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Juvenile Marbled Murrelet Nurseries and the Productivity Index

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ABSTRACT.—Late summer counts of juveniles at sea are used as an index of Marbled Murrelet (*Brachyramphus marmoratus*) reproductive success, but little is known about juvenile dispersal or habitat use. Further, it is not known whether these counts accurately reflect absolute breeding success. To address these questions we conducted five boat surveys for Marbled Murrelets and Pigeon Guillemots (*Cepphus columba*) in Kachemak Bay, Alaska between 7–24 August 1996. Juvenile murrelet distribution in the bay was patchy, and we identified a juvenile Marbled Murrelet 'nursery' area in the outer bay. Fifty-three of 61 juvenile murrelets were in this area, whereas after-hatch-year (AHY) murrelets were dispersed throughout the bay, as were juvenile and AHY Pigeon Guillemots. The murrelet nursery was characterized by water inside of or at the edge of a 20 m deep contour, semi-protected seas, productive waters, and a large bed of *Nereocystis* kelp. Juveniles comprised 16.1% of all murrelets and 24.8% of all guillemots observed at sea. These data suggest a maximum reproductive success of 0.32 chicks/pair if all AHY murrelets were breeding and 0.46 chicks/pair if only 70% of AHY murrelets were breeding. For guillemots, maximum productivity estimated from at-sea counts was 0.50 chicks/pair if all AHY were breeding and 0.71 chicks/pair if only 70% were breeding. The guillemot estimate was similar to that obtained by concurrent studies at nine guillemot colonies in the bay (0.56 chicks/pair). These results suggest that at sea surveys in late summer provide a reasonable index of local productivity for nearshore alcids. Further, if murrelet nursery areas can be found, at sea counts may provide a valid measure of absolute productivity. *Received 11 June 1998, accepted 7 Jan. 1999.*

Nests of the Marbled Murrelet (*Brachyramphus marmoratus*) are difficult to find or study, and reproductive success is known only from widely scattered nests studied over many years. Because of the murrelet's threatened status from British Columbia to California (Ralph et al. 1995), considerable effort has been devoted to finding alternate means of estimating murrelet reproductive success. The most practical approach is to use a productivity index based on surveys at sea, which uses the ratio of juveniles to adults or juvenile densities during the fledging period as indices of production (Ralph and Long 1995, Strong 1995, Kuletz and Kendall 1998). To be accurate, surveys require some knowledge of fledgling dispersal at sea, but little is known about juvenile movements or habitat use.

Anecdotal evidence suggests that juvenile Marbled Murrelets sometimes congregate in "nursery areas", often near shore or in extensive kelp beds (Sealy 1975, Beissinger 1995, Strachan et al. 1995, Strong et al. 1995). If juveniles gather in specific habitats after fledging, productivity surveys could be improved by identifying their location and time of use. Here, we report on a juvenile murrelet nursery and describe associated habitat features. We estimate murrelet productivity from the ratio of juveniles to adults at sea, and compare this with Pigeon Guillemot (*Cepphus columba*) productivity estimates obtained by both counts at sea and local colony studies.

STUDY AREA AND METHODS

We conducted surveys in Kachemak Bay, southcentral Alaska on five days between 7–24 August 1996 (Fig. 1). We surveyed the south side of Kachemak Bay because Marbled Murrelet densities are highest on the south side, which has deep water, many side bays, and a predominantly rocky, convoluted shoreline (Agler et al. 1998).

From a 10 m vessel we counted all Marbled Murrelets and Pigeon Guillemots within 100 m either side of the boat. Two observers used 8 × 42 and 10 × 50 binoculars to identify species and plumages. Juvenile murrelets, which resemble adults in basic plumage, were identified using characteristics described in Carter and Stein (1995) and Kuletz and Kendall (1998). A third person entered observations into a laptop computer using DLOG (Ecological Consulting Inc., Port-

