THE COMPOSITION AND INTERACTIONS OF SCAVENGERS ON A HUMPBACK WHALE CARCASS IN ALASKA

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ABSTRACT—Many avian and mammalian predators are facultative scavengers and will opportunistically forage from carcasses. A food source as large as a whale carcass could be valuable to wildlife because of its size and high lipid content. Large carcasses can elicit unique behaviors and interactions in wildlife, but because whale beachings are relatively uncommon, little research has examined the scavenging dynamics at whale carcasses. Here, we used a remote camera to investigate the composition and interactions of scavengers at a Humpback Whale (*Megaptera novaeangliae*) carcass that washed ashore in Glacier Bay National Park, Alaska, in 2016. We split the consumption process into 3 stages based on how much soft tissue remained. Bald Eagles (*Haliaeetus leucocephalus*) were the first to feed on the carcass and appeared to dominate the food source, preventing many smaller birds from feeding. Gray Wolves (*Canis lupus*), corvids (*Corvus* spp.), and gulls (*Larus* spp.) were also regularly detected. Scavenger numbers remained high during the first 2 stages of carcass consumption and declined by the 3rd stage. Most interactions observed were between individual Bald Eagles and occurred during the 1st stage. Following the eagles' departure after the 1st stage, interactions between individuals were far less common. These results suggest that a carcass of this size in the intertidal zone is utilized primarily by avian scavengers and that interactions between individuals decrease as the food resource declines. These findings help advance our understanding of scavenger dynamics and the general ecology of coastal Pacific Northwest ecosystems.

Key words: Alaska, community diversity, foraging behavior, Humpback Whale, interference competition, *Megaptera novaeangliae*, scavengers, subsidies, successional dynamics

Nearly all terrestrial carnivores are considered facultative scavengers (DeVault and others 2003), and reliance on carrion varies broadly among species. Species with small home ranges might not rely as heavily on carrion relative to wider-ranging species because of the difficulty and uncertainty of locating carrion food sources regularly (Gutiérrez-Cánovas and others 2020). Some bird species, notably soaring ones, have a higher reliance on carrion than mammalian scavengers owing to their greater efficiency when searching for food sources over large areas (DeVault and others 2003; Schmidt-Nielsen 2016). For example, Bald Eagles (*Haliaeetus leucocephalus*) in the Columbia River Estuary used scavenging as a foraging method 24% of the time and had a 98% success rate (obtaining food once item is located) in obtaining food at carcasses compared to a 66% and 46% success rate for catching live prey and stealing food from other animals, respectively (Garrett and others 1993). The number and type of scavengers that use a carrion food source depends on the size and location of the carcass; thus, a larger carcass will likely last longer and have a greater impact on the local ecosystem (Moleón and others 2015).

The parvorder *Mysteceti* (or Baleen Whales) contains the largest animals in the world. Because of their massive size, the carcass of a single whale can have a significant impact on the ecosystem by providing valuable nutrients to scavengers (Roman and others 2014). In the summer, whales build up their lipid stores in preparation for their migration to lower latitudes to calve in the winter (Narazaki and others 2018). Approximately 87% of great-whale biomass is soft tissue, which is known to be lipid rich (Smith and others 2015). Additionally, fresh bones act as a reservoir for lipids, and some bones can be composed of greater than 60% lipids (Smith 2006).

Owing to lung deflation, blood density, and the negatively buoyant nature of whales dying of natural causes, most whale carcasses sink to the ocean floor (Smith 2006). Smith and others (1989) first described their discovery of vent fauna, which are organisms specialized to hydrothermic vents located on the sea floor, on a submerged, intact whale skeleton. Subsequent research has revealed that whale carcasses on the ocean floor, often called 'whale falls', support complex communities of scavengers that change over time as the carcass is consumed in a predictable successional pattern (Bennett and others 1994; Smith and Baco 2003; Glover and others 2005; Dahlgren and others 2006; Fujikura and others 2006; Sumida and others 2016). Although these findings provide important insights into the importance of whale carcasses in deep sea ecosystems, more research must be conducted regarding their impact on terrestrial and intertidal ecosystems.

