A COMPARISON OF SAMPLING METHODOLOGIES TO IMPROVE ESTIMATES OF AVAILABLE FOODS FOR AMERICAN BLACK DUCKS IN NEW JERSEY

by

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ABSTRACT

Potential habitat limitations and availability of food energy may be the cause of decline in American black duck (*Anas rubripes*) populations. It is critical that food availability estimates are determined, in order to develop a carrying capacity estimate for black ducks, in the future. Research was recently conducted to estimate the biomass and energy supply of black duck foods using a single core sampling method, but high variance was found for these estimates. Our goal was to improve estimates of available foods for the American black duck in New Jersey by comparing a single core sampling method and a multiple core sampling method. Core samples were collected from 7 habitat types (mudflat, subtidal, low marsh, high marsh, quasi-tidal pools, east pool tidal impoundment, and west pool freshwater impoundment) in coastal New Jersey. There were no differences in the mean weight or the mean energy content for the single core samples and the multiple core samples, across all habitat types, for all black duck foods, black duck animal foods, or black duck seed foods. The only exception was the east pool impoundment, where the multiple sampling method found more animal foods (single: 0.005853g ± SE 0.000930 vs. multiple: 0.011661g ± SE 0.002376) and energy available (single: 0.004110 kcal ± SE 0.000642 vs. multiple: 0.008189 kcal ± SE 0.001739) than the single sampling method. Data was averaged between methodologies and we compared biomass weight and energy between habitats. Overall, since no differences existed, we recommend continuing to use the single core sampling method to save both time and money for future researchers.

INTRODUCTION

Waterfowl populations are affected by the condition of wintering habitat throughout multiple stages of their life cycle (U. S. Fish and Wildlife Service and Canadian Wildlife Service 1986). Research has demonstrated that American black duck (*Anas rubripes*) populations may be limited either directly through poor physical condition or survival during the winter (Conroy et al. 1989), or indirectly during migration and the breeding season (Heitmeyer and Fredrickson 1981, Miller 1986) as well as in subsequent years (Haramis et al. 1986). The availability of wintering habitat, and food energy derived from it, may currently be a primary factor limiting waterfowl populations. The availability of food energy is likely constrained due to poor habitat quality (U. S. Fish and Wildlife Service and Canadian Wildlife Service 1986), and severe weather conditions (Bergan and Smith 1993). Estimating the supply of food in waterfowl habitats is critical to evaluating their ability to support migrating and wintering waterfowl populations (Reinecke et al. 1989) and is a priority information need of the Black Duck and Atlantic Coast Joint Ventures. To properly estimate food supply, three things must be known: the amount of energy per habitat type, the area of a habitat type, and the percentage of a habitat type available for foraging over a time period.

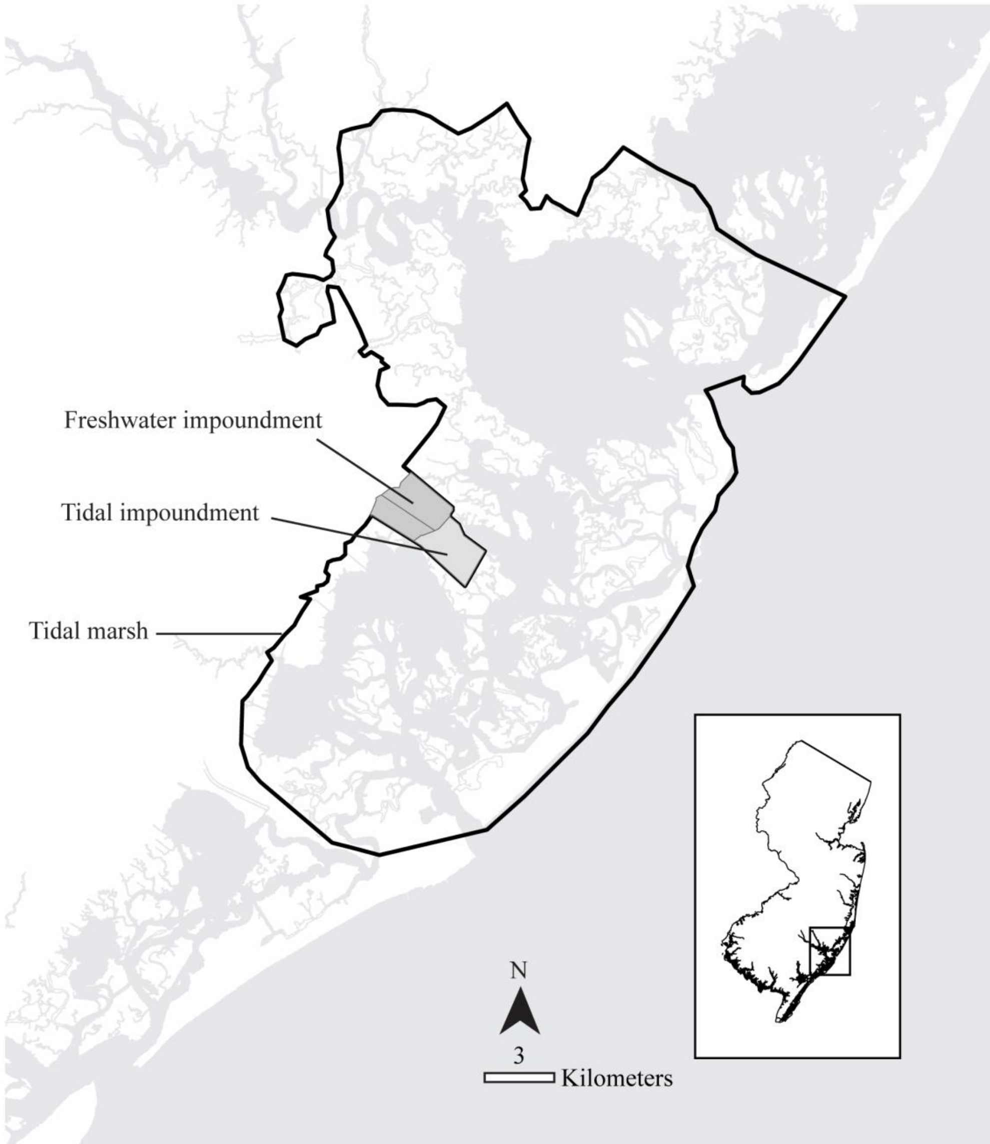
Recently, Plattner et al. (2010) and Cramer (2011) estimated energy supply for black ducks in Long Island, New York and southern New Jersey, respectively. Plattner et al. (2010) sampled nektonic and epiphytic invertebrates using a 33 cm diameter Dframe sweep net (500 mm), and sampled benthic invertebrates, vegetative material, and moist soil seeds using a 102 mm diameter 127 mm depth core sampler to take one sample within an imaginary 1 m^2 plot. Alternatively, Cramer (2009) established permanent sampling points and collected a pair of core samples (51 mm in diameter and 120 mm in depth) at 2 m and 20 m from each sampling point in randomly selected directions. Both studies found very high variance in biomass estimates; standard errors were half that or equal to the mean biomass estimate. Because of the high variance, methodologies must be considered to improve food supply estimates across multiple habitats. Similar variance has been observed in solute levels within soil core samples (Giesler and Lundstrom 1993), but subsampling from a composite sample of multiple single core samples is considered a solution to reduce variance (Mason 1992). Therefore, my objective was to test if subsampling saltmarsh core samples would reduce the variance in available black duck foods in wintering habitats. With this information, I hope to aid in the future development of standardized methods for collection and handling of winter black duck foods and carrying capacity estimation.

