large downies
	1957 June 20	2, flying		1957 June 20	3, flying
	1958 June 17	Site unoccupied		1958 June 17	2 eggs
Cohoe Point	1952 June 2	3 eggs	Third pin-nacle	1952 June 2	Occupied, not checked
	1955 June 8	3 large downies		1955 June 8	1, fully fledged
	1956, 1957, and 1958	Unoccupied		1956 June 19	1, fully fledged
	1957 June 20	2, flying		1957 June 20	2, fully fledged
Explorer Bay	1952 June 2	Occupied, young or eggs; not checked	Fourth pin-nacle	1952 June 2	Occupied, not checked
	1955 June 8	Unoccupied		1955 June 8	Unoccupied
	1956, 1957	Not checked		1956 June 19	Not checked
	1958 June 17	Unoccupied		1957 June 20	2, flying
	1952 June 2	2, flying young		1958 June 17	Unoccupied
Dadens	1952 June 2	2, flying young	Cox Island	1952 June 2	4 eggs
	1955 June 8	Occupied; no eggs or young		1955 June 8	4, fully fledged
	1956 June 19	2, flying		1956 June 19	2 large downies
	1957 June 20	2, flying		1957 June 20	?—flying (seen from Langara)
	1958 June 17	2, flying		1958 June 17	Not checked
Burial Cave	1952 June 2	One adult female, no nest	Northshore, Cloak Bay	1955 June 8	Unoccupied
	1955 June 8	One adult female, no nest		1958 June 8	Unoccupied
	1956	Not checked			
	1957 June 20	2, flying			
	1958 June 17	Unoccupied			

The total number of aeries examined on Langara during the five-year period was 61; of these 10 were unoccupied, and four held eggs. Seven aeries were definitely occupied but not checked. Of the 34 occupied aeries containing young that were examined, the total of young birds was 88; the estimated total (to include the seven not checked as to number) was about 102. The known average was 2.7. This is the same or perhaps slightly higher than 2.5 reported by Hickey (1942:188) for the continental aeries of Canada and by Cade (in press) for arctic Alaska. The error may lie in assuming that the "unoccupied" aeries were not occupied earlier in the season; but this error could fall either way, that is, the aeries could have been either deserted through predation or they could have been successful ones from which very early young had already flown.

Although the percentage of uncompleted nesting attempts is not known, the evidence

suggesting frequent second attempts after the loss of the first clutch of eggs (or loss of young), plus the large average number of fledged young per aerie, suggest that the Langara birds on the average produce at least two or more fledged young per pair. If so, the normal productivity of this population is about twice that of the population of arctic peregrines studied by Cade (in press) in northern Alaska.

*Sex ratio.*—I can find little evidence from the broods on Langara of any significant difference in the sex ratio. A very slightly higher production of females is indicated but not prominently so. Broods varied from all females (four) to all males (three) and any combination between. In 1955, for instance, at the radar site, the brood was all males (three); at McPherson Point, two females and one male; at Andrews Point, three females; Coho Point (very small downies), apparently two and two; Cleft, three females, one male; first pinnacle, two females; third pinnacle, one male; Cox Island, two females, two males. This totals 10 males and 14 females. In 1956, there were also more females than males, but the samples are too small to indicate anything very definite.

*Size difference between sexes.*—Among small downy young, there is no appreciable difference in body size, but even at this early age the sexes are quite well marked by the difference in the size of the feet. From the time the first feather-tips show on males, the sexes develop divergently. The females remain as downies, increasing in bulk for some days while the males begin to feather rapidly and become quite active without much additional gain in weight. At this age the sexes can be easily separated at a glance because the males look much larger and more advanced, whereas the females, although actually heavier, are still sprawling downies.

This difference in rate of development continues until the young leave the nest. Among three broods of free-flying young raised from downies, the males flew from three to five days before the females. On two occasions when large young were found in the nest, the males left the ledge and made successful flights as I slid down the rope while the females stayed on the ledge and were captured. They were certainly not yet capable of flight. Bannerman (1956) records the same difference in the growth rates of Gyrfalcons and European Goshawks, but he says nothing about this in relation to British peregrines. Bond (1942) also concurs with my observations. I have observed the same thing in broods of the Cooper Hawk (*Accipiter cooperii*), Sharp-shinned Hawk (*Accipiter striatus*), and Red-tailed Hawk (*Buteo jamaicensis*). I think further study will indicate that this pattern is the rule in the development of the raptorial birds except for those in which incubation begins with the first egg, with a resultant difference of several days in the age of the young.

In the aeries I have studied, I cannot see that greater size of females gave them any advantage during nestling life. The more rapid development of the males, both in feathering and coordination, seems in fact to be a direct compensation for any such advantage. It is my impression that the situation balances out, with neither sex having any real dominance in the nestling stage. Just at the time when the female could, through greater size and strength, achieve real dominance and become a threat to a male, the latter can leave the nest. With the broods I have raised, the same situation held true; if the male got food first, he kept it, not through superior strength, but by greater agility.

The foregoing does not alter the validity of Cade's (1955*b*) observations regarding social situations involving adult falcons of different sexes, nor does it add anything to the search for reasons why, in raptorial birds, the females are so consistently larger than the males. Other observations on the islands do not add anything either. It may be that in other environments the male falcon tends to bring smaller and therefore more digestible prey to the very small young while the female broods. It is not so here. Both

sexes attack the same few prey species to the exclusion of all others. Even in attacks on the small shifty petrels, the female, despite her greater size and ragged, molting wings, seemed just as adept as the male.

*Bathing and reactions to water.*—The fondness of tame falcons for water and for bathing is so well documented as to need no comment here. Observations of the same habit in wild birds are comparatively rare. Just west of the McPherson Point aerie site, there is a natural basin in the rock just above the high-tide line. High tides combined with any degree of surf spill sea water into this basin, and it is undoubtedly so changed several times every year. Even without the action of the sea, however, it would remain filled by heavy rainfall. This is the most obvious bird bath that I have seen anywhere. The water in it is brown and evil-looking and the entire margin is befouled with the "whitewash" droppings of raptorial birds. In 1952, Guiguet surprised a falcon bathing there. It was not one of the resident pair. The pronounced evidence of heavy, long-continued use is interesting. The resident pair of peregrines could not possibly by themselves account for its appearance. Perhaps it is also used by eagles.

