South Puget Sound and Nisqually Reach Aquatic Reserve

Pigeon Guillemot Breeding Surveys

2016-2018 Monitoring Report

Prepared for:

Nisqually Reach Aquatic Reserve Citizen Stewardship Committee

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Copies of this report will be available at: Washington State Department of Natural Resources (WDNR) Aquatic Reserves website https://www.dnr.wa.gov/managed-lands/aquatic-reserves, as well as the Nisqually Reach Aquatic Reserve (NRAR) webpage found at https://www.aquaticreserves.org/, and on the Nisqually Reach Nature Center (NRNC) website www.nisquallyestuary.org.

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South Puget Sound and Nisqually Reach Aquatic Reserve Pigeon Guillemot Breeding Surveys

2016-2018 Monitoring Report

Abstract

The Nisqually Reach Aquatic Reserve Citizen Stewards conducted Pigeon Guillemot surveys beginning in 2013 through 2018 in South Puget Sound, to document number of adults observed, burrow occupancy, chick feeding, disturbances, and seasonal changes at a maximum of 41 sites per year. Each week from June through September for an hour at a time, the highest number of Pigeon Guillemots were counted at each site along with burrow visits, fish deliveries, and disturbances. The purpose of the monitoring is to collect baseline data for South Puget Sound as part of a larger regional effort to detect trends and changes in Pigeon Guillemot populations.

Introduction

Pigeon Guillemot Description

The Pigeon Guillemot (PIGU) (*Cepphus columba*) is a small diving seabird that breeds widely in Puget Sound. They are in the Alcidae family of seabirds, and related to puffins, auks, and murres, among others. PIGU are stocky dark monomorphic seabirds with rounded wings, straight bills, and bright red feet and mouth lining (Seattle Audubon Society, n.d.). During the breeding season, adult birds develop a distinctive dark brown plumage with black iridescence and a white wing patch with a black wedge; however, they appear a mottled grey and black with white underparts in their non-breeding phase and as juveniles (Seattle Audubon Society, n.d.). They usually are between 3-5 years old before breeding (Seattle Audubon Society, n.d.) and will live about 4.5 years after the onset of breeding (Nelson, 1991). They are burrow-nesters, and utilize high bluffs along shorelines of rocky shores and mainland cliffs close to shallow water. Eggs are incubated by both sexes, and usually hatch after 26 to 32 days (National Audubon Society, n.d.). Chicks fledge between 34 to 42 days after hatching (Vermeer, Morgan, J. R., & Smith., 1993). A study of PIGU breeding colonies and populations indicated a strong partiality towards sand/clay bluffs as nesting habitat (Evenson, et al., 2003). Their preferred nesting sites are their own natal cavities or burrows within 200 m of natal sites (Nelson, 1991), exhibiting a strong site fidelity within the species. They differ from other alcids by usually laying two eggs in a nest (Seattle Audubon Society, n.d.). PIGU dive for their benthic prey, usually between 10 to 30 m deep (Ewins, 1993), and, from our data, usually select gunnel or sculpin within the South Sound, although other prey species are taken (Bishop, Rosling, Kind, & Wood, 2016).

PIGU are one of the key marine bird indicators in Puget Sound; the vitality of their population can serve as a measure of environmental health, biodiversity, habitat condition, and climate change (Pearson and Hamel, 2013). This becomes even more evident because they are “especially sensitive to the quality of the marine environment” (Pyle, 2001) and are considered a “climate threatened” species by the National Audubon Society (n.d., 2014). The species is so sensitive that Bixler (2010) asserts that they are “currently the only avian species that is listed as ‘not recovering’ on the *Exxon Valdez* Oil Spill Trustee Council’s Injured Resources List,” 20 years later. The health of the PIGU population reflects the health of the Salish Sea marine ecosystem, and can influence environmental policy changes, when backed by solid research and data (Pyle, 2001). The Puget Sound Partnership, Puget Sound Environmental Monitoring

Program, Marine Birds Workgroup selected the PIGU as a vital sign species because these birds are Puget Sound-dependent throughout the year. PIGUs are common in the waters of the NRAR during the summer breeding season and forage in near-shore waters. Past and current studies have also identified the presence of PIGUs throughout the Sound in the fall, winter and spring seasons (Nysewander, et al, 2005; Puget Sound Seabird Survey, 2018). Populations in South Puget Sound were found by Pearson (2016) to be relatively stable over a period of about 16 years, but smaller on average compared to populations on Whidbey Island where these birds have been studied for a longer period of time. Breeding and non-breeding PIGUs mingle as a group on the water, on the beach, and on the bluffs near the burrows, and show strong social interactions including vocalizing, synchronized flying, billing, and mating (US Fish and Wildlife Service(USFWS), 2006). Both male and female birds incubate eggs and care for chicks (Drent, 1965). Chicks typically hatch in late June and fledge in August, between 29 - 37 days after hatching (Thoresen & Booth, 1958; USFWS, 2006).

Project Background

In 2006, Anne Mills, as Program Coordinator for South Sound GREEN, a watershed education program, arranged for Francis Wood, founder of Whidbey Island Guillemot Research Group, to give a presentation about Pigeon Guillemots (PIGU) to local watershed educators in South Sound for a workshop on Marine Birds. Inspired by the talk, Anne resolved to become involved in researching these birds and thus added it to her retirement bucket list.

A count of PIGU around Anderson Island had been documented by Lindsay K. Raab and Govinda Rosling in 2010 as part of establishing the Nisqually Delta Important Bird Area (IBA). The Nisqually Reach Aquatic Reserve was established in 2011 and included the the IBA and colonies along the Nisqually Reach. Research and networking suggested multiple colonies were near or in the other South Sound inlets.

When Anne retired in 2012, she visited Whidbey Island to view PIGU breeding habitat, participated in their training, met volunteers, and heard results of their survey work. The South Sound PIGU Breeding Survey was initiated in 2013, serendipitously, when Anne found a sponsor in Daniel Hull, Executive Director of Nisqually Reach Nature Center (NRNC). She was seeking an organization for support in order to begin the research, and he was actively seeking an appropriate citizen science project to be conducted within the Nisqually Reach Aquatic Reserve.

Substantial and ongoing support has been provided by Whidbey Island Guillemot Research Group, including coming to Olympia to present and assist with volunteer training, sharing of survey materials, such as survey protocol and data sheets, answering questions, and coordinating regional consistency. The first year of the PIGU Breeding Survey in South Sound was coordinated by Anne, with additional support from the Nisqually Reach Aquatic Reserve Citizen Stewardship Committee and Washington Environmental Council. Terence Lee began to manage NRNC's citizen science projects, including this study, in 2014 as the science technician for the Center.

Currently, NRNC is compiling an extended dataset on the breeding ecology of PIGU colonies throughout South Puget Sound, to inform best practices in ecological conservation by establishing baseline data for historical population changes and trends (though an index of maximum abundance) over multiple years. Conducting this study, in advance of evident declines of the PIGU, is a rare exercise in population ecology studies, and the ability to affect such studies in a long-term monitoring effort is difficult to sustain for most study groups (Bonebrake, Christensen, Boggs, & Erlich, 2010).

The record of South Sound data may promote future studies within the region, be used for comparisons, or assist studies in other similar habitats through data-sharing. Most of the data collection occurs during the summer breeding season, but winter monitoring of resident birds is also conducted (however it is not reported herein). Acquired data may be used for natural resource damage prevention, mitigation, and assessment; natural resource management; and protection of critical habitats and protected species.

Reserve Background

The NRAR is part of the Washington State Department of Natural Resources (WDNR) Aquatic Reserves Program. An aquatic reserve can be designated for any of the following purposes, singly or in combination: educational, environmental, or scientific. Educational reserves are accessible areas of aquatic lands typical of selected habitat types which are suitable for educational projects. Environmental reserves are areas of environmental importance, sites established for the continuance of environmental baseline monitoring, and/or areas of historical, geological or biological interest requiring special protective management. Scientific reserves are sites set aside for scientific research projects and/or areas of unusually rich plant and animal communities suitable for continuing scientific observation (WDNR, 2011). NRAR was designated as an educational, environmental, and scientific reserve.

The NRAR encompasses approximately 6,000 hectares (14,826 acres) of state-owned and DNR-managed tidelands and bedlands. The ownership of adjacent lands is diverse: Tolmie State Park, the Billy Frank Jr. Nisqually National Wildlife Refuge (formerly known as Nisqually National Wildlife Refuge), local park districts, and private, tribal, WDFW, military, city, and county lands. There are nearly 63 km (39 miles) of shoreline adjacent to the reserve, the majority being privately owned. The NRAR area is shown in green on Figure 1.

