ARCTIC
VOL. 70, NO. 1 (MARCH 2017) P. 86–100
https://doi.org/10.14430/arctic4630

Calculating Food Production in the Subsistence Harvest of Birds and Eggs

Liliana C. Naves[1,2] and James A. Fall[1]

(*Received 31 March 2016; accepted in revised form 4 September 2016*)

ABSTRACT. Subsistence harvest studies use number-to-mass conversion factors (CFn-m) to transform numbers of animals harvested into food production (CFn-m = body mass × recovery rate; where recovery rate is the percentage of the body mass represented by the processed carcass). Also, if egg harvest was reported as volume (e.g., a bucket), volume-to-number conversion factors (CFv-n) are needed to calculate the number of eggs taken. Conversion factors (CF) for subsistence harvest of birds and eggs have been based on unclear assumptions. We calculated a mean recovery rate (65%) by weighing and processing wild birds, compiled data on bird and egg mass, developed an egg CFv-n equation, and presented CF for 88 bird species, 13 subspecies or populations, and 25 species categories likely to be harvested in Alaska. We also made recommendations on how to apply and adjust CF according to study objectives. We recommend that subsistence harvest studies (1) collect egg harvest data as egg numbers (not volume); (2) clearly explain considerations and assumptions used in CF; (3) report recovery rates and mass of birds and eggs; and (4) cite original sources when referring to CF from previous studies. Attention to these points of method will improve the accuracy of food production estimates and the validity of food production comparisons across time and geographic areas.

Key words: bird; egg; subsistence harvest; subsistence hunt; harvest survey; food production; edible mass; recovery rate; number-to-mass conversion factor; volume-to-number conversion factor; Alaska

RÉSUMÉ. Les études sur la récolte de subsistance utilisent des facteurs de conversion nombre-masse (CFn-m) pour transformer le nombre d’animaux chassés en production alimentaire (CFn-m = masse corporelle × taux de récupération; le taux de récupération étant le pourcentage de la masse corporelle représentée par la carcasse transformée). De plus, si la récolte des œufs était rapportée en volume (p. ex. un seau), les facteurs de conversion volume/nombre (CFv-n) s’avèrent nécessaires pour calculer le nombre d’œufs prélevés. Les facteurs de conversion (FC) pour la récolte de subsistance d’oiseaux et d’œufs s’appuient sur des hypothèses floues. Nous avons calculé une moyenne du taux de récupération (65 %) en pesant et en transformant des oiseaux sauvages, recueilli des données sur la masse des oiseaux et des œufs, trouvé une équation pour les facteurs de conversion volume/nombre pour les œufs et présenté des FC pour 88 espèces d’oiseaux, 13 sous-espèces ou populations et 25 catégories d’espèces susceptibles d’être chassées en Alaska. Nous avons également formulé des recommandations sur la façon d’appliquer et d’ajuster les FC selon les objectifs de l’étude. Nous recommandons que les études sur la récolte de subsistance (1) recueillent les données sur la récolte des œufs en nombre d’œufs (et non en volume); (2) expliquent clairement les considérations et les hypothèses utilisées pour les FC; (3) rendent compte des taux de récupération et de la masse des oiseaux et des œufs; et (4) citent les sources originales quand elles font référence aux FC d’études précédentes. L’attention portée à ces éléments méthodologiques améliorera la précision des estimations de la production alimentaire et la validité des comparaisons en matière de production alimentaire en fonction des périodes et des régions géographiques.

Mots clés : oiseau; œuf; récolte de subsistance; chasse de subsistance; enquête sur les récoltes; production alimentaire; masse comestible; taux de récupération; facteur de conversion nombre/masse; facteur de conversion volume/nombre; Alaska

Traduit pour la revue *Arctic* par Nicole Giguère.

INTRODUCTION

Number-to-Mass Conversion Factors for Birds and Eggs

Studies of subsistence uses of wild resources report harvest as the number of animals taken and as the amount of food produced (edible mass). Estimates of the number of animals taken are used to document subsistence activities, to assess harvest impacts on fish and wildlife populations, and to allocate harvestable amounts among user groups (Usher and Wenzel, 1987). Food production data are used to depict the relative importance of resources (e.g., moose, salmon, geese) and their role in subsistence economies (Brown and Burch, 1992), to assess exposure to contaminants derived from wild foods (Usher, 2000), and to estimate the monetary (replacement) value of harvest. Food production estimates do not account for the nutritional and cultural importance of different resources (Usher,

[1] Alaska Department of Fish and Game, Division of Subsistence, 333 Raspberry Road, Anchorage, Alaska 99502, USA
[2] Corresponding author: liliana.naves@alaska.gov

TABLE 1. Recovery rates used in conversion factors for subsistence bird harvest.

Recovery rate[1]	Information used to define the recovery rate or reference cited	Study[2]
70%	Proportion of live mass of domesticated pigs (heavy-bodied, short-legged animals)	White, 1953
70%	White (1953)	Foote, 1965
70%	White (1953) cited in Foote (1965)	Usher, 1970
70%	Carcass mass determined in consultation with village representatives	Patterson, 1974
70%	Not explained	Wolfe, 1981; Behnke, 1982; Georgette and Loon, 1993
60%–70%	White (1953) and poultry carcass yield (Watt and Merrill, 1963), including meat, edible organs, half of the bone mass, and two-thirds of the mass of blood and feathers	JBNQNHRC, 1982
60%–70%	JBNQNHRC (1982)	Berkes et al., 1994; Tobias and Kay, 1994
70%	Poultry carcass yield, White (1953); JBNQNHRC (1982); Georgette and Loon (1993)	Usher, 2000
60%	Poultry carcass yield	Gambell, 1984
40%	Researcher estimate	Fall and Morris, 1987; Fall et al., 1995
65%	Researcher estimate	Kristensen, 2011
68%	Poultry carcass yield	Goldstein et al., 2014
75%	Not explained	Wolfe et al., 1990; Wentworth, 2007
Unknown	Wolfe (1981); Braund & Associates (1993); CSIS (2016a)	Fuller and George, 1997; Brower et al., 2000
Unknown	Wolfe (1981); CSIS (2016a)	Braund & Associates, 1993; Ahmasuk et al., 2008
Unknown	Not explained	Whiting, 2006

[1] Percentage of live mass.

[2] This table summarizes our review of literature on the development and use of conversion factors for birds and other subsistence resources. It does not present all documents we consulted. It includes examples of application of conversion factors and issues related to these factors.

1976; Behnke, 1982). But these data are also important in adjudicating disputes among stakeholders, quantifying ecological services provided by resources and ecosystems, assessing food security, and prioritizing human activities on the basis of their socioeconomic contribution to communities' well-being (Jones, 1997; Magdanz et al., 2011; Hoover et al., 2013).

Food production is calculated by multiplying the number of animals taken by a number-to-mass conversion factor (CFn-m). A CFn-m integrates two variables: the live (whole, round) body mass of individual species or multi-species categories and the recovery (yield) rate, which is the percentage of the live mass represented by the processed carcass. Studies have commonly failed to explain assumptions used in CFn-m and to report body mass and recovery rates (Table 1). Over the decades, CFn-m developed in earlier studies have often been reused without critical evaluation or clear reference to original sources. Thus, it is difficult to evaluate discrepancies in CFn-m and food production estimates across studies. For instance, conversion factors (CF) used for Sandhill Crane *Grus canadensis* harvested in Alaska (CFn-m = 10 – 15 lb/bird) (4536 – 6804 g/bird) (Patterson, 1974; Wolfe, 1981; Ikuta et al., 2014) appear overestimated when compared to body mass of the subspecies occurring in Alaska (8.17 – 9.82 lb) (3705 – 4455 g) (Rodewald, 2015).

To inform stakeholders who rely on accurate food production data, studies need to clearly report considerations and variables used to derive CF. From subsistence users' perspectives, biased-low recovery rates conflict with the non-waste principle that is intrinsic to their cultural values (Zavaleta, 1999). Biased-low recovery rates also lead to underestimating the importance of wild resources in subsistence economies. On the other hand, biased-high recovery rates can discredit food production assessments and their use in mitigation and litigation.

Birds and eggs are a small proportion of the subsistence harvest, but data on their food production help address complex management issues (Fienup-Riordan, 1999; Zavaleta, 1999). In Alaska, the subsistence harvest (about 34 million edible pounds per year) is composed of fish (53%), land and marine mammals (23% and 14%), plants (4%), shellfish (3%), and birds and eggs (3%) (Fall, 2016). Developing CF for each of these resource categories involves diverse challenges. Previous efforts to consolidate information and clarify CF have addressed all resource categories (JBNQHRC, 1982; Usher, 2000; Ashley, 2002), and because this task is immense, some issues pertaining to bird and egg CF remained unresolved.

For wild birds, body mass depends on species, subspecies, population, sex, and age. Within these categories, body mass also varies because of ecological conditions and breeding, migration, and feather molting cycles (Piersma and Lindström, 1997). Because of difficulties in species identification, harvest surveys use species categories, which also complicate CFn-m because the species within a category may differ in body mass. Some studies have defined CFn-m for categories that include species with considerable size difference (Patterson, 1974). For instance, surveys have used one category for gull eggs, but eggs of large gulls are at least twice the size of those of small gulls (Rodewald, 2015). Social science researchers and other staff working on harvest surveys are often unfamiliar with the identification (including size), distribution ranges, and relative abundance of the dozens of bird species that may be harvested in a region. Thus, it is often difficult for them to critically evaluate bird and egg CF used in previous studies and to generate new CF.