Despite their close association with water and the disregard with which peregrines hunt on wing over large areas of open sea, all peregrines seem to have an instinctive fear of falling or being pulled down into water. Goshawks will often strike waterfowl in the air and drop with them into deep water, maintaining their hold until nearly pulled under before releasing the duck to swim (with flopping wings) ashore. The Bald Eagles of the northwest coast show an even greater disregard for water and have been observed by Guiguet (unpublished field notes) and myself actually to rest on the surface of the sea with a fish fast in their feet, and yet manage, after considerable flopping, to get clear again and tow the prey ashore. The adaptation of the Osprey (*Pandion haliaetus*) to plunges below the surface of large bodies of water and its ability to get clear, even when heavily burdened, is further evidence that not all raptors are helpless in water. Yet peregrines are apparently terrified at the prospect of finding themselves in any water of unknown depth, and the least little puddle that would afford no protection at all from a Goshawk or an eagle is ample sanctuary for any kind of waterfowl under attack by a peregrine. Peregrines will not come to grips with heavy quarry near the surface of water, and if they take quarry high in the air over a large body of water and cannot guide the fall to land clear of the water they invariably release their quarry rather than risk falling into water with it.

This fear of water of unknown depth is in odd contrast with their love of bathing and affinity for water in general. The actions indicate that a peregrine is helpless in deep water, but I have not tested this. Although peregrines are apparently terrified at any prospect of being forced down into water, they fly out over large areas of water. The worldwide distribution is itself ample proof of the ability of this species to cross oceans, but this is backed by further evidence. The peregrine is, considering its relative rarity, rather often recorded as coming on board ships at sea. With the marine falcons of the northwest coast, this fearlessness of crossing water seems particularly pronounced. They hunt over the sea and, except when the seabirds are ashore, must take most of their food either from the surface of the water or from over the water. West coast fishermen report seeing these birds 80 to 100 miles offshore, and Guiguet (unpublished field notes) has one noteworthy observation of a falcon capturing a petrel about 50 miles offshore and eating it on the wing. The abundance of large timber along the British Columbia coast permits the frequent occurrence of floating logs and driftwood far out at sea. Gulls, cormorants and sometimes eagles use this drift on which to perch. Whether peregrines also rest on such driftwood is as yet unobserved, but the possibility should be noted.

*Molt.*—The difference in time of the onset of the molt between the sexes of breeding

falcons is easily observed and often conspicuous. There appears to be at least a 30-day difference in the timing of the onset of the molt in the two sexes. By mid-June the females are deep in the molt with the consequent ragged-looking, irregular outline to the wings. The males are still full-winged. Cade (1955a:318) records the same difference in the timing of the molt of breeding American Rough-legged Hawks (*Buteo lagopus*) and of breeding arctic peregrines.

This is not observable in captive birds. Their molt is rather well known and well documented, beginning with the seventh primary in mid-April or early May and ending with the first (outermost) primary about the end of August or mid-September. Both sexes start to molt about the same time. Nor is there any observable difference in timing between birds entering their first molt and those beginning subsequent molts.

The successful use of progesterone as a molt-stimulant in captive falcons gives at least a hint as to the mechanism operative in the pronounced difference in molt onset between breeding and nonbreeding males. Pre-breeding and breeding activities would tend to stimulate the production of female sex-hormones *in the female* but the same activities resulting in high levels of male hormones, in the male, would tend to dominate or suppress the normal level of the female sex-hormones until the period of greatest sex activity was passed. This would tend to stimulate and perhaps advance the onset of molt in breeding females and to delay the onset of molt in breeding males. This would also explain the marked difference in onset of molt in the breeding as opposed to the non-breeding (captive) birds. Further observations and experiments are needed.

One of the most striking aspects of the molt, from first-year plumage to adult plumage, apart from the change in color and markings, is the difference in the length of individual feathers. All feathers on adult birds are measurably shorter than those on first-year birds with the exception of the longest primaries. This amounts to as much as half an inch on the secondaries and an inch on the tail. Thus, the adult bird appears smaller and measures smaller than do immature individuals. There is some evidence that the adults are a bit heavier. The difference in wing-loading between adults and immatures may therefore be considerable. The significance of this, if any, is not clear.

*Instruction of young.*—Whether adults of the more highly developed of raptorial birds actually instruct their young in hunting techniques has long puzzled ornithologists. The problem is one beset by a paucity of accurate observation as well as by the too frequent tendency toward anthropocentric interpretation. My own observations on Langara and on the Scott Islands, and those of Guiguet as well (unpublished field notes), indicate that there is at least a short period when something very close to actual instruction does occur. The deadly accuracy with which the adult falcons secure seabirds when these are thrown out from atop cliffs has already been observed. When an adult bird makes a sally of this kind accompanied by a flying young it is usual that the quarry is taken by the inexperienced immature bird and not by the adult. It is hard to reconcile the miss, sometimes the repeated miss, of the adult falcon and the final catch by the immature to accident, especially when the same thing is witnessed several times and when matched against the known deadliness and experience of the older bird. One is forced to conclude that the miss by the adult—always the leading bird—is deliberate and is intended to demoralize the quarry and “set it up” for the less practiced strike of the young falcon.

The foregoing is clearly similar to the cooperative hunting by mated pairs of peregrines observed by Cade (in press) in the arctic, and to the similarly coordinated styles of hunting that pairs of trained falcons will work out together when flown as a “cast.”

The stoop appears to be an innate pattern of flight behavior in falcons, yet although the young birds have the urge to dive at quarry, they make many attempts before gain-



ing confidence in this action. They will start a stoop readily enough, but apparently become alarmed at the sight of the ground coming up at them so fast, and they pull out short. All these techniques are perfected by wild birds much more quickly, probably through a combination of instruction by adults and imitation and through elimination of the less advanced and adaptable individuals. At any rate, wintering first-year wild falcons are not different in action and dash from adult peregrines.