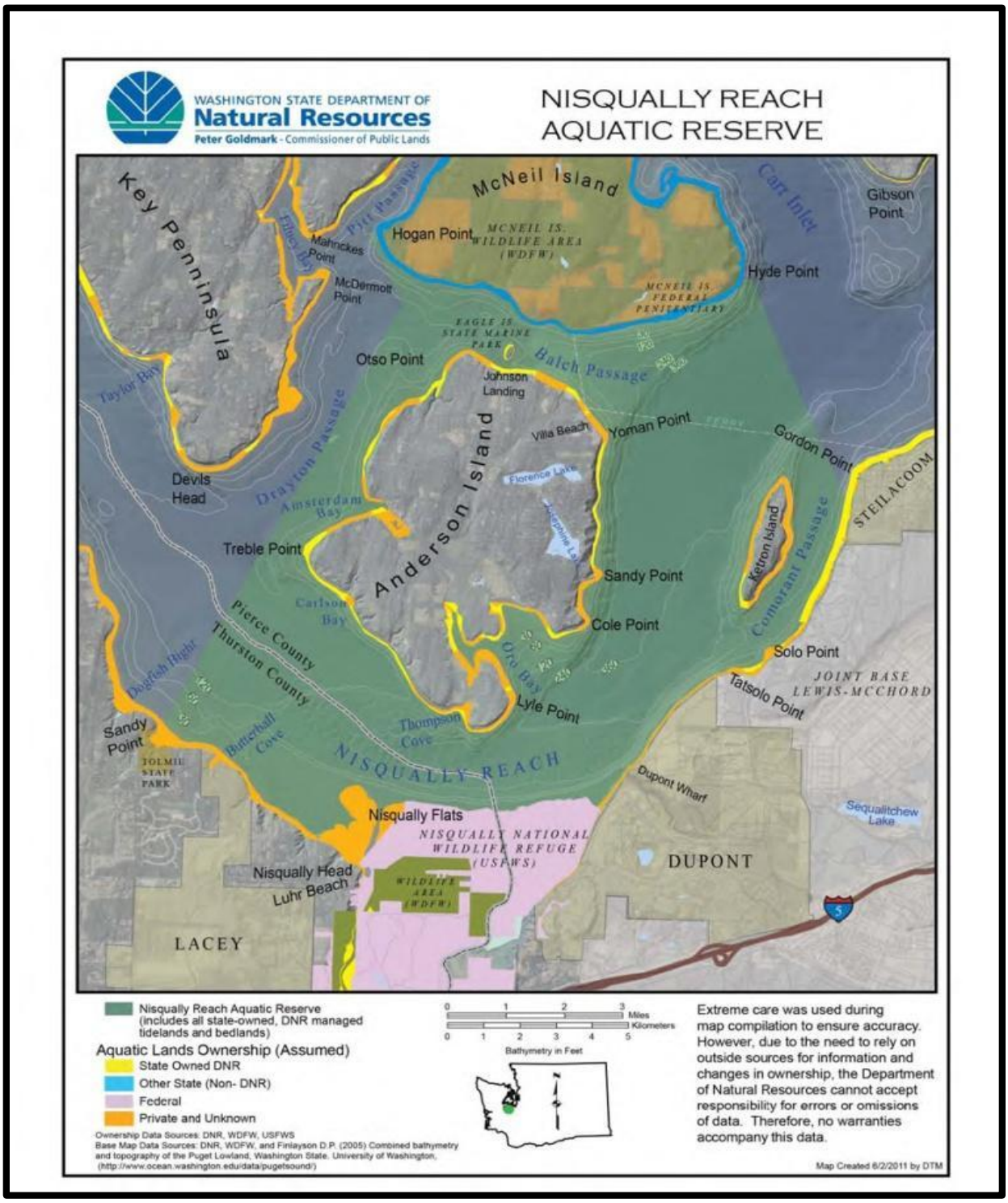


Figure 1. Nisqually Reach Aquatic Reserve and surrounding areas map (WDNR, 2011).

Goals and Objectives

The goals of the pigeon guillemot breeding surveys in South Puget Sound, near the NRAR, are to:

1) Provide a baseline for detecting changes and trends in local pigeon guillemot populations.
2) Create a multi-year dataset containing:
   - The number of Pigeon Guillemot breeding sites throughout South Puget Sound.
   - Colony and South Sound population estimates.
   - The number of active burrows at each site.
   - Prey type delivered to chicks.
   - Nesting disturbances and colony reaction to the same.
3) Continue vital monitoring efforts by educating and training volunteers to monitor Pigeon Guillemot breeding sites.

In order to accomplish the goals above, the following objectives are necessary to be accomplished:

- Train and retain a team of at least 30 volunteers to identify and monitor active breeding burrows of PIGU and be available each year for the surveys.
- Record weekly observations of PIGU behavior during the breeding season on the data sheet (Appendix A) at 30 or more South Sound sites.
- Provide data and findings to appropriate local and state agencies and the public, via website and other outreach, such as presentations to community groups.

Methods

Basis and Protocols

The Pigeon Guillemot study, conducted by the Nisqually Reach Nature Center, has produced a dataset of six discrete elements of the breeding ecology of these birds at colonies throughout South Puget Sound (see goal 2, above), with the intent of establishing baseline data for future studies and to estimate effects from both natural and anthropogenic disturbances, should they arise.

The survey protocols used for this project are detailed in Appendix B as well as the Quality Assurance Project Plan (QAPP) (Appendix C). Monitoring surveys conducted by volunteers, interns, and staff generated the data used in this report. The survey technique was based on the method established by the Guillemot Research Group, formerly Whidbey Island Pigeon Guillemot Research Group.

In the South Sound, our methods deviate from the Guillemot Research Group in two ways. First, we begin our survey visits to the selected colony sites about one week earlier than is done on Whidbey Island. Second, our surveys begin on any day no later than 7:45 am, rather than 8:45 am as on Whidbey Island. Both of these deviations from the base and established methods are due to our discoveries that feeding activity was already occurring upon arrival of the volunteers in the first study week, and that our birds are active earlier in the day and have already left the burrows if we start later. Not wishing to miss collecting good data points for the baseline, we opted to make the changes described.

Three types of data were collected:

1. **Population data** - Counts of PIGU are taken at the beginning of the survey, at the middle, and at the end. Throughout the survey hour, a tally of the highest number of birds observed at a given point in time is recorded. This may or may not coincide with one of the three counts. Emphasis is placed on counting only birds that are associating with the site being monitored.
2. **Burrow data** - Times when birds enter or leave burrows with prey are recorded as are fish deliveries, and entering without prey is recorded as a no prey visit. Fish are identified to general types (gunnel, sculpin, other) with times for each type recorded separately. All times of various burrow activities are recorded by burrow number.
3. **Disturbance data** - Events that can cause unnatural changes in behavior are categorized by type and duration. Start and end times for each event are recorded as applicable.

Surveys and Procedures

Monitoring surveys were conducted between the first week of June through the first week of September in 2016, 2017, and 2018, to capture data points within breeding colonies at a maximum of 41 sites per year. This effort was possible as a result of the more than 600 hours per year by a total of 61 volunteers. These hours include both transportation and on-site time.

A site survey team consists of at least one person, but ideally two or more, arriving at the designated site no later than 7:45 am to conduct unadjusted point census of PIGU at the site (Bibby, Jones, & Marsden, 1998; Gregory, Gibbons, & Donald, 2004) and record various data elements for one hour. An observer/survey team will go to their designated site once a week, for at least ten weeks from the start date. Each site is closed after ten weeks, if there have been at least two consecutive weeks without burrow activity (the delivery of prey to the burrow). If the two weeks have not been met at the ten-week time frame, the surveys continue until there are two consecutive weeks without burrow activity. Sites may be closed earlier than 10 weeks if there has been no burrow activity, with the permission of the Science Director.

Most survey sites are accessible via beach access by foot, but all of the sites on Ketron Island are only accessible by boat (Ketron Ferry, Ketron NE, and Ketron SW). Visual observations of birds and burrow activity are typically augmented by the use of binoculars. In order to minimize disturbance and influence on the PIGUs, volunteers typically sit off to the side of the site, positioned in such a manner that it is possible to simultaneously monitor all the burrows and activity on the water. Since PIGU are more apt to be at their burrows on mornings with a high tide (Vermeer, Morgan, K. H., & Smith, 1993), this can cause access difficulty during especially high tides while observing the Beachcrest, Butterball Cove, Lyle Point, Sandy Point, Totten, and Zangle colonies; and adjustments of survey dates is allowable to mitigate these effects.

Within each site, burrows were numbered, and burrow activity was attributed to the specific burrows as they occurred. PIGU entering burrows without food was considered as an attempt to choose a site for laying or incubation, and the burrow was designated "occupied." When fish were brought to the burrow it was designated as a "chick burrow." Prey were identified as either gunnel (*Pholidae*) or sculpin (*Cottidae*). Any unidentified fish, or those from other families were reported as "other prey" delivered.

Figure 2. Typical survey site; exposed sedimentary bluff with moderate sized holes preferred by PIGU (NRAR, n.d.).

Sites

A "site" is the location from which observations are made of the PIGU "colony" in that location. Each colony is a discrete sample, and the survey teams conduct a census for that sample during each visit (Gregory, et al., 2004). A colony can have multiple sites designated using a lettering system (A, B, C), based upon the time of burrow activity discovery. Therefore, the colony is named for the site, and site visits are of that colony. Names are typically associated with geographic landmarks marked on maps such as points, coves, bays, or in cases where there isn't a prominent land/water feature, road names or neighborhood names are used. Site selection was determined using reports and observation. Initial efforts were based on anecdotal, word of mouth reports of 'historical' breeding colonies, which were visited beginning in fall of 2012 to locate and assess the habitat. Validation of sites for use continues annually, and includes observing newly reported potential sites. Sites were chosen by visiting likely breeding areas. If PIGU were observed in the immediate vicinity of burrows, visiting burrows, or delivering fish, the location was selected for survey. Colony access was, and still continues to be, a significant driver of survey inclusion since most sites are located on private beaches.

Sites are typically characterized by high banks with exposed faces pockmarked with burrows of varying sizes as seen in Figure 2. The smallest burrows are used by swallows, while kingfishers use small to medium burrows, with PIGUs using medium to large burrows.