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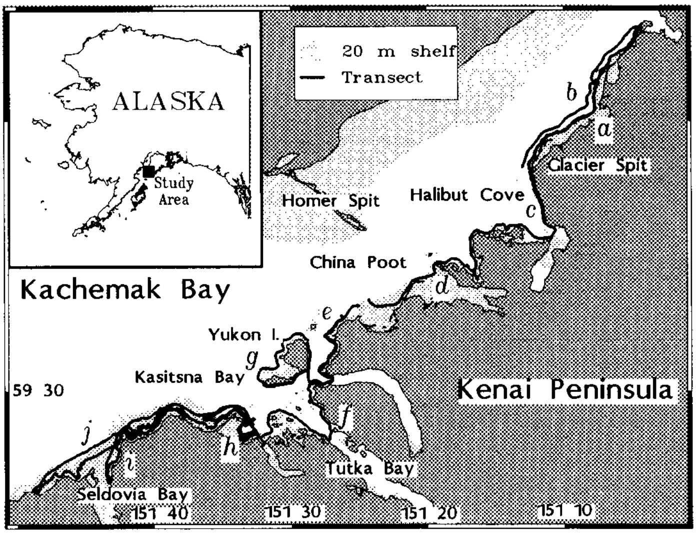

FIG. 1. Survey routes (*a–j*) in Kachemak Bay, Alaska, surveyed by boat on five days on 7–24 August 1996.

land, Oregon). The DLOG data entry program was linked with a Global Positioning System and every observation had an associated latitude and longitude. Survey routes followed a path parallel to shore. For most of the survey we used radar to maintain a distance of 100 m from shore. In rocky or shallow sections we surveyed outside the 20 m depth contour. From the head of the bay to Glacier Spit, and from Kasitsna Bay to Seldovia Bay, we also surveyed 0.5–1.0 km offshore (Fig. 1). The vessel traveled at speeds of about 7 km/hr, but because this was a reconnaissance survey, we temporarily paused or left our path to observe potential juvenile murrelets or guillemots (birds in black and white plumages).

We surveyed a linear distance of 214 km on 10 different survey routes over five days for a total area surveyed of 36.6 km^2 (Table 1). We refer to the area from the head of Kachemak Bay to China Poot Bay as the inner bay and the area west of China Poot to Seldovia Bay as the outer bay. Our main objective was to describe the spatial distribution of murrelets during the fledging period, but we obtained some temporal coverage. Portions of the survey routes overlapped on different days and all regions of the bay were surveyed both early and late in the fledging period (Table 1). Survey dates (7–24 August) encompassed the main and peak fledging period for murrelets, based on five replicate surveys conducted independently between 7 August and 4 September 1996 near Kasitsna Bay by KJK and J. Figurski. These dates correspond to the

TABLE 1. Numbers of adult (after-hatch-year) and juvenile Marbled Murrelets and Pigeon Guillemots observed on survey routes in Kachemak Bay, Alaska, in August 1996. Area (km^2) was calculated from the survey route length × width.

Bay area	Survey route	Date	Area (km^2)	No. Marbled Murrelets		No. Pigeon Guillemots	
				Adults	Juveniles	Adults	Juveniles
Inner	*a*	8–13	2.86	72	0	8	4
Inner	*b*	8–24	3.44	83	1	5	16
Inner	*c*	8–13	3.64	19	0	25	3
Inner	*d*	8–24	1.52	12	1	10	1
Total			11.46	186	2	48	24
Outer	*e*	8–13	2.89	37	1	21	1
Outer	*f*	8–07	5.25	43	2	12	1
Outer	*g*	8–07	1.26	7	3	94	3
Outer	*h*	8–12	1.54	3	0	0	1
Outer	*i*	8–12	4.66	7	23	0	0
Outer	*j*	8–23	9.57	34	30	12	32
Total			25.17	131	59	139	38

