Final Report

Marine Mammal Aerial Surveys Conducted in the Inland Puget Sound Waters of Washington:

Summer 2013 – Spring 2015

Prepared for:

Commander, U.S. Pacific Fleet
Commander, Navy Installations Command

Submitted to:

Naval Facilities Engineering Command Pacific
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Photo Credits: Harbor porpoise (*Phocoena phocoena*), including a mother/calf pair, photographed by Mark Deakos under National Marine Fisheries Service permit 15569.

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14. ABSTRACT
From 2013 to 2015, researchers conducted systematic line-transect aerial surveys for marine mammals in eight sub-regions of Puget Sound encompassing inland waters of Washington State. Effort consisted of five separate survey periods spanning four seasons (winter, spring, summer and fall) and was funded by the United States Navy (Navy). Surveys focused on estimating seasonal in-water density and abundance of cetaceans, particularly harbor porpoise (Phocoena phocoena).

Observations were conducted from a high-winged, twin-engine Partenavia aircraft by three observers, one on each side of the plane looking through bubble windows and an observer looking through a belly window. A dedicated recorder in the co-pilot seat recorded species, group size, number of calves, declination angle and bearing, behavior state, within-group individual spacing (i.e., dispersal distance) based on animals' body lengths apart, and reaction/no reaction to the aircraft on a laptop running Mysticetus™ observation software. Species, calf presence, and group size were confirmed with high-resolution photographs as needed. Density and abundance estimates were calculated following conventional distance-sampling methods using DISTANCE 6.2 software.

A total of 13,908 kilometers (km) of observation effort was conducted during 48 flights on 28 days in the following 5 survey periods: (1) September 2013 (n=10 flights), (2) July 2014 (n=9 flights), September 2014 (n=13 flights), January 2015 (n=1 flight), and April 2015 (n=15 flights). The January 2015 survey period was curtailed by inclement weather. Researchers observed 10 marine mammal species (including one river or sea otter) in a total of 5,005 groups for an

estimated 9,645 individuals. A sighting was defined as a group of one or more animals in close proximity to one another. Sightings identified to species consisted of: 3,803 of harbor seal (Phoca vitulina); 909 of harbor porpoise;115 of California sea lion (Zalophus californianus); 69 of Steller sea lion (Eumetopias jubatus); 5 of gray whale (Eschrichtius robustus); 3 of killer whale (Orcinus orca); 2 of common minke whale (Balaenoptera acutorostrata); 2 of Risso's dolphin (Grampus griseus); 1 of Dall's porpoise (Phocoenoides dalli); and 1 of otter (river [Lutra felina] or sea otter [Enhydra lutris]). A total of 1,332 digital photographs and 14.5 minutes of video was taken (including feeding gray whales near Everett in the East Whidbey Island sub-region).

A total of 98 harbor porpoise calves, 24 harbor seal pups, and 1 killer whale calf were seen. Pups and calves were defined as individuals less than half the body length of nearby adults and do not necessarily represent newborn animals. The highest relative proportion of harbor porpoise calves was observed during July (2014) and September (2013 and 2014) (6 to 8 percent of all groups vs. 1 percent during January and April 2015). Harbor seal pups were also most common during the July and September survey periods.

Mean group size was about 1 to 3 individuals for all species for in-water marine mammal sightings, except killer whales (mean group size 6.0 SE ±1.7, n=3 groups). Mean group size of hauled-out harbor seals was 19.1 (SE ±2.5, n=113). Most (97 percent n=3,987) pinniped groups were seen in the water (88 percent of California sea lions, 96 percent of Steller sea lions, and 97 percent of harbor seals), with the remaining groups hauled out.

Density and abundance analyses were limited to 338 harbor porpoise and 1,771 harbor seal in-water sightings made during 4,902 km of observation effort considered suitable for distance-sampling analysis (Beaufort Sea State <3, cloud cover ≤50 percent). Harbor porpoise density and abundance estimates were corrected for missed trackline animals using g(0) (trackline detection probability) from previous studies of harbor porpoise in Puget Sound.

Overall, estimated pooled harbor porpoise density was 0.91 individuals/square kilometer (km2), and abundance of 2,387 (95 percent Confidence Interval=1,942-2,935, Coefficient of Variation=0.11). Highest seasonal densities occurred in spring (1.60 individuals/km2) and lowest occurred in fall (0.90 individuals/km2). Geographically, highest densities occurred in the South Whidbey (2.47 individuals/km2), Admiralty Inlet (1.46 individuals/km2), and southern Puget Sound (0.89 individuals/km2) sub-regions, with notably fewer animals in the Bainbridge (0.23 individuals/km2) and Vashon Island (0.27 individuals/km2) sub-regions. Harbor porpoise were also observed in Hood Canal, including shallow tidal areas where they had been absent for decades.

For harbor seals seen in-water, overall estimated pooled density was 0.92 individuals/km2, with abundance 2.659 (95 percent Confidence Interval=2,266 to 3,121, Coefficient of Variation=0.08). Because haul-out areas were avoided during surveys, density estimates represent in-water densities outside of haul-out areas and abundance does not represent the total abundance in Puget Sound. Additional study by Washington Department of Fish and Wildlife (e.g., Jeffries et al. 2014) will consider counts at haul-outs and during times of year and day during which it would be expected that most harbor seals would be visible and counted. Highest seasonal densities occurred in spring (1.51 individuals/km2) and lowest in fall (0.67 individuals/km2). Geographically, highest densities occurred in the Southern Puget Sound (1.84 individuals/km2) and Hood Canal sub-regions (1.71 individuals/km2), with notably fewer animals in the Seattle (0.28 individuals/km2) sub-region.

Behavioral observations indicate that most observed marine mammal species tended to rest or transit (i.e., travel) Puget Sound during the day with intermittent feeding bouts. The predominant first-observed behavior state of nearly all marine mammal species groups was rest/slow travel, followed by medium/fast travel, with smaller proportions of milling (possible foraging and/or socializing). Milling behavior was more frequently seen among harbor porpoise (16 percent) than any other species (≤4 percent), a behavior that is likely associated with feeding and/or socializing. Actual foraging/feeding was rarely observed (<2 percent) and was only seen among harbor porpoise, harbor seals, Steller sea lions, gray whales, and a minke whale (outside of Puget Sound). Such behavior included the following specific behavioral events: harbor seals diving repeatedly near foraging birds, gray whales surfacing with mud plumes, and sightings/photographs of presumed gray whale feeding troughs in exposed mudflats near where feeding gray whales had been seen. It is unknown if feeding and socializing increase during the night. Acoustic studies by Jeffries (2014) indicate that harbor porpoise vocalize more at night than during the day in Burrows Pass, north of our survey area, suggesting that foraging may occur predominantly at night.

A potential reaction to the aircraft (all consisting of an abrupt dive) was rarely observed (<0.03 percent of the total 5,005 groups sighted). Mean maximum spacing (i.e., dispersal distance) between individuals was slightly farther for harbor porpoise (7.8 body lengths) than for harbor seals (6.2 body lengths). This distance varied by season for both species, though variance was high.

Harbor porpoise were historically common in Puget Sound in the 1940s. However, their abundance declined in

successive decades, with few to no individuals observed in Puget Sound during the 1991 and 1994 aerial and vessel surveys. The results confirm that harbor porpoise have recolonized all eight sub-regions of Puget Sound, and are at minimum, present in spring through fall in relatively large numbers. Reasons for this increase are unknown, but are concurrent with decreased Dall's porpoise sightings, reasons for which are also unknown. The highest proportion of harbor porpoise calf sightings during summer and fall support that calving occurs during this period in Puget Sound.

With respect to pinnipeds, results also support historical and other studies indicating that the harbor seal continues to be the most common marine mammal species in Puget Sound year-round. In contrast, Steller sea lions and California sea lions inhabit the region primarily during fall, when they occur throughout much of Puget Sound.

Future results of tagging and acoustic studies, along with additional surveys, may help elucidate behavioral patterns of Puget Sound marine mammals. This would help improve information about presence and behavior of the less-common species observed during our study. Additional winter aerial survey effort during suitable environmental conditions is needed to complete the project objective of estimating and comparing in-water seasonal and sub-regional density, abundance, distribution, and behavior of marine mammals in Puget Sound, most importantly for harbor porpoise.

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Executive Summary

From 2013 to 2015, researchers conducted systematic line-transect aerial surveys for marine mammals in eight sub-regions of Puget Sound encompassing inland waters of Washington State. Effort consisted of five separate survey periods spanning four seasons (winter, spring, summer and fall) and was funded by the United States Navy (Navy). Surveys focused on estimating seasonal in-water density and abundance of cetaceans, particularly harbor porpoise (*Phocoena phocoena*).

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- 2 of Risso's dolphin (*Grampus griseus)*
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- 1 of otter (river [*Lutra felina*] or sea otter [*Enhydra lutris*]).

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Acronyms and Abbreviations

BSS	Beaufort Sea State
CI	Confidence Interval
CV	Coefficient of Variation
ESA	Endangered Species Act
GPS	Global Positioning System
hr	hour(s)
ICMP	Integrated Comprehensive Monitoring Program
km	kilometer(s)
km2	square kilometer(s)
m	meter(s)
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
nmi	nautical mile(s)
NTR	Navy Technical Representative
NWTT	Northwest Training and Testing
NUWC	Naval Undersea Warfare Center
NWFSC	Northwest Fisheries Science Center
Obs	Observation
SE	Standard Error
U.S.	United States
WDFW	Washington Department of Fish and Wildlife

1. Introduction

The United States (U.S.) Navy, in order to meet regulatory requirements under the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA), and in order to meet program objectives under the Integrated Comprehensive Monitoring Program (ICMP) requested that marine mammal surveys be conducted in the Northwest Training and Testing (NWTT) study area. The ICMP is intended for use as a planning tool to focus U.S. Navy monitoring priorities pursuant to ESA and MMPA requirements (U.S. Navy 2010). The NWTT consists of the following:

1. U.S. naval installations in the inland Puget Sound study area (which includes the Strait of Juan de Fuca, the Georgia Strait, Puget Sound, Hood Canal, the waters surrounding the San Juan Islands, and several other associated waterways in northwestern Washington State and southwestern British Columbia, Canada) (Department of the Navy 2006).
2. Offshore and inland waters in the existing Northwest Training Range Complex.
3. Offshore and inland waters in the Naval Undersea Warfare Center (NUWC) Keyport Range Complex.

The Navy hired HDR, Inc. who contracted with Smultea Environmental Sciences, LLC. (Smultea Sciences) to perform line-transect aerial surveys to estimate densities and abundance of marine mammals near the U.S. naval installations in the inland Puget Sound Study Area. These operations were performed under two separate task orders as follows:

1. Contract # N62470-10-D-3011, Task Order JP02 consisting of one aerial survey during the late summer period of 2013; and
2. Contract # N62470-10-D-3011, Task Order JP04 consisting of at least four aerial survey periods across the four calendar seasons.

The results of the first contract were summarized in Smultea et al. (2014).

This report summarizes data from the five survey periods conducted under both of the aforementioned task orders. This was done to increase the robustness of the sample sizes and thus the resulting density and abundance estimates. The following were the primary objectives for these aerial surveys:

- Conduct surveys during at least four seasonal aerial survey periods within the inland Puget Sound survey area during 2014 and 2015 to assess potential differences in seasonal distribution, numbers, and behavior state patterns of marine mammals; seasons to be defined as winter (January–early March), spring (April–June), summer (August–September), and fall (October–December).
    - Note, however, that we were unable to calculate a winter (January-February/early March) density estimate due to very low sample sizes resulting from extremely poor survey conditions during the winter survey. As a result, seasonal analysis periods were changed during a subsequent meeting with the

Navy, HDR, Clymene Enterprises, and Smultea Sciences. It was decided to use the following seasonal analysis periods instead, to increase data robustness by pooling March and April 2015 surveys, as follows: summer = June to August; fall = September to November; and spring = March to May.

- Collect data to estimate densities of marine mammals in the inland Puget Sound waters for species with sufficient sightings.
- Estimate abundance for each marine mammal species seen an adequate number of times, with estimates of $f(0)$ and $g(0)$.
- Document the distribution and habitat use of each species observed.
- Document and describe behaviors seen without performing focal follows.

At least 22 species of marine mammals have been reported to be present in and/or near Puget Sound in inland Washington waters, but most are infrequent or rare to the area (Calambokidis and Baird 1994; Everitt et al.1980; Calambokidis et al 1992; Department of the Navy 2006). Common species in Puget Sound include the following (Calambokidis and Baird 1994; Everitt et al.1980; Calambokidis et al 1992; Department of the Navy 2006):

1. Harbor porpoise (*Phocoena phocoena*)
2. Dall's porpoise[1] (*Phocoenoides dalli*)
3. Harbor seal (*Phoca vitulina*)
4. California sea lion (*Zalophus californianus*)
5. Steller sea lion (*Eumetopias jubatus*).

Gray whales[2] (*Eschrichtius robustus*) have been increasingly seen in Puget Sound since the 1990s, and currently at least 10–12 gray whales return annually to feed near Whidbey Island and Port Susan (OrcaNetwork.org see http://www.orcanetwork.org/Main/index.php?categories_file=Gray%20Whales). Jeffries et al. (2014) observed two gray whales on the west side of Gedney Island during aerial surveys for pinnipeds in Puget Sound.

In addition, minke[3] (*Balaenoptera acutorostrata*), humpback[4] (*Megaptera novaeangliae*), and killer whales[5] (*Orcinus orca*) have been observed in small numbers in Washington inland waters

[1] Dall's porpoise were found in Puget Sound in high numbers in the 1970s and 1980s (Everitt et al 1980, Miller 1990). However, evidence suggests that this species is no longer common in Puget Sound (Anderson 2014), and the current study supports this suggestion, with only one Dall's porpoise observed in Hood Canal.

[2] Small numbers of gray whales have been seen in all months of the year in inland Washington waters, but most are observed feeding in shallow areas close to shore in spring and summer (Calambokidis and Baird 1994); Calambokidis et al. (1992) reported gray whales in the Strait of Juan de Fuca and Puget Sound around Whidbey Island.

[3] A minke whale was observed in Admiralty Inlet in 1991 (Calambokidis et al. 1992), and minke whales are found in inland Washington waters year round, with most sightings March to November; 30 individuals were photographically identified in the 1980s in the San Juan Islands (Calambokidis and Baird 1994).

[4] A single humpback was observed near Cape Flattery in 1991 (Calambokidis et al. 1992); humpbacks were once common in Puget Sound but were depleted by whaling; they continue to be seen regularly during summer at the mouth of Juan de Fuca Strait (Calambokidis and Baird 1994).

and Canadian waters near Puget Sound, but these species are not commonly seen in Puget Sound (Calambokidis and Baird 1994). However, transient killer whales slightly increased in annual occurrence in Puget Sound from 2004 to 2010, with a total of 33 transient killer whales observed in Puget Sound during that time period (Houghton et al. 2015). Transient killer whales in the Salish Sea (British Columbia and Washington inland waters) most often occur in the Strait of Juan de Fuca (Houghton et al. 2015).

Anomalous sightings of two Bryde's whales (*Balaenoptera brydei*) also occurred in Puget Sound; both whales were initially seen alive in southern Puget Sound and then found dead in 2010 (Calambokidis et al. 2011, 2015).

Risso's dolphins (*Grampus griseus*) were documented in Puget Sound in 1977 (Stacey and Baird 1991) and more recently, Risso's dolphins were observed in Puget Sound 32 times from 2011 to 2013 (Calambokidis et al. 2015), including two individuals observed in Puget Sound in 2013 during aerial surveys (Smultea et al. 2014).

A false killer whale (*Pseudorca crassidens*) was repeatedly seen ranging from Howe Sound to southern Puget Sound in the early 1990s (Calambokidis and Baird 1994), and 8–10 false killer whales were seen repeatedly in southern Puget Sound (south of Tacoma Narrows Bridge) in the 1990s (S. Jeffries, Washington Department of Fish and Wildlife [WDFW], pers. comm., September 2015).

A single Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) has been observed from summer 2012 to present (summer 2015) in the waters off Commencement Bay and Point Defiance near Tacoma. Another different, lone Pacific white-sided dolphin (based on different scarring patterns in the two individuals) was also observed in summer 2015 off Steilacoom, Washington, in Puget Sound (S. Jeffries, pers. comm., WDFW, September 2015). In the late 1970s, a group of 3–6 Pacific white-sided dolphins was regularly reported feeding in tide rips off the southeast corner of Fox Island (Gibson Point) in southern Puget Sound (S. Jeffries, pers. comm., WDFW, September 2015).

A bottlenose dolphin (*Tursiops truncatus*) was seen at Port of Tacoma 15 December 2010 with the last live confirmed sighting on 18 January 2011 near Nisqually Delta. This animal was found dead at Nisqually on 31 January 2011 (Calambokidis et al. 2011).

A common dolphin (*Delphinus* spp.) was reported off Boston Harbor Lighthouse in southern Puget Sound 2 June 2011, with another 1–2 common dolphins reported near Boston Harbor between 5 June and 6 October 2011 (Calambokidis et al. 2011). Two long-beaked common dolphins (*Delphinus capensis*) were documented in July and August 2003 in Budd Inlet and Dana Passage in southern Puget Sound (Calambokidis et al. 2011).

Northern elephant seals (*Mirounga angustirostris)* regularly occur in very small numbers (fewer than five animals) in Puget Sound, including one female that pupped on Whidbey Island in spring 2015. Most observations of elephant seals in Washington waters are outside of Puget Sound in the Strait of Juan de Fuca on Race Rocks, Dungeness Spit, Protection Island, and

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[5] The core of the Southern Resident population is found in Haro Strait, southern Strait of Georgia, and eastern Strait of Juan de Fuca (Calambokidis and Baird 1994).

Smith Island. Elephant seal pups have been recorded at all of these locations. A lone weaner pup was also recorded on Rat Island at the entrance to Kilisut Harbor between Marrowstone and Indian Island near Walan Point (S. Jeffries, WDFW, pers. comm., September 2015).

Steller sea lions (*Eumetopias jubatus)* regularly occur in Puget Sound from September to April, with a group of 8–10 Steller sea lions regularly using Craven Rock south of Marrowstone Point as a haul-out during this time. During November to February as many as 100 Steller sea lions have been observed in the water and hauled out on a derelict barge at the mouth of the Nisqually River in southern Puget Sound. Small numbers (1–3 individuals) are also regularly observed hauled out on Port Security Barriers at Naval Base Kitsap at Bremerton and Naval Station Everett (S. Jeffries, WDFW, pers. comm., September 2015). A group of 10–25 (maximum count 66 individuals in December 2014) Steller sea lions also regularly haul out on floats near the salmon net pens in Clam Bay just north of the Manchester Fuel Depot (S. Jeffries, WDFW, pers. comm., September 2015).

Lance et al. (2004) reports that a few sea otters (*Enhydra lutris*) have been seen in Puget Sound and the San Juan Islands. Other species that have been observed in inland Washington waters but not specifically stated to have been seen inside Puget Sound include northern fur seals (*Callorhinus ursinus*), fin whales (*Balaenoptera physalus*), short-finned pilot whales (*Globicephala macrorhynchus*), pygmy sperm whales (*Kogia breviceps*), Baird's beaked whale (*Berardius bairdii*), Cuvier's beaked whale (*Ziphius cavirostris*), and possibly beluga whale (*Delphinapterus leucas*), and *Mesoplodon* spp. (Everitt et al. 1980, Calambokidis et al. 1992, Calambokidis and Baird 1994). A fin whale was documented in September 2015 in the San Juan Islands area (T. Jefferson, Clymene Enterprises, pers. comm., September, 2015; photos available at orcanetwork.org).

Priority species for data collection in the current study were cetaceans, particularly harbor porpoise. It was anticipated that sightings of harbor porpoise and in-water sightings of harbor seals would be sufficient to estimate abundance and density of these species in the survey area, as well as draw some conclusions about current distribution and seasonality for Washington inland waters stocks as defined by Carretta et al. (2014). Other marine mammal species are less common in Puget Sound, so it was expected that aerial surveys would not provide enough data for abundance and density estimates. However, systematic observations would provide baseline information regarding current occurrence in Puget Sound by these species.

Harbor porpoise in Puget Sound are considered to be part of the Inland Washington harbor porpoise stock for National Oceanic and Atmospheric Administration management purposes (Carretta et al. 2014). Harbor porpoise were historically common in Puget Sound in the 1940s (Scheffer and Slipp 1948), but abundance declined considerably into the 1990s, with few harbor porpoise sighted in the region during aerial and vessel surveys in 1991 (Osmek et al. 1996) and 1994 (Osmek et al 1995). Based on analysis of data collected from 2000–2008 during small-vessel surveys focused on marbled murrelets (*Brachyramphus marmoratus*) in sub-areas of inland Washington waters (including the Strait of Juan de Fuca, Hood Canal, Admiralty Inlet, and southern Puget Sound, Ű (2009) reported an overall density of 0.196 harbor porpoise/square kilometer (km^2) and an estimated abundance of 686 (Coefficient of Variation [CV] 11.27; 95 percent Confidence Interval [CI] = 550 – 855) harbor porpoise in the primary sampling unit bird survey area. Ű (2009) found no significant trend in abundance during the survey period. However, increased numbers of strandings and sightings in 2009 and 2010 raised the question of whether or not harbor porpoise were returning to Puget Sound (Carretta et al. 2014).

Dall's porpoise were known from minimum counts of 39 to 71 individuals in Puget Sound in 1987 to 1988 during photo-identification efforts (Miller 1990). Miller (1990) produced a mark/recapture estimate of 78 Dall's porpoise for August. This is not considered a valid estimate of the overall population size in Puget Sound as the study was conducted in a small portion of Puget Sound between the southern end of Whidbey Island and Edmonds. However, it still suggests a substantial number of Dall's porpoise occurred in Puget Sound in the late 1980s. From 1987 to 1988, the highest estimated abundance in Puget Sound was in summer, and lowest in spring (Miller 1990). Dall's porpoise were reported to occur year-round in Puget Sound during 1977 to 1979 (Everitt et al. 1980). Based on analysis of small vessel surveys focused on marbled murrelets in sub-areas of inland Washington waters from 1995 to 2008, Ű (2009) reported that Dall's porpoise sightings and numbers increased from 1995 to 2000 but showed a downward decline from 2001 to 2008. Ű (2009) further reported that since 2001, Dall's porpoise sightings in Puget Sound during bird surveys have been considered rare. Anecdotal information suggested that Dall's porpoise are currently not found in sufficient numbers in Puget Sound to allow for abundance estimation from aerial surveys (Anderson 2014).

Unlike other marine mammals in Puget Sound waters, harbor seals are recognized as three distinct Washington inland stocks based on genetic analyses (Huber et al. 2010, 2012):

1. Southern Puget Sound,
2. Washington Northern Inland Waters, and
3. Hood Canal (Carretta et al. 2014).

The latest published population surveys of harbor seals in Washington were conducted as counts at haul-outs in 1999 (Jeffries et al. 2003). More recent counts of harbor seals were conducted by WDFW in 2013–2014 under contract with the Navy. Results of these surveys are not yet fully analyzed, but the surveys covered Puget Sound, the U.S. waters of the Strait of Juan de Fuca, and the San Juan Islands (Jeffries et al. 2014).

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2. Methods

Smultea Sciences conducted aerial surveys during five separate survey periods in 2013–2015, spaced as evenly apart in time as possible, to provide different “seasonal” perspectives. These survey periods were scheduled to occur during the following windows.

1. Summer 2013 – 30 August to 4 September 2013 (Smultea et al. 2014)
2. Summer 2014 – 21 to 27 July 2014
3. Fall 2014 – 14 to 21 September 2014
4. Winter 2015 – 5 to 12 January 2015
5. Spring 2015 – 15 to 22 April 2015

2.1 Study Area

The survey area was focused in Puget Sound, Washington, and was divided into eight survey blocks (i.e., sub-regions) developed by the U.S. Navy and National Marine Fisheries Service (NMFS). References to Puget Sound henceforth in this report are considered to be the polygon encompassed by these eight survey sub-regions:

1. Admiralty Inlet (255.20 km^2)
2. East Whidbey (646.00 km^2)
3. South Whidbey (267.70 km^2)
4. Hood Canal (391.1 km^2)
5. Bainbridge (93.80 km^2)
6. Seattle (211.30 km^2)
7. Vashon (316.50 km^2)
8. Southern Puget Sound (455.80 km^2)

Opportunistic surveys were also flown over the Strait of Juan de Fuca (3,047.65 km^2) (i.e., outside Puget Sound) during two survey periods in July 2014 and September 2014.

Parallel transect lines were positioned along an east-west orientation, generally perpendicular to the bathymetric contours/coastline to avoid biasing of surveys by following depth contours (**Figure 1**). Aerial survey lines were spaced 3.7 kilometers (km) apart. Final survey design was approved by the Navy Technical Representative (NTR).

Four restricted air traffic zones are indicated in **Figure 1** as smaller red polygons as follows:

1. Naval Base Kitsap at Bangor,
2. Naval Station Everett,
3. Naval Base Kitsap at Bremerton, and
4. Naval Magazine Indian Island.

However, only Naval Base Kitsap at Bangor is a true “no fly zone” where civilian planes are not permitted to enter. As such, three initially identified flight lines in the Bangor no fly zone could not be flown during any of the aerial surveys; thus, any marine mammals in that area would not have been seen by observers, resulting in a gap in sightings and effort.

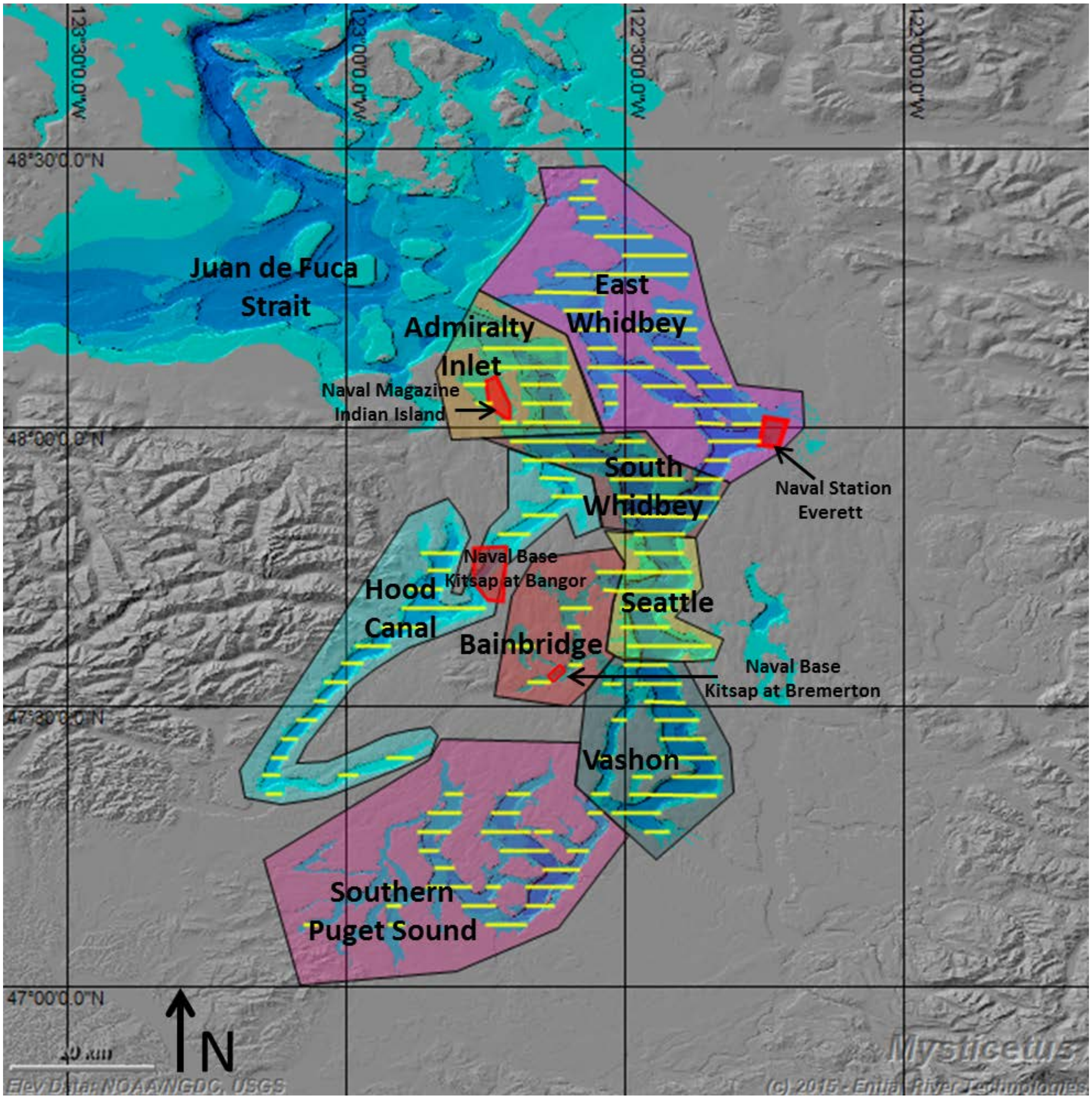

Figure 1. Map of the Puget Sound and Juan de Fuca Strait survey study areas, the Naval Base Kitsap at Bangor no fly zone, and National Security Areas at Naval Station Everett, Naval Base Kitsap at Bangor, and Naval Magazine Indian Island.