STUDY AREA

Food sampling was conducted in Ocean and Atlantic counties, New Jersey (Figure 1). The study area is bounded on the north by the northern shore of Great Bay Boulevard Wildlife Management Area and the northern boundary of the Holgate section of Forsythe National Wildlife Refuge and on the south by NJ Route 30. This area consistently has the highest number of wintering black ducks counted in the Midwinter Waterfowl Survey in the Atlantic Flyway (based on mid winter waterfowl surveys, USFWS MBDC 2010).

The major landscape features within the study area are salt marshes and shallow estuarine waters. Two large impoundments managed for waterbird habitat are also present. The "East Pool" Impoundment is primarily a brackish saltmarsh. The "West Pool" Impoundment is freshwater and managed for water seed plants. All 5 wetland and deepwater systems defined by the National Wetlands Inventory (NWI) exist in this area (i.e., marine, estuarine, palustrine, lacustrine, and riverine; Cowardin et al. 1979). Estuarine habitat is of particular importance to black ducks wintering in the Atlantic Flyway (Lewis and Garrison 1984). Within the estuarine system there are 4 commonly recognized habitat types which are categorized by the tidal regime and vegetative structure of each; high marsh, low marsh, mudflats, and subtidal waters (Tiner 1987). High marsh habitat is present above the mean high tide line and therefore irregularly flooded. High marsh habitat is dominated by the *Spartina* patens plant community (Tiner 1987, Collins and Anderson 1994). Pannes and quasi-tidal pools also occur within the high marsh habitat type. Low marsh habitat lies between the mean high and low tide lines and is regularly flooded. Low marsh habitat is dominated by a single species of vegetation, tall form *S. alterniflora*, which is more salt tolerant than *S. patens* and its allies. Mudflat habitat is also regularly flooded and exposed. Mudflats are characterized by a general lack of vegetation and accumulation of detritus, but can have tussocks of S. alterniflora. Mudflat habitat occurs in two general forms: extensive flats in estuarine bays or narrow ribbons along tidal creeks and ditches that are exposed at low tide. Subtidal water is below the mean low tide line and is therefore irregularly exposed but is still within dabbling depth for black ducks. Additionally, lacustrine and palustrine water bodies and wetland habitat occur around the margins of estuarine habitats within the study area. These environs are dominated by mixed hardwood overstory (e.g., sweet gum [*Liquidambar styraciflua*], red maple [*Acer rubrum*], and American holly [*Ilex opaca*]) and shrubby understory (e.g., highbush blueberry [*Vaccinium corymbosum*], common greenbrier [*Smilax rotundifolia*], and poison ivy [*Toxicodendron radicans*]) (Collins and Anderson 1994).

