Restoration notebook

November 1997 *Exxon Valdez* Oil Spill Trustee Council

Marbled Murrelet

Brachyramphus marmoratus marmoratus

Photo by Gus van Vliet

By Katherine J. Kuletz
U.S. Fish and Wildlife Service

Marbled murrelets, *Brachyramphus marmoratus marmoratus*, are small seabirds of the Alcid Family. Alcids are diving seabirds inhabiting the north Pacific and include murres, puffins, auklets, murrelets, and guillemots. Marbled murrelets occur in nearshore marine environments from California to Alaska, nesting primarily in old-growth forests. A larger subspecies, B. *m. perdix*, is found along the Kamchatka Peninsula and the Sea of Okhotsk in the western Pacific. Recent genetic studies indicate that the Asian form may be a distinct species.[1]

A drastic decline in population is cause for concern throughout its range. It is formally listed as a threatened species in California, Oregon, Washington and British Columbia. The main threat to marbled murrelets has been loss of their old-growth forest nesting habitat. Other threats come from gillnet bycatch mortality, oil spills, disturbance in nearshore feeding areas, and long-term changes in oceanic conditions affecting their prey.[2] The 1989 *Exxon Valdez* oil spill had a greater impact on marbled murrelets than any previous oil spill in North America, and most likely, in the world.[3]

Most of the world's population of marbled murrelets breed in Alaska and some of the highest densities of murrelets occur in the area hit by the *Exxon Valdez* oil spill. Thus, a large percentage of the world's population was at risk from the spill. In summer, the marbled murrelet is common throughout the spill zone, including Prince William Sound, where it is the most abundant seabird.[4] U.S. Fish and Wildlife surveys in southeastern Alaska, Prince William Sound, and lower Cook Inlet estimated 550,000, 100,000 and 60,000 in those regions, respectively.[5] The marbled murrelet began its decline in Prince William Sound before the oil spill. Post-spill estimates suggest a 67% decline since surveys done in 1972 and 1973,

Vital Statistics

Population
Approx. 100,000 PWS, 60,000 lower Cook Inlet

Population Trend
67% decline in PWS since 1972, stable since 1990

Lifespan
Unknown

Adult Size
length, 24-25 cm;
wing span,122-149 cm;
weight, 188-269 g.

Breeding Season
Lays eggs May/June;
Fledging July/August

Incubation/Fledging
Chick hatches in 27-30 days;
Chick fledges in 30-40 days

Clutch size
one egg per season

Chick weights
Hatch semi-precocial at 32-34 g; fledge at 146-157 g.

Maturity
Age at breeding unknown

Plumages
Winter & juvenile: black above, white below; Breeding: marbled brown

Diet
Sandlance, capelin, euphausids, small crustacea, juveniles of cod, herring, pollock, salmon.

when there were an estimated 300,000 murrelets.[4]

Prior to the 1990's, little was known about marbled murrelets because their behavior, nesting habitat and appearance made them difficult to study. Unlike most seabirds, this murrelet is noncolonial, cryptic in breeding plumage, and difficult to find, usually nesting inland in the branches of old-growth conifers. As a result, despite years of effort throughout its range, only 125 nests have been located and only a quarter of those provided data on hatching or fledging success.[1,6] Most of what is known about murrelets in Alaska has been the result of successive years of study funded by the *Exxon Valdez* Oil Spill Trustee Council to assist restoration planning and habitat protection efforts.

Annual Cycle and Nesting Habitat

Small numbers of murrelets remain in inshore waters all winter, but most start arriving in southcentral Alaska in April. Returning birds are still in their black-and-white winter plumage. Their numbers increase until early May when they reach summer densities.[7] Most birds have by then molted into their 'marbled' brown, reddish, and white summer (breeding) plumage. At this time, large concentrations may be observed on the water. Around dawn their piercing calls can be heard as birds fly inland to their nests hidden in the coastal forests. Although seldom seen, these dawn flights can be spectacular, as the birds chase each other and dive into the forest canopy with speed and agility. Using radar, researchers have estimated that murrelets fly up to 160 kph, often using river corridors and ridge tops as flyways.[8]

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Early in the season, most of the birds observed flying inland are in pairs, and it is thought that the vocalizations and aerobatics are territorial or courtship displays. The pair usually selects the largest tree in the area and nests on the mossy platform of a horizontal branch, usually near the trunk and with some overhead protection from higher branches.[9] Murrelets will nest in the same section of forest over many years, but scientists in Prince William Sound have not been able to document pairs nesting on the same branch or tree in successive seasons.

