ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF WILDLIFE CONSERVATION
PO Box 115526
Juneau, AK 99811-5526

Alaska Department of Fish and Game
State Wildlife Grant

GRANT AND SEGMENT NR: **T-1-16**

PROJECT NUMBER: **1**

PROJECT TITLE: Marbled Murrelet Activity Patterns and Health at Port Snettisham, Alaska

PARTNER: Wildlife Trust and Oregon State University

PRINCIPAL INVESTIGATORS: S. Kim Nelson and Scott Newman

PROJECT DURATION: May 20, 2005 – December 31, 2008

REPORT PERIOD: May 20, 2008 – December 31, 2008

I. PROBLEM OR NEED THAT PROMPTED THIS RESEARCH

We proposed to study the health, activity patterns, foraging ranges and habitat use of Marbled Murrelets (*Brachyramphus marmoratus*) in the Port Snettisham (PS) area of Southeast Alaska over 3 years beginning in 2005. This project was, in part, a continuation of work begun by Matt Kirchhoff (ADFG) on murrelet activity patterns at Port Snettisham in 2004.

The Marbled Murrelet (hereafter murrelet) is a small diving seabird in family Alcidae that breeds in coastal older-aged forests from Alaska to central California (Nelson 1997). This species generally occurs near shore and is the most common alcid in the sheltered waters of its range. Murrelets are unique among alcids in flying long distances inland to their solitary nests (generally within 40 km; Nelson and Hamer 1995). Because breeding birds are cryptic, secretive, and primarily crepuscular in their flights and at nest sites, relatively little is know about their activity patterns and few active nests have been found. Murrelets are currently listed as threatened or are thought to be declining over much of their range primarily because of breeding habitat loss (USFWS 1992, McShane *et al*. 2004, Huff *et al*. 2006, Piatt *et al*. 2006).

II. REVIEW OF PRIOR RESEARCH AND STUDIES IN PROGRESS ON THE PROBLEM OR NEED

Southeast Alaska is generally considered the center of abundance for murrelets in North America (Piatt and Naslund 1995). Surveys at inland sites in this area have provided us with some information on murrelet activity patterns in the forest (e.g., Brown *et al*. 1999). In addition, observations made during shipboard surveys in Southeast Alaska have indicated that local murrelet numbers fluctuated seasonally (Agler *et al*. 1998, Speckman *et al*. 2000), and suggested that murrelets fly long distances between nesting and foraging areas during the breeding season (DeGange 1996; G. van Vliet, M. McAllister, unpubl. data). With the advancement of murrelet capture and radio-marking techniques in the late 1990s (Newman *et al*. 1999a, 1999b), these long distance at-sea movements were verified in Southeast Alaska (Whitworth *et al*. 2000) and California (Peery *et al*. 2003) by tracking marked individuals. Murrelets were also successfully tracked to nest sites in many areas of their range providing detailed information on inland activity patterns and nesting habitat selection (Kuletz *et al*. 1995, Burkett *et al*. 1999, Lougheed 2000, Hull *et al*. 2001, Bradley 2002). While these data have provided us with a more complete picture of murrelet ecology, most of these studies were conducted outside of Southeast Alaska; we still know very little about murrelet activity patterns and habitat use in this area. Determining specific flight patterns and habitat preferences in Southeast Alaska will be crucial for understanding the marine and inland ecology of murrelets, and for future management efforts.

Concurrent with murrelet telemetry studies in central California (Burkett *et al*. 1999), blood samples were collected to evaluate the health and physiological condition of the nesting murrelets. Baseline health indices were established for murrelets inhabiting this geographic range, and we now have a better understanding of the murrelets' hematologic parameters, immune function, liver enzymes, kidney function, and electrolyte balance (Newman and Zinkl 1998, Newman 2000). Establishing baseline health indices for murrelets in central CA enable future comparisons to be made; either among years when environmental conditions differ, or among different geographic areas where ecological conditions and threats to murrelet health differ. Furthermore, baseline health indices can play a vital role in helping veterinarians assess the health of oil injured or diseased murrelet receiving care. To date, no blood-based health assessments have been conducted on murrelets from Alaska and it is unknown if birds from Southeast Alaska are physiologically healthy or have conditions that would place them at a survival disadvantage.

III. APPROACHES USED AND FINDINGS RELATED TO THE OBJECTIVES AND TO PROBLEM OR NEED

Activity Patterns and Habitat Use

OBJECTIVE 1: Determine daily flight and foraging patterns of radio-marked Marbled Murrelets during nesting, chick rearing, and post-fledging periods.

