

AN ABSTRACT OF THE DISSERTATION OF

Patrick G. R. Jodice for the degree of Doctor of Philosophy in Wildlife Science presented on November 10, 1998. Title: Behavioral Ecology of Marbled Murrelets (*Brachyramphus marmoratus*) in Forest and Marine Ecosystems of Oregon.

Abstract approved: \_\_\_\_\_

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Marbled Murrelets (*Brachyramphus marmoratus*) are threatened seabirds that are prone to disturbance both at sea and at old-growth forest nesting areas. I examined murrelet behavior and activity patterns in forest and marine ecosystems of Oregon. Diving behavior was studied during the 1995 and 1996 breeding seasons and was compared to predictions from optimal breathing models, which predicted a strong relationship between dive times and preceding pause times. Diving patterns appeared to fit these predictions more in 1996 than 1995 suggesting that diving behavior was affected more by annual changes in environmental conditions than by physiological constraints on breathing and diving as predicted by optimal breathing models.

Activity patterns at inland nest sites were monitored on a near-daily basis during three breeding seasons to assess the relationships between activity and both weather and date. Daily activity was highly variable within and among sites and years and I observed greater variability in activity levels than has been previously reported for this species. Activity varied greatly during all portions of the breeding season and analyses revealed that weather and date variates explained little of the variability present. It also appeared that variability in activity during the breeding season was not due entirely to breeding phenology; however, activity of nonbreeding birds attending nesting stands may contrib-

ute to daily variability.

Inland activity data also were used to assess the feasibility of developing long-term monitoring strategies based on counts of daily detections. I determined how effectively various survey strategies estimated measures of daily mean and standard deviation of detection counts of murrelets within a breeding season. Results indicated that it would be difficult to obtain reliable estimates of murrelet detections with sampling efforts up to 14 days/season. However, estimates of mean and standard deviation for daily detections during a breeding season may be reliably estimated to within + 50% with similar or less effort. The power of survey strategies to detect annual declines in detections of 25% and 50% were very low and moderate, respectively, except when variability was quite low.

Behavioral Ecology of Marbled Murrelets (*Brachyramphus marmoratus*)  
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## CONTRIBUTION OF AUTHORS

Dr. Michael W. Collopy was involved in all aspects of each manuscript and is as a co-author on each chapter. Dr. Steven L. Garman assisted in the analysis design and interpretation of data for Chapter 3 and is a co-author for that chapter.

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To my father, Patrick

You are missed

**BEHAVIORAL ECOLOGY OF MARBLED MURRELETS (*Brachyramphus marmoratus*) IN FOREST AND MARINE ECOSYSTEMS OF OREGON**

INTRODUCTION

The Marbled Murrelet (*Brachyramphus marmoratus*), a 200g alcid that typically nests in coastal old-growth forests and forages at sea in nearshore habitats, is considered a threatened species throughout much of its range (Kaiser et al. 1994, USDI Fish and Wildlife Service 1997). Although prone to disturbance at sea from oil spill events, gill net fisheries, and shifts in oceanographic conditions (Carter and Kuletz 1995, Carter et al. 1995, Hunt 1995), the primary and immediate threat to this species has been loss of and disturbance to nesting habitat (Ralph et al. 1995a). For example, habitat considered suitable for Marbled Murrelet nesting in the Oregon Coast Range has declined from ca. 1.25 million ha prior to the onset of intensive logging to ca. 200,000 ha currently (FEMAT 1993, Perry 1995). Moreover, the quality of the remaining nesting habitat has likely been impacted by associated changes in landscape patterns.

Based upon the potential for population declines due to these adverse effects, this species was listed as threatened in Washington, Oregon, and California (USDI Fish and Wildlife Service 1992). Subsequently, in order to comply with the Endangered Species Act and National Forest Management Act, many acres of federally managed old-growth forest were withheld from timber operations in these states. As a result, Marbled Murrelets are given special attention in the Northwest Forest Plan (FEMAT 1993, USDA and USDI ROD 1994). More recently, recovery plans in Canada and the U.S. were developed (Kaiser et al. 1994, USDI Fish and Wildlife Service 1997). Each plan identified information gaps, among them a lack of understanding and quantification of behavior and activity patterns in both forest and marine ecosystems.

