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SUSPECTED SURPLUS KILLING OF HARBOR SEAL PUPS (*PHOCA VITULINA*) BY KILLER WHALES (*ORCINUS ORCA*)

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Within the inland waters of Washington State and southern British Columbia Province, 3 distinct ecotypes of killer whales (*Orcinus orca*) occur. The better known ''resident'' and ''transient'' populations each display unique genetic (Hoelzel and others 2002), dietary (Baird and Dill 1995; Ford and others 1998), behavioral (Baird 2000), vocal (Ford 1990) and morphological differences (Baird and Stacey 1988). The resident pods, also known as the ''southern resident'' population, eat primarily fish and occur in large stable groups (Bigg and others 1990). Transients feed primarily on other marine mammals and occur in smaller and less stable groups (Baird and Dill 1995, 1996; Baird and Whitehead 2000; Baird 2000). The 3rd population, which is seen occasionally in the area, is called the ''offshore'' ecotype (Wiles 2004). These killer whales are believed to be primarily fish eaters (Hoelzel and others 2002) that are smaller in size than other ectotypes and genetically distinct from both residents and transients, although more closely related to the resident killer whales. We recently identified a novel mortality pattern in harbor seals (*Phoca vitulina*) that strongly suggests 1 or more individuals from 1 of these ecotypes killed seal pups for reasons other than consumption.

As part of an ongoing disease-screening project, complete postmortem examinations were performed on dead marine mammals in suitable condition from San Juan County, Washington (48.6°N, 123.0°W). Necropsies were oriented toward determining the cause of morbidity or mortality and to survey for specific pathogens. Routinely complete examinations were performed and gross observations were recorded. Tissue samples were preserved in 10% neutral buffered formalin, processed, and evaluated microscopically. Kidney and liver were screened for heavy metals, and other ancillary tests such as aerobic bacterial culture, polymerase chain reaction, and attempted virus isolation were performed as indicated.

Since 1977, The Whale Museum (Friday Harbor, Washington) has maintained a database of public and scientific sightings of killer whales and other cetaceans in Washington and southern British Columbia inland waters. In 1981, the marine mammal sighting network was expanded to include stranding data for San Juan County. These databases provided stranding

TABLE 1. Characteristics and gross lesions of harbor seal pup carcasses found in San Juan County, WA, September and November, 2002. Seal pups were killed but were largely uneaten.

Date found	Gender	Decapitation	Lacerated flippers	Puncture wounds	Whale ecotypes sighted
3 Sep	male	partial	unilateral	none	residents, transients, offshores
13 Sep	female	complete	no	yes	residents, transients, offshores
1 Nov	female	partial	bilateral	yes	residents, transients
10 Nov	female	complete	bilateral	yes	residents, transients
10 Nov	male	partial	no	yes	residents, transients

data as well as information on the presence of killer whale ecotypes within the region. All sighting and stranding data are recorded by species, date, location, and by quadrants of approximately 2 km^2 (Heimlich-Boran 1986, 1988; Felleman and others 1991; Olson 1998). The observers contributing to the killer whale database include the untrained general public, long time shoreline residents, trained marine naturalists, and marine mammalogists with extensive photo-identification experience. Observations submitted by the untrained general public are only included in the database when they are verified through an interview or have a convincing description of the species that can be corroborated with at least 1 other sighting. Stranding data are collected by a group of trained volunteers.

Between 3 September and 10 November 2002, 13 harbor seal pups were found dead on beaches in San Juan County during 2 distinct time spans: from September 3 to September 13 and November 1 to November 10 (Table 1). Five carcasses (3 females and 2 males) had similar gross lesions indicating predation without consumption (Table 1). Specifically, carcasses had various combinations of the following gross lesions: partial or complete decapitation, lacerations to the hind flippers, and 1- to 3-cm-diameter, semi-elliptical abrasions and occasional punctures on the thorax and/or abdomen (Fig. 1 and Table 1). In 1 animal, abdominal viscera herniated from an abdominal puncture, and 2 additional animals had large amounts of blood in their chest cavities (hemothorax). The acute hemorrhage noted in several animals suggested that trauma was antemortem and the proximate cause of death. Four carcasses were in good nutritional condition as evidenced by adequate subcutaneous and visceral adipose stores and only the seal pup found on 1 November, 2002 was moderately emaciated (Table 1). Aside from the nutritional status of 1 animal, gross and microscopic examination, trace mineral analysis of liver and kidney, and aerobic bacterial culture of multiple organs did not reveal underlying disease, suggesting that seals were healthy at the time of predation.