We captured 126 and radio-marked 111 murrelets in PS from 2005 to 2007. Individual radio-marked murrelets were tracked for periods of 3 to 74 days during the late (2005), early (2006), and peak (2007) portions of the breeding season: mean = 25 ± 12 d (n = 32) for 2005, 26 ± 10 d (n = 40) for 2006, and 61 ± 17 d (n = 39) for 2007. The dramatic increase in mean tracking periods during 2007 compared to 2005 (t = 10.0878, $p < 0.0001$) and 2006 (t = 11.1875, $p < 0.0001$) was mostly due to longer transmitter battery life, relatively calm weather, and an extended field season. Also, annual variations in food availability are potentially a factor affecting murrelet population levels in PS during the late breeding season.

The combination of boat survey and data logger radio-telemetry techniques allowed us to determine daily and seasonal activity patterns for murrelets foraging inside PS. During all three years of our study we observed murrelets exiting interior PS during the late evening hours and returning early the next morning. We also documented a steady decline in attendance in PS by radio-marked murrelets as each season progressed.

At Auke Bay, AK (Speckman *et al.* 2000 and Whitworth *et al.* 2000), Clayoquot Sound, BC (Tranquilla *et al.* 2005), and Desolation Sound, BC (Lougheed 2000), murrelets also moved out of inlets at night and returned in the early morning hours. While daily activity patterns for murrelets differ somewhat among areas, little is understood about the factors that affect a local murrelet population's daily movements. Our work on murrelet at-sea habitat use (Haynes *et al.* 2008) suggests that murrelets are not redistributing themselves in response to a change in prey abundance. Theories as to why most murrelets would leave PS at night include predator avoidance, social behavior, weather patterns, and marine conditions (sea surface temperature, salinity, etc.). Certainly, more research is needed to determine the mechanisms that drive murrelet offshore at night in Southeast Alaska.

We expected seasonal declines in numbers of radio-marked murrelets attending PS as murrelets dispersed post-breeding. The rate at which attendance declined varied each year and was likely affected by individual breeding status.

OBJECTIVE 2: Determine initial post-breeding dispersal movements as best as possible based on battery signal strength, flight time costs, and distances birds move from Port Snettisham.

Post-breeding dispersal for an individual radio-marked murrelet was considered to have begun after the last detection (using any survey method) inside PS or a surrounding area. Although efforts to identify post-breeding sites in 2006 failed due to radio failure, data collected during 2005 and 2007 gave us an idea of the immediate directions and general timing of post-breeding dispersal.

We obtained post-breeding dispersal locations for 17 (53%) radio-marked murrelets during 2005. Radio-marked murrelets began post-breeding dispersal as early as 30 June, with a mean departure date of 17 July (± 12 d), although one murrelet attended PS until at least 26 August. The number of dispersal locations for individual radio-marked murrelets ranged from 1 to 8, over periods ranging from 1 to 30 days after departure from PS. All detections of dispersed murrelets were within a 150 km radius of PS. Locations occurred as far north as Glacier Bay and Icy Strait and as far south as Chatham Strait off Kuiu Island. In 2007, we documented post-breeding dispersal dates for 17 (44%) radio-marked murrelets, of which 5 (13%) were known breeders. Considering our final aerial survey was 26 July, only dispersal dates prior to 25 July, were examined. Post-breeding dispersal dates ranged from 25 June to 24 July with a mean departure date of 12 July (± 9 d, n = 17). The mean departure date for murrelets with a documented breeding attempt was 11 July (± 8 d, n = 5). We also found current breeding status to be an important factor in determining timing of post-breeding dispersal from PS and surrounding areas. During our final aerial survey on 26 July 2007, 80% (12 of 15) of murrelets detected were known breeders with 67% (10 of 15) thought to have an active nest at that time. On the last two days of data logger monitoring (27-28 July), 71% (10 of 14) of murrelets detected inside PS were known breeders while 57% were thought to still have an active nest. Similar results from 2005 and 2007 show that mid-July is the peak of post-breeding dispersal from PS for non-breeding murrelets and murrelets with failed nest attempts.

No particular dispersal direction or destination was evident in movements of individual murrelets after leaving PS. Timing of post-breeding dispersal was previously unknown for most of southeast Alaska and was slightly later than dates observed in studies to the south (*e.g.,* Peery *et al*. 2004). This period of dispersal from PS coincided with previously mentioned peaks in flyway counts in PS (M. Kirhhoff, unpubl. data) suggesting that the observed influx of murrelets was due to dispersal to PS from other areas in southeast Alaska. Further research is required to gain an understanding of this fairly nomadic annual period for most murrelets.

OBJECTIVE 3: Identify nesting habitat and potentially locate nests.