Recovery rates in subsistence harvests depend on harvesting and processing conditions, cultural practices, species, and food preferences (Burch, 1985; Usher, 2000). Assumptions underlying recovery rates used for subsistence bird harvest are sometimes unclear, and rates have ranged from 40% to 75% (Table 1). Although in Alaska Native cultures birds have not been widely used as dog food, recovery rates in some earlier studies considered harvest for such use (Usher, 1970) and likely differ from rates that consider human consumption only. In many studies, recovery rates for egg harvest do not indicate whether the shell mass was included as edible mass.

Volume-to-Number Conversion Factors for Eggs

To facilitate accurate recall of harvest events and minimize burden on respondents, harvest surveys may use reporting units that are meaningful to harvesters (fish tub, truckload of wood, bucket of eggs) (Tobias and Kay, 1994). Even when respondents are asked to report their harvest in number of eggs, some values may instead be recorded in volume. For such cases, volume-to-number conversion factors (CFv-n) allow calculating the number of eggs taken. A method to estimate egg CFv-n involves comparing the mass (as a proxy for volume) of wild bird eggs to that of chicken eggs (J. Magdanz, pers. comm. in Naves, 2010). But CFv-n estimated in this way seemed high compared to CFv-n based on researcher or key respondent information (Burch, 1985; Fall et al., 1995). Use of padding material (e.g., grass, moss) to protect eggs reduces the total volume of eggs in a given container (Hunn et al., 2003). To clarify assumptions and refine this estimation method, we considered the use of padding material and the fact that full containers may not be filled to the brim to prevent egg damage during harvesting and transporting.

Study Objectives

It is impractical to account precisely for all sources of variation in recovery rate and wild bird body and egg mass that may affect CF (Usher, 1976; Burch, 1985). Thus, rather than defining highly precise and detailed CF, the objectives of this study were (a) to develop CFn-m and CFv-n equations based on clear variables and assumptions that can be easily adjusted depending on the study objectives and context and (b) to provide recommendations on the development and use of CF that will increase the accuracy of food production estimates and the validity of food production comparisons across time and geographic areas.

To achieve these objectives, we first collected ethnographic information from key respondents on subsistence practices in bird processing and egg harvesting. Information on bird parts usually consumed was needed to clarify which parts should be included as edible mass when calculating a recovery rate reflecting subsistence practices. Information on use of containers and padding material in egg harvesting was needed to refine the CFv-n estimation method. Second, we processed and weighed wild birds to calculate a recovery rate. Third, we compiled data on bird and egg mass, as well as distribution ranges and population sizes, for species likely to be harvested in Alaska. We integrated these social science and biological data to develop CFn-m and CFv-n equations and calculated CF for use in harvest studies. Although we addressed bird species composition and subsistence practices in Alaska, our approach and recommendations also apply to food production studies of other resources and regions.

METHODS

Ethnographic Information on Bird Processing and Egg Harvesting

To calculate the bird recovery rate, the first step was to determine which bird parts should be included as edible mass, depending on how birds are processed and which parts are usually consumed. Also, refining the CFv-n equation required information on egg harvesting (see below). To gather this ethnographic information, we designed 14 questions on bird and egg harvesting and processing related to CF (online Appendix S1). The questions asked for information about general harvesting and processing in a region, as opposed to individual practices. We identified 27 Alaska Native people as key respondents who could provide information on the subsistence harvest and culture in their region of origin. Rather than a random selection of individuals within a sampling universe, key respondents are particularly knowledgeable people who can provide expert opinion on a domain (Huntington, 1998; Bernard, 2011). Participation in the Alaska Migratory Bird Co-Management Council (AMBCC, 2016) and in the U.S. Fish and Wildlife Service Refuge Information Technician Program were the main criteria used to identify such individuals. Participation in these programs served as an index of key respondents' extensive experience as subsistence resource users and community leaders, including their engagement in harvest management.

In April – May 2015, printed copies of the questionnaire were distributed in person or via postal mail to the potential respondents. Pre-stamped, pre-addressed envelopes were provided for return of completed questionnaires. We followed ethical principles for social science research, including informed consent and voluntary participation (ARCUS, 1999). One month after the questionnaire was first distributed, a reminder was mailed to people who had not yet returned responses. We received 16 completed questionnaires (a 59% response rate). In results pertaining to the questionnaire, "n" refers to the number of responses to individual questions or the number of times respondents indicated a categorical answer (yes, no, sometimes).

Respondents were instructed to leave fields for answers blank if they did not know the answer or if some species categories did not occur or were not used in their region. Most responses referred to species categories commonly harvested across Alaska (ducks, geese, grouse, and ptarmigan). Fewer responses were obtained to questions related to egg harvest than to those about bird harvest.

Definition of Edible Mass

On the basis of key respondent information (see Results), we defined the edible mass as including the carcass mass (meat, bones, skin, fat, and other tissues remaining after removal of feathers, feet, head, and viscera), as well as the heart and gizzard mass because these parts were also usually consumed by subsistence users. Although some responses indicated that other parts are sometimes consumed (e.g., liver, blood, intestine, stomach; see Results), these responses were infrequent, and the exclusion of these parts from the edible mass was inconsequential for the calculation of the recovery rate. While the exclusion of these parts may have resulted in a minor underestimation of the recovery rate, such underestimation was likely offset by the inclusion of skin and bones, which are sometimes not consumed. In Alaska, wild birds and eggs cannot be bought or sold and therefore have no defined market value. To facilitate assessments of the monetary value of wild foods, the definition of edible mass must be comparable to likely replacement products available in grocery stores. For bird eggs, we used a recovery rate of 100% (whole egg including the shell). Although the shell is not consumed, chicken eggs are a likely replacement product and are sold whole and by the dozen (not directly by weight).

Processing and Weighing Wild Birds to Calculate Bird Recovery Rate

To calculate the mean bird recovery rate according to our definition of edible mass, we weighed and processed wild birds harvested for home use in September–October 2015 and September 2016. This sample included ducks (n = 18), geese (n = 9), and ptarmigan (n = 2) harvested at several locations in south-central Alaska and the Alaska Peninsula. Mass measurements were obtained using an electronic scale with precision of one gram. We weighed the whole body mass of freshly killed birds. We plucked and singed the birds, removed the head, wing tips (cut at the metacarpus and ulna-radius joint), feet (cut at the tarsometatarsus and tibia-fibula joint), and all viscera. The skin-on, bone-in mass of birds thus processed constituted the carcass mass. After the carcass mass was recorded, we cut out and weighed the breast fillets (boneless, skin-on outer and inner fillets, or pectoralis and supracoracoideus muscles) and the whole leg (bone-in, skin-on thigh and drumstick, or tibia-fibula and tarsus sections). We also weighed the heart and clean gizzard (opened to remove food remains and its tough inner lining) to be included as edible mass. Weights were presented as arithmetic means of proportions of the live mass including all species. The bird recovery rate was calculated as the mean proportion of the carcass, heart, and gizzard mass relative to the live mass.

Breast fillets and whole legs are common cuts in sport hunting and poultry processing. Mass data for these cuts are useful to gauge recovery rates used in previous subsistence harvest studies, to generate alternative recovery rates based on different processing methods, and to allow comparisons with potential replacement poultry products.

Bird and Egg Mass Data

We compiled body and egg mass data for bird species, subspecies, and populations occurring in Alaska from Rodewald (2015) unless otherwise noted. Data on sex and age composition of Alaska subsistence bird harvest were unavailable. Thus, it was impossible to account for variation in body mass among sex and age categories in the harvest. We calculated the arithmetic mean body mass including data for males, females, adults, and immatures (as available) to represent sex and age categories potentially harvested. Mass data referred to Alaska-breeding populations in spring (as available) because at least 51% of the annual bird subsistence harvest occurs in spring (Paige and Wolfe, 1997). We used mass of freshly laid eggs because water loss during incubation decreases egg mass.

Mean body and egg mass were calculated based on all items (species, subspecies, populations) within categories. Population size data were used to weight mass means. Population size data were sometimes unavailable because (a) populations have not been monitored; (b) surveys have not differentiated among species (goldeneyes, mergansers, scoters, scaups) (Stehn et al., 2013; Platte and Stehn, 2015); and (c) estimates of abundance were not directly comparable among items within categories. If mass data were unavailable for one or more items within a category, means or reference values were defined by considering data for similar species and species distributions (online Appendix S2).

Body and egg mass data were reported both in grams (as rounded numbers with no decimal places) and in pounds (body mass data with two decimal places and egg mass data with three decimal places). Rather than displaying excessive precision, this level of detail when dealing with mass data in pounds was needed to properly represent mass of small birds and eggs.

Number-to-Mass Conversion Factors for Birds and Eggs

Using the recovery rates defined in this study and the bird and egg mass data compiled, we calculated CFn-m as:

$$\text{Bird CFn-m} = 0.65 \times \text{body mass (see Results).} \quad (1)$$

$$\text{Egg CFn-m} = 1.00 \times \text{egg mass (shell included).} \quad (2)$$

Volume-to-Number Conversion Factors for Eggs

To refine the CFv-n estimation method based on comparison of chicken and wild bird egg mass, we considered how the volume of eggs in a container is affected by (1) use of padding material and (2) not filling the container to the brim. First, to assess whether these considerations reflect egg harvesting practices, the key respondent questionnaire included questions on characteristics of containers used, frequency of use of padding material, and whether containers are only partially filled to avoid egg loss and damage during transport (questions 8–11, online Appendix S1). On the basis of information from key respondents (see Results), we assumed that padding material is always used and that full containers are filled to 80% of their capacity.