Figure 1. Map of study area to collect black duck foods, coastal New Jersey



METHODS

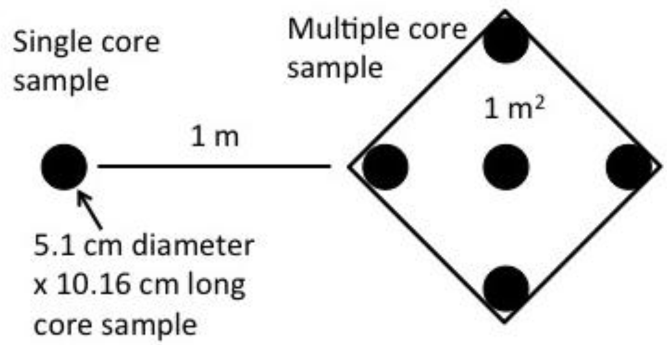
Food samples of invertebrates and seeds were collected 27 Dec 2010 -15 Feb 2011 using two different methods. First, a single core sample (5.1 cm diameter x 10.16 cm long) was taken 1 m in a random direction from the sample point (Figure 2). Second, 180˚ degrees from the single core sample, five core samples (5.1 cm diameter x 10.16 cm long) were taken on the corners and middle of an imaginary 1 m^2 square plot. The first core was 1 m from the sampling point and two other points were in line with the chosen random direction. All samples in quasi-tidal pools, high marsh, low marsh and mudflat habitats were taken when tidal water was no longer covering the habitat and in subtidal and tidal impoundment when tidal water was at half tide or below. Sweep nets were also used in sub-tidal, both impoundments, and quasi-tidal pool habitats at the same tidal stage as core samples. The net was lowered until the flat base was on the bottom and then dragged for 1 m.

Core samples were placed in polyethylene bags, and stored in a refrigerator for <7 days before they were sieved with clean water through No. 10 (2 mm) and No. 35 (500 μm) screens. The multiple core samples were mixed and separated into five equal size samples and one sample was randomly chosen to be sieved. Sieved material was placed in a 150 mL specimen storage cup, fixed with a 10% formalin buffer solution, and stained with Rose Bengal for a minimum of 7 d. Prior to sorting the material, the samples were washed a minimum of three times with clean water, while wearing gloves and a respirator. The sample was placed into a 35mm sieve over a container with no holes and rinsed with water until the water no longer ran pink with rose bengal dye. The waste from the container was placed in a chemical waste bin. The sample was placed back into its respective cup and the residue left in the 35mm sieve was placed into a 60mm sieve. The residue was directed into the middle of the sieve, with water, and then placed back into its cup.

The procedure for washing samples that contained vegetation was modified to make sorting more efficient. The samples with vegetation were placed into a container with no holes. The cup was then filled with water two times and added to the container to wash the sample. The water was mixed with the sample, using forceps, to wash out the formalin. The contents from the container were then placed into a 60mm sieve over another container with no holes. The sample was washed at least three more times, using the method previously stated. The 60mm sieve was stacked on top of three other sieves, so that it was closer to the faucet. The faucet was carefully turned on and then stacked sieves were placed under the slow stream of water. Large pieces of vegetation were picked up with forceps and washed over the 60mm sieve. These pieces were then placed into another empty storage cup. The vegetation in the sieve was then teased and bundled pieces were pulled apart. Large pieces of vegetation were washed as previously stated and placed into the other empty storage cup. The remaining parts of the sample were placed back into the original storage cup, when this washing process was complete. Seeds were identified to genus or species and invertebrates to the lowest taxonomic level possible. For quality control, the first 10 samples completed by a technician were rechecked by an experienced technician to ensure that potential food items were not being missed in the training phase. Once a sample was sorted through, each seed or invertebrate was placed into a different tin. The tins were dried in an oven at 50-55ºC for 48 hours and then weighed. Samples with masses of <0.0001 g were counted as 0.0001 g.

Once samples were dried and weighed, estimates of the energy content for each food item were used to calculate the energy available in each habitat type. Following Cramer (2009), a list of food taxa for wintering black ducks was used to determine which foods collected were consumed by American black ducks. Those that were not on the list were removed along with larger food items, such as the ribbed mussel, to avoid an overestimate of available energy. The weight of a food item was multiplied by its true metabolizable energy (TME; kcal/g), which was provided by Cramer (2009), to estimate the amount of energy available from it. The average weight and energy content per core sample were determined for all black duck foods using SPSS. The food items were also divided into two data sets to compare the average weight and energy per core sample of black duck animal foods only and black duck seed foods only. Single core sample weights and energy were compared to subsampled multiple samples for each habitat type using a paired t-test ($\alpha = 0.05$). Average weights and energy for black duck foods by habitat type were extrapolated to the kg/ha level to compare against Plattner et al.'s (2010) and Cramer et al.'s (2011) results. I also used a One-way ANOVA ($\alpha = 0.05$) with a Tukey's Post Hoc Test to identify if food weight and/or energy differed between habitat types.

Figure 2. Sampling methodology used to collect single and multiple core samples in coastal New Jersey, 2011.



RESULTS

For each habitat type, except the freshwater impoundments of the Forsythe National Wildlife Refuge (West Pool), 40 single samples and 40 multiple samples were used to estimate the energy available for the American black duck. For the West Pool, I had 44 samples. Single and multiple core samples were compared by weight for each habitat type for all black duck foods (animal and seed foods combined, Figure 2). In all habitat types, there was no difference in the mean weight for all black duck foods between the single core samples and multiple core samples ($t_{39 \text{ or } 43} < 1.78$, $P > 0.08$, Figure 3). Additionally, there was no difference in the mean energy content for all duck foods between single core samples and multiple core samples ($t_{39 \text{ or } 43} < 1.76$, $P > 0.09$, Figure 4).