We captured murrelets early in the breeding season during 2006 and 2007 allowing us to focus intensely on identifying breeding activity of radio-marked murrelets in PS. A total of 19 active nest sites were located (8 tree, 5 cliff, 6 either) via aerial telemetry, including three nests for radio-marked pairs and one second nesting attempt. Two additional murrelets were later determined to have attended an active nest using the “on/off” incubation pattern (henceforth, the incubation pattern) detected by combined data logger and boat survey information. Also, we identified three potentially inactive nesting areas where individual murrelets sporadically attended inland sites.

Most incubation patterns were first documented during aerial surveys with an inland location or the presence then absence of an individual murrelet from the waters of PS during consecutive aerial surveys. Later, all detections (aerial survey and data logger) were combined and analyzed for incubation success, chick feedings, overall nest success, and previously undetected incubation patterns. Nest initiation dates ranged from 12 May to 11 July and peaked during late May and early June. Incubation at individual nests ranged from 9 to 41 days. Chick feeding flights were recorded for 5 to 34 days. Thirteen eggs successfully hatched (6 failed to hatch) and of those only 3 successfully fledged (6 failed and 3 outcomes were unknown).

We found that radio-marked murrelets nested in a variety of inland habitats within river or creek drainages associated with PS. While most nest sites were inaccessible by foot, we were able to visually locate and document three tree nesting locations using hand-held telemetry as well as confirming one nest location on a cliff. All other nest-site locations were determined from repeated low-elevation aerial telemetry and examination of low elevation aerial photographs of the nest area. We determined nest-site characteristics for 16 of the 19 nesting areas using approximate nest location coordinates from aerial surveys and mapping software. Nesting areas occurred in older-aged forests or steep cliff areas with various aspects, elevations, and distances from the coastline. Elevations ranged from 42 to 986 m (0 = 374 ± 268 m; n = 19) and distance from the coast ranged from 1.2 to 52.3 km (0 = 15.1 ± 15.0 km). Two nests were found in Canada >50 km inland. The use of habitat so distant from the coast was surprising considering the vast amount of available nesting habitat (tree and cliff) near the coastline in most areas of PS.

We examined our active and inactive nesting areas relative to predicted murrelet nesting habitat from the Southeast Alaska Core Areas of Biological Value Database (Schoen and

Dovichin 2007). This database characterizes most terrestrial habitat types and forms of land cover, including different forest types and productivity levels (annual gross volume ft^3 growth per acre). The database also predicts the suitability of an area for important wildlife species, including murrelet nesting habitat. In this model, a productive old-growth forest is considered suitable for murrelet nesting habitat while non-forest areas are considered not suitable. After overlaying our nesting areas on the predicted murrelet nesting habitat, we found that nests were located in all levels of predicted murrelet habitat. All tree nests were inside or along the edge of the moderate to predicted murrelet habitat, while most cliff nests were outside the predicted murrelet habitat. Nests of unknown nest type (tree or cliff) were located nearby or within low to moderately suitable predicted murrelet nesting habitat. Overall, the amount of predicted murrelet nesting habitat in PS was relatively low compared to many nearby areas but no murrelets captured at the mouth of PS were found to breed in other areas despite aerial searches.

Health Assessment

OBJECTIVE 4: Conduct health evaluations for 30-35 murrelets/year using hematologic and biochemical testing.

We captured and collected blood from 101 murrelet in PS from 2005 to 2007 (2005 n = 42, 2006 n = 36, and 2007 n = 23). We analyzed blood samples for hematological parameters, plasma samples for biochemical parameters, and cloacal samples in 2007 to determine Avian Influenza Virus (AIV) and Newcastle Disease Virus (vNDV) status, all to establish baseline health reference intervals for this population.

For the hematological analysis, blood samples were analyzed for the white blood cell count (WBC) differential by counting 100 white blood cells on each blood smear and categorizing the following cell types: eosinophils, heterophils, lymphocytes, monocytes and basophils. Blood smears were examined for the presence of blood parasites. For the biochemical analysis, we sent frozen plasma samples on dry ice to the Division of Comparative Pathology at the University of Miami, Miller School of Medicine for a summary of alanine amino transferase (ALT), lactate dehydrogenase (LDH), aspartate amino transferase (AST), creatine phosphokinase (CK), calcium (CAL), phosphorus (PHOS), glucose (GLU), total protein (TP), and uric acid (URIC) using an Ortho Vitros 250 (Ortho Diagnostics, Rochester, NY). For the disease analysis, we sent cloacal swab samples taken in 2007 (n = 40) to the Alaska State Veterinarian in Anchorage, AK, to be analyzed for AIV and vNDV.

OBJECTIVE 5: Establish blood-based reference ranges for Southeastern Alaska murrelets.