The other three zones are termed National Security Areas and are marked on aviation charts as "…it is requested that pilots avoid flying below 2900 [Everett: 1900] feet." However, no survey lines were located within these three areas. Because of the small size of these three National Security Areas, observers were able to see marine mammals in these areas from tracklines flown near the areas. The no fly zone at Naval Base Kitsap at Bangor and the three National Security Areas are shown in **Figure 1**.

2.2 Aerial Surveys

Aerial surveys were conducted from a Partenavia P68-C or a Partenavia Observer small high-wing, twin-engine aircraft operated by Aspen Helicopters, Inc. (www.aspenhelicopters.com) out of Oxnard, California.

One pilot and four professionally trained marine mammal biologists (at least two with over 10 years of related experience) were aboard the aircraft. Two biologists served as observers in the center seats of the aircraft looking through bubble windows on each side of the plane. The third biologist observed through the belly window looking down beneath the plane behind the center row of seats. The belly observer was positioned to ensure that no sightings were missed directly below the plane "on" the survey line in order to meet line-transect analysis assumptions (see **Section 2.2.1**). The fourth observer was the data recorder in the front right co-pilot seat.

Surveys were flown at speeds of approximately 185 km/hour (hr) (100 knots) and a target altitude of 229 meters (m).

A pre-flight notification was provided to the NTR and NTR-designated personnel via email before each survey as required in the Statement of Work. A notification of the aerial survey dates was also emailed to other researchers and personnel based on a different NTR-approved contact list.

2.2.1 Defining Line Transects

Established line-transect survey protocol was used (see Buckland et al. 2001) following systematic survey lines. To maintain consistency, survey procedures were kept as similar as possible to previous marine mammal aerial survey work conducted in the Puget Sound area, which includes Puget Sound, the Strait of Juan de Fuca, and the San Juan Islands in U.S. waters (e.g., Calambokidis et al. 1992; Laake et al. 1997; Nysewander et al. 2005; Osmek et al. 1996). The aerial survey protocol also matched that used in other U.S. Navy training ranges (e.g., Smultea and Mobley 2009; Smultea and Bacon 2012).

2.2.2 Defining Sightings

Following assumptions of line-transect theory (Buckland et al. 2001), a sighting was defined as one or more individual animals in close proximity to one another that were not seen independently of each other. For harbor porpoise, this typically consisted of one or more individual animals behaving similarly and/or in a coordinated manner, sometimes within an estimated 500 m of each other. The latter distance was approximated based on the occasional aggregations of harbor porpoise occurring within this distance of one another that could not be considered independently sighted by the observer (i.e., the observer was cued to the presence of other animals based on the proximity of animals).

Pinniped sightings were considered "in-water" if their belly rested on sand, but a portion of the body was still in the water. These were included for in-water density estimates. Hauled-out sightings of pinnipeds were not used for in-water density estimation purposes, because the animals were completely out of the water. Note that this definition that determined which harbor seals were considered hauled out or in-water differs from the definition applied by Jeffries et al. (2014) for Puget Sound. Our surveys were focused on cetaceans, primarily harbor porpoise, while Jeffries et al.'s (2014) aerial surveys were focused on hauled-out pinnipeds. For example, Jeffries et al. (2014) estimated population abundance and density based on counts of hauled-out animals including known large haul-outs that were not surveyed during our aerial surveys; Jeffries et al. (2014) also applied different correction estimates for missed animals.

2.3 Data Collection

2.3.1 Data Collection Software System

We used customized Mysticetus™ Observation Platform software for data collection, including basic sighting and environmental data (e.g., Beaufort Sea State [BSS], visibility, glare, precipitation, and cloud cover, see **Tables 1 and 2**). Software was loaded onto a touchscreen laptop PC for use in the field (this set up was also used for U.S. Navy's Southern California Range Complex aerial surveys during 2011–2013 and other U.S. Navy range surveys, e.g., Smultea and Mobley 2009; Smultea and Bacon 2012). Each new entry was automatically assigned a time stamp, a sequential sighting number, and a Wide Area Augmentation System-enabled Global Positioning System (GPS) position. GPS locations of the aircraft were automatically recorded at 1- or 5-second intervals on a Wide Area Augmentation System-enabled Bluetooth Global-Sat BT368i mini GPS, and for redundancy/back up, on a handheld Garmin™ 78S GPS and the aircraft's Garmin 296 GPS. Suunto® handheld clinometers were used by the observers to measure declination angles to sightings. If the sighting was not directly in line with (i.e., perpendicular to) the right or left wing when the angle was taken, a bearing to that sighting was also recorded. Declination angle and bearing were used in Mysticetus to calculate a sighting position.

Table 1. Mysticetus environmental data collected

Data Point	Definition
Beaufort (BSS)	See table below
Visibility (Vis)	How far an observer can see clearly from the vessel, in km. For a perfectly clear day, enter 10. If visibility is variable due to fog or heavy rain, enter "< 3.5" for visibility variable at less than 3.5 km, and enter ">3.5" for visibility variable at greater than 3.5 km.
Glare	The amount of glare present. Dropdown options are: None, Little, Moderate, Severe (prevents observations), or Variable. Record glare over the forward 180 degrees of view.
Glare From	The "time" on a clock face (situated over your vessel, with 12:00 straight ahead) where the glare starts (e.g., 11:00 or 2:00).
Glare To	The "time" on a clock face (situated over your vessel, with 12:00 straight ahead) where the glare ends (e.g., 12:00 or 3:00).
Precip	Type of precipitation. Dropdown options are: None, Fog, Light Rain, Rain, Snow.
Cloud Cover	Percent cloud cover over 360 degrees. Dropdown menu gives ranges: 0-25, 25-50, 50-75, 75-99, or 100%.

Table 2. Beaufort Wind Scale at Sea

Force	Speed			Name	Conditions at Sea
	knots	km/hr	mi/hr		
0	< 1	< 2	< 1	Calm	Sea like a mirror.
1	1-3	1-5	1-4	Light air	Ripples only.
2	4-6	6-11	5-7	Light breeze	Small wavelets (0.2 m). Crests have a glassy appearance.
3	7-10	12-19	8-11	Gentle breeze	Large wavelets (0.6 m), crests begin to break.
4	11-16	20-29	12-18	Moderate breeze	Small waves (1 m), some whitecaps.
5	17-21	30-39	19-24	Fresh breeze	Moderate waves (1.8 m), many whitecaps.
6	22-27	40-50	25-31	Strong breeze	Large waves (3 m), probably some spray.
7	28-33	51-61	32-38	Near gale	Mounting sea (4 m) with foam blown in streaks downwind.
8	34-40	62-74	39-46	Gale	Moderately high waves (5.5 m), crests break into spindrift.
9	41-47	76-87	47-54	Strong gale	High waves (7 m), dense foam, visibility affected.
10	48-55	88-102	55-63	Storm	Very high waves (9 m), heavy sea roll, visibility impaired. Surface generally white.
11	56-63	103-118	64-73	Violent storm	Exceptionally high waves (11 m), visibility poor.
12	64+	119+	74+	Hurricane	14-m waves, air filled with foam and spray, visibility bad.

2.3.2 Data Points Collected

Observational and environmental data collected included the following:

1. Location and time of sighting (GPS), and distance of sighting from the trackline as applicable (converted based on bearing and declination angle to the sighting from the aircraft—see above)
2. Species identification of all marine mammal(s) or sea turtle(s) sighted (note that no sea turtles were seen during the survey periods)
3. Number of individuals (i.e., group [sighting] size,) and/or composition
4. If present, number of calves/pups (individuals less than half adult size) observed and/or photographed
5. Duration of sighting
6. The best possible detailed description of behavior, disposition, and reaction/no reaction to the aircraft
7. Direction of travel (magnetic)
8. Photographs and/or video, if needed
9. Environmental information associated with each sighting event (see **Table 1** for list).

Observers used internally stabilized Steiner 7 × 25 or Swarovski® 10 × 32 binoculars if helpful to identify species, number of individuals, behaviors, etc.

Environmental data were collected each time there was a change in effort type (systematic, random, transit, circling [see **Table 3**]) or environmental conditions. Behavioral data were collected when a sighting was first made and included the first-observed behavior state (slow travel/rest, medium travel, fast travel, mill, hauled out, foraging, other) that at least 50 percent of the group was engaged in (**Table 4**). Other first-observed data that were collected included heading (in degrees magnetic), and minimum and maximum dispersal distances (estimated in adult body lengths) between nearest neighbors within subgroups. The two closest individuals in a group were used to estimate minimum dispersion and the two individuals farthest from each other without intervening individuals were used to measure maximum dispersion.

Table 3. Definitions of leg types flown during Puget Sound Marine Mammal Aerial Surveys

Leg Type	Leg Type Definition
Systematic	Pre-determined line-transect legs
Transiting	Flying between the airport and the survey grid locations and transiting between transect lines
Overland	Flight over land
Circling	Flying clockwise circles around sightings to verify species and group size via photography

Table 4. Ethogram defining behavioral states and individual behaviors (events) used during focal follows. Behavior states determined based on what >50 percent of the group was doing.*

BEHAVIOR STATE (>50% of group's activity--note once per min; also note if unknown when animals not in view during that minute)	Code	Definition
Rest/Slow Travel	RE	≥50% of group exhibiting little or no forward movement (<1 km/hr) remaining at the surface in the same location or drifting/traveling slowly with no wake
Travel	TR	≥50% of group swimming with an obvious consistent orientation (directional) and speed, no surface activity. Medium travel = 1-3 km/hr wake no white water; Fast travel = >3 km/hr with white water
Mill	MI	≥50% of group swimming with no obvious consistent orientation (non-directional) characterized by asynchronous headings, circling, changes in speed, and no surface activity. Includes feeding.
Probable Foraging	PF	Apparent searching for prey; the process of finding, catching, and eating food
Unknown	UN	Not able to determine behavior state. (e.g., animals out of sight, too far to determine, on a dive, etc.)
Other	OT	Describe in notes

*Smultea and Bacon 2012; Heithaus and Dill 2009

A reaction was recorded when an animal made a sudden change in behavior state or heading in possible response to the aircraft. When sightings were circled, additional behavioral information was collected opportunistically. However, extended focal follows were not conducted, as the Scope of Work document indicated this approach was to be used only for exceptionally unusual sightings or behavior.

2.3.3 Photography/Videography

A Canon® EOS digital camera (e.g., Canon 7D) with an Image Stabilized 80–400-millimeter zoom lens was used to photograph sightings when possible to confirm species. A Sony Handycam HDR-XR55OV or a Sony Handycam HDR-PJ79OV video camera was available onboard to document any unusual behaviors.

When conditions allowed, photographs were taken opportunistically for species confirmation. Photographs were taken through a small opening porthole window on the plane's copilot window or a rear window on the left side of the plane.

2.4 Line-Transect Analysis

We used conventional line-transect methods (also known as Conventional Distance Sampling) to analyze the aerial survey data for estimating density and abundance of marine mammals (see Buckland et al. 2001). The survey data were filtered with the following criteria used to extract data for the final line-transect analyses (as part of an approach to ensure meeting assumptions of line transect theory):

- Only data (e.g., sightings and effort) collected on systematic transect lines (data during transit effort and connector effort were excluded).[6]
- Only data collected in BSS 0–2 (following protocol of Calambokidis et al. 1992; Laake et al. 1997, 1998).
- Only data collected during conditions with cloud cover of 50 percent or less, and without significant glare issues (i.e., "hard" glare within which a marine mammal could not be seen occurring within more than 30 percent of each of the three observers' fields of view [0 to 90 degrees left and right of the plane's nose and the belly window view] for more than three minutes).

The filtered data were assembled into Excel™ spreadsheets for preparation of the input files, which were analyzed using the software DISTANCE 6.2, Release 1 (see Thomas et al. 2010). Estimates of density and abundance (and their associated CVs) were calculated using the following standard formulae:

$$\hat{D} = \frac{n\,\hat{f}(0)\,\hat{E}(s)}{2\,L\,\hat{g}(0)}$$

[6] Note that "connector effort" refers to short lines that connect the main transect lines. In most cases, these lines are overland, but even over water, these lines are excluded because the data are often parallel to shore or at a depth contour that leads to issues regarding how representative they are of the density that is being estimated.

$$\hat{N} = \frac{n\ \hat{f}(0)\ \hat{E}(s)\ A}{2\ L\ \hat{g}(0)}$$

$$C\hat{V} = \sqrt{\frac{\hat{\text{var}}\,(n)}{n^2} + \frac{\hat{\text{var}}[\hat{f}(0)]}{[\hat{f}(0)]^2} + \frac{\hat{\text{var}}[\hat{E}(s)]}{[\hat{E}(s)]^2} + \frac{\hat{\text{var}}[\hat{g}(0)]}{[\hat{g}(0)]^2}}$$

where

D = density (of individuals)

n = number of on-effort sightings

f(0) = detection function evaluated at zero distance

E(s) = expected average group size (using size-bias correction in DISTANCE)

L = length of transect lines surveyed on effort

g(0) = trackline detection probability

N = abundance

A = size of the survey area

CV = coefficient of variation

var = variance

Estimates were made only for harbor porpoise and harbor seals because all other marine mammal species identified during the survey were detected fewer than 60 times (60 to 80 is the minimum number of sightings considered adequate to obtain reliable line transect estimates for marine mammals per Buckland et al. [2001]).

We did not stratify estimates by sea state or other environmental parameters. We produced estimates of density and abundance using the entire filtered dataset (i.e., all seasons). We then stratified by all eight survey regions, and also produced overall pooled estimates. To examine seasonal variation, we also produced estimates stratified by three seasons (summer = June to August; fall = September to November; and spring = March to May). However, sample sizes were not adequate to conduct an analysis with complete stratification by both season and survey region. We were not able to calculate winter (December to February) estimates, due to very low sample sizes resulting from extremely poor survey conditions during the winter survey period.

To avoid potential overestimation of group size, we used the size-bias-adjusted estimate of average group size available in DISTANCE. To facilitate modeling, the largest 5 to 10 percent of the Perpendicular Sighting Distance data were truncated (by deleting them before conducting the analysis). The data were modeled with the half-normal (with hermite polynomial and cosine adjustments) and hazard rate (with simple polynomial and cosine adjustments) models. The model with the lowest value of Akaike’s Information Criterion was selected for the final estimates.

Trackline detection probability could not be estimated from the data collected in this study. We did not conduct diving experiments, nor use independent observers. We, therefore, made use of values of $g(0)$ from previous surveys by Laake et al. (1997) for harbor porpoise. They used nearly identical methods and equipment to ours, and in fact we modeled our survey procedures after those of Laake et al. (1997). Because these values came from previous studies, and not our own analyses, we made the assumption that these $g(0)$ parameters were known with certainty and therefore we did not include a variance factor for $g(0)$ in our primary CV estimates. The CV of the density and abundance estimates is essentially a measure of the variance of the data that are used in calculating the density and abundance estimates. Since, in this case, we used the value of $g(0)$ from another study, and we did not incorporate the raw data from that study into our estimates, the variance of $g(0)$ is not part of our actual calculations. We simply used their computed value as a correction factor for our estimates. However, because there is indeed uncertainty associated with the $g(0)$ estimate used, we also presented the CV that includes the variance component for $g(0)$; we label this as CV' (presented in **Table 16**).

For harbor seals, we did not correct for submerged animals due to the fact that most harbor seal groups in this study were in shallow water, and many were milling/traveling at the surface or partially hauled out on sandbars. We assumed that $g(0) = 1.0$ for harbor seals.

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3. Results

3.1 Effort

A total of 48 survey flights were completed on 28 days during five survey periods within four different seasons (**Table 5**). Survey effort occurred during the majority of days (28 of 37, 76 percent) (**Table 6**) that the plane was available to fly each survey period, with the exception of January. Only one flight occurred during January due to heavy, low, persistent clouds that curtailed safe flying. Thus, although the overall project goal was to cover the full survey area at least once during each season and survey period, data were too sparse from the January survey period to represent a winter survey.

Weather permitting, two flights were conducted each day (**Table 5**). Morning flights were sometimes impeded by a heavy marine fog layer, which delayed the start of surveys until it had subsided.

A total of 148 hr or 28,625 km of flight (i.e., “in air”) time from “wheels up” to “wheels down” was flown over the 28 survey days (**Table 5**) (**Figures 2a and 2b; Appendix A,** Figures A1 through A5). This total includes opportunistic observations in the Strait of Juan de Fuca at the end of the July 2014 (**Figure A-2**) and September 2014 (**Figure A-3**) survey periods, after the primary survey tracklines had been fully completed at least twice. An additional approximate 65 hr was used to ferry the aircraft back and forth from Oxnard, California, to Auburn, Washington, plus approximately 4 hr 36 minutes of “engines-on” time on the runway (i.e., waiting in line to take off from the Auburn Municipal Airport) (**Table 5**).

The majority of in-air flight time consisted of either systematic effort (34 percent) when all three observers were on watch on systematic transect lines or flight time overland (**Table 7**). This was followed by 23 percent in transit, and 10 percent circling. Flight time over land was relatively high due to the large number of islands characterizing the survey area. The total hours and flight descriptions for each day by date are listed in **Table 5.**

The predominant BSS during the 2013 to 2015 surveys consisted of BSS 1 (37 percent) followed by BSS 2 (27 percent) or BSS 3 (26 percent) (**Table 8**). When BSS 5 was encountered for more than a few minutes, the survey route was aborted and another region was surveyed if BSS conditions were better, or the flight was terminated/postponed to avoid poor sighting conditions.

Table 5. Flight Effort during Puget Sound Marine Mammal Aerial Surveys 2013–2015.

Date	Flight of Day	Time Engines On	Time Engines Off	Total Engine Time (hh:mm)	Time Wheels Up	Time Wheels Down	Total Flight Time	Total Flight Distance (km)	Total Flight Distance (nm)	Start Obs.	End Obs.	Total Obs. Time
8/30/2013	1	8:52	12:42	3:50	8:59	12:41	3:42	718	387	9:12	12:28	3:16
8/30/2013	2	14:05	17:20	3:15	14:12	17:18	3:06	594	321	14:20	17:13	2:52
8/31/2013	1	8:14	12:19	4:05	8:33	12:18	3:45	698	377	8:39	12:12	3:33
8/31/2013	2	13:48	17:11	3:23	13:51	17:08	3:17	620	335	13:56	17:02	3:05
9/1/2013	1	8:11	11:44	3:33	8:18	11:41	3:23	647	349	8:46	11:39	2:53
9/1/2013	2	13:22	16:55	3:33	13:27	16:54	3:27	633	342	13:36	16:48	3:12
9/2/2013	1	7:58	11:09	3:11	8:04	11:07	3:03	559	302	8:12	11:00	2:47
9/2/2013	2	12:37	17:13	4:36	12:41	17:11	4:30	837	452	12:46	17:05	4:18
9/3/2013	1	14:22	18:44	4:22	14:27	18:42	4:15	784	423	14:35	18:34	3:59
9/4/2013	1	8:32	10:13	1:41	8:38	10:11	1:33	291	157	8:45	10:04	1:19
7/21/2014	1	9:40	13:38	3:58	9:46	13:36	3:50	733	396	9:51	13:25	3:34
7/21/2014	2	15:05	18:47	3:42	15:08	18:44	3:36	689	372	15:21	18:29	3:08
7/24/2014	1	13:54	15:45	1:51	13:57	15:43	1:46	352	190	14:04	15:37	1:33
7/25/2014	1	9:47	13:00	3:13	9:56	12:58	3:02	596	322	10:02	12:48	2:46
7/25/2014	2	14:33	18:06	3:33	14:38	18:04	3:26	630	340	14:45	17:58	3:13
7/26/2014	1	8:26	12:25	3:59	8:32	12:23	3:51	720	389	8:37	12:06	3:29
7/26/2014	2	14:07	16:28	2:21	14:13	16:25	2:12	422	228	14:55	16:16	1:21
7/27/2014	1	8:37	11:22	2:45	8:44	11:18	2:34	485	262	8:50	11:15	2:25
7/27/2014	2	12:41	16:12	3:31	12:44	16:10	3:26	651	352	12:45	16:02	3:17
9/14/2014	1	9:23	13:01	3:38	9:29	13:00	3:31	680	367	9:35	12:50	3:15
9/14/2014	2	14:29	16:30	2:01	14:35	16:28	1:53	363	196	14:42	16:21	1:39
9/15/2014	1	9:18	12:44	3:26	9:23	12:43	3:20	639	345	9:30	12:36	3:06
9/15/2014	2	14:14	16:14	2:00	14:19	16:12	1:53	351	190	14:24	16:05	1:41
9/16/2014	1	8:20	12:05	3:45	8:27	12:03	3:36	692	374	8:33	11:53	3:20
9/16/2014	2	13:23	16:26	3:03	13:28	16:23	2:55	568	307	13:32	16:16	2:44
9/17/2014	1	8:54	12:43	3:49	9:00	12:40	3:40	685	370	9:06	12:33	3:27
9/17/2014	2	14:07	16:35	2:28	14:12	16:33	2:21	466	252	14:30	16:26	1:56
9/18/2014	1	13:19	16:29	3:10	13:24	16:26	3:02	586	316	13:29	16:19	2:50
9/19/2014	1	9:04	12:35	3:31	9:07	12:27	3:20	667	360	9:12	12:12	3:00
9/19/2014	2	13:56	17:46	3:50	13:59	17:44	3:45	749	404	14:05	17:36	3:31
9/20/2014	1	13:00	16:06	3:06	13:04	16:03	2:59	617	333	13:10	15:55	2:45
9/21/2014	1	9:04	12:04	3:00	8:53	12:03	3:10	662	358	9:00	11:55	2:55

Date	Flight of Day	Time Engines On	Time Engines Off	Total Engine Time (hh:mm)	Time Wheels Up	Time Wheels Down	Total Flight Time	Total Flight Distance (km)	Total Flight Distance (nm)	Start Obs.	End Obs.	Total Obs. Time
1/06/2015	1	12:02	15:25	3:23	12:09	15:23	3:14	620	335	12:39	15:07	2:28
4/15/2015	1	10:53	15:20	4:27	10:59	15:17	4:18	816	441	11:03	15:08	4:05
4/16/2015	1	7:58	12:05	4:07	8:05	12:03	3:58	748	404	8:12	11:56	3:44
4/16/2015	2	13:35	16:44	3:09	13:39	16:43	3:04	591	319	13:43	16:37	2:54
4/17/2015	1	7:57	11:44	3:47	8:03	11:43	3:40	690	373	8:07	11:33	3:26
4/17/2015	2	16:18	17:07	0:49	16:26	17:05	0:39	146	79	16:26	16:55	0:29
4/18/2015	1	8:00	11:35	3:35	8:06	11:33	3:27	665	359	8:09	10:31	2:22
4/18/2015	2	13:11	16:17	3:06	13:16	16:15	2:59	577	311	13:22	16:09	2:47
4/19/2015	1	7:51	10:31	2:40	7:58	10:29	2:31	483	261	8:02	10:23	2:21
4/19/2015	2	12:11	16:36	4:25	12:14	16:34	4:20	773	417	12:18	16:26	4:08
4/20/2015	1	8:15	11:49	3:34	8:21	11:47	3:26	660	356	8:27	11:40	3:13
4/20/2015	2	13:16	15:11	1:55	13:20	15:09	1:49	352	190	13:24	15:03	1:39
4/21/2015	1	7:56	11:03	3:07	8:03	11:00	2:57	576	311	8:09	10:53	2:44
4/21/2015	2	12:23	15:16	2:53	12:27	15:15	2:48	535	289	12:56	15:05	2:09
4/22/2015	1	7:52	11:10	3:18	7:58	11:08	3:10	614	331	8:02	11:03	3:01
4/22/2015	2	12:13	14:20	2:07	12:16	14:18	2:02	395	213	12:20	14:12	1:52
Totals	**48 Flights**		**Total Engine Time**	**155:31:00**		**Total Flown:**	**149:31:00**	**28,625**	**15,456**		**Total Obs Time**	**135:31:00**

Table 6. Survey periods and total observation effort by survey.

Year	Season	Survey Period	No. of Flights	No. of Days Flown of Days Available	Total Observation Hours*
2013	Summer	30 August–4 September	10	6 of 6	20:54
2014	Summer	21–27 July	9	5 of 7	17.36
2014	Fall	14–21 September	13	8 of 8	25.06
2015	Winter	5–12 January	1	1 of 8	2.12
2015	Spring	15–22 April	15	8 of 8	26.48
Total			**48**	**28 of 37**	**92:36**

*Indicates periods of at least two wing observers observing.