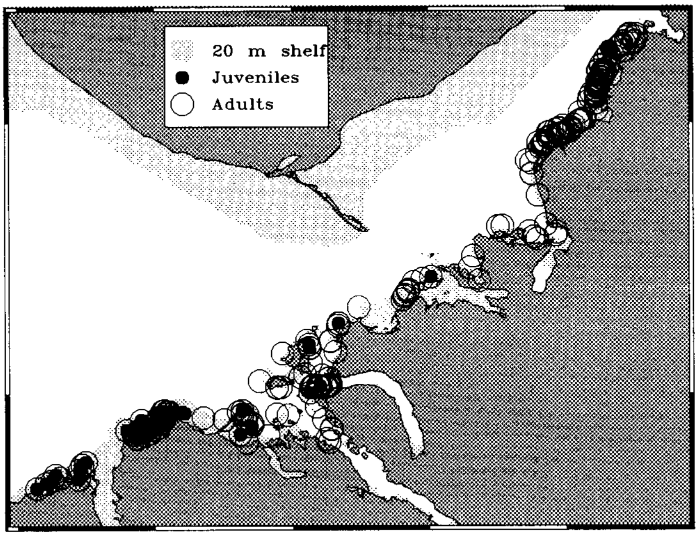

FIG. 2. Distribution of adult (after-hatch-year) and juvenile Marbled Murrelets on surveys conducted in Kachemak Bay, Alaska, on 7–24 August 1996.

fledging period in nearby Prince William Sound, Alaska (Kuletz and Kendall 1998). Pigeon Guillemot fledging dates were similar and were verified from local colony studies (Piatt et al. 1997).

Because we wanted to describe the general distribution of murrelets and our survey routes varied, we pooled all bird counts for a single tally. For both Marbled Murrelets and Pigeon Guillemots we determined the ratio at sea of juveniles to adults and subadults (after-hatching-year birds; AHY). We also calculated an index of juveniles/pair based on counts of juveniles and half the number of adults counted on the same surveys. Piatt and coworkers (1997) obtained detailed observations of Pigeon Guillemots on 60 nests in 9 colonies distributed along the south shore of Kachemak Bay from Glacier Spit to Seldovia Bay.

RESULTS

Fifty-nine of 61 juvenile Marbled Murrelets were found in outer Kachemak Bay and two were found in the inner bay (Table 1). Most of the juveniles in the outer bay were concentrated 0.5–1.0 km offshore, near the mouth of Seldovia Bay (Fig. 2). This area has an extensive kelp bed (*Nereocystis* sp.) and covers an underwater shelf less than 20 m deep. Adult Marbled Murrelets (n = 317; 5 in basic plumage) were distributed throughout Kachemak Bay, with highest densities in the inner bay between Glacier Spit and the bay head (Fig. 2). We found Pigeon Guillemots, both adults (n = 249) and juveniles (n = 62), distributed throughout Kachemak Bay (Table 1).

Juveniles represented 16.1% of all Marbled Murrelets and 24.8% of all Pigeon Guillemots counted. If all of the AHY Marbled Murrelets were breeding, our counts suggest a maximum reproductive success of 0.32 chicks/pair. A more conservative estimate is that only 70% of AHY birds were breeding (Piatt and Ford 1993), and therefore maximum productivity is calculated as 0.46 chicks/pair. For Pigeon Guillemots, the maximum productivity would be 0.50 chicks/pair if all AHY birds were breeding, and 0.71 chick/pair if only 70% were breeding adults.

DISCUSSION

Juvenile Marbled Murrelets in Kachemak Bay showed a clear preference for the kelp beds approximately 4 km on either side of the mouth of Seldovia Bay. This distribution contrasts sharply with the distribution of adult murrelets found throughout the bay. Adult murrelets forage on Pacific sand lance (*Ammodytes hexapterus*) in the inner bay (J. Piatt, unpubl. data), suggesting that the distribution of forage fish was not limiting the distribution of juvenile murrelets.