To quantify the reduction of the volume of eggs in a container resulting from use of padding material, we packed large chicken eggs (24 ounces or 680 g per dozen) (U.S. Department of Agriculture, 2000) in a one-gallon (3.8 L) bucket, filling it without any padding material and then adding dry grass between egg layers. We repeated packing with and without grass three times and counted the number of eggs needed to fill the bucket to the brim. With grass, the number of eggs needed to fill the bucket in the three measurements was 37, 36, and 33 eggs (mean = 35.3). Without grass, in each of the three measurements, 48 large chicken eggs were needed to fill the bucket.

We then developed a CFv-n equation including four variables: (a) number of chicken eggs needed to fill a 1-gallon (3.8 L) bucket; (b) proportion of container volume filled; (c) mass of a chicken egg; and (d) mass of a wild bird egg [CFv-n = (a × b) × (c ÷ d)]. Considering our assumptions:

Number of eggs/gallon: CFv-n = (35.3 × 0.8) × 0.126 ÷ mass of wild bird egg, in pounds). (3)

Number of eggs/L: CFv-n = (9.3 × 0.8) × (57.0 ÷ mass of wild bird egg, in grams). (4)

RESULTS

Number-to-Mass Conversion Factors for Birds and Eggs

The following ethnographic information was used to identify bird parts that should be included as edible mass when calculating the recovery rate. Key respondents reported that Alaska subsistence users consumed wild birds as bone-in, skin-on preparations, usually as a roast or soup (see also Mishler, 2003; Unger, 2014). Birds were consumed fresh or preserved by freezing, drying, or canning. Bird processing involved plucking, singeing, and gutting birds.

Meat from the breast, legs, neck, head, back, and wings was usually consumed, as well as skin, fat, heart, and gizzard (Table 2). The liver was indicated as consumed in more than half of responses. Other parts were identified as not usually consumed, but some respondents indicated consumption of blood, intestine (ptarmigan, ducks, and geese), stomach (ducks and geese), kidney, and tongue. Bones were boiled to render broth, and bone marrow was sometimes consumed. We did not ask about non-food uses, but respondents reported that sometimes goose down was used and that the viscera and wings of harvested birds were used as bait in traps for fur animals.

Plucking seemed a preferred processing method among subsistence users, although skinning was sometimes used as a quicker option. To facilitate plucking, birds whose feathers are difficult to remove (swan, crane, seabirds, sea ducks) may be dipped in hot water. Such birds were sometimes skinned. The thin skin of grouse and ptarmigan often tears off during plucking, so these birds were commonly skinned. Plucking allowed consumption of the skin and associated fat. We asked respondents what proportion of the bird's body weight they thought is usually consumed when birds are plucked or skinned (the recovery rate) (questions 5 and 6, online Appendix S1). Responses ranged from 50% to 100%, but some seemed to refer to total mass after processing [recovery rate = 100% (n = 2) and "90% minus guts and bones"]. Because this question seemed unclear to respondents, we based the recovery rate solely on the data from wild birds processed in this study.

Using our data from processed wild birds (n = 29), the mean carcass mass was 60% of the live mass (range = 54%–66%), the heart was 1% (range = 0.5%–1.2%), and the gizzard, 4% (range = 1%–7%), resulting in a mean bird recovery rate of 65% (range = 56%–70%) (Table 3). Breast fillets were 22% (range = 18%–28%) and the legs were 10% (range = 7%–13%) of the live mass.

Using a recovery rate of 65% for birds and 100% for eggs and the mass data compiled, we calculated bird and egg CFn-m for 88 bird species, 13 subspecies or populations, and 25 species categories (Table 4 and online Appendix S2).

Volume-to-Number Conversion Factors for Eggs

The key respondent questionnaire indicated that five-gallon (19 L; n = 7) and one-gallon (3.8 L; n = 5) buckets were commonly used for egg harvesting, but that any available container may be used (basket, tea pot, bag, cooler; n = 8). In areas where eggs were commonly harvested, padding material was almost always used (question 9.a, online Appendix S1: "every time" n = 7, "three out of four times" n = 2). Padding was sometimes not used in murre egg harvesting because murre eggs are sturdy. Responses indicating infrequent use of padding material occurred for regions where eggs are harvested occasionally and in small numbers ("two out of four times" n = 2, "one out of four times" n = 1, "do not use moss, grass" n = 1).

Some responses to the question on whether containers are only partially filled to avoid egg loss and damage during transport considered (1) the volume of padding material separately from the volume of eggs; (2) whether

TABLE 2. Consumption of bird parts by subsistence users in Alaska.[1]

	Breast	Legs	Neck	Head	Back	Wings	Skin	Fat	Heart	Feet	Gizzard	Liver	Bone marrow	Blood	Intestines	Pancreas	Stomach	Kidneys	Lungs	Bones	Tongue
Usually consumed:																					
Ducks	15	14	13	11	14	12	14	14	11	4	13	9	4	2	1	–	1	2	–	–	1
Geese	15	13	13	9	14	12	13	13	10	3	12	8	4	2	1	–	1	2	–	–	1
Swans	10	9	8	7	10	8	7	9	8	2	9	7	5	2	–	–	–	1	–	–	1
Crane	9	8	7	6	9	8	6	7	7	2	7	6	3	2	–	–	–	1	–	–	1
Gulls, murres, puffins	1	1	1	1	1	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–
Loons	2	2	1	1	2	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Snipe, godwit, whimbrel	2	2	1	1	2	2	1	2	2	1	1	2	1	1	–	–	–	–	–	–	–
Grouse, ptarmigan	12	11	10	8	11	11	10	11	9	3	10	8	3	2	1	–	–	2	–	–	1
Sometimes consumed:																					
Ducks	–	1	1	–	–	–	–	–	1	–	–	–	1	1	–	–	–	–	–	–	–
Geese	–	–	–	1	–	–	–	–	–	1	–	–	–	1	1	–	–	–	–	–	–
Swans	–	–	1	–	–	–	2	–	–	2	–	–	–	1	1	–	–	–	–	–	–
Crane	–	–	1	1	–	–	2	2	–	–	–	–	–	1	1	–	–	–	–	–	–
Gulls, murres, puffins	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Loons	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Snipe, godwit, whimbrel	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grouse, ptarmigan	–	–	–	–	–	–	2	1–	1	–	–	1	1	1	–	–	–	–	–	–	–
––																					
Usually not consumed:																					
Ducks	–	–	2	–	2	1	–	3	7	1	5	7	7	9	11	10	8	11	2	–	–
Geese	–	–	–	3	–	1	–	–	3	7	1	5	7	6	8	10	9	7	8	2	–
Swans	–	–	1	3	–	2	2	1	2	6	1	3	4	4	6	7	7	5	7	2	–
Crane	–	–	1	3	–	1	1	–	2	6	2	3	5	5	6	7	7	5	7	2	–
Gulls, murres, puffins	–	–	–	–	–	1	1	–	–	1	1	–	1	1	1	1	1	–	–	–	–
Loons	–	–	–	–	–	1	3	1	–	1	1	1	1	1	1	1	1	–	–	–	–
Snipe, godwit, whimbrel	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Grouse, ptarmigan	–	–	2	4	1	1	–	–	2	7	2	3	4	5	8	11	10	7	10	2	–

[1] Values are number of key respondents that indicated bird parts as "usually," "sometimes," and "usually not" consumed in this study's questionnaire (online Appendix S1).
– : Consumption not indicated by key respondents.

TABLE 3. Mass (g) of wild birds and common cuts in harvest processing of birds harvested in south-central Alaska and the Alaska Peninsula in September – October 2015 and September 2016.

Species	Live mass	Carcass[1]	Heart	Gizzard	Total edible[2]	Breast fillets[3]	Whole legs[4]
American Wigeon *Anas americana*	922	563	6	22	591	213	84
	919	492	8	25	525	211	71
	738	423	8	31	462	160	56
	901	533	7	31	571	193	71
	766	437	7	43	487	167	57
	566	307	3	35	345	113	39
	777	426	7	53	486	162	58
	598	349	6	39	394	119	45
Mallard *A. platyrhynchos*	1157	721	11	45	777	285	102
	1080	679	9	54	742	267	95
	1307	814	11	57	882	305	141
	1055	609	9	47	665	214	92
	1149	669	9	49	727	251	106
Northern Pintail *A. acuta*	1167	752	9	32	793	256	95
	848	527	8	44	579	206	76
	948	627	8	28	663	228	97
	686	424	8	30	462	164	59
Green-winged Teal *A. crecca*	386	243	2	3	248	95	45
Black Brant *Branta bernicla*	1952	1153	16	89	1258	412	202
Canada/Cackling Goose *Branta* spp.	1485	882	13	82	977	301	179
	1732	1000	14	84	1098	336	186
	1677	1010	13	64	1087	342	204
	2549	1491	17	110	1618	507	312
	1685	1097	12	75	1184	350	220
	1471	851	10	71	932	287	155
	1602	919	9	87	1015	305	186
	2493	1494	16	129	1639	452	287
Willow Ptarmigan *Lagopus lagopus*	590	378	7	14	399	166	69
	611	372	7	16	395	163	71
Mean proportion of live mass	100%	60%	1%	4%	65%	22%	10%
Range of proportions of live mass		54% – 66%	0.5% – 1.2%	1% – 7%	56% – 70%	18% – 28%	7% – 13%

[1] Bone-in, skin-on. Feathers, wing tips, feet, head, and viscera removed (see Methods).