I further broke down the black duck foods into animal and seed foods to determine if the sampling methodology would favor representation of certain foods over others. Analyzing black duck animal foods, there was no difference in the mean weight for the single core samples versus the multiple core samples for subtidal, mudflat, low marsh, high marsh, quasi-tidal pools, and the West Pool freshwater impoundment ($t_{39 \text{ or } 43} < 1.49$, $P > 0.14$, Figure 5). However, the multiple sampling method found more animal foods in the saltwater impoundment of the Forsythe NWR East Pool (single: 0.005853g ± SE 0.000930 vs. multiple: 0.011661g ± SE 0.002376, $t_{39} = 2.42$, $P = 0.02$, Figure 5). The same result was observed in the energy of single vs. multiple core samples with no difference observed in all habitat types ($t_{39 \text{ or } 43} < 1.14$, $P > 0.26$) minus the East Pool (single: 0.004110 kcal ± SE 0.000642 vs.

multiple: 0.008189 kcal ± SE 0.001739, $t_{39} = 2.41$, $P = 0.02$, Figure 6). Lastly, in all habitat types, there was no difference in the mean weight of black duck seed foods for the single core samples and multiple core samples ($t_{39 \text{ or } 43} < 1.41$, $P > 0.17$, Figure 7). Additionally, there was no difference in the mean energy content for seed foods between single core samples and multiple core samples ($t_{39 \text{ or } 43} < 1.43$, $P > 0.16$, Figure 8).

Since only one significant difference was found between the sampling methodologies, I assumed that overall no difference existed. Therefore I averaged single and multiple core samples for each site and extrapolated values to a kg/ha and kcal/ha level. I compared all black duck food core sample weights and energy between habitat types (One-way ANOVA, Tukey's post-hoc tests). Analyzing core sample weights, although high marsh and the West Pool freshwater impoundment had greater weights (383.65 kg/ha ± SE 179.25 and 318.25 kg/ha ± SE 114.79 respectively, Table 1), I found no difference in black duck foods between habitats ($F_{6,277} = 1.279$, $P = 0.267$). However extrapolating weight to energy, I found a significant difference between habitats ($F_{6,277} = 3.312$, $P = 0.004$) with the West Pool freshwater impoundment having significantly greater energy (559.35 kcal/ha ± SE 219.41 kcal/ha) than all other habitat types (Tukey's post hoc tests, $P < 0.05$) presumably due to the large amounts of high energy seeds available from freshwater impoundment management.

Table 1. Mean weight (kg/ha) and energy content (kcal/ha) per core sample in 7 habitat types in coastal New Jersey, 2011.

		Weight (kg/ha)		Energy (kcal/ha)	
Habitat	N	Mean	SE	Mean	SE
Subtidal	40	109.47	18.92	69.96	11.57
Mud Flat	40	164.48	24.59	83.64	13.48
Low Marsh	40	237.31	52.52	112.49	40.86
High Marsh	40	383.65	179.25	158.04	64.94
Quasi-tidal Pools	40	160.88	64.43	103.87	47.29
East Pool	40	149.18	31.00	151.67	39.26
West Pool	44	318.25	114.79	559.35	219.41

Figure 3. Comparison of mean weight per single and multiple core sample (g) in mudflat, subtidal, low marsh, high marsh, quasi-tidal pools, east pool, and west pool for all black duck foods, Coastal New Jersey, 2011

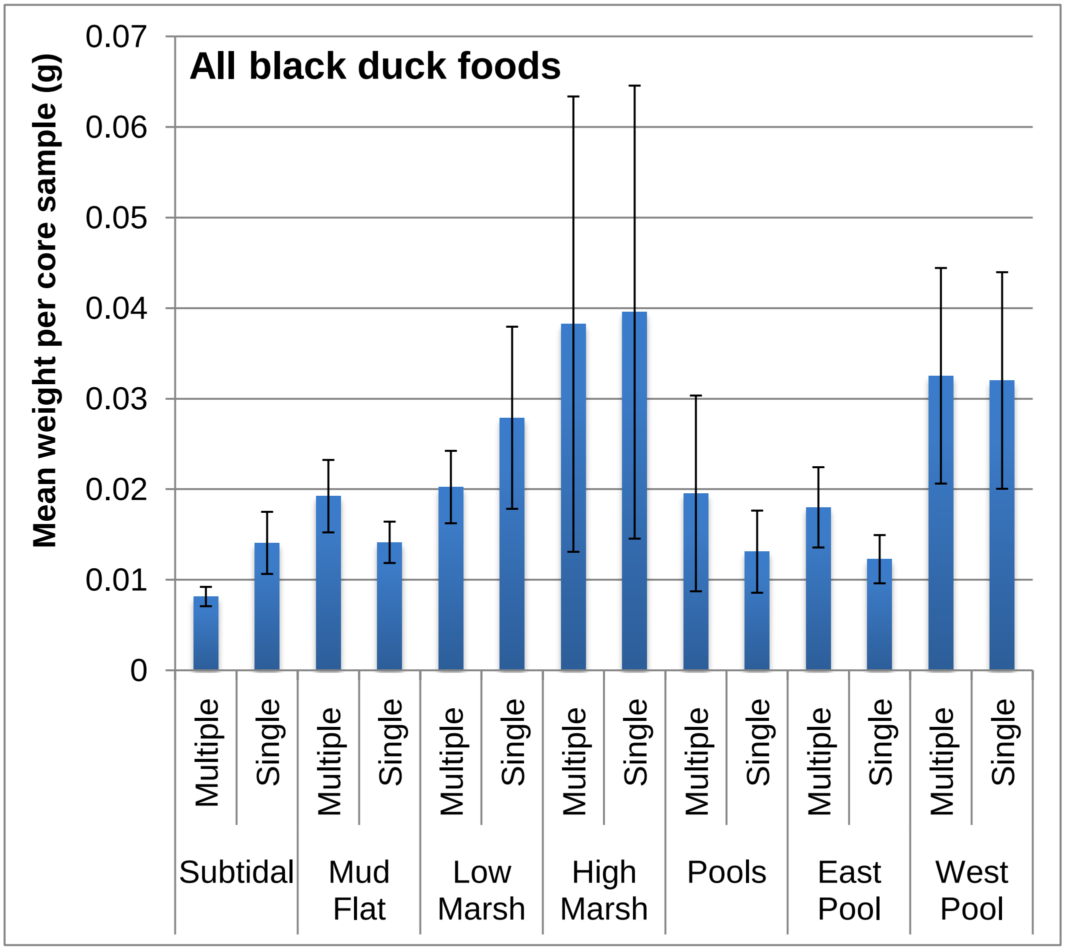


Figure 4. Comparison of mean energy per single and multiple core sample (kcal) in mudflat, subtidal, low marsh, high marsh, quasi-tidal pools, east pool, and west pool for all black duck foods, Coastal New Jersey, 2011