#### MIGRATION

The major part of the land areas of the entire coastal region is unavailable as habitat for peregrines, being heavily timbered and about as utterly devoid of life as any region in the world, differing in this respect markedly from the land areas of the same latitude on the coast of Europe. Yet by the middle of August the shorebird migrations are beginning. These include the large flocks of Red Phalarope (*Phalaropus fulicarius*) which tend to stay offshore and feed entirely from the surface of the water. This species is heavily utilized by the marine peregrines as soon as it makes its appearance. A number of other species follow the broad open beaches of the east coast of the Charlottes, and from early September through the winter, the entire region collects an ever-increasing bird population as the waders move southward along the beaches and the wintering waterfowl move out to the coast.

Although not markedly migratory, the coast peregrines do follow the migrating shorebirds and waterfowl, both those of truly marine habitat that move down the outer coast and also those that move down the more sheltered beaches on the east side of the Queen Charlotte Islands and of Vancouver Island. They are accordingly found, in fall and winter, in areas where they are absent during the breeding season.

The first falcons appear in the Puget Sound region by mid-August, most of them in the dark, first-year plumage and usually in the littoral habitat, associated with the migrating flocks of phalaropes and other shorebirds. In late August and early September, the Band-tailed Pigeon (*Columba fasciata*) forms great flocks that move slowly southward, feeding as they go. Although usually a forest species, these birds move out into open agricultural lands and the fringes of the forest. Such flocks are shadowed by falcons, and in association with them falcons may be seen as much as 50 miles inland. Once the Band-tailed Pigeons move on, no falcons are again seen inland until the heavy autumn rains flood the low-lying agricultural fields, summer pasture lands and deltas, and the great flocks of wintering waterfowl move into this habitat. From then until spring, falcons can be seen occasionally anywhere in the Puget Sound region. They are neither common nor rare. There appears to be some variation with the season: In "hard" winters when open fresh water is frozen for a considerable period of time, there is a marked increase of falcons in and about the islands of Puget Sound in littoral habitats. I am inclined to think that this represents simply a higher concentration there of wintering birds, certainly of waterfowl, that are normally spread out over much greater areas.

Some points along the outer coast are reported to have high populations of wintering peregrines. Most notable of these is the great area of tidal mudflats and salt marshes at Tofino on the west coast of Vancouver Island. This is a fabulous area for wintering waterfowl and a mecca for duck hunters. The complex nature of the region—a maze of bays and inlets running into, and ending abruptly at, the great walls of the coast forest—makes much of it inaccessible even to the most determined. I do not know the area in winter, but Guiguet has done considerable field work there, and he tells me that between eight and a dozen falcons can be seen almost daily from a duck blind in the course of a day's shooting. The area appears to be very important for wintering Peale Falcons. At the present time the number killed by hunters is not large as the region is not too

accessible. This toll is certain to increase, however, as a road is being opened, and the area is in process of being developed to encourage waterfowl shooting.

The region about Puget Sound seems to be very nearly the southern limit of migration of this falcon except along the outer coast where they are taken occasionally as far south as southern California (Grinnell and Miller, 1944). There is always some room for doubt about any sight records of the Peale Falcon, either much south of the Oregon-California border or inland from the coast at any distance. Unless the specimen is trapped or shot, it cannot be clearly identified as belonging to this race.

In this regard it is interesting to note that the British race, *Falco peregrinus peregrinus*, with a rather parallel range and habitat is listed by Bannerman (1956:32) as being also resident over most of its range.

#### WINTERING

The habits of wintering peregrines have been the subject of some study in Europe and Britain but have been given little attention on this continent. In winter Peale Falcons tend to frequent two rather different types of habitat. The first of these is the typical west coast habitat of heavy shoreline forest or timbered islands overlooking beaches and sea, with the falcons oriented to relatively small marine or shoreline species taken from, or over the water. The other is the floodland habitat referred to previously, in which the falcons are oriented primarily to waterfowl taken over land areas.

*Territoriality.*—I have seen much more evidence of territorial behavior among wintering falcons than is apparent at breeding aeries. Cade (1955*b*), in his study of winter territoriality of the American Kestrel, points out much that is characteristic of the behavior of wintering peregrines, especially the habit of challenging and attempting to drive off other falcons. Many of these wintering falcons would not have been observed at all except for the fact that when a trained falcon is flown in the territory of a wild bird, the latter quickly shows itself in an effort to drive out the intruding (trained) bird.

Encounters between two wild falcons are not often seen. Presumably one or the other would dominate, probably the individual with the longer residence. In my experience with encounters of this kind between wild and trained birds, the trained bird has been dominant. I have seen perhaps a dozen such encounters, and each time the trained bird not only refused to be driven away but generally took up the challenge and drove off the wild falcon, even though it was the wild bird that initiated the fight—this, too, regardless of sex, for I have seen a trained male drive off a female.

I suspect here that the trained bird has some psychological advantage in the presence of the falconer. I also have a strong impression that the relative age of the two birds is important. When two falcons of different age are flown together, the bird in first-year plumage will, in my experience, invariably yield quarry to a bird in adult plumage. The longest encounters in which neither bird seemed capable of clear-cut dominance have been between two immature-plumaged birds. I have not seen an encounter between a trained immature and a wild adult. In encounters between a trained adult and a wild immature (this was true in the male-female encounter just mentioned), the adult bird either achieved a definite superiority, or, on some occasions, totally ignored the immature bird by simply keeping a higher position in the air over the falconer.

At any rate, after such encounters the wild falcon, even if driven off, shortly returns to the vacated territory. Repeated encounters set up a tolerance to the point that the wild bird accepts the situation of another falcon hunting on the same territory and no longer attacks. Once such a stalemate is established, I have seen the wild falcon go high above the trained bird, apparently with the intention of raiding it if the trained bird took quarry. Wild falcons do not usually try to kill quarry sprung under the trained

birds, but they will occasionally do so, and I have seen two birds break off a rough aerial encounter and then follow through with beautifully timed and coordinated flight at quarry sprung under them. At other times, only the trained bird will make any effort to kill; but should it succeed the wild falcon nearly always attempts to rob it. Here again in the encounters I have watched (three) it has always been the trained bird that dominated and that retained its prey. Conversely, I have seen the trained birds attack wild falcons and take their prey from them. Again, I do not discount the presence of the falconer as a very important factor in these encounters, for the trained bird has learned to expect help from the falconer in difficult situations.