[2] Edible mass included the carcass, heart, and gizzard.

[3] Boneless, skin-on, outer and inner fillets, right and left sides.

[4] Bone-in, skin-on thigh and drumstick, right and left sides.

eggs were abundant enough to fill containers; or (3) the number of eggs that people needed and intended to harvest (question 10.a: "yes" n = 7, "no" n = 2; question 10.b: "yes" n = 6, "no" n = 7; question 10.c: mean = 69%, range = 30% – 100%). Although these questions may have been understood differently by some respondents, responses indicated that, even if reports refer to full containers (e.g., two buckets), these were often not filled to the brim.

We asked the number of eggs packed in a five-gallon bucket (question 11, online Appendix S1). Only one respondent provided direct information on the number of eggs per gallon, and the answer indicated a range (36 – 60 large gull eggs in a five-gallon bucket). Three respondents indicated proportions of volume, which suggested that this question was not clear for them. Two respondents specified that they did not know the answer (e.g., "I never count them"). This question was left blank in the remaining 10 completed questionnaires.

DISCUSSION

Bird Recovery Rate

Although the composition of our wild bird sample reflected species availability at a limited set of locations and time of the year, our results were consistent with diverse data sources, including previous subsistence harvest studies, poultry production, and biological data on the relative mass of bird body parts. Considering the range of recovery rates used in previous subsistence harvest studies (40% – 75%; Table 1), 40% was likely an underestimate, because it was little more than the percentage (32%) that we measured for only the breast fillets and legs. A recovery rate of 75% was likely an overestimate, because (1) it would involve including as edible mass bird parts other than those identified in this study as commonly consumed, and (2) it is higher than our recommended recovery rate (65%), which included the skin and bones, although the skin is sometimes removed during processing. Our recommended recovery rate (65%) agreed with several subsistence harvest studies in which the rate was based on assumptions by researchers.

TABLE 4. Conversion factors to estimate food production in subsistence harvest of birds and eggs in Alaska. Source for body and egg mass was Rodewald (2015) unless otherwise noted. To calculate CF for multi-species or multi-population categories, we weighted body and egg mass by population size whenever possible. Asterisks indicate species or categories for which further information is available in online Appendix S2.

	Bird					Egg			
	Body mass (g)	Relative mass[1]	CFn-m[2] (g)	Body mass (pound)	CFn-m[2] (pound)	CFn-m = egg mass[3] (g)	CFv-n[4] (eggs/L)	CFn-m = egg mass[3] (pound)	CFv-n[4] (eggs/gallon)
American Wigeon *Anas americana*	735		478	1.62	1.05	43	9.8	0.095	37.5
Gadwall *Anas strepera*	859		558	1.89	1.23	43	9.8	0.095	37.5
Teal (unidentified)*	328		213	0.72	0.47	28	15.1	0.062	57.4
Green-winged Teal *A. crecca*	328	12%	213	0.72	0.47	–	–	–	–
Blue-winged Teal *A. discors*	371		241	0.82	0.53	28	15.1	0.062	57.4
Mallard *A. platyrhynchos*	1122		729	2.47	1.61	52	8.1	0.115	30.9
Northern Pintail *A. acuta*	820		533	1.81	1.18	43	9.8	0.095	37.5
Northern Shoveler *A. clypeata*	603		392	1.33	0.86	38	11.1	0.084	42.4
Black Scoter *Melanitta nigra*	1052		684	2.32	1.51	67	6.3	0.148	24.0
Surf Scoter *M. perspicillata*	1022		664	2.25	1.46	78	5.4	0.172	20.7
White-winged Scoter *M. fusca*	1825		1186	4.02	2.61	82	5.1	0.181	19.7
Bufflehead *Bucephala albeola*	397		258	0.88	0.57	37	11.4	0.082	43.4
Goldeneye (unidentified)*	887		577	1.96	1.27	66	6.4	0.146	24.4
Common Goldeneye *Bucephala clangula*	863	5%	561	1.90	1.24	64	6.6	0.141	25.2
Barrow's Goldeneye *B. islandica*	910		592	2.01	1.31	68	6.2	0.150	23.7
Canvasback *Aythya valisineria*	1210		787	2.67	1.74	68	6.2	0.150	23.7
Scaup (unidentified)*	943		613	2.08	1.35	63	6.7	0.139	25.6
Greater Scaup *Aythya marila*	943		613	2.08	1.35	63	6.7	0.139	25.6
Lesser Scaup *A. affinis*	751	20%	488	1.66	1.08	48	8.8	0.106	33.6
Common Eider *Somateria mollissima v-nigrum**	2288		1487	5.04	3.28	101	4.2	0.223	16.0
King Eider *S. spectabilis**	1570		1021	3.46	2.25	69	6.1	0.152	23.4
Spectacled Eider *S. fischeri**	1466		953	3.23	2.10	71	5.9	0.157	22.7
Steller's Eider *Polysticta stelleri**	833		541	1.84	1.20	55	7.7	0.121	29.4
Harlequin Duck *Histrionicus histrionicus*	588		382	1.30	0.85	53	8.0	0.117	30.4
Long-tailed Duck *Clangula hyemalis**	814		529	1.79	1.16	43	9.8	0.095	37.5
Merganser (unidentified)*	1209		786	2.67	1.74	69	6.1	0.152	23.4
Common Merganser *Mergus merganser*	1472		957	3.25	2.11	70	6.0	0.154	23.1
Red-breasted Merganser *M. serrator*	946	36%	615	2.09	1.36	68	6.2	0.150	23.7
Black Brant *Branta bernicla*	1321		859	2.91	1.89	100	4.2	0.220	16.2
Canada/Cackling Goose (unidentified)*	1972		1282	4.35	2.83	113	3.7	0.249	14.3
Lesser Canada Goose *Branta canadensis parvipes*	3060	9%	1989	6.75	4.39	–	–	–	–
Dusky Canada Goose *B. c. occidentalis*	2936	13%	1908	6.47	4.21	–	–	–	–
Vancouver Canada Goose *B. c. fulva*	3366		2188	7.42	4.82	–	–	–	–
Taverner's Cackling Goose *B. hutchinsii taverneri*	2514	25%	1634	5.54	3.60	124	3.4	0.273	13.0
Aleutian Cackling Goose *B. h. leucopareia*	1825	46%	1186	4.02	2.61	–	–	–	–
Cackling Cackling Goose *B. h. minima*	1429	58%	929	3.15	2.05	101	4.2	0.223	16.0
Greater White-fronted Goose *Anser albifrons**	2218		1442	4.89	3.18	129	3.3	0.284	12.5
Tundra Greater White-fronted Goose *A. a. gambelli*	2420	4%	1573	5.34	3.47	129	3.3	0.284	12.5
Pacific Greater White-fronted Goose *A. a. sponsa*	2015	20%	1310	4.44	2.89	128	3.3	0.282	12.6
Tule Greater White-fronted Goose *A. a. elgasi*	2510		1632	5.53	3.59	–	–	–	–
Emperor Goose *Chen canagica*	2148		1396	4.74	3.08	122	3.5	0.269	13.2
Lesser Snow Goose *C. caerulescens*	1955		1271	4.31	2.80	122	3.5	0.269	13.2
Swan (unidentified)*	7662		4980	16.89	10.98	287	1.5	0.633	5.6
Tundra Swan *Cygnus columbianus*	7111	34%	4622	15.68	10.19	273	1.5	0.602	5.9
Eastern population	7014	3%	4559	15.46	10.05	273	1.5	0.602	5.9
Western population	7207		4685	15.89	10.33	–	–	–	–
Trumpeter Swan *C. buccinator*	10 700		6955	23.59	15.33	363	1.2	0.800	4.4

TABLE 4. Conversion factors to estimate food production in subsistence harvest of birds and eggs in Alaska. Source for body and egg mass was Rodewald (2015) unless otherwise noted. To calculate CF for multi-species or multi-population categories, we weighted body and egg mass by population size whenever possible. Asterisks indicate species or categories for which further information is available in online Appendix S2 – *continued:*

