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Distinguishing offshore bird hunting from beach scavenging in archaeological contexts: the value of modern beach surveys

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Abstract
Determining whether seabirds recovered from coastal shell middens were obtained via active hunting or scavenging of beached carcasses is a challenge for archaeologists. Traditional methods have included analyzing skeletal part frequencies, abundance, age profiles, and contextual evidence. The assumption has been made, based on limited biological data, that an assemblage of carcasses scavenged from the beach will have more wing elements, and fewer legs and heads. Few studies, however, have embraced modern beaching data to verify this assumption and assess the potential faunal resources available for scavenging. We analyze the skeletal part representation of modern beached birds observed by the Coastal Observation and Seabird Survey Team (COASST), comparing the COASST dataset to two idealized hypotheses used by archaeologists: the human scavenging hypothesis (wings only are recovered, while heads and legs are absent) and the human hunting hypothesis (all body parts are found in equal proportions). Finally, we apply these results to analysis of the bird remains from the Minard site (45-GH-15), a late Holocene coastal site in Grays Harbor, Washington. We find that contemporary beached bird data are closer to replicating the human hunting hypothesis as compared to the human scavenging hypothesis, as >75% of the 19,599 carcasses in the COASST dataset had a combination of head, wings and legs. This result, and the similarity in taxonomic distribution between our contemporary beached bird data and Minard assemblage, suggests that indigenous peoples may have used scavenging as a viable means of resource acquisition in the past. Use of contemporaneous beached bird data may provide zooarchaeology with a statistically defensible baseline of information on the phenology, abundance and condition of bird carcasses.

Keywords: birds, zooarchaeology; scavenging; beached carcasses; Northwest Coast; skeletal part frequency

1. Introduction

Humans have lived and foraged along coastlines for hundreds of thousands of years (Erlandson 2001; Erlandson and Fitzpatrick 2006; Parkington 2006). Early use of coastal resources likely involved the collection of shellfish and/or scavenging beached carcasses of marine mammals or birds (e.g. Braun et al. 2010; Jerardino and Parkington 1993; Klein et al. 2004; Marean et al. 2007; Stringer et al. 2008). Birds, in particular, may have been quite prevalent on shorelines after large storms or during certain times of year (e.g. Avery and Underhill 1986; Miller 1960; Schäfer 1972). During the early Holocene era—and perhaps as far back as the Pleistocene (Erlandson and Braje 2011:29; Pitblado 2011)—people in many coastal regions developed seaworthy boats allowing efficient hunting and fishing of offshore taxa (e.g. Erlandson et al. 1998; Glørstad 2013; Ward 2010; Whitaker and Byrd 2012). Birds may have been attracted to hunters by "chumming" (DePuydt 1994) and hunted via nets or with bow and arrows. Colony-based hunting may also have occurred during the breeding season.

Distinguishing whether people were actively hunting offshore animals or scavenging beached carcasses can be very challenging for archaeologists and is sometimes a matter of debate (Moss and Losey 2011). Assumptions of scavenging seem logical in early time periods such as the Middle Stone Age in South Africa (e.g. Avery 1981; Avery and Underhill 1986; Plug and Clark 2008), where no evidence for sea-going vessels has been recovered. Evidence of ocean vessel-based hunting may be ambiguous even in more recent times. For example, researchers have often assumed that pelagic birds found in archaeological sites in the southern Washington and Oregon coasts (USA) were scavenged from the beach (e.g. Bovy 2007; Greenspan and Wigen 1991; Losey 2002; Schalk 1993; 2003; Ulrich 2009), in part due to the relative scarcity of ethnographic accounts of offshore hunting (but see Minor 2001; Losey and Yang 2007).

Serjeantson (2009:240) notes that "very few ethnographic accounts make any reference to scavenging and in view of the range of simple as well as complex methods used to catch birds, scavenging may have been a rare strategy of last resort." While indigenous people certainly had many ingenious methods for hunting birds, beached carcasses may also have been opportunistically scavenged for their meat (when fresh), bones (for tools) or feathers (Avery 1981, 2011; Bovy 2002; Eda et al. 2015, Schalk 2003), and may represent the foraging efforts of women and children (Miller 1960:393).

How then can we distinguish the hunting of seabirds from scavenging beached carcasses in the past? Archaeologists have considered this question in other contexts and coastal regions (in addition to the Pacific Northwest), including Peru (deFrance 2005), South Africa (Avery 1981; Avery and Underhill 1986; Plug and Clark 2008), Tasmania (Dunnett 1992), and Japan (Eda et al. 2006, 2015). We briefly summarize previous archaeological attempts to evaluate hunting versus scavenging of birds as a precursor to developing quantitative hypotheses of skeletal part ratios. We then test these models against a large database of modern observations of beached bird carcasses by the Coastal Observation and Seabird Survey Team (COASST). Finally, we evaluate the bird assemblage from the Minard site (45-GH-15) in Washington State in light of these discussions to assess how well archaeologists can determine hunting versus scavenging of bird remains in coastal settings. Our results suggest that use of contemporaneous beached bird survey data may provide a more nuanced baseline than theoretical constructs against which zooarchaeological data can be assessed.

2. Previous Work: Hunting versus Scavenging of Birds

As with mammals (e.g. Hildebrandt and Jones 1992; Klein 1982; Lyman 1989), distinguishing whether people hunted or scavenged birds is a difficult task requiring multiple lines of evidence (Serjeantson 2009:240), including skeletal part frequencies (discussed here), species composition and relative abundance (e.g. Avery 1981:85; Bovy 2007:1093; LeFévre 2010:127; Losey 2002:289), age profiles (e.g. Bovy 2011a; Eda et al. 2015), and contextual information (such as associated faunal remains, canoes or hunting technology). Unfortunately, significant ambiguities exist in the archaeological measures used to evaluate these two strategies. For example, while large numbers of chicks or juvenile birds in an archaeological assemblage may logically be interpreted as active hunting on nesting colonies, young individuals may also dominate beached carcasses at specific times of year, particularly immediately post-breeding when young-of-the-year are especially vulnerable to early fall storms (Harrison 1990:103-104).

In her study of the Late Pleistocene site of Quebrada Tacahuay in Southern Peru, deFrance (2005) presented a compelling argument for active hunting of a seabird assemblage by combining skeletal representation and age of individuals with taphonomic and contextual data. Her interpretations were also aided by great preservation and a unique context (a relatively short term occupation capped by a debris flow deposit, possibly resulting from an El Niño event). deFrance (2005:1134) provides a useful table of archaeological correlates for a number of different human behaviors, such as scavenging of dead birds and the hunting of stressed birds versus healthy birds.

Analyzing skeletal part frequencies is one of the more common methods of determining whether faunal assemblages result from hunting or scavenging. Numerous researchers, including biologists, paleontologists, and archaeologists, have noted that wing and pectoral elements may be more common on beached carcasses than other body parts, such as the head and legs (e.g. Bovy 2002; deFrance 2005; Eda et al. 2015; Emslie et al. 1996; Ericson 1987; Schäfer 1972; Schalk 2003; see Lyman 1994 and Serjeantson 2009 for detailed summaries of these studies). In one commonly cited report of observations on a mallard duck disintegration, Schäfer (1972:48) describes the disarticulation of birds that die at sea: “As the disintegrating body is repeatedly lifted and dropped by water, the hind limbs finally separate from the trunk, the pelvis from the lumbar vertebrae, and are transported away. Wings, coracoid, clavicle, and sternum continue to hold together as a unit for a long time” and are most likely to wash ashore. Scavenging both at sea and on shore may exacerbate the tendency for wings/pectoral elements to survive relative to other body parts (e.g. Oliver and Graham 1994).

Based on these studies, archaeologists have assumed that if bones of the wing and pectoral region heavily dominate seabird assemblages to the exclusion of other elements at a site, they were likely scavenged from the beach (Bovy 2002, 2012; deFrance 2005; Lyman 2003; Ulrich 2009). If more equally distributed skeletal element proportions are found (seen by the inclusion of legs, skull, and pelvis in addition to wings), the birds were more likely actively hunted from breeding colonies or the open water.

3. Research Questions & Hypotheses

In order to make arguments about the hunting or scavenging of birds more rigorous, we examine skeletal part frequencies in light of modern surveys of beached carcasses along the Pacific Northwest Coast by the Coastal Observation and Seabird Survey Team. Our goals are to assess the validity of the human scavenging hypothesis and explore the potential of using data on modern beached carcasses to aid archaeological interpretations. Specifically, we address four main questions: (1) What birds are most frequently beached today? (2) How complete are modern beached carcasses? (3) How do the COASST data compare to the human scavenging and human hunting hypotheses? (4) Were the seabirds at the Minard site hunted or scavenged?

3.1 What birds are most frequently beached today?

The large COASST dataset allows for detailed examination of the bird taxa that are most commonly recovered on beaches along the southern Washington and Oregon coasts. Although the relative abundance of birds may have varied through time, knowing which species are commonly beached today, and during what season and point in their life cycle this occurs, may help us better understand the resources available to past occupants of the coast.

3.2 How complete are modern beached carcasses?

We compare the COASST data to the skeletal part frequencies expected in complete birds to assess the overall completeness of the beached carcasses, and examine trends between different taxonomic groups.

3.3 *How do the COASST data compare to the human scavenging and human hunting hypotheses?*

Assuming that the COASST dataset is a proxy for what might have been found on the beach by indigenous peoples, we evaluate whether skeletal part frequencies derived from the COASST dataset conform to the "human scavenging hypothesis" outlined above (Section 2): are modern beached carcasses primarily comprised of wings? For the sake of this analysis, we also compare the COASST data to a "human hunting hypothesis," which predicts that relatively whole carcasses are returned to sites, and thus all body parts should be found in equal proportions. Our quantitative analyses are primarily focused on a comparison of idealized hypotheses versus modern beached bird data:

- Human scavenging hypothesis: *only* wings would be found by human scavengers and returned to sites.
- Human hunting hypothesis: the frequency of wings, legs, and heads returned to sites would be equal.

However, because there may be additional factors affecting which skeletal elements end up at a site, including differential transport, preservation, and/or processing/ cooking techniques (Bovy 2002, 2012; Lyman 1994; Serjeantson 2009), we also discuss these potential biases.

3.4 Were the seabirds at the Minard site hunted or scavenged?

Bovy (2005, 2007) previously analyzed the birds from the Minard site on the southern Washington coast and hypothesized that some of the seabird remains from the site may have been collected from the beach. We compare the species composition at Minard to that of the COASST assemblage to help assess this hypothesis. The northern spit of Grays Harbor, where the Minard site is located (Fig.1), has the longest-running beached carcass monthly monitoring dataset of any in the COASST sample, with systematic observations from multiple beaches dating back to 2000. To further evaluate how the prehistoric assemblage may have been created, we focus on the most abundant species at Minard, and statistically compare these data to three skeletal part distributions: the idealized scavenging hypothesis (wings only), the COASST dataset (representing a more realistic scavenging hypothesis in terms of expected skeletal frequencies) and the expected frequencies in a complete bird (representing the hunting hypothesis).

