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ABSTRACT: Harbor seals (*Phoca vitulina*) are a well-studied marine mammal, particularly in downtown Bellingham Whatcom Creek through an ongoing undergraduate research program that was started in 2011. While the hunting behavior and the threat of individual seals on fish populations has largely been studied, harbor seal social behavior in Whatcom creek has not seen as much attention. Past data was sorted and organized, then separated into independent hunting events to analyze the hunting success of individuals relative to different sizes of groups of harbor seals. Cooperative hunting was found to occur in the study system, but it was unclear what, if any, benefit the harbor seals incurred from the behavior. Much further research and analysis should be performed to fully understand the question.

Introduction

Cooperative hunting is defined as any type of active hunting behavior that includes the effort of more than one individual (Parker and Ruttan 1988). Cooperative hunting is common and leads to higher success rates than that of individual hunting when the prey is large or difficult to catch (Parker and Ruttan 1988; Strander 1992). Hence, it has been largely observed among predatory carnivores as a means of catching prey that may be larger or faster than themselves (Parker and Ruttan 1988; Strander 1992). This behavior occurs most commonly in predators with strong social bonds, such as wolves (*Canis lupus*) (Robbins et al. 2019) and lions (*Panthera leo*) (Stander 1992). Wolves approach large prey in large group sizes to attack and capture individuals; larger group sizes usually led to more success in capturing bison (*Bison bison*), one of the most difficult prey for wolves to catch (MacNulty et al. 2014). In the case of marine mammals, cooperative hunting has been reported in baleen whales, sirenians, and pinnipeds, and has been well described in cetaceans, particularly odontocetes or toothed whales (Packer and Ruttan 1988; Sachs et al. 2004; Heithaus et al. 2018). However, in many species it is unclear whether individuals combine efforts to pursue and capture prey, or merely aggregate in an area where food is concentrated. One of the clear examples of cooperative hunting (and a support of the argument that marine mammals live in groups because of foraging benefits) is provided by transient killer whales (*Orcinus orca*) living in the Pacific Northwest. They prey on harbor seals and other small marine mammals and maximize their caloric intake if they feed in groups of three, which is the size of the group in which they live. The small size of these groups

is apparently maintained by the departure of all offspring and all but one male offspring from their natal group (Baird and Dill 1996).

Pinnipeds (seals, sea lions, fur seals, and the walrus) do not appear to show the strong individual bonds that are found in social odontocetes. However, several studies have described the presence of cooperative hunting in different pinniped species. For example, Galapagos sea lions (*Zalophus wollebaeki*) hunt in groups with multiple different roles – while one individual herds yellowfin tuna (*Tunnus albacares*) in from the open sea into a bay, other individuals would capture the prey or prevent it from escaping (Páez-Rosas et al. 2019). In another study, leopard seals (*Hydrurga leptonyx*) were documented as having one seal anchoring the catch for another individual to tear off a piece (Robbins et al. 2019). However, we know little about the foraging success of individual pinnipeds hunting in groups relative to that of those hunting by themselves, which is a hallmark of cooperative hunting.

Harbor seals (*Phoca vitulina*) are the most abundant and widely distributed marine mammal in the Salish Sea, the inland waters of Washington State, USA, and British Columbia, Canada. In Whatcom Creek, downtown Bellingham, WA, harbor seals have been studied since 2011, as they tend to aggregate during the peak adult salmonid runs – which are mainly comprised of Chum salmon (*Oncorhynchus keta*) – in the fall (Woodrich 2016; Newmarch 2018). At the site, harbor seals have prey on adult salmon, which are relatively challenging to capture and handle given their agility and size. Observations of harbor seals hunting are easy to make and document from a boardwalk that gives a full view of the narrow (< 50 m) creek. Over the many years of observation, the occurrence and hunting behavior of identified individual harbor seals has been well documented, including the fact that the best predictor of hunting success is the number of seals in the creek (McKay 2019). As such, Whatcom Creek is an ideal

system to examine the existence of cooperative hunting in harbor seals and determine the foraging success of individuals hunting alone or in groups. My objectives were to determine if harbor seals exhibit cooperative hunting behavior and to determine the foraging success of individual seals. Given that other pinniped species appear to hunt cooperatively, I hypothesized that harbor seals in Whatcom Creek hunt cooperatively and that individual seals consume more salmon when hunting in a group than by themselves. To conduct this study, I documented the foraging success of individual harbor seals relative to group size.