Whether it is due to human interference, the location of death, or the buildup of gases in the carcass causing buoyancy, whale carcasses occasionally wash ashore. These rare, yet large and nutrient-rich marine subsidies may be an important resource for a variety of coastal wildlife species. For example, previous research has shown that whale carcasses likely helped facilitate the survival of Polar Bears (*Ursus maritimus*) during interglacial periods when access to seals as a food resource was limited (Laidre and others 2018). In recent years, unexpected and significant die-offs of marine mammals, termed unusual mortality events in the Marine Mammal Protection Act, have been increasing (NOAA Office of Protected Resources 2019). Although the specific reason for these events varies, if this trend continues, beached whale carcasses might become a more common occurrence.

On 26 June 2016, a dead Humpback Whale was discovered by a private fishing vessel in the waters of Glacier Bay National Park and Preserve in Southeast Alaska. This whale was identified by biologist as #441, also nicknamed "Festus". Festus was a 66-y-old male Humpback Whale, first sighted in 1972 (Gabriele and others 2021). National Park Service staff, along with veterinary partners, conducted a necropsy and determined that the cause of death was a variety of health issues including a fungal infection and a spinal bone condition (Gabriele and others 2021). Here, we examine the dynamics of scavengers on this carcass using images from a remote camera.

Our objectives were to: (1) document the successional dynamics of scavengers as the whale carcass was consumed; and (2) quantify patterns of interference competition by documenting interactions among scavengers. Whether an individual chooses to feed at a whale carcass may depend on the location of the carcass, quality of the carrion, the availability of alternative food resources, and competition with other scavengers (Wikenros and others 2013; Pereira and others 2014; Gomo and others 2017; Kane and others 2017). Hyper-abundant resources are often too costly to defend (Gill and Wolf 2019), and we therefore hypothesized that individuals would tolerate each other at the beginning of the consumption process when large amounts of soft tissue remained, leading to a low frequency of aggressive interactions. We expected birds to be the 1st to arrive at the carcass owing to their high search efficiency, followed by the mammals. As the carrion supply depleted over time, we expected the number of both interspecific and intraspecific interactions to increase because of increasing scarcity of the resource. We predicted that large carnivores such as bears (*Ursus* spp.), Gray Wolves (*Canis lupus*), and eagles would attempt to exclude smaller scavengers such as Coyotes (*Canis latrans*), gulls (*Larus* spp.), and corvids (*Corvus* spp.) from the carcass (Allen and others 2015).

METHODS

Study Area

Glacier Bay National Park and Preserve is located in Southeast Alaska and covers 13,354 km^2 of glacial- and river-made valleys surrounded by mountain peaks and fjords (Boggs and