Serrated lacerations consistent with shark bites were not seen on any of the carcasses. Margins of the partially to completely truncated torsos or heads were sharply delineated and variably hemorrhagic. Based on wound measurements and comparison with archived killer whale skulls (The Whale Museum, unpubl. data), the dimensions and spacing of the semi-elliptical pattern of puncture wounds seen on 4 of the 5 carcasses were consistent with the mandibular span and dentition of killer whales. Sighting records confirm the presence of resident (all 3 pods; J, K. and L) and transient killer whales in the region during both periods and the presence of offshores only during the 1st time period (Table 1). Consequently, we hypothesize that 1 or more killer whales were likely responsible for all 5 killings.

Between 1982 and 2002, 281 dead harbor seals were reported in San Juan County (The Whale Museum, unpubl. data), with no injuries of this type found. We hypothesize these events represent a novel pattern of killing without intent to eat and that 1 or more transient killer whales were most likely responsible. In this region transient killer whales are the main predator of harbor seals and seals are the whales' most important prey (Baird and Dill 1996). Additionally, the pattern of these seals being killed in 2 short and distinct periods matches the travel patterns of transient whales that often make relatively brief appearances in the inland waters of Washington and British Columbia and then are not seen for sometimes years at a time (Baird and Dill 1995). If 1 or more transients were responsible for these mortality

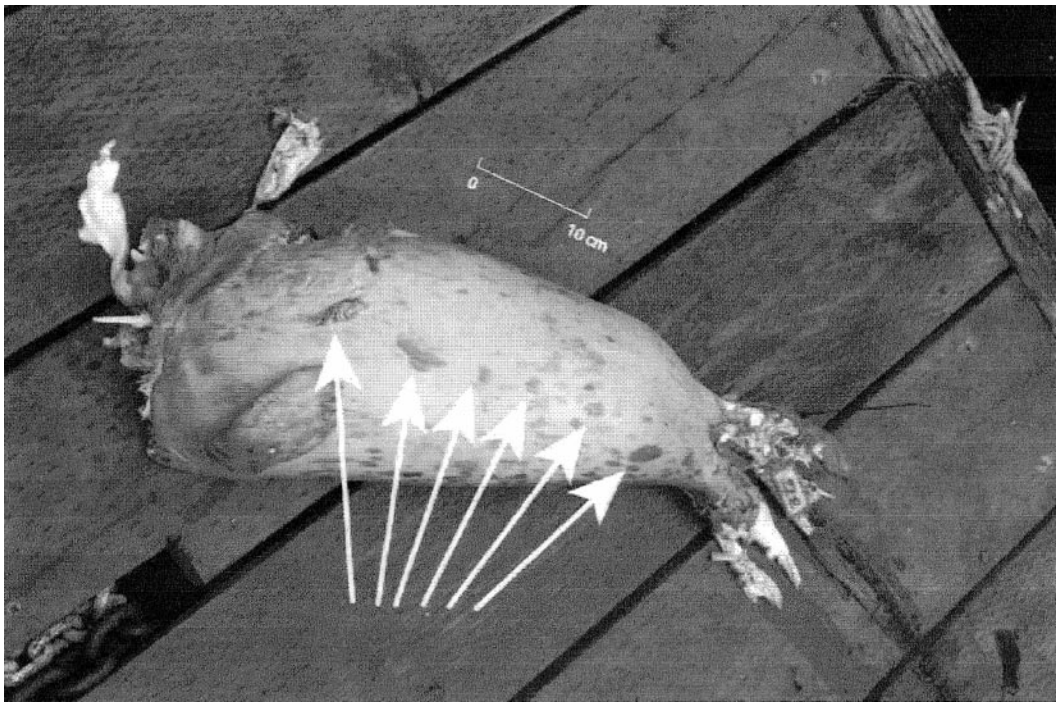

FIGURE 1. Photograph of a harbor seal pup (2002- SJ036) with lesions suggestive of killer whale predation without consumption. Note the missing head, arrows pointing to the puncture wounds arranged in a semi-elliptical pattern, and the lacerated hind flippers. Photo courtesy of KC Balcomb III, Center for Whale Research, Friday Harbor, Washington.