Methods

Study site

The mouth of Whatcom Creek is located in the heart of downtown Bellingham (48°45'14"N, 122°29;00"W) and connects Lake Whatcom to Bellingham Bay. The study site is approximately 215 meters long and ranges from 25 to 58 meters across. Seals can safely be observed from a boardwalk built along the north bank of the creek. The creek and its four main tributaries provide about four miles of accessible salmon habitat to support wild self-sustaining runs of Coho (*Oncorhynchus kisutch*) and Steelhead (*O. mykiss*), as well as hatchery Chum and Chinook salmon (City of Bellingham n.d.; R2 Resource Consultants Inc. 2009).

Data collection

Data on occurrence and behavior of harbor seals have been collected at Whatcom Creek since 2011 by undergraduate students at Western Washington University. Observations occurred four to five times a week during the busy season (September through January) and one to two times a week during the rest of the year. Each observation lasted for two hours, during maximum

and minimum daylight tides. Students recorded details every half hour the number of sports fishers, the number of seals, and the number of fish caught by either fishers or seals. Additionally, every time a seal surfaced, a picture was taken, and behavioral data were recorded. When taking pictures, observers attempted to take a picture of three angles of each seal's face: the front, the right side, and the left side. This only could occur with cooperation of the individual. If there were multiple seals that surfaced at the same time and were hunting cooperatively, observers took a wide shot that included all seals in the frame.

Behavioral data collected for each surfacing event included time of day, number of seals surfacing, amount of seconds from when the first seal came up until the last seal went down, where the seals were located in the creek, time spent at the surface, behavioral state of seals, hunting technique if applicable, and a notes section. The behavior state included several different options for the observer to choose (Table 1a).

Table 1a: Catalog of seal behavioral states

Behavior	**Distinguishing characteristics**
Hunting	Seal is observed employing one of the techniques listed in table 1b
Eating	Seal is visually confirmed to have a fish in its mouth or flippers
Social, non-hunting	Multiple seals are observed interacting less than a meter apart while not hunting. If seals are hunting or eating cooperatively, they are recorded as hunting
Inactive	Seal is passively floating or appears to be resting
Other	Behavior not encompassed by any of the above categories

If seals were hunting, observers could select a hunting technique that seals were employing during the hunt (Table 1b). Indications of hunting behaviors were quick movements through the water, quick changes of direction, upside-down behavior, splashing, or quick, consistent surfacing events.

Table 1b. Catalog of hunting techniques employed by harbor seals

Hunting Technique	Distinguishing characteristics
Wake/Chase	Seal is moving quickly through the water generating a wake in its path
Upside Down	Seal is scanning the surface of the water while upside down
Bank	Seal is scanning the shallow area or using the bank to trap prey
Jump	Seal partially leaves the water in order to capture a fish near the surface
Parked	Seal is stationary waiting for prey to enter close proximity

Observers also made notes that helped conceptualize observations, ranging from short comments such as “noisy construction” to more descriptive statements such as, “two seals hunting together in group while two other seals parked by fish ladder”.

Data Processing

Data on seal occurrence and general behavior have been collected since 2011. However, I excluded all observations from 2011-2013 because researchers at the time were not recording data on when new fish were caught. Starting with data collected since 2014, I tallied how many seals were observed at that time and how many new fish were successfully caught during each foraging occurrence which I defined as an observation of a seal or seals eating or hunting. Foraging or hunting success was defined by a seal catching a fish, or a fish in the mouth of an individual seal. When there was a fish in the mouth of a seal, the observer could indicate that it was eating on the data sheet. To ensure that observations were independent, I only analyzed foraging occurrences from different days or from different individuals at different times during the same day. New events occurred when I was sure that a new seal had arrived or a seal had for sure left, if it was a new day, or if there was a change in behavior state, or if the seal was not directly involved in the hunting process (for example, if a new seal came after the fish had already been caught or was inactive during the hunt and had presumably only come back to steal or share the fish).

Number of seals, or group size, was defined as the number of seals that appeared to be working together with another seal in a hunt. This is the distinction between several seals in the same creek hunting on their own and a group of seals hunting together but defining number of seals as groups that were working together to hunt in the creek proved to be a difficult task. Sometimes there was not enough information to determine how many seals were in which group. Because group size used to be recorded in the notes section, sometimes there was not enough information to determine how many seals were in which group. Thus, I only included surfacing events where I could confidently determine group size based on the notes sections.

After organizing the data sheet, successful foraging events were counted and divided that by the number of total independent surfacing events for each group size and turned into a percentage. Success was calculated for both the entirety of the Chum salmon run for each year (October through December), and just November, which is when the amount of salmon is the most significant during the run season.

Results

For my study, I only employed data from 2014 through 2016, totaling 243 independent feeding events. Of these, 79 events were carried out by single seals, 52 by two seals, 41 by three seals, and 71 by four or more seals. Harbor seals did engage in cooperative behaviors at the creek. Observers frequently observed seals working together when hunting, and this involved anywhere from two to eight seals working together. Seals would sometimes both chase a fish on using the bank of the creek, and other times, seals would circle around a fish. It often appeared that seals would chase or corner fish into shallower waters on the bank of the creek.