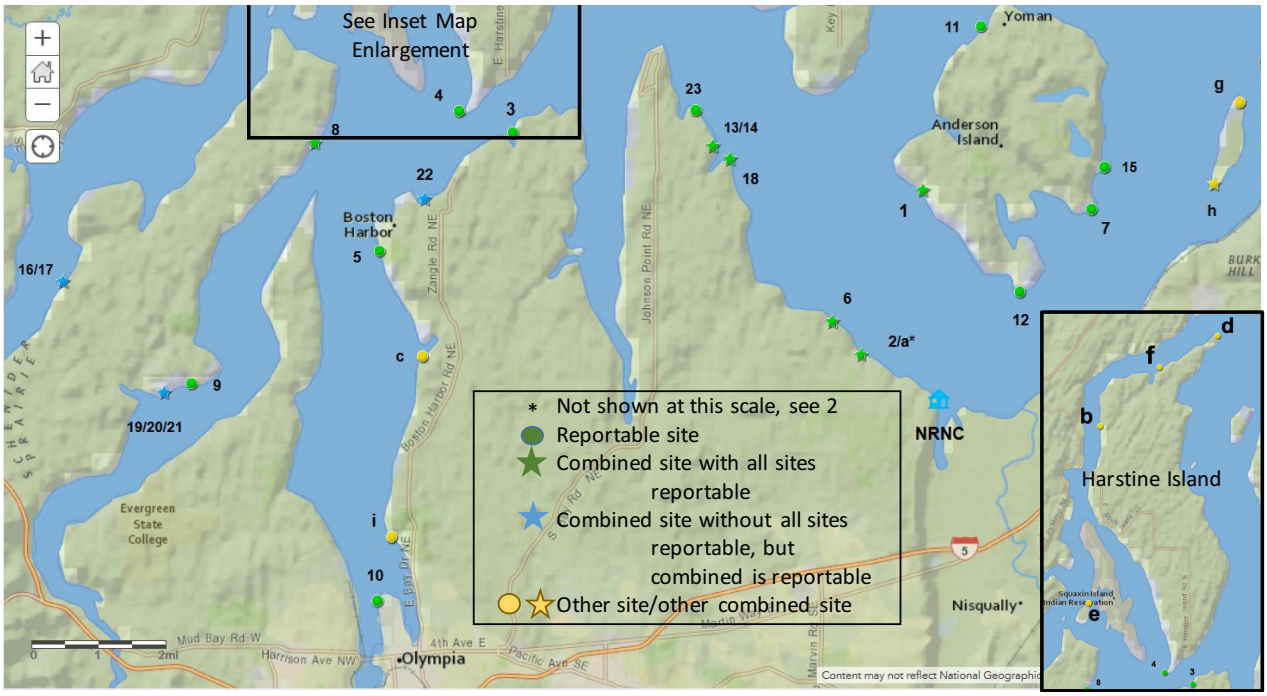


Figure 3. Map of 2016-2018 South Sound Pigeon Guillemot survey locations (Lee, 2019). Numbered sites are considered reportable, and lettered sites were incompletely surveyed. Parenthetical numbers on Table 2 correlates reportable site numbers on map with site name. Sites with multiple numbers are due to map scale.

Sites were added or removed from monitoring each year. The number of unmonitored sites was 27 in 2016, 14 in 2017, and 16 in 2018. These unmonitored sites are subtracted from the total number of sites we have surveyed (n=53) over the total duration of the study. As an example, if a new site was added in 2018, it is counted as an unmonitored site for 2016 and 2017, even though it did not exist as a site at those times.

Figure 3 represents the geographic extent of our study area, and labels the vast majority of surveyed sites. Labelling exceptions are for those combined sites which are in close proximity to one another and identified only as the combined site location. The inset indicates the three sites on the northern end of Harstine Island (b, d, and f), and the site on Hope Island (e).

Recordkeeping

Survey observations are recorded on a standardized data sheet (Appendix A) per the protocol established at Whidbey Island (Appendix B), and entered into the www.pigeonguillemotdata.org database, that is operated by the Whidbey Island group. The sheet is requested to be turned in to the NRNC within one week of the survey date by the site volunteers.

The survey data sheet requests basic information about the survey site, such as the name of the site, date of survey, and time of survey start, tide information at the start of the survey. It also has space for information about the observers at the site that day; capturing the team lead name and email, names of other observers, and the total volunteer time for that survey. Each data sheet is mailed or emailed to the NRNC for filing and quality assurance and control measures. The actual data entries captured on the sheet include:

- the survey's highest PIGU abundance count, with counts at the beginning/middle/end of the allotted time;
- burrow number identification and notes on use by time stamp of occurrence (described either as a "no prey delivery," or by indicating the type of prey delivered);
- disturbances experienced during the survey, the time of occurrence, type and duration of PIGU response; and
- additional notes about the burrows or the colony/site.

Quality assurance and quality control (QA/QC) measures stated in the QAPP (Appendix C) are implemented in all project steps, including ensuring each sheet is complete, that the data is entered into the database, and the sheets are properly filed within the NRNC. One of the most difficult QA/QC tasks is to ensure each survey has the respective data sheet on file as a backup to the online record, and that lack has caused some potential data to be excluded.

Reporting Individual Abundance Data

In colonies with multiple sites, the birds are well able to travel to those other sites nearby. Where birds comingle and could potentially be double counted, only the highest count of PIGU at any one of the sites was designated as the high count for the combined colony (Gregory, et al., 2004, pp. 41, 44) (see below list). This would only be shown if there was data for those sites. The high counts of birds did not attempt to differentiate between breeding pairs and non-breeding birds in this monomorphic species. Below is a list of sites for which the individual abundance data would be reported only under the combined site name:
Andy's Marine Park South + Andy's Marine Park West --> Andy's Marine Park Combined
Butterball Cove South A + Butterball North --> Butterball Cove Combined
Edgewater A + B + C + D --> Edgewater Combined
Ketron SE + Ketron SW --> Ketron Combined (Ketron Ferry Remains separate)
Mill Bight A + B --> Mill Bight Combined (Mill Bight C remains separate)
Totten @Elizan A Tower + A North + A South + B --> Totten @Elizan Combined
Totten @Legacy + C --> Totten @ Legacy Combined
Walnut Rd A + B + C --> Walnut Rd Combined
Young's Cove A + A West + B --> Young's Cove AB Combined
Young's Cove C + D + F --> Young's Cove CDF Combined (Young's Cove E remains separate)
Zangle Cove A + B + C --> Zangle Cove Combined

Citizen Science Training

Since inception of this project, the Nisqually Reach Nature Center provided training for volunteers in a tri-county area: in Thurston County at the NRNC, in Pierce County on Anderson Island, and in Mason County on Harstine Island. Table 1 provides information on the number of volunteers trained by site by year, and indicates if they were new that year or a returning volunteer. A total of 31 citizen scientists

were trained in 2016, 47 in 2017, and 24 in 2018. Returning volunteers are encouraged to attend the training, but their attendance is not required. Training provides access to diverse population of learners at different skill levels through use of multiple methods, and includes: background information about PIGU, breeding habitat, prey identification, data collection, and data entry. Classroom sessions lasted an average of four hours. Field orientations are included as part of the training to demonstrate site locations, associated burrows, and best practices for site use during observations/surveys.

Table 1.
Number of Volunteers Trained by Year and Location.

Training Site	2016		2017		2018	
	New	Returning	New	Returning	New	Returning
NRNC	9	8	24	15	9	10
Anderson Island	5	3	7	1	0	2
Harstine Island	2	4	-	-	2	1
Total by Year	31		47		24	

Note: Table 1 only records volunteers attending the formal training sessions, it does not provide total numbers of volunteers.

Results

Sites

Sites with surveys that met the QAPP guidance of ten weeks, with two consecutive weeks of no burrow activity to close out the season, were considered 'reportable' sites (as listed in Table 2, and throughout this document). Despite having nine surveys Big Fish Trap was included in this list, because the site was closed within the QAPP guidelines for low activity. There were 15 reportable sites in 2016, 17 in 2017, and 22 in 2018. Other sites surveyed (15 sites in 2016, 24 sites in 2017, and 15 sites in 2018) throughout the three years did not meet the criteria of providing 10 weeks of data. However, these other sites had good observations of bird numbers, prey delivery by type and number, and burrow usage, and are included as additional data in the 'adjusted' figures that are used throughout the report in order to present a more complete picture of total PIGU activity in the South Sound.

Of the 53 total potential sites, not all sites were surveyed each year, nor were they completely surveyed each year. In 2016, 31 separate sites were surveyed. Of these sites, 20 were completed but four were not in accordance with QAPP guidelines and are not considered in the 'reportable' category (see Table 2 for reportable sites by year). Additionally, four 2016 sites were incompletely surveyed due to site inactivity, three because of volunteer issues, two were prematurely closed, and one due to late start. Ten sites were added in 2017 for a total of 41 which were surveyed. Twenty-one were completed, however four sites were again not in accordance with the QAPP and are not reportable. Nine sites were closed due to lack of PIGU activity, five sites were incompletely surveyed due to volunteer issues, three were prematurely closed, and two had late starts (an additional effect of the volunteer issues for the sites). In 2018 there were 37 sites surveyed. Twenty-five of these were completed, 22 are reportable and three were not reportable. Six sites were closed due to lack of PIGU activity, four experienced volunteer issues, two were started late, and one was prematurely closed. Since the Ketron sites must be

accessed by boat, the lack of boat captains severely hampers our monitoring ability in those locations. Table 2, below, shows the number of visits to each of the reportable sites over three years, and the number of other sites surveyed by year, with a summation of the total sites surveyed per year.

Table 2.
Number of Visits Per Reportable Site as Surveyed 2016 - 2018 and Total Number of Surveyed Sites (data extracted from annual reports at http://www.pigeonguillemotdata.org).