For example, although distribution of murrelets at sea has been well documented (Ralph et al. 1995a), there is little quantitative information available on foraging behavior or the factors that affect it. Such data would improve our understanding of marine distribution, improve the design and interpretation of marine population surveys, and improve our understanding of how murrelets react to shifts in oceanographic conditions. Similarly, while inland distribution of murrelets has been well-documented (Ralph et al. 1995a) there is little quantitative information available on daily and annual variability in murrelet activity at nest stands (Rodway et al. 1993). Such data would improve our interpretation of inland survey data, improve our understanding of the factors that affect attendance at the nest stands, and allow us to determine the feasibility of using inland survey data to seek temporal or spatial differences in activity levels. Furthermore, the link between behaviors and activity patterns in forest and marine systems is poorly understood. For example, seabird reproductive success and attendance at nesting areas are each affected by foraging conditions or large-scale oceanographic processes (Bost and LeMaho 1993, Graybill and Hodder 1985, U.W. Wilson 1991). Therefore, murrelet behaviors in forests might be explained in part by oceanographic conditions and associated marine behaviors.

The three chapters of this dissertation examine Marbled Murrelet behavior and activity patterns in forest and marine ecosystems and attempt to fill voids in information and provide data valuable to interpreting survey results. Chapter 1, “Diving and foraging patterns of Marbled Murrelets: Testing predictions from optimal breathing models”, examines foraging behavior of telemetered Marbled Murrelets along the Oregon Coast. Empirical field data from murrelet diving patterns are compared with predictions from two different diving optimization models. Ecological factors that might affect the fit of the field data to the model predictions are explored. Since nesting ecology and reproductive success of seabirds is ultimately driven by their ability to provision themselves and their young, identifying the ecological factors that might affect murrelet diving and

forging improve our ability to interpret inland activity and behavior.

The second chapter, “Activity patterns of Marbled Murrelets in Douglas-Fir old-growth forests of the Oregon Coast Range”, examines the temporal patterns that occur in activity levels of Marbled Murrelets at inland nest areas. Although inland surveys for this species are common there are little quantitative data on temporal patterns in activity or the factors that might affect them. Without such data it is difficult to understand the magnitude or meaning of daily and annual fluctuations in activity at the nesting stands and interpret survey results accordingly. Furthermore, as with most seabirds, murrelet activity patterns at the nesting area are likely affected by marine conditions. Therefore, diving data discussed in Chapter 1 have some bearing on results of Chapter 2.

Chapter 3, “Using resampling to determine reliability of survey results: An example with the threatened Marbled Murrelet”, concludes the dissertation by examining the variability observed in inland activity data discussed in Chapter 2 and considers how this variability affects monitoring efforts for this species. Although inland surveys for murrelets are primarily focused on determining presence and probable nesting status, survey data present an opportunity to quantify daily activity as well. These daily activity data have begun to be used, both formally and informally, to compare levels of activity among stands or between years. This chapter quantifies the probability that a given survey strategy will produce data that can reliably be used to seek temporal or spatial differences in inland activity levels of murrelets. The techniques developed, while based on Marbled Murrelet surveys, are applicable to a wide range of situations where count data are used.

These three chapters provide a substantial increase in the knowledge base of Marbled Murrelet ecology. Ensuring the long-term viability of this species rests upon many factors; however, without an understanding of behavioral ecology in both forest and marine systems, biologists will not be able to design the management plans or survey strategies necessary to maintain populations or manage habitats. Marbled Murrelets are a

unique seabird, using both forest and marine systems extensively; a comprehensive examination of this species' behavioral ecology should therefore consider data from both systems.