4. Materials/ Methods

4.1 The Coastal Observation and Seabird Survey Team (COASST)

COASST is an independently funded, citizen science organization housed at the University of Washington that is dedicated to monitoring marine ecosystem health through the collection of standardized, effort-controlled, and verified data on the identity, condition and abundance of beached birds. In a single 5-hour expert-led session, coastal community members are trained in survey techniques and in species identification using a dichotomous key to beached birds (Hass and Parrish 2000). Data also include morphometrics (wing, culmen, and tarsus), foot type, carcass condition and presence of body parts. All species identifications are independently confirmed by staff experts using raw data (measurements, foot type, plumage characteristics) and photographs collected by COASST participants. Because all carcasses are marked, double counting of carcasses found on previous surveys is prevented. Following training, pairs or larger teams of participants select and monitor specific sites on a monthly basis. At present, COASST monitors approximately 450 sites from Mendocino, California to Kotzebue, Alaska and west to Adak, Alaska. Since the program began in 2000, observations have been made on more than 25,000-beached carcasses along the southern Washington and Oregon coasts. Thus the database that COASST has created represents a substantial resource that can augment archaeological observations about the role of human scavenging of beached carcasses along the Northwest coast.

We compiled data on all “finds,” or the first time a COASST participant encountered a carcass, to generate comparative representations for this project; only carcasses identified to species (~92% of the entire COASST dataset) are used. We chose to focus on data from the southern Washington and Oregon coasts (hereinafter referred to as the Northwest Coast or NWC dataset; Fig. 1) because of the ongoing debate in this region about whether native peoples hunted offshore (Minor 2001; Losey and Yang 2007). The Minard site is found within the Washington “South Coast” region of the COASST program, and specifically within the Grays Harbor area. Therefore, we also created a subset of the NWC dataset targeting a 10-kilometer radius around Minard (between 6 and 14 beaches surveyed annually by COASST; hereinafter referred to as the Grays Harbor or GH dataset). We compressed all taxonomic information into frequency distributions of all carcasses identified (and verified) to species, regardless of date, season or year. The NWC dataset was sampled from 2005 through 2013, whereas the GH dataset was assembled from 2000 through 2013. The difference in temporal coverage reflects more recent expansion of the program into southern Oregon such that data prior to 2005 were unevenly distributed seasonally and sparse spatially in this part of the state.

In this study, we used five categories of body part presence recorded by data collectors (shown in Fig. 2):

1. “Intact”: a carcass was designated as intact if all major parts of the body are present (head, breast, wings, and legs) *and* the carcass was devoid of obvious wounds. In general, “intact” signifies that the carcass is relatively fresh and that no scavenging has occurred.
2. “Head”: presence/absence.
3. “Legs”: presence recorded if *at least* one leg was present.
4. “Wings”: presence recorded if *at least* one wing was present.
5. “Wings only”: presence recorded if *only* wings (one or both) were present.

According to the COASST protocol, a carcass can only be counted as a “COASST bird” if one of the three morphometric measurements (culmen, tarsus, wing chord) can be reliably made; thus volunteers will never record truly disarticulated or rotting carcasses, or bones only.

4.2 The Minard Site

The Minard site is a late prehistoric shell midden, which was excavated by Washington State University students in 1969 and 1970 under the direction of Tom Roll (Roll 1974). The site, located approximately 640 m east of the Pacific shore (prior to historic landscape changes), was continuously occupied from approximately AD 1000-1600, with some use after European contact (Bovy 2007). The midden was excavated using 20-centimeter arbitrary levels and screened through 0.64 cm (1/4”) screens. All vertebrate remains collected are curated at the Museum of Anthropology, Washington State University. Analysis of the Minard bird bone assemblage was initially undertaken to help assess the role of climate change, seasonality, tectonic activity, and human impacts on bird populations during the late Holocene.

Bovy completed identification of the large (n=3498) and diverse (at least 67 taxa) bird assemblage from Minard using the extensive zoological reference collection at the Burke Museum of Natural History and Culture. She identified all bone fragments (whole elements, articular ends, shafts), excluding vertebrae and ribs, to element and taxon, if possible. Bovy attempted to refit specimens from the same level bags, and refit specimens were counted only once. Measurements were used to distinguish closely related species, such as Surf (*Melanitta perspicillata*) and White-winged Scoters (*Melanitta fusca*), and Sooty (*Puffinus griseus*) and Short-tailed Shearwaters (*Puffinus tenuirostris*; Bovy 2005).

A number of quantitative measures are used to describe the most abundant taxa (NISP> 100) in the Minard assemblage, including Number of Identified Specimens (NISP), Minimum Number of Elements (MNE), and Minimum Number of Individuals (MNI). NISP is correlated with both MNE and MNI and is simpler to calculate (Grayson 1984; Grayson and Frey 2004). However, MNE values are also provided due to differential fragmentation of certain elements in the assemblage; for example, only 1% (2 out of 174) of shearwater humeri specimens in the assemblage are complete, while 78% (80 out of 102) shearwater femora are complete. Bovy calculated the MNE values using recorded observations on the side, segment (distal, proximal, shaft), portion (landmarks), and estimated completeness (%) for each specimen. Given that the collection had already been returned, she was not able to directly check for overlap on broken specimens; the MNE values are therefore conservative estimates given that more overlap may have existed than was captured in her coding system for landmarks. In addition, we calculated MNE values for the entire assemblage, rather than by the arbitrary 20-centimeter excavation levels, to avoid problems with aggregation (Grayson 1984).

4.3 Comparing the two datasets

It is challenging to compare modern survey data, which record presence/absence data for numerous body parts on individual bird carcasses, to archaeological bird assemblages, which often contain isolated skeletal elements from many different individuals and accumulate over larger periods of time (Avery and Underhill 1986:357). We adapt a standardized anatomical region approach developed by Stiner (1994:240, Table 9.4), who compared ungulate bones from Mousterian cave sites to assemblages created by modern hyenas. Briefly, this method tallies individual elements within an anatomical region, allowing the comparison of expected frequencies among regions. Stiner identified nine anatomical regions in her study; however, we are only able to compare three regions (Head, Wings, Legs), given how the COASST data were collected. Expected MNE values for each anatomical region are calculated as follows: Head (½ mandible= 2; ½ skull= 2; Total Head= 4), Wings (humerus= 2; radius= 2; ulna= 2; carpometacarpus= 2; Total Wing= 8), and Legs (femur= 2; tibiotarsus= 2; tarsometatarsus= 2; Total Leg= 6). Pectoral elements and the pelvis/synsacrum are excluded because their presence was not recorded for the beached carcasses. The rear phalanges, distal wing digits, and carpals are excluded because they are less likely to be recovered in 0.64 cm mesh (Bovy 2011b), and were not always identified to species

(Bovy 2005). We use the ratio of expected MNE values following Stiner (1994) in two ways. First, we generate ratios representing the human scavenging and human hunting hypotheses and test these against the Minard MNE values. Second, we standardize the Minard MNE values according to these ratios, which allows direct comparison to the COASST datasets.

5. Results

5.1 Species frequency distributions within the COASST datasets

The NWC dataset tallied 21,280 birds over the past decade; 19,750 were identified to species (2005-2013; Supplementary Table 1). COASST participants identified the carcasses of 124 species, encompassing seabirds, waterfowl, shorebirds, and terrestrial birds. We classified all species into larger taxonomic groups (subfamily, family, order), and removed any group with fewer than 100 specimens from further analysis to avoid overemphasizing rare species; these included hawks, falcons, herons, owls, turkeys, pheasants, coots, chickens, boobies and passerines. The remaining assemblage (19,599 specimens) contained 90 species and one species group – large immature gulls (*Larus spp.*). Of these, the majority were Alcids (auks; 42.7%), especially Common Murres (*Uria aalge*; n = 6,125) and Rhinoceros Auklets (*Cerorhinca monocerata*; n = 1,449). Procellariiformes (tubenoses) comprised an additional 27.9% of the assemblage, including Northern Fulmars (*Fulmaris glacialis*; n = 4,281) and Sooty Shearwaters (*Puffinus griseus*; n = 855), while albatrosses (*Phoebastria spp*) and storm-petrels (*Oceanodroma spp.*) collectively comprised only 1.1% of the total. The third most abundant taxon was the Laridae (14.7%), including a variety of gulls, kittiwakes and terns, and the multi-species category large immature gulls.

Within the more spatially proscribed GH dataset, COASST participants identified 4,738 specimens to one of 86 species (Supplementary Table 2). Once rare species and terrestrial species had been removed (see procedure above), 4,704 specimens from 12 taxon groups remained, comprising 69 species. The frequency distribution of species largely mirrored the NWC dataset (Fig. 3), with minor differences: Northern Fulmars, large immature gulls and Sooty Shearwaters were relatively more frequent, and Common Murres, Rhinoceros Auklets, and the cormorants were comparatively under-represented. Of the species found at Minard (see 5.4) and prevalent in the COASST datasets, only Common Murres occurred at statistically different frequencies across the NWC and GH datasets (Fig. 3).

5.2 Skeletal part distributions within the COASST datasets

Summed across all species in the NWC dataset, wings were the most observed body part (Table 1). Almost all (98.2%) of the observed carcasses were found with at least one wing. However, only 10.4% of carcasses were found as *only* wings, suggesting that most carcasses survive with multiple skeletal elements. In fact, 78.3% of identified carcasses were found with heads, and 85.1% had one or more legs. Intact birds, those carcasses without any sign of trauma, predation or scavenging, represented a minority of the dataset (16.6%).

The relative abundance of major skeletal elements was a function of taxonomic group (Fig. 4). We compared group-specific frequencies of body part occurrence against the global (N = 19,599 carcasses) distribution. Because percentages were derived from the cumulative dataset, rendering statistical measures of variability moot, we used a threshold of 10% difference as a threshold over (under) which we reasoned anomalies may be indicative of a larger and/or persistent pattern. Shorebirds, gulls and especially ducks were far more likely to be discovered as “wings only” relative to the overall average. Almost 40% of the ducks, including 78.8% of Green-winged Teal (*Anas carolinensis*), 54% of Bufflehead (*Bucephala albeola*), and 42% of Northern Pintail (*Anas acuta*)—the three most abundant small ducks in the dataset (Supplemental Table 1)—were found as "wings only." By contrast, heads and legs of these taxonomic groups were comparatively less likely to be discovered.

Paradoxically, shorebirds were also slightly more likely to be found as intact carcasses. This trend, however, is rooted in a single mass mortality event of post-breeding, migrating Red Phalaropes (*Phalaropus fulicarius*) in 2005 when birds were literally alighting on the beach exhausted and dying during COASST surveys. In this single event, half (n = 33) of all phalaropes in the dataset were found. Podicipeds were more likely than average to be found with heads. This trend is artificially inflated as identification of Western (*Aechmophorus occidentalis*) versus Clark's (*A. clarkii*) Grebes by COASST volunteers necessitates the presence of a head (i.e., whether the eye is contained in the dark or light facial plumage). Thus, headless large grebes cannot be identified to species and are not represented in the dataset.