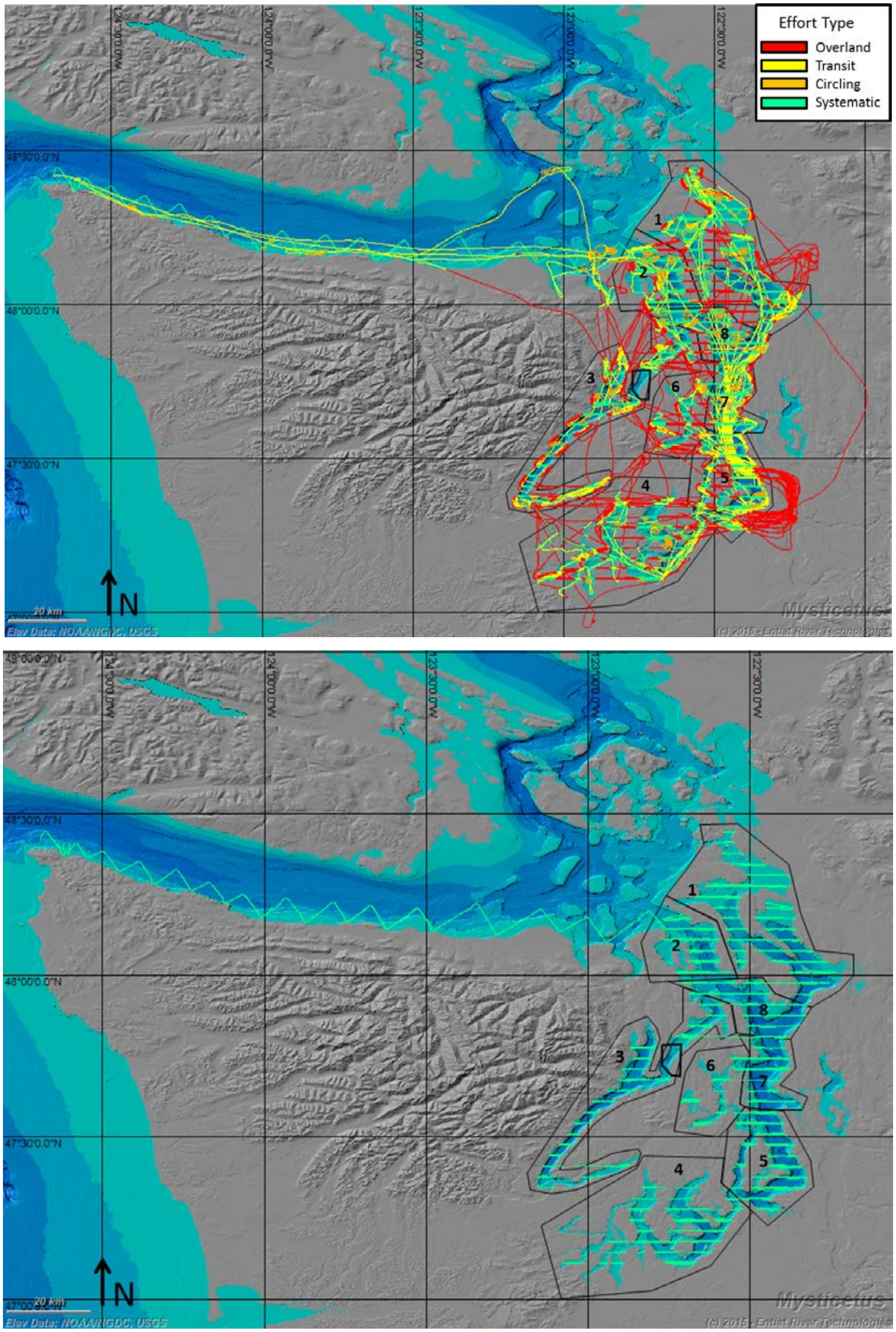

Figure 2. a) All tracklines flown for Puget Sound aerial surveys 2013–2015, including opportunistic effort in the Strait of Juan de Fuca. b) systematic, on-effort tracklines only for Puget Sound aerial surveys 2013–2015, including opportunistic effort in the Strait of Juan de Fuca.

Both maps include outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey), and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

Table 7. Total flight time and distance by survey leg type.

Date/Survey	Leg Type								Total	
	Overland		Transit		Systematic		Circling			
	hr:min	km	hr:min	km	hr:min	km	hr:min	km	hr:min	km
Aug–Sep 2013	11:43	2,235	5:57	1,161	11:58	2,205	3:52	666	33:33	6,267
Jul 2014	7:48	1,687	6:57	1,343	8:22	1,531	1:22	246	24:30	4,807
Sep 2014	12:19	2,451	10:05	2,075	13:42	2,543	3:00	547	39:08	7,616
Jan 2015	0:45	152	0:41	149	1:14	219	0:31	95	03:13	615
Apr 2015	16:19	3,157	10:19	2,035	14:55	2,811	5:31	978	47:04	8,981
OVERALL TOTAL	**48:56**	**9,682**	**34:02**	**6,763**	**50:12**	**9,309**	**14:19**	**2,532**	**147:30**	**28,286**

Key: Apr = April; Aug = August; hr:min = hours:minutes; Jan = January; Jul = July; km = kilometer(s); Sep = September

Table 8. Beaufort Sea State during surveys conducted in 2013 to 2015.

Beaufort Sea State	Observation Effort (km)	% of Flight Effort*
0	1,018	7%
1	5,093	37%
2	3,765	27%
3	3,603	26%
4	363	3%
5	64	<1%
Total	**13,906**	

*Flight Effort percentages are rounded to the nearest whole number

3.2 Sightings and Relative Occurrence

For 2013 to 2015 surveys, there were a total of 5,005 sightings of an estimated 9,645 total individual marine mammals (**Table 9**). Of these sightings, 4,909 groups totaling 9,528 individuals were identified to species. The remaining 96 sightings (117 individuals) were of unidentified marine mammals. Ten species were documented over the 28 survey days in the Puget Sound and opportunistically in the Strait of Juan de Fuca, including an unidentified single otter (either a river or sea otter). The following species were observed in descending order of frequency:

- Harbor seal
- Harbor porpoise
- California sea lion
- Steller sea lion
- Gray whale
- Killer whale

- Common minke whale (only in Strait of Juan de Fuca, not in Puget Sound)
- Risso's dolphin
- Dall's porpoise
- Sea or river otter.

Table 9. Total numbers of marine mammal sightings and mean group sizes by species.

Common Name	# Groups	% of all Groups Sighted	Total # Individuals *	# Calves/ Pups	Mean Group Size	Standard Error
Harbor Seal	3,803	76%	7,292	24	1.9	0.1
Harbor Porpoise	909	18%	1,971	98	2.2	0.1
California Sea Lion	115	2%	157	0	1.3	0.1
Steller Sea Lion	69	2%	76	0	1.1	<0.1
Gray Whale	5	<1%	7	0	1.4	0.2
Killer Whale	3	<1%	18	1	6.0	1.7
Minke Whale	2	<1%	2	0	1.0	<0.1
Risso's Dolphin	2	<1%	4	0	2.0	<0.1
Dall's Porpoise	1	<1%	1	0	1.0	n/a
Unidentified Marine Mammal	18	<1%	20	0	1.1	0.1
Unidentified Pinniped	26	<1%	35	0	1.3	0.2
Unidentified Porpoise	2	<1%	3	0	1.5	0.5
Unidentified Small Marine Mammal	46	1%	53	0	1.2	0.1
Unidentified Dolphin	3	<1%	5	0	1.6	0.3
Unidentified Otter	1	<1%	1	0	1.0	n/a
Total	**5,005**		**9,645**	**123**		

* Species are listed in descending order of group sighting frequency. Total number of all individuals includes calves and pups.

Although two rare sightings of a pair of Risso's dolphins were made in 2013 (Smultea et al. 2014), none were seen in 2014 and 2015 surveys (see **Section 3.4**). Based on number of individuals, the harbor seal was the most commonly seen species, comprising 76 percent of all 9,645 observed individuals identified to species, followed by the harbor porpoise (20 percent) (**Table 9**).

Overall, the mean group sizes of marine mammal species tended to be approximately 1 to 2 individuals across survey periods, with the exception of a mean group size of 6.0 for the three killer whale sightings (**Table 9**). In addition, mean group size of hauled-out harbor seals was much larger (19.1 SE ±2.5) than those in water (1.3 SE ±0.3) (**Table 12**). Group sizes of marine mammal species ranged from 1 to 150 individuals (**Table S1** in Smultea et al. 2015)[7]. The largest groups consisted of hauled-out harbor seals, although large groups/aggregations of harbor porpoise were also seen (**Table S1**).

[7] Provided separately as a supplemental document to this report.

Mean group size varied somewhat across seasons. The largest mean group size by season among harbor porpoise of 7.5 (SD ±10.39) was observed during the January 2015 survey period, though this was based on only one flight during January. In addition, killer whale mean group size was 7.5 (SD ±2.12) during the April 2015 survey period based on two sightings near Seattle; the only other killer whale sighting consisted of three whales and was made near San Juan Island (**Table 9**).

Calves/pups were observed only among harbor porpoise, killer whales, and harbor seals (**Table 9**). Note that calves/pups were defined as individuals less than half the body length of nearby adults. Overall, across all five survey periods, calves comprised 5 percent (*n*=98) of all individual harbor porpoise seen. The proportion of calves to all harbor porpoise seen by seasonal survey period ranged from 1 percent in January and April 2015 to 6 to 8 percent during September 2013 and July and September 2014 (**Table 10**). In the 98 cases in which calves were observed with harbor porpoise groups, only one calf was present in 82 percent of those cases. Seven calves were counted in one group/aggregation on 26 July 2014 in the South Whidbey sub-region (**Table S1**). The only other calf observed was a single killer whale calf in a group of nine total whales (**Table 9**). Among harbor seals, pups comprised 0.3 percent (*n*=24) of all individuals observed, and all pups were seen in the water (**Table 9**). Harbor seal pups were seen most commonly during the July 2014 survey period (**Table 11 and Figure 3**). **Table S1** lists all marine mammal sightings separately from 2013 to 2015, including information on number of calves, group size, GPS location, and other sighting details.

Table 10. Number and proportion of harbor porpoise calves seen in the eight pre-defined Puget Sound survey sub-regions and the Strait of Juan de Fuca by seasonal survey period 2013–2015. Individuals less than ½ the body length of nearby adults were considered calves.

Harbor Porpoise	Sept 2013	July 2014	Sept 2014	Jan 2015	April 2015	Total
Total calves	11	36	46	1	4	**98**
Total all individuals	143	567	771	128	362	**1,971**
Percent of all individuals	8%	6%	6%	1%	1%	**5%**

Table 11. Numbers and proportions of harbor seal pups seen in the eight pre-defined Puget Sound survey sub-regions and the Strait of Juan de Fuca by seasonal survey period 2013–2015. Individuals less than ½ the body length of nearby adults were considered pups.

Harbor Seal	Sep 2013	Jul 2014	Sep 2014	Jan 2015	Apr 2015	Total
Total pups	5	16	2	0	1	**24**
Total all individuals	1,499	1,866	2,092	71	1,764	**7,292**
Percent of all individuals	<1%	1%	<1%	0	<1%	**0.3%**

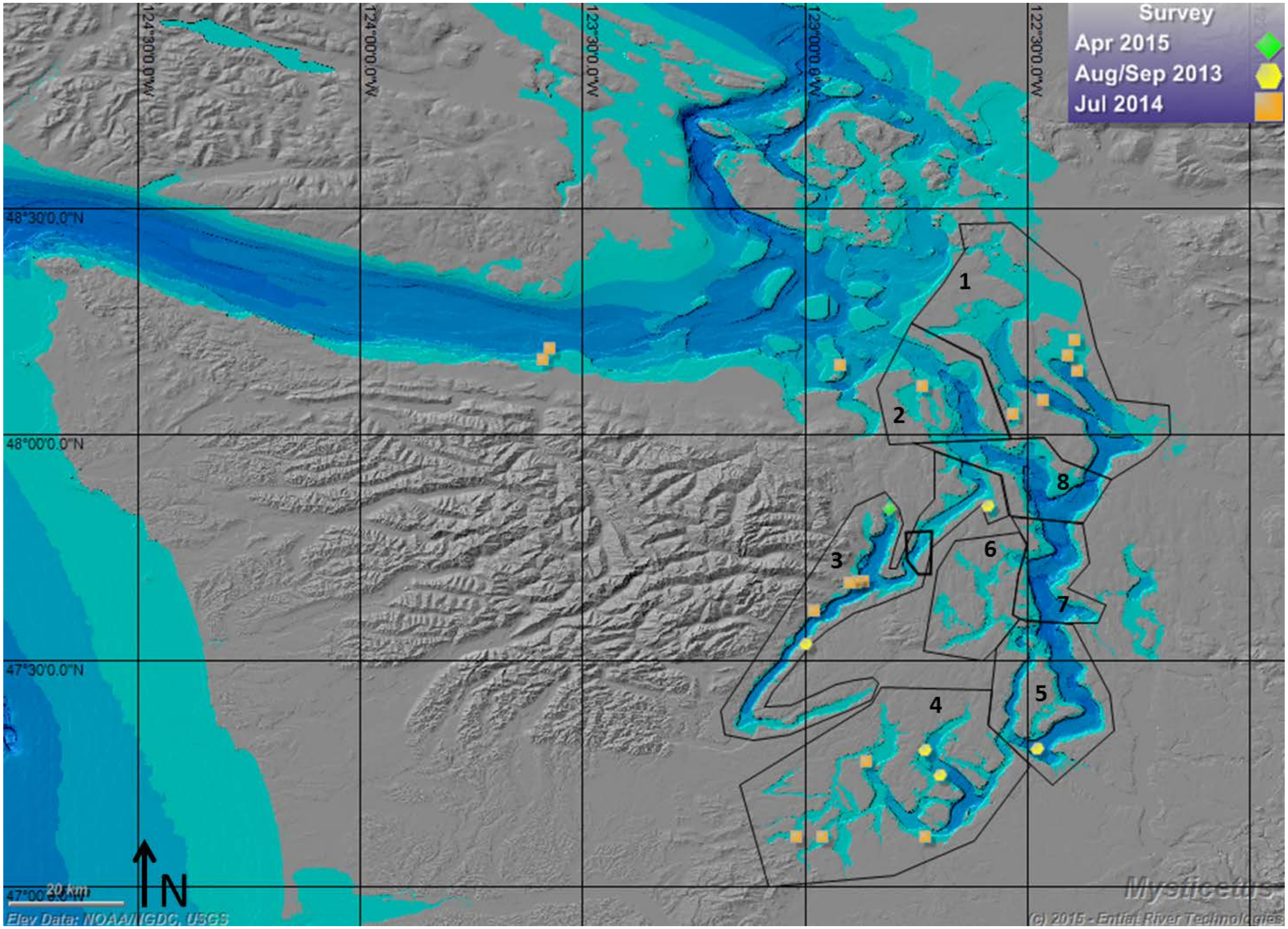

Figure 3. Locations at which harbor seal pups were recorded by survey period. Note that "pup" was defined as individuals less than ½ the body length of nearby adults, so pups are not restricted to newborn animals. All pups were recorded in water.

Map includes outlines of the eight pre-defined survey sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

3.3 Pinnipeds In Water and Hauled Out

Most harbor seal, Steller sea lion, and California sea lion groups were seen in-water (97 percent, 96 percent, and 88 percent respectively), with little variation across seasonal survey periods (**Table 12**). However, it should be noted that surveys were designed to detect cetaceans in water and specifically avoided seal and sea lion haul out areas, and some haul out areas were in the designated no-fly zone. For completeness of data, numbers of seals and sea lions opportunistically observed hauled out are included in **Table 12**.

Table 12. Total number of pinniped groups observed in water or hauled out.*

Species	No. of Groups	No. of Groups in Water	% of Groups in Water	Mean Dispersal for In-water Groups (SE)	Mean Group Size in Water (SE)	No. of Groups Hauled Out	% of Groups Hauled Out	Mean (max) Dispersal for Hauled-out Groups (SE)	Mean Group Size Hauled Out (SE)
Harbor Seal	3,803	3,690	97	6.6 (0.7)	1.3 (0.1)	113	3	3.6 (0.63)	19.1 (2.5)
California Sea Lion	115	101	88	1.5 (0.4)	1.4 (0.1)	14	12	0.5 (n/a)	1.2 (0.1)
Steller Sea Lion	69	66	96	1.4 (0.3)	1.1 (<0.1)	3	4	No Data	1.3 (0.3)

*Dispersal distance values based only on those groups of at least two individuals, estimated in species body lengths. Dispersal here refers to maximum dispersal distance between neighbors within a group with no intervening individuals. Dispersal was not recorded for every group observed.

Key: % = percentage; max = maximum; n/a = not available; No. = number; SE = standard error; No Data = all sightings consisted of single individuals, thus dispersal could not be estimated as by definition it is the distance between individuals within a group of at least two individuals.

3.4 Occurrence and Distribution within Survey Sub-regions

Overall (for all sub-regions and the opportunistic surveys in the Strait of Juan de Fuca) from 2013 to 2015, individual harbor porpoise were most frequently seen in the South Whidbey sub-region (26 percent or 503 individuals), followed by Strait of Juan de Fuca (16 percent) and 12–13 percent in Admiralty Inlet, East Whidbey, and Southern Puget Sound sub-regions (**Table 13**). The lowest proportions were observed in Vashon and Bainbridge (both 4 percent), and Seattle and Hood Canal (6 percent each) sub-regions. A general notable gap in harbor porpoise distribution occurred during all five survey periods within the Vashon sub-region in waters from Federal Way north to Burien and west to Vashon Island (**Figure 4**).

Table 13. Harbor porpoise and harbor seal sightings by sub-region during aerial surveys of Puget Sound during 2013–2015.

Survey Sub-region	Harbor Porpoise			Harbor Seal*		
	# Indiv.	# Groups	% Total Indiv./ Sub-region	# Indiv.	# Groups	% Total Indiv./ Sub-region
Admiralty Inlet	233	91	12%	252	186	3%
Bainbridge	80	23	4%	169	103	2%
East Whidbey	258	135	13%	1,890	780	26%
Hood Canal	125	86	6%	1,504	763	21%
Seattle	116	65	6%	162	108	2%
South Whidbey	503	171	26%	249	218	3%
Southern Puget Sound	238	136	12%	1,940	1,044	27%
Vashon	86	50	4%	366	318	5%
Strait of Juan de Fuca (Opportunistic)	319	143	16%	405	213	6%
Other	13	9	1%	355	70	5%
TOTAL	**1,971**	**909**	**100**	**7,292**	**3,803**	**100**

* Includes harbor seals in water and hauled out.

Individual harbor seals within all sub-regions were most frequently seen in the Southern Puget Sound (27 percent or 1,940 individuals) and East Whidbey sub-regions (26 percent or 1,890 individuals), followed by Hood Canal (21 percent) (**Table 13**). The lowest proportions (2 percent each) occurred in the adjacent Bainbridge and Seattle sub-regions (**Figure 5**). During all five survey periods, a notable gap in harbor seal distribution occurred in the upper northeastern portion of Hood Canal; however, approximately the southern one-third of this area was not surveyed or observable due to the presence of a restricted no-fly area associated with the North Kitsap at Bangor Installation (**Figures 1 and 4**).

For pinnipeds other than harbor seals, observations were made of California sea lions and Steller sea lions in all eight of the sub-regions across the five survey periods from 2013 to 2015 (**Table 14**).

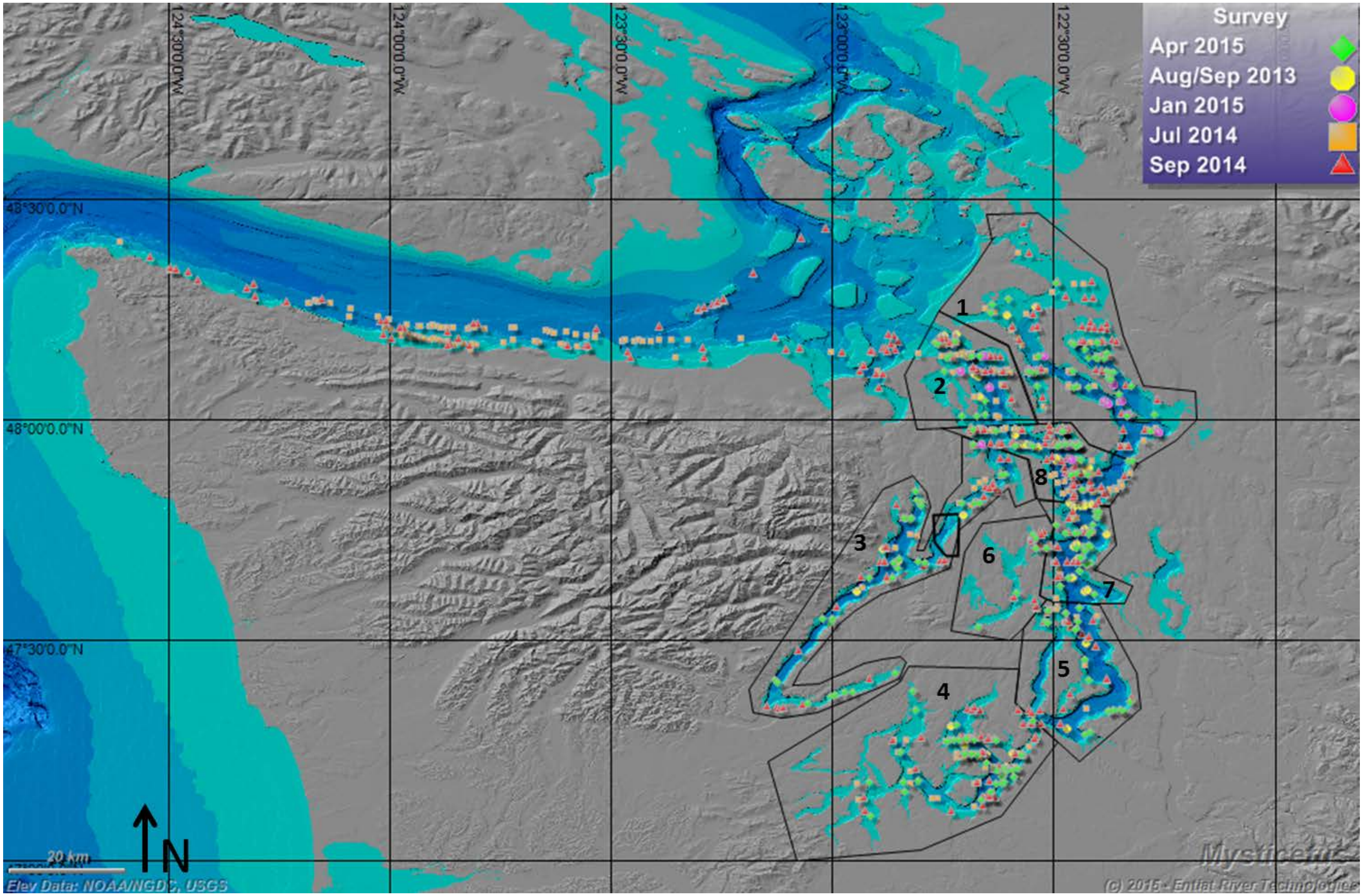

Figure 4. All harbor porpoise group sightings from Puget Sound aerial surveys 2013-2015 by seasonal survey period.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1). For breakdown maps by seasonal survey period see Appendix A, Section A.2.

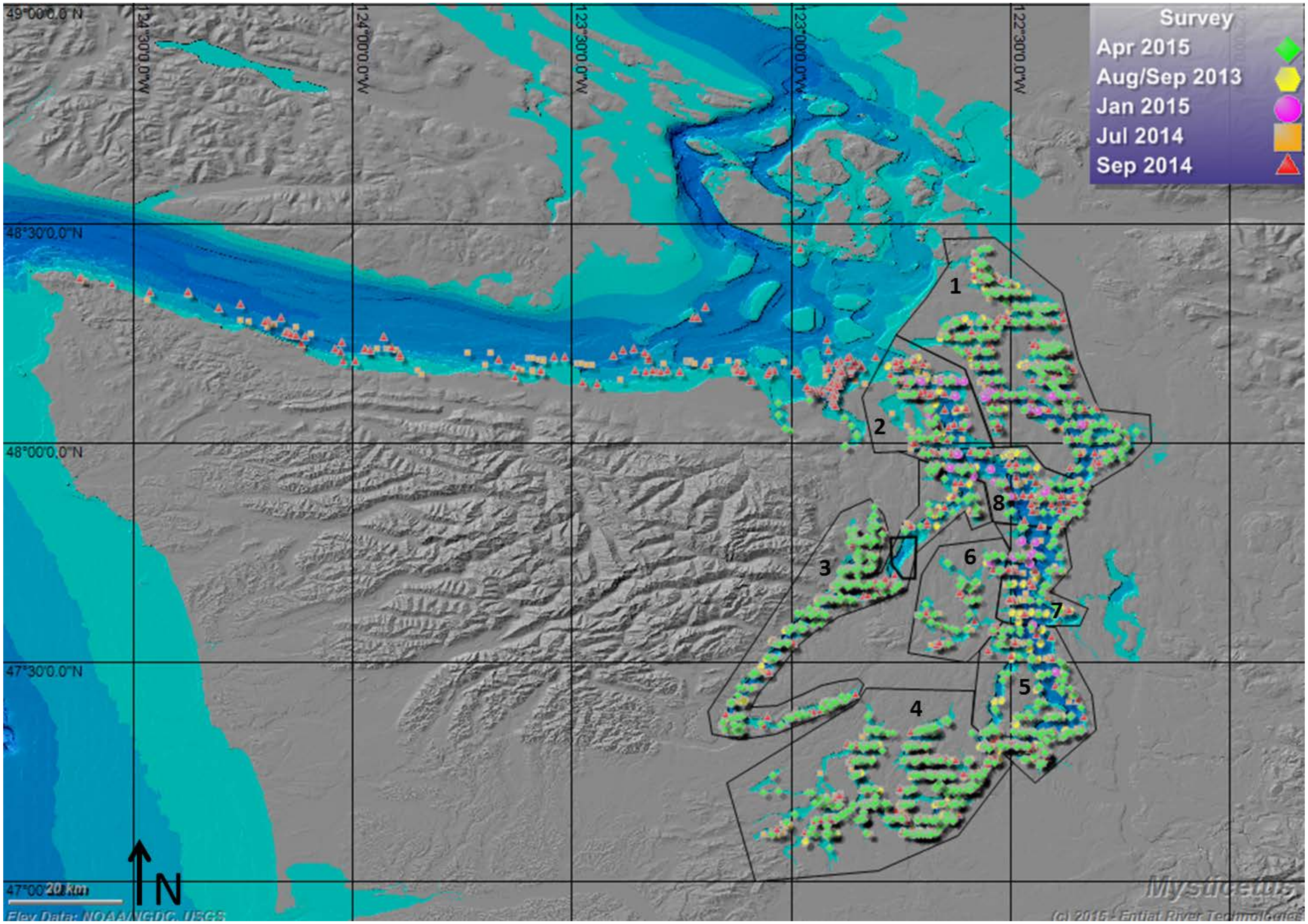

Figure 5. All harbor seal group sightings for Puget Sound aerial surveys 2013–2015 by seasonal survey period.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1). For breakdown maps by seasonal survey period see Appendix A, Section A.3.

Table 14. Number of groups sighted by species and survey period in the primary eight sub-regions and the Strait of Juan de Fuca during the 2013–2015 Puget Sound aerial surveys.*

Species	Admiralty Inlet	Bainbridge	East Whidbey	Hood Canal	Seattle	South Whidbey	Southern Puget Sound	Vashon	Strait of Juan de Fuca (Opportunistic)	Other	Total
September 2013											
Harbor Seal	45	14	99	117	27	29	260	76	0	2	669
Harbor Porpoise	19	0	2	4	12	16	9	2	0	1	65
California Sea Lion	2	0	2	2	4	0	2	2	0	1	15
Risso's Dolphin	0	0	0	0	1	0	0	1	0	0	2
Survey Total	**66**	**14**	**103**	**123**	**44**	**45**	**271**	**81**	**0**	**4**	**751**
July 2014											
Harbor Seal	46	12	203	119	26	43	272	49	60	11	841
Harbor Porpoise	36	1	41	13	9	56	40	10	85	0	291
California Sea Lion	0	0	1	0	0	1	0	0	0	0	2
Survey Total	**82**	**13**	**245**	**132**	**35**	**100**	**312**	**59**	**145**	**11**	**1,134**
September 2014											
Harbor Seal	49	26	201	179	21	83	180	69	152	39	999
Harbor Porpoise	21	15	48	37	17	74	49	18	58	7	344
California Sea Lion	0	2	0	1	2	4	1	11	0	1	22
Killer Whale	0	0	0	0	0	0	0	0	0	1	1
Minke Whale	0	0	0	0	0	0	0	0	2	0	2
Steller Sea Lion	24	1	3	6	4	11	5	8	6	0	68
Survey Total	**94**	**44**	**252**	**223**	**44**	**172**	**235**	**106**	**218**	**48**	**1,436**
January 2015											
Harbor Seal	13	2	23	2	9	14	0	1	0	0	64
Harbor Porpoise	2	1	10	1	0	1	0	0	0	0	15
Survey Total	**15**	**3**	**33**	**3**	**9**	**15**	**0**	**1**	**0**	**0**	**79**

Species	Admiralty Inlet	Bainbridge	East Whidbey	Hood Canal	Seattle	South Whidbey	Southern Puget Sound	Vashon	Strait of Juan de Fuca (Opportunistic)	Other	Total
April 2015											
Harbor Seal	33	49	254	346	25	49	332	123	1	18	1,230
Harbor Porpoise	12	6	34	31	27	23	38	20	0	1	192
California Sea Lion	10	2	11	13	14	4	2	20	0	0	76
Dall's Porpoise	0	0	0	1	0	0	0	0	0	0	1
Gray Whale	0	0	5	0	0	0	0	0	0	0	5
Killer Whale	0	0	1	0	0	0	0	1	0	0	2
Steller Sea Lion	0	0	0	0	0	1	0	0	0	0	1
Otter (sea or river)	0	0	0	0	0	0	1	0	0	0	1
Survey Total	**55**	**57**	**305**	**391**	**66**	**77**	**373**	**164**	**1**	**19**	**1,508**
OVERALL TOTAL	**312**	**131**	**938**	**872**	**198**	**409**	**1,191**	**411**	**364**	**82**	**4,908**

*Sightings are uncorrected for effort.

