Results of the 2021 Survey of the Sea Otter Population in Washington State

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Introduction

Northern sea otters, *Enhydra lutris kenyoni* (hereafter sea otter or otter), historically ranged throughout much of the coastal North Pacific. In the western North Pacific Ocean, sea otters could be found from the northern islands of Japan through the Commander and Aleutian Islands, including areas as far north as the Pribilof Islands. In the eastern North Pacific Ocean, sea otters ranged from the Alaska Peninsula south along the coast to Oregon (Wilson et al. 1991). In Washington, areas of sea otter concentration were reported from the Columbia River north along the coast of the Olympic Peninsula (Scheffer 1940). Washington's sea otter population was extirpated through hunting by the early 1900s. In 1969 and 1970, sea otters were captured at Amchitka Island, Alaska, and translocated to regions where they had been extirpated, including locations in Alaska, British Columbia, Washington, and Oregon. In Washington, a total of 59 sea otters were translocated to the outer coast of the Olympic Peninsula, with 29 individuals released near Point Grenville in 1969 and an additional 30 otters released near La Push in 1970 (Jameson et al. 1982; Jameson et al. 1986). In 2004, Washington State published a recovery plan for sea otters (Lance et al. 2004), and the status of the Washington sea otter population is reviewed by the WDFW every five years (for the most recent status review see Sato et al. 2018).

Since 1989, aerial and ground surveys have been conducted by WDFW and USFWS/USGS to monitor Washington's sea otter population. Only three years of counts are missing from this time series – 2009 due to poor weather conditions, 2018 due to lack of funding, and 2020 due to the COVID-19 pandemic. In 1989, the population was estimated to be 208 sea otters, living primarily in the rocky habitats north of La Push, but with a small number counted as far south as Destruction Island. By 2019, the population had grown to at least 2,785 otters (Jeffries et al. 2019). During this time, sea otters have

continued to occupy the primary range between Point Grenville and Cape Flattery, with population growth occurring within this range. Extralimital reports of sea otters have come from Oregon, as far south as Cape Arago, in the Strait of Juan de Fuca, San Juan Islands, Admiralty Inlet, Bellingham Bay, and southern Puget Sound. A translocated population of sea otters also occurs along the outer Vancouver Island coast from Barkley Sound to Cape Scott.

Methods

Survey Protocol

Sea otter aerial surveys are flown in WDFW's Partenavia P-68C-TC (N 357 PN) (Figure 1) or in a contracted Cessna 206, and cover coastal waters within the historical range of sea otters in Washington. A reconnaissance flight from Tillamook Rock, OR (45.3852° N -124.0184° W), north to Cape Flattery, WA (48.3861° N; -124.7261° W), then east into the Strait of Juan de Fuca to Freshwater Bay (48.1432° N; -123.6089° W), WA, is conducted the day prior to beginning surveys to establish sea otter distribution and investigate the possibility of range expansion. This reconnaissance flight is then followed by three consecutive days of surveys covering coastal waters from just north of Grays Harbor, WA, at Copalis Rocks (47.2952° N; -124.2610° W) to Cape Flattery, and then east in the Strait of Juan de Fuca to Freshwater Bay. For discussion purposes, this survey area is broken up into a southern segment (from La Push south) and northern segment (from La Push north and into the Straight of Juan de Fuca).

Surveys are flown at approximately 800–1000' Above Ground Level (AGL) following a trackline along the coast about 0.5 mile from shore, allowing observation of a strip from the shoreline to ~2 miles offshore. This trackline covers all kelp beds and nearshore rocks and reefs along the outer Washington coast from Copalis Rocks north into the Strait of Juan de Fuca. The flight crew consists of the pilot and three observers – a primary observer, secondary observer/data recorder, and a tertiary observer. The primary observer sits in the right front seat and is responsible for locating otters and directing the pilot; photographing otters with a digital camera (Canon EOS 7D Mark II equipped with a 100–400 mm lens); and counting (groups < 25 otters) or estimating (groups >25 otters) group size. The secondary observer in the right rear seat looks for otters, especially individuals or small groups near to but not part of large groups, and records times, counts, locations, and photo numbers on a flight log. The tertiary observer sits in the rear left seat, focusing on locating offshore groups and otters that the primary and secondary observers may have missed while focusing on the right side of the plane. For larger groups of sea otters, the aircraft circles clockwise to enable the primary observer to estimate numbers of otters and take digital photos without glare from the sun. For safety purposes, Automatic Flight Following (AFF) is used to track real-time locations for the aircraft. A Garmin GPSmap76Cx is used to record track lines.