*Hunting and food.*—As has already been implied, the wintering falcons are by no means as single-minded in their choice of food species as are the breeding birds. Instead they behave much as wintering peregrines elsewhere, taking a wide range of marine and floodland wintering species. Even when hunting waterfowl, they show a strong preference for the smaller species; teal, widgeon, and coot are hunted much more persistently than Mallard (*Anas platyrhynchos*) and Pintail (*Anas acuta*). They seem mostly to ignore the large marine ducks such as scoters, Redhead (*Aythya americana*) and Canvasback (*Aythya valisineria*), but will attack scaup, Oldsquaw (*Clangula hyemalis*), goldeneye, and Bufflehead (*Bucephala albeola*). Like other raptors when in areas where waterfowl are being shot, they may take to feeding on cripples, this habit being particularly observable at Tofino, according to Guiguet.

In some respects the hunting methods of these marine falcons differ from those of falcons observed in other areas. Aside from their tendency to take small quarry from the water, they also do a considerable amount of very accipiter-like hunting from trees. Most of the species frequenting the tidal mudflats and beaches seldom seek escape by flying into cover, it being in the nature of most ducks and shorebirds to try to outfly a falcon rather than to hide. The abrupt rise of the shorelines and the great height of the timber gives the waiting falcon a considerable advantage in height, while the dense evergreen foliage of the conifers conceals the perching falcon even though it does not particularly seek concealment. Whether by design or accident the fact remains that these falcons, when perched motionless in the tall trees, are overlooked by shorebirds and waterfowl.

When attacking larger quarry over land, falcons prefer to have an advantage of height, although I have seen them tail-chasing. Experience with trained birds, however, leads me to be wary of this last observation. A falcon seen chasing a duck from behind and rapidly overtaking it has, in all likelihood, come in on the quarry from a considerable height and picked up the great speed differential from the impetus of the downhill rush. The observer sees only the terminal third or less of the entire sequence and may get an incorrect impression. Smaller quarry, birds up to the size of widgeon, are usually seized in the feet and borne to the ground or, if light enough, may simply be carried off for some distance. Heavy birds—Mallard, Pintail, and (occasionally) pheasant and the smaller geese—may be hit very hard in the classic style with the falcon going on past and up after the stroke. Such birds may be killed outright, disabled, or forced to earth.

Trained falcons, in which this style of attack is encouraged and often highly developed, make spectacular kills on large quarry in this way, but the hardest strike I ever saw was delivered by a wild falcon. I had just flushed a group of Mallards under a very good falcon, flying her second season. She missed her stoop, but broke and scattered the flock. As she pulled up and out to my left, over to the right I heard a loud heavy thud and a Mallard drake was literally hurled end-over-end back toward the water where it crashed out of my sight in a dense growth of willows. I looked up to see a big black falcon, somewhat larger than my bird, pulling out of a terrific stoop. Neither bird made

the least attempt to follow the quarry down, nor did they pay the least attention to one another. The black falcon flew one circle around the pond, then went on. The trained bird was called down without incident. I never did find that duck, but from the way it came down, I suppose it was killed outright. The loss of kills, and the killing of quarry that peregrines cannot retrieve, must be rather commonplace where they are hunting heavy quarry over water and marshes, or over areas of brush and high grass. Experience with trained birds indicates the same thing, for many times quarry is cut down and taken (by the falconer) in places where the bird could not possibly have found it unaided.

A forceful, hard stoop by a determined falcon is very demoralizing to the quarry, and I have seen Mallards forced down that were not even hit. At such times the falcon may strike repeatedly, five or six times, or more, at the downed quarry, hitting and raking it time and again before checking speed to close with it on the ground. This maneuver of a falcon with something down is most characteristic, so much so that it is recognized at once by any other falcon in the area, which at once makes all haste to the scene of action. So also do eagles, buteos, accipiters and even Marsh Hawks (*Circus cyaneus*). Facing any of these, the falcon will stand its ground and retain its quarry only against the Marsh Hawk, the smaller accipiters, or another falcon. To the others it yields, and wintering peregrines often, perhaps usually, partially support a number of less efficient raptors.

Carion feeding is not normally associated with falcons, but a ring of feathers on an open mudflat will cause any passing falcon to investigate, and, if there are any remains of a recent kill in that circle, the falcon is not above coming down to clean up what is left. On one occasion I watched a dark, first-year bird making pass after pass over something floating a short distance from shore in a flooded field. It finally grappled and flew ashore with the object in its feet, alighted, and began to feed. Investigation proved that it had picked up the remains of a coot, dead for many days and far from fresh.

Despite their fondness for water and bathing, wild falcons are often quite muddy and dirty when shot or trapped. This is due to their habit of working tidal mudflats and flooded fields for waterfowl and tumbling about in the mud when struggling to overcome the larger prey species.

#### POPULATION CONTROLS

The low numbers of falcons in first-year plumage, or birds in transition from first-year to adult plumage, observable in the breeding areas and, for that matter in collections, is one of the more puzzling aspects of the biology of the peregrine. The same may be said regarding most of the large raptors with the very marked exception of the Bald Eagle, in which species immature birds always seem to be more abundant than adults. The evidence, insofar as peregrines are concerned, is that very few of the young reaching flying age live through their first winter.

In this regard the falcons of the outer coast, from all available evidence, do not differ from those studied elsewhere. In 1952, a single full-grown bird in first-year plumage was observed on the rocky beach just east of Dadens in late May. This is the only immature bird that I have seen on the breeding grounds that could possibly have been an over-wintering immature. All other birds have either been adults or newly-fledged young, the latter always easily distinguished by flight action and their habit of screaming.

The high reproductive success of this population would lead one to look for a considerably higher population of immature birds than appears to be present. Observations as to causes of mortality in wild falcons are difficult to make. Some of the factors that are suggested are tentative and based far more on inference than on evidence. They are suggested to stimulate observation.