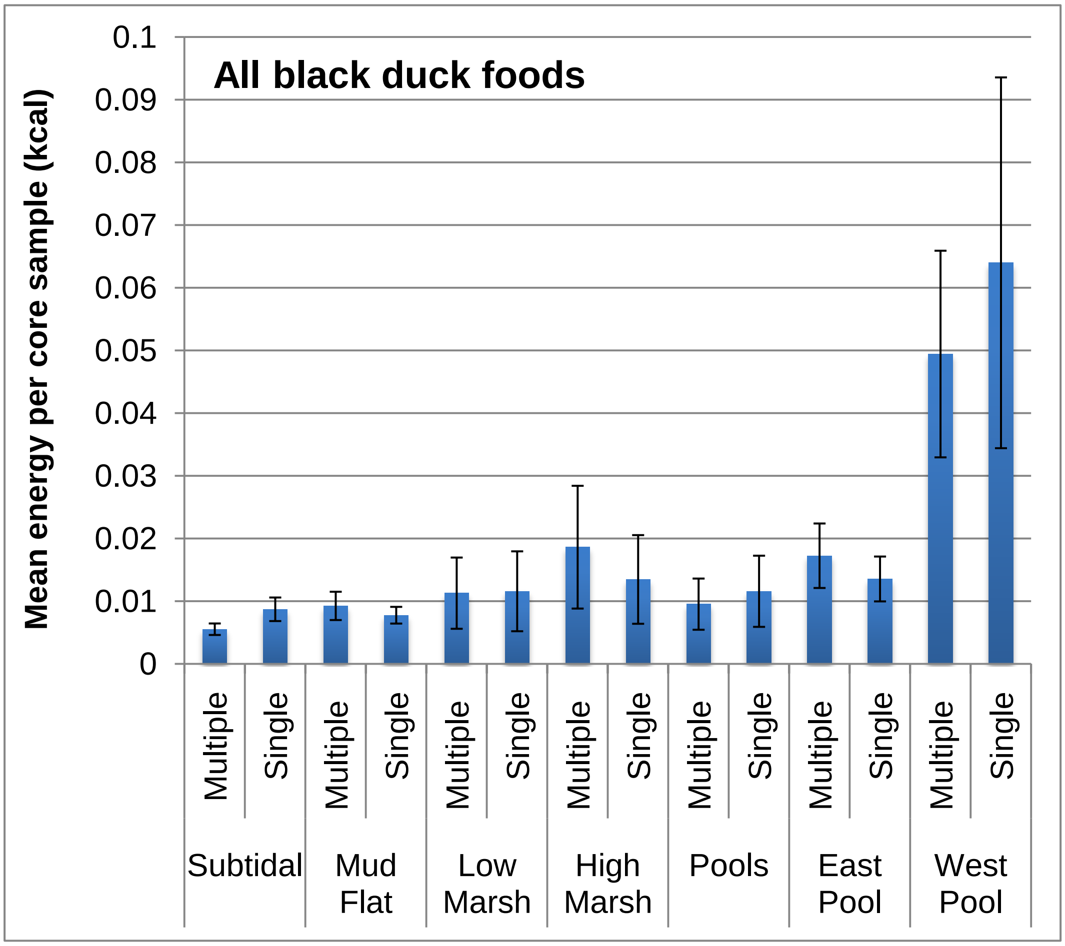


Figure 5. Comparison of mean weight per single and multiple core sample (g) in mudflat, subtidal, low marsh, high marsh, quasi-tidal pools, east pool, and west pool for black duck animal foods, Coastal New Jersey, 2011.