2021 Survey Details

The week reserved for sea otter surveys in 2021 experienced high temperatures, resulting in dense fog on the Washington coast. Thus, the reconnaissance flight was canceled and only a single complete survey was flown before the marine layer became established. A single complete survey was completed June 21, 2021. A second survey was attempted June 25, 2021, but was aborted midway through due to persistent fog in the Kalaloch area. Due to COVID-19 safety considerations and restricted access to certain

sites, ground surveys were not conducted as part of the 2021 sea otter survey effort. The 2021 survey crew consisted of M. Kimbrel (pilot), S. Jeffries (primary observer, right front seat), S. Ament (secondary observer/data recorder, right rear seat), and C. Clark (tertiary observer/observer in training, left rear seat).

Photo Counts and Analyses

All digital images of groups of otters taken during the aerial surveys were reviewed and the best photo of each group was identified for use in counting. The best photos are those that are in focus, at an appropriate zoom, have minimal sun glare, and ideally capture the otters rafted at the surface, not swimming directionally or diving. Authors collectively counted adults and pups in the digital images using Image J 1.5i (http://imagej.nih.gov/ij). Photo counts only included otters that were distinguishable (e.g., submerged objects that could not be confidently identified as otters were not counted). Pups identified within digital images were distinguished from adults and classified as dependent based on their small size, wooly light brown pelage, and close association/orientation (generally resting on the chest) with an adult.

Counts of adult and pup sea otters from the digital images were then added to the counts of otters observed during the survey but not photographed (groups smaller than ~25 individuals) to obtain the full count of sea otters from the aerial surveys. Thus, the final estimate consists of the most accurate aerial count of larger groups and estimates of small groups or individuals made during the aerial survey.

Once there is a total count for each flight conducted, the flight with the highest total count becomes the annual estimate. Because only one complete survey could be conducted in 2021, the count from that flight was used by default. This estimate represents the minimum population count over the sea otter range in Washington because there is no correction factor to account for individual animals or small groups off the flight path, outside of the survey area, or underwater when the plane flew over. Because annual estimates are based on the single highest count with no correction factors, an associated variance or confidence limits are not calculated.

Prior WDFW sea otter survey reports presented an average rate of population change (% increase/decrease) and a 3-year moving average of minimum sea otter abundance. The present report includes an average rate of change from 1989 to 2021, but instead of presenting counts with a moving average this document has fit an exponential curve to the count data. This approach provides an estimate of sea otter population growth based on all years in the time series, but also allows prediction across gaps in the dataset (i.e., 2009, 2018, 2020) and assessment of model fit using the R^2 value. An exponential model was chosen because it outperformed other methods (e.g., linear model, 2^{nd} or 3^{rd} order polynomial model) and because it is biologically relevant to a depleted or introduced wildlife population in the early stages of growth towards carrying capacity (Snider and Brimlow 2013). The 3-year moving average is included in the Appendix for comparison with previous reports (Supplementary Figure 1).

Results

Washington sea otter surveys are usually a collaborative effort between biologists and volunteers from the Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, Olympic Coast National Marine Sanctuary, The Seattle Aquarium, Point Defiance Zoo and Aquarium and Quinault Indian

Nation. For 2021, unfortunately, partners that typically participate as ground observers were unable to join the survey effort due to COVID-19 restrictions. The 2021 survey was conducted on June 21, 2021. A reconnaissance flight could not be conducted this year due to dense fog in the study area limiting the survey window. This reconnaissance flight would typically have covered nearshore sea otter habitat and coastal kelp beds from the Columbia River to Port Angeles. We were only able to conduct one full aerial survey, with poor weather conditions precluding surveys on June 22-25, 2021.

The single 2021 aerial survey covered nearshore waters, reefs, and kelp beds from Copalis Rocks north to Cape Flattery, then east along the Strait of Juan de Fuca to Freshwater Bay – the entire sea otter range was completed (Figure 2). Observation conditions were variable ranging from very good to excellent.

The minimum population estimate from the 2021 Washington sea otter survey was 1,811 animals counted on June 21, which included 595 otters in the northern segment and 1,216 otters in the southern segment (Table 1; Figures 3a-6). The count includes 44 pups, 42 in the north segment and 2 in the south segment, though photo quality precluded accurate identification of dependent pups for two large groups in the south segment. Further, dependent pup identifications are typically easier to make through shore-based observations, where observers can spend more time observing animal behavior. Thus, the pup counts from the 2021 surveys, which were aerial-only and did not include observations made by shore-based observers, should not be considered comparable to previous years and are likely to be biased low. The 2021 value predicted from the exponential fit ($R^2 = 0.966$) of the sea otter count data for the entire 1989-2021 time series is 2,353 otters (Figure 4). The predicted values for 2019 and 2020 were 2,033 and 2,187 otters, respectively. This prediction for 2019 is clearly lower than the 2,785 otters observed in that year's surveys; however, it is worth noting that an exponential fit of the counts from 1989-2019 ($R^2 = 0.973$) yield a modeled estimate of 2,245 otters for 2019, which is still >500 fewer otters than were counted in the survey that year (Figure 4). Thus the 2019 count may be anomalously high and could have resulted from sighting conditions and otter behavior or distribution that resulted in a higher-than-average proportion of the population being counted in the annual survey.