*Atmospheric moisture.*—There is some slight evidence that aridity may be a factor limiting brood success in peregrines in areas other than the one under discussion. This inference is based on the following incident: In June of 1955, 13 young falcons were taken from the Langara aeries. These ranged in size from medium-sized downies to birds almost fledged and ready to fly. At Vancouver, I took two of the youngest and the remaining 11 were taken to Denver, Colorado. The climate of Denver is markedly different from that of the Pacific coast, being high (6000 feet) with very low relative humidity and with hot summer weather. The young falcons were housed in a garage, and the building was cooled during the heat of the day by spraying the roof with water. The young birds were also supplied with direct access to water in shallow basins. The entire 11 lived and appeared to thrive for nearly three weeks, feathering out and developing normally until in late July when there came a prolonged period of very hot and excessively dry weather. In rapid succession all but three of the young birds died. Of some significance were two things: (1) the surviving birds were the three oldest; (2) the two small downies kept on the Pacific coast lived and developed normally. The dead birds were examined by a veterinarian who found evidence of severe dehydration; this in spite of the fact that fresh water had been available to them at all times and had been used for both drinking and bathing.

Falcons are quite incapable, of course, of supplying young in the nest with free water. This being so, it seems that there is some evidence here that atmospheric moisture rather than nearness of free water may be an important and perhaps critical factor in brood success in some areas. The strong affinity that peregrines show for water has long been known, and it may well be that the water economy of this species is less efficient than that of some, perhaps most, other raptors. If extremely dry atmosphere can cause such excessive water loss as to induce death in young birds supplied with water, it would be even more swiftly fatal to young in the aeries not so supplied. The distribution of peregrines in arid regions should accordingly be governed by the presence of major humidifying agents—either large bodies of water, rapids, or waterfalls along rivers or streams. It is perhaps significant that, insofar as the arid regions of North America are concerned, this is exactly where they are found, and nowhere else.

*Hunting risks of young.*—It is characteristic of most raptors for the young of the year to utilize the young of the chief prey species as their main source of food. Both are clumsy and inept, but the odds are about even. The young falcons of the outer coast do not have this opportunity open to them since the young of the prey species go far out to sea. The immature falcons must, therefore, learn to make their first kills on adults of the prey species. Despite the evidence of some early instruction in the procedures of attack early in the season, the time quickly comes when any kills must be made farther and farther offshore as the food species, their breeding cycle over, move out to sea. Further, these same food species so highly concentrated about the islands during the nesting period, now scatter out over wide reaches of ocean, no longer in masses or even in flocks, but as single individuals or small family groups of three or four birds.

All this happens in a very short time. Most of the seabirds have left the vicinity of Langara by mid-July, and two weeks later the island is utterly deserted except for the colony of petrels on Cox Island.

The young falcons that survive these conditions thus come under severe selection. They must hunt offshore in an environment of gales, fog, and rain which totally obscures all shorelines for days on end. They must take mostly adults of prey species from, or from over, the water, and either carry such prey ashore or learn to feed on the wing or (perhaps) on floating drift. The two prime qualifications for survival are the

ability to fly tirelessly and an accurate sense of orientation. I doubt that many of these marine peregrines starve; but the least error in orientation or the least weakening due to lack of food would force them into the sea. I suspect that loss at sea is probably the most important factor in reducing numbers of fledged young of the Peale Falcon.

*Area of the nest platform.*—The aerie on the third pinnacle on Langara Island is singular in that it has consistently produced but one young, and it is the only one of the entire series studied in which this has been true. In 1957, when two young were produced the nest was not on the favored site on the pinnacle but on an alternate site on the old shore cliffs.

The pinnacle site has a markedly small (for Langara) nest platform. The open exposed portion is only about  $1\frac{1}{2} \times 2$  feet, but a cave about 18 inches in depth runs back under the spruce roots for another three feet. This is still much the smallest nest platform of any of the Langara aerie sites. The high-production sites have, without exception, large nest platforms. The largest of the series is under a great rock overhang at the site in the cleft. Here the nesting ledge is a triangular flat platform almost six feet wide and ten feet long. Comparably large platforms are found at the radar site, McPherson Point and one of the sites on Cox Island. Broods of three or four seem to occur consistently at these sites. Most of the others although less generously supplied with open level space, nevertheless, have adequate platforms averaging perhaps  $3 \times 4$  feet or  $4 \times 4$  feet, giving some 12 to 14 square feet of level area for the growing young.

I can find no reference linking brood size to the size of the nest platform, yet there is a definite mechanical limitation here, and it is obvious that too many birds crowding a small platform will result in some falling off. To check this I placed two well-known young on a flat board platform  $2 \times 2$  feet in size and placed flush to a wall, some  $4\frac{1}{2}$  feet from the ground. After about two hours one bird fell off. When replaced the same bird again fell off within the half hour. The platform was then increased in size to about  $2 \times 5$  feet, and neither bird fell off for four days. While not conclusive, the experiment substantiates the observation. There is a possibility that some of the very small broods reported from other areas may be due simply to inadequate size of nest platforms.

*Predation on falcons.*—Hickey (1942:197) considers "wilderness" as one of the main components of "cover" for peregrines. Cade (in press) is critical of this concept from the standpoint that wilderness affords protection from human molestation only, not from mammalian or avian predation. One of the most significant findings from Langara is the frequency with which eggs are found in any given season at the same time as flying young and the parallel fact that eggs are sometimes found at an aerie on the same date that flying young were present the previous season. The birds at the Dadens site had flying young on June 2, 1952, but on June 8, 1955, they had either not begun to lay, had lost the first set of eggs (or young), or were preparing to raise a second brood. The last is considered unlikely. Similarly the pair at the twin pinnacles had fresh eggs on June 8, 1955, and yet had three young on the wing on June 20, 1957.