Hunting success appeared to be higher in groups of one and four seals during the month of November, when there is a high certainty of fish being located in the creek (Fig. 1). However, there was no significant difference among group sizes ($\chi_4 = 1.43$, $p = 0.84$),

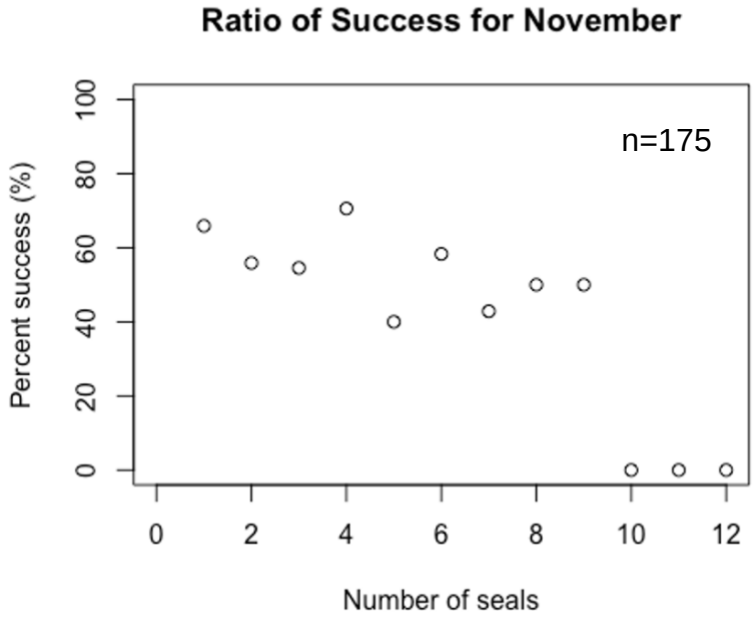

Figure 1. Ratio of harbor seal hunting success at Whatcom Creek during November. Data points show the percentage of successful hunting events relative to harbor seal group size.

Hunting success was slightly lower when including data from September through December, which is the full period when the Chum run occurs. In addition, there was no significant difference among group sizes ($\chi_3 = 1.29$, $p = 0.73$) (Fig. 2).

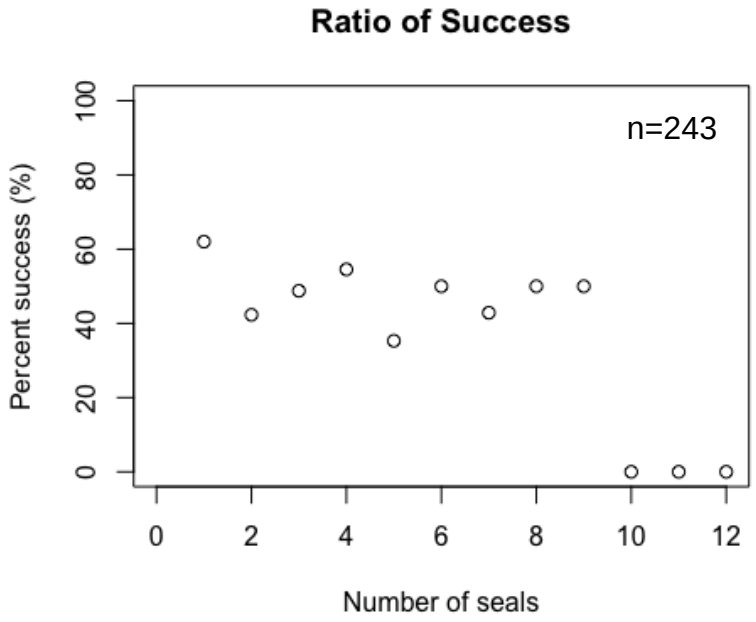

Figure 2. Ratio of harbor seal hunting success at Whatcom Creek during the full Chum salmon run (September through December). Data points show the percentage of successful hunting events relative to harbor seal group size.

Discussion

Harbor seals exhibited coordinated hunting behaviors as described in other pinnipeds. In addition, they hunt in groups larger than one relatively frequently. However, their hunting success was not higher when hunting in a cooperative manner versus individually. The results did not support my hypothesis that harbor seals are more successful when they hunt cooperatively. Yet, there is still much more work to do to fully understand the question.

