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Introduction

The northern sea otter, *Enhydra lutris kenyoni*, historically ranged throughout the North Pacific, from the northern islands of Japan through the Commander and Aleutian Islands, originally as far north as the Pribilof Islands, and in the eastern Pacific Ocean 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 by the early 1900, but in 1969 and 1970, sea otters were captured at Amchitka Island, Alaska, and translocated where they had been extirpated including locations in Alaska, British Columbia, Washington and Oregon. In Washington, a total 59 sea otters were translocated to the Olympic Peninsula coast with 29 released near Point Grenville (1969) and an additional 30 near La Push (1970) (Jameson et al. 1982; Jameson et al. 1986). Since 1989, consistent aerial and ground surveys have been conducted by WDFW and USFWS/USGS to monitor Washington's sea otter population. Within this time span, only two years do not have a population estimate – 2009 due to poor weather conditions and 2018 due to lack of funding. In 1989, the population was estimated to be 208 sea otters, primarily living in the rocky habitats north of La Push, but with a small number counted as far south as Destruction Island. By 2017, the population had grown to at least 2,058 otters (Jeffries et al. 2017). During this time, 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 Straits of Juan de Fuca, San Juan Islands, and southern Puget Sound. An additional translocated sea otter population also occurs along the outer Vancouver Island coast from Barkley Sound to Cape Scott.

Methods

Aerial surveys were flown in WDFW's Partenavia P-68C-TC (N 357 PN) (Figure 1) and covered coastal waters within the historical range of sea otters in Washington. The day prior to the beginning of surveys, a reconnaissance flight was conducted to identify the southern-most otter and the general location of otter groups. The reconnaissance flight included areas just south of the mouth of the Columbia River (Tillamook Rock, OR 45.3852° N - 124.0184° W) northward 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), which lies just west of Port Angeles, WA. Three consecutive days of survey flights (1 pass per day) were scheduled to cover 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.

Reconnaissance and survey flights were flown at approximately 800' Above Ground Level (AGL) following the coastline about 0.25 mile outside the surf break line and covering all kelp beds and nearshore rocks and reefs along the outer Washington coast and into the Strait of Juan de Fuca. The flight crew consisted of the pilot and three observers – a primary observer, secondary observer/scribe, and sea otter surveyor in training. The primary observer was responsible for locating otters and directing the pilot; photographing otters with a digital camera (Nikon D100) equipped with an 85–200 mm lens; counting (groups < 25 otters) or estimating (groups >25 otters); and recording counts on a series of coastal kelp resource maps. The secondary observer in the back right seat looked for otters, especially individuals or small groups near large groups, and recorded counts, locations and photo numbers on a flight log. For larger groups of otters, the aircraft circled the group to enable the primary observer to estimate numbers of otters and take digital photos. For safety purposes, Automatic Flight Following (AFF) was used to track real-time locations for the aircraft. A Garmin GPSmap76Cx was used to record tracklines.

Ground observers conducted surveys using binoculars and spotting scopes from locations in Olympic National Park at Duk Point (near Seafield Creek), Sand Point, Cedar Creek, Giants Graveyard, and Kalaloch South Beach Campground, as well as on the Quinault Indian Nation inshore of Split and Willoughby Rocks. A full count of the viewable area was conducted by ground observers within approximately 30 minutes of the aerial observations of the same location. Observations of adults (independent) and large or small pups (dependent) were recorded on a topo or aerial photo delineated with the viewable area during each count (noting visual obstructions and environmental conditions that limit visibility during the count). Ground observers also recorded weather conditions, otter behaviors, their assessment of the accuracy of the count and any potential disturbance (boats, kayaks, response to aircraft, predators, etc.) that occurred during the count.

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. Authors collectively counted adults and pups in the digital images using Image J 1.5i (http://imagej.nih.gov/ij). The photo count only included otters that were distinguishable (e.g., objects in the photo that might or might not be a submerged otter were not counted). Pups observed by ground counters or 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.