At the present time, aside from man, there are no mammalian predators on Langara Island. Crows, Ravens (*Corvus corax*), and eagles, however, do abound, and any of these are capable of predation, on eggs in the case of crows, eggs and young in the case of Ravens, or young in the case of eagles. Guiguet (unpublished field notes) records watching a Northwestern Crow take a falcon egg with complete impunity. To understand how this can happen it should be noted that this small crow is extremely abundant all along the shorelines of the island and that the falcons pay no attention to them. The density of brush and cover permits the crow to approach the aerie site very closely and in perfect safety, and it is exposed to detection only for the brief instant it is on the actual nest platform. Such predation can only occur when the attention of the falcons

is elsewhere, and the eggs are left unguarded, as when the birds are engaged with an eagle. Such opportunities, however, are of rather frequent occurrence.

Falcons and Ravens have long been known to utilize the same cliffs in many parts of the world, and many observers have noted this association both with Prairie Falcons and with peregrines. Bannerman (1956:30) quotes Nethersole-Thompson as stating that heavy fighting occurs between Ravens and peregrines in March at the aerie sites in Britain. On Langara, and for that matter on all the islands of the outer coast, there seems to be neither association nor enmity of any kind between these two species although both are common. Guiguet (unpublished field notes) does list one interesting encounter in which a Raven attacked, with the apparent intention of killing, a crippled falcon. In this instance the Raven came to grips with the falcon, and the latter was saved only by timely intervention. Nevertheless, there are no observations of clashes between wild, normal birds. The Ravens of the northwest coast always nest in trees, they scavenge the beaches, and are not in the least dependent on the remains of falcon kills, a habit that seems to be the basis for most of the association between falcons and Ravens. The Ravens in this environment, therefore, are found in association with open beaches backed by heavy forest, and their nests are seldom in very close proximity to those of the falcons. They do not appear to constitute a menace to the nesting falcons.

From the actions of the peregrines, it seems that Bald Eagles are the greatest menace to young falcons. Except for the attack on the adult falcon described earlier, no attempted predation by eagles on peregrines was actually observed, but the violence with which the eagles are attacked if their flight course is toward the falcon nest ledge certainly suggests there is some good reason for their strong reactions. The falcons are markedly less apprehensive of eagles when incubating than when young are in the nest, but even then an eagle is not permitted too close. Later, especially when the young are large, the falcons become increasingly aggressive and attack much farther from the aerie. This pattern of behavior continues for some time after the young are on the wing, in sharp contrast to the behavior toward humans at this time. During this period it is remarkable how much of the time both falcons are in attendance at the nest, and the question comes to mind as to just when they do their hunting. As long as the young are so attended, they are probably reasonably safe. Nevertheless, opportunities for predation must occur. The abundance of eagles is an important factor in this regard; the open, often exposed, position of the young falcons is another. They are very conspicuous as large white downies, from that stage on until they fly, as they have a habit of standing out in the open on the nest platform and flapping their wings. Moreover, I am not convinced that if an eagle once decided to attack and started a determined course for this purpose, it would be turned aside by the falcons. Yet for lack of more definite data, I can only list the eagles as a probable predator of young falcons and perhaps occasionally flying young and adults.

The relationship between the eagles and falcons on Langara has one other rather interesting implication for the biology of peregrines. "Disturbance" has often been considered as a factor causing desertion of aeries. That is, it has been thought that the birds cannot continue normal reproductive functions if exposed to repeated or prolonged periods of excitement and stress. It is significant that the birds of the outer coast live and reproduce under conditions of almost constant disturbance and annoyance. The similarity of the reactions of the falcons to the approach of man and to the approach of an eagle has already been pointed out. I do not think that they are more disturbed by the one than by the other. The high reproductive success of these falcons in the presence of the large eagle population would indicate that disturbance alone is not as significant as it may at times appear.

Raccoons were introduced on the Queen Charlotte Islands by the Provincial Game Commission about 1940 (Carl and Guiguet, 1958:86) and are now established on the large islands of the group. There is a verbal report of one supposedly seen on Langara in 1958, but I saw no evidence of them there. The end effect of the introduction of this mammalian predator may be expected to differ on different islands. If there are no sea-bird colonies, the introduction should make little difference, provided that raccoons fail to reach the smaller islands of the group such as Frederick and Langara. Raccoons would of course affect the food supply more than the falcons themselves. At the same time some of the low aeries would present no problem at all to the agile, nocturnal raccoon, and these small islands, could, like Cox Island of the Scott Island group, ultimately support a large population of this predator.

Alexandrine rats (*Rattus rattus alexandrinus*) are feral on Langara Island. The date of introduction is not known, but they have been there for many years, probably introduced by whaling vessels. They are somewhat predatory on the burrowing seabirds but not alarmingly so, and they seem to have had no visible effect on either the falcons or their food supply.

On the Pacific coast, wintering peregrines are parasitized by just about every other large predatory bird sharing their wintering range. On the ground with prey, they distinctly fear eagles, Red-tailed Hawks, and Goshawks, and it seems likely that a certain number are killed, although the willingness of the falcon to yield its kill would, I think, usually save it. Such interference is probably insignificant, although it might result in starvation for the falcon in extreme cases.

Thus, it appears that crows and eagles are the only predators that affect the falcons at the present time, the former by occasional (but observed) predation on eggs, the latter by what is considered as likely (but unobserved) predation on large downies or young and (perhaps) on flying young and even adults. The newly introduced raccoon has so far not reached the breeding islands. The avian predators, eagle and crow, may be moderately limiting to brood success and are almost certainly the factor responsible for the staggered breeding season so characteristic of the study area.

*Territoriality.*—Despite the high density of peregrine population in this area and the lack of observable territorial aggressiveness between pairs, it is likely that this factor is important in limiting the number of breeding pairs. Small islands, such as Beresford, Sartine, Solander and Cox, are occupied by single pairs. Larger islands, such as Langara and Triangle, seem to have a relatively fixed upper limit. There is ample food and no lack of nesting sites for many more birds than are represented in any of these situations. The extremely high density on Cloak Bay is simply an indication of the extent to which territory and territorial behavior can be contracted under the influence of an abundance of food. It does not preclude the existence of territoriality as a factor in the population control of even these, almost social peregrines.