In this study, we not only established reference ranges for baseline blood health indices for murrelets in AK, but also identified significant differences between these parameters spatially, temporally, and with respect to gender and parasite presence. See other objectives for a summary of reference ranges.

OBJECTIVE 6: Compare health indices inter-annually.

We compared hematological and biochemical parameters among years.

We found significant differences among years for WBC, eosinophil, heterophil, monocyte, and lymphocyte counts, and *post-hoc* tests revealed that mean WBC count was significantly larger in 2007 than 2005 and 2006, and the eosinophil count was significantly smaller in 2005 than 2006 and 2007. The monocyte and lymphocyte counts were significantly smaller in 2006 than 2005 and 2007. H/L values were significantly different for all 3 years, with the largest ratio in 2006, followed by 2005 and 2007. CAL, URIC, TP, ALT, and CK were significantly smaller in 2005 than in 2006 and 2007. Blood parasites (*Haemoproteus* spp. and *Plasmodium* spp.) were present on 23%, 47%, and 36% of blood smears in 2005, 2006, and 2007, respectively. Eosinophil counts were significantly larger for birds with blood parasites than for birds without blood parasites, and monocyte counts were significantly larger for birds without blood parasites than for birds with blood parasites. When biochemical parameters were compared, CAL, TP, ALT, and CK were significantly higher for birds with blood parasites than for birds without blood parasites. In 2007, there were no significant differences between birds that nested and those that did not nest, and all 2007 cloacal swab samples were negative for AIV and vNDV.

Total WBC, an indicator of immune system function, reflects the balance between supply and need for white blood cells, or leukocytes, to defend the body against pathogens upon exposure and infection (Amand 1986). Mean WBC for birds in 2007 was about twice that of the previous two years. Varying environmental conditions and the timing of sampling in all three years may have influenced WBC. In 2006, PS murrelets experienced high mortality (Nelson *et al*. 2008), likely due to poor environmental factors that also limited breeding success. Conversely, we captured birds during the height of their breeding season in May 2007 (Nelson 1997) and normal physiological processes associated with egg production in females, particularly antigen stimulation, may have been associated with increased WBC count for 2007 murrelets. Additionally, 2007 eosinophil counts were significantly larger than 2005, and monocyte and lymphocyte counts were larger than 2006. These results may be linked to the same breeding issues as WBC.

H/L values for 2006 were significantly larger than those in 2005 and 2007. The cause of this large H/L ratio was a relatively low lymphocyte count despite an overall higher WBC for that year. In 2006, PS birds with high H/L ratios experienced high mortality. Increased H/L ratios can result from a variety of stressors including handling (Vleck *et al.* 2000), however, a transient elevation in H/L ratios would not lead to increased mortality in murrelets. Therefore, we believe that true ecological stressors (lack of food, unusual temperatures, inclement weather, etc.) were contributing to the high mortality observed. Ecological conditions may be part of the reason that breeding success of murrelets was so low (13%; Nelson *et al*. 2008).

Activity levels for CK were highest for murrelets in 2006. CK is an enzyme associated with muscle function (Newman *et al.* 2007) and may be elevated due to physical exertion, traumatic restraint, or muscle atrophy secondary to poor environmental conditions, leading to starvation and emaciation. The 2006 spring was particularly wet and cold and may have added atypical environmental stress, or increased metabolic demands. Consequently, CK levels following capture and sampling may have been elevated. The average daily temperature recorded at the Juneau weather station in May 2006 was colder (9.4˚ C [48.9˚ F]), and wetter (21.59 cm [8.50 in] precipitation) than 20-yr averages (9.7˚

C [49.5˚ F] and 12.75 cm [5.02 in] precipitation) (Nelson *et al*. 2008). The extreme weather conditions and potentially poor prey availability, coupled with increased metabolic demands in 2006 also could have played a role in the poor breeding effort, failed nesting attempts, and high number of mortalities recorded by radio-marked PS murrelets that year (Nelson *et al.* 2008). Other less likely causes of increased CK in PS murrelets include Vitamin E/ Se deficiency and lead toxicity but we did not have the opportunity to evaluate these parameters.

OBJECTIVE 7: Conduct geographic health comparison between murrelets from Southeast Alaska and murrelets from central California (samples previously collected and analyzed).

We compared hematological and/or biochemical parameters between California (CA) and Alaska (PS) birds using Mann-Whitney U tests. Total WBC, monocytes, eosinophils, lymphocytes, PHOS, LDH, and TP were higher for AK murrelets than for CA birds. Basophils and H/L were higher for CA murrelets, although the differences are not as striking or thought to be of clinical significance. However, hematological and biochemical values for AK birds were similar to reference ranges established for murrelets from the Aleutian Islands (Newman *et al.* 1997) and Xantus' Murrelets (*Synthliboramphus hypoleucus*) from CA (Newman *et al.* 2005).