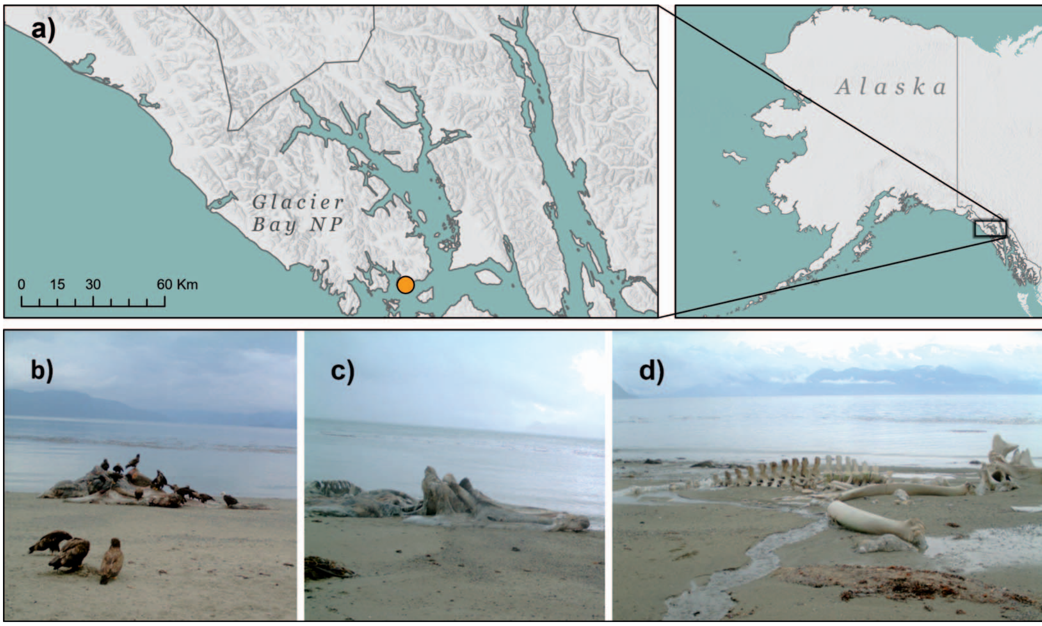

FIGURE 1. (a) Location of the Humpback Whale carcass in Glacier Bay National Park. Photos show the state of the carcass from 29 June–20 September 2016, categorized into 3 different stages: (b) Stage 1: no exposed bone visible; (c) Stage 2: some exposed bone visible, but soft tissue remains; and (d) Stage 3: most soft tissue no longer on bones.

others 2010). The whale carcass was located within park waters, southeast of the mouth of Glacier Bay. After its discovery, the whale was towed to shore in preparation for an examination and necropsy to determine cause of death. The necropsy involved opening the carcass and taking relevant samples. After the necropsy was completed, the carcass was left on the beach to resume its natural decomposition in the ecosystem. Although the majority of the carcass was left at the site with the exception of some bone and tissue samples, it is important to note that opening the carcass for the necropsy likely accelerated the scavenging and decomposition process. The final location of the carcass was along the southern coast of Glacier Bay National Park and Preserve (Fig. 1). The beach where the carcass was placed was a rocky, tidal-influenced beach. Because it was isolated and difficult to access, this beach does not receive much human activity other than the occasional fishing boat or kayaker.

Camera Deployment

We mounted a Reconyx PC900 HyperFire™ professional covert IR trail camera (Reconyx, Holmen, Wisconsin, USA) on a fallen tree root roughly 25 m from the carcass. The camera was programmed to take a timelapse photo every 15 min in addition to anytime it was triggered by motion. The camera was mounted on 29 June 2016 and retrieved on 14 October 2016, for a total deployment of 108 d. We visited the site approximately every 3 wk to check the camera and change the memory card. Researchers worked quickly (<20 min on the ground) to minimize the amount of time spent near the carcass so as to not disturb wildlife in the area. The camera was retrieved when it was visually determined that no soft tissue remained on the whale carcass.

Analysis

Once the photos were retrieved and downloaded, we separated the timelapse photos from the motion-activated photos for separate analyses. The motion-activated photos were more sensitive to certain species based on their size, movement, and distance from the camera, and thus may have missed some visits from smaller scavengers. The timelapse photos provided a regular snapshot of all species present with no bias for certain species, so we used these photos to identify which species fed on the carcass and the order in which they arrived. However, the timelapse photos likely missed many of the species interactions. Therefore, we used the motion-activated photos to examine interactions among scavengers. Using Timelapse2 software (http://saul.cpsc.ucalgary.ca/timelapse), we counted how many individuals of each species were present in each image. Species were categorized as: Bald Eagle, Wolf, Gull, Corvid, and other bird.

We examined a single timelapse photo per day to classify stages of consumption and found 3 distinct physical stages based on the amount of soft tissue remaining on the bones (Wilmers and others 2003a; Fig. 1). Because it was not clear from the photos which specific parts of the carcass were consumed and the site was only visited once every 3 wk, our stages of consumption were based primarily on physical appearance rather than ecological succession or functional stage. We described the stages as follows: (1) when the carcass was completely covered (100% coverage) in soft tissue (Stage 1: 29 June to 18 July 2016; 19 d); (2) when some bone (20–80% coverage) was exposed (Stage 2: 19 July to 13 August 2016; 25 d); and (3) when most of the soft tissue (0–20% coverage) was no longer attached to the skeleton (Stage 3: 14 August 2016 to 20 September 2016; 37 d). Analysis ended on 20 September when the area surrounding the skeleton had no more available visible food resources for scavengers.

To account for changes in the amount of daylight during different parts of the summer, we averaged the number of detections of each species per photo per day. To determine the impact that consumption stage had on scavenger composition, we conducted a permutational analysis of variance (PERMANOVA; Anderson 2001). A PERMANOVA is analogous to an ANOVA, except the response data consist of multivariate community-composition data, which in our case was number of each species per photo per day. The species-composition data were relativized based on the maximum for each species. This analysis was conducted using function *adonis* in the vegan package (Oksanen and others 2012) in Program R, using 999 permutations. We then used the *betadisper* function in the vegan package to determine whether any significant results were due to variability in composition such as differences in the dispersion of points around the mean, rather than compositional change (Likar and others 2017). In addition to testing changes in species composition by stage, we used a Kruskal-Wallis test (Kruskal and Wallis 1952) to test for changes in the frequency of each individual species by stage and a pairwise Wilcoxon test to assess which stages differ.