Discussion

The 2021 survey results are difficult to interpret on their own. Because 2021 is the first year in the time series to have a substantially lower count than the previous survey (974 fewer animals than in the 2019 survey), the numbers reported here should be considered with caution. Future surveys are needed to determine whether this low count represents an anomaly resulting from otters not documented by the survey, an actual decline in sea otter numbers, or some combination of the two. Even including this apparent drop in numbers, the average yearly rate of growth for the Washington sea otter population from 1989 through 2021 is 8.4%. The change between the 2019 and 2021 surveys, however, was -35.0%, which even partitioned equally among 2020 and 2021 would represent an annual decline of 17.5% in each of those years. Careful consideration is required of the possible causes of the low count in 2021 and whether survey methods should be altered to avoid missing animals.

Between 1989 and 2002, most of the Washington sea otter population was located north of La Push; however, since the late 1990s, the population in the southern segment has been growing at a much faster rate than the population in the northern segment (Figures 5-6). Examination of the growth rates in

the two segments may give some indication as to where otters were "missing" from the 2021 survey (possible explanations for the 2021 low estimate are explored further below). From 1989 to 2019, the average annual growth rate of the sea otter population in the northern segment was 5.6%, whereas sea otters in the southern segment had an average annual growth rate of 20.0%. Divided evenly among 2020 (not surveyed due to COVID-19) and 2021, the change in the sea otter population in the northern segment from 2019 to 2021 maintained a modest growth of 4.2% per year. In contrast, the observed change from 2019 to 2021 in the southern segment amounted to an annual decline of 22.8% in 2020 and 2021 for sea otters in the southern segment. This substantial drop in the number of otters observed in the southern segment resulted in a reversal of the longstanding increase in the proportion of the Washington sea otter population in the southern segment (Figure 6); however, further data are required to determine whether the apparent decrease in sea otter numbers in the southern segment represents a real decline in sea otter numbers or if it is an anomaly.

In the northern segment of the survey area, most sea otters raft in locations where *Macrocystis* kelp beds are a prominent feature, such as Sand Point (Figure 7). In contrast, in the southern segment, recent annual surveys have documented multiple large sea otter rafts in open water 1-2 miles offshore between Hoh Head and the Queets River in sandy bottom habitat without kelp beds (Figure 8). During the 2021 survey, the southernmost sighting was a group of ~25 animals observed near Willoughby Rock. The northernmost otters were two individuals observed at Tatoosh Island. Several otters were recorded in the Strait of Juan de Fuca, including five at Neah Bay, one individual at Seal and Sail rocks, and another at Pillar Point, the easternmost of our otter observations in 2021. Our surveys did not cover waters east of Freshwater Bay, although we are aware of credible sightings in the area, including a mortality at Ediz Hook. Additional verified observations in 2021 of one to three individual otters include the southeastern Strait of Juan de Fuca, San Juan Island's Cattle Pass, multiple reports in Admiralty Inlet, and an observation in Carr Inlet in South Puget Sound. The small number of sea otters frequenting the inland waters of Washington would not add significantly to the population total but would be expensive to locate. Similarly, we did not cover waters in Oregon south of Tillamook Head where credible sightings including multiple mortalities were reported in 2021. To the best of our knowledge no sea otter pups (or dependents) were observed anywhere in Washington or Oregon waters outside of the survey area.

The substantial drop in the number of sea otters observed in 2021 (1,811) compared with the 2019 survey (2,785) may have resulted from any number of causes. First, the apparent decline may have resulted from these animals either being missed during the survey or outside of the survey area when the 2021 aerial survey was conducted. The possibility that observers missed >900 otters in the survey area seems unlikely, as the primary and secondary observers in the plane were highly experienced and sighting conditions were very good or excellent on the day of the complete survey in 2021. That said, the typical approach is to fly several surveys in a single year and choose the highest number for that year's count. The single flight in 2021, if biased low, could not be replaced by a flight with a higher count as it might have in another year. Additionally, in a typical year, counts from shore-based observers would be compared with those from aerial survey counts at sites with shore-based observers present. Historically, this has resulted in some otters being added to the total count that were not observed from the plane; however, this number has generally been small and is not expected to have substantially contributed to the low otter count in 2021.

Perhaps more likely is the explanation that a large number of sea otters were not present in the survey area or were missed on the day the survey was conducted. In 2019, more than 1,000 otters were

observed in the Kalaloch area, many of them in large rafts offshore (though still within several miles of the coast). Such large offshore rafts were not observed in 2021. It is possible that the "missing" sea otters had moved offshore beyond observer limits or dispersed for feeding in 2021, thus were not counted. Similarly, the reconnaissance flight typically flown from central Oregon northward along the Washington coast could not be completed in 2021 due to weather limitations, and if a large number of sea otters were located outside of the typical survey area (i.e., south of Grays Harbor, north of the Strait of Juan de Fuca, or east of Freshwater Bay in Washington's inland waters) on the day the 2021 aerial survey was flown, they would have been missed. Future surveys including southern and offshore legs might help to determine whether Washington's sea otters have shifted their distribution south or farther from shore in recent years.