To statistically compare the patterns of body part occurrence between the NWC and GH datasets, we narrowed our focus to the suite of species that were prevalent in the Minard dataset (Table 2), with one exception. The albatross bones at Minard most closely resemble the Short-tailed Albatross (*Phoebastria albatrus*) in size (Bovy 2005:324). As this species is extremely rare today and COASST participants did not record any finds of this species, we substituted both Black-footed (*P. nigripes*) and Laysan Albatross (*P. immutabilis*) for comparison. Across all taxa, only Common Murres had statistically different skeletal part distributions (Table 2). We therefore use the NWC dataset as representative of the finer scale Gray's Harbor area (for both species and carcass condition), but also include the GH murre data in subsequent analyses.

5.3 *Comparing COASST data to the human scavenging and human hunting hypotheses*

Focusing on the major species occurring at Minard and present in the COASST dataset, only a minority were found as either intact or "wings only" by COASST participants (Table 3). Most carcasses were discovered with multiple skeletal elements, albeit rarely without any signs of predation or scavenging (i.e., intact). Contrary to the human scavenging hypothesis, however, only the scoters had higher "wings only" counts. All other species were indistinguishable (albatrosses) or had intact carcass counts 2-3 times as large as "wings only" counts. Common Murres in the Gray's Harbor region actually had intact counts that were more than an order of magnitude higher (17x) than "wings only" counts.

A strict interpretation of the human scavenging hypothesis predicts that only wings would wash ashore. The COASST dataset clearly belies this pattern (Fig. 5A-C and inset). To statistically compare the COASST dataset to the human scavenging hypothesis, we created a "wings only" distribution based on the total number of carcasses found within species, and added a minimal count value to the head and leg cells (n = 5) to facilitate the use of chi-square contingency tables. All species were significantly different from a "wings only" distribution (Table 3), with fairly consistent percent deviations of head (+35-40%) and legs (+35-41%). To compare the COASST dataset to the human hunting hypothesis, we created an ideal distribution of body parts (head, wings, legs), scaled to the maximum count (always wings) within each species (e.g., for Surf Scoters, the HH distribution would be head=156, wings=156, legs=156; Table 3; Fig. 5A-C and inset). The majority of the principal species examined have "on-the-beach" (i.e. COASST) skeletal element distributions that are significantly divergent from those expected in a complete bird (the strict interpretation of the hunting hypothesis). Only albatrosses, White-winged Scoters, and Common Murres (in the restricted Gray's Harbor dataset) are indistinguishable from hunting, and scoters marginally so. For species with significant differences in skeletal part distribution, heads were less prevalent than predicted by the hunting hypothesis and/or wings were more prevalent than expected, with percent deviations ranging upwards of 20% (e.g. Cassin's Auklet heads).

In sum, the COASST data are closer to replicating an equal occurrence of body parts as compared to only wings available. In three cases (White-winged Scoters, Albatrosses, and Common Murre at Gray's Harbor sites), there is no statistical difference between the COASST data and an equal availability of body parts. However, in all cases there is a highly significant (and absolutely larger percent deviation) difference between the COASST data and the prediction that only wings would be available (Table 3).

5.4 *The Minard Site: Hunting or Scavenging?*

Although the Minard assemblage includes at least 45 marine bird species (SupplementaryTable 3), only a few species predominate: Surf Scoter, White-winged Scoter, Short-tailed Albatross, Northern Fulmar, Sooty Shearwater, Cassin's Auklet (*Ptychoramphus aleuticus*), and Common Murre. Of these, five are also abundant in the COASST datasets (Fig. 3), including the top two species found by COASST participants, murres and fulmars.

The skeletal part frequency (NISP, MNE, MNI) for the seven most abundant taxa at Minard (NISP>100) indicate a high degree of fragmentation (Table 4), seen in the discrepancy between the NISP and MNE values, particularly in long and thin elements such as the humerus, ulna, radius and tibiotarsus. The MNI values take both portion and side (left or right) into account; for example, the MNI of 65 for Cassin's Auklet was calculated based on the number of proximal right ulnae.

For all taxa at Minard except the Sooty Shearwater, wings were the most abundant body part (Fig. 5D-F). To compare the Minard data to the human scavenging hypothesis, we created a distribution based on the maximum MNE within each taxon, and maintained otherwise zero cells (i.e., head, legs) at n = 5 or an exact numeric match in cases where the relevant MNE was <5. This made the comparison conservative relative to the strict human scavenging hypothesis, but preserved the integrity of the contingency table comparison. Although several species exhibited highly significant statistical differences from the scavenging hypothesis, Northern Fulmars were only marginally significantly different and albatrosses were indistinguishable (Table 5).

To compare the Minard findings to the human hunting hypothesis, we created skeletal element distributions based on the standardized anatomical region ratios scaled to the maximum MNE count within each species (e.g., for Surf Scoters, the scaled distribution was head= 31, wing= 62, leg= 47). The equal skeletal element distribution was significantly different from the Minard dataset (Table 5) in all cases except albatross. Far fewer cranial elements were found than expected (percent deviation ranged from 38-94%). Legs were also somewhat less represented than expected.

The COASST dataset represents an alternate (third) base comparison for the human scavenging hypothesis, as it may be the closest to what would have been available to human foragers along the Northwest Coast. Anatomical part comparisons between the COASST dataset and the Minard archaeological data suggest that in all cases, COASST and Minard distributions of body parts are significantly different (Fig. 5, Table 5). Excluding albatrosses (for which low counts at Minard rendered statistical power insufficient), the percent deviation in cranial elements in the Minard data were 71-95% lower than expected. In fact, four of the seven species pulled out for more detailed study had actual (i.e. Minard) versus expected (i.e. COASST) head counts that were over 90% lower.

In sum, the Minard dataset does not easily match any of the three potential comparisons (Table 5). Albatrosses (not shown) were not statistically different from any hypothesis, although this was most probably a function of low counts in the Minard dataset. White-winged scoters were significantly and equally different from all three hypotheses. Of the remaining species, chi-square minima indicate that Surf Scoters, Northern Fulmars and Cassin's Auklets were relatively more similar to the human scavenging hypothesis, while Sooty Shearwaters and Common Murres were relatively more similar to the human hunting hypothesis. None of the species were most similar to the COASST dataset.

6. Discussion

The COASST data demonstrate that contemporary beached bird carcasses are closer to replicating the human hunting hypothesis (equal body part representation) than the human scavenging hypothesis (wings only), throwing into doubt the use of theoretical constructs of body part ratios (Bovy 2012, Lyman 2003; Ulrich 2009) as indicators of the foraging behaviors of indigenous peoples. For all species examined, there was a highly significant difference between the COASST data and the prediction that only wings would be available. Although there were few completely intact birds in the COASST dataset (7-33%, depending on species and location), most (>75%) carcasses had a combination of head, wings and legs (Fig. 4).

An important caveat to our analysis is that the COASST data does not speak to the relative presence of the pectoral girdle. Thus the presence of wings on a carcass does not necessarily indicate the availability of breast musculature; and the condition "wings only" is indicative of this absence. Because the presence of an intact breast was not uniformly recorded by COASST participants, we did not include these data in our analysis; however, these percentages are, by definition, additional to the most conservative COASST carcass condition category "intact." Globally across the dataset, 16.6% of the carcasses were intact, or 3,261 birds found. Given that the COASST data represents a small fraction of what washes ashore (because survey effort represents a fraction of all kilometers of shoreline and a very small fraction of all days), this would translate into tens of thousands of such carcasses available to coastal residents assuming the contemporaneous carcass-fall is not larger than it was historically.

Many factors may affect the integrity of beached carcasses, including the cause of death (predation, storm, starvation, old age), the length of time a bird floats at sea before being beached, ocean temperatures, the distance traveled due to wind drift and oceanic currents, whether or not the carcass is scavenged, the species, and the age and/or size of the bird (Bibby and Lloyd 1977; Wiese and Jones 2001). Various experiments, including tethering tests (Ford et al. 1991) and drifter studies (e.g. Camphuysen 1989), have tested the effects of the ocean on carcass sinking times and recovery on beaches; these factors impact the number and preservation of birds that wash up onshore. In fact, some of these factors may have been at play in the COASST dataset, as skeletal part frequencies were species specific (Fig. 4). For instance, the relative lack of heads and legs in small-bodied birds (shorebirds, small ducks) combined with a higher prevalence of "wings-only" carcasses suggests raptor predation. Throughout coastal regions including along the NWC COASST region, Peregrine Falcons, *Falco peregrinus*, are known to prey preferentially on small seabirds, shorebirds and waterfowl (Garcia et al. 2014; Olsen et al. 2008), often leaving only wings at beach kill sites (Paine et al. 1990). Clearly, archaeologists need to consider skeletal part patterns for individual taxa, not all birds together, when attempting to assess whether an assemblage was scavenged, and ideally with relatively large sample sizes (e.g. hundreds).

Comparison of the COASST and Minard datasets reveals a relative lack of skulls and mandibles for all species at Minard (Fig. 5), which may result from a number of factors such as screen size, bone density, preservation, fragmentation, and identification bias. Additionally, cultural factors (harvesting, processing, transport, cooking) and taphonomic agents (soil acidity, bioturbation, weathering) impact the final archaeological assemblage unearthed at this and other sites. Despite this difference, scavenging beached bird carcasses may have been one of the many subsistence strategies used by Minard site occupants. While native peoples in the region were certainly capable of hunting birds effectively (e.g. Elmendorf 1960; Olson 1936), there are several reasons to believe that scavenged carcasses were also obtained at this particular site. First, the most abundant species recovered from Minard include many of the most frequently beached carcasses in the COASST dataset. All of the top four marine bird species recovered at Minard – Sooty Shearwaters, Cassin's Auklets, Common Murres and Northern Fulmars (using NISP, Table 4, Supplemental Table 3) – were among the top 10 species beached along the Northwest Coast region in the contemporary dataset (Fig. 3). In fact, the overlap between Minard species and COASST species breaks down in only three cases: relative absence of Rhinoceros Auklets and cormorants in the Minard dataset as compared to COASST, and a significantly higher occurrence of Short-tailed Albatross in the Minard versus contemporary data. The latter pattern is easily explained as this species was driven to the brink of extinction during the early 1900s and only a few thousand individuals comprise the current world's population (Hasegawa and DeGange 1982). The lack of cormorants and Rhinoceros Auklets is more difficult to explain, although the former harbor extremely high parasite loads (Dziekonska-Rynko and Dzika 2011; El-Dakhly et al. 2012) and may have been avoided by Minard occupants.

Second, the COASST and Minard species distributions include species that would have required varying degrees of effort to hunt in large numbers. Common Murres and large-bodied gulls (Glaucous-winged, Western) are ubiquitous local breeders that frequent nearshore waters throughout the Northwest Coast region (McGowan et al. 2013; Zamon et al. 2014). These species may have been equally available by scavenging or hunting (e.g., on the breeding colonies). By contrast, both Northern Fulmars and Sooty Shearwaters are pelagic migrants to the Northwest Coast region. These species, although extremely numerous within the California Current large marine ecosystem (Adams et al. 2012; McGowan et al. 2013), are principally found in offshore waters at the edge of and off the coastal shelf (Hatch et al. 2010). Hunting would have required both boats capable of navigating offshore (5-50 miles offshore) waters and systems for attracting these birds within range. On the other hand, not only would scavenging have been comparatively simple, both of these species occur at predictable times of year (fall and spring-summer, respectively; COASST unpub. data). In fact, the Minard site is located in an area – the Columbia River Plume - that has been shown to be prolific for both local and migrant marine bird species (Kudela et al. 2010; Zamon et al. 2014), with oceanographic forcing bringing large amounts of flotsam, including carcasses, to shore especially during fall-winter-early spring months (Hickey and Banas 2003; Parrish et al. 2007). Within the Gray's Harbor region (Fig. 1), hundreds of carcasses per year have been observed by COASST participants, which scales to thousands of carcasses available annually within 10 kilometers of the Minard site (Parrish unpub. data).