The adult and pup counts from the digital images were then added to the otters noted on the coastal kelp resource maps to obtain the full count of sea otters from the aerial surveys. For the six locations with ground observers, the total aerial count was compared to ground count maps to identify otters not observed by the aerial count; these "missed" otters were then added to obtain the specific location count. Ground counts for specific locations were used when 1) digital images were not available for a specific group of otters or 2) the ground count was deemed more accurate (e.g., the digital images were of poor quality). The final estimate for each flight consists of the most accurate aerial or ground count of larger groups, estimates of small groups or individuals made during the aerial survey, and any individuals or small groups noted by ground observers but missed by aerial observers.

Once there is a total count for each flight conducted, the flight with the highest total count becomes the annual estimate. 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 or outside of the survey area, nor those missed because they are underwater. Because annual estimates are based on the single highest count with no correction factors, an associated variance or confidence limits are not calculated.

An average rate of population change and a 3-year running average were calculated for the period 1989 to 2019. The average rate of population change was calculated by finding the annual percent change using (year2-year1)/year 1 and then calculating the average annual percent change. The 3-year running average uses the following formula: example to calculate year 3: (year 2+year 3+year 4)/3.

Results and Discussion

The 2019 Washington sea otter survey was 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 (Appendix 1). The 2019 survey was conducted June 24-27, 2019. A reconnaissance flight was conducted on June 24, 2019 and covered nearshore sea otter habitat and coastal kelp beds from the Columbia River to Port Angeles (Figure 2). We conducted two surveys (aerial and ground) on June 25 and 26, but poor weather conditions precluded surveys on June 27, 2019.

Aerial surveys successfully covered nearshore waters, reefs and kelp beds from Point Grenville north to Cape Flattery then east along the Strait of Juan de Fuca to Freshwater Bay – the entire target survey geography. Observation conditions were variable ranging from good to very good. Ground observers had good to excellent conditions on both days. After reviewing flight logs, we determined the flight on June 26 likely missed otters and that the June 25 survey provided the best estimate of sea otter abundance along the Washington coast in 2019.

The minimum population estimate from the 2019 Washington sea otter survey was 2,785 animals counted on the June 25 that included 549 otters in the north segment and 2,236 otters in the south segment (Table 1; Figure 3). The count includes 152 pups, 57 in

the north segment and 96 in the south segment. The 3-year running average is 2,422 otters. For comparative purposes, the 3-year running averages for the Washington sea otter population in 2016 and 2017 were 1,753 and 2,095 otters respectively (a survey was not conducted in 2018).

Survey results for 2019 indicate growth of the Washington sea otter population continues to remain positive (Figure 4). Overall, the average rate of growth for the Washington population from 1989 through 2019 is 9.81 % ($R^2 = 0.8327$).

Between 1989 and 2002, the majority 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 (Figure 4). The growth rate of the sea otter population in the area south of La Push was 22% while the growth rate of the sea otter population in the area north of La Push was only 5.5%. This has resulted in an uneven distribution of otters within the primary range, at least during the summer when surveys are conducted. In June 2019, the majority (80% or 2,236 otters) of Washington's sea otter population was observed within the survey segment south of La Push (Figure 5). Whether this unequal distribution persists throughout the year is unknown, but during a separate training flight conducted in September 2019, observers noted the otter groups were not observed in the same locations.

In the northern segment, most sea otters rafted in locations where *Macrocystis* kelp beds are a prominent feature, such as Sand Point (Figure 6). 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 7).

During the 2019 surveys, the southernmost sighting was a single animal observed near Copalis Rocks. The northernmost otter was a single animal observed at Tatoosh Island. A single otter was recorded in the Strait of Juan de Fuca just west of Low Point. Our surveys did not cover waters east of Freshwater Bay, although we are aware of credible sightings of scattered individual sea otters in the San Juan Islands and Puget Sound in recent years. Most of these sightings have been of one or two animals, with the most recent reports from 2019 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 (1-2 animals) have been reported in the past.

Acknowledgements

Thank you to the participants (Appendix 1), without your assistance this survey would not have been possible. Funding for this survey was provided by U.S. Fish and Wildlife Service under Cooperative Agreement No. F19AC00046. WDFW WILDCOM dispatch for providing Aircraft Flight Following (AFF) services. Jeff Well and Kristi Meek with Rite Bros. Aviation in Port Angeles for providing ground support services and pre- and post-flight briefing area. Overflights of the Olympic Coast National Marine Sanctuary below 2000' AGL were conducted under NOAA permit number OCNMS-2018-003 issued to WDFW and USFWS. Research activities in Olympic National Park were

conducted under Scientific Research and Collecting Permit (OLYM-2019-SCI-0026) for access to ONP locations used by ground observers. Cover photograph of sea otters hauled out at Destruction Island taken by Joseph Evenson with Washington Department of Fish and Wildlife.