There is little information on nesting density or the degree of colonialism among murrelets. Nesting density also may vary depending on habitat or proximity to good feeding areas. There is evidence that marbled murrelets are loosely colonial, based on nesting densities and dawn activity levels. On one island in PWS, researchers estimated that 7-12 pairs used a 17.5 hectare stand of prime old-growth forest.[9] Dawn activity patterns suggest that ground-nesting birds are fewer in number or at least more widely dispersed than tree-nesting birds.[10] Data from six birds radio-tagged in a PWS fjord showed that half of the birds were ground nesters. Three of the seabirds used tree nests less than 1 km from each other at the head of a side bay, while the remaining three nested on the ground in widely scattered locations.[11]

Dawn surveys throughout PWS showed higher breeding activity at the heads of bays, at moderate elevations, and in areas where large stands of large old-growth trees had abundant moss platforms.[12] Along the outer Kenai coast, however, the heads of bays were recently deglaciated and murrelet activity was highest on the outer peninsulas, where forest cover was greatest.[10,12] Even there, small coves or slopes affording protection from prevailing winds appeared to be favored as nest sites.

An unknown (but probably small) portion of the murrelet population in southcentral Alaska nests on the ground. These ground nests are more commonly found in areas where there are few trees, such as the mountainous regions of western PWS, the Kenai Fjords, the Barren Islands, and the Alaska Peninsula. These nests may be in a rocky cliff crevice, in lee side of a boulder, or at the base of an alder on a rocky slope.[10,11] Marbled murrelet ground nests can be confused with those of the closely related Kittlitz's murrelet (*B. brevirostris*), which nests exclusively on the ground.

The egg of the marbled murrelet is about the size of a chicken egg, large relative to the adult

bird. Its blue-green color and dark speckling matches the moss and lichen of the nest platform, camouflaging it from predators such as crows, jays, ravens and owls. Adult birds are at risk when leaving or entering the forest, and are taken by peregrine falcons, sharp-shinned hawks, owls and possibly bald eagles.[2,6] Parents exchange incubation duties every 24 hours, about 1 hour before dawn. The incubating bird remains completely still, and this behavior combined with its mottled plumage makes it difficult to spot. The non-incubating parent feeds at sea, ranging as far as 75 km, but usually remaining within 20 km of its nest.[11]

Photo by Gus van Vliet

The chick hatches 27-30 days after the egg is laid and has a mottled downy plumage, which it retains as an anti-predator adaptation. The chick is brooded 2-3 days after hatching, but then it is left alone at the nest. Many chicks are lost to avian predators. The parents return around dawn and dusk, carrying a single fish to deliver to the chick. The chick plucks off its downy plumage the day before fledging to reveal the sleek black-and-white feathers that have grown under the down. After 27-40 days, the chick leaves the nest and is on its own at sea.[1]

How the chick gets to the ocean is not clear. Most likely they fly, since the nests are inland from the sea.[2] In southcentral Alaska, located nests have been less than 1 km from the ocean, except for two nests that were 2 and 6 km from sea.[9,11] Elsewhere, nests have been found as far as 40 km inland.[2] Once at sea, juveniles are rarely observed in flight, causing some researchers to speculate that they use rivers or creeks flowing to the ocean or that they walk through the forest. Chicks have been spotted in creeks and on the forest floor, so it is possible that individual birds use any of these methods.

Because murrelets are not colonial, they are not tightly synchronized in their breeding phenology. As a result, murrelets in southcentral Alaska fledge from July to September, although most fledge between late July and late August. Peak fledging in PWS, determined by counting juveniles at sea, occurs around the first week of August.[13] Concurrently, inland dawn activity declines and adults trickle out of PWS. By late August the dawn flyways are silent; the juveniles remaining in nearshore waters. It is not known how long the juveniles remain in PWS, or if they leave at all during their first winter. Surveys in March show that about 25 percent of the summer population of murrelets are present, still in their winter plumage.[4] We do not know where most of the birds go to molt and overwinter.

Photo by Kathy Kuletz

Marbled murrelets usually are found in the upper story of moss covered trees in old growth forests (upper photo), but some nest in the crevice of a cliff (lower photo).