These data do not include any unidentified marine mammals, other than otter.

Sightings of the four non-harbor porpoise cetacean species observed were relatively uncommon and/or seasonal in nature (**Tables 9 and 14; Figure 6; Appendix A,** Figures A-16 through A-19). All four of the gray whale sightings occurred during April 2015 in the East Whidbey sub-region, three of which were in the eastern portion of Possession Sound northwest of Naval Station Everett. The three killer whale sightings occurred in the following three areas: East Whidbey sub-region in April 2015, Vashon sub-region in April 2015, and outside of the survey area near San Juan Island in September 2013. The two single common minke whales were observed during opportunistic surveys in the southeastern Strait of Juan de Fuca (outside of the eight primary sub-regions) in September 2013. Both sightings of Risso's dolphins occurred in the Seattle/Vashon sub-regions during the September 2013 survey period. The single Dall's porpoise was observed in Hood Canal sub-region, specifically in Dabob Bay, in April 2015.

One otter sighting (a river or sea otter) was observed in southern Puget Sound sub-region in the April 2015 survey period.

In Dabob Bay, within the northern portion of the Hood Canal sub-region, the following group sightings were made: 230 harbor seal (267 individuals), 16 harbor porpoise (18 individuals), 2 Steller sea lion (2 individuals), 2 California sea lion (2 individuals), and a single Dall's porpoise (**Figures 3 through 5**). The Dall's porpoise was photo-documented

3.5 Photography

A total of 1,332 digital photographs was taken during the five survey periods (**Table 15**). As indicated previously, photographs were taken primarily of unusual/rare sightings and initially unidentified or unconfirmed species to confirm or verify species as possible (see **Appendix B**). Photographs included feeding gray whales and what appeared to be feeding pits made by gray whales in mudflats of the Snohomish River Delta during low tide in the eastern half of Possession Sound northwest of Naval Station Everett in April 2015. Video was taken only during the April 2015 survey period and included feeding gray whales, totaling 14:29 minutes.

Table 15. Summary of digital photographs and video taken during the 2013–2015 Puget Sound aerial surveys.

Survey Period	# of Photos Taken	Video Taken (min:sec)	Description
Sep 2013	500	0:00	
Jul 2014	74	0:00	
Sep 2014	188	0:00	
Jan 2015	32	2:13	
Apr 2015	538	12:16	15 April—killer whales traveling, identified by NMFS researchers as west coast Biggs' transients consisting of T65As, T65Bs, T75Bs and T75C, including a new calf (C. Emmons, NMFS NWFSC, pers. comm. August 2015; Orca Network n.d.[a]); 20 April—gray whale; 21 April—probable gray whale feeding pits in mud; 22 April—gray whales feeding
Total	**1,332**	**14:29**	

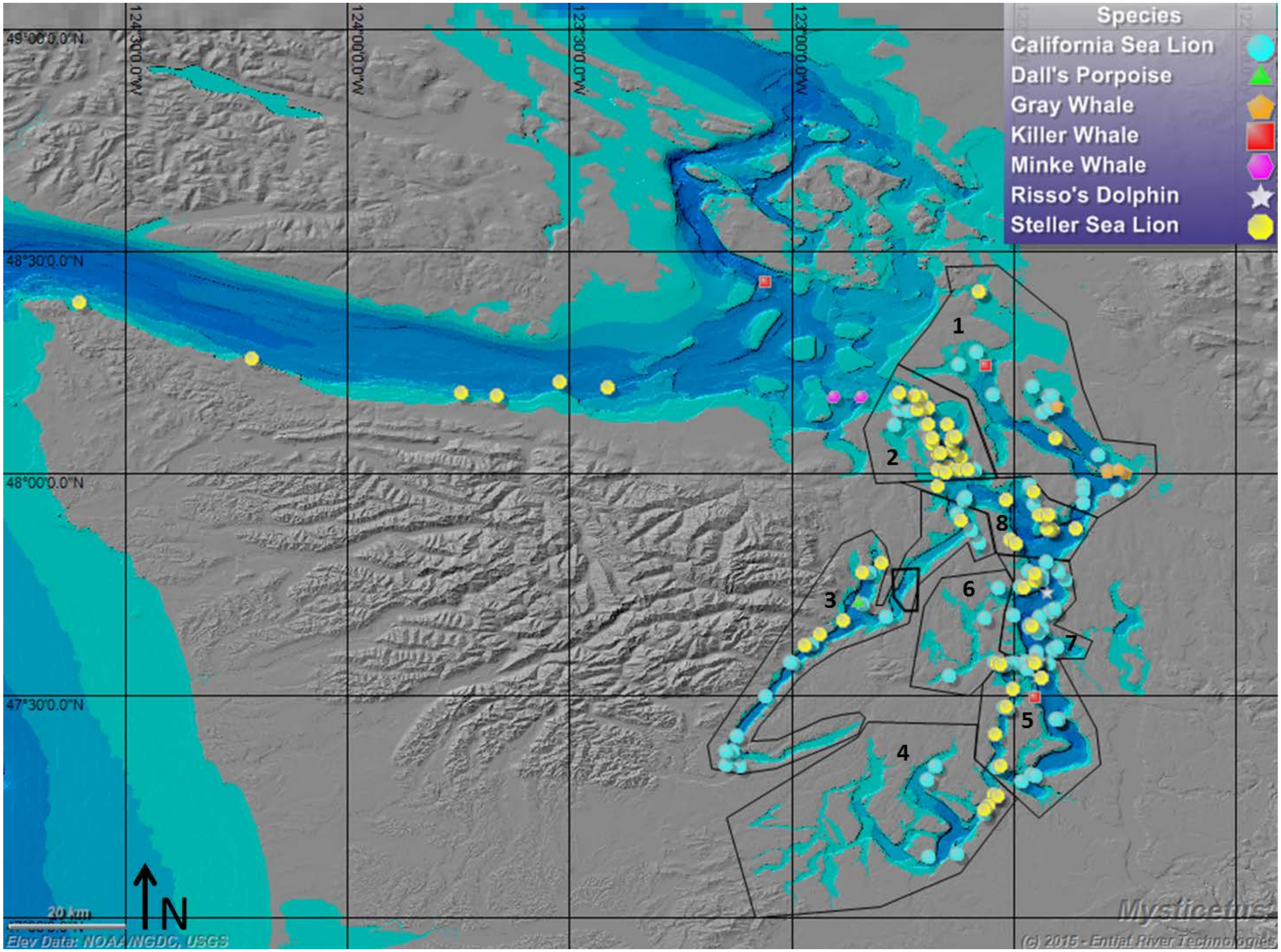

Figure 6. All group sightings of other marine mammal species by seasonal survey period for Puget Sound aerial surveys 2013-2015.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

3.6 Density and Abundance

After we filtered for conditions suitable to estimate density and abundance, sample size was sufficient for only two of the ten species sighted during the surveys, the harbor porpoise and the harbor seal (see **Section 2.3**). Of 909 total harbor porpoise groups seen, 338 (37 percent) were suitable for density and abundance analyses, while 1,771 of 3,803 (47 percent) total harbor seal groups were suitable for these analyses based on the suitable conditions described in **Section 2.3** of Methods (**Tables 9, 13, and 14**). Hauled-out harbor seal sightings were not used for in-water density estimation purposes because seals were completely out of the water. However, harbor seals with their bellies resting on sand but still in the water were included for in-water density estimates. Perpendicular Sighting Distance histograms and fitted detection functions for harbor porpoise and harbor seal group sightings are shown in **Figure 7 and 8**. Input parameters and results of the line transect analyses are presented in **Tables 16 and 17** below.

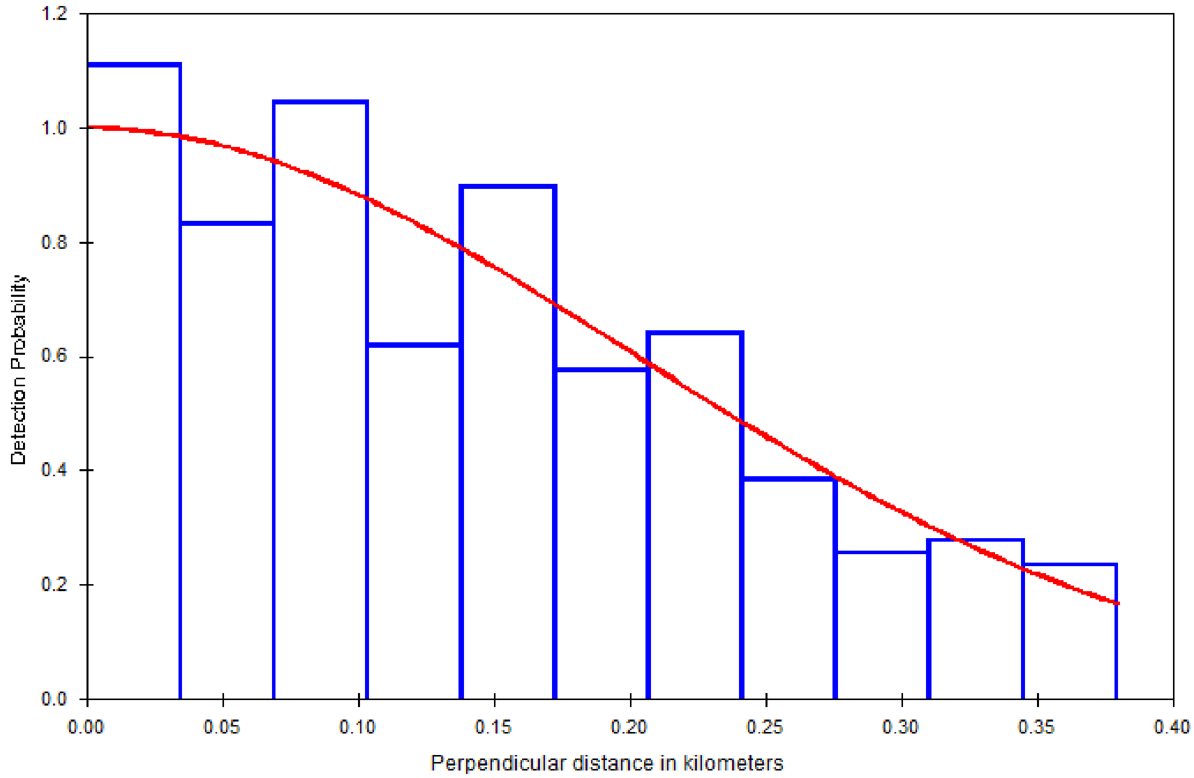

Figure 7. Harbor porpoise Perpendicular Sighting Distance histogram and fitted detection function based on 2013–2015 sighting data. Model used is Half-Normal, with hermite polynomial adjustment.

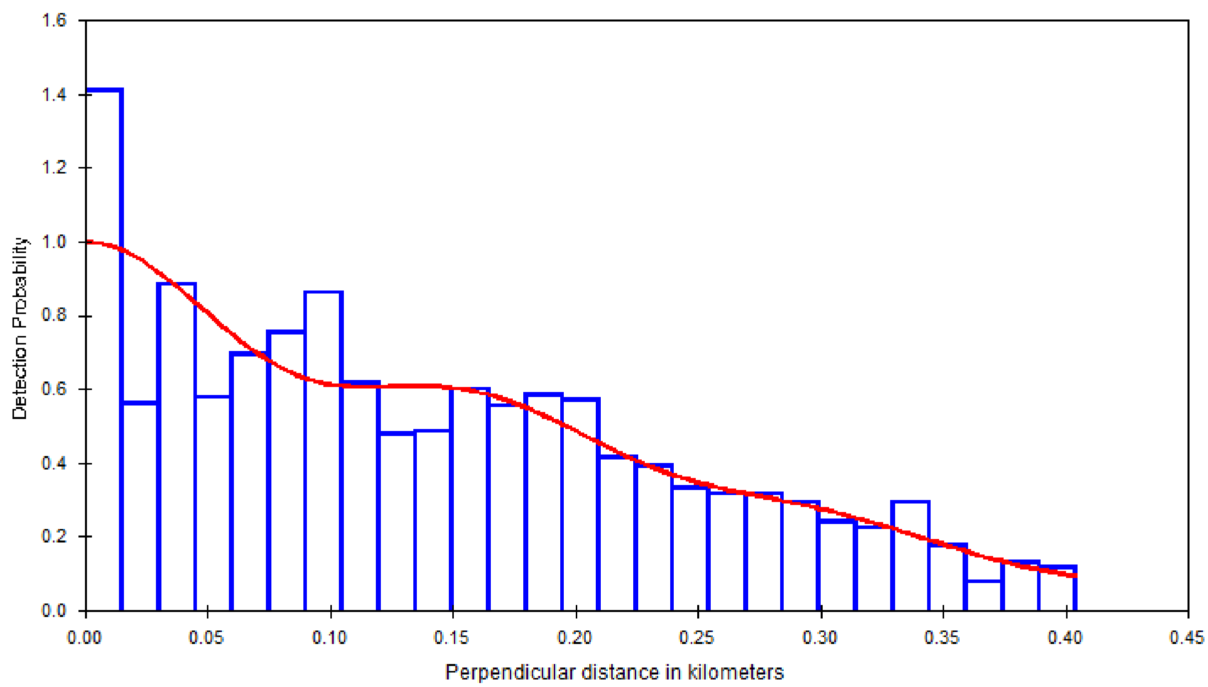

Figure 8. Harbor seal Perpendicular Sighting Distance histogram and fitted detection function based on 2013-2015 sighting data. Model used is Half-Normal, with cosine adjustment.

Table 16. Harbor porpoise line-transect parameters and estimates of density and abundance for Puget Sound aerial surveys 2013–2015.

Season	Sub-Region	No. Stgs.*	Effort (km)	Avg. Grp. Size	Trackline Detection Prob. - g(0)#	Individual Density (#/km^2)	95% CI (Density)	Abundance	95% CI (Abundance)	%CV	%CV’
Spring	Pooled	103	1,658	2.2	0.292	1.6	0.93-2.92	4,349	2,452-7,712	29	47
Summer	Pooled	128	1,574	2.2	0.292	1.0	0.69-1.49	2,674	1,815-3,942	19	42
Fall	Pooled	107	1,670	1.5	0.292	0.9	0.44-1.75	2,253	1,130-4,497	32	49
	Admiralty Inlet	48	294	1.3	0.292	1.46	1.04-2.09	377	267-534	17	41
	Bainbridge	6	188	1.0	0.292	0.23	0.10-0.55	21	10-51	41	55
	East Whidbey	69	1,122	1.8	0.292	0.77	0.48-1.20	497	322-771	21	43
	Hood Canal	27	661	1.6	0.292	0.47	0.29-0.75	185	116-291	23	44
	Seattle	28	381	1.3	0.292	0.69	0.28-1.69	147	58-396	43	57
	South Whidbey	57	373	2.2	0.292	2.47	1.54-3.94	661	414-1,055	23	44
	Southern Puget Sound	90	1,163	1.7	0.292	0.89	0.57-1.37	404	264-627	21	43
	Vashon	13	720	2.3	0.292	0.27	0.16-0.54	96	51-171	29	47
	Overall Pooled	**338**	**4,902**	**1.7**	**0.292**	**0.91**	**0.72-1.10**	**2,387**	**1,942-2,935**	**11**	**39**

* Before truncation.

From Laake et al. (1997)

CV’ includes the variance component for g(0)

Table 17. Harbor seal line-transect parameters and estimates of density and abundance for Puget Sound aerial surveys 2013–2015. Note that abundance estimates are based on observations of harbor seals in water and likely underrepresent actual harbor seal abundance in Puget Sound because no correction was made for seals that were hauled out during surveys.

Season	Stratum	No. Stgs.*	Effort (km)	Avg. Grp. Size	Trackline Detection Prob. - g(0)	Individual Density (#/km^2)	95% CI (Density)	Abundance	95% CI (Abundance)	%CV
Spring	*Pooled*	*681*	*647*	1.0	1.0	*1.15*	*0.93-1.13*	*3,049*	*2,457-3,783*	*11*
Summer	*Pooled*	*572*	*1574*	1.2	1.0	*0.90*	*0.62-1.32*	*2,389*	*1,630-3,503*	*17*
Fall	*Pooled*	*518*	*1670*	1.2	1.0	*0.67*	*0.55-.084*	*1,961*	*1,597-2,407*	*9*
	Admiralty Inlet	54	294	*1.3*	1.0	0.59	0.43-0.83	152	109-211	16
	Bainbridge	50	188	*1.2*	1.0	0.79	0.51-1.19	74	41-112	19
	East Whidbey	358	1,122	*1.1*	1.0	0.88	0.61-1.29	566	385-833	18
	Hood Canal	375	661	1.2	1.0	1.71	1.37-2.13	668	537-831	11
	Seattle	41	381	1.1	1.0	0.28	0.17-0.41	59	39-88	19
	South Whidbey	72	373	1.0	1.0	0.51	0.34-0.77	137	92-206	19
	Southern Puget Sound	682	1163	1.3	1.0	1.84	1.35-2.51	838	614-1,144	6
	Vashon	139	720	1.2	1.0	0.52	0.41-0.67	165	128-211	12
	Overall Pooled	***1771***	***4,902***	***1.2***	***1.0***	***0.92***	***0.77-1.07***	***2,659***	***2,266-3,121***	***8***

* Before truncation.

Estimates of abundance of harbor porpoise in the various survey sub-regions ranged from 21 to 661. The highest abundance and density for any survey sub-region was South Whidbey, with an estimated 661 porpoise (density=2.47 porpoise/km^2). Seasonal fluctuations were apparent, with highest numbers in spring (4,349) and lowest in fall (2,253). The overall pooled estimate of abundance for harbor porpoise in the entire survey area throughout the year was 2,387 porpoise (CV=11 percent). This is a precise estimate that represents an average of the three seasons.

Estimates of abundance of harbor seals in the various survey sub-regions ranged from 59 to 838. The highest abundance and density for any survey sub-region was southern Puget Sound, with an estimated 838 seals (density=1.84 seals/km^2). Seasonal fluctuations were apparent, with highest estimated numbers in spring (3,049) and lowest in fall (1,961). The overall pooled estimate of abundance for harbor seals in the entire survey area throughout the year was 2,659 seals (CV=8 percent). This is a precise estimate that represents an average of the three seasons. The graph of perpendicular sighting distances (**Figure 8**) shows a large spike near the trackline and a very long tail. These features make the data challenging to model, and achieving monotonicity can be difficult. It should also be noted that the focus of surveys was cetaceans, and that haul-out areas of seals were avoided during surveys. Our opportunistic observations provide some in-water sightings that can complement currently unpublished data collected by Washington Department of Fish and Wildlife in 2013–2014, which were specifically focused on evaluating harbor seal abundance in Puget Sound. Abundance estimates reported in **Table 17** represent values based on in-water observations of harbor seals that underestimate total harbor seal abundance because haul-out areas were not observed and surveys were not on dates or at times specific to optimal observation of harbor seals.

To address harbor porpoise and harbor seal occurrence near specific naval installations in Puget Sound, we report observations of these species and the average estimated number of individuals based on density in the sub-region for areas of 2-nautical mile (nmi) radius around six naval installations (**Tables 18–20, Figure 9**). Raw counts are reported for information purposes only and are not corrected for effort or other variables. Abundances within the 2-nmi radii represent average expected abundances within in-water areas based on densities within the larger sub-regions. Thus, the latter estimated values do consider effort, visibility, sighting bias, etc. However, associated data were not sufficient to include a seasonal component or to consider how density may differ within the smaller 2-nmi areas compared to the larger sub-regions.

Table 18. Names and locations of naval installations for which harbor porpoise and harbor seal abundances were estimated in water for a 2-nmi radius around the installation. Latitudes and longitudes were chosen to be close to the shoreline of each installation in order to include the largest area of water within the 2-nmi radii.

Naval Installation	Longitude	Latitude	Description
Naval Base Kitsap at Bangor	-122.7248	47.7544	Northwest edge of *Trident* Support Facilities Second Explosives Handling Wharf at Naval Base Kitsap at Bangor
Naval Air Station Whidbey Island	-122.5873	48.2829	Crescent Harbor approximately 2 miles west of neck of Polnell Point
Dabob Bay	-122.8530	47.7116	Center of bay approximately halfway between Seal Rock and Zelatched Point
Naval Station Everett	-122.2337	47.9816	Southwest corner of western Everett pier
Manchester Fuel Depot	-122.5310	47.5650	Approximate mid-point of the northeast point of the depot
Naval Base Kitsap at Bremerton	-122.6421	47.5531	Central location along the shoreline at edge of dock at approximate center of facility along shoreline of Sinclair Inlet

Table 19. Harbor porpoise sightings and estimated average abundances within a 2-nmi radius of six naval installations based on densities in the appropriate larger sub-regions.

Number of Harbor Porpoise Sightings/Individuals

Sub-Region	Aug/Sep 2013		Jul 2014		Sep 2014		Jan 2015		Apr 2015		Total # Groups	Total # Indiv.
	# Groups	# Indiv.	# Groups	# Indiv.	# Groups	# Indiv.	# Groups	# Indiv.	# Groups	# Indiv.		
Naval Base Kitsap at Bangor	1	1	0	0	0	0	0	0	0	0	1	1
Naval Air Station Whidbey Island	0	0	0	0	0	0	0	0	1	1	1	1
Dabob Bay	2	4	1	1	2	3	0	0	1	1	6	9
Naval Station Everett	0	0	4	4	1	1	1	2	0	0	6	7
Manchester Fuel Depot	0	0	3	4	7	10	0	0	3	4	13	18
Naval Base Kitsap at Bremerton	0	0	0	0	0	0	0	0	1	1	1	1

Abundance in each 2-nmi radius based on sub-regional density data

Sub-Region	Total Area (km^2)	Water Percentage	Water Area (km^2)	Density in Sub-region	Abundance in 2nmi Radius
Naval Base Kitsap at Bangor	43	43.3%	18.6	0.47	9
Naval Air Station Whidbey	43	64.1%	27.6	0.77	21
Dabob Bay	43	78.8%	33.9	0.47	16
Naval Station Everett	43	54.4%	23.4	0.77	18
Manchester Fuel Depot	43	54.7%	23.5	0.27	6
Naval Base Kitsap at Bremerton	43	34.7%	14.9	0.23	3

Table 20. Harbor seal sightings and estimated average abundances within a 2-nmi radius of six naval installations based on densities in the appropriate larger sub-regions.

Number of Harbor Seal Sightings

Sub-Region	Aug/Sep 2013		Jul 2014		Sep 2014		Jan 2015		Apr 2015		Total # Groups	Total # Indiv.
	# Groups	# Indiv.	# Groups	# Indiv.	# Groups	# Indiv.	# Groups	# Indiv.	# Groups	# Indiv.		
Naval Base Kitsap at Bangor	0	0	0	0	0	0	0	0	0	0	0	0
Naval Air Station Whidbey	9	21	5	17	11	27	0	0	7	14	32	79
Dabob Bay	19	21	9	11	30	33	0	0	40	43	98	108
Naval Station Everett	0	0	7	7	3	3	1	1	20	34	31	45
Manchester Fuel Depot	2	16	3	3	15	104	0	0	13	14	33	137
Naval Base Kitsap at Bremerton	3	3	4	4	5	5	0	0	4	4	16	16

Abundance in each 2-nmi radius based on sub-regional density data

Sub-Region	Total Area (km^2)	Water Percentage	Water Area (km^2)	Density in Sub-region	Abundance in 2nmi Radius
Naval Base Kitsap at Bangor	43	43.3%	18.6	1.71	32
Naval Air Station Whidbey	43	64.1%	27.6	0.88	24
Dabob Bay	43	78.8%	33.9	1.71	58
Naval Station Everett	43	54.4%	23.4	0.88	21
Manchester Fuel Depot	43	54.7%	23.5	0.52	12
Naval Base Kitsap at Bremerton	43	34.7%	14.9	0.79	12

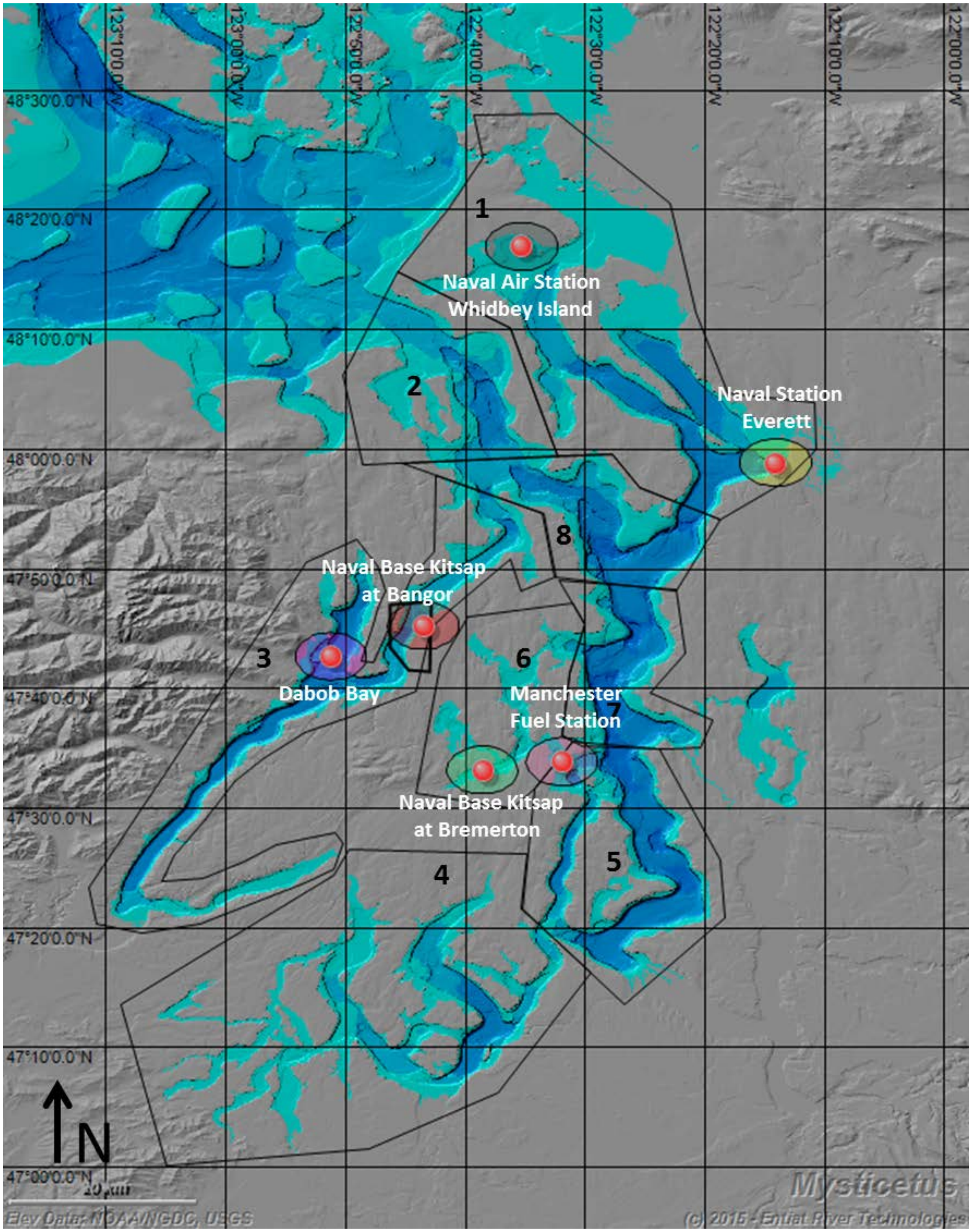

Figure 9. Naval installations for which harbor porpoise and harbor seal in-water abundance was estimated within a 2-nmi radius of the installation based on densities of sub-regions determined during Puget Sound aerial surveys 2013–2015. Red dots indicate the location within each installation that was used as the center of the 2-nmi radius. (Note: 2-nmi circles look slightly oval due to projection of a round globe on a flat map.)