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Table 1. Results of the 2019 survey of the Washington sea otter population. (Independent = Adults; Dependent = Large or Small Pups).

Location	*Independent*	*Dependent*	*Total*
SOUTH SURVEY SEGMENT			
Point Grenville	2	1	3
Willoughby Rock *	107	11	118
Kalaloch Area*	1004	2	1006
Destruction Island	46	6	52
Diamond Rock	9	6	15
North Rock	51	12	63
Perkins Reef	868	50	918
Alexander Island	1		1
Goodman Creek	2		2
Toleak Point	1		1
Giants Graveyard*	48	8	56
Quillayute Needles	1		1
NORTH SURVEY SEGMENT			
Bluff Pt	4	0	4
Sandy Island	44	7	51
Cedar Creek/Norwegian Memorial*	117	14	131
Yellowbanks	79	8	87
Sandpoint*	89	13	102
Inshore of White Rock/Wedding Rock area	14	2	16
Ozette Island	2	0	2
Ozette/Cape Alava/Bodelteh	60	2	62
S of Ozette River	3	0	3
Duk Pt*	37	6	43
Anderson Point	41	5	46
Tatoosh Island	1	0	1
Low Point	1	0	1
Total	2630	152	2785

* Locations where ground observers were stationed during survey flights.

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 reconnaissance flight on 24 June 2019.