It is also possible that the lower number resulted from an actual decline in Washington's sea otter population. A record number of sea otters were reported stranded in Washington and northern Oregon in 2021 (n = 63 as of 12/15/2021). A large proportion of marine mammal carcasses do not come ashore and many of those that do are not reported. The nearshore distribution of sea otters, however, makes it much more likely that carcasses from this species will be deposited on the beach, and a decline of the magnitude represented here would likely be represented as a more extreme increase in stranding reports.

The total number of strandings reported in 2020 and 2021 was 108, which represents 11% of the apparent decline across those years. Even with the relatively sparse stranding reporting on some remote areas of the Washington coast, a larger number of strandings would be expected if more than 950 sea otters died in these years. Strandings in 2020 and 2021 did not reveal a consistent cause of mortality, as might be expected if a disease or decline in food resources caused a substantial population decline in these years. Further, despite the record number of strandings in 2021, neither 2020 nor 2021 stand out as substantial outliers in the stranding record, which generally shows an increasing trend of strandings that tracks the increases in the sea otter population.

The most likely explanation for the apparent decline from 2019 to 2021 is a combination of factors described above. The uncertainty surrounding the status of this population highlights the importance of continued survey efforts to track the abundance and range of sea otters in Washington, as recommended in WDFW's sea otter recover plan (Lance et al. 2004). Incorporating an offshore component into the next Washington sea otter survey will be important for determining whether the population has shifted its distribution offshore, and including a reconnaissance flight will help to determine whether the range has expanded to the south or east into Washington's inland waters.

Acknowledgements

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Tables

Table 1. Results of the 2019 survey of the Washington sea otter population. (Independent = Adults; Dependent = Large or Small Pups). A "+" symbol indicates instances where independent/dependent classifications could not be reliably made, though pups were noted to be present.

Location	*Independent*	*Dependent*	*Total*
SOUTH SURVEY SEGMENT			
Willoughby Rock	29	1	30
Raft River	1	0	1
Kalaloch Area	170	0	170
Destruction Island	729	+	729
Abbey Island	16	0	16
Diamond Rock	206	1	207
Hoh Head Area	22	0	22
Rock 443	2	0	2
Goodman Creek	2	0	2
Giant's Graveyard	1	0	1
Quillayute Needles	36	0	36
NORTH SURVEY SEGMENT			
Chilean Monument	331	23	354
Cedar Creek/Norwegian Memorial	5	0	5
Yellowbanks	51	4	55
Sandpoint	83	11	94
Ozette Island	7	1	8
Tskawahyah/Cannonball Island	40	1	41
Bodelteh Island	2	0	2
S. of Ozette River	13	2	15
Point of Arches	11	0	11
Waatch Point	1	0	1
Tatoosh Island	2	0	2
Neah Bay	5	0	5
Seal and Sail Rocks	1	0	1
Pillar Point	1	0	1
Total	1767	44	1811

Figure 1. WDFW's Partenavia (N357PH) surveying sea otters over Destruction Island. (Photo: Scott Pearson, WDFW)

Figure 2. Garmin GPSmap76Cx mapping GPS trackline from Washington sea otter aerial survey on 21 June 2021.