Site Name	Number of Visits		
	2016	2017	2018
(1) Andy's Marine Park South		14	
(1) Andy's Marine Park West		10	
(2) Beachcrest West			12
(3) Big Fish Trap	9	11	10
(4) Briscoe Point			10
(5) Burfoot Park	11	11	16
(6) Butterball Cove South A	14	12	12
(6) Butterball North		16	10
(7) Cole Point	10		
(8) Edgewater A			11
(8) Edgewater B			12
(8) Edgewater C			10
(8) Edgewater D			10
(9) Flapjack			11
(10) Hearthfire		11	10
(11) Higgins Cove	10		
(12) Lyle Point	12		11
(13) Mill Bight A	12	13	11
(13) Mill Bight B	13	12	12
(14) Mill Bight C	11		
(15) Sandy Point		14	
(16) Totten @ Elizan A North	10		
(17) Totten @ Elizan C	10		
(17) Totten @ Legacy	10		
(18) Walnut Road A		10	10
(18) Walnut Road B		12	11
(18) Walnut Road C		10	11
(19) Young's Cove A	11	11	13
(20) Young's Cove C	11	11	12
(20) Young's Cove D	10	10	12
(21) Young's Cove E			15

(22) Zangle Cove A		15	
(23) Zittel's Marina	11		
Total Reportable Sites	16	17	22
Total Other Sites	15	24	15
Total Sites Surveyed	31	41	37

Note: Parenthetical numbers before the site name correspond to locations indicated on Figure 2; not all sites are reportable and are considered "other sites," indicated by letters on Figure 2. These "other sites" include: a. Beachcrest East; b. Fern Creek; c. Gull Harbor; d. Harstine Pointe Lagoon; e. Hope Island NE; f. Jarrell Cove State Park; g. Ketron Ferry; h. Ketron Combined; and i. Priest Point Park.

Indication of Maximum Abundance

The abundance of PIGU was calculated by adding the highest count of PIGU seen throughout the year's weekly surveys at each reported site (Table 3), following the methodology from Whidbey Island (Bishop, et al., 2016). As on Whidbey Island (Bishop, et. al., 2016), the numbers of birds counted and the resulting indications of maximum abundance do not include birds who were not seen for the reasons of remaining within burrows, or absent from the colony for the entire survey time, nor do they attempt to exclude birds who may have traveled from another colony to the site being surveyed. The methods section, above, indicates which colonies have multiple sites and which are listed as "combined" (in Table 3) for the purposes of counting the number of PIGU; the high count is deemed to be the single highest value from any of the sites within the colony.

Table 3, below, provides PIGU high counts per reportable site. Other site high counts were added to the reportable sites to provide an aggregate annual total as an indicator of PIGU individual abundance in the South Sound, as shown at the bottom of Table 3.

Table 3.
Reportable Indication of Maximum Abundance (High Count) by Site as Surveyed 2016 - 2018
(data extracted from annual reports at http://www.pigeonguillemotdata.org).

Site Name	High Count of PIGU		
	2016	2017	2018
Andy's Marine Park Combined		20	
Beachcrest West			19
Big Fish Trap	12	6	16
Briscoe Point			18
Burfoot Park	13	14	10
Butterball Cove Combined	20	29	33
Cole Point	19		
Edgewater Combined			26
Flapjack			15

Hearthfire		8	3
Higgins Cove	20		
Lyle Point	28		27
Mill Bight Combined	15	26	24
Mill Bight C	7		
Sandy Point		22	
Totten @ Elizan Combined	5		
Totten @ Legacy	6		
Walnut Road Combined		32	41
Young's Cove AB Combined	11	9	10
Young's Cove CDF Combined	10	10	9
Young's Cove E			6
Zangle Cove Combined		6	
Zittel's Marina	6		
Total Reportable Site High Count	172	182	257
Total Other Sites High Count	144	209	69
Total Adjusted Annual High Count	299	374	313
(Indication of PIGU Maximum Abundance in South Puget Sound)			

Note: Only the *highest value* for of all sub-sites was listed as the entry for a combined site and included into the totals. The inclusion of the values for other sites into the Adjusted High Count is not straight addition of the reportable and other sites totals, as several of the other sites were sub-sites reported under a combined site.

A one-way ANOVA was run for the three years' data from reportable sites and indicated there was no statistically significant difference between or within the measures of maximum abundance reported [$F_{(2, 35)} = 1.07$, $p = 0.353963$], nor between or within the adjusted maximum abundance figures [$F_{(3, 70)} = 0.29$, $p = 0.749158$]. These results lend credence to the hypothesis that the numbers are representative of the abundance of PIGU over the study period and area.

The adjusted average yearly index of maximum abundance for the South Sound was 329 individuals. The site with largest abundance was the Walnut Road Combined colony, with a high count of 41 PIGU in 2018, and the smallest was the Hearthfire colony with 3 PIGU also in 2018. An average abundance per site (using each daily high count) was not calculated since high counts were considered the peak for the season. As additional data is collected, it will be possible to compare abundance data from year to year at each specific site.

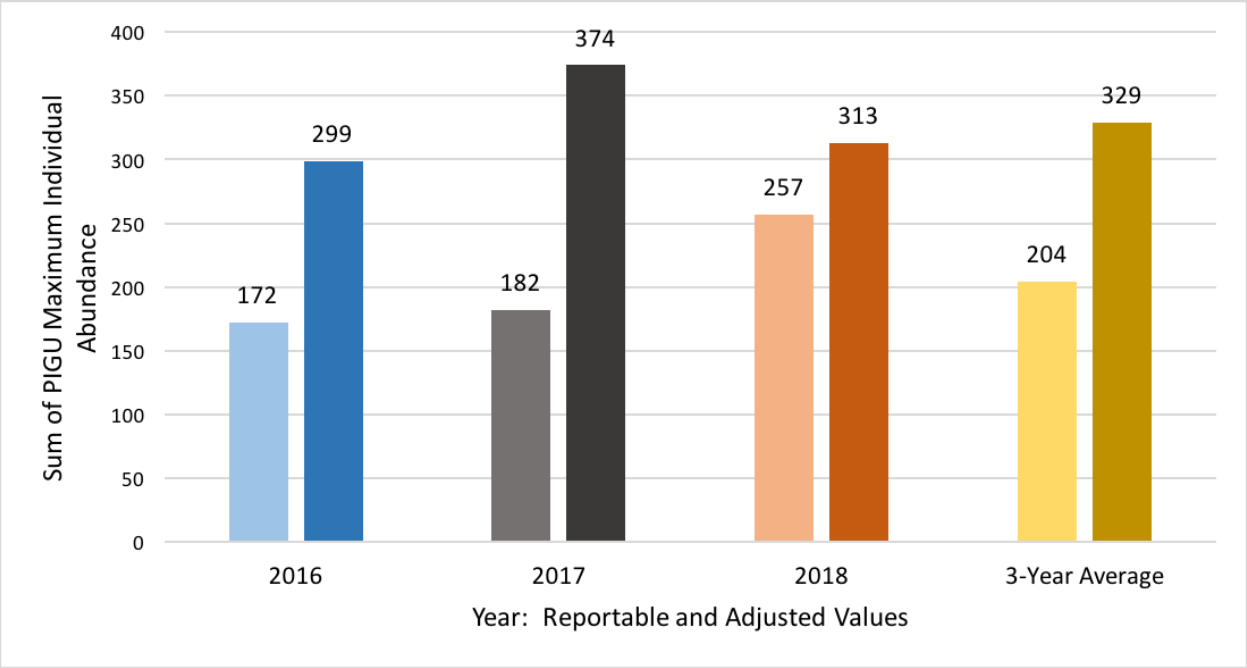


Figure 4. Sum of indication of maximum abundance of Pigeon Guillemots.
Annual and average indications of maximum abundance of Pigeon Guillemots at reportable colonies during June to September, 2016 through 2018 in South Puget Sound (2016: n_{sites} = 16; 2017: n_{sites} = 17; 2018: n_{sites} = 22) as compared to adjusted colony data (2016: n_{sites} = 31; 2017: n_{sites} = 41; 2018: n_{sites} = 37) in the second column of each year.

Burrows

Number of occupied burrows (identified by visits into burrows without prey delivery) were compared to the number burrows with prey delivery visits, identified as 'chick burrows.' Occupied burrows, for reportable sites, numbered 27 in 2016, 25 in 2017, and 44 in 2018. Chick burrows were 25 in 2016, 29 in 2017, and 36 in 2018. The adjusted occupied burrows were 48, 61, and 52, and 39, 49, and 40 for chick burrows, in each year respectively, beginning at 2016. Individual results by reportable site are presented in Table 4. A one-way ANOVA was run for the three years' data and indicated there was no statistically significant difference between or within the amount of occupied versus chick burrows reported [$F_{(2, 52)}$ = 0.73, p = 0.487].

Table 4.
Reportable Occupied and Chick Burrows by Site as Surveyed 2016 - 2018 (data extracted from annual reports at http://www.pigeonguillemotdata.org).

Site Name	Burrow Type					
	2016		2017		2018	
	Occupied	Chick	Occupied	Chick	Occupied	Chick
Andy's Marine Park South	*	*	3	3	*	*
Andy's Marine Park West	*	*	1	1	*	*

Beachcrest West	Note	Note	Note	Note	0	2
Big Fish Trap	1	0	0	0	1	1
Briscoe Point	Note	Note	Note	Note	8	3
Burfoot Park	4	3	5	4	5	4
Butterball Cove South A	6	3	4	4	4	4
Butterball North	*	*	1	2	0	0
Cole Point	3	3	*	*	*	*
Edgewater A	*	*	*	*	0	1
Edgewater B	*	*	*	*	2	3
Edgewater C	*	*	*	*	1	0
Edgewater D	*	*	*	*	1	1
Flapjack	Note	Note	Note	Note	3	3
Hearthfire	*	*	0	0	0	0
Higgins Cove	2	2	Note	Note	Note	Note
Lyle Point	3	4	Note	Note	5	2
Mill Bight A	1	1	0	1	1	2
Mill Bight B	2	2	2	2	2	2
Mill Bight C	0	0	Note	Note	Note	Note
Sandy Point	*	*	3	3	*	*
Totten @ Elizan A North	0	1	Note	Note	Note	Note
Totten @ Elizan C	0	1	Note	Note	*	*
Totten @ Legacy	0	1	Note	Note	Note	Note
Walnut Road A	Note	Note	2	3	0	1
Walnut Road B	Note	Note	0	1	3	2
Walnut Road C	Note	Note	1	1	1	1
Young's Cove A	3	2	0	2	2	2
Young's Cove C	1	1	1	1	2	0
Young's Cove D	1	1	2	0	1	1
Young's Cove E	Note	Note	Note	Note	2	1
Zangle Cove A	Note	Note	0	1	Note	Note
Zittel's Marina	0	0	*	*	*	*
Total Reportable Sites	27	25	25	29	44	36
Total Other Sites	21	14	36	20	8	4
Adjusted Annual Total	48	39	61	49	52	40

* Site not surveyed during the year indicated.