events, this marks a distinct pattern variation from prior observations. Previous observations by Baird and Dill (1996) detected only 4 instances when >1% of a pinneped carcass was apparently abandoned by transient killer whales. In the 5 cases we identified, the entire carcasses, excluding all or part of the head, were abandoned. The cases observed by Baird and Dill (1996) were found in August and September, the period when harbor seal pups in the area are being weaned, are foraging on their own, and are most vulnerable to predation. Food intake rates for transients are more than double during this period compared to the remainder of the year, and prey handling times are also approximately double during this period, presumably because the whales are more than meeting their energetic needs and extended prey handling is serving some other purpose (Baird and Dill 1995). The 5 killings from 2002 described here occurred in September and November, just after the time when food intake rates are highest for transient killer whales in the region. The killing of these harbor seal pups appears to be for reasons other than consumption. Evidence of bite wounds to the head and flippers of all animals and to the thorax and abdomen of 4 of the 5 animals indicates that whales had ample opportunity to consume these seals, but did not do so. Similarly, Stacey and others (1990) observed transients killing or wounding seabirds in the same study area without consuming them.

Because they were sighted during only 1 of the 2 time periods in which these seal carcasses were found and because they are believed to be fish eaters (Hoelzel and others 2002), it is unlikely that offshore ecotype killer whales were responsible for these killings. Although resident killer whales feed primarily on fish (Ford and others 1998), they have been reported to harass, but not kill harbor seals and porpoises (*Phocoena phocoena* and *Phocoenoides dalli*) (Jefferson and others 1991; Ford and others 1998; Richard Osborne, The Whale Museum, Friday Harbor, WA, pers. obs.). Also, all 3 resident

pods were sighted in the region during both of the time periods in which these seal carcasses were found. Consequently a potentially valid hypothesis for these 5 cases is killing by 1 or more resident killer whales. ''Aberrant'' behavior by a single resident whale could explain all of these moralities. If true or if an offshore killer whale was responsible for these mortalities, then there is concern this behavior could result in the transmission of pathogens from harbor seals to these killer whale ecotypes. While transient whales are probably regularly exposed to such pathogens through routine handling and consumption of harbor seals, this would represent a novel route for disease transmission in resident killer whales. Disease is an important ecological force and exposure to potential novel pathogens such as a morbillivirus or herpes virus could impact the health status of the southern resident killer whale population (Gaydos and others 2004), which is considered endangered in Canada (Baird 2001) and Washington (Wiles 2004).

Regardless of the ecotype responsible it is apparent that these harbor seals were killed for a purpose other than consumption. These deaths could represent examples of surplus killing, which is defined as predators killing prey in numbers exceeding that which can be consumed at 1 time (Wobeser 2000). It is characterized by an absence of, or a low level of, utilization of the carcass by the predator (Short and others 2002). This behavior has been described in red foxes (*Vulpes vulpes*) (Short and others 2002), spotted hyenas (*Crocuta crocuta*) (Kruuk 1972), mink (*Mustela vison*) (Wobeser 2000), and other mammalian predators (Short and others 2002) and has been previously proposed in transient killer whales (Stacey and others 1990; Jefferson and others 1991). The mortality pattern involving harbor seal pups in 2002 resembles surplus killing. Alternate explanations are that such predation could represent a form of play behavior or result from adults training younger whales to hunt. This mortality pattern has not been observed in harbor seal carcasses found since 2002. This is not likely to be due to a reduced abundance of harbor seal pups as seal abundance has not varied greatly since 2002. Continued surveillance should reveal whether this pattern of predation resumes in the future or was a single event.

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