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

3.7 Summary of First-Observed Behavioral Analysis

Behavioral data were summarized for the first-observed maximum dispersal distance (estimated in adult body lengths by species) and behavior state for the subsample of marine mammal sightings for which such data were available. It was not always possible to record these data because during periods with many sightings, observers prioritized data needed for density and abundance estimation (e.g., species, group size, bearing and declination angle/lateral distance). Summary statistics for maximum dispersal distance were calculated for the two most commonly sighted species, the harbor porpoise and harbor seal (n=329 and 320 groups, respectively) (**Table 21**). Including both in-water and hauled-out harbor seals, mean maximum dispersal distance was slightly smaller for harbor seals (6.2 body lengths) compared to harbor porpoise (7.8 body lengths), with less variability among harbor seals (**Table 21**).

Table 21. Summary statistics for dispersal distance (in body lengths) within groups of harbor porpoise and harbor seals.

	Species	# of Groups	Minimum Dispersal	Maximum Dispersal	Mean of Maximum Dispersal	Standard Deviation
Sep 2013	Harbor Seal	41	0.5	50	6.4	9.5
	Harbor Porpoise	29	0.5	50	4.1	9.4
Jul 2014	Harbor Seal	49	0.2	15.0	45	4.6
	Harbor Porpoise	80	0.0	10.0	2.2	2.4
Sep 2014	Harbor Seal	80	0.1	70.0	7.9	13.5
	Harbor Porpoise	106	0.1	275.0	9.4	33.1
Jan 2015	Harbor Seal	2	0.5	1.0	0.8	0.4
	Harbor Porpoise	9	0.5	35.0	0.8	11.3
Apr 2015	Harbor Seal	80	0.0	50.0	7.1	9.2
	Harbor Porpoise	51	0.0	25.0	4.8	5.7
Total	**Harbor Seal**	**252**	**0.0**	**70.0**	**6.2**	**9.5**
	Harbor Porpoise	**275**	**0.0**	**275.0**	**7.8**	**26.9**

Data on behavior state were obtained for the ten species we sighted (**Table 22**). For species with at least 10 sightings (harbor seal, California sea lion, Steller sea lion, and harbor porpoise), the most commonly observed behavior state was slow travel/rest (**Table 22**), with the exception of the harbor porpoise, where medium-fast travel was more frequently seen than slow travel/rest. Mill was also commonly seen among harbor porpoise. Rest was the only behavior state noted among hauled-out pinnipeds, as expected. Feed/forage consisting of what appeared to be chasing prey while turning in tight circles or sprinting was occasionally seen among harbor porpoise and harbor seals, and for one Steller sea lion (**Table 22**). On one occasion, a group of harbor seals was seen foraging below a large group of diving birds (species unknown) in the Strait of Juan de Fuca during opportunistic survey effort.

Table 22. Overall frequency of occurrence and percentage of behavior states of marine mammal groups during Puget Sound marine mammal aerial surveys 2013–2015.*

Species	Frequency of Occurrence (Group Count)								
	Slow Travel/ Rest	Med. Travel	Fast Travel	Mill	Dive	Probable Forage	Other	Unk.	Total No. of Groups
Harbor Seal, In-Water	2,938 (80%)	450 (12%)	13 (0%)	141 (4%)	21 (1%)	7 (0%)	32 (1%)	87 (2%)	**3,689**
Harbor Seal, Hauled-Out	96 (84%)	1 (1%)	-	1 (1%)	-	-	3 (3%)	13 (11%)	**114**
California Sea Lion, In-Water	66 (65%)	22 (22%)	-	4 (4%)	-	-	7 (7%)	2 (2%)	**101**
California Sea Lion, Hauled-Out	11 (79%)	-	-	-	-	-	-	3 (21%)	**14**
Steller Sea Lion, In-Water	42 (64%)	17 (26%)	5 (8%)	1 (2%)	-	1 (2%)	-	-	**66**
Steller Sea Lion, Hauled-Out	3 (100%)	-	-	-	-	-	-	-	**3**
Harbor Porpoise	287 (32%)	392 (43%)	29 (3%)	146 (16%)	1 (<1%)	5 (1%)	35 (4%)	14 (2%)	**909**
Gray Whale	4 (80%)	1 (20%)	-	-	-	-	-	-	**5**
Killer Whale	1 (33%)	1 (33%)	1 (33%)	-	-	-	-	-	**3**
Minke Whale	2 (100%)	-	-	-	-	-	-	-	**2**
Risso's Dolphin	-	1 (50%)	-	-	-	-	-	1 (50%)	**2**
Dall's Porpoise	-	1 (100%)	-	-	-	-	-	-	**1**
Otter (River or Sea)	1 (100%)	-	-	-	-	-	-	-	**1**

* Limited to groups where behavior state was recorded. Feeding gray whales and a probable feeding (milling) minke whale were observed once, though the first-observed behavior was travel as recorded here.

One gray whale group was observed feeding after they were first observed traveling, and video was taken of this group in the East Whidbey sub-region. Plumes of mud were seen at the surface as these whales surfaced. In addition, photographs of gray whale feeding pits were taken in the general vicinity of the feeding gray whales.

Reaction, no reaction, or unknown was recorded for all marine mammal sightings to indicate whether or not the observer thought an observed change in behavior may have been related to the presence of the aircraft. A possible reaction was rarely observed (0.3 percent or 27 of the total 9,645 individual marine mammals sighted). A possible reaction was recorded only for harbor porpoise (*n*=6 single animals), harbor seals (19 individuals in 7 groups), and a pair of Steller sea lions. All of these possible observed reactions to the aircraft consisted of an abrupt dive. This information is indicated for each individual sighting in **Table S1**.

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4. Discussion

Our five seasonal aerial survey periods in 2013 to 2015 provide the best available systematically collected data across seasons on the in-water density, abundance, distribution, and behavior of marine mammals throughout Puget Sound, with a focus on harbor porpoise. Harbor seals and harbor porpoise were the most commonly observed species during our surveys, providing robust sample sizes facilitating estimation of their density and abundance within Puget Sound. However, estimates associated with harbor seals are limited to in-water observations and did not include haul-out areas or adjustment for tidal state or variation in pupping season through the region. Our data regarding harbor seals will complement currently unpublished data collected in 2013-2014 by Jeffries et al. (2014) for the purpose of estimating harbor seal abundance in Puget Sound. Although eight other marine mammal species were documented (including one river or sea otter), sample sizes were too small to provide meaningful density and abundance estimates.

Results confirm increased numbers and recolonization of harbor porpoise in Puget Sound, particularly southern Puget Sound and Hood Canal, where they had previously substantially declined (Calambokidis et al. 1992, Osmek et al. 1995). These results provide an updated population estimate for the harbor porpoise. These data are critically needed to update the NMFS Marine Mammal Stock Assessment Report for this species in inland Puget Sound waters because of outdated estimates (Carretta et al. 2014, NMFS et al. 2005). Results confirm other stranding, acoustic, and sightings data indicating that harbor porpoise use of Puget Sound has increased in recent years (e.g., Hanson et al. 2012, Jeffries 2011, 2012, 2014, Anderson 2014, Calambokidis et al. 2015).

Everitt et al. (1980) documented 15 species of cetaceans in the Puget Sound region, which included the Strait of Juan de Fuca, the San Juan Islands, and northern Puget Sound, in 1977 to 1979 and reported that the most common cetaceans at that time were the harbor porpoise, Dall’s porpoise, gray whale, minke whale, and killer whale. These cetaceans were most abundant in spring and summer, with the exception of gray whales, which were most common in November to December and February to March (during migrations). We observed all of the latter six species, but only the harbor porpoise was commonly seen during 2013 to 2015. Other cetacean species we observed relative to historical reports are described below and include sightings made within the primary eight sub-regions as well as opportunistic sightings made in the Strait of Juan de Fuca and other areas such as the southern San Juan Islands/Haro Strait (**Figure 6**; **Appendix A,** Figures A-16-19).

Some cetaceans that have been occasionally documented in Puget Sound were not observed in our study. The Navy’s Marine Resources Assessment of the Pacific Northwest Operating Area and Puget Sound Study Area (which includes the Strait of Juan de Fuca, the Georgia Strait, Puget Sound, Hood Canal, the waters surrounding the San Juan Islands, and several other associated waterways in northwestern Washington State and southwestern British Columbia, Canada) (Department of the Navy 2006) and a comprehensive review of the literature indicate that the following cetacean species occur in the Puget Sound study area as defined by Department of the Navy (2006): killer whales, humpback whales, minke whales, gray whales, Pacific white-sided dolphin (in Strait of Juan de Fuca only), false killer whales, harbor porpoise, and Dall's porpoise.

The following subsections discuss our results by species in the context of other studies conducted in the region based on density, abundance, distribution, and behavior. We end with a summary synopsis discussion.

4.1 Harbor Porpoise

Harbor porpoise were historically (i.e., in the 1940s) common in Puget Sound (Scheffer and Slipp 1948). However, Flaherty and Stark (1982) cite a personal communication with J. Slipp indicating that the harbor porpoise population essentially disappeared from southern Puget Sound sometime between the late 1940s and early 1960s. Few harbor porpoise were sighted in the region during aerial and vessel surveys in 1991 (Osmek et al. 1996) or 1994 (Osmek et al. 1995). Osmek et al. (1996) reported that a substantial decline in harbor porpoise had occurred in Puget Sound. Aerial surveys for harbor porpoise in Washington and British Columbia in 1996 did not include Puget Sound because densities were expected to be extremely low in those areas (Osmek et al. 1997). Surveys in 2002–2003 suggested some potential recovery (Calambokidis et al. 2015). However, Ű (2009) reported no significant trend in harbor porpoise abundance based on small vessel surveys in portions of inland Washington waters from 2000 to 2008. In 2009-2012, increased numbers of strandings raised the question of whether or not harbor porpoise were returning to Puget Sound (Carretta et al. 2014; Huggins et al. 2015, Hanson et al. 2012); however, no density or abundance estimates specific to Puget Sound have been reported from these surveys.

WDFW has also been recording harbor porpoise observations annually during bird surveys in the Puget Sound and Strait of Juan de Fuca regions since 1993 (Evenson et al. 2015). These observations reveal the shift of harbor porpoise further into Puget Sound with larger numbers observed overall from 1993 to 2014 (Evenson et al. 2015). Reasons for harbor porpoise declines prior to the 1990s and 2000s are unknown, though some suggestions have included entrapment in gillnet fisheries, pollutant effects, habitat degradation, and vessel avoidance (Calambokidis and Baird 1994). Osmek et al. (1995) suggested competition with Dall's porpoise could also have contributed to the decline, as Dall's porpoise increased in abundance during the harbor porpoise decline. This may be supported by evidence that increases in harbor porpoise abundance in Puget Sound and the Strait of Juan de Fuca have occurred coincidentally with declines in Dall's porpoise in those areas (Evenson et al. 2015). Harbor porpoise return to Puget Sound may be related to improvements in underlying ecosystem conditions, but threats to long-term viability may still exist in the area (Hanson et al. 2012).

Our study suggests that the harbor porpoise population in Puget Sound is rebounding. We estimated density to be 0.91/km^2 (95 percent CI=0.72–1.10), and abundance in Puget Sound was 2,387 (95 percent CI=1,942–2,935) (CV=0.11) (**Table 16, Figure 7**). The harbor porpoise estimates provided here are considered to be of a high level of precision (**Figure 7)**. Since the harbor porpoise was one of the focal species for our surveys, we made special effort to conduct the field work and analyses to maximize the chances of obtaining high-quality data for this species. The overall sample size is adequate for obtaining a reliable estimate of the current number of animals using Puget Sound.

Our data suggest that harbor porpoise currently occur in all major regions of Puget Sound throughout the year (**Table 14**). This is further supported by acoustic studies documenting harbor porpoise year-round in Puget Sound (Jeffries 2011, 2012, 2014; Anderson 2014). Jeffries (2014) reported highest acoustic detection rates in winter, and WDFW has been observing increases in harbor porpoise in winter from 1993 to 2014 (Evenson et al. 2015). Harbor porpoise occur in relatively large numbers and appear to be using nearly all of the waters of Puget Sound again. The highest densities occurred in the Admiralty Inlet and South Whidbey sub-regions, but moderate densities occurred in most of the other areas (with the exception of Bainbridge and Vashon sub-regions, which only had low densities [**Table 16**]). The reason for the apparent general gap in distribution within the Vashon sub-region from Federal Way north to Burien and west to Vashon Island is unknown (**Figure 4**) but could be related to a number of potentially inter-related factors including prey availability, vessel traffic, water quality, water depth, or current. These apparent anomalies may merit further investigation.

Group size of harbor porpoise ranged from 1 to 46 individuals, with means for each survey season of approximately 2, with the exception of 7.5 (SD ±10.4) in January 2015. This may indicate group size tends to be larger in winter, but the sample size is low (1 day of surveys in the January 2015 survey period). Thus, more data would be needed to draw strong conclusions about seasonal shifts in group size. Mean group size was comparable to that reported for a study conducted near the San Juan Islands in 1991 to 1992, which resulted in a mean group size of 1.87 (SE ±0.06) (Raum-Suryan and Harvey 1998). Mean maximum dispersal distance of harbor porpoise varied across seasons, with the highest values in fall 2014 and winter 2015 (**Table 14**). This may indicate harbor porpoise groups are spread out further during these seasons, but again, more data would be needed to draw conclusions about these patterns.

The most recent estimate of the abundance of the harbor porpoise Inland Washington stock is 10,682 porpoise (from a 2002–2003 aerial survey—see Carretta et al. 2014). However, this estimate is now over 12 years old and is not considered recent enough for use in Marine Mammal Stock Assessment Reports (NMFS 2005). Our estimates will contribute to a new abundance estimate for the Inland Washington stock of harbor porpoise, once data from our spring 2015 survey periods funded by NMFS/National Marine Mammal Laboratory in the Strait of Juan de Fuca, San Juan Islands area, and southern Strait of Georgia, are analyzed later this summer (NMML/Smultea Sciences, unpublished data). There may possibly be a corresponding reduction in numbers in these latter, more northern areas, which would suggest that the ‘recovery’ in Puget Sound may be at least partially a result of redistribution of animals rather than a numerical increase. Alternatively, the evidence may point to an actual increase in abundance. Calambokidis et al. (2015) reported that harbor porpoise abundance in waters adjacent to the Strait of Juan de Fuca and San Juan Islands has increased since the early 1990s and Evenson et al. (2015) reported sightings of harbor porpoise have been increasing in the Strait of Jan de Fuca since 1993 and have remained relatively stable in Puget Sound since 2000. These data suggest that harbor porpoise increases in Puget Sound are unlikely to be caused by immigration from these areas.

4.2 Harbor Seals

Harbor seals were the most common species of marine mammal we observed in Puget Sound, consistent with other historical studies conducted in the region. For example, a baseline study of marine mammals in northern Puget Sound and the Strait of Juan de Fuca in 1977 to 1979 found that harbor seals were the most abundant marine mammal (2,000 counted in 1979) (Everitt et al. 1980). Calambokidis and Baird (1994) indicated harbor seals were the most abundant marine mammal in the trans-boundary area between the U.S. and Canada and were increasing in abundance in the late 1980s and early 1990s. Osmek et al. (1997) found harbor seals were the most commonly sighted species in Washington and British Columbia inside waters in 1996. Jeffries et al. (2003) reported that harbor seal populations in Washington were near carrying capacity in 1999. Data from 1999 surveys in Jeffries et al. (2003) are the most recent data used for abundance estimates in the NMFS Marine Mammal Stock Assessment Report (Carretta et al. 2014). New assessment of harbor seal abundance is currently being conducted by WDFW (e.g., Jeffries et al. 2014).

We estimated in-water density of harbor seals in the Puget Sound area to be 0.92 seals/km^2 (95 percent CI=0.77-1.07) and abundance to be 2,659 (95 percent CI= 2,266-3,121) (CV=0.08) (**Table 17**). Our harbor seal estimates, although statistically precise, suggest that the data may have some issues that make analysis for this species somewhat complicated (see **Section 3.6** and **Table 17**). Therefore, harbor seal estimates should be considered somewhat tentative, even though the statistical precision of the estimates is high. It should also be noted that there are differences in methodology between the Jeffries et al. (2014) aerial survey for harbor seals and this survey. Jeffries et al. (2014) followed the methodology of Jeffries et al. (2000) and Huber et al. (2001) by surveying counts at haul-outs during the summer, and correcting for animals in the water but missed during the haul-out count. This methodology provides a population number to be used in the Stock Assessment Reports. Our survey periods only included animals in the water (and partially submerged on sand/mud banks). Therefore, the estimates are not comparable. Our observations also did not include haul-out areas. Further, we did not consider differences in haul-out behavior in Hood Canal in which harbor seals have been found to be more likely to haul-out at high tide (implying more time spent in water at low tide) than in other areas of Puget Sound (London et al 2012). Pupping and molting periods also differ between Hood Canal and other areas of Puget Sound (London et al 2012). These trends were accounted for in survey design in Jeffries et al. (2014) but not in our surveys, which were focused on cetaceans rather than pinnipeds.

For harbor seals in the Inland waters of Washington, NMFS currently recognizes three stocks:

1. Hood Canal
2. Southern Puget Sound
3. Northern Inland waters

The total numbers for these three stocks were most recently estimated at 13,692 seals (Carretta et al. 2014). This was estimated from haul-out counts during the 1999 pupping season, incorporating a correction factor for animals considered to be in the water at the time of survey (Jeffries et al. 2003). The Northern Inland waters stock also includes animals in the Strait of Juan de Fuca, San Juan Islands, and southern Strait of Georgia areas. Thus, the Jeffries et al.

(2003) estimate is for a larger area than our survey periods covered. Our estimates will contribute to the current understanding of harbor seal stocks in the inland waters of Washington State and potentially will help develop or ground-truth correction factors for harbor seals in-water during land-based surveys.

Mean group size of in-water harbor seals was 1.3, with means for each survey period of approximately 1 to 2 individuals (**Tables 9 and 14**). This may indicate group size remains stable across seasons, but sample size is low in winter (one day of surveys in January). Therefore, more data would be needed to draw strong conclusions about seasonal shift in group size. Mean maximum dispersal distance between individuals within harbor seal groups in water and hauled out was 6.2 (SD ±9.5) (**Table 12**). This distance varied slightly over spring, summer, and fall ranging from 4.5 to 7.9, but was only 0.8 (SD ±0.4) in winter (**Table 12**). These results suggest the possibility of lower dispersal in groups in the water in winter, but again, sample size is low.

4.3 California and Steller Sea Lions

We observed Steller sea lions in small numbers in April and September 2015. California sea lions were more abundant than Steller sea lions during our survey periods, and were observed in all survey months (April, July, August, September) except January. In 1977–1979, Everitt et al. (1980) documented California and Steller sea lions from October to June at abundances of less than 300 for each species during peak periods. It should be noted that the three largest documented California sea lion haul outs in Puget Sound are located at three Navy installations: Naval Base Kitsap at Bangor, Naval Station Everett, and Naval Base Kitsap at Bremerton (Jeffries et al. 2014). However, our survey area did not include the haul out location at Naval Base Kitsap at Bangor as this air space is considered a “no fly” zone. Thus, though results of our surveys noted California sea lions in the water, sighting data exclude the large haul out located at Naval Base Kitsap at Bangor.

Steller sea lions are known to occur regularly in Puget Sound, with as many as 100 individuals observed each winter on a derelict barge at the mouth of the Nisqually River south of Tacoma. Steller sea lions are also regularly observed hauled out in small numbers on Port Security Barriers at Naval Base Kitsap at Bremerton and Naval Station Everett (S. Jeffries, WDFW, pers. comm., September 2015).

4.4 Gray Whales

We observed gray whales on four occasions in the East Whidbey sub-region in April 2015, including feeding gray whales documented with photographs and video. A small number of gray whales were observed in Puget Sound 1984-1993 (Calambokidis et al. 1994) and observations have continued to be collected to present (Calambokidis et al. 2002, Orca Network n.d.(b)). Sighting reports of gray whales in south and central Puget Sound increased from 2004 to 2011 where gray whales feed on ghost shrimp (Orca Network n.d.(b)). Between 10 and 12 gray whales return most years to northwestern Whidbey Island or southeastern Whidbey Island and Port Susan, Camano Island to feed arriving as early as January and leaving as late as July (Orcanetwork.org provides a map of feeding areas at http://www.orcanetwork.org/Main/index.php?categories_file=Gray%20Whales). Prior to 1980, gray whales were considered common in Puget Sound (Everitt et al. 1980). (Photographs and video of gray whales from April 2015 were sent to Cascadia Research Collective in response to a request from J. Calambokidis as they are conducting studies of this species in Puget Sound.)

4.5 Minke Whales

We observed and photo-documented two solitary common minke whales outside of the eight Puget Sound sub-regions during opportunistic survey effort in the Strait of Juan de Fuca in September 2014. On one occasion, the minke whale appeared to be feeding, based on its tight circling behavior. The occurrence of minke whales is uncommon in central and southern Puget Sound (see Department of the Navy 2006). However, minke whales are seasonally common during summer in the more northern San Juan Islands (Dorsey et al. 1990; Jefferson et al. 2008). Prior to 1980, minke whales were considered common in Puget Sound (Everitt et al. 1980).

4.6 Killer Whales

Two ecotypes of killer whales (transient and resident) are found in the waters of Puget Sound (see Department of the Navy 2006). The killer whales observed during our surveys are likely to belong to the Southern Resident or West Coast Transient stocks based on the stock boundaries (Carretta et al. 2014). It is unlikely that killer whales observed in Puget Sound are part of the offshore stock given its boundaries (Carretta et al. 2014).

The ecotypes of killer whales often share the same range, but are not believed to intermix (Jefferson et al. 2008). Southern Resident killer whales, listed as endangered under the U.S. Endangered Species Act, are seen in northern (Admiralty Inlet and East and South Whidbey study area sub-regions) and central Puget Sound (Seattle, Bainbridge and Vashon sub-regions) occasionally during the winter and in spring, summer, and fall in the San Juan Islands and the Strait of Juan de Fuca, British Columbia (Hanson et al. 2010; Holt et al. 2012). Southern resident killer whales are rarely seen in southern Puget Sound (Southern Puget Sound sub-region). Transient killer whales are occasional visitors to the inland waters of Puget Sound during all seasons (Houghton et al. 2015; Wiles 2004). Department of the Navy (2014) estimated that density of killer whales would be very low (approximately 0.00051 animals/km^2) in Puget Sound, with even lower density in Hood Canal (0.00001 animals/km^2) based on data collected by the Orca Network (http://www.orcanetwork.org).

Data from our three killer whale sightings (e.g., date, time, location, group size/composition) were compared to the Orca Network online sightings archives (Orca Network, n.d.(a)), including associated maps, and with researchers at the NMFS NWFSC, to assess population and pod membership. As the presence of killer whales is well documented and studied in the Puget Sound region, detailed sighting data are often available and are thus summarized below:

- On 20 September 2014 at around 15:00, we observed a group of three killer whales engaged in rest/slow travel amidst numerous small vessels, including whale watching vessels, off the southwest side of San Juan Island (offshore of False Bay). These whales likely belonged to the Southern Resident J pod, or possibly the Resident K or L pods (**Appendix A,** Figure A-18). Our sighting location best matched the only three reported sightings of killer whales in the Orca Network online database on that day. The latter included a sighting of a J pod whale (J27 "Blackberry") reported off False Bay off the southwest coast of San Juan Island (no time of day indicated; Orca Network n.d. (a)). Also on that day, killer whales were reported at 10:30 in the morning near Lime Kiln (central-west coast of San Juan Island, approximately 8 km northwest of False Bay). Finally, the Resident J, K and likely L pod members were reported as present near Turn Point, approximately 25 km north-northwest of False Bay on this date.

- On 15 April 2015 at 13:23, we observed a group of nine killer whales including one small calf traveling at medium speed in the Vashon sub-region at the northeastern tip of Vashon Island (**Appendix A,** Figure A-19). We observed a small research boat following these whales. We later learned via email communications with NMFS NWFSC researchers that this was their boat (B. Hanson and C. Emmons, NMFS NWFSC, pers. comm., August 2015). They informed us via email that this group belonged to the West Coast Transient (Biggs) population and included members of the pods T65A, T65B, T75B and T75C. Per their post on Orca Network (Orca Network n.d.(a)), this pod included a new calf that still had fetal folds and a bent-over dorsal fin. When these researchers first arrived at the whale group, the whales were working on a kill and one individual was carrying around part of the kill that appeared to have been a large mammal based on the bits and pieces left behind.
- Four days later on 19 April 2015 at around 15:30, we observed a group of six killer whales composed of two subgroups, including a possible calf. The whales were traveling fast in the Whidbey sub-region off the central west coast of the island (**Appendix A,** Figure A-19). This sighting closely matched the location and time of numerous reported Orca Network sightings of a similar number of killer whales, reported by one observer as Transients (Orca Network, n.d.(a)). Orca Network reports indicated that a small calf and at least two males and three females were present in this group.

4.7 Risso's Dolphins

We saw Risso's dolphins in 2013 and obtained aerial photographs of them (see Smultea and Bacon 2014), but did not see them again in 2014 or 2015. Although sightings of Risso's dolphins in Puget Sound are quite rare, a pair of Risso's dolphins was seen there intermittently from 2011 to at least 2013 (C. Emmons, NMFS NWFSC, pers. comm., July 2012).On 30 December 2011, a Risso's dolphin pair was seen at the entrance of Eld Inlet near Olympia (southern Puget Sound) and photographs were sent to Cascadia Research Collective. On 4 July 2012, a pair was observed between Lagoon Point and Marrow Stone Island (southern Puget Sound). On 13 July 2012, a pair was seen near Colvos Pass near Gig Harbor, also in southern Puget Sound. Calambokidis et al. (2015) report that there were 32 sightings of a pair of Risso's dolphins in southern Puget Sound from 12 November 2011 to 4 April 2013. To the best of our knowledge, it has not been confirmed whether or not these sightings are of the same two Risso's dolphins. We sent our photographs of two Risso's dolphins obtained during our 2013 aerial survey to Cascadia Research Collective in Olympia, Washington; however, photos were not of sufficient quality across sightings to determine if the photographs were from the same two animals (A. Douglas, Cascadia Research Collective, pers. comm., July 2014). Everitt et al. (1980) did not report any records of Risso's dolphins in Puget Sound, even as rare or extralimital occurrences. Calambokidis and Baird (1994) reported that Risso's dolphins were observed once in British Columbia in inshore waters in the late 1970s.