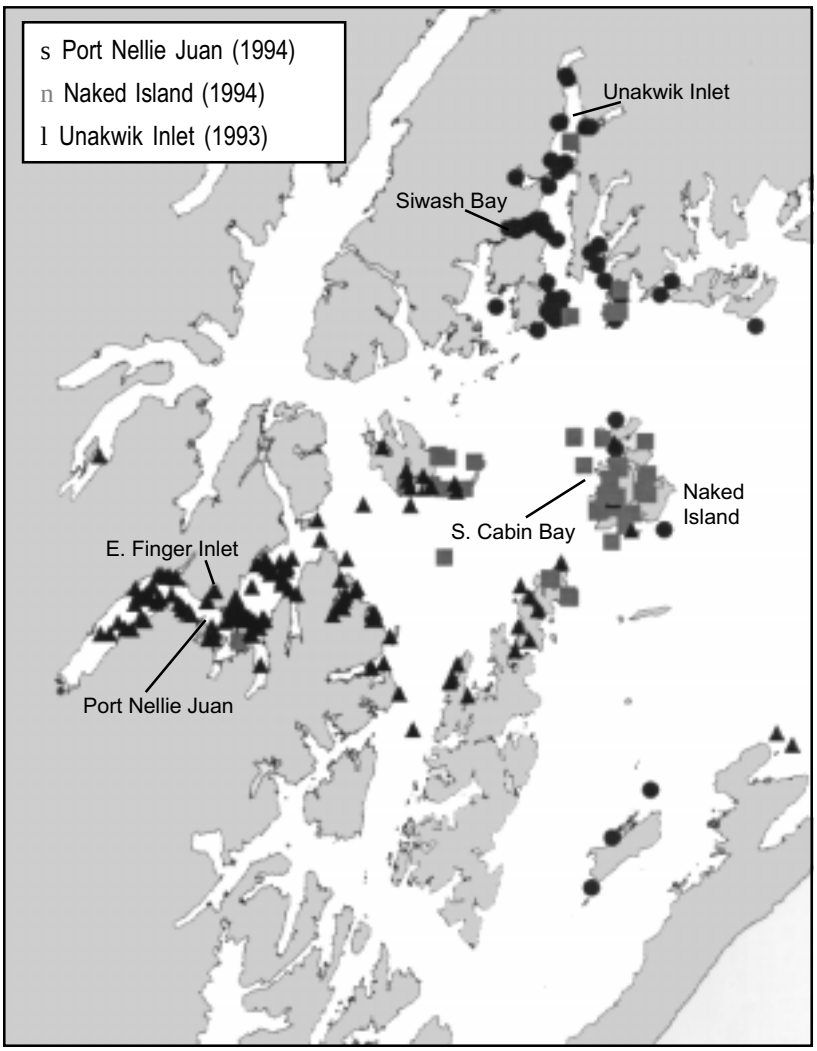
Feeding and Marine Habitat Use

Marbled murrelets are at the top of the food chain, eating primarily small fish. In PWS, where murrelets are the most abundant predator, they are an important component of the marine ecosystem. Murrelets feed on a variety of small forage fish, such as sandlance, cape-

lin, juvenile pollock and juvenile herring or smelt. They also will feed on small crustacea, such as euphausids, particularly in spring and winter.[14] Since 1994, the focus of EVOS restoration studies for the marbled murrelet has been marine habitat preference and foraging patterns.

The marbled murrelet is primarily a nearshore diver, and is typically found in water less than 50 m deep, although it can probably dive to 100 m.[1,2] It is usually less than 2 km from shore and in PWS the highest densities are found within 200 m of shore.[11,15] Under certain conditions, murrelets are found in deeper waters. In Port Nellie Juan, one site frequently visited by 32 radio-tagged murrelets was the deep central portion framed by a sharp bend in the channel and a deep underwater sill.[11] Aggregations of feeding murrelets often are found over deep-water sills or near landforms that cause tidally-induced upwelling, presumably because their prey concentrate in these micro-habitats.[11,16]

Movements of radio-tagged marbled murrelets captured at Port Nellie Juan (s), Naked Island (n), and Unakwik Inlet (l).



In 1993 and 1994 scientists fitted 55 marbled murrelets in PWS with radio tags to follow their foraging activities.[11] In both years, birds from all three capture sites displayed similar patterns. Individual birds often visit the same foraging sites and generally remain within 10-20 km of where they were captured. For the six birds whose nest sites were located, average distance from the nest to the foraging area was 20 km, although one bird averaged 40-km trips. A few birds traveled more extensively, with one making a 150-km round trip and another covering at least 920 square kilometers during the month it was tracked.

Researchers also found that murrelet behavioral patterns adapted to the daily patterns of their prey. For example, radio-tagged murrelets known to be nesting made frequent flights after dusk or before dawn, presumably catching and delivering fish to chicks, whereas other tagged birds were not active during those periods.[11] Many forage fish rise to the water's surface during twilight hours to feed. Thus, birds with chicks may be maximizing their provisioning rate in this way.[14,17] Because unintentional mortality of murrelets in salmon gillnets occurs more frequently in twilight hours,[17] this behavior may have implications for reducing bycatch mortality.