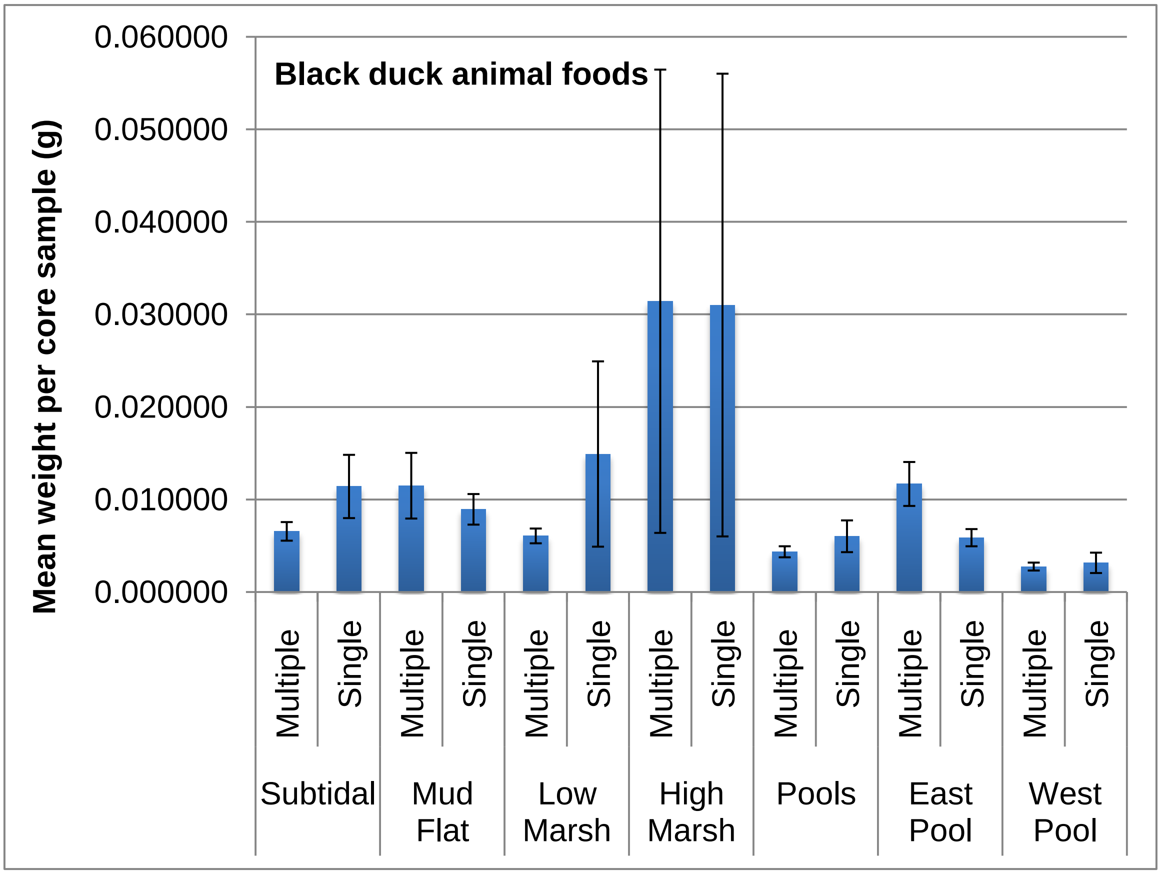


Figure 6. Comparison of mean energy per single and multiple core sample (kcal) in mudflat, subtidal, low marsh, high marsh, quasi-tidal pools, east pool, and west pool for black duck animal foods, Coastal New Jersey, 2011.

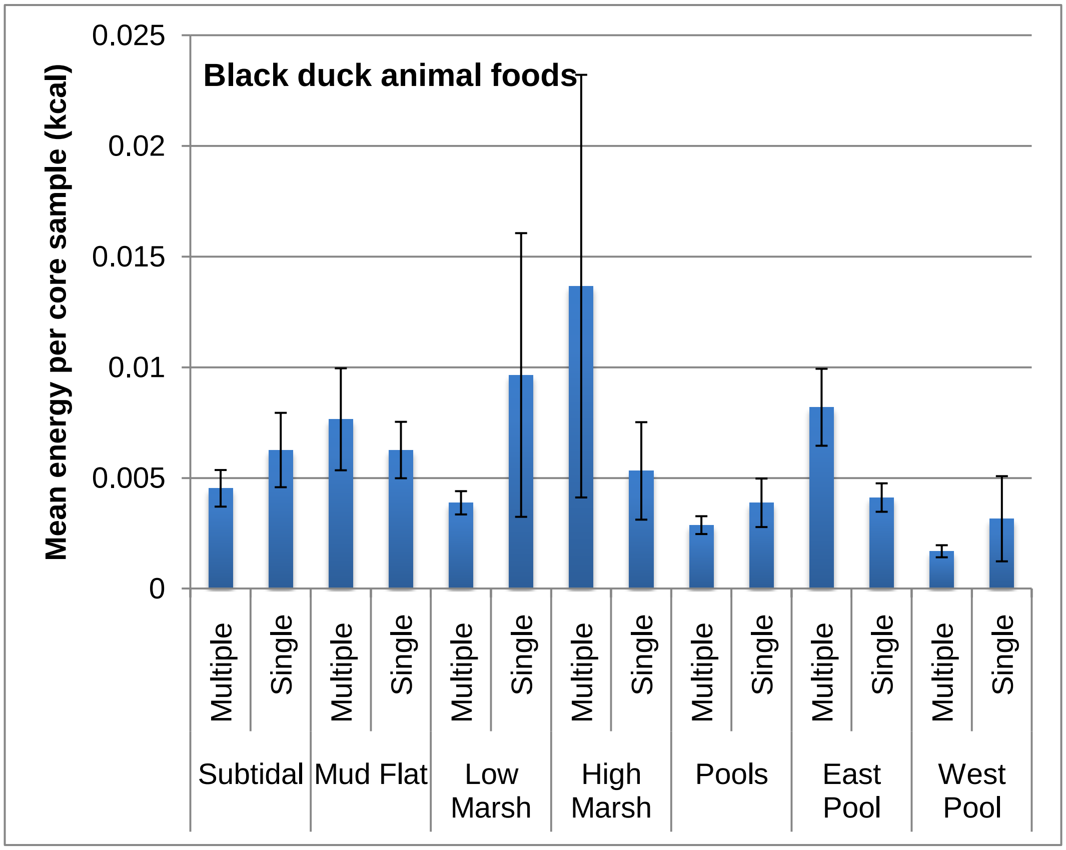


Figure 7. Comparison of mean weight per single and multiple core sample (g) in mudflat, subtidal, low marsh, high marsh, quasi-tidal pools, east pool, and west pool for black duck seed foods, Coastal New Jersey, 2011.