4.8 Dall's Porpoise

Everitt et al. (1980) reported that Dall's porpoise were present year-round in Puget Sound in the late 1970s. Dall's porpoise were commonly observed in Puget Sound in the past, with counts as high as 71 individuals in the late 1980s (Miller 1990). Dall's porpoise were the third most commonly observed species in aerial surveys of the inside waters of Washington and British Columbia in 1996 (Osmek et al. 1997), and declines in observations of Dall's porpoise were reported by Washington Department of Fish and Wildlife from 1993 to 2014 (Evenson et al. 2015). Our results support the decline of Dall's porpoise in Puget Sound, with only a single Dall's porpoise sighted (in Hood Canal) in almost 14,000 km of survey efforts throughout the Puget Sound. Similarly, Jeffries (2011) reported no Dall's porpoise sightings in Burrows Pass near Anacortes during a year-long study (located 137 km north of Seattle and outside our primary survey area). It is unknown whether this decline is due to emigration or an actual decline in population abundance. Anderson (2014) and Evenson et al. (2015) noted that Dall's porpoise abundance was thought to have increased in conjunction with declines in harbor porpoise in Puget Sound. Thus, it is possible that declines in Dall's porpoise are associated with harbor porpoise recovery in the area. For example, this could be due to behavioral exclusion or niche competition because there is overlap in prey species (Walker et al. 1998).

4.9 Humpback Whales

Humpback whales also have been documented in Puget Sound (Green et al. 1992, Falcone et al. 2005), but we did not observe this species during our surveys. Calambokidis and Baird (1994) reported that humpback whales were once common in the trans-boundary area between the United States and Canada, including Puget Sound, but that sightings were uncommon in the early 1990s. There was a series of sightings of a humpback whale in Hood Canal, including Dabob Bay, between 2 and 23 February 2012, and at least one humpback was confirmed, though photos were not suitable quality for photo-identification (J. Calambokidis, Cascadia Research Collective, pers. comm., August 2015).

4.10 River or Sea Otter

We observed one otter which may have been a sea otter (*Enhydra lutris*) or a North American river otter (*Lontra canadensis*) and thus included it as a marine mammal in our results. Sea otters are rare in Puget Sound (Everitt et al. 1980), although a few individuals have been reported there and in the San Juan Islands (Lance et al. 2004). The current range of sea otters in Washington State extends from near Destruction Island on the outer coast to Pillar Point into the Strait of Juan de Fuca, where 504 to 743 individuals were counted in 2000 to 2004 (Lance et al. 2004). In contrast, river otters are commonly sighted along shorelines of both freshwater and marine water bodies in Washington State, including Puget Sound (Lance et al. 2004). Based on the distribution of the two species, it is likely that our sighting was of a river otter, but this could not be confirmed from the aircraft.

4.11 Behavior

Behavior state of marine mammals observed during our surveys consisted primarily of travel. Flaherty and Stark (1982) similarly found that harbor porpoise behavior in the Strait of Juan de Fuca, Strait of Georgia, and San Juan Islands mostly consisted of traveling and milling. It should be noted that our surveys occurred only during daylight hours, so activities during the night are unknown. Aside from rest and travel, milling was observed for 16 percent of harbor porpoise groups, but represented less than 5 percent of group behavior among other species (). Milling behavior is likely to involve foraging as it consists of animals within a group with asynchronous headings, with individuals often changing their headings. Such behavior has been associated with feeding/foraging in numerous marine mammal species including delphinids, mysticetes, and pinnipeds, while searching for or chasing prey (e.g., Shane et al. 1986; Heithaus and Dill 2009). We also observed foraging behavior by harbor seals, harbor porpoise, Steller sea lions, gray whales, and a minke whale, for which the animals were swimming in tight rapid circles or crisscrossing one another and associated with feeding birds. Note that the two minke whales observed during this study were seen outside of Puget Sound in the Strait of Juan de Fuca. Milling has also been associated with social behavior, characterized by animals touching and/or interacting/facing one another (e.g., Wűrsig et al. 1985; Shane et al. 1986; Shane et al. 1990; Heithaus and Dill 2009). Harbor seals were additionally observed diving and harbor seals, California sea lions, and harbor porpoise all spent small amounts of time in undefined “other” behavior states (**Table 22**). The lack of observed milling and foraging may indicate that marine mammals do not use Puget Sound much for socializing or feeding during the day, but more information is needed to determine nocturnal behavior patterns.

Apparent possible reactions to the aircraft were rarely observed (0.3 percent of all sightings) and consisted of abrupt dives, mostly by harbor seals or harbor porpoise. It is possible that this behavior could also have been indicative of normal foraging or other types of dives.

4.12 Summary

In summary, the harbor seal and harbor porpoise were the most abundant species observed in Puget Sound during aerial survey periods in 2013–2015. These species were observed in all seasons in which surveys were conducted. California sea lions were the next most abundant species, seen most commonly during spring and fall. This was followed by Steller sea lions, seen nearly exclusively during the fall. Other rare species were distributed throughout the survey sub-regions and seasons.

There is some evidence to suggest that harbor seals tend to have smaller dispersal distance within groups in the water during winter. Harbor porpoise appeared to have more cohesion (i.e., smaller within-group dispersal distance) in fall and winter. However, the sample sizes are not sufficient in winter to make strong conclusions about dispersal distance of individuals within groups. Group sizes of harbor porpoise also appeared to increase in winter, but again, sample size is not adequate to make strong statements about changes during this season.

Data were sufficient to estimate in-water densities and abundances of harbor seals and harbor porpoise with good precision, though harbor seal estimates have some modeling challenges and data collected on harbor seals were opportunistic and did not include haul-out areas.

Although information obtained during these surveys is generally consistent with prior information indicating that harbor seals are common in Puget Sound, our density estimates differ notably from those reported by Jeffries et al. (2014). This is due to a number of factors, including different protocol, different density modeling input, and different focal species and thus approaches (we focused on in-water densities of cetaceans while the Jeffries et al. (2014) study focused on counting hauled out pinnipeds at haul-out concentration areas that we did not observe as they were not within view).

In contrast, harbor porpoise abundance had declined to the point at which none were observed during surveys in the early 1990s, though they have been reported in small numbers in the last decade during aerial bird surveys in Puget Sound (e.g., Nysewander et al. 2005). Our observations therefore document a marked increase in the abundance and density of this species since that time. This is concurrent with a decline in Dall's porpoise sightings in Puget Sound, the reasons for which are unknown.

Behavior state of all species observed was mostly rest or travel, with a few observations of milling, as well as a very low percentage of foraging by harbor seals, gray whales, and a minke whale (which was observed in the Strait of Juan de Fuca). This may indicate that marine mammals tend to transit Puget Sound during the day with intermittent feeding bouts, but it is unknown if feeding and socializing may increase during the night. Acoustic studies by Jeffries (2012) indicate that harbor porpoise vocalize more at night than during the day in their Burrows Pass/Anacortes survey area (outside of our study area), suggesting that foraging occurs predominantly at night for that species. Tagging and acoustical studies, along with additional surveys, may help elucidate behavioral patterns of Puget Sound marine mammals and help improve information about presence and behavior of the less common species observed during our study.

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A

Maps

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A.1 Seasonal Survey Effort Maps

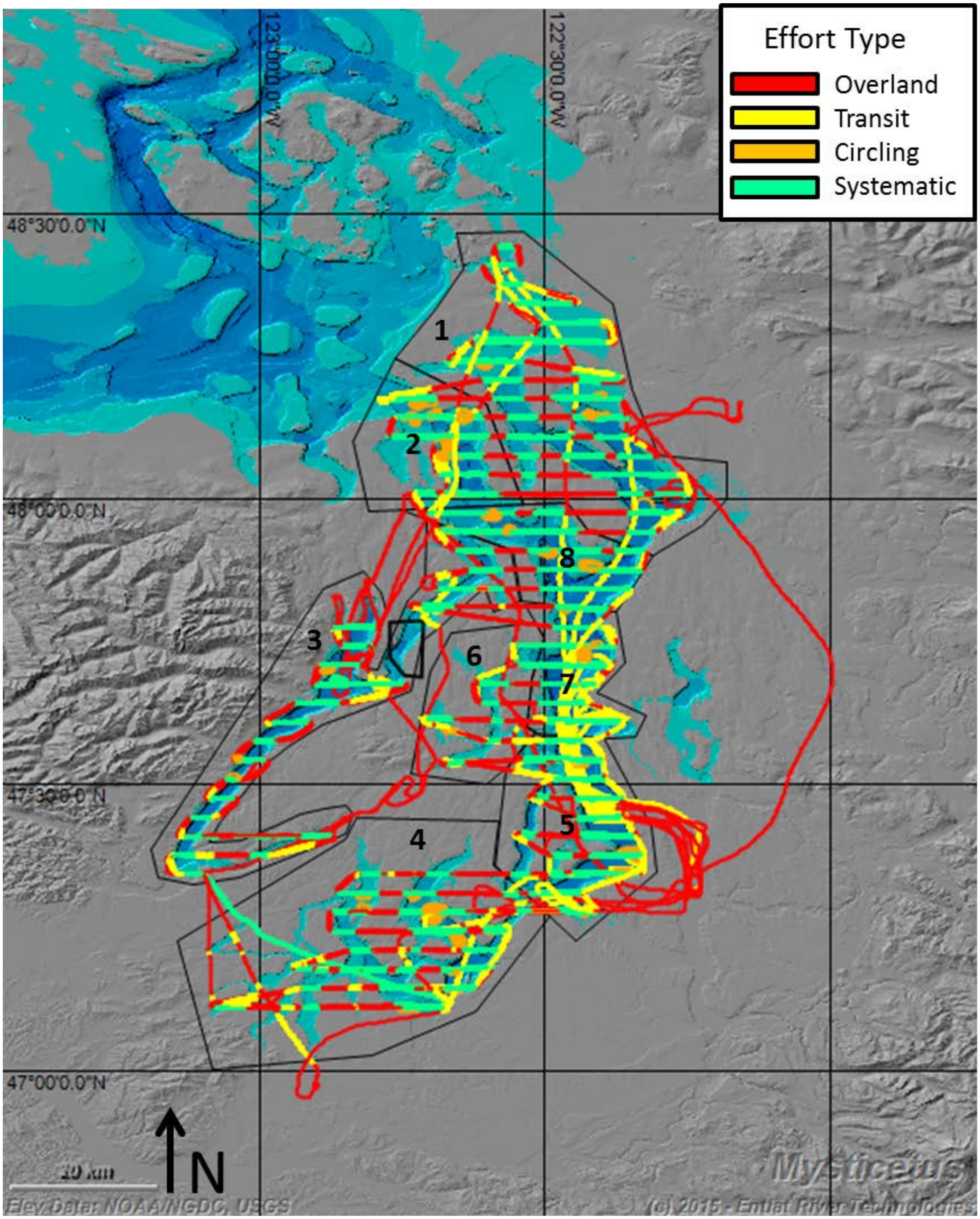

Figure A-1. August to September 2013 effort tracklines for Puget Sound aerial surveys in primary survey area.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

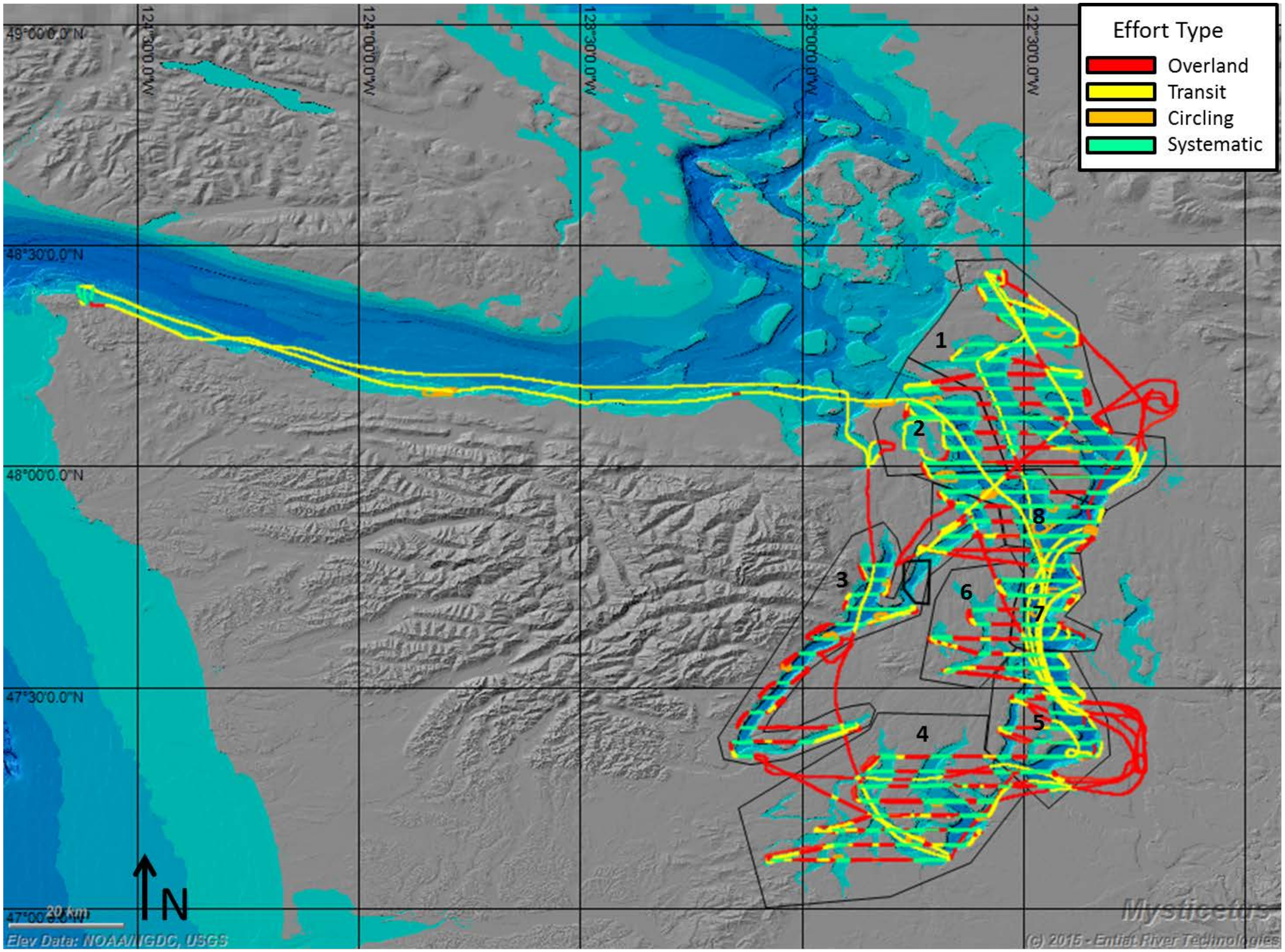

Figure A-2. July 2014 effort tracklines for Puget Sound aerial survey including opportunistic effort in the Strait of Juan de Fuca.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

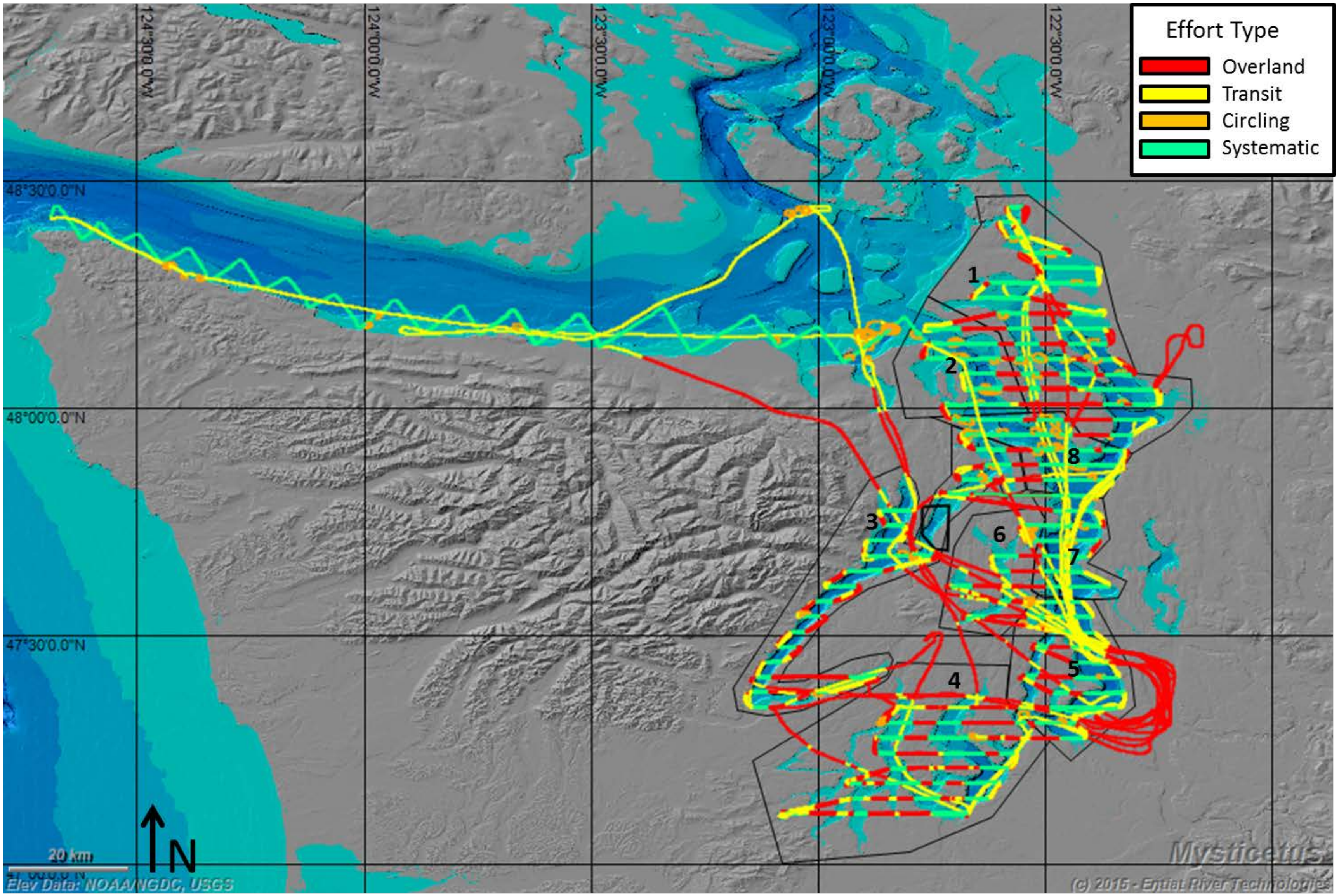

Figure A-3. September 2014 effort tracklines for Puget Sound aerial survey including opportunistic effort in the Strait of Juan de Fuca.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

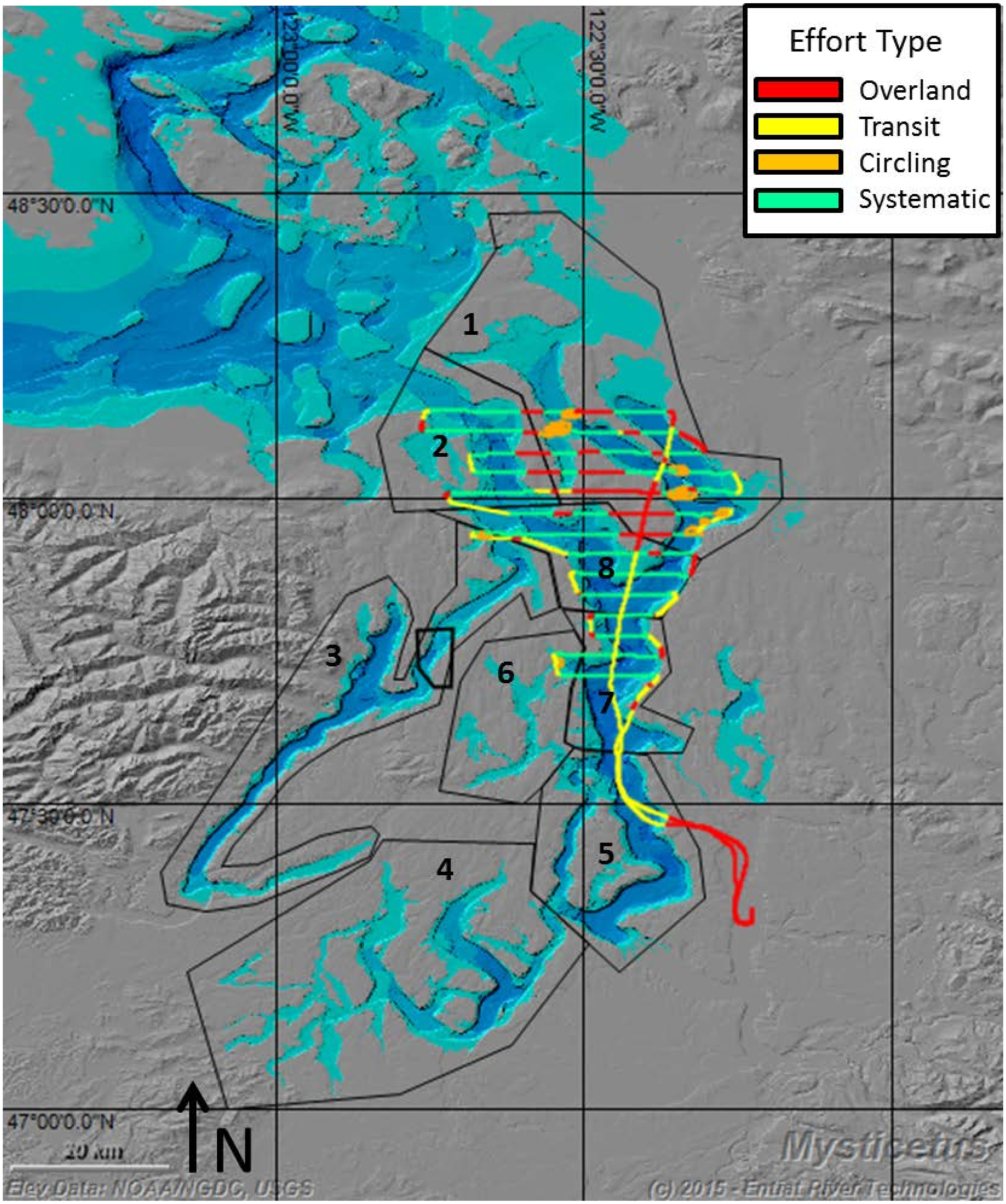

Figure A-4. January 2015 effort tracklines for Puget Sound aerial survey in primary survey area.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

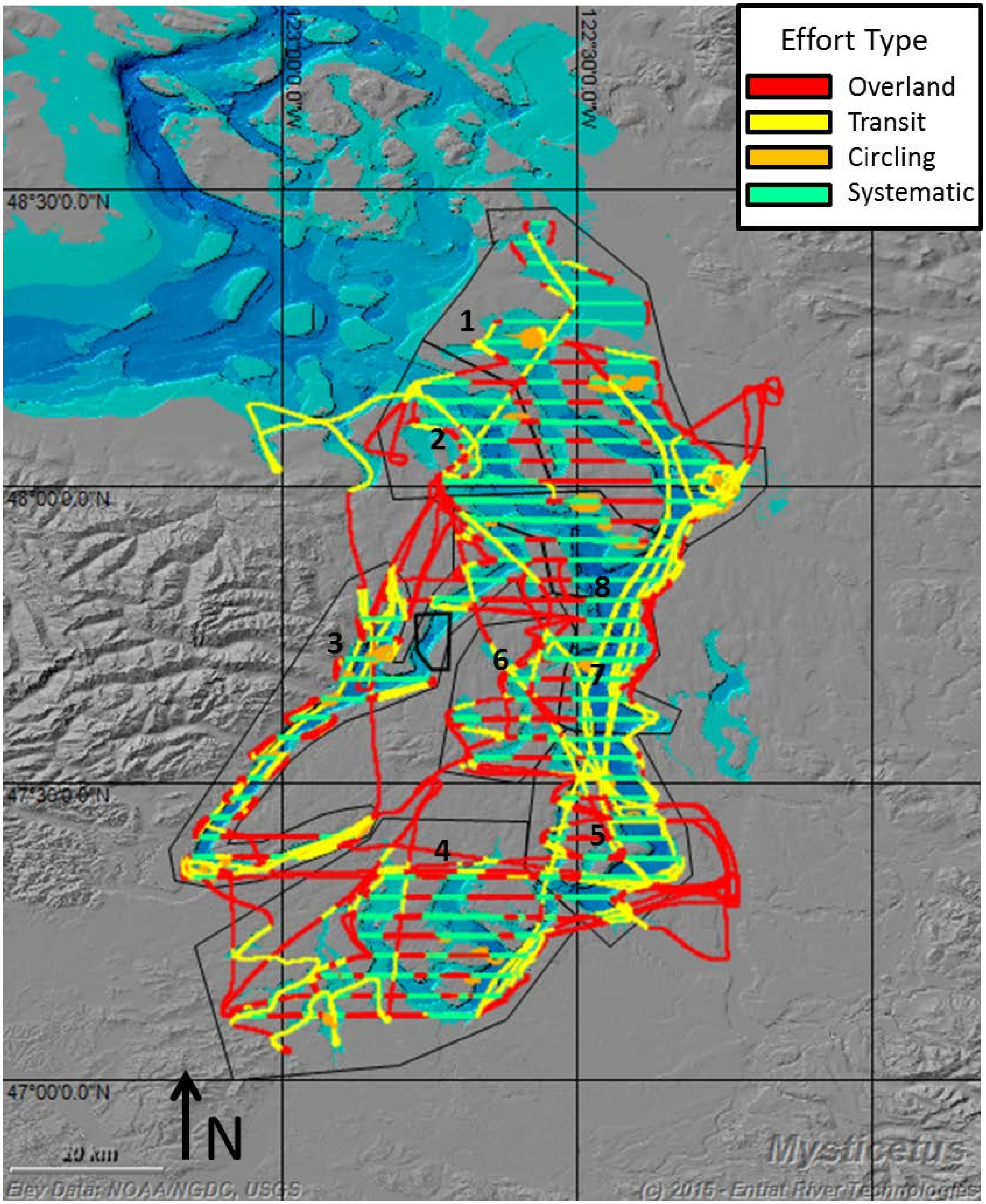

Figure A-5. April 2015 effort tracklines for Puget Sound aerial survey in primary survey area.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