On the water, murrelets may be widely scattered nearshore, or concentrated in 'hot spots' of feeding activity, but they are usually seen in pairs. This may reflect a strong pair-bond that carries over to the marine habitat, but may also be a cooperative feeding technique. Murrelets 'swim' underwater with their wings. Often, paired murrelets synchronize their dives and swim toward each other, possibly scattering and chasing schooled fish to the surface during coordinated pursuit.

The murrelet habit of bringing fish splashing to the surface may alert non-diving seabirds to the presence of fish or make fish accessible to other birds. Recent EVOS studies have shown strong associations between murrelet feeding activity and the formation of mixed-species feeding flocks.[18] Additionally, kittiwakes have higher feeding success when they feed near murrelets. Thus, indirectly, a decline in the murrelet population in PWS could affect the foraging success of other seabirds. Investigations are continuing into the importance of murrelet foraging behavior to surface-feeding birds in PWS.

Photos by Kathy Kuletz

Marbled murrelets prefer to nest high in the moss-covered trees of old-growth forests. Tree nests, usually located near the shoreline, are difficult to find and even more difficult to study. Researchers must climb high into the canopy to get a look at the marbled murrlet on its nest.

Effects of the Oil Spill

Most of the summer breeding population was not in PWS at the time of the spill. Throughout April, however, as the oil moved south through PWS, into the GOA and along the outer Kenai Peninsula coast, murrelets returning to their breeding grounds encountered the oil.[7] Mortality records and carcass recovery estimates indicate that mortality of murrelets increased southward of PWS and peaked in mid April. An estimated 8,400 murrelets were killed directly by oil, based on identified carcass recoveries. This is considered a minimum number, since the small murrelets are difficult to find on rocky shoreline, and many 'unidentified small alcids' were probably marbled murrelets.[7] Based on a study of total seabird mortality, an estimated 12,800 to 14,800 murrelets were killed by the oil spill. This represents the largest single-event loss of marbled murrelets due to oil spills.[3]

After the immediate mortality

Few murrelets were brought to rehabilitation centers during the spill, and those birds did not respond well to cleaning and handling. Only three of 33 marbled murrelets were released back to sea, compared to 51% of the other 1,630 treated birds. Necropsies found enlarged adrenal glands, indicating that stress hastened their deaths.[3]

In oiled areas, murrelets ingested sub-lethal doses of oil when preening feathers or eating contaminated prey. Twenty-seven apparently normal adult murrelets were collected in PWS in August, 1989[19]: 10 at an unoiled site, eight at a moderately oiled site and nine at a heavily oiled site. The livers of murrelets from the unoiled and moderately oiled sites had similar aliphatic and polycyclic aromatic hydrocarbons, possibly of biogenic origins. Aliphatic compounds in the livers of eight of nine murrelets from the heavily oiled sites were indicative of oil ingestion. These compounds can cause detrimental behavioral abnormalities in seabirds, but their biological implications to murrelets are unknown.

Based on the low numbers of juvenile murrelets near the Naked Island study site, there was some indication that murrelet reproduction was disrupted in 1989 and 1990. In contrast, juvenile counts in Kachemak Bay, farther removed from the spill epicenter, did not decline after the spill.[7] However, these juvenile surveys were not systematic and thus not conclusive. In addition to direct mortality and ingestion of oil, the disturbance caused by cleanup efforts may have had a secondary effect on murrelets. In 1989 and 1990, areas used as staging grounds for the cleanup, such as Naked Island, showed a negative correlation between murrelet numbers and boat traffic or low-flying aircraft.[7] Many of these areas had previously been used by murrelets to forage during the summer.

Photo by Kathy Kuletz

An adult marbled murrelet in its summer (breeding) plumage, which provides good camouflage in its nesting habitat.

Long-term effects of the spill

Despite the magnitude of the immediate impact, the oil spill cannot account for the entire decline in the PWS murrelet population.[4] Based on shoreline surveys done in 1985 compared to 1972, it's likely that much of the decline occurred before the 1989 oil spill. In addition to the trends observed in marbled murrelets, other fish-eating seabirds and marine mammals of PWS have declined in numbers over the last 20 years. One hypothesis for this broad, long-term pattern is that forage-fish abundance or species composition, has changed during that time.[20,21] In particular, sandlance and capelin, high-quality prey used by many top predators, appear to have been replaced by cod species.