The results of cooperative hunting observations did align with other research suggesting that pinnipeds and other marine mammals corner or chase their prey into shallower waters to make it easier to catch (Páez-Rosas et al. 2019; Baird and Dill 1996). It is possible that hunting

success did not increase with the number of seals because the seals gain other benefits outside of being more successful at catching fish. Even if the analysis of the rest of the data continued to show that hunting success does not increase with number of seals, there are two other potential benefits that harbor seals may receive when hunting in groups. One of them could be that it is less energetically costly for them to capture fish in groups than by themselves, as is shown by Galapagos sea lions when hunting together (Páez-Rosas et al. 2019). An indirect way to measure this potential benefit is to tally the time that it takes seals to capture a fish. The prediction being that time to capture would be highest when seals hunt individually. The second potential benefit of cooperative hunting by seals would be an increase with group size in the number of fish captured per individual seal.

Several unexpected issues arose when working through the data. Separating independent hunting events was challenging given that the data did not directly address my questions. In addition, that factor mad it nearly impossible for me to determine the time that it took to catch fish with confidence. In the future, exact questions asking how many seals are in each group, what each group is doing, how many fish are caught by each seal, and when exactly a new fish is caught can and should be added to the data sheet. There were also inconsistencies in the data in earlier years, which made the sample size smaller than anticipated.

In conclusion, harbor seals engaged in coordinated feeding behavior; however, it is unclear what benefit they are incurring. Future work could determine if harbor seals receive any of the two benefits proposed here. In addition, this study has generated further research questions such as how frequently do the seals hunt cooperatively when more than one seal is present? Do they show preferred hunting partners? How many different hunting techniques are there?

Answering these questions will help further understand cooperative hunting behavior of harbor seals at Whatcom Creek and of pinnipeds in general.

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References

Baird, R. W., & Dill, L. M. (1996). Ecological and social determinants of group size in transient killer whales. *Behavioral Ecology 7*: 408–416.

City of Bellingham, WA. Whatcom Creek Habitat restoration. (n.d.). https://www.cob.org/services/environment/restoration/Pages/whatcom-creek.aspx. Accessed April 26, 2020.

Heithaus, M. R., Dill, L. M., & Kiszka, J. J. (2018) Feeding Strategies and Tactics. In: Würsig, B., Thewissen, J. G. M. & Kovacs, K. K. (eds.) *Encyclopedia of Marine Mammals*. pp 354-363. 3rd edition. Academic Press, San Diego, USA.

Jourdain, E., Vongraven, D. (2017). Humpback whale (*Megaptera novaeangliae*) and killer whale (*Orcinus orca*) feeding aggregations s for foraging on herring (*Clupea harengus*) in Northern Norway. *Mammalian Biology*, *86*: 27-32.

MacNulty, D. R., Tallian, A., Stahler, D. R., & Smith, D. W. (2014). Influence of Group Size on the Success of Wolves Hunting Bison. PLoS ONE, *9*: 11. https://doi.org/10.1371/journal.pone.0112884

McKay, M. (2019). Effects of Sport Fishing on Harbor Seal Hunting Success. Poster presented at WWU's 2019 Scholar's week Poster session, Bellingham, WA.

Newmarch, M. (2018). Feeding success of harbor seals in relation to hunting technique at Whatcom Creek. Poster presented at WWU's 2018 Scholar's week Poster session, Bellingham, WA.

Nicholson, T. (2000). Social Structure and Underwater Behavior of Harbor Seals in Southern Monterey Bay, California (Thesis).

Packer, C., & Ruttan, L. (1988). The Evolution of Cooperative Hunting. *The American Naturalist, 132:* 159-198.

Páez-Rosas, D., Vaca, L., Pepolas, R.,Wollocombe, R., Roy, T., & Rivas-Torres, G. (2019). Hunting and cooperative foraging behavior of Galapagos sea lion: An attack to large pelagics. *Mar Mam Sci. 2019*;1–6.

R2 Resource Consultants Inc. 2009. Whatcom Creek Ten-Years After: Summary Report. Page City of Bellingham, Department of Public Works.

Robbins, J., Poncet, D., Evans, A., & Hocking, D. (2019). A rare observation of group prey processing in wild leopard seals (*Hydrurga leptonyx)*. *Polar Biology 43:*1625-1630.

Sachs, J., Mueller, U., Wilcox, T., & Bull, J. (2004). The evolution of cooperation. *Quarterly Review of Biology 79(2)*:135–160.

Stander, P. E. (1992). Cooperative hunting in lions: The role of the individual. *Behavioral Ecology and Sociobiology 29:*445–54.

Woodrich, D. (2016). Effects of environmental variables on harbor seal (Phoca vitulina) occurrence at a seasonal foraging site in Bellingham, Washington. Poster presented at WWU's 2016 Scholar's week Poster session, Bellingham, WA.