To investigate scavenger interactions, we used the motion-activated photos. With these photos, we used the program Timelapse2 to record all interactions that were detected. We defined an interaction as anytime 1 individual displayed dominant or aggressive behavior toward another; these interactions included physical fighting, chasing, displacement (for example, a scavenger leaving the carcass due to the approach of another individual), or other dominant-submissive interactions (for example, subordinate pack members waiting for the dominant pack member to feed before approaching the carcass). Figure 2 shows examples of different types of interactions recorded. We coded interspecific pairwise interactions based on which species initiated the interaction, with the initiator first and the other species second (for example, eagle-wolf indicated that an eagle initiated an interaction with a wolf).

As with the timelapse photos, we calculated the average number of intra- and interspecific interactions per photo per day. We tested data for normality using a Shapiro-Wilk normality test (Shapiro and Wilk 1965). Additionally, we conducted a Kruskal-Wallis test as a nonparametric alternative to an ANOVA for both interspecific and intraspecific interaction type to determine if the number of interactions changed depending on the stage of consumption, with stage (1, 2, or 3) as factors and frequency of interactions per photo per day as the response variable. Following the Kruskal-Wallis test, we conducted a pairwise Wilcoxon test for each type of interaction to compare the means of each treatment.

Results

Successional Dynamics of Scavengers

From 29 June to 20 September 2016, a total of 3993 timelapse photos were taken, 2939 of which included 1 or more scavengers. A total of 14,690

FIGURE 2. Examples of different interactions between scavengers at the Humpback Whale carcass from 29 June–20 September 2016 in Glacier Bay National Park. (a) Eagle-eagle interaction. (b) Wolf-wolf interaction. Although more subtle than the eagle interaction, it can be observed that 1 wolf is feeding on the carcass while the other is not and is exhibiting submissive behavior (tail between legs). (c) Eagle-gull interaction. (d) Interaction categorized as "other". Here, a heron is chasing a corvid and gull away from the carcass.

observations of individuals (many likely counted multiple times) were recorded feeding on the carcass: 4745 observations of Bald Eagles, 2017 corvids, 95 wolves, 7824 gulls, and 9 other birds including Great Blue Herons (*Ardea herodias*), American Robins (*Turdus migratorius*), and other unidentified bird species. During the 1st stage, eagles were the most prominent scavenger, followed by corvids during Stage 2, and gulls during Stage 3 (Table 1). Eagles were the first of the scavengers to appear, feeding on the carcass from the 1st day recorded (Fig. 3). Corvids and wolves began to appear regularly after 7 d. Wolves visited every few days until they were

TABLE 1. The average number (±SE) of each type of scavenger per day for Stages 1, 2, and 3 on a whale carcass in Glacier Bay National Park & Preserve ($n = 14{,}690$). Stage 1: the carcass was completely covered in soft tissue. Stage 2: some bone was exposed. Stage 3: most of the soft tissue was no longer attached to the skeleton. Birds that did not fall into Bald Eagle, corvid, and gull categories were coded as other bird.

		Stage		
Common Name	Scientific Name	1	2	3
Bald Eagle	*H. leucocephalus*	10.89 ± 2.37	0.85 ± 0.29	0.04 ± 0.02
Corvid	*Corvus* spp.	1.12 ± 0.26	2.71 ± 0.46	1.01 ± 0.24
Gray Wolf	*Canis lupus*	0.14 ± 0.06	0.09 ± 0.02	0.00
Gull	*Larus* spp.	0.00	12.45 ± 2.37	4.82 ± 1.02
Other Bird		0.01 ± 0.00	0.01 ± 0.00	0.00