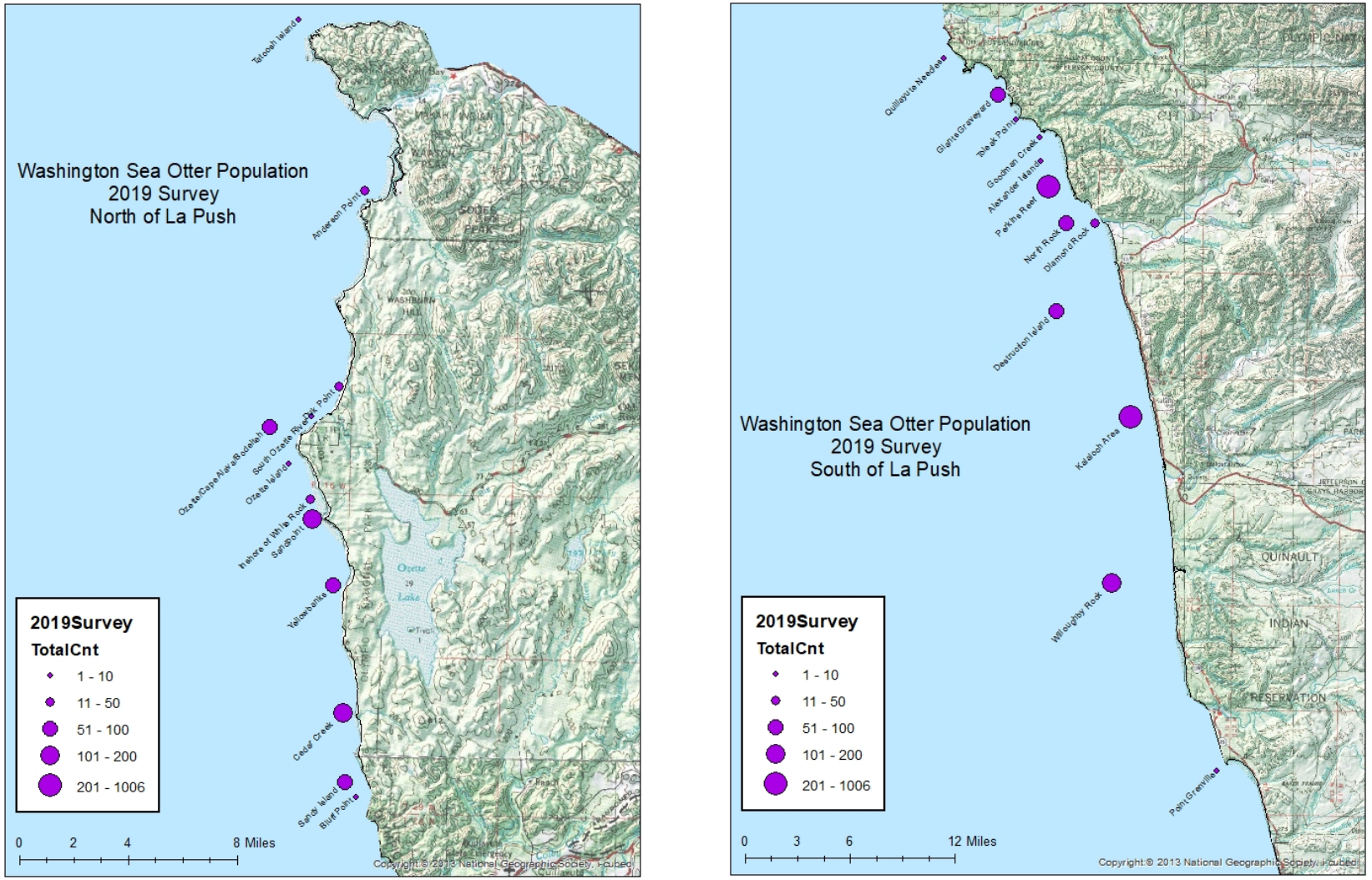

Figure 3. Washington sea otter population distribution during 2019 sea otter survey.

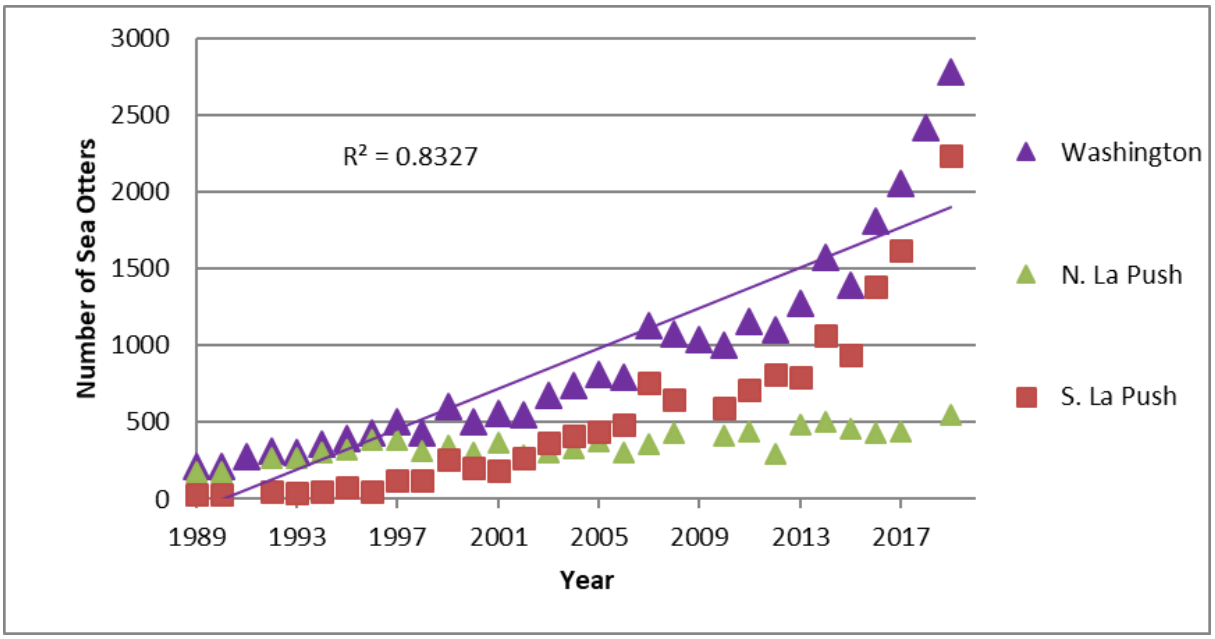

Figure 4. Growth patterns for Washington's sea otter population from 1989 and 2019.