A.2 Harbor Porpoise Group Sightings by Season

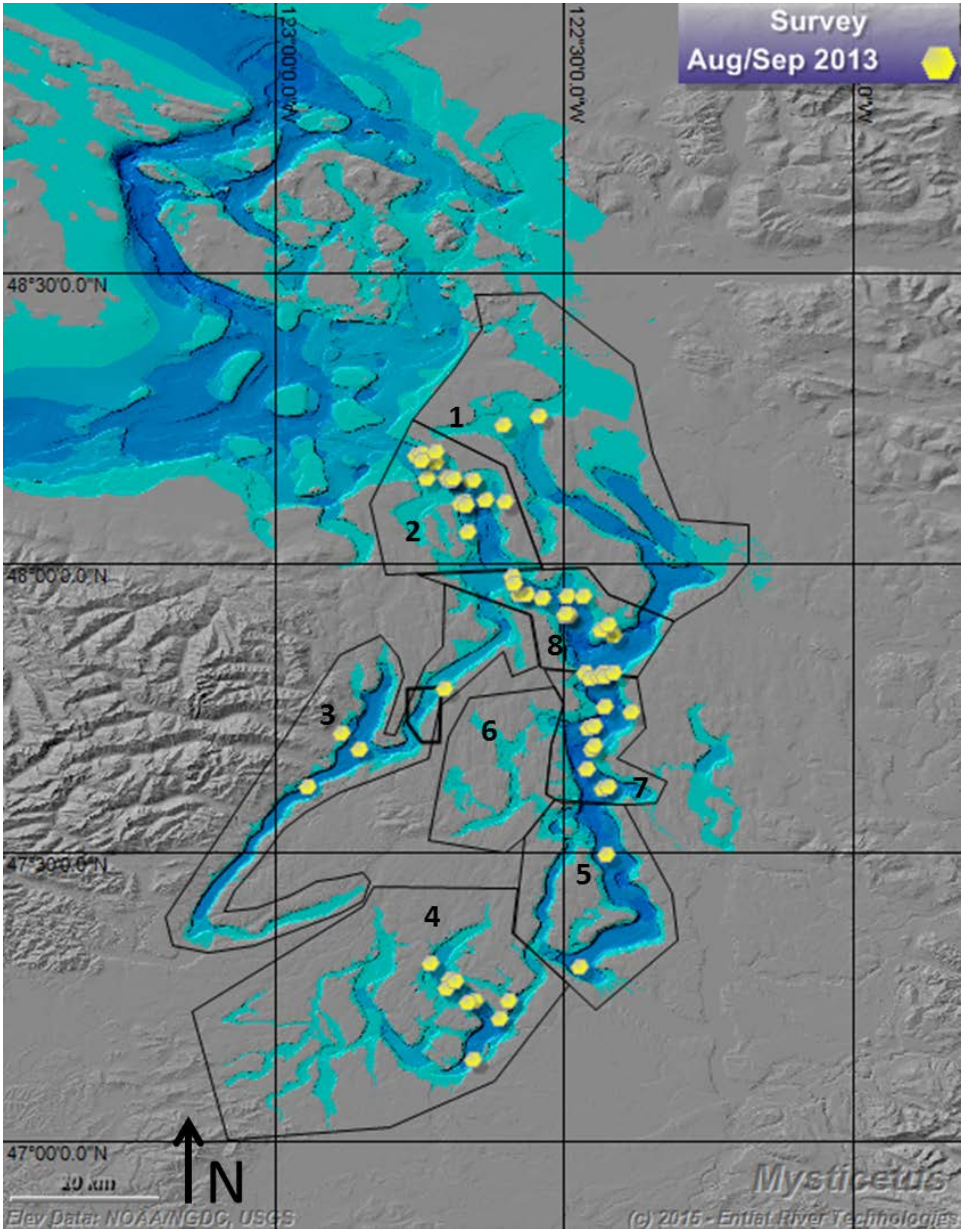

Figure A-6. Harbor Porpoise group sightings August-September 2013 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

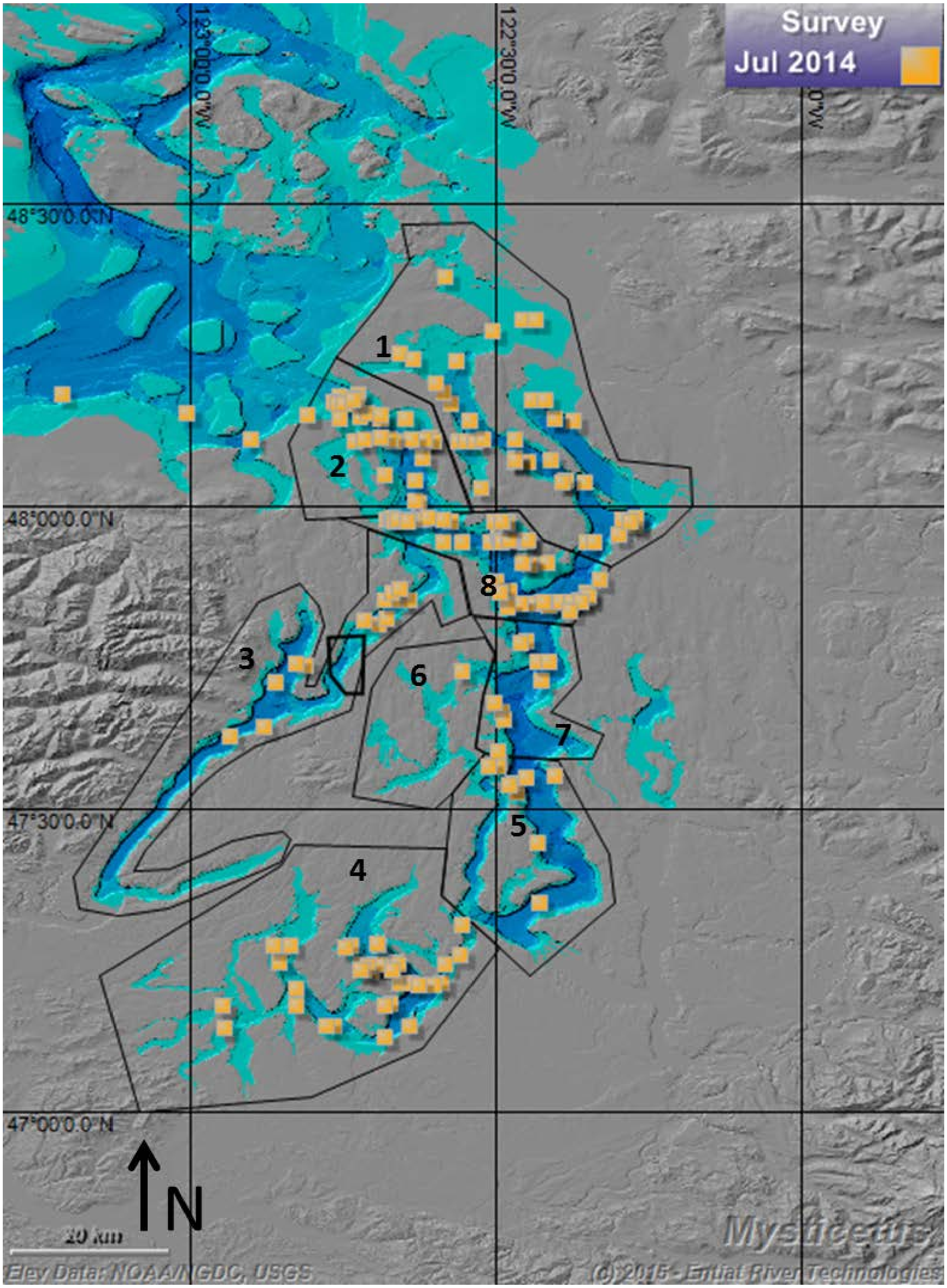

Figure A-7. Harbor Porpoise group sightings July 2014 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

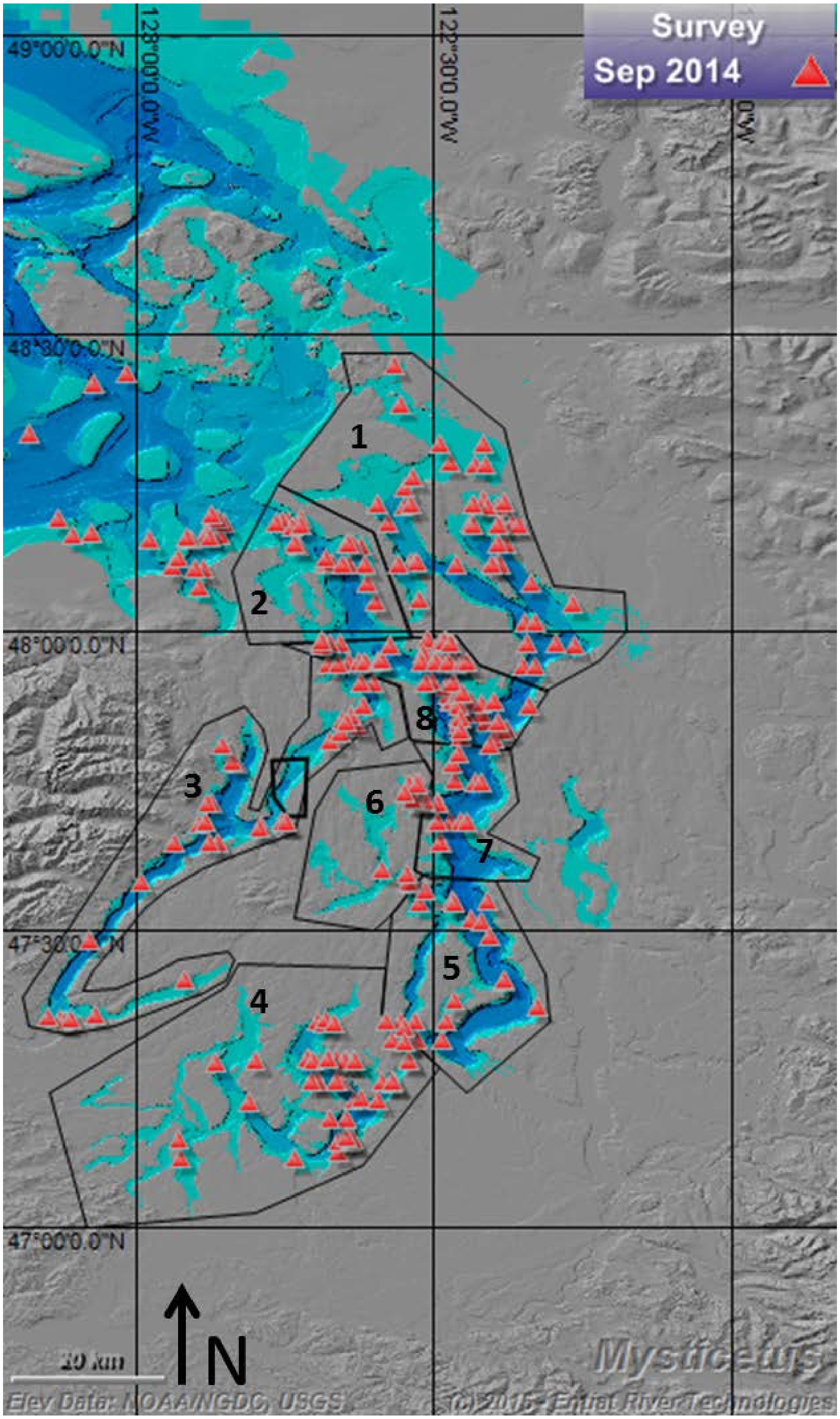

Figure A-8. Harbor Porpoise group sightings September 2014 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

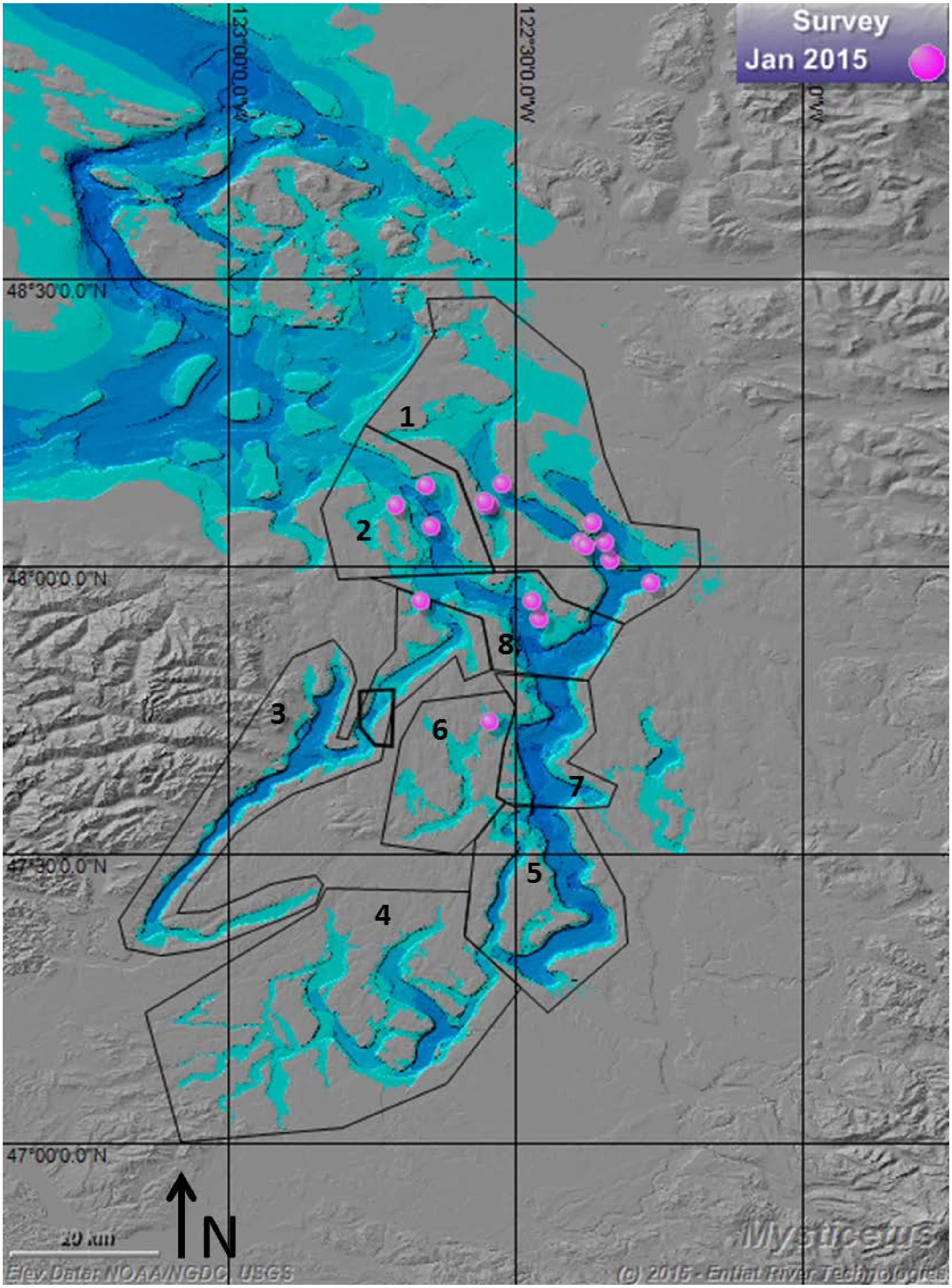

Figure A-9. Harbor Porpoise group sightings January 2015 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

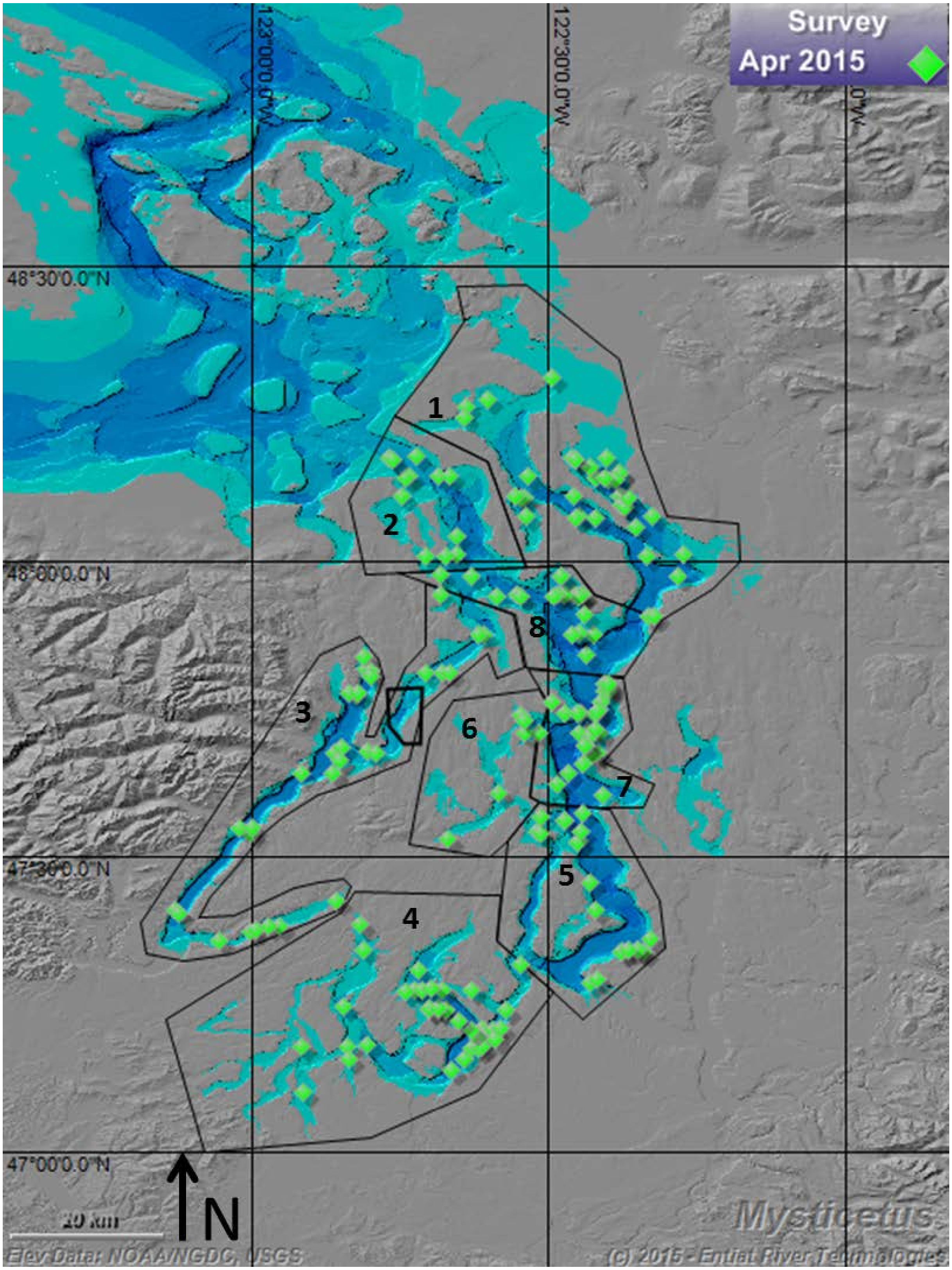

Figure A-10. Harbor Porpoise group sightings April 2015 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

A.3 Harbor Seal Group Sightings by Season

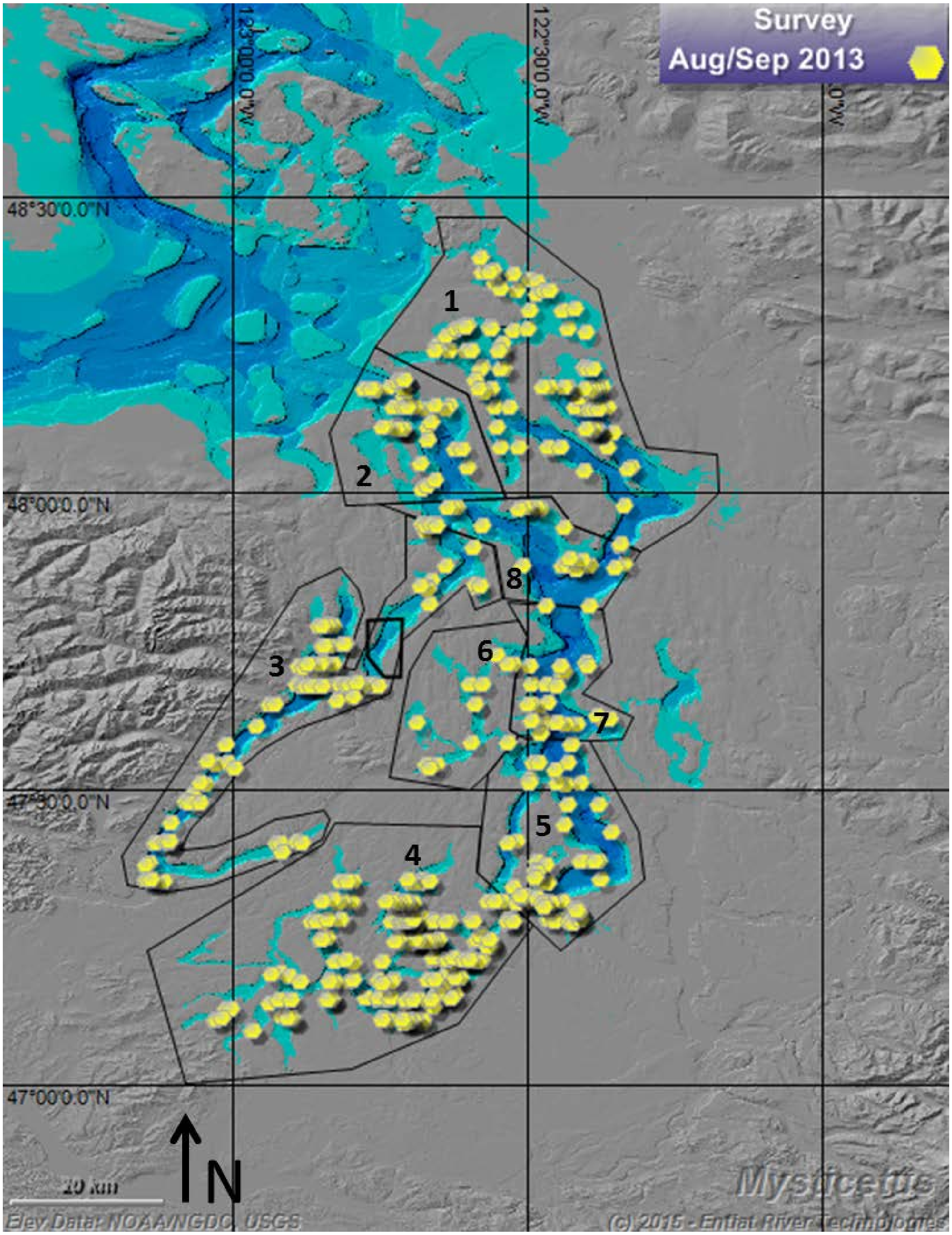

Figure A-11. Harbor seal group sightings Aug-Sep 2013 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

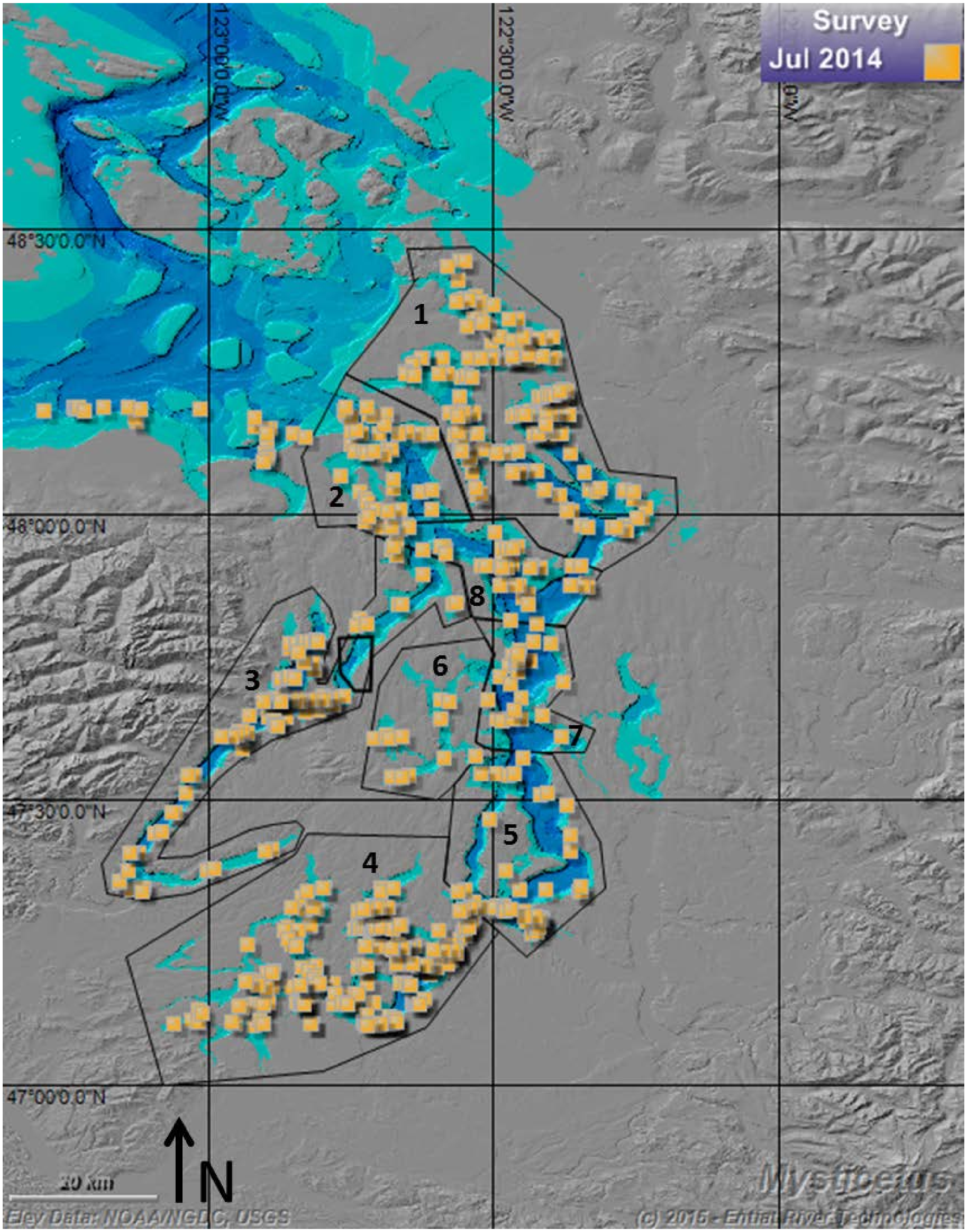

Figure A-12. Harbor seal group sightings July 2014 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

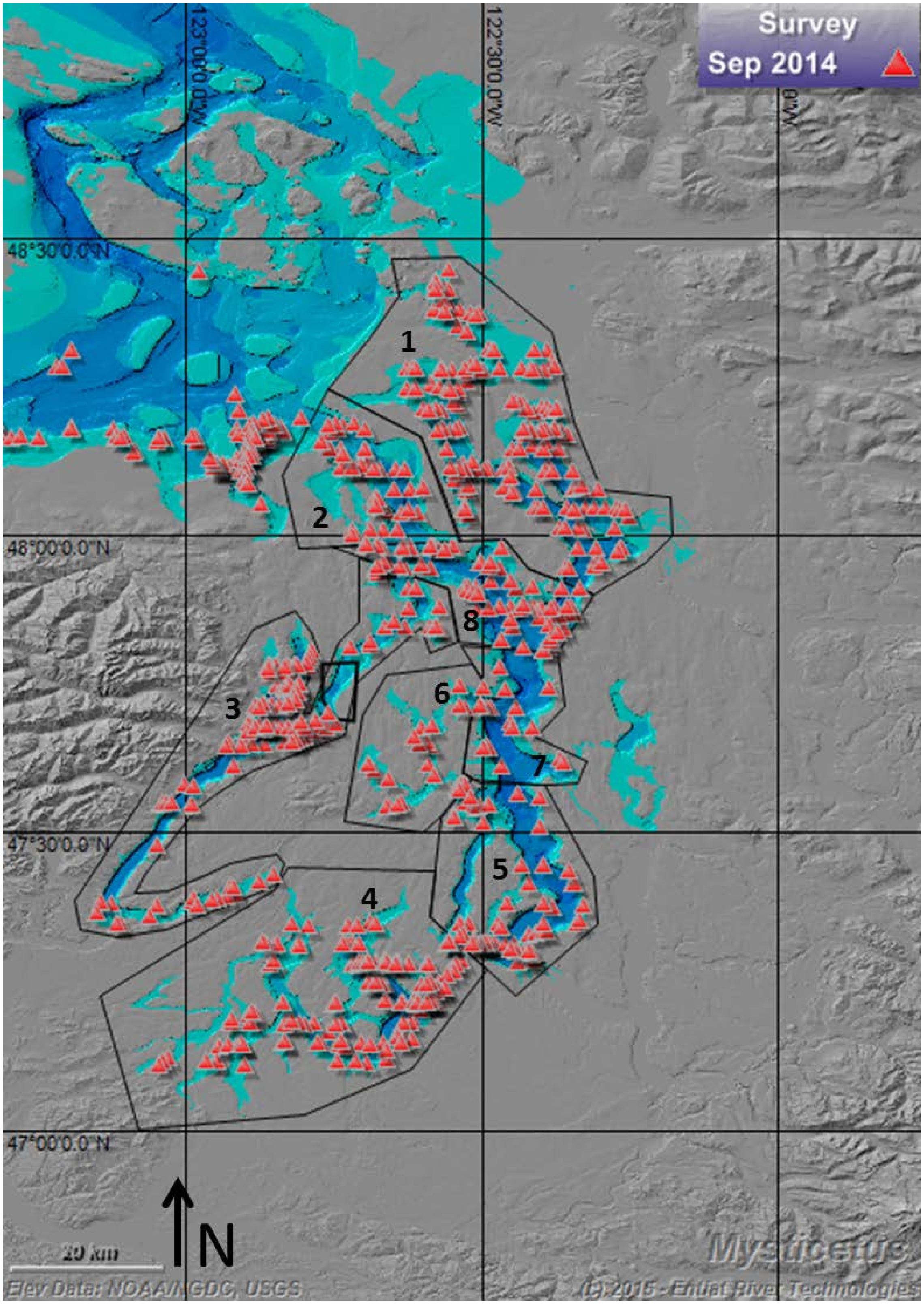

Figure A-13. Harbor seal group sightings September 2014 during Puget Sound aerial survey.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