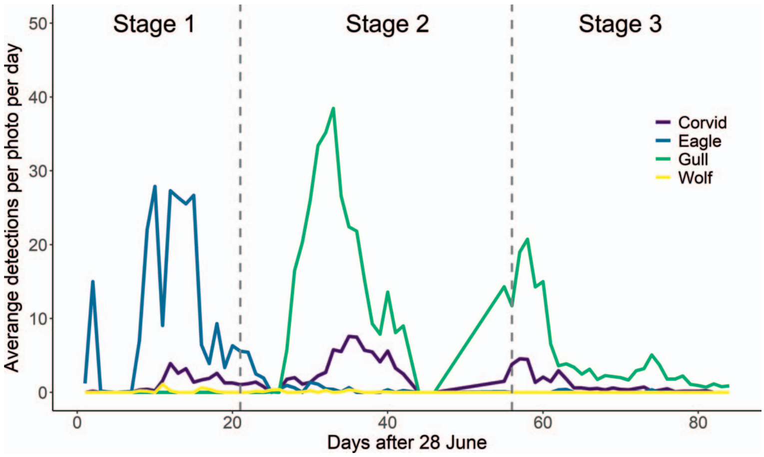

FIGURE 3. The composition of corvid, eagle, gull, and wolf scavengers throughout the carcass consumption process from 29 June–20 September 2016 in Glacier Bay National Park. Daily sums of each species shown (n = 14,690).

last detected on 7 August (day 40), and corvids scavenged from day 7 and continued for the remainder of the study. Gulls arrived at the carcass beginning on 23 July (after 24 d), after most of the eagles had left.

During the 1st stage, an average of 12.15 individuals visited the carcass per photo per day (SE ± 0.78) (Fig. 4). Stage 2 had 16.1 individuals d^{-1} on average (SE ± 0.78), and Stage 3 had 5.87 individuals d^{-1} (SE ± 0.32). PERMANOVA analysis found that the composition of scavengers differed between the 3 stages (Fig. 4; $F_{2,72} = 13.525$, $P = 0.001$) with 27% of variation explained by the stage. Analysis of dispersion showed that the differences in scavenger composition between stages were likely caused by dispersion of the samples, or variability in the community composition (Fig. 5; $F_{2,72} = 13.25$, $P < 0.001$). Scavenger abundance did not differ between Stage 1 and Stage 2 ($P = 0.68$), but abundance during Stage 3 was significantly lower when compared to Stages 1 and 2 ($P = 0.001$ and $P < 0.001$, respectively).

The frequency of each of the 4 species differed by stage (Eagle: $\chi^2 = 37.85$, $P < 0.001$, Corvid: $\chi^2 = 8.76$, $P = 0.01$, Wolf: $\chi^2 = 15.08$, $P < 0.001$, Gull: $\chi^2 = 33.66$, $P < 0.001$). The frequency of eagles declined across all 3 stages (all $P < 0.001$), whereas the frequency of corvids increased between Stages 1 and 2 ($P = 0.045$) and declined between Stages 2 and 3 ($P = 0.015$). Wolf frequency declined after Stage 2 ($P < 0.001$) and Gull frequency increased from after Stage 1 ($P > 0.001$).

Species Interactions

A total of 812 interactions were detected and occurred in 13% of the 5952 motion-activated photos. Of these interactions, 121 (15%) were interspecific and 691 (85%) were intraspecific.

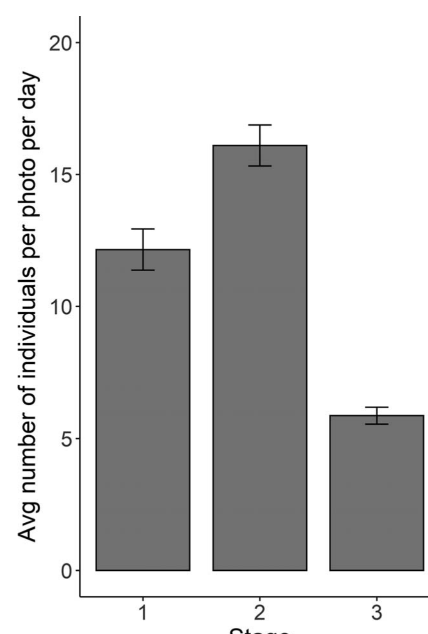

FIGURE 4. The total number of scavengers per photo per day by stage from 29 June–20 September 2016 in Glacier Bay National Park based on timelapse photos taken every 15 min. Error bars indicate standard error.