Finally, up to hundreds of carcasses per kilometer may have washed up daily during less frequent massive mortality events known as "wrecks." Wrecks of many different types of marine top predators, including seabirds, have been noted in recent years (Materna et al. 2011). Species-specific wrecks are associated with severe cold weather (Mallory et al. 2009; Schreiber 2001:204), winter storms (Camphuysen et al. 1999, Philipson 2014), and more broadly with changing climate conditions (Parrish et al. 2007). Five of the most abundant species recovered at Minard, including both pelagic migrants, were involved in at least one wreck during the NWC COASST sampling interval: Surf Scoter, Cassin's Auklet, Sooty Shearwater, Northern Fulmar and Common Murre (Parrish et al. 2007, COASST unpub. data). While scavenged carcasses are often assumed to be primarily useful as a source of feathers or bones for tools (Eda et al. 2015; Lyman 2003; Schalk 2003), wrecks may have also been valuable sources of meat. Common to all monitored shorelines, wrecks are most predictable during the post-breeding and winter months when relatively poor body condition and degrading environmental conditions push many individuals beyond their capabilities (Fort and Gremillet 2009). Of import to Minard occupants, wrecks typically deliver large numbers of intact, relatively fresh carcasses, occasionally numbering in the tens of thousands (Camphuysen et al. 1999; Harris and Wanless 1996; Piatt and VanPelt 1997). During such events, moribund specimens are not uncommon (Work and Rameyer 1999), providing scavengers with a ready supply of fresh meat.

7. Conclusions and Future Research

The COASST data presented here strongly support a rejection of at least the idealized version of the human scavenging hypothesis based on a theoretical distribution of the skeletal part frequencies of drift carcasses. The results from this study also reinforce Serjeantson's (2009:240) assertion that "the survival of the different skeletal elements is affected by so many different processes [e.g. bone density, human butchery, preservation] that *on its own* it is an unreliable guide to the origin of a deposit" (emphasis in original). Similarities between the Minard and COASST datasets suggest that use of contemporaneous beached bird data may provide zooarchaeology with a statistically defensible baseline of information on the phenology, abundance, and condition of bird carcasses. We suggest that archaeologists should redefine the material expectations of scavenging versus hunting of marine birds, using multiple lines of evidence including but not limited to: consideration of the natural histories and life histories of the birds found at archeological sites (e.g. migration patterns, breeding locations, seasonal abundance, habitat tendencies, molt cycles); the species distribution and abundance, and species-specific body part distribution in spatially coincident contemporaneous beached bird datasets; and the relative incidence of mass mortality events or wrecks in these same areas.

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Table 1: Skeletal part frequencies of the most common taxonomic groups found in the COASST datasets.[a]

Taxonomic Name	Common Name	Intact	Head	Legs	Wings	Wings Only	Total Carcasses
Anatidae - Goose	geese	0.12	0.80	0.84	0.99	0.12	103
							29
Anatidae - Duck	dabbling ducks,	0.10	0.47	0.59	0.99	0.39	472
	diving ducks	0.17	0.48	0.59	1.00	0.38	203
Gaviidae	loons	0.28	0.87	0.93	1.00	0.05	233
		0.41	0.94	0.97	1.00	0.02	64
Podicipedae	grebes	0.29	0.97	0.94	0.99	0	606
		0.40	0.95	0.93	0.98	0.01	185
Diomedeidae	albatrosses	0.07	0.81	0.81	0.95	0.11	95
							26
Procellariidae	fulmar, shearwaters,	0.17	0.83	0.87	0.98	0.09	5259
	petrels	0.41	0.89	0.91	0.98	0.06	1666
Hydrobatidae	storm-petrels	0.24	0.68	0.79	0.98	0.18	8370
							27
Phalacrocoracidae	cormorants	0.19	0.87	0.90	0.98	0.04	1065
		0.35	0.93	0.90	0.98	0.02	125
Pelecanidae	pelicans	0.15	0.82	0.87	0.93	0.06	246
							40
Charadriiformes	shorebirds	0.27	0.60	0.77	0.99	0.22	146
		0.21	0.46	0.69	0.96	0.30	67
Alcidae	murre, guillemot, puffins,	0.19	0.81	0.91	0.99	0.05	8370
	auklets, murrelets	0.33	0.90	0.95	0.99	0.02	1434
Laridae	gulls, kittiwakes, terns	0.06	0.60	0.63	0.98	0.29	2887
		0.07	0.66	0.64	0.99	0.26	838
All Species		0.166	0.783	0.851	0.982	0.104	19599
		0.303	0.830	0.856	0.985	0.101	4704

[a]Data are proportion of total carcasses found with the relevant body part, and are not exclusive (e.g., an intact carcass would be represented in all categories except "wings only"). For each taxonomic group, the top line is the NWC dataset and the second line is the GH dataset. Frequencies are reported for all groups with count thresholds of N>100 (NWC; excepting albatrosses) and N>50 (GH).

Table 2. Skeletal part comparison of the seven most prevalent taxa in the Minard data.[a]

Common Name	Intact	Head	Legs	Wings	Wings Only	Total Carcasses	χ^2	p
Surf Scoter	0.153	0.548	0.669	0.994	0.287	157	0.21	0.900
Melanitta perspicillata	0.264	0.540	0.724	0.989	0.241	87		
White-winged Scoter	0.114	0.667	0.727	0.992	0.242	132	0.08	0.961
Melanitta fusca	0.195	0.707	0.707	1.000	0.220	41		
Albatrosses	0.074	0.811	0.811	0.947	0.105	95	0.01	0.995
Phoebastria spp.	0.154	0.846	0.846	0.962	0.115	26		
Northern Fulmar	0.179	0.842	0.871	0.98	0.088	4281	2.52	0.284
Fulmarus glacialis	0.457	0.905	0.910	0.980	0.059	1327		
Sooty Shearwater	0.130	0.780	0.881	0.977	0.078	855	0.58	0.748
Puffinus griseus	0.223	0.838	0.890	0.977	0.074	309		
Cassin's Auklet	0.244	0.556	0.910	1.000	0.087	356	0.29	0.865
Ptychoramphus aleuticus	0.326	0.616	0.930	1.000	0.070	86		
Common Murre	0.175	0.810	0.915	0.984	0.054	6125	**6.43**	**0.040**
Uria aalge	0.335	0.918	0.952	0.991	0.019	1093		

[a]Data are as in Table 1. Chi-square contingency table results comparing counts of heads, wings, and legs are reported, with significant differences highlighted in bold print (df=2 in all cases). Albatrosses include both Black-footed and Laysan's.

Table 3. Comparison of the COASST dataset versus the human scavenging (HS) and human hunting (HH) hypotheses.[a]

Common Name	Intact	Head	Legs	Wings	Wings Only	Total Finds	HS χ^2, p	HH χ^2, p
Surf Scoter	24	86	105	156	45	157	113.95 <0.0001	12.53 0.0019
White-winged Scoter	15	88	96	131	45	132	105.73 <0.0001	**5.31** **0.0703**
Albatrosses	7	77	77	90	10	95	84.64 0.0109	**0.71** **0.7012**
Northern Fulmar	765	3604	3730	4197	376	4281	5049.17 <0.0001	26.02 <0.0001
Sooty Shearwater	111	667	753	835	67	855	962.24 <0.0001	9.92 0.0070
Cassin's Auklet	87	198	324	356	31	356	339.60 <0.0001	28.29 <0.0001
Common Murre	1071	4961	5605	6028	329	6125	7261.62 <0.0001	55.07 <0.0001
Common Murre - GH	366	1003	1040	1083	21	1093	1355.75 <0.0001	**1.57** **0.4561**

[a]Data are counts of carcasses with the relevant condition, where the maximum count is wings (in all cases). HS comparison: counts of head, legs and wings versus a manufactured “wings only” distribution scaled to actual total finds. HH comparison: counts of head, legs and wings versus a manufactured equal distribution scaled to the maximum actual count. Comparisons indicating no difference between the COASST dataset and the hypothesis are in bold (df=2 in all cases).

Table 4. Skeletal part frequency for the seven most abundant species recovered at Minard (NISP, MNE, MNI).[a]

	SUSC			WWSC			STAL			NOFU			SOSH			COMU			CAAU		
	NISP	MNE	MNI	NISP	MNE	MNI	NISP	MNE	MNI	NISP	MNE	MNI	NISP	MNE	MNI	NISP	MNE	MNI	NISP	MNE	MNI
Axial Skeleton[b]																					
skull				1	1	1	1	1	1	1	1	1	5	4	4	2	1	1	4	3	3
quadrate							3	3	3							1	1	1			
mandible				5	4	4	4	2	1				3	3	3	7	4	2			
pelvis/ synsacrum	n/a			n/a			5	3	2	7	4	4	64	36	36	21	17	17	24	19	19
Total Axial	0	0	0	6	5		13	9		8	5		72	43		31	23		28	22	
Pectoral Girdle																					
sternum	3	2	2	9	7	7	1	1	1	2	2	1	25	20	20	14	9	9	2	2	2
furcula	1	1	1	7	5	5	3	3	3	2	2	2	13	8	8	10	6	6	1	1	1
coracoid	24	23	13	33	30	16	4	3	2	4	4	2	70	70	36	30	30	30	40	39	21
scapula	5	5	4	8	8	4	1	1	1	2	2	1	27	27	18	13	13	8	1	1	1
Total Pectoral	33	31		57	50		9	8		10	10		135	125		67	58		44	43	
Wing																					
humerus	26	18	9	42	32	17	15	11	6	23	12	6	174	101	62	54	35	20	147	91	53
radius	13	9	6	22	12	6	2	2	1	3	2	1	58	43	22	35	31	20	11	10	5
ulna	21	18	11	32	22	11	13	8	5	17	12	8	86	68	37	62	57	30	150	119	65
carpometacarpus	20	17	10	22	20	10	5	4	3	14	12	6	60	57	35	50	46	24	45	44	24
pollex	n/a			n/a			2	2	1	n/a			n/a								
digit 2, phalanx 1	n/a			n/a			9	8	4	n/a			n/a			4	4	3			
digit 2, phalanx 2	n/a			n/a			1	1	1	n/a			n/a			1	1				
Total Wing	80	62		118	86		47	36		57	38		378	269		206	174		353	264	
Leg																					
femur	21	19	10	27	22	11	7	7	5	7	6	6	102	101	52	48	48	26	57	55	32
tibiotarsus	6	5	4	31	15	8	8	6	3	7	5	4	103	78	40	50	34	21	30	22	12
fibula																3	3	2			
tarsometatarsus	7	7	5	16	12	6	3	3	2	8	8	6	124	106	54	27	26	14	25	24	14
phalanx	n/a			n/a			16	14	3	7	7	1	49	49	10	6	6	2			
Total Leg	34	31		74	49		34	30		29	26		378	334		134	117		112	101	
Total	147	124	13	255	190	17	103	83	6	104	79	8	963	771	62	438	372	30	537	430	65

[a]Species abbreviations follow Figure 5 (except STAL= Short-tailed Albatross). n/a= not available (not identified to species).
[b]= vertebra not identified

Table 5. By taxon statistical comparison of the distribution of skeletal elements found at the Minard site versus the human scavenging and human hunting hypotheses, and the COASST dataset.[a]

Common Name	HS χ^2, p	HH χ^2, p	COASST χ^2, p
Surf Scoter	**14.95** **0.0006**	25.85 <0.0001	31.19 <0.0001
White-winged Scoter	28.64 <0.0001	24.23 <0.0001	33.94 <0.0001
Northern Fulmar	**6.37** **0.0414**	13.34 0.0013	26.28 <0.0001
Sooty Shearwater	208.63 <0.0001	**129.00** **<0.0001**	277.10 <0.0001
Cassin's Auklet	**74.21** **<0.0001**	107.58 <0.0001	110.11 <0.0001
Common Murre	74.33 <0.0001	**56.89** **<0.0001**	113.01 <0.0001
Common Murre - GH	NA	NA	122.04 <0.0001

[a]Distributions for the HS and HH comparisons were manufactured using a standardized anatomical region approach (see text). To compare the Minard data to the COASST data, the MNE of the former was standardized using the anatomical ratios, allowing direct comparison to body part ratios. Based on chi-square values, the comparison that is least significant (that is, most similar) is in bold. Albatrosses were removed from the comparison due to a lack of sufficient sample size to discern differences among comparisons.