	Bird					Egg			
	Body mass (g)	Relative mass[1]	CFn-m[2] (g)	Body mass (pound)	CFn-m[2] (pound)	CFn-m = egg mass[3] (g)	CFv-n[4] (eggs/L)	CFn-m = egg mass[3] (pound)	CFv-n[4] (eggs/gallon)
Sandhill Crane *Grus canadensis**	3763		2446	8.30	5.40	151	2.8	0.333	10.7
G. c. canadensis	3705	17%	2408	8.17	5.31	150	2.8	0.331	10.7
G. c. rowani	4455		2896	9.82	6.38	161	2.6	0.355	10.0
Ptarmigan (unidentified)*	542		352	1.19	0.77	22	19.2	0.049	72.6
White-tailed Ptarmigan *Lagopus leucura**	355	34%	231	0.78	0.51	19	22.2	0.042	84.7
Rock Ptarmigan *L. muta**	420	23%	273	0.93	0.60	21	20.1	0.046	77.4
Willow Ptarmigan *L. lagopus**	542		352	1.19	0.77	22	19.2	0.049	72.6
Grouse (unidentified)*	635		413	1.40	0.91	21	20.1	0.046	77.4
Ruffed Grouse *Bonasa umbellus**	591	41%	384	1.30	0.85	20	21.1	0.044	80.9
Spruce Grouse *Falcipennis canadensis**	595	41%	387	1.31	0.85	22	19.2	0.049	72.6
Sooty Grouse *Dendragapus fuliginosus*	1004		653	2.21	1.44	36	11.7	0.079	45.0
Sharp-tailed Grouse *Tympanuchus phasianellus**	720		468	1.59	1.03	–	–	–	–
Short-tailed Shearwater *Puffinus tenuirostris**	527		343	1.16	0.75	NA	NA	NA	NA
Cormorant (unidentified)*	1985		1290	4.38	2.85	45	9.4	0.099	35.9
Double-crested Cormorant *Phalacrocorax auritus*	2330		1515	5.14	3.34	47	9.0	0.104	34.2
Red-faced Cormorant *P. urile*	2138	8%	1390	4.71	3.06	–	–	–	–
Pelagic Cormorant *P. pelagicus*	1868	20%	1214	4.12	2.68	45	9.4	0.099	35.9
Bonaparte's/Sabine's Gull (unidentified)*	185		120	0.41	0.27	26	16.2	0.057	62.4
Bonaparte's Gull *Chroicocephalus philadelphia*	180	5%	117	0.40	0.26	–	–	–	–
Sabine's Gull *Xema sabini*	190		124	0.42	0.27	26	16.2	0.057	62.4
Mew Gull *Larus canus**	389		253	0.86	0.56	52	8.1	0.115	30.9
Large gull (unidentified)*	1199		779	2.64	1.72	97	4.3	0.214	16.6
Herring Gull *L. argentatus*	1085	24%	705	2.39	1.55	95	4.4	0.209	17.0
Glaucous-winged Gull *L. glaucescens*	1077	25%	700	2.37	1.54	92	4.6	0.203	17.5
Glaucous Gull *L. hyperboreus*	1434		932	3.16	2.05	105	4.0	0.231	15.4
Black-legged Kittiwake *Rissa tridactyla*	429		279	0.95	0.62	52	8.1	0.115	30.9
Red-legged Kittiwake *R. brevirostris*	377		245	0.83	0.54	49	8.6	0.108	32.9
Tern (unidentified)*	112		73	0.25	0.16	19	22.2	0.042	84.7
Arctic Tern *Sterna paradisea*	112	7%	73	0.25	0.16	19	22.2	0.042	84.7
Aleutian Tern *Onychoprion aleuticus*	120		78	0.26	0.17	20	21.1	0.044	80.9
Murre (unidentified)*	965		627	2.13	1.38	105	4.0	0.231	15.4
Common Murre *Uria aalge*	966		628	2.13	1.38	106	4.0	0.234	15.2
Thick-billed Murre *U. lomvia*	963	<1%	626	2.12	1.38	103	4.1	0.227	15.7
Guillemot (unidentified)*	505		328	1.11	0.72	54	7.8	0.119	29.9
Black Guillemot *Cepphus grille*	378	25%	246	0.83	0.54	54	7.8	0.119	29.9
Pigeon Guillemot *C. columba*	507		330	1.12	0.73	54	7.8	0.119	29.9
Auklet (unidentified)*	171		111	0.38	0.25	25	16.9	0.055	64.7
Least Auklet *Aethia pusilla*	84	83%	55	0.19	0.12	18	23.4	0.040	89.0
Crested Auklet *A. cristatella*	255	50%	166	0.56	0.36	36	11.7	0.079	45.0
Least/Crested Auklet	170		111	0.37	0.24	27	15.6	0.060	59.3
Cassin's Auklet *Ptychoramphus aleuticus*	185	63%	120	0.41	0.27	25	16.9	0.055	64.7
Parakeet Auklet *Aethia psittacula*	262	48%	170	0.58	0.38	34	12.4	0.075	47.4
Whiskered Auklet *A. pygmaea*	120	76%	78	0.26	0.17	–	–	–	–
Rhinoceros Auklet *Cerorhinca monocerata*	507		330	1.12	0.73	78	5.4	0.172	20.7

TABLE 4. Conversion factors to estimate food production in subsistence harvest of birds and eggs in Alaska. Source for body and egg mass was Rodewald (2015) unless otherwise noted. To calculate CF for multi-species or multi-population categories, we weighted body and egg mass by population size whenever possible. Asterisks indicate species or categories for which further information is available in online Appendix S2 – *continued:*

	Bird					Egg			
	Body mass (g)	Relative mass[1]	CFn-m[2] (g)	Body mass (pound)	CFn-m[2] (pound)	CFn-m = egg mass[3] (g)	CFv-n[4] (eggs/L)	CFn-m = egg mass[3] (pound)	CFv-n[4] (eggs/gallon)
Puffin (unidentified)*	707		460	1.56	1.01	87	4.8	0.192	18.5
Horned Puffin *Fratercula corniculata*	537	31%	349	1.18	0.77	76	5.6	0.168	21.2
Tufted Puffin *F. cirrhata*	774		503	1.71	1.11	91	4.6	0.201	17.7
Black Oystercatcher *Haematopus bachmani*	535		348	1.18	0.77	46	9.2	0.101	35.2
Whimbrel/Curlew (unidentified)*	399		259	0.88	0.57	50	8.4	0.110	32.3
Whimbrel *Numenius phaeopus rufiventris*	391	10%	254	0.86	0.56	49	8.6	0.108	32.9
Bristle-thighed Curlew *N. tahitiensis*	433		281	0.95	0.62	56	7.5	0.123	28.9
Godwit (unidentified)*	421		274	0.93	0.60	36	11.7	0.079	45.0
Bar-tailed Godwit *Limosa lapponica baueri*	464		302	1.02	0.66	37	11.4	0.082	43.4
Hudsonian Godwit *L. haemastica*	241	48%	157	0.53	0.34	32	13.2	0.071	50.1
Marbled Godwit *L. fedoa beringiae*	368	21%	239	0.81	0.53	48	8.8	0.106	33.6
Golden/Black-bellied Plover (unidentified)*	162		105	0.36	0.23	30	14.1	0.066	53.9
American Golden Plover *Pluvialis dominica*	133	39%	86	0.29	0.19	27	15.6	0.060	59.3
Pacific Golden Plover *P. fulva*	148	32%	96	0.33	0.21	27	15.6	0.060	59.3
Black-bellied Plover *P. squatarola squatarola*	219		142	0.48	0.31	35	12.1	0.077	46.2
Turnstone (unidentified)*	122		79	0.27	0.18	18	23.4	0.040	89.0
Ruddy Turnstone *Arenaria interpres interpres*	107	14%	70	0.24	0.16	17	24.8	0.037	96.2
Black Turnstone *A. melanocephala*	125		81	0.28	0.18	18	23.4	0.040	89.0
Phalarope (unidentified)*	42		27	0.09	0.06	7	60.3	0.015	237.2
Red-necked Phalarope *Phalaropus lobatus*	35	33%	23	0.08	0.05	6	70.3	0.013	273.7
Red Phalarope *P. fulicarius*	53		34	0.12	0.08	8	52.7	0.018	197.7
Small shorebird (unidentified)*	37		24	0.08	0.05	8	52.7	0.018	197.7
Western Sandpiper *Calidris mauri*	28	60%	18	0.06	0.04	7	60.3	0.015	237.2
Dunlin *C. alpina arcticola*	65		42	0.14	0.09	11	38.3	0.024	148.3
Wilson's Snipe *Gallinago delicata*	99		64	0.22	0.14	15	28.1	0.033	107.8
Loon (unidentified)*	2513		1633	5.54	3.60	103	4.1	0.227	15.7
Red-throated Loon *Gavia stellata*	1759	65%	1143	3.88	2.52	77	5.5	0.170	20.9
Arctic Loon *G. arctica*	3101	39%	2016	6.84	4.45	–	–	–	–
Pacific Loon *G. pacifica*	2232	56%	1451	4.92	3.20	101	4.2	0.223	16.0
Common Loon *G. immer*	5015	1%	3260	11.06	7.19	143	2.9	0.315	11.3
Yellow-billed Loon *G. adamsii*	5056		3286	11.15	7.25	154	2.7	0.340	10.5
Grebe (unidentified)*	799		519	1.76	1.14	30	14.1	0.066	53.9
Horned Grebe *Podiceps auritus*	405	66%	263	0.89	0.58	21	20.1	0.046	77.4
Red-necked Grebe *P. griseana*	1192		775	2.63	1.71	38	11.1	0.084	42.4
Snowy Owl *Bubo scandiacus*	1873		1217	4.13	2.68	57	7.4	0.126	28.2

[1] Relative mass is the percent difference in body mass (g) between a given species and the heaviest species, subspecies, or population within the same category. That is, relative mass = [1 - (focal item ÷ heaviest item in category)] × 100.

[2] Bird CFn-m (number-to-mass conversion factor) = recovery rate (65%) × body mass.

[3] Egg CFn-m (number-to-mass conversion factor) = recovery rate (100%) × egg mass.

[4] Egg CFv-n: volume-to-number conversion factor.