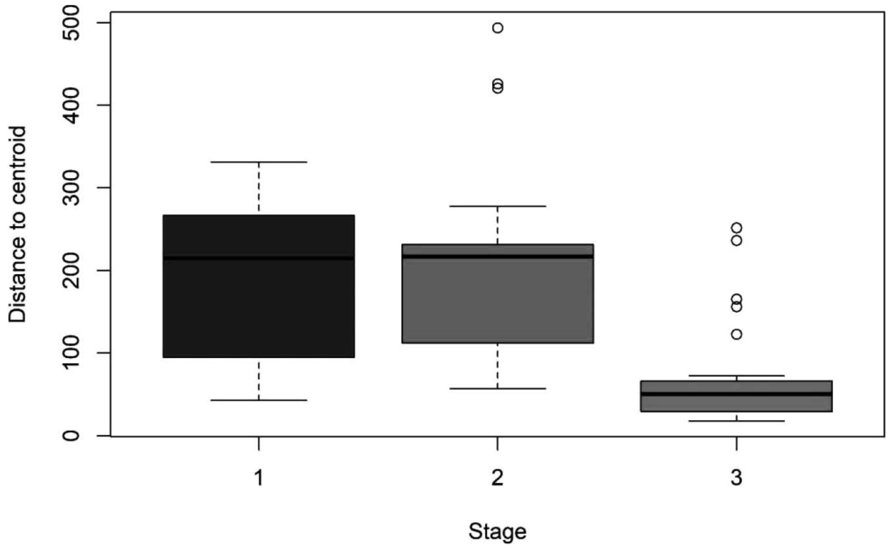

FIGURE 5. Distances to the group centroid for each stage as a measure of comparing species composition dissimilarity on a whale carcass in Glacier Bay National Park & Preserve. Dispersion was calculated for Stage 1, 2, and 3. Results showed that the scavenger species composition during Stage 3 was significantly different from Stages 1 and 2, but scavenger composition was not different between Stages 1 and 2. In Stage 1, the carcass was completely covered in soft tissue. At Stage 2, some bone was exposed. In Stage 3, most of the soft tissue was no longer attached to the skeleton.

Some examples of the interactions detected included eagles fighting, wolves exhibiting submissive behavior while other, more dominant, pack members were feeding, and smaller birds such as gulls flushing in response to an eagle's arrival (Fig. 2). Data were found to be not normally distributed, so we used the non-parametric Kruskal-Wallis test. The frequency of intraspecific interactions declined with consumption stage (Fig. 6; $\chi^2 = 6.34$, $P = 0.042$. The frequency of intraspecific interactions during Stage 1 was marginally higher than during Stages 3 ($P = 0.06$), but the number of interactions during Stage 2 was not significantly different from stages 1 and 3 ($P = 0.1$ and $P = 0.27$ respectively). The majority of intraspecific interactions involved eagles (Fig. 6). In contrast, there was no detected change in the frequency of interspecific interactions across stages of carcass consumption ($\chi^2 = 1.60$, $P = 0.45$).

DISCUSSION

Marine-pulse subsidies, where a food resource that is not regularly available becomes available, have been known to alter coastal ecosystems; they can benefit plant communities by providing unique nutrients (Spiller and others 2010) and influence animal communities by causing shifts in predator diets, which can cascade down to affect lower trophic levels (Spiller and others 2010). Salmon (*Oncorhynchus* spp.) are one of the main resource-pulse subsidies (Gende and others 2002), whereby carnivores transport fish to land and only partially consume them. The rest of the carcass is left to decompose or be scavenged by other organisms, where the nutrients are deposited through excretion (Gende and others 2001). Although beached whale carcasses do not provide nutrients at the same spatial scale or with the predictability of salmon runs, this subsidy could provide similar benefits. The carcass in Glacier Bay National Park was used by a variety of different vertebrate scavengers, which may indirectly benefit plants in the ecosystem through the transport of nutrients in their feces to other coastal areas. Scavengers may also reduce consumption of primary food sources, thus relieving prey from some predation pressure during that time. This phenomenon was observed in Wolverines (*Gulo gulo*) when the introduction of wolves shifted Wolverine diet from their usual prey to scavenging carcasses from wolf kills (Dijk and others