Figure 1

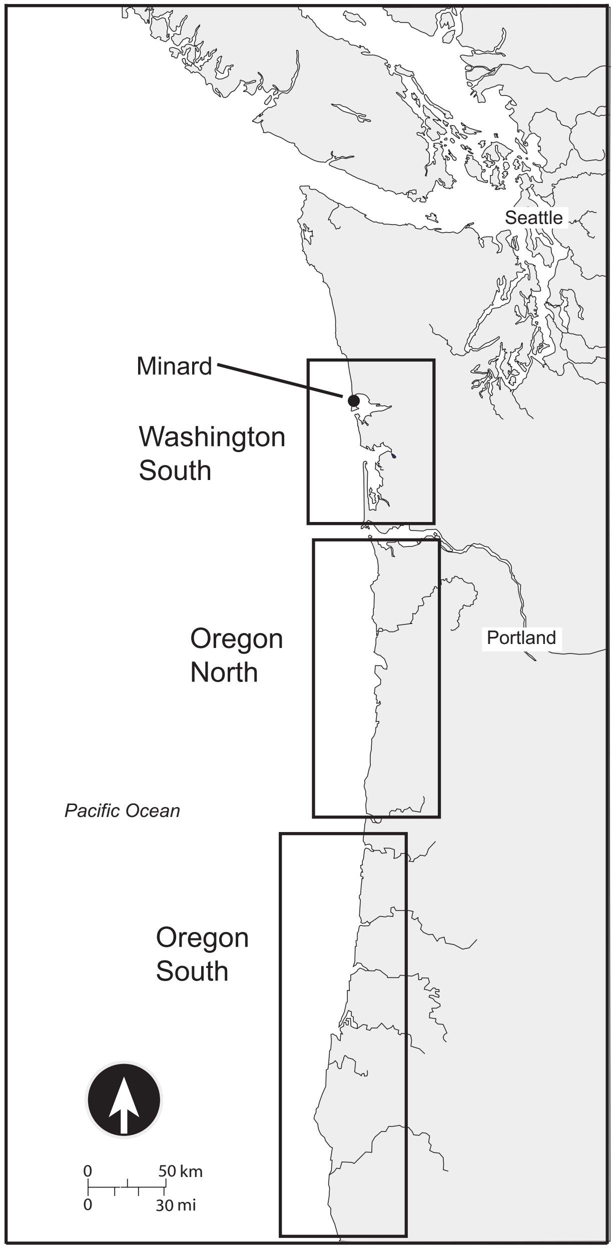

Figure 1: Map of Washington and Oregon coasts, showing the location of the Minard site, and the COASST regions used in this study (all three are combined and referred to as the “Northwest Coast” dataset in subsequent analyses). The beaches used in the Grays Harbor COASST dataset are within a 10-kilometer radius of Minard.

Figure 2

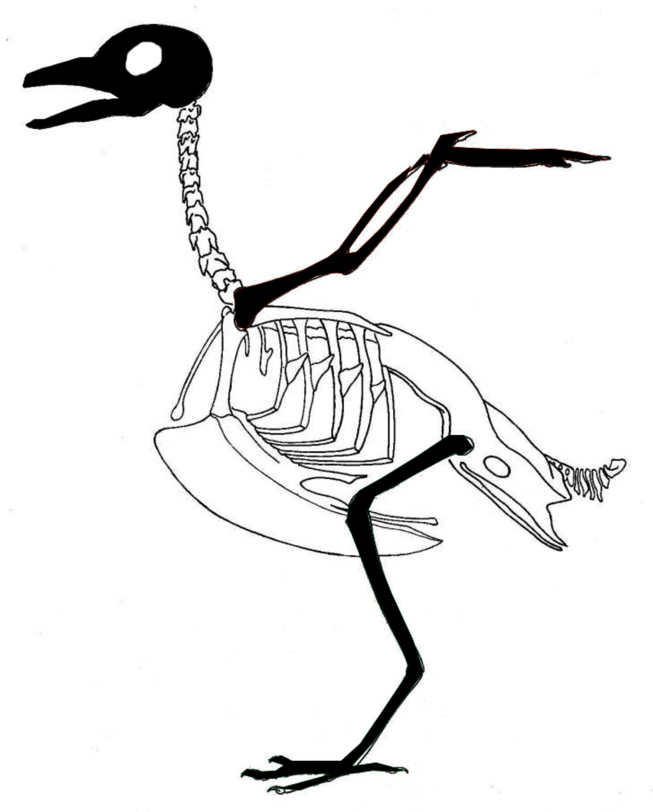

Figure 2: Body part present in COASST protocol. “Intact” includes all body parts shown; “Head”, “Legs”, “Wings”, and “Wings only” are highlighted in black. The bones observed in archaeological assemblages for each category have been highlighted here. Image used with permission from DG Mackean and www.biology-resources.com .

Figure 3

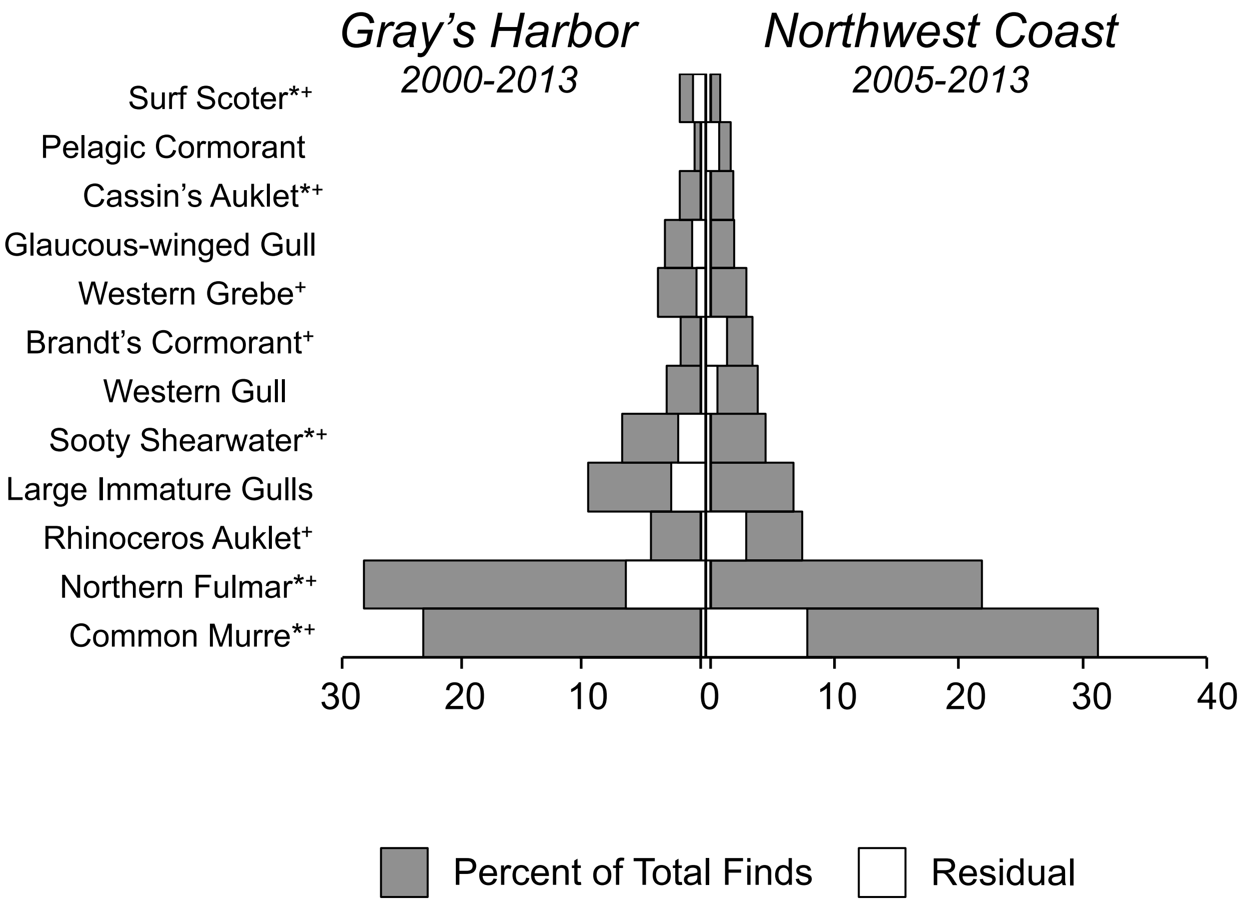

Figure 3: Differences in percent of total for major species in COASST dataset. Bars are the frequency of occurrence (percent of total specimens) for each species (or species group in the case of "large immature gulls") in the COASST datasets, respectively. White insets indicate the residual (absolute value) of the dataset comparison. Asterisks indicate species well represented in the Minard site archeological data. + indicate species involved in at least one "wreck" (massive mortality event) during the Northwest Coast sampling interval.