Hematological and biochemical profiles have been used in other studies to reveal the geographic differences among stable and declining populations of seabirds (Hollmen *et al.* 2001). Thus, geographic comparisons of hematology and biochemistry may be useful in revealing differences between murrelet populations in PS, which are thought to have remained relatively stable (although see Piatt *et al*. 2006 about SE AK populations), and murrelet populations in Año Nuevo Bay, CA which are steadily declining. The CA population of murrelets has been on the threatened species list in California since 1992 (USFWS 1992; Ralph *et al.* 1995), and the most recent survey has determined the CA population to still be in decline (Henkel and Peery 2008).

Overall, LDH activity for PS birds was elevated in comparison to murrelets from CA and the Aleutian Islands or Xantus' Murrelets from CA. It has been determined that LDH rises and declines more rapidly upon muscle exertion in birds, followed by rising CK and AST activity. Therefore, the high LDH activity serves as an indicator of physical exertion associated with a specific temporal marker of sampling approximately 30 min after capture. On the other hand, CK activity was lower for PS birds in comparison to murrelets from CA and the Aleutian Islands. CK is an enzyme associated with muscle function (Newman et al. 2007) and may be elevated due to physical exertion, traumatic restraint, or muscle atrophy secondary to poor environmental conditions leading to starvation and emaciation. The CK activity for CA murrelets was almost twice that of AK murrelets, suggesting that CA birds may have experienced more stress as a result of capture and handling, in addition to potentially poor environmental conditions. Activity levels of CK and AST were relatively low in PS birds and this suggests little, if any, prolonged muscle associated exertion due to capture or restraint.

One factor that can compromise the avian immune system is pollution. The marine environment along the CA coast may be affected by organic contaminants from agricultural run-off, trace elements discharged as waste from industrial areas, and oil pollution, and as a result, the health of murrelet populations in this area may be threatened. Further study to carefully evaluate murrelet health concurrent with contaminant levels in water, prey, and murrelets in central CA is necessary to draw such conclusions.

OBJECTIVE 8: Archive blood samples for future DNA analyses, disease testing, and isotope research.

Blood samples have been archived at Wildlife Trust and the Division of Comparative Pathology at the University of Miami, Miller School of Medicine. Some samples are currently undergoing DNA and stable isotope analyses.

IV. MANAGEMENT IMPLICATIONS

Activity Patterns and Habitat Use Study – Important and unexpected information about Marbled Murrelets in the PS area, Southeast Alaska, was obtained during each year of our study from 2005 to 2007. Highlights were the: (1) identification of PS as an important regional breeding and foraging area between April and August; (2) discovery of 19 nesting areas with at least 8 nests in trees and 5 nests located on rock cliffs; (3) details from our stationary data loggers which documented nest success, several cases of egg neglect, and revealed the exact timing of incubation and chick feeding flights in PS; (4) determination of the daily and seasonal activity patterns for murrelets attending the PS area during the breeding season; (5) documentation of long-distance movements of murrelets from PS during the post-breeding dispersal period; (6) evaluation of different telemetry tracking techniques for the PS area, including identification of stationary data loggers as a viable method for monitoring activity patterns and nest success; (7) documentation of high transmitter failure rates and potential environmental effects in 2006 resulting in few breeding attempts and high mortality; and (8) identification of varied seasonal weather patterns over the years and related affects on murrelet breeding and mortality rates.

Additional research in needed in Southeast Alaska to determine the range of conditions in murrelet activity patterns, post-breeding dispersal, breeding behavior, and nesting habitat use. Port Snettisham is located on the Alaska mainland where tree and cliff nesting habitat are abundant and tidewater glaciers are present. An investigation of murrelet behavior and habitat use is needed on the islands of Southeast Alaska, which comprise a majority of the land base in the region and where available habitats are significantly different. Without further exploration of the preferences of this unique seabird on and adjacent to the islands, murrelet management options will remain limited.

Health Study – In this study, we not only establish reference ranges for baseline blood health indices for murrelets in AK, but also identified significant differences between these parameters spatially, temporally, and with respect to gender and parasite presence. These results will provide future AK murrelet health assessments with information for comparative purposes and allow for continued monitoring of avian populations and ecosystem health over time. Currently, the birds sampled in our study appear to be physiologically healthy based on blood hematological and biochemical parameters measured. However, they often face unpredictable environmental conditions during both their over-wintering and breeding seasons which can result in chronic stress and increased metabolic demands. Severe environmental conditions may result in poor nesting effort, low nest initiation rates, failed nesting attempts, and greater mortalities as supported by our 2006 results. As animals are programmed to survive and maintain their own homeostasis and physiological health, if environmental conditions are not favorable, reproductive efforts would be compromised in an attempt to maintain their own health. However, in extraordinary conditions, despite efforts to maintain health, severe nutritional stressors and environmental conditions result in increased mortality rates. Our data supports a combination of both of these effects in PS as well as in central CA.