Why were juvenile murrelets concentrated along the shore in outer Kachemak Bay and in extensive, dense beds of *Nereocystis* kelp? Although exposed relative to the inner bay, the orientation of the shoreline in this area provided protection from prevailing southwesterly winds. The southwest portion of Kachemak Bay receives upwelled waters from the Alaska Coastal Current entering Cook Inlet from the southeast, and gyres in the outer bay retain nutrients and promote high local productivity (Trasky et al. 1977). The presence of *Nereocystis,* which attach to rocky substrate and grow in water 20–40 m deep where fast currents or upwelling occurs, is often associated with productive waters (Lalli and Parsons 1993). Thus, shallow water, semi-protected seas, the presence of kelp, and locally productive waters appear to combine here to create a favorable nursery area for newly-fledged murrelets. In addition, the kelp made it difficult to see the juveniles, and so may provide protection from avian predators such as gulls and Bald Eagles (*Haliaeetus leucocephalus*), which are common in this area. Large *Nereocystis* kelp beds are not common elsewhere in Kachemak Bay so this feature may be the primary defining characteristic of the nursery.

Juvenile murrelets may use the inner bay temporarily after fledging, and if fledging peaked early in August 1996, it is possible that we missed seeing them before they emigrated to the outer bay. It is also possible that juveniles were absent from the inner bay because few murrelets may breed there now as the result of extensive damage to mature forests from spruce beetle (*Dendroctonus rufipennis*). However, the middle portion of the bay (China Poot to Kasitsna Bay) still has largely intact forests, and while the inner bay is clearly an important foraging area for adults, most juveniles were found in the outer bay. The use of kelp beds in the outer bay by juvenile murrelets appears to be a recurring event; we have observed juvenile murrelets in this area in previous years. Surveys of the entire bay throughout the fledging period would be necessary to determine whether, and if so when, juveniles from throughout the bay move to the kelp beds.

Estimates of Pigeon Guillemot productivity obtained from juvenile surveys at sea compared well to the productivity of guillemots measured from colony-based reproductive studies. Pigeon Guillemots at nine Kachemak Bay colonies in 1996 produced 0.56 chicks/pair, which falls within the range we estimated from counts at sea. The estimate of production we obtained for Marbled Murrelets also approximates that found for Marbled Murrelets throughout their range (0.28 chicks/pair), based on 32 nests followed to completion (Nelson and Hamer 1995). It is noteworthy that our estimate of murrelet production in Kachemak Bay is much higher than those calculated from surveys at sea in areas south of Alaska (e.g., 0.001–0.11 chicks/pair), even after adjustments (0.01–0.17 chicks/pair) for the timing of surveys (Beissinger 1995). This is undoubtedly because we located the nursery area near Seldovia Bay, which accounted for 53 of 61 juveniles we observed on surveys.

While the possibility of juvenile murrelet nurseries has been suggested in some areas (Sealy 1975, Strachan et al. 1995), they have never been documented, and murrelet distribution may not always be as patchy as it appears to be in Kachemak Bay. In southeast Alaska, VanVliet (pers. comm.) observed juvenile murrelets clustered near or in kelp beds in late August in discrete areas of Port Althorp, whereas adults were distributed from Inian Pass to Icy Strait. In Prince William Sound, Alaska, however, juvenile murrelets were evenly dispersed in nearshore waters (relative to local murrelet abundance), with the exception of highly exposed shoreline where they were absent (Kuletz et al. 1997). The areas surveyed in Prince William Sound did not have large kelp beds and were characterized by convoluted, rocky shorelines with numerous protected bays and coves. In addition, the juveniles in Prince William Sound may not travel far in the first two weeks after fledging (Kuletz and Marks 1997; Kuletz, unpubl. data).

These results confirm that surveys at sea provide a reasonable index of productivity for nearshore seabirds such as Pigeon Guillemots and Marbled Murrelets. However, it is important to determine the post-fledging movements of adults and juveniles for any given area of study because adult:juvenile ratios are sensitive to late summer movements of adults and subadults (Kuletz and Kendall 1998). Although our temporal data were limited in this study, we did not find obvious declines in adult numbers in August, such as occurs in Prince William Sound. If juvenile murrelet nurseries can be located, it would facilitate the use of juvenile densities to measure productivity and thus avoid problems associated with using adult:juvenile ratios (Kuletz and Kendall 1998). If adults remain in an area during the main fledging period where murrelet nurseries exist, surveys at sea may provide a valid measure of absolute productivity, and not just an index of production (e.g., Beissinger 1995).

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