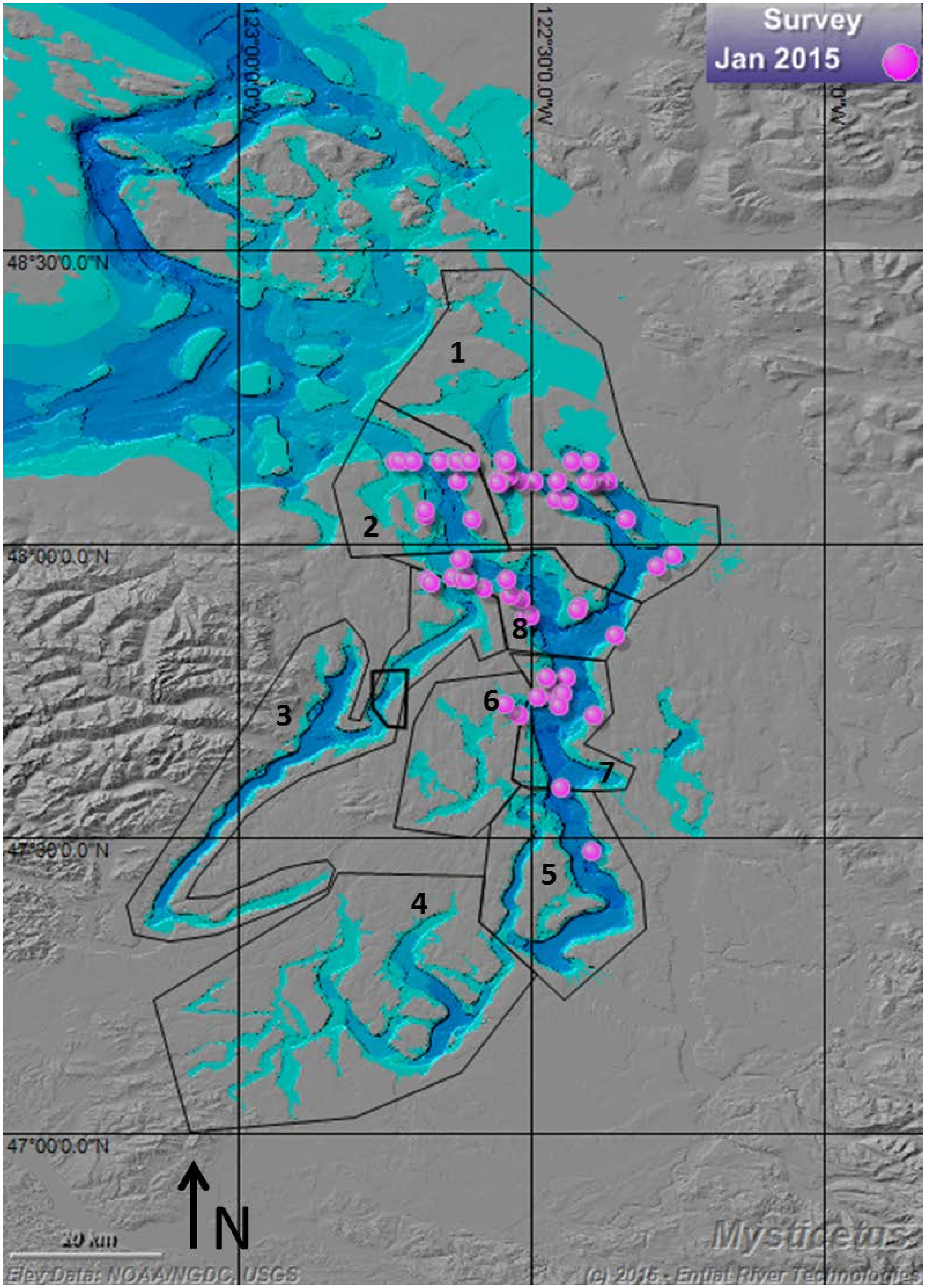

Figure A-14. Harbor seal group sightings January 2015 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

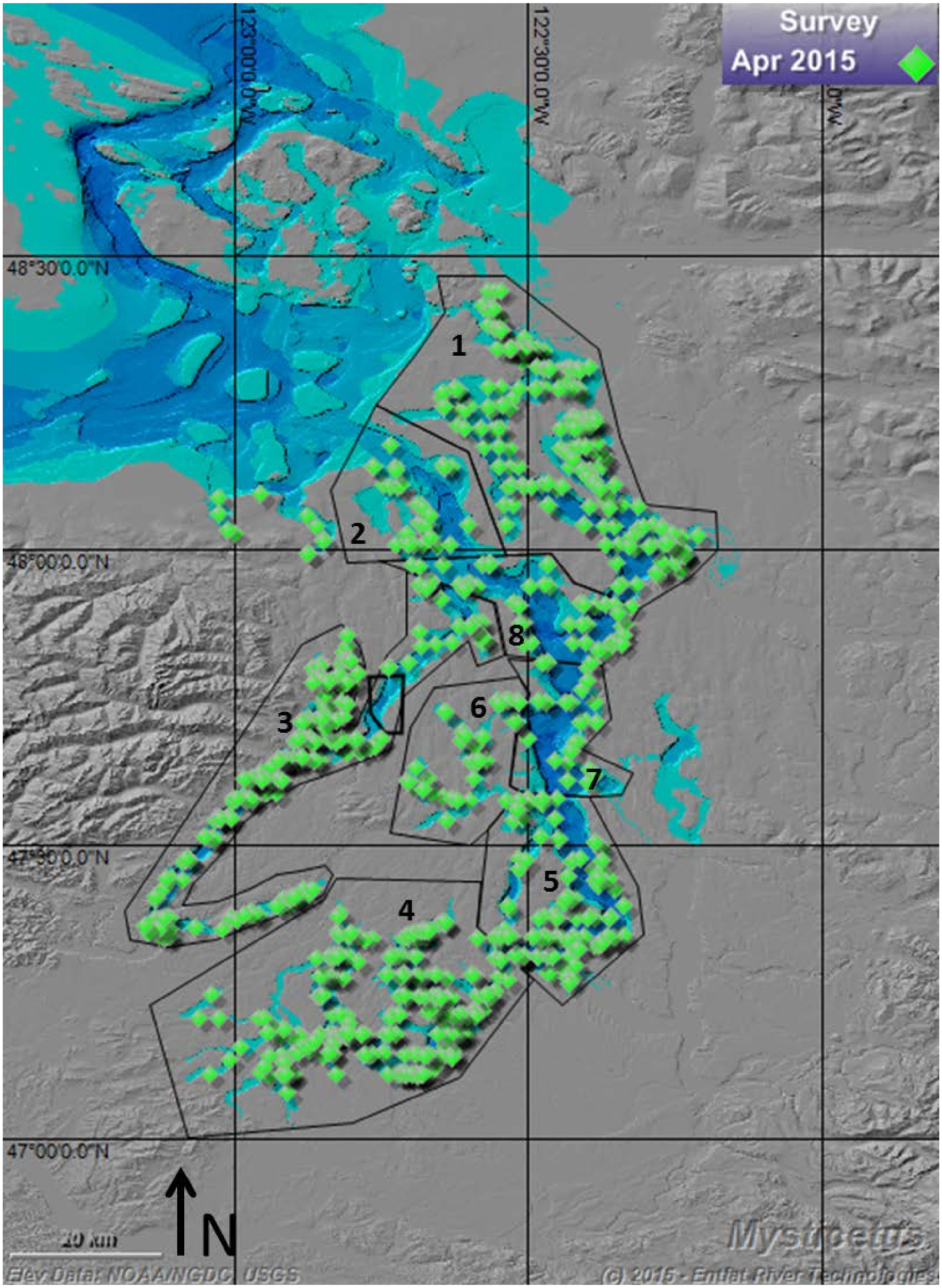

Figure A-15. Harbor seal group sightings April 2015 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

A.4 All Other Marine Mammal Group Sightings by Season

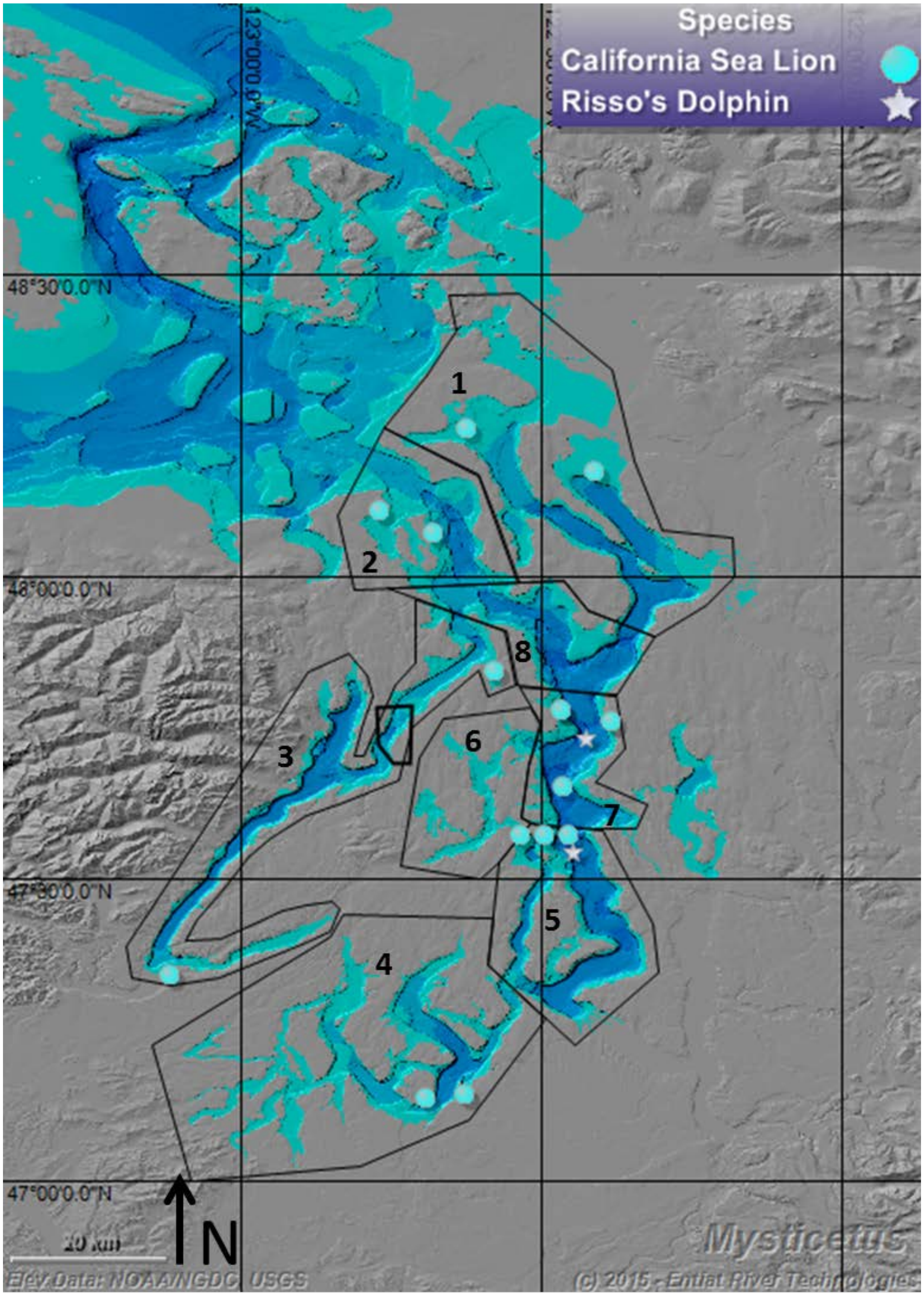

Figure A-16. Other marine mammal group sightings Aug-Sep 2013 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

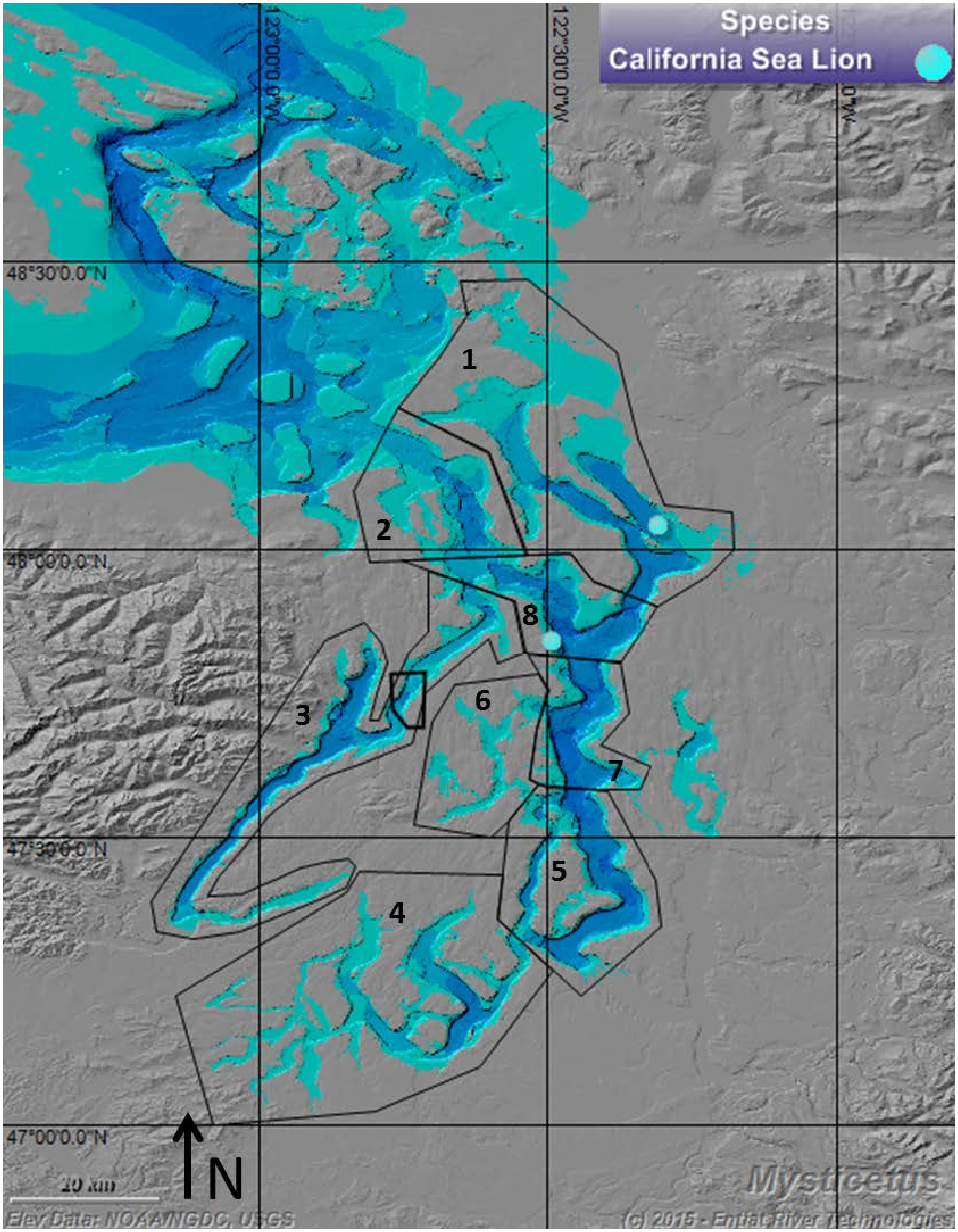

Figure-A-17. Other marine mammal group sightings July 2014 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

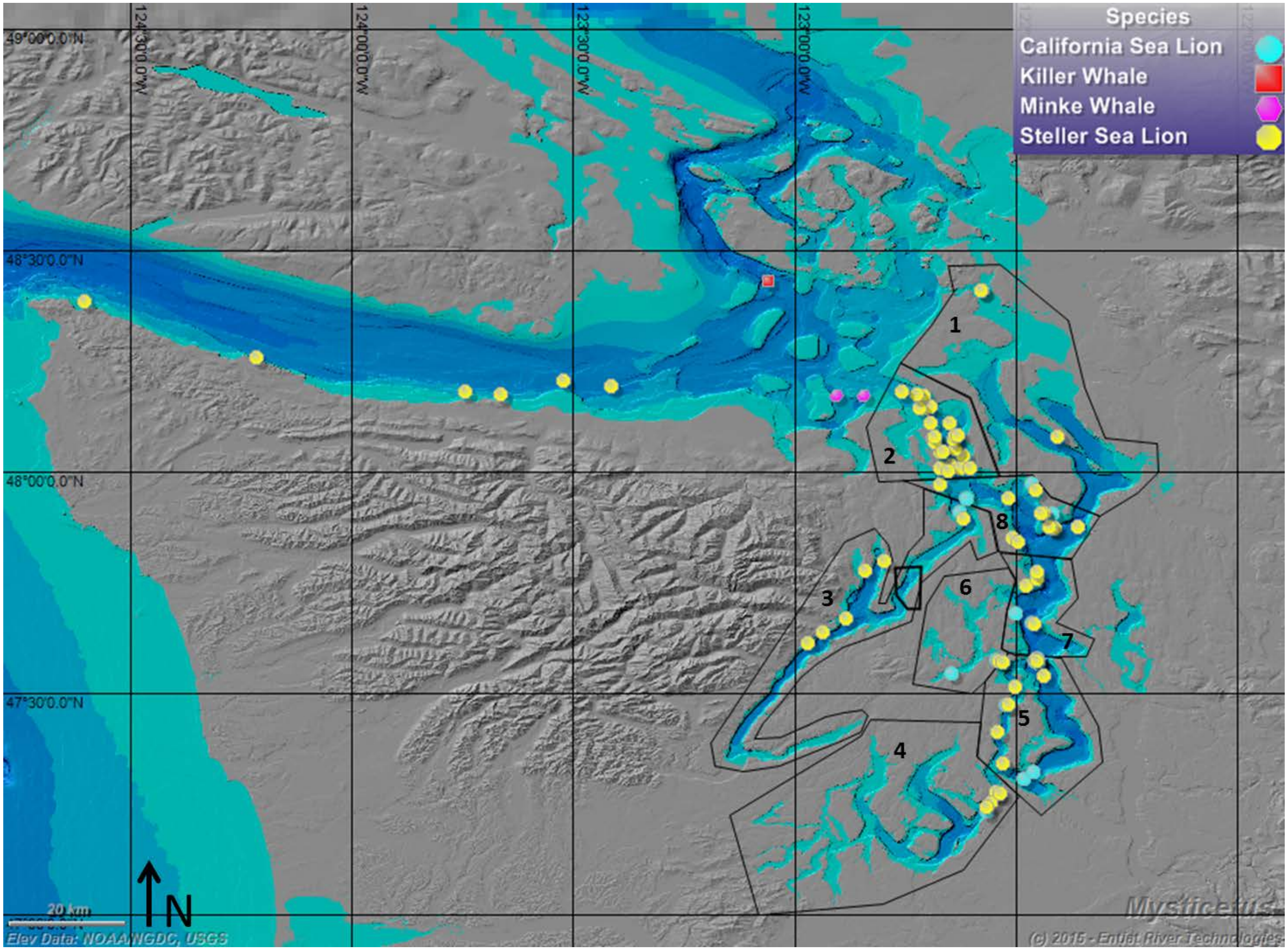

Figure A-18. Other marine mammal group sightings September 2014 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

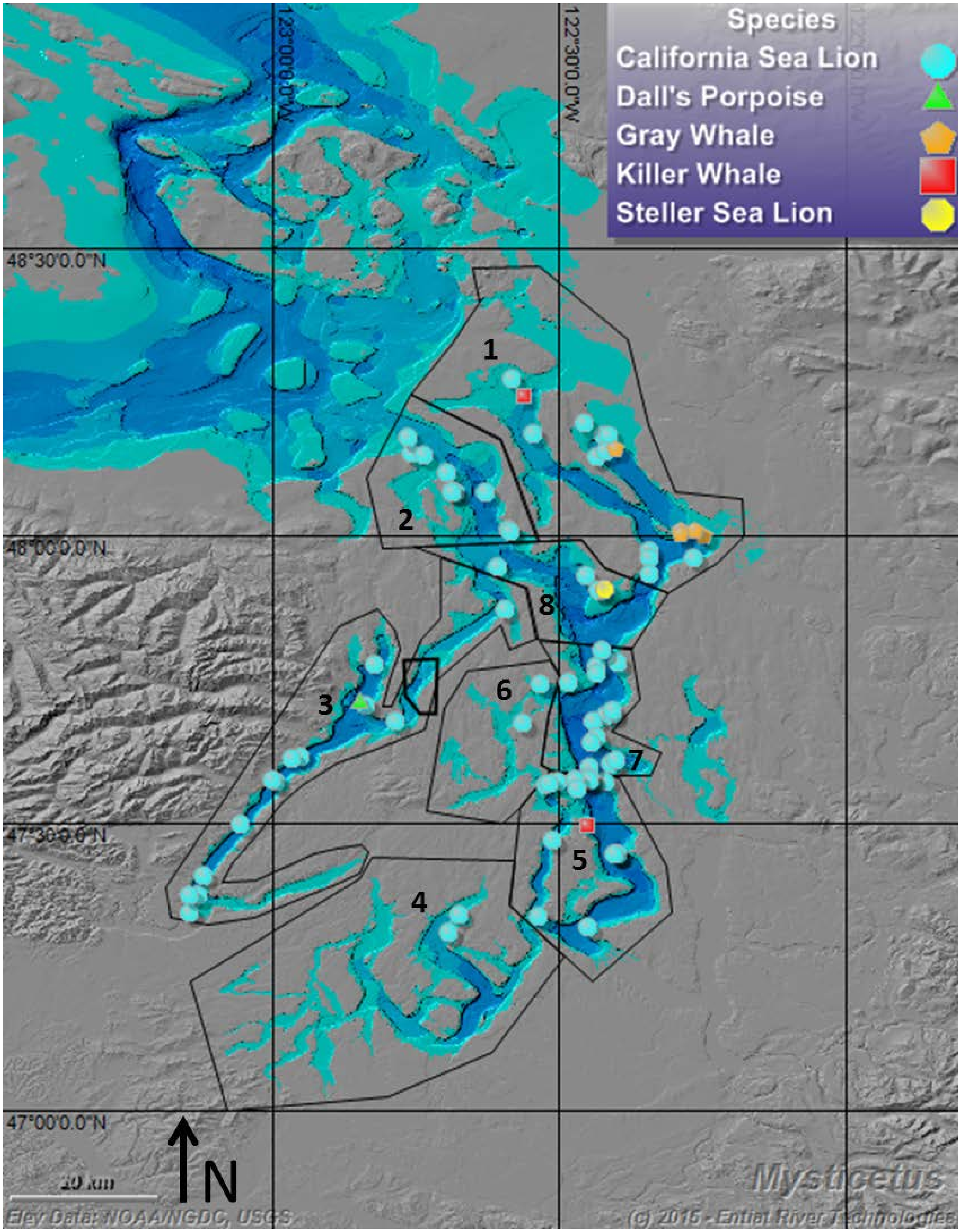

Figure A-19. Other marine mammal group sightings April 2015 during Puget Sound aerial surveys.

Map includes outlines of the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey) and the one no-fly zone (Naval Base Kitsap at Bangor—see Figure 1).

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B

Photographs

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Puget Sound Aerials Best Photos Appendix

11 December 2015

Prepared for:

HDR, Inc.

Smultea Environmental Sciences,LLC.
PO Box 256, Preston, WA 98050

Photo B-1. Harbor porpoise mother/calf pair, 1 September 2013, lat 48.17498: lon -122.721, photographed by M. Smultea under NMFS permit 15569.

Photo B-2. Harbor porpoise mother/calf pair, 30 August 2013. lat 47.24332: lon -122.594, photographed by D. Steckler under NMFS permit 15569.

Photo B-3. Harbor porpoise, including mother and calf, 26 July 2014, lat 47.94209: lon-122.584, photographed by M. Smultea under NMFS permit 15569.

Photo B-4. Harbor seal, 31 August 2013, lat 47.30708: lon -122.82, photographed by M. Deakos under NMFS permit 15569

Photo B-5. Harbor seal mother and calf, 1 September 2013, lat 47.30353: lon-122.73, photographed by D. Steckler under NMFS permit 15569.

Photo B-6. Harbor seals hauled out, 25 July 2014, lat 48.3063: lon -122.447, by M. Deakos, NMFS 15569.

Photo B-7. Gray whale, 20 April 2015, lat 48.00869: lon-122.29, photographed by T. Hanks under NMFS permit 14451.

Photo B-8. Gray whale, 20 April 2015, lat 48.00869: lon -122.29, photographed by T. Hanks under NMFS permit 14451.

Photo B-9. Possible gray whale feeding pits, 21 April 2015, lat 47.99231: lon 47.99231, photographed by T. Hanks under NMFS permit 14451.

Photo B-10. Killer whale adults and possible calf, 19 April 2015, lat 48.2436: lon -122.563, photographed by M. Deakos under NMFS permit 14451.

Photo B-11. Killer whale adults and possible calf, 19 April 2015, lat 48.2436: lon -122.563, photographed by M. Deakos under NMFS permit 14451.

Photo B-12. Risso's dolphin pair, 4 September 2013, lat 47.73312: lon -122.423, photographed by V. James under NMFS permit 14451.

Photo B-13. California sea lion, 2 September 2013, lat 48.07333: lon -122.679, photographed by D. Steckler under NMFS permit 15569.

Photo B-14. Steller sea lion, 17 September 2014, lat 47.51727: lon -122.501, photographed by T. Hanks under NMFS permit 15569.

Photo B-15. Minke whale, 20 September 2014, lat 48.17361: lon -122.844, photographed by M. Deakos under NMFS permit 14451.

Photo B-16. Minke whale diving, 20 September 2014, lat 48.17163: lon -122.904, photographed by M. Deakos under NMFS permit 14451.

Photo B-17. Otter, (undetermined sea or river otter), 21 April 2015, lat 47.10331: lon -122.921, photographed by M. Deakos under NMFS permit 14451.