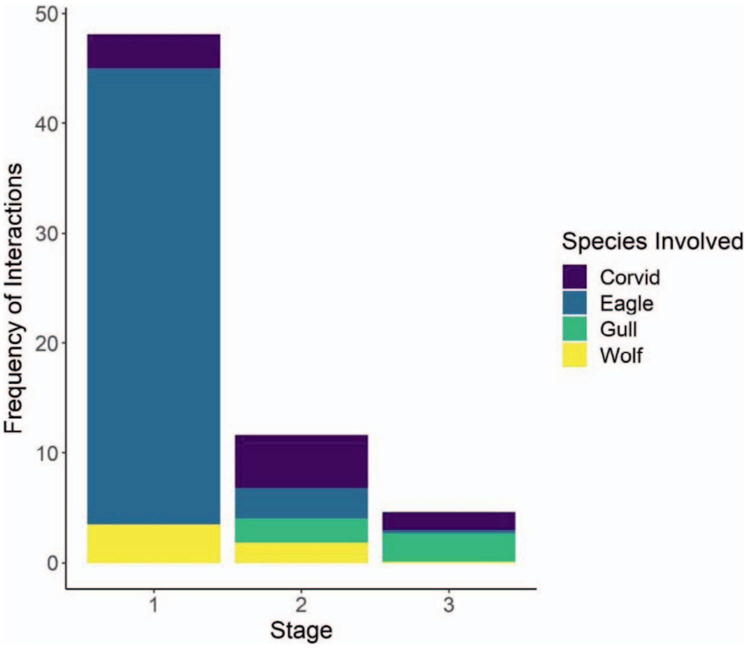

FIGURE 6. The frequency of interactions per stage of consumption from 29 June–20 September 2016 in Glacier Bay National Park based on motion activated photos. Colors indicate which species were involved. Interaction is defined as anytime 1 individual displayed dominant or aggressive behavior toward another. Stage 1 occurred when the carcass was completely covered in soft tissue. Stage 2 occurred when some bone was exposed. Stage 3 occurred when most of the soft tissue was no longer attached to the skeleton.

2008). Changes to foraging behavior of scavengers were also observed in Andean Condors (*Vultur gryphus*) as a result of reduced marine subsidies (Lambertucci and others 2018).

The Humpback Whale carcass in Glacier Bay was scavenged primarily by avian scavengers, with only a single mammalian species, the Grey Wolf, detected scavenging over a 108-d period. Bald Eagles were the 1st scavenger to appear at the carcass, likely owing to their ability to search wide areas with little effort. Most of the eagle activity occurred during the 1st stage of carcass consumption and then declined after the first stage, similar to what was observed by Wilmers and others (2003b) in Yellowstone, in that eagles and ravens arrived at ungulate carcasses first, followed by mammals such as Coyotes. After Stage 1, the numbers of eagles feeding on the carcass markedly decreased. Optimal foraging theory predicts that an animal's foraging behavior should maximize the net energy gained per unit of time (MacArthur and Pianka 1966). If the food source is no longer the most abundant or profitable source accessible to that animal, it is likely to move on to another, more beneficial food source. The lack of eagles likely allowed smaller birds such as gulls and corvids to feed on the carcass during Stage 2. During Stage 3, the number of scavengers feeding on the carcass declined, likely because less carrion was available to feed on.

Contrary to our expectations, the highest number of daily interactions occurred during Stage 1. We predicted that a whale carcass would be too large of a resource to defend, and although many individuals foraged simultaneously on the carcass during Stage 1 (avg = 12.15 individuals per photo), the abundant resource attracted large numbers of individuals, which increased the number of interactions while also swamping the ability for individuals to monopolize the resource. Most of the interactions occurring during the carcass consumption were among Bald Eagles. Bald Eagles dominated the carcass during the 1st stage, so there were few opportunities for interactions with other species. Eagles may therefore have effectively excluded smaller scavengers from the carcass, and we were unable to quantify this avoidance because of the relatively small field of view of the camera. Gulls appeared almost immediately after eagles left, suggesting that they were avoiding the area when the eagles were present. Thus, the frequency of interactions detected by cameras on carcasses may not provide a complete picture of competitive dynamics. Cortés-Avizanda and others (2009) found that the presence of facultative scavengers at a carcass caused avoidance behavior from potential prey animals in the surrounding area. Additional cameras in the surrounding area could provide useful insights regarding the presence of potential scavengers that may be avoiding a carcass due to the presence of a dominant competitor.

As expected, all interspecific interactions involved a larger species initiating an interaction with a smaller species. However, many of these interactions did not involve direct confrontation; instead, an individual or group of smaller scavengers often left the carcass when a larger scavenger arrived. For example, there were many instances where gulls and corvids either flew completely away or moved to a different spot when an eagle arrived. Hiraldo and others (1991) observed similar behaviors where large raptors, such as eagles, displaced smaller birds at carcasses.

