Methods for Seabird Collection:

Seabirds were collected in waters within 200 kilometers of the Pribilof Islands, St. George (56.60°N, 169.58°W) and St. Paul (57.19°N, 170.26°W) and extending southeastward to Bogoslof Island (53.93°N, 168.03°W; Figure 1).

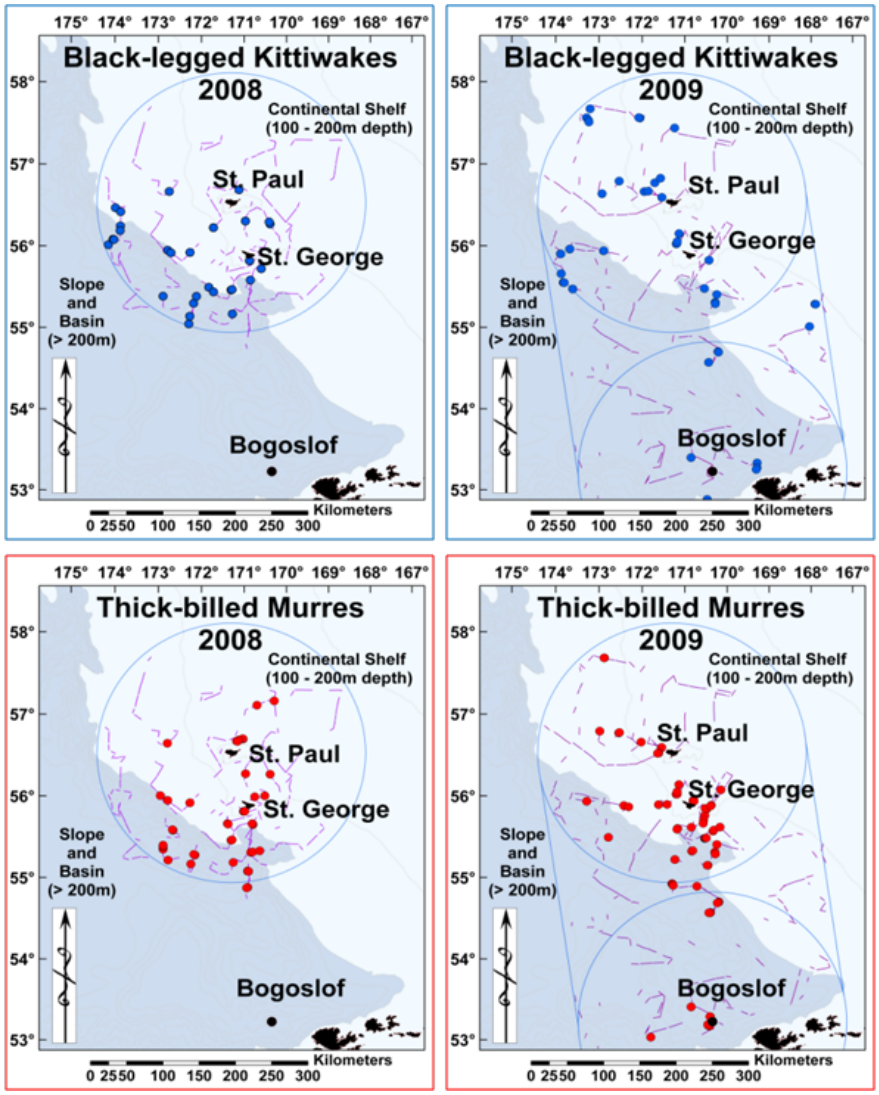

Figure 1. Seabird collection locations and study area. Ship survey tracks are shown within the 200 kilometer radius of St. Paul Island (2008, 2009), and extending south to within 200 km of Bogoslof Island, near the Aleutians (2009). No more than 3 individuals of a given bird species were collected from any one location (within 500m of first collection point). Birds were collected between the hours of 0300 and 2340 AST, while foraging, or associated with foraging activity, wherever they were encountered.

Sample Collection

A lethal take of adult birds was necessary to characterize stomach contents and obtain organ tissue samples of foraging birds on the open ocean. Large (150-225') research vessels are too imposing and slow to approach foraging birds for live capture, and the rough ocean conditions prevalent in the Bering Sea precluded the deployment of small skiffs. Birds were collected with a shotgun, under the auspices of the US Fish and Wildlife Service (USFWS/Migratory Bird collection permit #MB08537-1) and Alaska Department of Fish and Game (Fish and Game #08-134). Concerns for ethical treatment were ascertained before sample collections by reviews and permits from San José State University Animal Care and Use (IACUC Harvey#926), and US Fish and Wildlife Care and Use permits (IACUC #2008013). Birds were collected as they engaged in foraging activity in the open ocean (Figure 1). A total of 47 murres and 39 kittiwakes were collected in 2008, and 78 murres and 66 kittiwakes in 2009. Collection locations were associated with randomly distributed net tow sampling and strip transects which were stratified to include all potential habitat types, in each week of data collection, for the duration of the study periods. Birds were collected between the hours of 0300 and 2340 hrs, Alaska Standard Time (AST). Based on personal shooting experience, personal communications with professional instructors, and current literature, it was estimated that an average of four shots would be needed for each successful take, and in fact the average was three (pers. comm. D. Irons, L. Boyle, D. Roby, L. Rogers; Noer et al. 2007). This study preferentially targeted foraging birds that were within 25 m range and on the water surface rather than in flight, because on-water birds could be linked more confidently to the specified collection location, and because on-water birds were more likely to contain identifiable prey remains (Duffy and Jackson