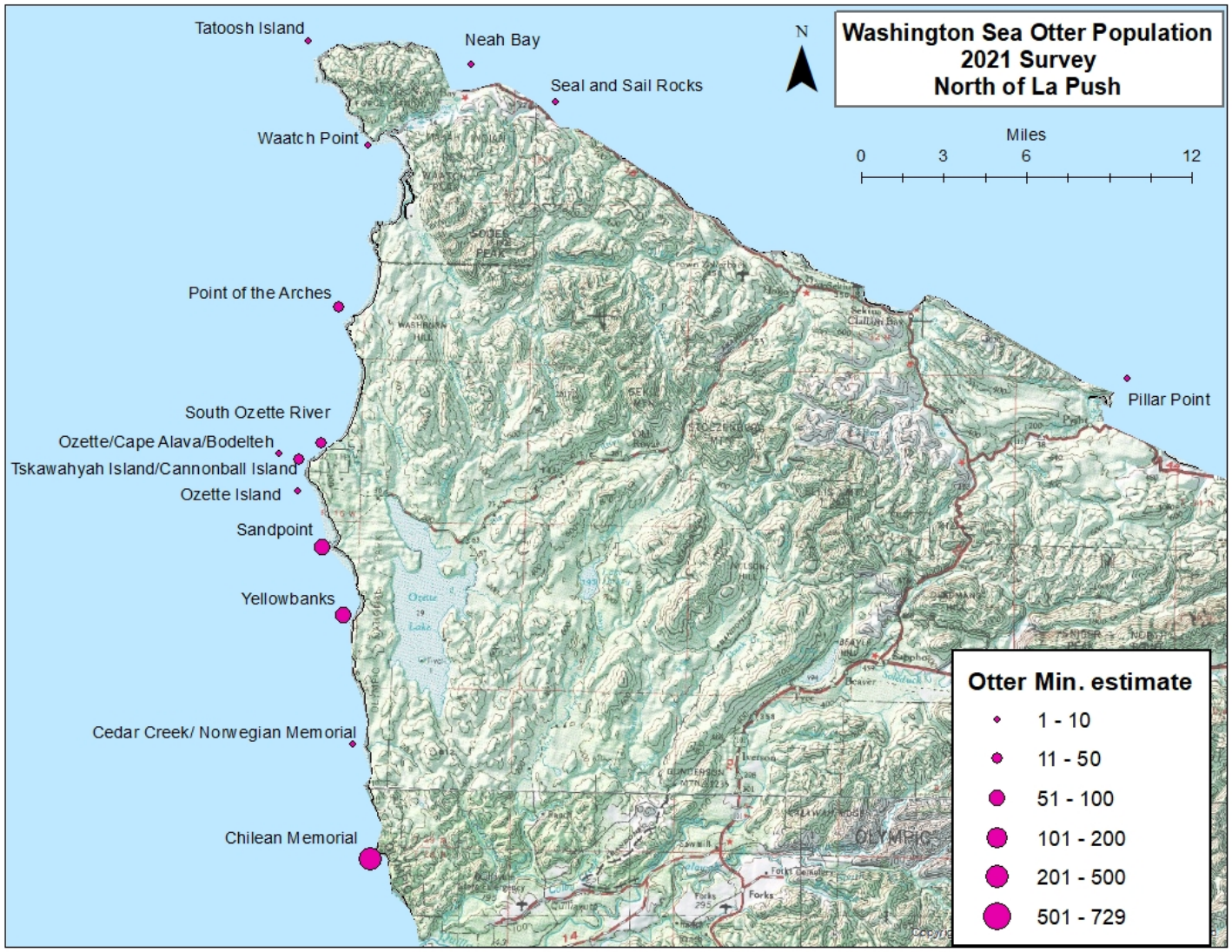


Figure 3a. Washington sea otter population distribution during 2021 sea otter survey in the northern segment of the range.