Figure 4

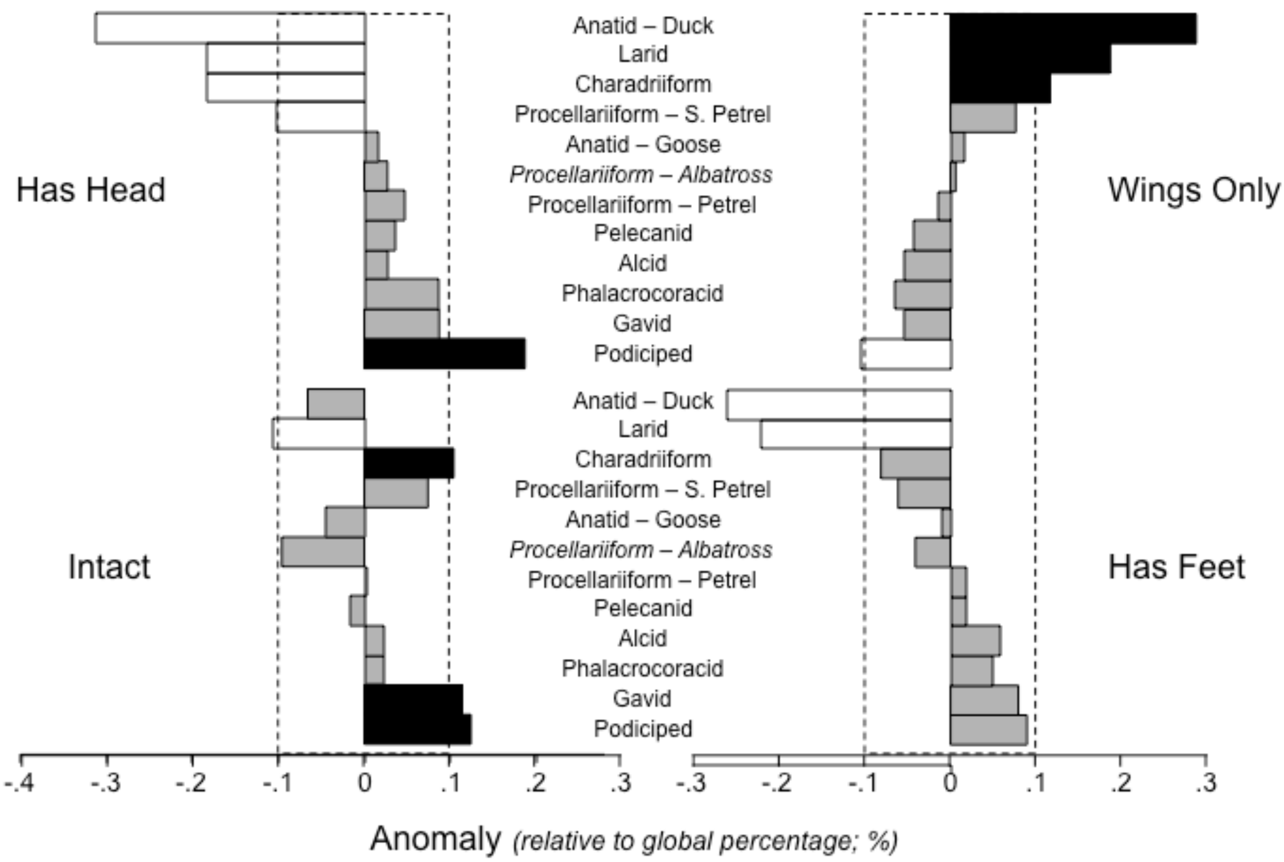

Figure 4: Body part occurrence as a function of taxonomic grouping displayed as the anomaly relative to the global (all carcasses) percentage. Intact – all parts present, no wounds; Has head and has feet – carcasses with these parts, regardless of the presence of any other part; Wings only – carcass is only wings (i.e., without head, feet or breast musculature). Taxonomic groups with <100 representative specimens are noted in *italics*. Dashed box is +/- 10%; groups with higher than a 10% anomaly are highlighted (negative – white; positive – black). Data are NWC COASST 2005-2013 (n=19,599 carcasses).

Figure 5

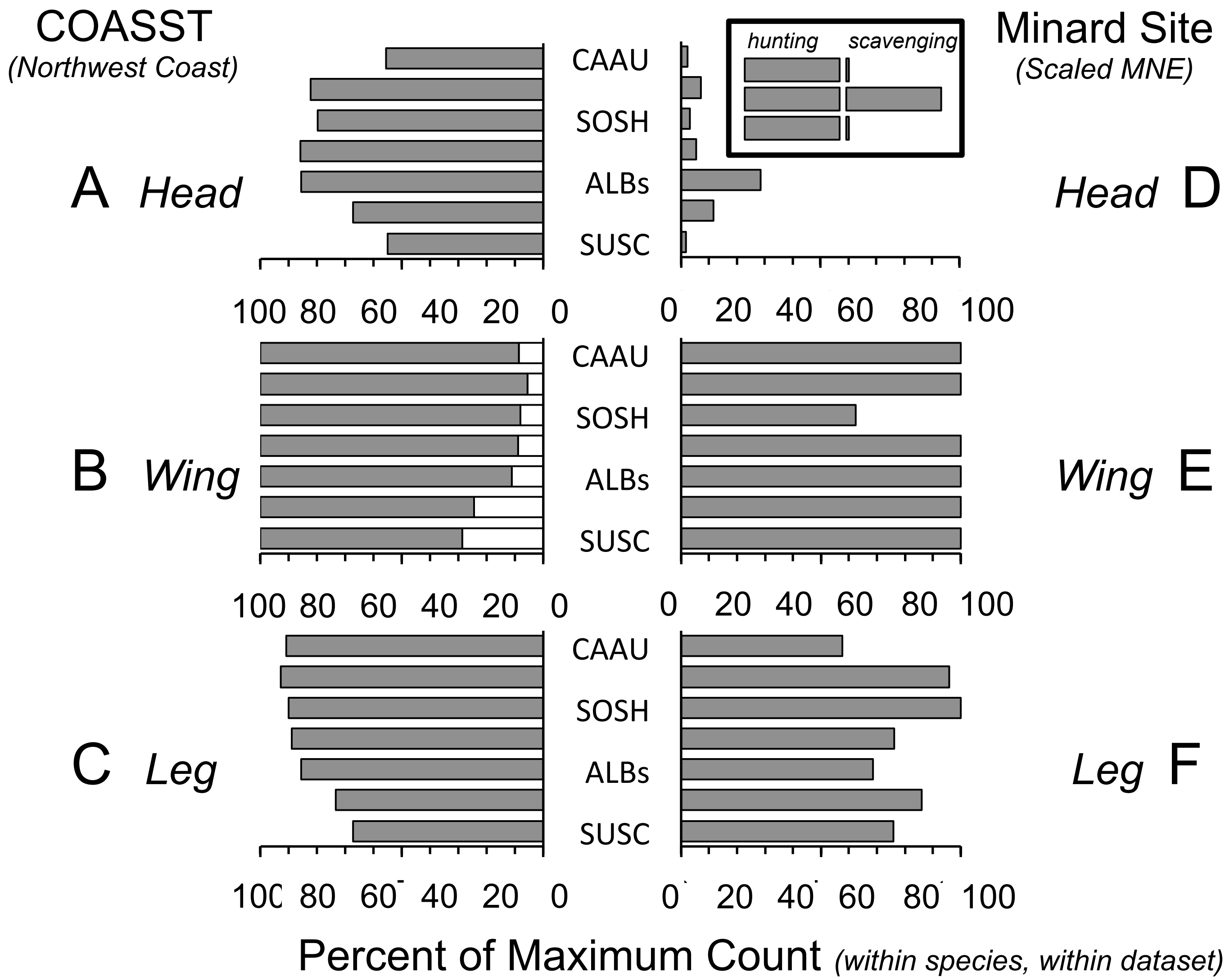

Figure 5: The percent of maximum element count for the NWC COASST (left) and Minard (right) datasets. COASST data are counts of total carcasses identified to species and possessing the relevant skeletal element (for wings and legs – at least one present). Inset white bars in the wing graph are those carcasses possessing "wings only." Minard site data are scaled MNE values, which allow for direct comparison with the COASST dataset. Inset graphic (top right) depicts the theoretical relative occurrence of head, wing and leg element predictions as a function of hunting versus scavenging. Species abbreviations are as follows: CAAU – Cassin's Auklet; COMU – Common Murre; SOSH – Sooty Shearwater; NOFU – Northern Fulmar; ALBs – albatrosses (in the COASST dataset these are Laysan Albatross and Black-footed Albatross, in the Minard dataset this is Short-tailed Albatross); WWSC – White-winged Scoter; SUSC – Surf Scoter.

Supplemental Table 1: Complete COASST Data for Oregon and Southern Washington Coasts, 2005-2013.

Scientific Name	Common Name	Intact	Head	Legs	Wings	Wings Only	Total Finds
Anser albifrons	Greater White-fronted Goose	3	26	26	31	2	31
Chen canagica	Emperor Goose		2	2	1		2
Branta bernicla	Brant	1	2	3	5	2	5
Branta canadensis	Canada Goose (aleutian)	2	21	20	21		21
Branta canadensis	Canada Goose (canadensis)		4	4	5	1	5
Branta canadensis	Canada Goose (minima)	6	27	32	39	7	39
Anas strepera	Gadwall			0	1	1	1
Anas penelope	Eurasian Wigeon			0	1	1	1
Anas americana	American Wigeon	1	1	2	10	8	10
Anas platyrhynchos	Mallard	2	6	7	18	10	18
Anas clypeata	Northern Shoveler	1	3	3	8	5	8
Anas acuta	Northern Pintail	3	18	28	51	23	52
Anas crecca	Green-winged Teal		4	8	33	25	33
Aythya marila	Greater Scaup	1	7	11	24	13	24
Aythya affinis	Lesser Scaup	1	1	1	3	2	3
Melanitta perspicillata	Surf Scoter	24	86	105	156	45	157
Melanitta fusca	White-winged Scoter	15	88	96	131	32	132
Melanitta americana	Black Scoter		2	5	4		5
Bucephala albeola	Bufflehead		2	6	20	14	20
Bucephala clangula	Common Goldeneye			0	3	3	3
Lophodytes cucullatus	Hooded Merganser			1	1		1
Mergus merganser	Common Merganser		1	1	1		1
Mergus serrator	Red-breasted Merganser			1	1		1
Oxyura jamaicensis	Ruddy Duck	1	1	2	2		2
Gallus gallus	Red Junglefowl (Chicken)		4	5	6		6
Phasianus colchicus	Ring-necked Pheasant			1	1		1
Meleagris gallopavo	Wild Turkey			1	0		1
Gavia stellata	Red-throated Loon	15	46	47	52	2	52
Gavia pacifica	Pacific Loon	22	91	100	103	3	104
Gavia immer	Common Loon	29	65	69	76	7	76
Gavia adamsii	Yellow-billed Loon		1	1	1		1
Podiceps auritus	Horned Grebe	2	9	14	16	2	16
Podiceps grisegena	Red-necked Grebe	1	4	3	5		5
Podiceps nigricollis	Eared Grebe		1	3	3		3
Aechmophorus occidentalis	Western Grebe	163	559	534	559	0	565
Aechmophorus clarkii	Clark's Grebe	8	16	17	17	0	17
Phoebastria immutabilis	Laysan Albatross	2	11	11	11		11
Phoebastria nigripes	Black-footed Albatross	5	66	66	79	10	84
Fulmarus glacialis	Northern Fulmar	765	3604	3730	4197	376	4281
Pterodroma inexpectata	Mottled Petrel	1	4	4	6	2	6
Puffinus creatopus	Pink-footed Shearwater	5	12	15	14		15
Puffinus pacificus	Wedge-tailed Shearwater		1	1	1		1
Puffinus bulleri	Buller's Shearwater	1	2	2	2		2
Puffinus griseus	Sooty Shearwater	111	667	753	835	67	855
Puffinus tenuirostris	Short-tailed Shearwater	19	80	90	97	7	97
Oceanodroma furcata	Fork-tailed Storm-Petrel	18	53	63	82	18	84
Oceanodroma leucorhoa	Leach's Storm-Petrel	10	27	29	33	3	33

Supplemental Table 1: Complete COASST Data for Oregon and Southern Washington Coasts, 2005-2013.