1986). However, both species are capable of traversing the entire study area in hours; thus the length of time a bird had spent at a given location was unknown (Hatch et al. 2000). Shooters attempted to collect two birds within a 500m radius at each location in order to account for anticipated "empty" stomachs and therefore ensure the collection of usable stomach contents. This was not always possible, and in some cases only one bird was taken. However, to minimize sampling bias, shooters never took more than three birds from a given location (within a maximum 500 m radius of initial take).

Birds were shot with a Remington™ brand, model 870, 12-guage shotgun, firing steel 4-shot. Shooters were experienced, and in preparation for collection also completed a comprehensive firearms safety course, and underwent approximately ten hours of live-fire target practice under professional supervision by a licensed instructor. The target distance in this study (< 25 m) was substantially closer than average sport hunting distances (42.4 m; Anderson and Sanderson 1979, 33.4 m; Humburg et al. 1982). The extensive field sampling by Humburg and colleagues (4,219 hunting attempts, 10,587 shots fired) indicated that sport hunters crippled flying waterfowl at a rate of 11.9%; however, murres and kittiwakes were targeted at close range and on the water surface whenever possible, and these were relatively stationary, so a crippling rate of less than 5% was achieved in this study (Humburg et al. 1982, Noer et al. 2007). All crippled birds were shot immediately a second time to limit suffering and expedite retrieval. The birds were retrieved from the water using a long-handled dip net and then frozen (-20°F) immediately on the ship for preservation (Barrett et al. 2007; Bugoni et al. 2008). The few birds that were still alive upon immediate retrieval were killed quickly by cervical dislocation (Gaunt et al. 1997). It was expected that few wounded birds would escape, because they were exposed on the open ocean surface and unable to dive or fly once crippled. In practice, only two murres

were lost (< 1% of all birds targeted); one disappeared in rough seas after being killed, and another in a dive immediately after being wounded.

Upon return to laboratories (University of Orgeon; 2008, California Fish and Game; 2009), tissue samples of cheek feather, muscle, and liver were removed for stable isotope analyses, and whole stomachs were sent frozen to University of Alaska Fairbanks for identification of hard parts and soft material to the lowest possible taxonomic level. In the process, wet material was weighed and hard parts (otoliths, carapaces, squid beaks) were enumerated to determine minimum number of individuals represented in each stomach. In all cases, the carcasses were re-frozen immediately after organ and feather tissue removal, and stored at Moss Landing Marine Laboratories for further studies.

Stable Isotope Analyses of seabird tissues

2.3 Stable Isotope Analyses

Before testing, all samples were dried at 40°C for 48 h, then ground into a fine powder and lipid-extracted using a methanol-chloroform mixture (Bligh and Dyer, 1959, Sotiropoulos et al., 2004, Kojadinovic et al., 2008). Seabird tissues were analyzed at the University of Alaska, Fairbanks. Fish and euphausiid tissues were analyzed at Northern Arizona University. Isotope values for $\delta^{13}C$ and $\delta^{15}N$ were measured with continuous-flow isotope-ratio mass spectrometry, using a Thermo-Electron Deltaplus Advantage gas isotope-ratio mass spectrometer interfaced with a Costech Analytical ECS4010 elemental analyzer. Internationally-accepted isotope elemental calibration standards were used to determine accuracy (acetanilide, cyclohexanone, cystine, methionine, nicotinamide, sulfanilamide). Secondary isotopic reference materials

included NIST bovine liver, and NIST mussel, as well as NIST pine needles, and NIST tomato leaves. Calibration runs were conducted frequently to check for run drift and linearity. Blanks were analyzed every twenty samples and Secondary isotopic reference materials were analyzed every ten samples. Precision of secondary isotope reference material (n = 82) was < 0.25 ‰ for both carbon and nitrogen. Twice a year the Secondary isotopic reference materials from these labs are compared to NIST standards for quality assurance. The $\delta^{13}C$ and $\delta^{15}N$ values are expressed relative to Vienna-Pee Dee Belemnite limestone V-PDB for carbon, and to air for nitrogen. Stable isotopes are reported here in δ notation as the deviation from standards, in parts per thousand (‰), according to the following equation: $\delta X = [(R_{sample}/R_{standard}) - 1]$ where X is the isotope in question (^{15}N or ^{13}C) and R is the ratio of the heavier (e.g., ^{15}N) to the lighter (e.g., ^{14}N) isotope of the element (Fry, 2005).