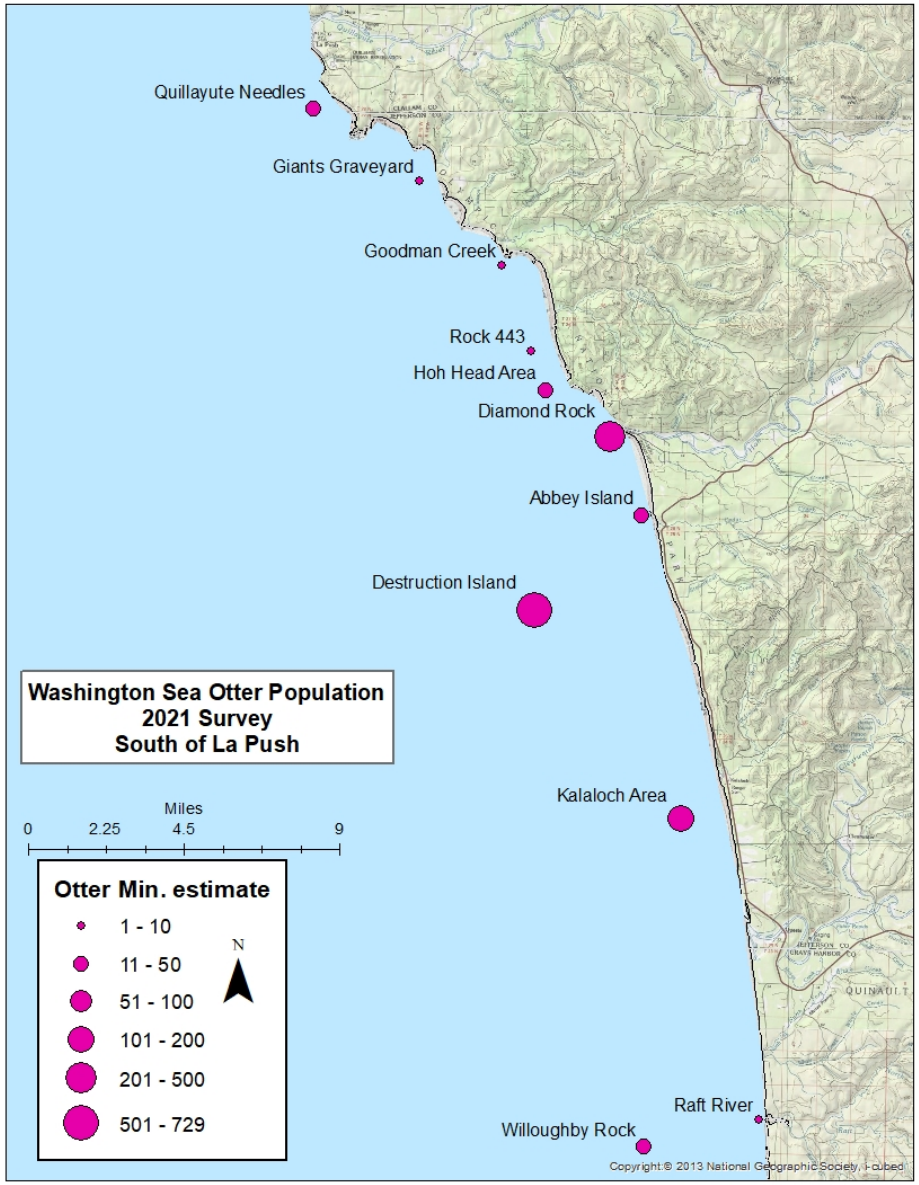


Figure 3b. Washington sea otter population distribution during 2021 sea otter survey in the southern segment of the range.

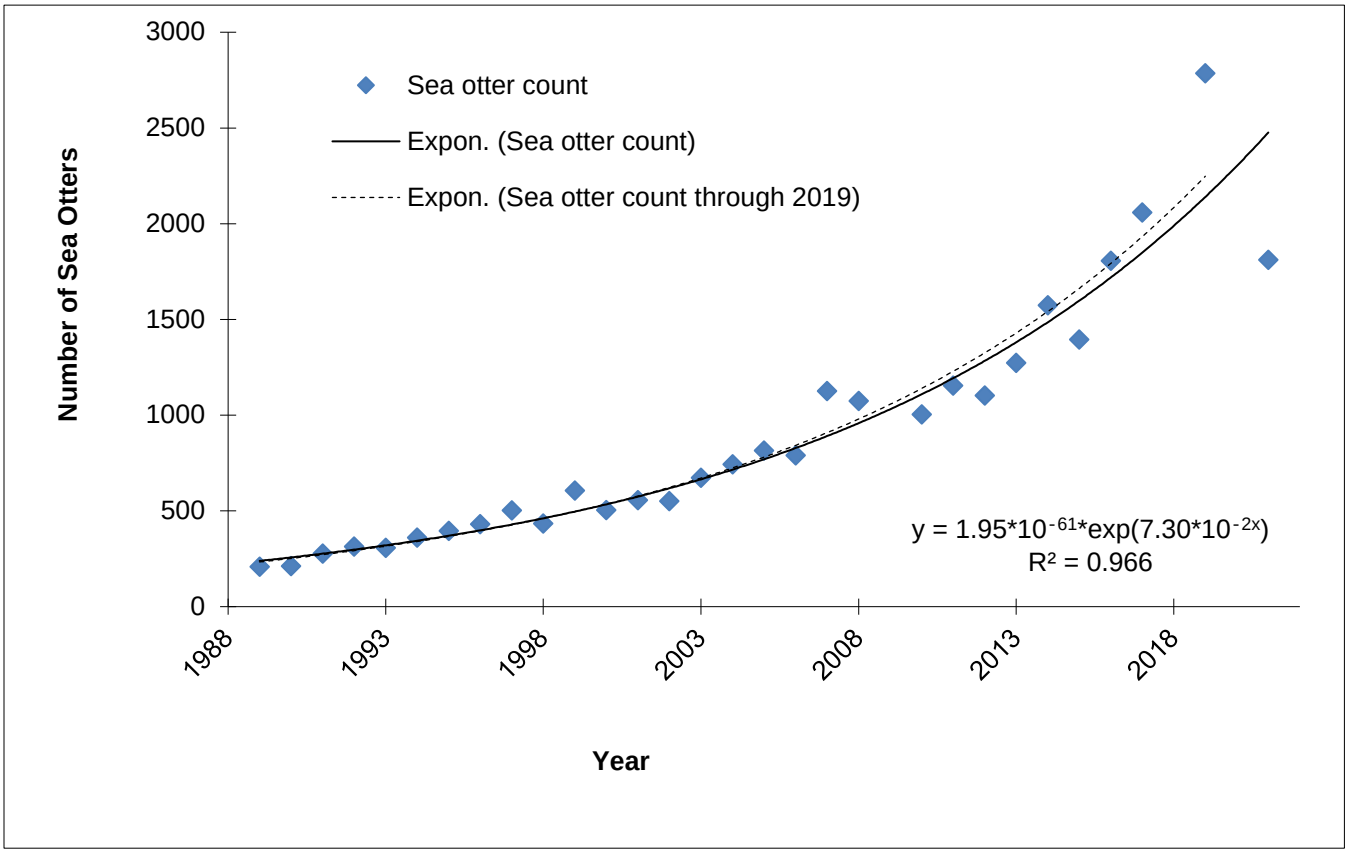


Figure 4. Sea otter counts for Washington State 1989-2019. The solid line depicts an exponential fit for all data 1989-2019. The equation and goodness of fit (R^2) for this model are in the bottom right corner of the plot. The thin dashed line depicts an exponential fit for survey data excluding the low 2021 count, to illustrate the effect of that count on the overall model fit and the deviation of the 2019 data point above the predicted line for both models.