Other threats to murrelet health in PS include compromised water quality, contaminated prey items due to oil pollution, cruise ship and industry discharges, and changes in prey availability and abundance. However, this project provided an opportunity to assess health of murrelets in PS at a time when no obvious oil pollution or discharge threats existed. This type of assessment, conducted before a problem or disaster occurs, is an excellent way to ensure proper health assessments without complicating factors affecting interpretation of results and should be conducted more frequently to evaluate the health of populations of marine birds and other wildlife species.

If environmental conditions and food resources are compromised, the health of murrelets and other organisms in Southeast Alaskan ecosystems could be affected. Detrimental effects would, in turn, be indicated by changes in blood health indices (Newman *et al*. 2007). Should changes in blood health indices be seen in the future, a study of contaminants in prey items may help elucidate underlying pollution problems.

V. SUMMARY OF WORK COMPLETED ON JOBS FOR LAST SEGMENT PERIOD ONLY (May 20, 2008 – December 31, 2008)

During this last period, we analyzed data and completed reports on the T-1-16-1 project. Fieldwork on the T-8-1 project (Marbled Murrelet Habitat Use and Activity Patterns at Port Snettisham, Alaska), with an effective date May 8, 2008, began where this project left off.

JOB/ACTIVITY 8: Archive blood samples for future DNA analyses, disease testing, and isotope research.

All of the blood samples have been archived or are currently undergoing DNA and stable isotope analyses.

VI. PUBLICATIONS

Reports

Nelson, S.K., B.A. Barbaree, S.H. Newman, H.R. Carter, and D.L. Whitworth. 2008. Marbled Murrelet (*Brachyramphus marmoratus*) Breeding Ecology, Terrestrial Habitat Use, and Activity Patterns in Port Snettisham, Southeast Alaska, 2005-2007. Unpublished report prepared for the Alaska Department of Fish and Game by Wildlife Trust, New York, NY.

Newman, S. H., V.M. Padula, S.K. Nelson, and T.B. Haynes. 2008. Health Assessment of Marbled Murrelets in Port Snettisham, Southeast Alaska. Unpublished report

prepared for the Alaska Department of Fish and Game by Wildlife Trust, New York, NY. 41pp.

Publications in Review

Padula, V.M., S.H. Newman, S.K. Nelson, T.B. Haynes, and C. Cray. In review. Health assessment of Marbled Murrelets in Port Snettisham, Southeast Alaska. Journal of Wildlife Diseases.

Haynes, T.B., S.K. Nelson, F. Poulsen, and V.M. Padula. In review. At-sea habitat use and patterns in spatial distribution of Marbled Murrelets in Port Snettisham, Southeast Alaska. Marine Ornithology.

Presentations

Newman, S.H., S.K. Nelson, D.L. Whitworth, H.R. Carter, and M. Kirchhoff. Marbled Murrelet activity patterns and health at Port Snettisham, Alaska. Poster, 2006 Pacific Seabird Group Annual Meeting.

Nelson, S.K., S.H. Newman, D.L. Whitworth, H.R. Carter, and M. Kirchhoff. Marbled Murrelet activity patterns and health at Port Snettisham, Alaska. Poster, 2006 North American Ornithological Conference.

Nelson, S.K., S.H. Newman, B.A. Barbaree, T.B. Haynes, D.L. Whitworth, and H.R. Carter. Nesting habitat, activity patterns, and distribution of Marbled Murrelets at Port Snettisham, Southeast Alaska. Paper, 2008 Pacific Seabird Group Annual Meeting and 2008 Oregon Chapter of the Wildlife Society Annual Meeting.

Haynes, T.B., S.K. Nelson, F. Poulsen, and V.M. Padula. At-sea habitat use and patterns in spatial distribution of Marbled Murrelets in Port Snettisham, Southeast Alaska. Poster, 2009 Pacific Seabird Group Annual Meeting.

LITERATURE CITED

Agler, B.A., S.J. Kendall, and D.B. Irons. 1998. Abundance and distribution of Marbled and Kittlitz’s Murrelets in southcentral and southeast Alaska. Condor 100:254-265.

Amand, W.B. 1986. Avian clinical hematology and blood chemistry. Pages 264-276 i*n* Fowler, M.B., ed. Zoo and Wild Animal Medicine, W. B. Saunders Co, Philadelphia, Pennsylvania.