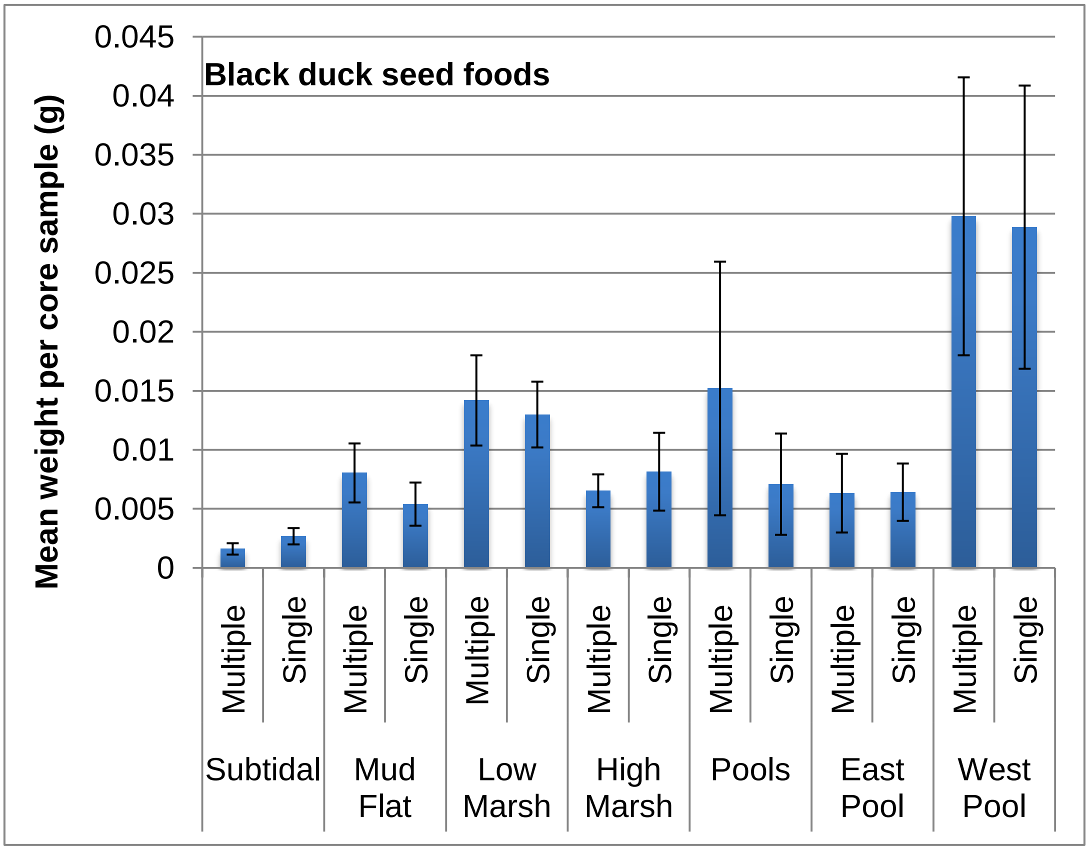
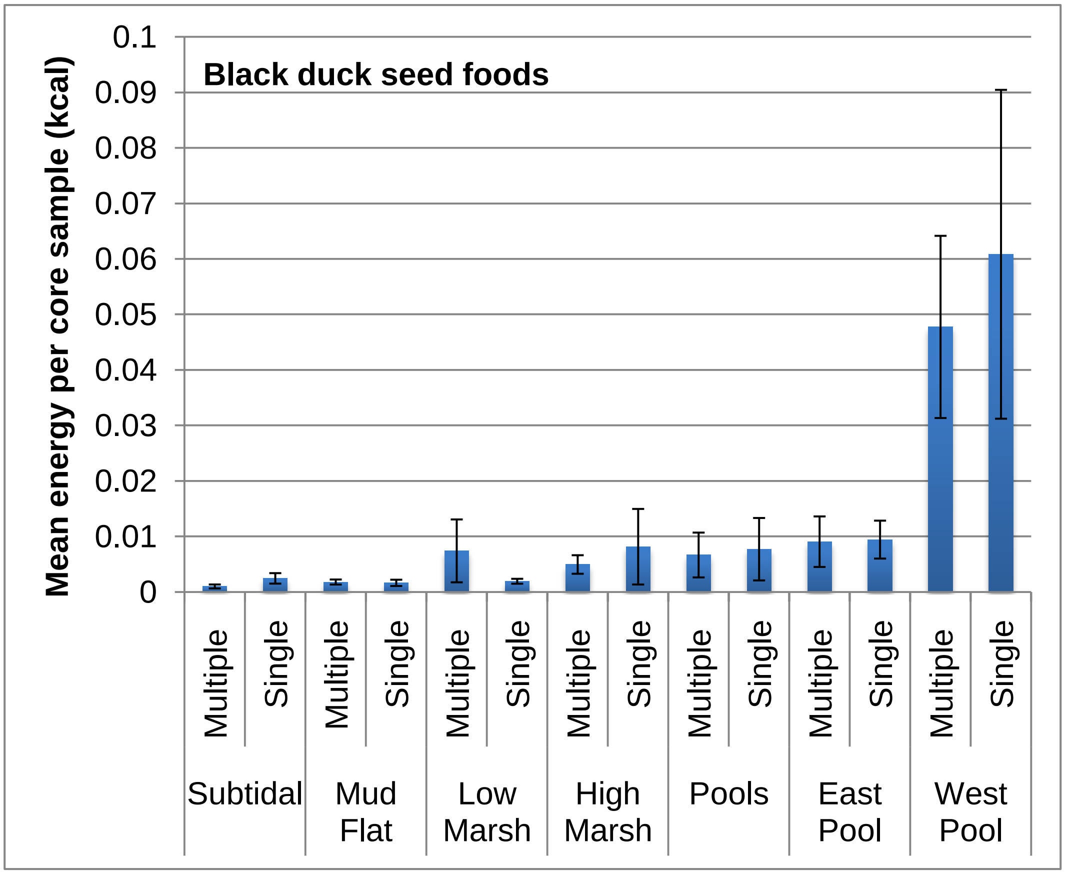


Figure 8. Comparison of mean energy per single and multiple core sample (kcal) in mudflat, subtidal, low marsh, high marsh, quasi-tidal pools, east pool, and west pool black duck seed foods, Coastal New Jersey, 2011.