Number of eggs/gallon: CFv-n = (35.3 × 0.8) × (0.126 ÷ mass of wild bird egg, in pounds).

Number of eggs/L: CFv-n = (9.3 × 0.8) × (57.0 ÷ mass of wild bird egg, in grams).

– : Data unavailable.

Even if not explained, recovery rates in some studies were likely based on information from local, Native experts and from researchers with wide experience in ethnographic work involving participant observation and residency in subsistence communities.

Selective breeding and commercial production conditions may result in differences in body composition between poultry and wild birds, but recovery rates in wild birds and poultry were similar. For poultry, the recovery rate for a carcass processed for removal of blood, feathers, head, feet, and all viscera was 65% (range = 58% – 72%) of the body mass (Watt and Merrill, 1963; Fanatico, 2003; Lessler et al., 2007; Połtowicz and Doktor, 2011). The breast and legs were about 38% of the body mass (Solomon et al., 2006; Haslinger et al., 2007). In wild birds, the breast and legs were 32% of the body mass in our sample and 28% in other sources (Raveling, 1979; Thompson and Drobney, 1996; Jacobs et al., 2011).

Both our study and other sources reported the heart as 1% of the body mass of wild birds (Thompson and Drobney, 1996; Piersma and Gill, 1998; Jacobs et al., 2011). The gizzard was 1% – 2% of the body mass in seabirds and shorebirds (Piersma and Gill, 1998; Jacobs et al., 2011), 5% – 7% in geese (Raveling, 1979; Barnes and Thomas, 1987), and 2% – 5% in ducks (Barnes and Thomas, 1987; Goudie and Ryan, 1991; Thompson and Drobney, 1996). The relative gizzard mass we obtained (4%) was at the mean for ducks and geese. Using this mean was appropriate because it was in accordance with the overall species composition of subsistence harvest in Alaska (ducks were 58% and geese were 31% of the number of birds annually taken; Paige and Wolfe, 1997).

Using the allometric equation of Prange et al. (1979), bone mass for wild bird species likely harvested in Alaska accounted for 7% – 9% of the body mass (results not presented here). Because some bone mass is removed during processing (head, feet, wing tips), the lower end of this range could be used to adjust the recovery rate when exclusion of bones is appropriate.

Recovery rates must reflect prevailing processing practices, which may differ among hunting traditions. A characterization of bird processing by sport users was beyond the scope of this study. In Alaska, bird sport hunting generally applies to harvest in non-subsistence areas as defined by the Joint Board of Fisheries and Game, which are primarily urban areas (State of Alaska, 2015:5 AAC 99.015). Sport hunters pluck birds for bone-in, skin-on preparations, and a recovery rate of 60% is likely adequate for this use (if the heart and gizzard are not usually consumed). But sport hunters also commonly skin birds, and only the breast (recovery rate = 22% for skin-on processing) or the breast and legs (recovery rate = 32%) may be consumed (Shaw, 2013). These three values could be combined to generate a recovery rate for sport hunting. In contrast to subsistence harvest studies, sport hunting economic valuations have focused on hunting activities and expenditures rather than food production (Gan and Luzar, 1993; ECONorthwest, 2014). A better understanding of food production in bird sport hunting as well as other differences and similarities between sport and subsistence bird hunting traditions could help alleviate conflict between user groups and promote positive outcomes in management and conservation issues.

Egg Recovery Rate

Studies have often assumed an egg recovery rate of 100% (e.g., Georgette and Loon, 1993), although this assumption may not be clearly stated. The eggshell is 8% – 14% of the total egg mass (Williams et al., 1982). Across species, larger eggs have proportionally thicker shells and higher shell mass (Rahn and Paganelli, 1989). Murre eggs are an important subsistence resource, and their shells are about 14% of the total egg mass (Williams et al., 1982). Whether to include eggshell mass within edible mass depends on the study objectives. In replacement cost evaluation, eggshell should be included as edible mass (recovery rate = 100%) because a likely store-bought replacement product (chicken eggs) would include shells. When assessing exposure to contaminants, eggshells should be excluded from the edible mass because they are not consumed. If discounting shell mass, we recommend a recovery rate of 90% for all egg harvest.

Volume-to-Number Conversion Factors for Eggs

It is possible that the previous attempt to calculate CFv-n based on 48 chicken eggs/gallon (12.6 eggs/L) (J. Magdanz, pers. comm. in Naves, 2010) assumed that padding material was not used and that containers were filled to the brim. Estimates based on these assumptions were likely too high and resulted in numbers of eggs about 40% higher than ours. For murre eggs, the CFv-n calculated using our equation (16.0 eggs/gallon) (4.0 eggs/L) was half of that estimated by Burch (1985) (32 eggs/gallon) (8.4 eggs/L). Considerations used by Burch (1985) were unknown, but this difference may be related to the fact that we assumed use of padding material. For large gull eggs, our CFv-n (17.5 eggs/gallon) (4.3 eggs/L) was higher than (a) empirical data in Hunn et al. (2003) (12 eggs/gallon) (3.2 eggs/L); (b) the range provided by a key respondent in this study (7 – 12 eggs/gallon) (1.8 – 3.2 eggs/L); and (c) the value for "gull (unidentified)" provided by a key respondent in Fall et al. (1995) (10 eggs/gallon) (2.6 eggs/L). Although our CFv-n equation relied on simple assumptions, these were clearly stated and their variables can be easily adjusted to suit different study objectives and contexts. For example, if it is known that padding was not used, the equation could consider 35 chicken eggs/gallon (9.2 eggs/L).

In harvest survey interviews, considering individual harvest events, respondents can provide the best data on the number of eggs harvested. If respondents report eggs as volume, surveyors can assist respondents by sequentially asking (1) the kind of eggs harvested (species); (2) the size of containers used; and (3) whether padding material was used. Then, respondents may be asked to estimate how many eggs were harvested. For egg harvest reported as volume, the unit used in the original report must be reported so that standard CFv-n can be applied. Undocumented conversions of egg volume to number make it difficult to compare results among studies.

Species Categories, Regional, and Seasonal Conversion Factors

Mean body and egg mass used in CFn-m should approximate the harvest composition in a given geographic area and season of the year. In this study, we calculated mean mass for species categories weighted by Alaska-wide populations. Using the same principle, the mean mass for species categories may be adjusted for smaller geographic scales. Use of means weighted by population size is relevant for categories that include species of very different sizes. However, to simplify the application of CF and facilitate comparison among studies, whenever appropriate, CF should refer to relatively large geographic areas and encompass all seasons of the year.

Regardless of the level of analytical complexity researchers can implement when using CF, we offer four recommendations for this method. First, surveyors must be prepared to assist respondents in accurately reporting the number of eggs harvested, instead of volume. Second, considerations and assumptions used in CF must be clearly explained. Third, recovery rates and mass of birds and eggs used to generate CF must be reported (with citation of the source) so that users can assess which of these two variables accounts for potential differences from CF in other studies. Fourth, if using CF from previous studies, citations must refer to original sources, avoiding second-hand citations. Attention to these points will improve the accuracy of food production estimates and our ability to compare them across time and geographic areas.

ACKNOWLEDGEMENTS

This study was funded by the Alaska Department of Fish and Game, Division of Wildlife Conservation (RSA-1155353), as a component of the Harvest Assessment Program of the Alaska Migratory Bird Co-Management Council. We thank the key respondents for sharing information on bird processing and egg harvesting; Andrew Ramey and Txai-the Tundra Drummer for providing wild birds for weighing and processing; and Christian Dau (U.S. Fish and Wildlife Service) and Craig Ely (U.S. Geological Service, Alaska Science Center) for providing unpublished data on swan body mass. We also thank Jim Magdanz, Tom Rothe, Julian Fischer, and two anonymous reviewers for suggesting improvements to manuscript drafts.

APPENDICES

The following appendices are available as supplementary files to the online version of this article at:
http://arctic.journalhosting.ucalgary.ca/arctic/index.php/arctic/rt/suppFiles/4630/0

APPENDIX S1. Key respondent questionnaire to collect ethnographic information on subsistence harvesting and processing of birds and eggs in Alaska.

APPENDIX S2. Notes to accompany TABLE 4. Conversion factors to estimate food production in subsistence harvest of birds and eggs in Alaska.

REFERENCES

Ahmasuk, A., Trigg, E., Magdanz, J., and Robbins, B. 2008. Bering Strait Region Local and Traditional Knowledge Pilot Project: A comprehensive subsistence use study of the Bering Strait region. North Pacific Research Board Project Final Report #643. Nome: Kawerak Inc.

AMBCC (Alaska Migratory Bird Co-Management Council). 2016. Anchorage: U.S. Fish and Wildlife Service. http://www.fws.gov/alaska/ambcc/index.htm

Andres, B.A., Smith, P.A., Morrison, R.I.G., Gratto-Trevor, C.L., Brown, S.C., and Friis, C.A. 2012. Population estimates of North American shorebirds, 2012. Wader Study Group Bulletin 119(3):178–194.