Note. Site not reportable for the year indicated, burrow figures for these sites are included in the "other sites" category for the indicated year.

Data gathered at non-reportable sites is included in the "total other sites" calculations of burrow usage by year, the results of which are listed in Table 4. The inclusion of this data changed the number of

burrows in both categories, adding 21, 36, and 8 occupied burrows, as well as 14, 20, and 4 chick burrows, respectively.

There was no statistically significant difference between or within the reportable occupied burrows by year [one-way ANOVA produced $F_{(2, 50)} = 0.2$, $p = 0.819383$], or for the adjusted occupied burrows by year [one-way ANOVA produced $F_{(2, 94)} = 1.11$, $p = 0.333839$]. This is also true of the reportable chick burrows [$F_{(2, 50)} = 0.41$, $p = 0.665861$] as compared to the adjusted chick burrows [$F_{(2, 940)} = 2.1$, $p = 0.128165$]. The 3-year means for each burrow type are 32.00 for reportable occupied, 30 for adjusted occupied, 53.57 for reportable chick, and 42.67 adjusted chick burrows.

The annual totals of reportable active burrows (those with either type of activity: occupied or chick burrow designations) were: 2016 – 31, 2017 – 32, and 2018 – 55. This differs from the totals in Table 4, because some burrows may have only been reported as a chick burrow, and were not observed as occupied burrows, and are based on the discrete burrow identification numbers assigned. Adjusted active burrows numbered: 2016 – 56, 2017 – 75, and 2018 – 64. Overall, the occupancy percentage of reportable occupied burrows was 89.29% and reportable chick burrows was 76.27%. When using all available data, the percentage of adjusted occupied burrows was 76.27 and adjusted chick burrows was 65.64%.

Prey Delivery

The date of fish delivery to burrows was monitored and recorded, and the data was used to calculate reportable and adjusted rates of fish delivery per hour across the three years, and to determine three-year mean rates of delivery. Prey-type delivery records were used to determine the delivery proportions between gunnel, sculpin, and other prey.

In each year the PIGU at the reportable colonies delivered over 2 fish per hour to their burrows, with a mean value of 2.53 fish per hour (Table 5). There was no statistically significant difference between or within the amount of reported prey delivered by year as shown in Table 5 [$F_{(2, 42)} = 1.37$, $p = 0.265228$]. The two sites with the highest delivery rates in 2016 were Burfoot Park (2.33) and Butterball Cove South A (2.78); in 2017 they were Butterball Cove South A (5.67) and Mill Bight B (8.67); and in 2018 they were Flapjack (4.75) and Butterball Cove South A (6.50). The the lowest delivery rates in 2016 were 1.00 at four separate sites; in 2017 the lowest was also 1.00 at Walnut Road B, followed by Andy's Marine Park West (1.33); and in 2018 Young's Cove A had the lowest delivery rate (1.17) and Big Fish Trap (1.33) just above.

Table 5.
Rate of Fish Delivery to Hatchlings per Hour at Reportable Sites Surveyed 2016 - 2018 (data extracted from annual reports at http://www.pigeonguillemotdata.org*).*

	Reportable Fish Delivery Rate			
	2016	2017	2018	3-Year Mean Values
Hours with Fish Delivery	49	62	69	60.00
Number Fish Delivered	102	175	178	151.67
Rate	2.08	2.82	2.58	2.53

Table 6 provides the adjusted rate of delivery for all fish over the years of this study. The additional data did not change the rates much from the reportable figures in Table 5. These results were not statistically different in a one-way ANOVA [$F_{(2, 63)} = 1.81$, $p = 0.313977$]. The additionally reported other sites varied between the years with 8 in 2016, 10 in 2017, and 3 in 2018. For the three-year total, these sites added 59 hours with 136 fish delivered.

Table 6.
Adjusted Rate of Fish Delivery to Hatchlings per Hour at all Sites Surveyed 2016 - 2018 (data extracted from annual reports at http://www.pigeonguillemotdata.org*).*

	Adjusted Fish Delivery Rate			
	2016	2017	2018	3-Year Mean Values
Hours with Fish Delivery	69	93	77	79.67
Number Fish Delivered	145	249	197	197.00
Rate	2.10	2.68	2.56	2.47

The total prey deliveries were not significantly different between and within the three years of this report in a one-way ANOVA ($F_{(2, 45)} = 1.16$, $p = 0.322682$). The addition of the excluded sites increased deliveries of prey species by almost 300, and is at Figure 6. The adjusted prey deliveries were not significantly different for the three reported years ($F_{(2, 45)} = 1.06$, $p = 0.354946$).

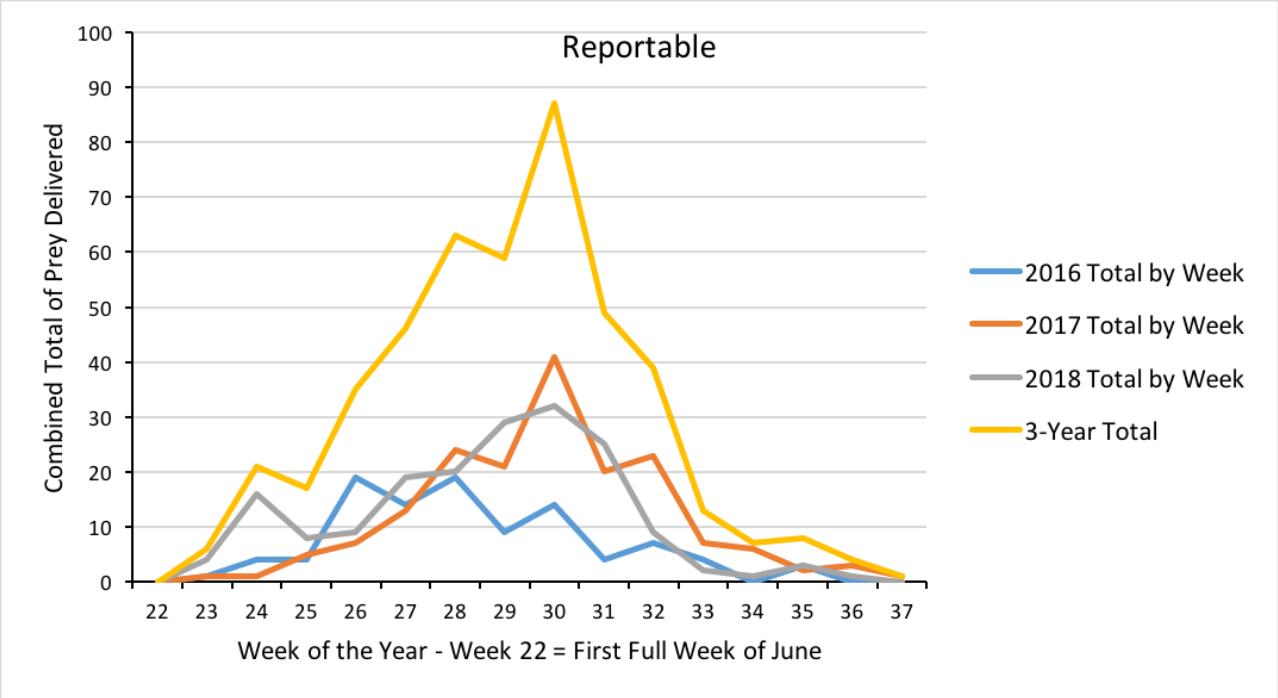


Figure 5. 3-Year summary of reported prey deliveries by week, all prey combined.

The peak in the prey delivery charts coincide with the timing between incubation and fledging, and decreases after fledging. The total time for incubation and fledging is between 60 to 74 days (National

Audubon Society, n.d.; Vermeer, Morgan, K. H., & Smith, 1993). Since adult PIGU eat whilst on the water, all prey deliveries to burrows are considered to be for chick consumption.

