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SUMMARY

JANSSEN, M.H., ARCESE, P., KYSER, T.K., BERTRAM, D.F., MCFARLANE TRANQUILLA, L., WILLIAMS, T.D. & NORRIS, D.R. 2009. Pre-breeding diet, condition and timing of breeding in a threatened seabird, the Marbled Murrelet [illegible] 37: 33–40.

Marbled Murrelets [illegible] are small, threatened seabirds that nest in old-growth coniferous forests along the west

INTRODUCTION

Identifying mechanisms causing a population decline is essential for designing effective management strategies for population recovery (Green 1995, Jones 2004, Norris 2004). Marbled Murrelets [illegible] (hereafter “murrelets”) are small (~ 220 g) seabirds that nest in old-growth coasta10(g)10(rxt<FT0edffa)10(t)10ra10(g)10(u(b)10(i)10(r)10fa10(g)10(ra)10(t)10( )-56(n)1s(t)-2(i2.9-a10(s)1

diet composition and annual reproductive success (Peery et al. 2004, Becker et al. 2007b). However, whether pre-breeding trophic feeding level directly influences breeding success and the mechanisms that underlie potential relationships between diet composition and reproduction remain uncertain.

Here, we examine the hypothesis that trophic feeding level during the pre-breeding period influences breeding success through positive effects on body condition and timing of breeding in female murrelets. In long-lived species such as murrelets, life-history theory predicts a tradeoff between current and future reproduction: When resources are scarce or individuals are in poor condition, birds forego current reproduction to enhance their survival and future reproductive potential (Williams 1966, Goodman 1974). Murrelet eggs weigh 16%–19% of adult body mass and represent a significant energy investment (Nelson 1997). Murrelets are also highly asynchronous breeders (McFarlane Tranquilla et al. 2003), and evidence suggests that early nesters achieve higher nest success (Zharikov et al. 2006). Taken together, these observations suggest that, during periods within a given season when prey abundance or quality is low, individual murrelets may postpone reproduction until sufficient body reserves have accumulated.

Murrelets take a wide variety of prey (Burkett 1995), but there is some evidence that they preferentially select fish over krill early in the breeding season (Sealy 1975). Forage fish from higher trophic levels contain more energy per item than do smaller fish or macrozooplankton (Becker et al. 2007b), and individual murrelets able to find and capture higher trophic level prey during the pre-breeding period may therefore have higher energy reserves and be able to breed earlier than do birds feeding on lower trophic level prey. We predicted that trophic feeding level would be positively associated with body condition and that female murrelets producing eggs early in the breeding season would have fed at higher trophic levels during the pre-breeding period than females not producing eggs early in the breeding period.

To estimate diet, we used stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope signatures in murrelet feathers and their prey. Stable isotopes provide advantages over traditional methods of estimating seabird diet, such as gut content analysis, because they represent assimilated rather than ingested foods, indicate averages over an extended period of tissue formation, and involve minimal impact to the animals being sampled (Tieszen et al. 1983, Hobson & Welch 1992).

To identify the females that were producing eggs at the time of capture, we measured plasma vitellogenin (VTG) levels, a lipophosphoprotein yolk precursor that becomes highly elevated in females during egg production (Challenger et al. 2001, McFarlane Tranquilla et al. 2003, Vezina & Williams 2003).

METHODS

Marbled murrelet capture and specimen collection

tissues and the zooplankton samples were freeze-dried and then ground to a fine powder. Lipids were removed from powdered prey samples by three repeated 30-minute treatments with 2:1 chloroform:methanol solution, samples were then air dried (Bligh & Dyer 1959). Between 0.20 mg and 0.40 mg of each tissue sample was loaded into a tin capsule, combusted and oxidized in a TC Elemental Analyzer (Thermo Finnigan MAT GMBH, Bremen, Germany) and introduced online into a Finnigan MAT Delta Plus XL Isotope Ratio Mass Spectrometer (Thermo Finnigan MAT GMBH, Bremen, Germany). During analysis, we ran four standards [mean ± standard error (SE)]. For carbon, these were the international standard NBS 21 Graphite (–27.7‰ ± 0.1‰, n = 7) and an in-house standard UC-1 Graphite (–25.6‰ ± 0.2‰, n = 7). For nitrogen, we used the international standard RM 8548 Ammonium Sulphate (19.6‰ ± 0.2‰). For both elements, we also used an in-house organic standard: Domestic Chicken ⁄ ,,- ⁄ , blood ($\delta^{13}C$: –20.1‰ ± 0.1‰; $\delta^{15}N$: 3.9‰ ± 0.2‰; n = 17) prepared in the same fashion as murrelet blood. We also ran duplicate tissue samples from the same feather, blood or prey sample (n = 34),

were weakly correlated (= 0.20, n = 99, < 0.05), and both were significant predictors (wing: = 4.9, < 0.03; tarsus: = 4.37, < 0.04) in a least-squares multiple regression predicting female mass (^{2} = 0.11, n = 99, = 0.005). We therefore took the residuals of this mass–size regression as an index of body condition. Body condition was estimated only for murrelets captured in 2007, because we could not test predictions relating body condition to diet composition in the other three years.

C a fy g ear y breeder

We considered birds captured between 6 April and 4 May 2007—the first third of the egg-laying period in Desolation Sound (McFarlane Tranquilla ., / . 2003)—as being captured "early" in the breeding season, and we included only those birds in our analyses. This approach reduced the likelihood of erroneously classifying a bird that had already laid an egg as a non-breeder or of classifying a bird that had re-nested as a first-time breeder. Additionally, after 4 May, blood isotope signatures indicated a diet shift towards higher trophic level prey (M. Janssen, P. Arcese, T.K. Kyser & D.R. Norris unpubl. data), and so any influence of pre-breeding diet on body condition or probability of breeding would have been less evident beyond that date.

For analyses among years, we used samples obtained from 6 April

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producers before breeding, the opposite relationship was observed in 2007. Isotope signatures from brown-tipped breast feathers of murrelets captured in 2007 suggest that females that were in better physiological condition and producing eggs early in the breeding season had fed at a lower trophic level during the pre-breeding period than had females in poorer condition and not producing eggs.

Diet–feather fractionation values for seabirds can vary significantly between and within species (Becker ⁄ .

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