*Human disturbance.*—At the present time, and for the foreseeable future, disturbances by man cannot be considered of any real importance as a limiting factor in population levels or reproductive success of the Peale Falcon. But there is evidence that this population was subjected to far more human interference under primitive conditions than is true now.

At present, a toll of wintering falcons is taken by duck hunters in the Puget Sound region and, to a lesser extent, at other favored duck-hunting areas along the coast. The use of decoys is just as lethal to falcons as it is to ducks; a hunting falcon will often make a low, flat "pass" at any group of waterfowl it sees on the surface, especially near shore, as sometimes (as with murrelets) a bird or two from such a group is panicked into flight by the appearance of the falcon. Decoys are all too frequently thus attacked,



the falcon climbing steeply and slowing almost to a hover after the pass. Falcons are supposed to be a protected species in British Columbia, but any hawk checking thus against the sky over the average duck hunter is almost invariably shot.

Other than this, the falcons do not often expose themselves. Although not exactly shy, their habits are such that they do not get into much trouble. They never raid domestic flocks of birds except pigeons, and in a region where large dark birds are commonplace they are scarcely noticed. Large, dark-colored immature gulls are not very different in outline and flight action from the peregrines, and these gulls are extremely abundant. Perched birds are scarcely visible, so effective is the concealment afforded by huge dark evergreens.

The region of the outer British Columbian coast, and particularly the outer coast of the Queen Charlotte Islands, is unique in that it is one of the few areas in the world where the primitive human population was far higher than that which obtains at the present time. Anthropologists have mapped at least seven permanent native villages along the west coast that were populated within historic times. These are Dadens, Kiusta, Tian, Nesta, Chaatl, Kaisun and Ninstantins; all were occupied at the close of the last century. Although today this country is "remote" and difficult of access, the falcons of the outer coast have not always been completely free of interference from mankind.

The Haida certainly knew the species and the hawk is an important figure in their mythology and art. Green's (1916:475-476) interesting observation of a belief that "the best way to bring a west wind is to visit an aerie and hurl the eggs or young to the west into the sea [on the west side of the island] and for an east wind to go to the other side of the island" further indicates that falcons may have been subjected to direct persecution by this primitive population.

Probably more important was the intensive use of large seabird colonies. The very species most important to the falcons were subjected to heavy, and what must have been long-continued annual predation by primitive peoples. Both eggs and adults were taken and in numbers that makes predation by falcons utterly insignificant by comparison.

When a field party was on Langara in 1952, there were several nights when great bonfires were alight ashore and the natives were busy all night catching murrelets. For several days natives carrying long strings of dead birds were a common sight. We seem to have witnessed almost the last of these harvests; the custom is certainly dying out rapidly. Only the older generations still hunt birds, and now they come but seldom to the islands. In 1957 and 1958, I saw no killing of murrelets at all and the little shore villages at Dadens and Henslung Bay become more deserted each year. Raids of this kind along the other of the outer islands have long since ceased, and the great bird colonies must have built up to maximum populations.

For at least the past 60 years any human disturbance suffered by the west coast peregrines has been confined almost entirely to Langara Island. Such disturbance has, moreover, been sporadic and not long continued. Several oologists have visited the islands from time to time, specifically to collect peregrine eggs. Among these was Green in 1916, W. Maguire in 1947, and Darcus in the 1930's. Brooks, Stewart, Cowan, Guiguet and others have visited the islands on scientific collecting expeditions, and some adult birds are in the specimen collections represented by these ornithologists. As nearly as can be ascertained, none of these activities has resulted in permanent desertion of any of the better aerie areas. Considering the population of falcons on Langara and the inviolate nature of the coast to the south, this is to be expected.

My opinion is that casual, irresponsible shooting has accounted for more falcons on Langara Island than any activity oriented directly to them, and even this has not been high. Deer were introduced to the Charlottes in 1901 and in 1912 and have since become

so plentiful that residents are permitted to shoot deer for personal use at any season. They have become well established on Langara and even on tiny Cox Island. The fishermen go ashore at various places where easy landings can be made, specifically to hunt deer. When they come into the territory of a pair of falcons, the birds become so noisy and conspicuous that the hunter rather often becomes annoyed at their attentions and shoots them. We found the female from the third pinnacle on the ground with a broken wing from a heavy calibre rifle bullet in 1956, yet the aerie was reoccupied the next year. Some aeries are more vulnerable than others by reason of good landing beaches nearby. By contrast the site at Dadens is directly above the spot where the natives anchor their fishing boats during much of the season, and the young falcons are in plain sight from the water. This would seem a singularly vulnerable site for idle shooting, but fledged young are the rule here.

Since 1952 and regularly since 1955, a number of young birds have been taken by falconers. Such birds do, in a sense, constitute a harvest, and the taking of them is certainly a disturbance factor, although perhaps no more so than the ever-present eagles. Since falconers have visited the islands, the native youths, not to be outdone, have also taken a few young birds. The exact number is, of course, not known. They keep them essentially as pets and once they have one, they cannot be induced to part with it. They feed them mostly on fish and fish hearts, and it is interesting to note that the young birds grow and take no harm from such a diet. The four birds I have seen lived on fishing boats with their owners and were quiet, good-natured, and surprisingly well kept. None were wing clipped, and as nearly as I could learn they were permitted a good deal of freedom as soon as they could fly. Most, if not all such birds would tend to start taking their own food and slowly return to the wild population. The interest taken by local natives has at least had the effect of making them aware of the falcons, and once they have kept one or have seen a tame bird flying about the camp or the village at Masset, they are much less likely to use falcons for target practice.

As long as attention is focused entirely on young, I do not think that a total take of all available young every year from a place like Langara could possibly have a long-term effect. First, there is plenty of evidence that most of the young perish shortly after leaving the aeries anyway, and second, there is such a consistent staggering of the age groups in any one season that a two- or three-day visit still leaves close to half the annual brood potential of Langara alone quite untouched, to say nothing of the young hatched out on the known, and comparably large, number of aeries farther south on Graham, Frederick and Hippa islands.