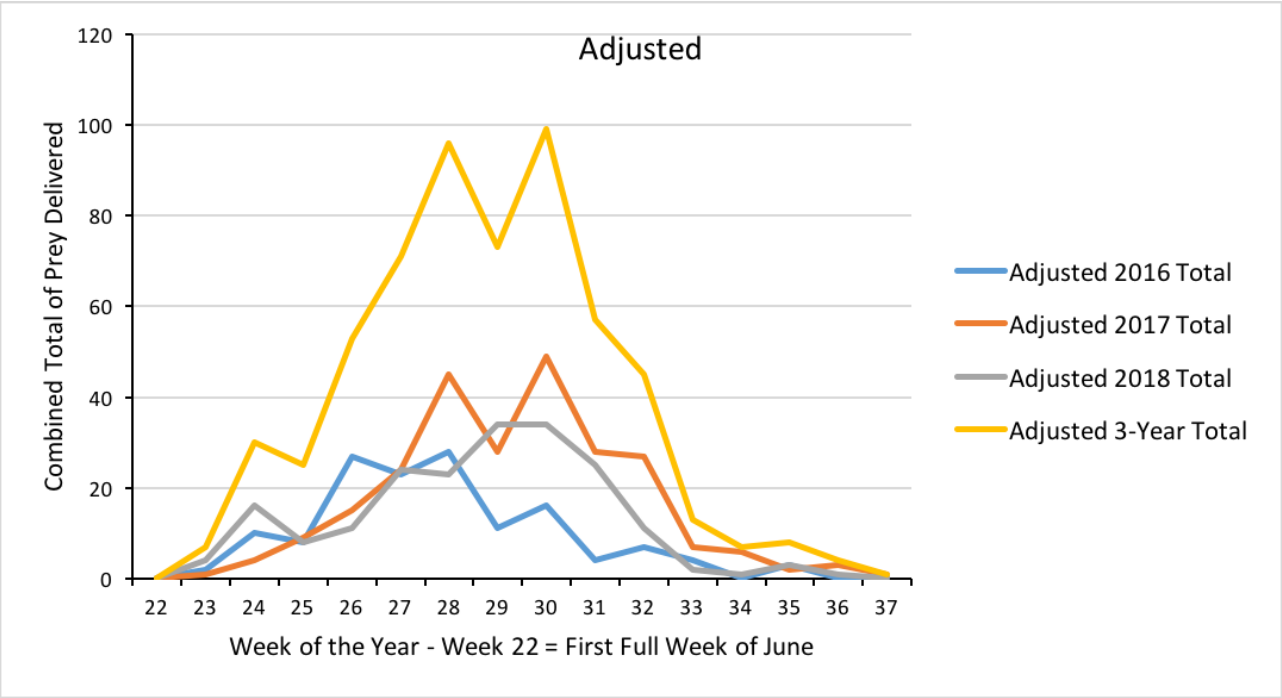


Figure 6. Adjusted 3-Year summary of prey deliveries by week, all prey combined.

PIGU delivered a total of 328 gunnels, 95 sculpins, and 32 other prey (Figure 7) over the three-year period, to chicks in reported burrows, without statistical difference between the years by fish type delivered [gunnel one-way ANOVA ($F_{(2, 51)}$ =0.7, p = 0.501293), sculpin one-way ANOVA ($F_{(2, 52)}$ = 0.42, p = 0.659256), and other prey one-way ANOVA ($F_{(2, 52)}$ = 0.13, p = 0.878380)].

Prey choice, based on numbers delivered to burrows are shown in Figures 7 and 8. In the South Sound, PIGU are highly selective of gunnels as their preferred species (71-72%), with sculpins their next preference (21-22 %), and finally, any other species at a consistent 7%, despite adjustments.

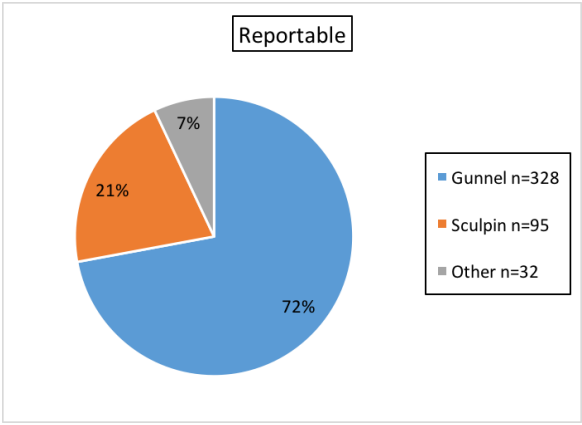


Figure 7. Reportable 3-Year total prey delivered to burrows.

Prey delivered to burrows at reportable sites during June to September, 2016 through 2018 in South Puget Sound (2016: n_{sites} = 16; 2017: n_{sites} = 17; 2018: n_{sites} = 22).

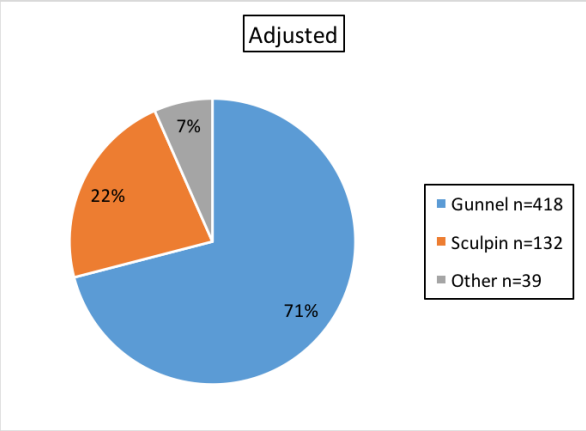


Figure 8. Adjusted 3-Year total prey delivered to burrows.
Total prey delivered to burrows at each surveyed colony during June to September, 2016 through 2018 in South Puget Sound, with the addition of excluded sites to the base of the reported sites in Figure 5 (2016: n_{sites} = 31; 2017: n_{sites} = 41; 2018: n_{sites} = 37).

Discussion

To date, we have six years of data - three of which are included in this report. However, as evidenced in Table 2, not all sites were consistently surveyed over that time. Various factors can lead to less than the minimum number of surveys conducted including: early breeding, PIGU inactivity, tide heights, and/or volunteer issues. Island locales have proven challenging to recruit and retain volunteers. More effort will be required to resume monitoring at a number of sites. Multiple key sites have been identified (Andy's Marine Park, Higgin's Cove, Lyle Point, Sandy Point) and will be prioritized in coming years, as well as those for which we have identified a data shortfall in not having reportable data with 10 survey dates. These are deemed key sites, because PIGUs are frequently observed using the breeding habitat on an annual basis by birders and beach goers. NRNC staff have observed birds at these locations during transit while conducting other surveys or during site visits for reasons other than to conduct breeding surveys. Additionally, 10-week monitoring for all sites would create a more robust dataset. Improving training by emphasizing the how crucial it is to have 10 consecutive weeks of surveys in order for the data to be analyzed would provide basis for a more complete dataset.

The number of PIGU observed for sites surveyed at least 10 weeks for all three years generally did not vary much (Table 4). This indicates a level of stability in individual PIGU numbers, but more data is needed to verify whether it remains true or not. According to the US Fish and Wildlife Service (2006), the world population of this species is estimated, and "use of unsystematic census techniques permits detection of only dramatic changes and little trend information is available." This survey attempts to rectify that situation within the NRNC sphere of influence. Documenting physical habitat changes at the breeding sites could possibly explain why the number of birds observed changes from year to year, especially in light of their propensity toward burrow fidelity (Evenson, et al., 2003). If there is a decrease in available burrows, the number of birds would change unless they could adapt in different ways such as different breeding pairs utilizing burrows at different times during the season or potentially finding different habitats elsewhere.

Gunnels are the most common prey of choice across all years of this study (Figures 7 and 8). They are almost always observed at least three times as often as sculpins. This stability in prey composition

suggests that Pigeon Guillemot prey species have remained at equally healthy levels during this study period. More data is needed to detect any long term changes and trends. More consistent data collection across all sites would give a more complete picture of the prey composition throughout the region.

A question of the PIGU prey composition is why there is such a strong preference for gunnel over sculpin. They are both benthic fish that utilize similar habitats and are often found in the same areas. A study of Mandt's Black Guillemots found in the Arctic showed that reproductive success was tied to prey type; diets high in cod resulted in greater success while diets high in sculpin resulted in greater failure (Waters, 2017). Sculpin were determined to represent a poor diet choice due to the bony nature of the fish and difficulty in digestion. Retreating sea ice as a result of rapid climate change led to decreased availability of cod, which forced the guillemots to seek less desirable prey (Waters, 2017). Although both birds and prey are different species in the cited study, the similarity could explain why PIGUs prefer gunnels to sculpins. Litzow, Piatt, Prichard, and Roby (2001) conducted a study comparing the lipid content of the local PIGU prey that may provide further insights into preference towards gunnels, even in the South Sound.

The increasing pressure of climate change could potentially have an effect on prey availability in Puget Sound as waters become warmer, or on the birds, themselves. PIGU are listed by the National Audubon Society (2014) as "climate threatened" on their website. Some of the effects we can anticipate are that PIGU will begin experiencing additional population pressures, such as failed breeding attempts in "unusually warm water temperatures" (National Audubon Society, n.d.). Additionally, their population numbers may drop in the South Sound, as they may be required to move north to find more favorable climactic conditions for their survival.

PIGU are highly susceptible to environmental changes, such as oil spills (Bixler, 2010; US Fish and Wildlife Service, 2006) due to their sensitivity to the marine environment, and they experience the effects longer than many other species. Oil or other hazardous materials spills into the environment that change their food availability would affect PIGU sooner, and longer than other species. It is anticipated that the data collected during this study could be applied to natural resource damage assessment in the event of an oil spill or other anthropogenic catastrophe, mitigation of any consequences of those hazards, and used for aquatic reserve management.