DISCUSSION

Recently, Plattner et al. (2010) and Cramer (2011) estimated energy supply for black ducks in Long Island, New York and southern New Jersey, respectively. Despite different core sampling methodologies (Plattner et al.: 102 mm diameter 127 mm depth core sampler vs. Cramer: 51 mm in diameter and 120 mm in depth), both studies found high variance in biomass estimates and discussions were initiated amongst waterfowl biologists for investigating other methodologies that might reduce this error. In sampling solutes within soil core samples, it is routine to “bulk” a composite sample from multiple samples and subsample to reduce variation (Mason 1992, Giesler and Lundstrom 1993). However our test of bulking 5 samples over a square meter failed to detect any difference in average weights or energy in comparison to single core samples and variance was not noticeably different between methods. Frogbrook et al. (2002) suggested subsampling from bulking 16 soil cores over 2 m^2 to reliably estimate soil chemistry. Therefore, it is possible a larger composite sample is needed to detect differences in waterfowl foods as well.

High marsh habitat had the greatest biomass of all black duck foods (384 kg/ha) and was higher than both studies. Cramer et al. (2011) reported a mean black duck foods biomass estimate of 109kg/ha (81 kg/ha animal foods and 27 kg/ha seed foods) in High Marsh habitat while Plattner et al. (2010) reported a mean biomass of both high marsh and low marsh combined of 136–137 kg/ha (34–35 kg/ha in animal foods and 102 kg/ha in seed foods). This increase in salt marsh biomass may be for biological reasons; however, anecdotally, I also spent more time sorting through salt marsh vegetation under the microscope as compared to Cramer's methodology who washed saltmarsh vegetation under a stream of water to dislodge food matter into the sieve. Researchers should examine a standardized methodology for removing foods for salt marsh grasses.

Our mean biomass estimate for black duck foods in mudflat habitat (165 kg/ha) was notably lower than previous studies. In Southern New Jersey, Cramer et al. (2011) found that mudflat habitat contained the greatest biomass (1,550 kg/ha) of black duck foods (1,516 kg/ha from animal foods and 34 kg/ha from seed foods). On Long Island, New York, Plattner et al. (2010) found that mudflat had a great diversity of values between two years with a range of total black duck foods ranging from 148–1,267). Plattner's variability was due to a large biomass of black duck animal foods in the first year of the study (1,204 kg/ha), but dropped to low level during the second year of the study. It is unclear what could cause such massive variation in mud flat weights but there is the possibility that the appearance of a few large animal foods items (e.g. ribbed mussels) within a small core sample could greatly bias estimates. Additionally, since my sampling occurred only in January of 2011, which was a very cold month on record, my sampling could have been hampered by animal foods moving further down the soil column. Because mudflat has the potential to provide a very large food source for a small area, I encourage future researchers explore the mechanisms (either biological or sampling) that cause such high variation in food availability.

In my study, the West Pool freshwater impoundment had the second greatest biomass of black duck foods (318 kg/ha), but notably, the high energy content (559 kcal/ha) was driven largely by a very high biomass of energy rich black duck seed foods. These results corresponded to Cramer et al. (2011) who reported a mean black duck seed foods biomass estimate of 399 kg/ha in freshwater habitat and Plattner et al. (2010) who reported a mean black duck seed foods biomass estimate of 260 kg/ha. Although freshwater impoundments make up a small area of the available landscape, if they occur in protected areas, they have the potential to provide large amounts of energetic reserves if stochastic events or disturbance limit feeding in the larger saltmarsh ecosystem.

Our results suggest food density in January in Coastal New Jersey was somewhat limiting with an observed biomass of 1,524 kg/ha, which was similar to Plattner et al.'s finding of 961–1,854 kg/ha in Long Island, but substantially lower than Cramer et al.'s (2011) estimate of wintering grounds of 2,732 kg/ha. Despite the ranges, it is important to recognize such energy densities are still below those available to other dabbling ducks elsewhere in North America, as suggested by Plattner et al. (2010). For example, moist-soil seed density, the primary food of most dabbling ducks feeding in natural habitats, varies from approximately 400 kg/ha to as high as 3,155 kg/ ha, depending on specific wetland type and location (Fredrickson and Taylor 1982, Reinecke et al. 1989, Naylor 2002, Penny 2003, Bowyer et al. 2005).

The primary purpose of this study was to investigate if a subsampling from bulked soil core samples could aid in a better estimation of black duck foods given the high variability observed by past studies. The methodology, as I tested (5 samples in a square meter), failed to improve biomass estimates or reduce variance as compared to single core sample. This methodology did take more processing time in both the field and in the lab, therefore this methodology was not temporally or monetarily efficient and I would recommend against using it in the future. Although I acknowledge future researchers may want to test combinations of larger bulking samples, I would recommend resources be put toward collecting more single samples over a larger area to better represent the foods present in various habitats.

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