Brown, M., J.G. Doerr, J. Fowler, A. Russel, and P.J. Walsh. 1999. Marbled Murrelet activity patterns and survey efficiency at inland sites in southeastern Alaska. Northwestern Naturalist 80:44-50.

Bradley, R.W. 2002. Breeding ecology of radio-marked Marbled Murrelets *(Brachyramphus marmoratus*) in Desolation Sound, British Columbia. M.S. Thesis, Simon Fraser University, Burnaby, BC.

Burkett, E.E., H.R. Carter, J.Y. Takekawa, S.N. Newman, R.T. Golightly, and J.L. Lanser. 1999. Marbled Murrelet radio telemetry in central California in 1997 and 1998: a reduced effort noted in an El Nino year. Pacific Seabirds 26:32.

DeGange, A.R. 1996. A conservation assessment for the Marbled Murrelet in southeast Alaska. USDA Forest Service Gen. Tech. Rep. PNW-GTR-388, Portland, OR.

Haynes, T.B., S.K. Nelson, F. Poulsen, and V.M. Padula. 2008. At-sea habitat use and patterns in spatial distribution of Marbled Murrelets in Port Snettisham, SE Alaska. Unpublished report to the Alaska Department of Fish and Game by Wildlife Trust and Oregon State University. 57 pp.

Henkel, L.A., Peery, M.Z. 2008. Abundance and productivity of Marbled Murrelets off Central California during the 2007 breeding season. California State Parks, Moss Landing, CA.

Hollmen, T., Franson, J.C., Hario, M., Sankari, S., Kilpi, M., Lindstrom, K. 2001. Use of serum biochemistry to evaluate nutritional status and health of incubating Common Eiders (*Somateria mollissima*) in Finland. Physiological and Biochemical Zoology 74:333-342.

Huff, M.H., M.G. Raphael, S.L. Miller, S.K. Nelson, and J. Baldwin, tech. coords. 2006. Northwest Forest Plan—The first 10 years (1994-2003): status and trends of populations and nesting habitat for the Marbled Murrelet. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Gen. Tech. Rep. PNW-GTR-650, Portland, OR. 149 pp.

Hull, C.L., G.W. Kaiser, C. Lougheed, L. Lougheed, S. Boyd, and F. Cooke. 2001. Intraspecific variation in commuting distance of Marbled Murrelets (*Brachyramphus marmoratus*): Ecological and energetic consequences of nesting further inland. Auk 118:1036-1046.

Kuletz, K.J., D.K. Marks, D. Flint, R. Burns, and L. Prestash. 1995. Marbled Murrelet foraging patterns and a pilot productivity index for murrelets in Prince William Sound, Alaska. Exxon Valdez Oil Spill Restoration Project Final Rep. (Project 94102), U.S. Fish and Wildlife Service, Anchorage, AK.

Lougheed, C. 2000. Breeding chronology, breeding success, distribution and movements of Marbled Murrelets (*Brachyramphus marmoratus*) in Desolation Sound, British Columbia. Canadian Wildlife Service Tech. Rep. Series No. 352, Pacific and Yukon Region, BC.McShane, C., T. Hamer, H.R. Carter [et al.]. 2004. Evaluation report for the 5-year status review of the Marbled Murrelet in Washington, Oregon, and California. USDI Fish and Wildlife Service, Portland, OR.

Nelson, S.K. 1997. Marbled Murrelet (*Brachyramphus marmoratus*). Pages 1-32 *in* A. Poole and F. Gill, eds. Birds of North America, No. 276. The Academy of Natural Sciences, Philadelphia; The American Ornithologists Union, Washington, D.C.

Nelson, S.K. and T.E. Hamer. 1995. Nesting biology and behavior of the Marbled Murrelet. Pages 57-68 *in* C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the Marbled Murrelet. USDA Forest Service Gen. Tech. Rep. PSW-GTR-152, Albany, CA.

Nelson, S.K., B.A. Barbaree, S.H. Newman, H.R. Carter, and D.L. Whitworth. 2008. Marbled Murrelet (*Brachyramphus marmoratus*) breeding ecology, terrestrial habitat use, and activity patterns in Port Snettisham, Southeast Alaska, 2005-2007. Wildlife Trust, New York, NY (prepared for the Alaska Department of Fish and Game).

Newman, S.H. 2000. Establishing Hematologic and Serum Biochemical Reference Ranges for Central California Marbled Murrelets and Evaluation of Individual Animal Health and Population Health. Final Report. California Department of Fish and Game, Resource Management Division, Sacramento, CA.

Newman, S.H., H.R. Carter, D.L. Whitworth, and J.G. Zinkl. 2005. Health assessments and stress response of Xantus' Murrelets to capture, handling and radio-marking. Marine Ornithology 33: 147-154.