The adoption of this Citizen Science project developed with the intent to gather and report data regarding a specific indicator bird species, to establish a baseline of data. This baseline may be use to indicate impacts to that population via continued observation within the study area, or used for extrapolation to other areas, in conjunction with their studies. Baselines are very important to determine whether or not there is an issue being observed and against which one can measure change efforts. Baselines are usually an expression of "normal" as a reference frame with an expectation of something that is desirable, and are used to set the standard against which work to improve or maintain the baseline is set (Bull, Gordon, Law, Suttle, & Milner-Gulland, 2014). In the ecological management community, baselines are an attempt to define the true natural status of an ecosystem (Bull, et al., 2014; Gatti et al, 2015), and may be used as a goal to return to after some event that disrupts a species or ecosystem - they may be a target for restoration work. Baselines may also be used for maintenance of an area or species - monitoring how increasing pressures are effecting the target in order to not deviate from a specified measure. Alternatively, baselines may inform the need for interventions as unnecessary, or whether specific methods used are working to solve the issue. Despite the need for baselines to include information over a period of time, there is not a specific time requirement for

incorporation into setting one, although a timeline of 3-5 years is commonly used within ecosystem studies. The concept of shifting baselines was introduced in the literature in the mid-1990s by Pauly (1995), who identified that the span of a career was the baseline used by individuals to evaluate changes in a fishery. The concept of shifting baselines has become widely used in many fields, and is now used to described as the incremental shifting we experience over time as changes occur and how that alters decision making to determine what the baseline is for an area or species. Longer-term studies can inform that loss of information and provide better "reference points for evaluating . . . losses . . . or identifying . . . rehabilitation" requirements (Pauly, 1995). With this in mind, the PIGU monitoring at NCRC is intended to continue indefinitely, to provide the best information possible in the event of a catastrophic event toward the goal of recovery, here or in other areas of the PIGU range.

Recommendations and Improvements

A number of recommendations were made over the years to improve spatial coverage, training, data collection, and quality control. The implementation of some of these recommendations increased the number of sites monitored, provided better trained volunteers, improved data quality, and more enhanced quality control measures. There remain some recommendations to be fully implemented or considered, and some clarifications to be made. Recommendations for following years were included in reports at the end of each season using results of informal survey evaluations and debriefings.

The following recommendations were made at the end of YEAR 6 (2018) and will be implemented in YEAR 7 (2019):

- Refocus survey efforts on sites with previous documented burrow activity where fish deliveries were observed to ensure complete coverage of said sites for the entirety of the survey season
- Ensure all monitoring sites have team sizes adequate for complete coverage
- Make a stronger effort to ensure that sites are surveyed for the amount of time required to ensure data integrity
- Make sure all surveys are conducted according to the established protocol and designate team leads to perform field level quality control
- Continue exploring options for long-term data storage and data visualization
- Explore options for additional extended morning surveys and/or mid-day or afternoon survey data which may yield information about patterns and frequency of feeding
- Conduct preseason surveys on a more consistent basis to ensure completeness
- Hire interns for fall and winter terms. This should result in earlier compiling and analysis of data and release of results, provide earlier feedback and reward to volunteers for their efforts, and allow planning for the following season to begin earlier
- Post past seasons' reports on NRNC website and/or create a 2-page high interest summary for the public
- Pair new volunteers and those who request it with the intern or an experienced volunteer who will provide additional mentoring
- Facilitate a more efficient process for submitting electronic copies of field data sheets to ensure all data is archived
- Provide database training, probably at two venues
- Change the non-breeding database user interface to obtain more complete anecdotal observations
- Develop a standard for the minimum number of surveys in order for data to be included in statistical analysis

Our plan to collect 10 or more years of data is intended to establish a strong dataset of abundance, breeding sites, and patterns of prey selection. We hope this data can be analyzed for trends and patterns or red flags that might indicate any trouble for PIGU populations. We continually add new breeding sites as they are discovered and when volunteers can be recruited to conduct surveys at these sites. Some sites are discontinued when survey data indicates the sites are not currently active for at least one full season. Recruiting new volunteers is an ongoing effort.

We plan conduct advanced research to learn more about other facets that are not currently being addressed or have only received cursory attention. Pre-season surveys are one of those activities that would provide insight into how early some sites become active and when chicks at those sites are hatching. Conducting surveys during other times of day may yield information on how much burrow activity occurs outside of normal survey times. We are also initiating efforts to learn more about the population dynamics by starting a pilot banding project. This would allow us to learn about male to female ratios, population age structure for a single breeding colony, and site fidelity. Another area of interest in the pilot banding effort would be to learn more about migration patterns. We intend to explore the feasibility of such a project.

We have chosen not to change major methods in the protocols without discussions with other area PIGU surveys, especially Whidbey Island Guillemot Group, who have been the lead on the survey for many years. We hope to keep the survey methods consistent region-wide, so regional analysis is more feasible.

Ongoing annual surveys will allow comparisons from year to year. In doing so, changes in population abundance and distribution may be detected. If detected, causes could be potentially evaluated and investigated. Additionally, these surveys will fill existing data gaps. Synchronicity of data will allow for advanced data analysis by regional researchers. These surveys may also be used in any Natural Resource Damage Assessment in the event of an oil spill or other environmental disaster.

References

Bibby, C.J., Jones, M. and Marsden, S., (1998). Expedition field techniques: Bird surveys. London: Expedition Advisory Centre.

Bishop, E., Rosling, G., Kind, P., & Wood, F. (2016). Pigeon Guillemots on Whidbey Island Washington: A six-year monitoring study. *Northwestern Naturalist, 97,* 237-245. Available at http://www.pigeonguillemot.org/breeding-survey-resources-and-data.html

Bixler, K. S. (2010). Why aren't Pigeon Guillemots in Prince William Sound, Alaska recovering from the *Exxon Valdez* oil spill? (Master's thesis). Retrieved from https://ir.library.oregonstate.edu/downloads/dz010t437

Bonebrake, T. C., Christensen, J., Boggs, C. L., & Erlich, P. R. (2010). Population decline assessment, historical baseline, and conservation. *Conservation Letters, 3*(6), 371-378. doi:10.1111/j.175-263X.2010.00139.x

Bull, J. W., Gordon, A., Law, E. A., Suttle, K. B., and Milner-Gulland, E. J. (2014). Importance of baseline specification in evaluating conservation interventions and achieving no net loss of biodiversity. *Conservation Biology, 28*(3), 799-809. doi:10.1111/cobi.12243

Drent, R. H. (1965). Breeding biology of the Pigeon Guillemot, *Cepphus columba. Ardea, 53*(3-4), 99-160.

Evenson, J. R., Nysewander, D. R., Mahaffy, M., Murphie, B. L., & Cyra, T. A. (2003). Status, abundance, and colony distribution of breeding Pigeon Guillemots (*Cepphus columba*) from the inland marine waters of Washington State, as documented by PSAMP efforts, 2000-2002 in Proceedings from Georgia Basin/Puget Sound Research Conference.

Ewins, P. J. (1993). Pigeon Guillemot (Cepphus columba), version 2.0. In *The Birds of North America* (A. F. Poole & F. B. Gill, Eds.). Cornell Lab of Ornithology, Ithaca, NY, USA. doi: 10.2173/bna.49

Gatti, G., Biabchi, C. N., Parravicini, V., Rovere, A., Peirano, A., Montefalcone, M., . . . Morri, C. (2015). Ecological change, sliding baselines and the importance of historical data: Lessons from combining observational and quantitative data on a temperate reef over 70 years. PLoS ONE 10(2): e0118581. doi: 10.1371/journal.pone.0118581

Gregory, R. D., Gibbons, D. W., & Donald, P. F. (2004). Bird census and survey techniques. In W. J. Sutherland, I. Newton, & R. Green, *Bird Ecology and Conservation*, pp.17-56. New York: Oxford University Press. doi: 10.1093/acprof:oso/9780198520863.003.0002

Lee, T. (2019). Map of 2016-2018 South Sound Pigeon Guillemot breeding survey colony locations.

Litzow, M. A., Piatt, J. F, Prichard, A. K., & Roby, D. D. (2002). Response of Pigeon Guillemots to variable abundance of high-lipid and low-lipid prey. *Oecologia, 132,* 286-295. doi: 10.1007/s00442-002-0945-1.

National Audubon Society. (n.d.). Audubon field guide: Pigeon Guillemot. Retrieved from https://www.audubon.org/field-guide/bird/pigeon-guillemot

National Audubon Society. (2014). Climate threatened: Pigeon Guillemot. Available at http://climate.audubon.org/birds/piggui/pigeon-guillemot

Nelson, D.A. (1991). Demography of the Pigeon Guillemot on Southeast Farallon Island, California. *The Condor, 93*(3), 765-768. doi: 10.2307/1368213.

Nisqually Reach Aquatic Reserve. (n.d.). Typical survey site; exposed sedimentary bluff with moderate sized holes preferred by PIGU (photo).

Nisqually Reach Nature Center. (2016). Quality assurance project plan. Available at https://www.aquaticreserves.org/wp-content/uploads/2016-Pigeon-Guillemot_QAPP-NRNC-FINAL_0201UPDATE.pdf

Nysewander, D. R., Evenson, J.R., Murphie, B. L., & Cyra, T. A. (2005). Report of marine bird and mammal component, Puget Sound ambient monitoring program, for July 1992 to December 1999 period

[Unpublished report]. Olympia, WA: Washington State Department of Fish and Wildlife, Wildlife Management Program, 181 pp. Retrieved from https://wdfw.wa.gov/publications/01135/

Pauly, D. (1995). Anecdotes and shifting baseline syndrome of fisheries. *Trends in Ecology and Evolution, 10*(10), 430. doi: 10.1016/S0169-5347(00)89171-5

Pearson, S. F., & Hamel, N. J. (2013). Marine and terrestrial bird indicators for Puget Sound. Washington Department of Fish and Wildlife and Puget Sound Partnership, Olympia, WA, 55 pp. Retrieved from http://www.psp.wa.gov/vitalsigns/documents/Pearson%20and%20Hamel%20Bird%20Indicators%202013_Final.pdf

Pearson, S. F. (2016). Marine bird population abundance: Indicator status and progress. Retrieved from http://www.psp.wa.gov/vitalsigns/in-marine-bird-population-abundance.php

Puget Sound Seabird Survey. (2018). Map of observations of Pigeon Guillemots in Puget Sound Retrieved from http://seattleaudubon.org/seabirdsurvey/bird_detail.aspx?bird_id=222

Pyle, P. (2001). Beyond the Golden Gate - Oceanography, geology, biology, and environmental issues in the Gulf of the Farallones: Seabirds (chapter) (US Geological Survey Circular 1198), pp.150-161. Retrieved from https://pubs.usgs.gov/circ/c1198/chapters/150-161_Seabirds.pdf

Rosling, G. (n.d.). Pigeon Guillemot on rock (shared personal photo).