The amount of human interference a population of peregrines can endure seems to vary regionally. Certainly the aeries listed by Cade (1954) on the upper Mississippi that averaged only 0.64 fledged young per pair could not be expected to take any long-continued pressure and maintain their numbers, unless they do much better some years than the study indicates. At the other extreme are the strong aeries of Langara which could probably stand total destruction annually for a long time.

In marginal or near marginal habitat, desertion of long-occupied aeries can and does occur, but not in optimal habitat. Thus, Bannerman (1956:28-29) writes, "Prior to the First World War there was scarcely a headland or cliff range of any altitude round our entire coast-line including the big groups of islands as well as many a steep-sided rocky islet, where a pair of these noble birds did not at least attempt to breed annually. It says much for the powers of recovery of the peregrine that it has successfully withstood the persecution meted out to it in the years 1914-1918 and in 1939-1945 when a price was put upon its head owing to the menace it remained to pigeons carrying urgent messages of war . . . despite the numbers destroyed there were still quite a number of eyries

surviving at the close of hostilities and the orders for the birds' extermination were not carried out too literally . . . all this goes to prove that *Falco peregrinus* is, when given a chance, far from being the great rarity that some people assume . . . . There has been a less marked decline in its numbers in the twentieth century and by 1939 it was probably holding its own." Ferguson-Lees (1951, 1957) takes a somewhat less optimistic view and reports only about 75 to 80 per cent recovery to prewar levels. Even this, however, is rather remarkable on islands with a human population density of over 800 persons per square mile. Bannerman's notes indicate that egg collector, gamekeeper, and falconer have all taken their toll for hundreds of years without having much of a long-term effect on the population, and even government orders to wipe out the species failed to do so.

The British aeries are, of course, much more accessible than any of those along the outer North American coast to predation by both man and other mammals. Few could be considered, by North American standards, as being in a wilderness habitat. Food supplies, although good, apparently do not approach the optimum that obtains on the northwest coast of this continent. Here the peregrines live in what is, by comparison, a total wilderness. Except at Langara they have been entirely free of all human persecution for nearly a hundred years. They also live in a region entirely free of land predators and amidst a food supply of unlimited abundance. Theoretically, they should be able to withstand pressures at least as great as those to which the British peregrines have been so long subjected without serious reduction.

#### SUMMARY

The Peale Falcon is a race of marine peregrines with a range that formerly extended from the mouth of the Columbia River northwestward along the outer coast of Washington State, Vancouver Island, the islands of Queen Charlotte Sound, the Queen Charlotte Islands, and the Alexander Archipelago west and south to the outermost of the Aleutian Islands and, possibly, to the Komandorski Islands, the coast of Kamchatka and the Kuriles. It is now local or absent south of latitude 50°N. except in winter. The birds showing the strongest visible characters of *pealei* are found between 50° and 55°N. latitude in the eastern (outer British Columbian coast) and western (Aleutian) sectors of the postulated range. The bipartite distribution is attributed to the comparatively recent glacial activity in the Gulf of Alaska region. Intergradation with arctic peregrines in the latter area is suggested as the reason for the less clearly characterized birds found on Cook Inlet and Alaska Peninsula.

The characters that distinguish *pealei* from continental peregrines are the extension of the markings of the under parts upward onto the upper breast in both sexes, strongly so in the female, as shaftlines in the male, coupled with darker, generally grayer tone to the entire plumage, and little contrast. Immature birds in life are dark slate gray on the back and streaked grayish or grayish brown below. The tendency toward suppression of shades of rufous or tawny is marked in all plumages. This race also averages larger and heavier than continental peregrines; it is markedly larger than arctic peregrines.

The area studied in this paper is linear in nature and extends from Carrol Island on the Washington coast to Langara Island at the northwestern tip of the Queen Charlotte Islands. Most of the observations and data are from the Scott Islands and Langara Island. Over this area, the Peale Falcon seems to be entirely confined to the outer coast during the breeding season.

The high density present on Langara Island may, or may not, extend to other favored areas along the entire west side of the Queen Charlotte Islands. This high density is

considered to result from certain factors that appear to modify strikingly the spatial requirements of peregrines and that collectively act to provide optimal habitat for the species. These are (1) a food supply of such abundance that territorial competition for food between pairs appears to be entirely absent, (2) relative freedom from persistent persecution by man and total freedom from mammalian predators, (3) a cool moist climate, (4) abundant good nesting sites, and (5) large nest platforms.

Broods are large and reproductive success is high. There is some evidence that the large nest platforms are a permissive factor in the raising of large broods when coupled with the abundant food supply. Predation, if any, is by crows (on eggs) and by eagles. The large amount of easily secured food precludes any starvation or stunting of maximum-sized broods prior to flying age.

Food of breeding birds in the study area was confined to four species of marine birds, two alcids and two petrels. No evidence was found that any other species was taken. In the southern sector (west coast of Vancouver Island and the Scott Islands), the Cassin Auklet was the only species utilized, while farther north on Langara the Ancient Murrelet was the most important food species. Breeding falcons killed mostly those species that had nest burrows close to the aerie sites. Experiments and observations indicate that most hunting is done close to the aerie site, both early in the morning and late in the evening, the hunting being crepuscular to semi-nocturnal because of timing of movements to and from nests by all four prey species. All aeries studied were in close association with colonies of marine birds; but some aeries are known that are not so located, and there food habits must differ markedly.

Some factors that may limit the size and location of the colonies of seabirds and, consequently, the population of the peregrines are discussed, together with the potential for damage and change by a newly introduced factor, the nocturnal, predatory raccoon.

The largest single control of the population is considered to be loss of the young at sea shortly after they begin to fly well. The abrupt change of the economy from one of food abundance to one of scarcity coincident with the marine birds leaving the island for the open sea is considered to cause young birds to range over waters at distances beyond their strength and endurance.

Observations on wintering birds in the Puget Sound region are compared with the behavior, flight, and hunting style of trained falcons at the same time of the year. Molt is described briefly, and comparisons in time of molt between breeding and nonbreeding (tame) falcons is discussed.

The high breeding success of marine peregrines of the race *pealei* coupled with an apparently high loss of young before reaching maturity indicates that this loss has little effect on stability of a nesting population living in optimal habitat.

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