Newman, S.H., S.K. Nelson, J.Y. Takekawa, E.E. Burkett, and R.T. Golightly. 1999a. An improved radio attachment technique for a variety of marine bird species. Pages 415-425 *in* J. H. Eiler, D. J. Alcorn, and M. R. Neuman, eds. Biotelemetry 15: Proceedings of the 15th Int. Symposium on Biotelemetry, Juneau, AK. International Society of Biotelemetry, Wageningen, The Netherlands.

Newman, S.H., V.M. Padula, C. Cray, and L.D. Kramer. 2007. Health assessment of Black-crowned Night-herons (*Nycticorax nycticorax*) of the New York Harbor estuary. Journal of Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology 148: 363-374.

Newman, S.H., J.F. Piatt, and J. White. 1997. Hematological and Plasma Biochemical Reference Ranges of Alaskan Seabirds: Their Ecological Significance and Clinical Importance. Colonial Waterbirds 20: 492-504.

Newman, S.H., J.Y. Takekawa, D.L. Whitworth, and E.E. Burkett. 1999b. Subcutaneous anchor attachment increased retention of radio transmitters on Xantus' and Marbled Murrelets. Journal of Field Ornithology 70:520-534.

Newman, S.H. and J.G. Zinkl. 1998. Establishment of hematological, serum biochemical and electrophoretogram reference intervals for species of marine birds likely to be impacted by oil spill incidents in the state of California. Baseline Marine Bird Project, Contract FG 3460-OS Final Report submitted to California Department of Fish and Game, Office of Oil Spill Prevention and Response, Sacramento, CA. 28 pp.

Peery, M.Z., S.R. Beissinger, and S.N. Newman. 2003. Post-breeding movements and distribution of Marbled Murrelets in central California. Unpubl. Rep., Oiled Wildlife Care Network, Univ. California, Davis, CA and California Department of Fish and Game, Sacramento, CA.

Peery, M.Z., S.R. Beissinger, S.H. Newman, E. Burkett, and T.D. Williams. 2004. Applying the declining population paradigm: diagnosing causes of poor reproduction in the Marbled Murrelet. Conservation Biology 18: 1088-1098.

Piatt, J.F. and N.L. Naslund. 1995. Abundance, distribution and population status of Marbled Murrelets in Alaska. Pages 285-294 *in* C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the Marbled Murrelet. USDA Forest Service Gen. Tech. Rep. PSW-GTR-152, Albany, CA.

Piatt, J.F., K.J. Kuletz, A.E. Burger, S.A. Hatch, V.L. Friesen, T.P. Birt, M.L. Arimitsu, G.S. Drew, A.M.A. Harding, K.S. Bixler. 2006. Status review of the Marbled Murrelet (*Brachyramphus marmoratus*) in Alaska and British Columbia. U.S. Geological Survey Open-File Report 2006-1387. 258 pp.

Ralph, C.J., G.L. Hunt, J., Raphael, M.G., Piatt, J.F. 1995. Ecology and conservation of the Marbled Murrelet in North America: an overview. Pages 3-22 *in* Ralph, C.J., G. L. Hunt, J., Raphael, M.G., Piatt, J.F. (eds.). Ecology and conservation of the Marbled Murrelet. USDA Forest Service, General Technical Report PSW-GTR-152, Albany, CA.

Schoen, J. and E. Dovichin, eds. 2007. The coastal forests and mountain ecoregion of southeastern Alaska and the Tongass National Forest. Audubon Alaska and The Nature Conservancy, 715 L. Street, Anchorage, AK.

Speckman, S.G., A.M. Springer, J.F. Piatt, and D.L. Thomas. 2000. Temporal variability in abundance of Marbled Murrelets at sea in southeast Alaska. Waterbirds 23:364-377.

Tranquilla, L.M., N.R. Parker, R.W. Bradley, D.B. Lank, E.A. Krebs, L. Lougheed, and C. Lougheed. 2005. Breeding chronology of Marbled Murrelets varies between coastal and inshore sites in southern British Columbia. J. Field Ornithol. 76:357-367.

U. S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants; determination of threatened status for the Washington, Oregon and California population of the Marbled Murrelet. USDI Fish and Wildlife Service Fed. Reg. 57: 45328-45337.

Vleck, C.M., Vertalino, N., Vleck, D. and Bucher, T.L. 2000. Stress, corticosterone, and heterophil to lymphocyte ratios in free-living Adelie Penguins. Condor 102: 392-400.

Whitworth, D.L., S.K. Nelson, S.H. Newman, G.B. Van Vliet, and W.P. Smith. 2000. Foraging distances of radio-marked Marbled Murrelets from inland areas in southeast Alaska. Condor 102: 452-456.