ARCUS (Arctic Research Consortium of the U.S.) 1999. Arctic social sciences: Opportunities in Arctic research. Fairbanks: ARCUS. https://archive.arcus.org/assp/downloads/ASSP_all.pdf

Ashley, B. 2002. Edible weights of wildlife species used for country food in the Northwest Territories and Nunavut. Manuscript Report No. 138. Yellowknife: Wildlife and Fisheries Division, Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. http://www.enr.gov.nt.ca/sites/default/files/weights_of_wildlife.pdf

Banks, R.C. 2011. Taxonomy of Greater White-fronted Geese (Aves: Anatidae). Proceedings of the Biological Society of Washington 124(3):226–233. https://doi.org/10.2988/11-14.1

Barnes, G.G., and Thomas, V.G. 1987. Digestive organ morphology, diet, and guild structure of North American Anatidae. Canadian Journal of Zoology 65(7):1812–1817. https://doi.org/10.1139/z87-274

Behnke, S.R. 1982. Wildlife utilization and the economy of Nondalton. Technical Paper No. 47. Anchorage: ADF&G, Division of Subsistence.

Berkes, F., George, P.J., Preston, R.J., Hughes, A., Turner, J., and Cummins, B.D. 1994. Wildlife harvesting and sustainable regional Native economy in the Hudson and James Bay lowland, Ontario. Arctic 47(4):350–360. https://doi.org/10.14430/arctic1308

Bernard, H.R. 2011. Research methods in anthropology: Qualitative and quantitative approaches, 5th ed. Lanham, Maryland: Altamira.

Braund, S.R. & Associates. 1993. North Slope subsistence study, Barrow, 1987, 1988, 1989. Technical Report No. 149. OCS Study MMS 91-0086. Prepared for the U.S. Department of the Interior, Minerals Management Service, Alaska OCS Study, Anchorage.

Brower, H.K., Jr., Olemaun, T.P., and Hepa, R.T. 2000. North Slope Borough Subsistence Harvest Documentation Project: Data for Kaktovik, Alaska, for the period December 1, 1994 to November 30, 1995. Barrow: North Slope Borough, Department of Wildlife Conservation.

Brown, T.C., and Burch, E.S., Jr. 1992. Estimating the economic value of subsistence harvest of wildlife in Alaska. In: Peterson, G.L., Swanson, C.S., McCollum, D.W., and Thomas, M.H., eds. Valuing wildlife resources in Alaska. Boulder: Westview Press. 203–254.

Burch, E.S., Jr. 1985. Subsistence production in Kivalina, Alaska: A twenty-year perspective. Technical Paper No. 128. Juneau: Alaska Department of Fish and Game, Division of Subsistence.

CSIS (Community Subsistence Information System). 2016a. Alaska Department of Fish and Game, Division of Subsistence. Special topic reports: Conversion factor summary. http://www.adfg.alaska.gov/sb/CSIS/index.cfm?ADFG=main.conversionFactorSelRes

———. 2016b. Welcome to the Community Subsistence Information System: CSIS. Juneau: Alaska Department of Fish and Game, Division of Subsistence. http://www.adfg.alaska.gov/sb/CSIS/

Douglas, H., and Sowl, K. 1993. Northeastern extension of the breeding range of the Arctic Loon in northwestern Alaska. Western Birds 24(2):98–100.

Dunn, J.L., and Alderfer, J. 2011. National Geographic field guide to the birds of North America, 6th ed. Washington, D.C.: National Geographic.

ECONorthwest. 2014. The economic importance of Alaska's wildlife in 2011: Summary report to the Alaska Department of Fish and Game, Division of Wildlife Conservation. Portland, Oregon: ECONorthwest.

Fall, J.A. 2016. Regional patterns of fish and wildlife harvests in contemporary Alaska. Arctic 69(1):47–64. https://doi.org/10.14430/arctic4547

Fall, J.A., and Morris, J.M. 1987. Fish and wildlife harvests in Pilot Point, Ugashik, and Port Heiden, Alaska Peninsula, 1986–1987. Technical Paper No. 158. Juneau: Alaska Department of Fish and Game, Division of Subsistence.

Fall, J.A., Hutchinson-Scarbrough, L.B., and Coiley, P.A. 1995. Fish and wildlife harvest and use in five Alaska Peninsula communities, 1989: Subsistence uses in Chignik Bay, Chignik Lagoon, Chignik Lake, Ivanof Bay, and Perryville. Technical Paper No. 202. Juneau: Alaska Department of Fish and Game, Division of Subsistence.

Fanatico, A. 2003. Small-scale poultry processing. Butte, Montana: National Center for Appropriate Technology (NCAT), National Sustainable Agriculture Information Service (ATTRA).

Fienup-Riordan, A. 1999. *Yaqulget qaillun pilartat* (what the birds do): Yup'ik Eskimo understanding of geese and those who study them. Arctic 52(1):1–22. https://doi.org/10.14430/arctic905

Foote, D.C. 1965. Exploration and resource utilization in northwestern Arctic Alaska before 1855. PhD thesis, Department of Geography, McGill University, Montreal, Québec.

Fuller, A.S., and George, J.C. 1997. Evaluation of subsistence harvest data from the North Slope Borough 1993: Census for eight North Slope villages for the calendar year 1992. Barrow: North Slope Borough, Department of Wildlife Management.

Gambell, R.L. 1984. A preliminary study of the Native harvest of wildlife in the Keewatin region, Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences 1282. Winnipeg, Manitoba: Department of Fisheries and Oceans.

Gan, C., and Luzar, E.J. 1993. A conjoint analysis of waterfowl hunting in Louisiana. Journal of Agricultural and Applied Economics 25(2):36–45.

Georgette, S., and Loon, H. 1993. Subsistence use of fish and wildlife in Kotzebue, a Northwest Alaska regional center. Technical Paper No. 167. Juneau: Alaska Department of Fish and Game, Division of Subsistence.

Goldstein, J.H., Thogmartin, W.E., Bagstad, K.J., Dubovsky, J.A., Mattsson, B.J., Semmens, D.J., López-Hoffman L., and Diffendorfer, J.E. 2014. Replacement cost valuation of Northern Pintail (*Anas acuta*) subsistence harvest in Arctic and Sub-Arctic North America. Human Dimensions of Wildlife 19(4):347–354. https://doi.org/10.1080/10871209.2014.917345

Goudie, R.I., and Ryan, P.C. 1991. Diets and morphology of digestive organs of five species of sea ducks wintering in Newfoundland. Journal of the Yamashina Institute for Ornithology 22(1):1–8. https://doi.org/10.3312/jyio1952.22.1

Groves, D.J. 2012. The 2010 North American Trumpeter Swan survey. Juneau: U.S. Fish and Wildlife Service, Division of Migratory Bird Management.

Groves, D.J., Conant, B., King, R.J., Hodges, J.I., and King, J.G. 1996. Status and trends of loon populations summering in Alaska, 1971–1993. The Condor 98(2):189–195. https://doi.org/10.2307/1369136

Haslinger, M., Leitgeb, R., Bauer, F., Ettle, T., and Windisch, W.M. 2007. Slaughter yield and meat quality of chicken at different length of preslaughter feed withdrawal. Die Bodenkultur 58(1-4):67–72.

Hoover, C., Bailey, M., Higdon, J., Ferguson, S.H., and Sumaila, R. 2013. Estimating the economic value of narwhal and beluga hunts in Hudson Bay, Nunavut. Arctic 66(1):1–16. https://doi.org/10.14430/arctic4261

Hunn, E.S., Johnson, D.R., Russell, P.N., and Thorton, T.F. 2003. Huna Tlingit traditional environmental knowledge, conservation, and the management of a "wilderness" park. Current Anthropology 44(Suppl.):79–103.

Hunt, G.L., Jr., Baduini, C., and Jahncke, J. 2002. Diets of Short-tailed Shearwaters in the southeastern Bering Sea. Deep-Sea Research II 49(26):6147–6156.

Huntington, H.P. 1998. Observations on the utility of semi-directive interview for documenting traditional ecological knowledge. Arctic 51(3):237–242. https://doi.org/10.14430/arctic1065

Ikuta, H., Brown, C.L., and Koster, D.S., eds. 2014. Subsistence harvests in 8 communities in the Kuskokwim River drainage and lower Yukon River, 2011. Technical Paper No. 396. Fairbanks: Alaska Department of Fish and Game, Division of Subsistence.

Jacobs, S.R., Edwards, D.B., Ringrose, J., Elliott, K.H., Weber, J.-M., and Gaston, A.J. 2011. Changes in body composition during breeding: Reproductive strategies of three species of seabirds under poor environmental conditions. Comparative Biochemistry and Physiology Part B 158(1):77–82. https://doi.org/10.1016/j.cbpb.2010.09.011

JBNQNHRC (James Bay and Northern Quebec Native Harvesting Research Committee). 1982. The wealth of the land: Wildlife harvest by the James Bay Cree 1972–73 to 1978–79. Quebec City, Quebec: JBNQNHRC.

Johnson, L.L. 1971. The migration, harvest, and importance of waterfowl at Barrow, Alaska. MSc thesis, Agriculture, Forestry, and Wildlife, University of Alaska, Fairbanks.

Jones, C.A. 1997. Use of non-market valuation methods in the courtroom: Recent affirmative precedents in natural resource damage assessments. Water Resources Update 109(1):10–18.

Kristensen, T.J. 2011. Seasonal bird exploitation by recent Indian and Beothuk hunter-gatherers of Newfoundland. Canadian Journal of Archeology 35(2):292–322.

Lessler, J., Ranells, N., and Growers' Choice. 2007. Grower guidelines for poultry and fowl processing. Raleigh: North Carolina State University Cooperative Extension.