The use of motion-triggered photos to quantify interactions could have led to some biases. For example, interactions between larger individuals may have been more likely to have triggered the camera than interactions between smaller individuals. Because all interactions require some sort of movement, we assumed that the camera caught all motion within its range, but there is a chance that interactions were missed based on the size and distance of the individual involved, as remote cameras are more likely to be triggered by animals of larger size or closer to the camera (Rowcliffe and others 2011). If there was a size bias, there may have been more interactions in the later stages of consumption than were detected. Because eagles were mostly present during the 1st stage, their interactions were likely detected more often because of their large size. In stages 2 and 3, few eagles appeared, and the carcass was dominated by smaller birds such as corvids or gulls. These stages may have had more interactions that weren't detected by the camera. However, the differences among the types of interactions that we detected during each stage should not be affected by this potential size bias.

The biggest surprise coming from of this study was the lack of diversity in mammalian scavengers. We expected Black (*Ursus americanus*) and Brown Bears (*Ursus arctos*) to have scavenged this carcass, yet neither species was observed over the course of our study. Lewis and Lafferty (2014) examined the interactions between bear and wolf scavengers at a Humpback Whale carcass on the shoreline of Glacier Bay, located about 64 km (40 miles) northwest of the current study site, and found 1 to 6 Brown Bears at a time feeding on the carcass every day except for 1 from May–September 2010. In addition, 1 to 7 wolves were seen scavenging on the carcass sporadically throughout the study, at times feeding simultaneously with Brown Bears. Lafferty and others (2016) reported scavenging on a hunter-provisioned Moose (*Alces alces*) carrion in the Gustavus forelands near Glacier Bay and found that Black and Brown Bears were common scavengers on the carcasses in addition to wolves. Similarly, whale carcasses have been found to attract aggregations of both Polar (*Ursus maritimus*) and Brown Bears in other parts of Alaska (Lunn and Derocher 2006; Van Daele 2007). Both Black and Brown Bears occupy the areas surrounding this carcass (Lewis and others 2020). Though mainland population densities of Brown Bears have not been tested in this area, the Alaska Department of Fish and Game considers the population stable (Bethune 2015). Black Bears occupy this area with an estimated density of 1.3–1.5 bears per square mile (Sell 2014). We do not know why bears did not scavenge the Humpback Whale carcass during this study. One possibility is that this area contained abundant food resources for bears during this study. If plant, berry, and salmon resources were abundant that summer, bears may not have needed to travel long distances in search of food and therefore did not discover and feed on the carcass. If bears were present at the carcass, the community composition of scavengers would likely shift, with bears being the dominant scavenger. We hypothesize that the presence of bears would have excluded or shifted the behavior of smaller scavengers during times where bears are feeding, similar to what was observed when wolves were present.

An unpredictable marine subsidy like a whale carcass can have large effects on intertidal and terrestrial ecosystems. The quality of carrion available has been known to affect the degree to which a scavenging event alters the ecosystem (Wilson and Wolkovich 2011), and a carcass as large as a Humpback Whale can support scavengers for many months. Our study showed a successional pattern of primarily avian scavengers, with eagles dominating the resource subsidy during the 1st stage of consumption when the carcass was covered in soft tissue. After eagles left the carcass, smaller birds arrived and fed for the remainder of the process. Avian scavengers seemed to benefit most from this carcass, as only 1 mammalian species was detected utilizing the resource. More research is needed to understand the indirect effects of a whale carcass on terrestrial ecosystems and the scavenging use by smaller invertebrate and microbial organisms. In addition to the impact on the ecosystem, a carcass of this magnitude can also impinge on human safety. If a carcass is located near a populated area, it can cause a potential safety hazard to people nearby. Some large carnivores like Brown Bears that are known to scavenge carcasses may exhibit resource protection behaviors and become dangerous to humans. Knowing which scavengers are present and how long they stay can help managers keep both the humans and the wildlife safe by minimizing the potential negative human-wildlife interactions. Whether it is to the natural ecosystem or human safety, a whale carcass has an impact on its surroundings, and our knowledge of the patterns of the scavenging process is valuable to our understanding and management of the ecosystem.

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