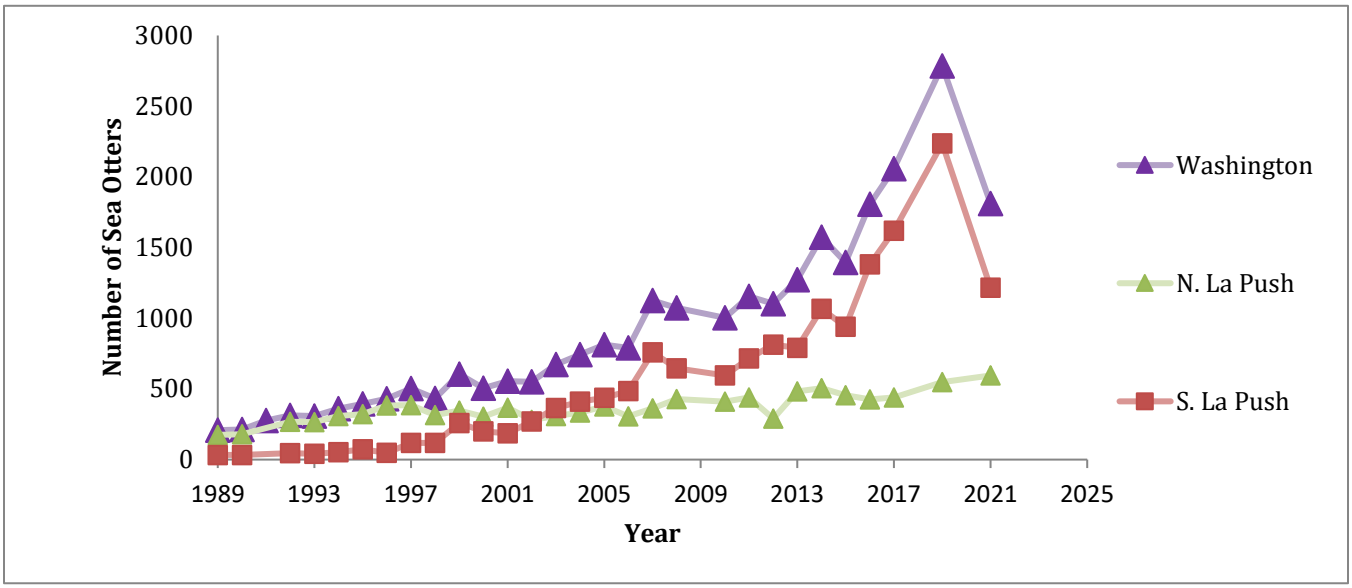


Figure 5. Growth patterns for Washington's sea otter population from 1989 and 2021. Large purple triangles depict the overall count for Washington State. Red squares represent counts for the southern segment (south of La Push) and small green triangles depict counts for the northern segment (north of La Push).