Seattle Audubon Society. (n.d.). Pigeon Guillemot. Retrieved from http://www.birdweb.org/birdweb/bird/pigeon_guillemot

Thoresen, A. C. & Booth, E. S. (1958). Breeding activities of the Pigeon Guillemot *Cepphus columba columba* (Pallas). Walla Walla College Publications, Department of Biological Sciences, *23,* 1-36.

Vermeer, K., Morgan, J. R., & Smith, G. E. J. (1993). Nesting biology and predation of Pigeon Guillemots in the Queen Charlotte Islands, British Columbia. *Colonial Waterbirds*, *16*, 119-127.

Vermeer, K., Morgan, K. H., & Smith, G. E. J. (1993). "Colony attendance of pigeon guillemots as related to tide height and time of day". *Colonial Waterbirds*, *16*, 1–8.

US Fish and Wildlife Service (USFWS). 2006. Alaska seabird information series: Pigeon Guillemots. Retrieved from https://www.fws.gov/alaska/mbsp/mbm/seabirds/pdf/pigu.pdf

Washington Department of Natural Resources (WDNR). 2011. Nisqually Reach Aquatic Reserve Management Plan. Retrieved from http://www.dnr.wa.gov/Publications/aqr_nisqually_reserve_finalplan_2011.pdf.

Appendix A: Data Sheet

Below is the two-sided data sheet used in this project for standardized record keeping between observers:

2018 Pigeon Guillemot Survey Data Sheet

Colony Site _____ **Survey Date** _____ **Start Time** _____

Team lead name and email: _____ **Tide in feet @ start of** _____ **Incoming / Outgoing**

Observers: _____ **Total Volunteer Time** _____

PIGU Counts

Highest Count By 9:00 a.m.	Beginning Count	Middle Count	End Count

(**1.0 hour survey + round trip travel time to site + settling in time + data entry+ website entry from lead)

BURROW ACTIVITY: Times of visits w/or w/o prey

	Burrow ID _____	Burrow ID _____	Burrow ID _____
No Prey (Visit to Burrow)			
Gunnel			
Sculpin			
Other/ Unknown			

Other Notes Re. These Burrows _____

	Burrow ID: _____	Burrow _____	Burrow _____
No Prey (Visit to Burrow)			
Gunnel			
Sculpin			
Other/ Unknown			

Other Notes Re. These Burrows _____

BURROW ACTIVITY: Times of visits w/or w/o prey

	Burrow ID _____	Burrow ID _____	Burrow ID _____
No Prey (Visit to Burrow)			
Gunnel			
Sculpin			
Other/ Unknown			

Other Notes Re. These Burrows _____

Response to Disturbances: Select event, record beginning and end times and response code to disturbance

Event	**No**(or minimal)response= 0-1 minute **Small**= 2-10 minutes **Medium**=10-30 minutes **Large**= 30+ min.
Eagle	
Beach	
Walker w/ Dog	
Motorized Boat	
Non-Motorized Boat	
Unknown	
Other Cause	

Any additional comments about this colony

_____

Please mail to: Terence Lee Nisqually Reach Nature Center, 4949 D'Milluhr Dr. NE, Olympia, WA 98516

Associated data sheets remain on file at the NRAR.

Appendix B: Data Collection Protocols Used

Pigeon Guillemot Study -- Protocol for 2018 season

1. The procedures and field card have been revised for 2018 to reflect changes in procedures. Please discard any old field cards.
2. Safety is our first priority. If you can't go with a partner, take a cell phone and/or be sure someone knows you are on the beach and when you're planning to return.
3. It is expected that for each field card record you will sit quietly at your study area for exactly **one hour** and observe the activity. Arrive early and let the birds settle into normal behavior before you begin the survey. All volunteers at one colony should begin at the same time.
4. The earlier you can get to your colony the better chance of seeing more activity. Arrive at your site no later than 7:45 AM. You may begin your survey anytime before 8:00 AM and be finished no later than 9:00 AM. We need a total count of birds by 9:00.
5. We ask that you visit your site at least **ten** times this season. One visit should fall during each week beginning with the week of June 4th. Continue visiting your site for 10 consecutive weeks. After the 10 weeks, if there are two consecutive weeks with no burrow activity you may stop the survey.
6. The focus of this study is to determine five things:
    a. The maximum birds present before 9:00 am.
    b. Three point-in-time counts of the birds: beginning, middle, and end of survey.
    c. The number of active burrows.
    d. The type of fish delivered.
    e. Colony wide response to a known or unknown event. (Disturbances.)
7. First locate and identify the active/occupied burrows. Make a drawing or take a photo so that you can locate, number, and remember the burrows. Make a duplicate drawing or photo and send it to Terence, so that we can more easily fill in substitutes and so that we can understand your colony more completely.
8. A burrow is considered "active/occupied" when: You see a bird disappear into or emerge from the burrow. (A "ledge sit" is not valid, nor is fresh guano.)
9. For each active/occupied burrow, document the times of each activity observed. These will include **No Prey** (a burrow visit without prey), fish deliveries of **Gunnel**, **Sculpin,** or **Other/Unknown**. Note time for each activity.
10. **Guest Policy**: The survey coordinators carefully assign volunteers to colonies taking into account the number of volunteers needed to adequately cover the burrows. We expect all volunteers to attend volunteer trainings so that the quality of our data remains high. A guest may accompany you on the survey provided that he/she remains quiet and does not interfere with the birds' activity. Guests may not serve as data collectors.
11. **Pet Policy**: No pets may accompany you on the beach.
12. **Make a decision**. Question marks or number ranges are difficult to interpret.
13. Either before or after your survey walk under the burrows and look for dead chicks, egg shells, rejected prey, etc. We encourage you to mark down any unusual behavior or anything that seems noteworthy.
14. **If for any reason you must miss a week, or your plans change and you are not able to complete the study, contact the coordinator assigned to your site immediately. For a planned vacation, please let your site contact know at least one week ahead of your absence so that a substitute can go out with you and shadow your survey to learn about the colony**.

Directions for filling out field card:

Section 1 -- Colony Wide Activity

Fill in the **Colony Name, Survey Date, Team Lead** and e-mail, **Names of Observers**.
Total volunteer time: This includes one hour of survey, settling in time prior to the survey, travel time for all volunteers. Also include data entry time.
Survey Start time: Must be started by 8:00 with a 15 minute settling period prior to the start of the survey.
Tide in feet at start of survey: Consult tide charts or apps.
Incoming or Outgoing: Circle appropriate answer.
PIGU Counts:

A) **Highest Count by 9:00:** As you conduct the survey frequently count the birds *associated with your colony*. Include birds seen on the water, beach and bluff. Record the largest count noted at anytime during the survey, as long as it is before 9:00 AM.
B) **Count at beginning:** After the birds have settled and you begin the survey take a point count of birds seen.
C) **Count in middle:** 30 minutes into the survey take and record a second point count.
D) **Count at end:** At the one hour mark take and record final point count.

Section 2 -- Burrow Activity

Record **Burrow Id** for each burrow where activity is observed. Use numbers instead of letters. Letters are reserved for site ID.
For a visit to the burrow with **no prey** mark the time in the box. Subsequent burrow visit times can be added separated by a comma in the same box.
Most fish delivered will be either **gunnels** or **sculpins.** Mark the times of each fish delivery in the appropriate box(es). If you can't identify the prey, record the time in the box marked **Other/Unknown**. (Identify the prey if possible. For example, if you see a perch, cod or shrimp mark that under "Other/Unknown" along with the time.)
For burrows with multiple burrow visits and/or fish deliveries, record all times under the same burrow ID.

Section 3 – Response to Disturbances

Occasionally disturbances will occur that cause the birds to fly away from the beach, vacate the burrows, or retreat offshore and away from the colony.

Record the time of the disturbance next to the listed cause. **Monitor the birds' colony wide reaction** to the disturbance and select the approximate length of reaction. **NO** for no or minimal disturbance 0-1 minutes. **S**mall for 2-10 minutes. **M**edium for 10-30 minutes, **L**arge for 30 minutes or longer. If the disturbance extends to the end of the survey, mark "end".

Record survey data in web site: www.pigeonguillemotdata.org. as soon as possible after survey.

Please snail mail field cards within one week of your survey. Send to:
Terence Lee, Nisqually Reach Nature Center, 4949 D'Milluhr Dr. NE, Olympia, WA 98516

Please feel free to contact Terence (360-556-2738) or Anne (360-888-9417) with any questions or concerns.

Thank you for your time and effort given to this study. It is deeply appreciated.

Pigeon Guillemot Prey

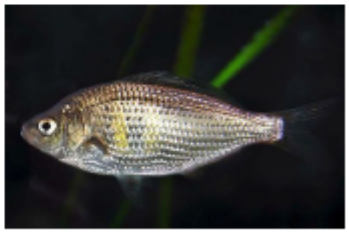
1) Sculpin

2) Gunnel

3) Shiner Perch

1) Sculpin: spiny and bony, large head compared to body

2) Gunnel: elongated, eel-like fish



3) Perch: shiny, flat-bodied fish

Appendix C: Quality Assurance Project Plan (QAPP)

The quality assurance project plan was written in 2016 and has been used as the basis for monitoring conducted from 2016 to 2018. That plan can be found at this link: https://www.aquaticreserves.org/wp-content/uploads/2016-Pigeon-Guillemot_QAPP-NRNC-FINAL_0201UPDATE.pdf