Scientific Name	**Common Name**	**Intact**	**Head**	**Legs**	**Wings**	**Wings Only**	**Total Finds**
Sula nebouxii	Blue-footed Booby	1	2	2	2		2
Phalacrocorax penicillatus	Brandt's Cormorant	145	623	604	639	3	660
Phalacrocorax auritus	Double-crested Cormorant	9	79	76	99	16	99
Phalacrocorax pelagicus	Pelagic Cormorant	52	224	280	301	20	306
Pelecanus erythrorhynchos	American White Pelican		1	0	1		1
Pelecanus occidentalis	Brown Pelican	37	200	213	228	15	245
Ardea herodias	Great Blue Heron	3	12	10	12		12
Cathartes aura	Turkey Vulture		2	2	2		2
Accipiter cooperii	Cooper's Hawk			1	1		1
Buteo jamaicensis	Red-tailed Hawk		1	1	1		1
Fulica americana	American Coot	6	10	18	26	9	27
Haematopus bachmani	Black Oystercatcher	2	4	5	5		5
Pluvialis squatarola	Black-bellied Plover		1	1	6	4	6
Tringa melanoleuca	Greater Yellowlegs		1	2	2		2
Tringa semipalmata	Willet			1	1		1
Numenius phaeopus	Whimbrel	1	3	2	11	9	12
Numenius americanus	Long-billed Curlew			0	1	1	1
Limosa fedoa	Marbled Godwit			0	1	1	1
Arenaria melanocephala	Black Turnstone			1	1		1
Calidris virgata	Surfbird			1	1	0	1
Calidris alba	Sanderling	3	3	4	6	2	6
Calidris alpina	Dunlin	18	35	36	39	3	39
Calidris mauri	Western Sandpiper	5	8	8	8		8
Limnodromus griseus	Short-billed Dowitcher			0	1	1	1
Phalaropus lobatus	Red-necked Phalarope		1	2	2		2
Phalaropus fulicarius	Red Phalarope	11	32	49	60	11	60
Stercorarius maccormicki	South Polar Skua		2	2	2		2
Stercorarius pomarinus	Pomarine Jaeger		2	2	2		2
Stercorarius parasiticus	Parasitic Jaeger		1	1	1		1
Stercorarius longicaudus	Long-tailed Jaeger		1	1	1		1
Uria aalge	Common Murre	1071	4961	5605	6028	329	6125
Cepphus columba	Pigeon Guillemot	19	73	102	131	26	132
Brachyramphus marmoratus	Marbled Murrelet	5	15	24	24		24
Synthliboramphus antiquus	Ancient Murrelet	6	16	30	37	6	37
Ptychoramphus aleuticus	Cassin's Auklet	87	198	324	356	31	356
Aethia psittacula	Parakeet Auklet	2	5	8	8		8
Cerorhinca monocerata	Rhinoceros Auklet	336	1293	1351	1435	38	1449
Fratercula corniculata	Horned Puffin	20	76	73	80	2	82
Fratercula cirrhata	Tufted Puffin	29	152	139	151	2	157
Rissa tridactyla	Black-legged Kittiwake	10	70	74	117	35	118
Rissa brevirostris	Red-legged Kittiwake		1	2	3	1	3
Laridae	Large Immature Gull	57	731	818	1274	393	1313
Xema sabini	Sabine's Gull		1	1	4	3	4
Chroicocephalus philadelphia	Bonaparte's Gull			4	15	11	15
Larus heermanni	Heermann's Gull	2	22	23	39	14	41
Larus canus	Mew Gull	1	4	6	15	8	15
Larus delawarensis	Ring-billed Gull	1	6	6	10	3	10

Supplemental Table 1: Complete COASST Data for Oregon and Southern Washington Coasts, 2005-2013.

Scientific Name	**Common Name**	**Intact**	**Head**	**Legs**	**Wings**	**Wings Only**	**Total Finds**
Larus occidentalis	Western Gull	49	480	496	731	176	738
Larus californicus	California Gull	19	124	129	170	32	172
Larus argentatus	Herring Gull	1	19	18	29	10	31
Larus thayeri	Thayer's Gull		1	1	1		1
Larus glaucescens	Glaucous-winged Gull	21	224	217	377	128	378
Larus hyperboreus	Glaucous Gull	1	4	4	4		4
Hydroprogne caspia	Caspian Tern	2	27	22	35	9	37
Sterna hirundo	Common Tern	1	3	3	3		3
Columba livia	Rock Pigeon	1	3	4	9	4	10
Patagioenas fasciata	Band-tailed Pigeon			1	1		1
Bubo virginianus	Great Horned Owl		1	1	1		1
Bubo scandiacus	Snowy Owl		1	1	1		1
Strix varia	Barred Owl		7	8	15	6	15
Asio flammeus	Short-eared Owl		1	2	2		2
Megaceryle alcyon	Belted Kingfisher			0	1	1	1
Colaptes auratus	Northern Flicker		2	1	6	4	6
Falco peregrinus	Peregrine Falcon			1	1		1
Cyanocitta stelleri	Steller's Jay		1	1	1		1
Corvus brachyrhynchos	American Crow	3	18	21	24	3	25
Corvus corax	Common Raven		1	1	2	1	2
Troglodytes pacificus	Pacific Wren	1	1	1	1		1
Catharus guttatus	Hermit Thrush	1	1	1	1		1
Turdus migratorius	American Robin		1	1	1		1
Ixoreus naevius	Varied Thrush	1	3	5	15	10	15
Sturnus vulgaris	European Starling		2	3	3		3
Cardellina pusilla	Wilson's Warbler	3	3	3	3		3
Passerculus sandwichensis	Savannah Sparrow		1	1	1		1
Passerella iliaca	Fox Sparrow	1	1	1	1		1
Melospiza melodia	Song Sparrow		1	1	1		1
Zonotrichia atricapilla	Golden-crowned Sparrow		1	1	1		1
Junco hyemalis	Dark-eyed Junco	1	2	2	2		2
Piranga ludoviciana	Western Tanager		1	1	1		1
Pheucticus melanocephalus	Black-headed Grosbeak		1	1	1		1
Unknown		120	643	977	1418	474	1530
Grand Total		3403	16076	17769	20820	2546	21280
% of Total Finds		16.0	75.5	83.5	97.8	12.0	

Supplemental Table 2: COASST Data for the Grays Harbor Region, 2000- 2013.

Scientific Name	**Common Name**	**Intact**	**Head**	**Feet**	**Wings**	**Wings Only**	**Total Finds**
Anser albifrons	Greater White-fronted Goose	1	7	6	9	2	9
Branta bernicla	Brant	1	1	2	3	1	3
Chen caerulescens	Snow Goose		1	1	1		1
Branta canadensis	Canada Goose (aleutian)		1	1	1		1
Branta canadensis	Canada Goose (canadensis)		6	6	6		6
Branta canadensis	Canada Goose (minima)	1	5	6	9	3	9
Anas strepera	Gadwall			0	1	1	1
Anas americana	American Wigeon			1	5	4	5
Anas platyrhynchos	Mallard	1	1	1	3	2	3
Anas clypeata	Northern Shoveler		1	1	3	2	3
Anas acuta	Northern Pintail		7	11	22	11	22
Anas crecca	Green-winged Teal		3	4	25	21	25
Aythya marila	Greater Scaup	1	4	5	9	4	9
Melanitta perspicillata	Surf Scoter	23	47	63	86	21	87
Melanitta fusca	White-winged Scoter	8	29	29	41	9	41
Bucephala albeola	Bufflehead	1	2	2	3	1	3
Bucephala clangula	Common Goldeneye			0	1	1	1
Mergus merganser	Common Merganser		1	1	1		1
Mergus serrator	Red-breasted Merganser	1	2	2	2		2
Gallus gallus	Red Junglefowl (Chicken)	1	2	1	2		2
Gavia stellata	Red-throated Loon	3	9	8	10	1	10
Gavia pacifica	Pacific Loon	9	27	29	29		29
Gavia immer	Common Loon	14	24	25	25		25
Podiceps auritus	Horned Grebe	1	1	1	2	1	2
Podiceps grisegena	Red-necked Grebe		3	2	3		3
Podiceps nigricollis	Eared Grebe		2	1	1		2
Aechmophorus occidentalis	Western Grebe	70	163	161	169	1	171
Aechmophorus clarkii	Clark's Grebe	3	7	7	7		7
Phoebastria immutabilis	Laysan Albatross	1	3	3	3		3
Phoebastria nigripes	Black-footed Albatross	3	19	19	22	3	23
Fulmarus glacialis	Northern Fulmar	606	1201	1207	1301	78	1327
Pterodroma inexpectata	Mottled Petrel		1	1	2	1	2
Puffinus creatopus	Pink-footed Shearwater	2	4	5	5		5
Puffinus pacificus	Wedge-tailed Shearwater		1	1	1		1
Puffinus griseus	Sooty Shearwater	69	259	275	302	23	309
Puffinus tenuirostris	Short-tailed Shearwater	6	17	19	21	2	21
Oceanodroma furcata	Fork-tailed Storm-Petrel	7	14	16	17	1	18
Oceanodroma leucorhoa	Leach's Storm-Petrel	3	9	9	9		9
Phalacrocorax penicillatus	Brandt's Cormorant	31	80	76	82		82
Phalacrocorax auritus	Double-crested Cormorant	5	17	17	20	2	20
Phalacrocorax pelagicus	Pelagic Cormorant	8	19	20	21	1	23

Supplemental Table 2: COASST Data for the Grays Harbor Region, 2000- 2013.