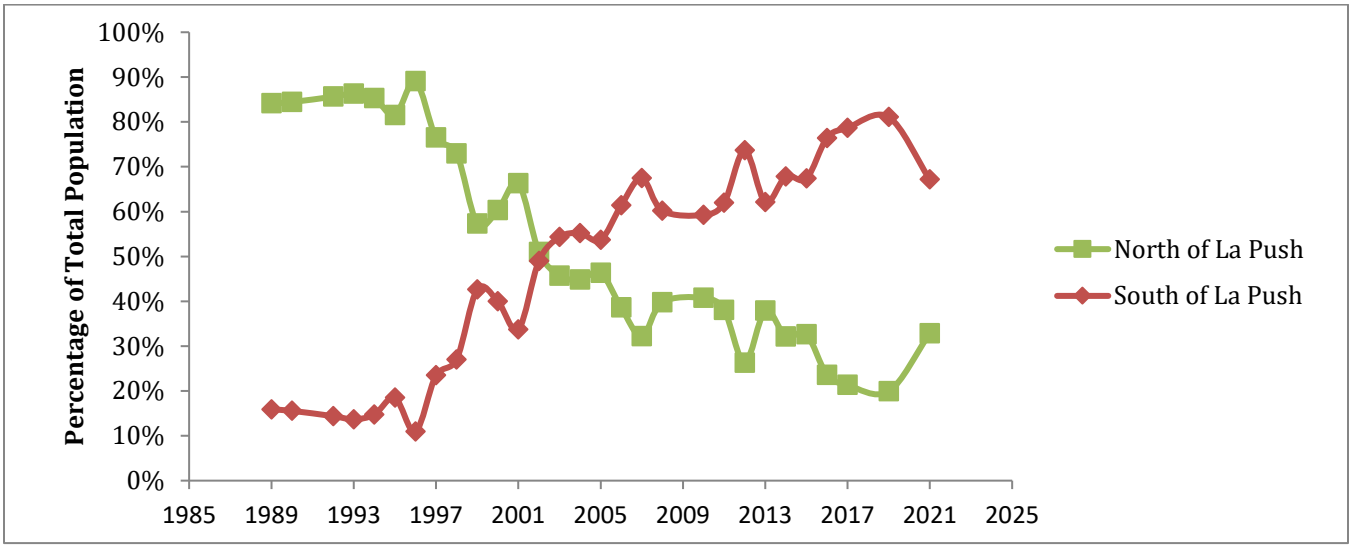
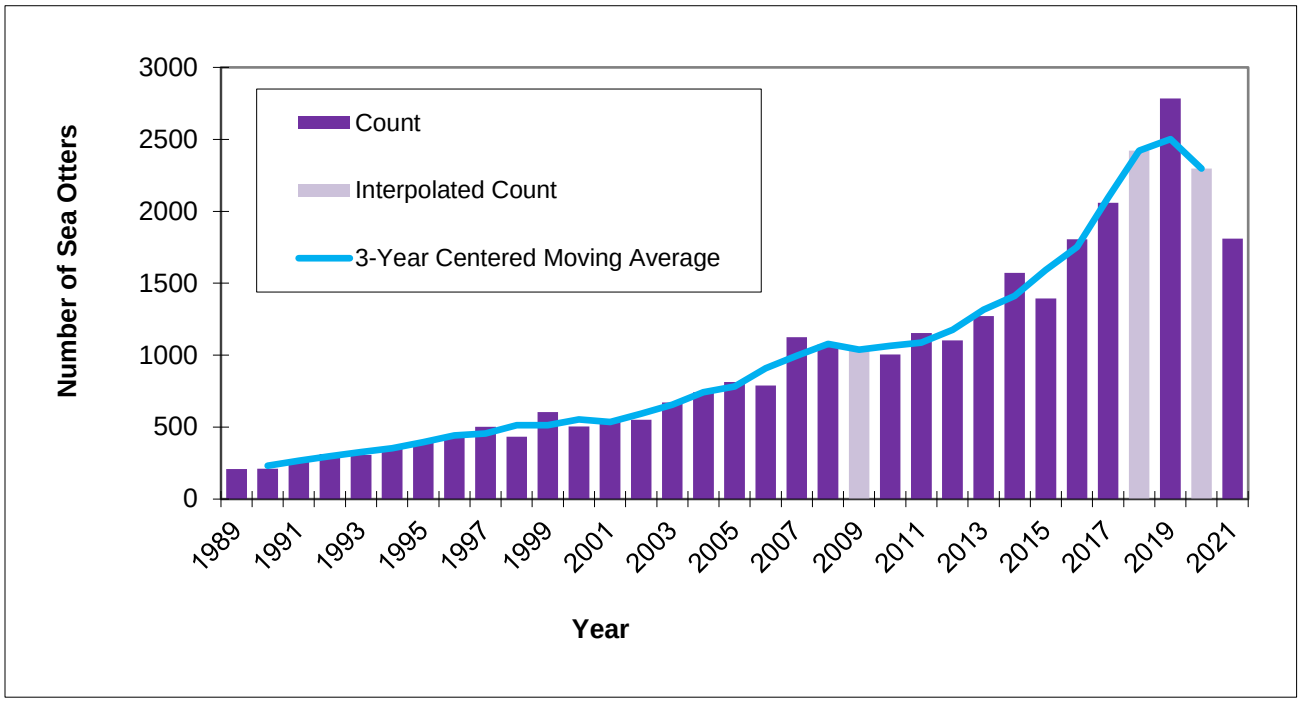


Figure 6. Comparative percentage of Washington sea otter population between the north and south (of La Push, WA) survey segments from 1989-2021.

Figure 7. Sea otters rafted in *Macrocystis* kelp bed off Sand Point on 26 June 2017. (Photo: Jenny Waddell, OCNMS)

Figure 8. Sea otter rafted in open water ~2 miles offshore from Kalaloch, WA on 26 June 2017. (Photo: Jenny Waddell, OCNMS)

Appendix 1.



Supplemental Figure 1. Three year centered moving average of sea otter counts from 1989 to 2020. The moving average is calculated using interpolated data for the years without counts (2009, 2018, 2020).