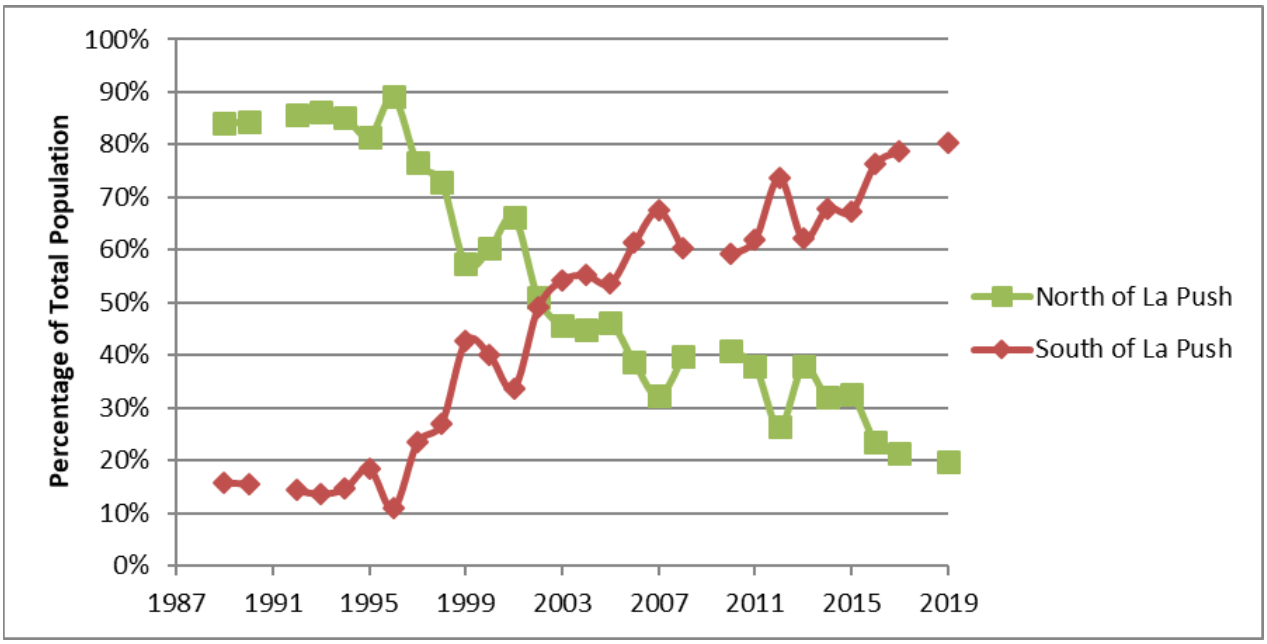

Figure 5. Comparative percentage of Washington sea otter population between the north and south survey segments from 1989-2019.

Figure 6. Sea otters rafted in *Macrocystis* kelp bed off Sand Point on 26 June 2019. (Photo: Jenny Waddell, OCNMS)

Figure 7. Sea otter rafted in open water ~2 miles offshore from Kalaloch, WA on 26 June 2017. (Photo: Jenny Waddell, OCNMS)

Appendix 1.

2019 Washington Sea Otter Survey Participants.

Aerial Surveyors	**Affiliation**
Steven Jeffries – Primary Observer	Washington Department of Fish and Wildlife
Martin Kimbrel - Pilot	Washington Department of Fish and Wildlife
Shelly Ament – Secondary Observer	Washington Department of Fish and Wildlife
Jenny Waddell	Olympic Coast National Marine Sanctuary
Ground Surveyors	
Deanna Lynch – Coordinator	U.S. Fish and Wildlife Service
Michele Zwartjes	U.S. Fish and Wildlife Service
Terre Zorman	Volunteer
Jessica Hale	University of Washington
Stephanie Rager	Point Defiance Zoo and Aquarium
Ed Bowlby	Volunteer
Jerry Joyce	Volunteer
Shawn Larson	The Seattle Aquarium
Amy Olsen	The Seattle Aquarium
Caroline Hempstead	The Seattle Aquarium
Aubrey Theiss	The Seattle Aquarium
Jennifer Van Brocklin	The Seattle Aquarium
Andrew Annine	Quinault Indian Nation
Deidre Hayward	Quinault Indian Nation
Franklin Pope Jr.	Quinault Indian Nation