Magdanz, J.S., Koster, D.S., Naves, L., and Fox, P. 2011. Subsistence harvests in Northwest Alaska, Buckland and Kiana, 2003 and 2006. Technical Paper No. 363. Kotzebue: Alaska Department of Fish and Game, Division of Subsistence.

Mallek, E.J., and Groves, D.J. 2011. Alaska-Yukon waterfowl breeding population survey. Fairbanks and Juneau: U.S. Fish and Wildlife Service.

Mishler, C. 2003. Black ducks and salmon bellies: An ethnography of Old Harbor and Ouzinkie, Alaska. Virginia Beach, Virginia: Donning Company Publishers.

Naves, L.C. 2010. Alaska migratory bird subsistence harvest estimates, 2004–2007, Alaska Migratory Bird Co-Management Council, rev. ed. Technical Paper No. 349. Anchorage: Alaska Department of Fish and Game, Division of Subsistence.

———. 2015. Alaska subsistence bird harvest, 2004–2014 data book, Alaska Migratory Bird Co-Management Council. Special Publication 2015-005. Anchorage: Alaska Department of Fish and Game, Division of Subsistence.

Naves, L.C., and Zeller, T.K. 2013. Saint Lawrence Island subsistence harvest of birds and eggs, 2011–2012, addressing Yellow-billed Loon conservation concerns. Technical Paper No. 384. Anchorage: Alaska Department of Fish and Game, Division of Subsistence.

Paige, A., and Wolfe, R. 1997. The subsistence harvest of migratory birds in Alaska – Compendium and 1995 update. Technical Paper No. 228. Juneau: Alaska Department of Fish and Game, Division of Subsistence.

Patterson, A. 1974. Subsistence harvests in five Native regions. Report prepared for the Joint Federal-State Land Use Planning Commission for Alaska. Anchorage: Resources Planning Team.

Pearce, J.M., and Bollinger, K.S. 2003. Morphological traits of Pacific Flyway Canada Geese as an aid to subspecies identification and management. Journal of Field Ornithology 74(4):357–369. https://doi.org/10.1648/0273-8570-74.4.357

Piersma, T., and Gill, R.E., Jr. 1998. Guts don't fly: Small digestive organs in obese Bar-tailed Godwits. The Auk 115(1):196–203. https://doi.org/10.2307/4089124

Piersma, T., and Lindström, Å. 1997. Rapid reversible changes in organ size as a component of adaptive behaviour. Trends in Ecology & Evolution 12(4):134–138. https://doi.org/10.1016/S0169-5347(97)01003-3

Platte, R.M., and Stehn, R.A. 2015. Abundance and trend of waterbirds on Alaska's Yukon-Kuskokwim Delta coast based on 1988 to 2014 aerial surveys. Anchorage: U.S. Fish and Wildlife Service, Division of Migratory Bird Management.

Połtowicz, K., and Doktor, J. 2011. Effect of free-range raising on performance, carcass attributes and meat quality of broiler chickens. Animal Science Papers and Reports 29(2):139–149.

Prange, H.D., Anderson, J.F., and Rahn, H. 1979. Scaling of skeletal mass to body mass in birds and mammals. The American Naturalist 113(1):103–122. https://doi.org/10.1086/283367

Rahn, H., and Paganelli, C.V. 1989. Shell mass, thickness and density of avian eggs derived from the tables of Schönwetter. Journal für Ornithologie 130(1):59–68. https://doi.org/10.1007/BF01647162

Raveling, D.G. 1979. The annual cycle of body composition of Canada Geese with special reference to control of reproduction. The Auk 96(2):234–252.

Rodewald, P., ed. 2015. The birds of North America online. Ithaca, New York: Cornell Laboratory of Ornithology. http://bna.birds.cornell.edu/BNA/

Shaw, H. 2013. Duck, duck, goose: Recipes and techniques for cooking ducks and geese, both wild and domesticated. New York: Ten Speed Press, Random House Inc.

Sibley, D. 2007. Sibley guides online. Distinguishing Cackling and Canada Goose. http://www.sibleyguides.com/2007/07/identification-of-cackling-and-canada-goose/

Solomon, J.K.Q., Austin, R., Cumberbatch, R.N., Gonsalves, J., and Seaforth, E. 2006. A comparison of live weight and carcass gain of Pekin, Kunshan and Muscovy ducks on a commercial ration. Livestock Research for Rural Development 18(11): 154.

State of Alaska. 2015. Alaska fish and game laws and regulations annotated: Reprinted from the Alaska statutes and from the Alaska administrative code, as updated through register 225. 2015–2016 ed. Charlottesville, Virginia: Matthew Bender & Company, Inc.

Stehn, R.A., Larned, W.W., and Platte, R.M. 2013. Analysis of aerial survey indices monitoring waterbird populations of the Arctic Coastal Plain, Alaska, 1986–2012. Anchorage: U.S. Fish and Wildlife Service, Migratory Bird Management.

Stephensen, S.W., Pungowiyi, C., and Mendenhall, V.M. 1998. A seabird survey of Saint Lawrence Island, Alaska, 1996–1997. Anchorage: U.S. Fish and Wildlife Service, Migratory Bird Management, and Inuit Circumpolar Conference.

Taylor, W.P. 2013. Status of upland game within Alaska's highway system: A comprehensive report focusing on 2007–2011. Wildlife Management Report No. 2013-1. Palmer: Alaska Department of Fish and Game, Division of Wildlife Conservation.

Thompson, J.E., and Drobney, R.D. 1996. Nutritional implications of molt in male Canvasbacks: Variation in nutrient reserves and digestive tract morphology. The Condor 98(3):512–526. https://doi.org/10.2307/1369565

Tobias, T.N., and Kay, J.J. 1994. The bush harvest in Pinehouse, Saskatchewan, Canada. Arctic 47(3):207–221. https://doi.org/10.14430/arctic1291

Unger, S. 2014. Qaqamiiĝux: Traditional foods and recipes from the Aleutian and Pribilof Islands. Anchorage: Aleutian Pribilof Islands Association, Inc.

U.S. Department of Agriculture. 2000. United States standards, grades, and weight classes for shell eggs. AMS 56. Washington, D.C.: USDA, Agricultural Marketing Service, Poultry Programs.

USFWS (U.S. Fish and Wildlife Service). 2009. Alaska seabird conservation plan. Anchorage: USFWS, Migratory Bird Management. 136 p.

———. 2014. Species status assessment report Yellow-billed Loon (*Gavia adamsii*). Fairbanks: USFWS, Fish and Wildlife Field Office.

———. 2015. Waterfowl population status, 2015. Washington, D.C.: USFWS, Migratory Bird Management.

U.S. National Archives and Records Administration. 2015. Code of Federal Regulations. Title 50: Wildlife and Fisheries, Part 92 – Migratory bird subsistence harvest in Alaska. https://ecfr.io/Title-50/pt50.9.92

Usher, P.J. 1970. The Bankslanders: Economy and ecology of a frontier trapping community. PhD thesis, University of British Columbia, Vancouver, Canada.

———. 1976. Evaluating country food in the northern Native economy. Arctic 29(2):105–120. https://doi.org/10.14430/arctic2795

———. 2000. Standard edible weights of harvested species in the Inuvialuit Settlement Region. Report to the Northern Contaminants Program, Department of Indian Affairs and Northern Development.

Usher, P.J., and Wenzel, G. 1987. Native harvest surveys and statistics: A critique of their construction and use. Arctic 40(2):145–160. https://doi.org/10.14430/arctic1759

Watt, B.K., and Merrill, A.L. 1963. Composition of foods: Raw, processed, prepared. Agriculture Handbook No. 8. Washington, D.C.: U.S. Department of Agriculture, Consumer and Food Economics Institute, Agricultural Research Service.

Weeden, R.B. 1979. Relative heart size in Alaskan Tetraonidae. The Auk 96(2):306–318.

Wentworth, C. 2007. Subsistence migratory bird harvest survey, Yukon-Kuskokwim Delta, 2001–2005 with 1985–2005 species tables. Anchorage: U.S. Fish and Wildlife Service, Migratory Birds and State Programs.

White, T.E. 1953. A method of calculating the dietary percentage of various food animals utilized by aboriginal peoples. American Antiquity 18(4):396–398. https://doi.org/10.2307/277116

Whiting, A. 2006. Native Village of Kotzebue harvest survey program 2002 - 2003 - 2004: Results of three consecutive years cooperating with Qikiqtagrugmiut to understand their annual catch of selected fish and wildlife. Kotzebue: Native Village of Kotzebue.

Williams, A.J., Siegfried, W.R., and Cooper, J. 1982. Egg composition and hatchling precocity in seabirds. Ibis 124(4):456–470. https://doi.org/10.1111/j.1474-919X.1982.tb03791.x

Wolfe, R.J. 1981. Norton Sound/Yukon Delta sociocultural systems baseline analysis. Technical Paper No. 59. Anchorage: Alaska Department of Fish and Game, Division of Subsistence.

Wolfe, R.J., Paige, A.W., and Scott, C.L. 1990. The subsistence harvest of migratory birds in Alaska. Technical Paper No. 197. Juneau: Alaska Department of Fish and Game, Division of Subsistence.

Zavaleta, E. 1999. The emergence of waterfowl conservation among Yup'ik hunters in the Yukon-Kuskokwim Delta, Alaska. Human Ecology 27(2):231–266. https://doi.org/10.1023/A:1018773211034