Scientific Name	**Common Name**	**Intact**	**Head**	**Feet**	**Wings**	**Wings Only**	**Total Finds**
Pelecanus occidentalis	Brown Pelican	4	26	32	36	6	40
Ardea herodias	Great Blue Heron	3	5	4	5		5
Buteo jamaicensis	Red-tailed Hawk		1	1	1		1
Fulica americana	American Coot			2	2	1	3
Pluvialis squatarola	Black-bellied Plover			0	4	4	4
Tringa melanoleuca	Greater Yellowlegs		1	2	2		2
Numenius phaeopus	Whimbrel			0	2	2	2
Limosa fedoa	Marbled Godwit		1	2	2		2
Calidris alba	Sanderling	1	1	3	2		3
Calidris alpina	Dunlin		2	1	2	1	3
Calidris mauri	Western Sandpiper	5	5	5	5		5
Phalaropus fulicarius	Red Phalarope	8	21	33	45	13	46
Stercorarius maccormicki	South Polar Skua		1	1	1		1
Uria aalge	Common Murre	366	1003	1040	1083	21	1093
Cepphus columba	Pigeon Guillemot	3	6	8	9	1	9
Brachyramphus marmoratus	Marbled Murrelet		4	6	6		6
Synthliboramphus antiquus	Ancient Murrelet	1	5	7	9	2	9
Ptychoramphus aleuticus	Cassin's Auklet	28	53	80	86	6	86
Aethia psittacula	Parakeet Auklet		1	1	1		1
Cerorhinca monocerata	Rhinoceros Auklet	60	190	191	196	2	198
Fratercula corniculata	Horned Puffin	4	9	8	9		9
Fratercula cirrhata	Tufted Puffin	6	23	22	23		23
Rissa tridactyla	Black-legged Kittiwake	7	19	20	29	8	29
Laridae	Large Immature Gull	26	284	286	435	117	443
Xema sabini	Sabine's Gull			0	1	1	1
Chroicocephalus philadelphia	Bonaparte's Gull		1	2	3	1	3
Larus heermanni	Heermann's Gull		13	11	17	4	17
Larus delawarensis	Ring-billed Gull	1	3	3	5	1	5
Larus occidentalis	Western Gull	10	96	92	138	34	138
Larus californicus	California Gull	4	24	21	32	8	33
Larus argentatus	Herring Gull		7	8	12	4	12
Larus glaucescens	Glaucous-winged Gull	10	93	84	143	43	143
Larus hyperboreus	Glaucous Gull		1	1	1		1
Hydroprogne caspia	Caspian Tern	1	11	10	12	1	12
Sterna hirundo	Common Tern	1	1	1	1		1
Columba livia	Rock Pigeon			1	1		1
Bubo scandiacus	Snowy Owl		1	1	1		1
Strix occidentalis	Spotted Owl		1	1	1		1
Strix varia	Barred Owl		2	2	3		3
Asio flammeus	Short-eared Owl		1	1	1		1
Colaptes auratus	Northern Flicker		2	1	4	2	4

Supplemental Table 2: COASST Data for the Grays Harbor Region, 2000- 2013.

Scientific Name	**Common Name**	**Intact**	**Head**	**Feet**	**Wings**	**Wings Only**	**Total Finds**
Cyanocitta stelleri	Steller's Jay		1	1	1		1
Corvus brachyrhynchos	American Crow	1	3	5	4		5
Ixoreus naevius	Varied Thrush	1	1	1	2	1	2
Cardellina pusilla	Wilson's Warbler	1	1	1	1		1
Passerculus sandwichensis	Savannah Sparrow		1	1	1		1
Passerella iliaca	Fox Sparrow	1	1	1	1		1
Junco hyemalis	Dark-eyed Junco	1	1	1	1		1
Unknown		63	271	343	498	155	533
Grand Total		1497	4198	4394	5165	636	5271
% of Total Finds		28.4	79.6	83.4	98.0	12.1	

Supplemental Table 3: Complete List of Identified Specimens from the Minard Site.

Scientific Name	Common Name	NISP
Anatidae	Duck, Goose, Swan	2
Anserini- small	Goose, small-sized	10
Anserini- medium	Goose, medium-sized	94
Chen caerulescens	Snow Goose	2
cf. *Chen caerulescens*	Snow Goose	1
Branta canadensis	Canada Goose	2
Branta cf. *canadensis*	Canada Goose	17
Cygnus sp.	Swan	2
Anatinae	Duck	50
Anatinae- medium	Duck, medium-sized	25
Anatinae- medium/large	Duck, medium/large-sized	17
Anatinae- large	Duck, large-sized	24
Anas sp.- small	Dabbling Duck, small-sized	6
Anas sp.- small/medium	Dabbling Duck, small/medium-sized	1
Anas sp.- medium	Dabbling Duck, medium-sized	9
Anas sp.- medium/large	Dabbling Duck, medium/large-sized	18
Anas sp.- large	Dabbling Duck, large-sized	42
Aythya sp.- medium	Pochard, medium-sized	9
Aythya sp.- large	Pochard, large-sized	8
Aythya sp. or Mergini- medium	Pochard or Sea Duck (medium-sized)	4
Mergini- medium	Sea Duck, medium-sized	12
Mergini- large	Sea Duck, large-sized	9
Melanitta sp.- small	Scoter, small-sized	57
cf. *Melanitta* sp.- small	Scoter, small-sized	33
Melanitta sp.- medium	Scoter, medium-sized	3
Melanitta sp.- large	Scoter, large-sized	139
cf. *Melanitta* sp.- large	Scoter, large-sized	55
Melanitta perspicillata	Surf Scoter	26
Melanitta cf. *perspicillata*	Surf Scoter	23
Melanitta fusca	White-winged Scoter	22
Melanitta cf. *fusca*	White-winged Scoter	33
Bucephala albeola	Bufflehead	11
Bucephala sp.- large	Common or Barrow's Goldeneye	1
Mergus sp.	Merganser	3
Mergus serrator	Red-breasted Merganser	1
Oxyura jamaicensis	Ruddy Duck	1
Bonasa umbellus	Ruffed Grouse	12
Dendragapus fuliginosus	Sooty Grouse	6
cf. Dendragapus fuliginosus	Sooty Groue	1
Gavia sp.- small	Red-throated or Pacific Loon	35
Gavia sp.- large	Common or Yellow-billed Loon	4
Gavia stellata	Red-throated Loon	39
Gavia cf. *stellata*	Red-throated Loon	3
Gavia pacifica	Pacific Loon	11
Gavia cf. *immer*	Common Loon	1
Podicipedidae- large	Grebe, large-sized	5
Podiceps sp.- small	Horned or Eared Grebe	1
Podiceps auritus	Horned Grebe	2

Supplemental Table 3: Complete List of Identified Specimens from the Minard Site.

Scientific Name	Common Name	NISP
Podiceps cf. *auritus*	Horned Grebe	1
Aechmophorus sp.	Western or Clark's Grebe	27
Phoebastria sp.	Albatross	1
Phoebastria cf. *immutabilis*	Laysan Albatross	1
cf. *Phoebastria immutabilis*	Laysan Albatross	1
P. immutabilis or *P. nigripes*	Laysan or Black-footed Albatross	1
Phoebastria albatrus	Short-tailed Albatross	84
Phoebastria cf. *albatrus*	Short-tailed Albatross	17
cf. *Phoebastria albatrus*	Short-tailed Albatross	1
Procellariidae	Shearwater, Fulmar, Petrel	20
Fulmarus glacialis	Northern Fulmar	99
cf. *Fulmarus glacialis*	Northern Fulmar	5
Puffinus sp.- small	Shearwater, small-sized	1
Puffinus sp.- medium	Shearwater, medium-sized	2
Puffinus sp.- large	Shearwater, large-sized	1
Puffinus griseus	Sooty Shearwater	961
cf. *Puffinus griseus*	Sooty Shearwater	3
Puffinus cf. *tenuirostris*	Short-tailed Shearwater	1
Phalacrocorax sp.	Cormorant	11
cf. *Phalacrocorax* sp.	Cormorant	1
Phalacrocorax penicillatus	Brandt's Cormorant	7
Phalacrocorax auritus	Double-crested Cormorant	5
Phalacrocorax pelagicus	Pelagic Cormorant	9
Phalacrocorax cf. *pelagicus*	Pelagic Cormorant	1
Pelecanus sp.	Pelican	1
Pelecanus occidentalis	Brown Pelican	4
Ardea herodias	Great Blue Heron	1
Accipitridae- large	Bald or Golden Eagle	1
Haliaeetus leucocephalus	Bald Eagle	19
cf. *Haliaeetus leucocephalus*	Bald Eagle	6
Circus cyaneus	Northern Harrier	1
Accipiter striatus	Sharp-shinned Hawk	1
Accipiter gentilis	Northern Goshawk	1
Buteo sp.- small	Hawk, small-sized	1
Buteo sp.- large	Hawk, large-sized	5
Buteo cf. *jamaicensis*	Red-tailed Hawk	1
B. jamaicensis or *B. lagopus*	Red-tailed or Rough-legged Hawk	1
Grus canadensis	Sandhill Crane	3
Charadriiformes	Shorebird, Gull, Alcid	1
Scolopacidae	Sandpiper	1
Tringini- medium	Tringine Sandpiper	3
Actitis macularius	Spotted Sandpiper	1
Limosa fedoa or *Numenius phaeopus*	Marbled Godwit or Whimbrel	5
Limosa fedoa	Marbled Godwit	2
cf. *Limosa fedoa*	Marbled Godwit	3
Calidris sp.- smallest	Calidrine Sandpiper, smallest-sized	9
Calidris sp.- medium	Calidrine Sandpiper, medium-sized	11
Limnodromus sp.	Short-billed or Long-billed Dowitcher	2

Supplemental Table 3: Complete List of Identified Specimens from the Minard Site.

Scientific Name	Common Name	NISP
cf. *Limnodromus* sp.	Short-billed or Long-billed Dowitcher	1
Alcidae- small	Alcid (Auk, Murre, Puffin), small-sized	1
Alcidae- medium	Alcid, medium-sized	2
Alcidae- large	Alcid, large-sized	1
cf. *Uria* sp.	Common or Thick-billed Murre	2
Uria aalge	Common Murre	25
Uria cf. *aalge*	Common Murre	413
cf. *Brachyramphus marmoratus*	Marbled Murrelet	1
Ptychoramphus aleuticus	Cassin's Auklet	537
Aethia psittacula	Parakeet Auklet	1
Fraterculini	Puffin	6
cf. Fraterculini	Puffin	1
Fraterculini- small	Puffin, small-sized	8
Cerorhinca monocerata	Rhinoceros Auklet	2
cf. *Cerorhinca monocerata*	Rhinoceros Auklet	5
Fratercula cirrhata	Tufted Puffin	2
Fratercula cf. *cirrhata*	Tufted Puffin	6
cf. Laridae	Gull, Tern	1
Laridae- small	Gull, Tern (small-sized)	16
Laridae- large	Gull, Tern (large-sized)	6
cf. Laridae- large	Gull, Tern (large-sized)	1
Rissa tridactyla	Black-legged Kittiwake	2
Rissa cf. *tridactyla*	Black-legged Kittiwake	25
cf. *Rissa tridactyla*	Black-legged Kittiwake	1
Larus sp.- small	Gull, small-sized	16
Larus sp.- large	Gull, large-sized	68
cf. *Larus* sp.- large	Gull, large-sized	7
Bubo virginianus	Great Horned Owl	3
Bubo cf. *virginianus*	Great Horned Owl	2
Bubo virginianus or *B. scandiacus*	Great Horned or Snowy Owl	5
Bubo scandiacus	Snowy Owl	1
Glaucidium gnoma	Northern Pygmy-Owl	2
Strix occidentalis or *Strix varia*	Spotted or Barred Owl	2
Aegolius acadicus	Northern Saw-whet Owl	1
Megaceryle alcyon	Belted Kingfisher	4
Picidae- small	Woodpecker, small-sized	1
Picoides villosus	Hairy Woodpecker	1
Colaptes auratus	Northern Flicker	2
Falco sp.- large	Peregrine Falcon or Gyrfalcon	2
Falco cf. *rusticolus*	Gyrfalcon	2
Falco cf. *peregrinus*	Peregrine Falcon	1
Passeriformes	Perching Bird	1
Passeriformes (non-Corvid)	Perching Bird	9
Corvus brachyrhynchos	American Crow	24
Corvus corax	Raven	11
Aves	Bird, unidentified	30
Total		3498