Several EVOS studies are investigating the link between forage-fish abundance and the reproductive success of apex predators. Similarly for the marbled murrelet, the focus of research has shifted from upland nesting habitat to marine habitat, with emphasis on the effects of prey abundance and distribution on reproductive success. The causes of changes in the reproductive success of any wild population are difficult to ascertain. Murrelets present a particular challenge. Despite radio-telemetry and labor-intensive dawn watches, researchers cannot find enough nests to describe reproductive success on an annual basis.

Due to the difficulty of locating nests, scientists have developed a murrelet productivity index using surveys at sea.[13, 22] This technique uses repeated surveys of selected areas from late July through August, when fledgling murrelets are on the water. By comparing the number of juveniles on the water and the ratio of juveniles-to-adults, researchers will compare reproductive success among sites and years. Simultaneously, other studies will track oceanic effects on forage-fish abundance and distribution, to see how these parts of the ecosystem interact.

The juvenile survey technique was explored in other areas of the murrelet's range, but PWS is particularly well-suited to development of such an index. Compared to areas farther south, PWS has a large murrelet population, a brief breeding season, and early migration of adults, which reduces the chances of confusing winter-plumaged adults with juveniles.[13]

To refine the index, future research will focus on murrelet behavior that would affect murrelet counts. These behaviors include possible differences in habitat selection between adults and juveniles, adult and juvenile movement patterns, juvenile length of residence in the area of its nest, variability in counts among surveys, and weather-related effects on murrelet distribution.

Restoration Activities

South of Alaska, where the marbled murrelet is listed as threatened, the primary cause of population decline has been the loss of nesting habitat due to logging of old-growth forests.[2] Thus, recovery plans there have focused on protection of nesting habitat. Declines in the murrelet population in the spill zone may have additional causes, but habitat preservation remains the most direct means of preventing further decline in the murrelets' numbers.

Prior to the oil spill, only a few ground nests

had been found in southcentral Alaska, so the importance of old-growth forests had not been established in the spill zone. Additionally, the forests of southcentral Alaska are substantially different from those in more southern regions of the murrelet's range. Thus, nesting habitat had to be better defined in southcentral Alaska before recommending specific types of habitats be protected. Between 1991-1993, the dawn watch technique was used to characterize nesting habitats throughout the spill zone and 22 murrelet nests were discovered.[12]

To assist natural recovery of murrelets, large tracts of land have been preserved with Trustee Council funds. These are primarily areas of old-growth forests with large trees near coastlines where murrelets are abundant. In Kachemak Bay, 23,800 acres of state park inholdings were purchased in 1993. An area with extremely high inland-murrelet activity on Afognak Island, totalling 17,166 acres on Seal Bay and 24,383 acres on Tonki Cape, was purchased in 1994. In 1995, the Trustees purchased timber rights near Orca Narrows in PWS. Future parcels under consideration include lands in Prince William Sound, Kodiak, Afognak and Shuyak islands, and the outer Kenai coast.

Conclusion

Our knowledge of marbled murrelet life history and habitat requirements has greatly increased over the last 6 years, but much of the mystery remains. Since 1989, boat surveys of PWS show little change in the population[23] and limitations to recovery remain unclear. On the positive side, there is no evidence of a further decline in the population. Almost nothing is known about marbled murrelet demographics, but based on their body size, single-egg clutch and data from other alcids, murrelets probably depend on high adult survival to offset low reproductive potential.[22] If murrelets are long-lived but suffering low replacement due to low productivity, it could be one or more decades before the effects can be observed in the total population. By monitoring their productivity, trends may be discerned in time to adjust management decisions.

A possible avenue for future restoration efforts may be to reduce bycatch mortality. The importance of gillnet mortality on murrelets in Alaska is poorly known, but murrelets were the most common seabird caught in PWS salmon gillnets. In 1990 and 1991, approximately 1400 and 700 murrelets were killed in those years, respectively.[24] Additional effort will be required to obtain information on which age-classes are most susceptible to bycatch and under what conditions. This information may lead to a reduction in bycatch.

Photo by Kevin Hartwell

Kathy Kuletz has been a wildlife biologist for the U.S. Fish and Wildlife Service for 10 years and has worked as a biologist in Alaska since 1976. Her work has included fisheries and wildlife diet and monitoring surveys. Most of her research has been on the distribution, habitats, feeding habits and breeding success of seabirds in southcentral Alaska.

The Restoration Notebook series is published for educational purposes. Persons wishing to cite this material in scientific publications should refer to the technical reports and literature listed at the end of each account.

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