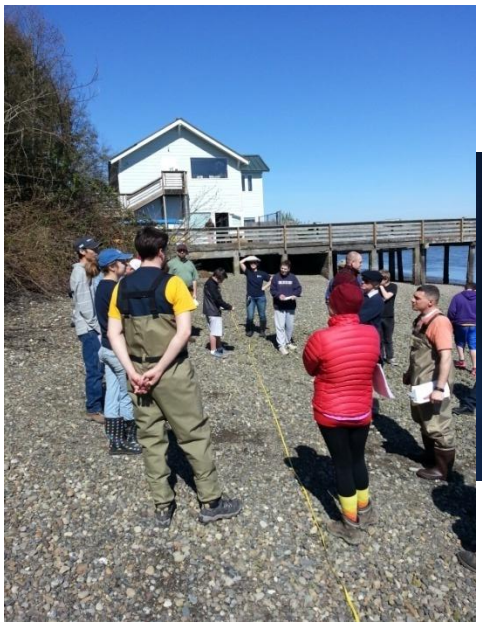
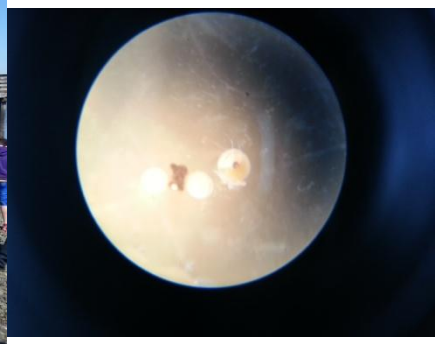
Intertidal Forage Fish Spawning Surveys in the Nisqually Reach Aquatic Reserve

Final Monitoring Report

Grant #: PC-00J29801-0: Ensuring regulatory effectiveness in Puget Sound's most special places





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Nisqually Reach Aquatic Reserve Citizen Stewardship Committee and Washington Department of Natural Resources

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September 2014

Publication Information

This Monitoring Report describes the research and monitoring study of forage fish beach surveys conducted in 2013-14 in the Nisqually Reach Aquatic Reserve. This project has been funded wholly or in part by National Estuary Program (NEP) of the United States Environmental Protection Agency (EPA) under assistance agreement PC-00J29801-0 to Washington Department of Natural Resources (WDNR).The contents of the report do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Copies of this Report will be available from the Washington State Department of Natural Resources at http://www.dnr.wa.gov/ResearchScience/Topics/AquaticHabitats/Pages/aqr_rsve_aquatic_reserves_program.aspx and http://www.aquaticreserves.org/resources/

Cover photo: Volunteers at first training in 2013 and forage fish eggs under a microscope.

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Intertidal Forage Fish Spawning Surveys in the Nisqually Reach Aquatic Reserve

2014 Monitoring Report

Abstract

The Nisqually Reach Aquatic Reserve is a Washington Department of Natural Resources Aquatic Reserve east of Olympia and west of Tacoma in the southernmost portion of the Salish Sea. Nisqually Reach Aquatic Reserve Forage Fish Beach Surveys started in early to mid 2013 as part of the Nisqually Reach Aquatic Reserve Citizen Stewardship Committee monitoring program. The goals of this project are in line with those outlined in the management plan for this particular aquatic reserve. The purpose of the program is to survey beaches for presence/absence of surf smelt and sand lance eggs and monitor changes in forage fish beach usage over time. Once remaining 2014 samples are processed, we will have enough data to start determining which forage fish species spawn within the reserve. Monitoring change in beach use over time is a long-term goal that we will be able to assess once we have built up several years of data. One of the other longer-term goals is to assist the Washington State Department of Natural Resources and Washington State Department of Fish & Wildlife with their effort to survey the entire south Puget Sound by assuming responsibility for conducting surveys on all beaches within the Nisqually Reach Aquatic Reserve. This goal is still in progress and still requires volunteers to adopt current sampling sites so that new ones can be established. At the present rate, it will take considerable time to achieve this goal.

No eggs of either species were found in any of the samples. The sampling follows a modified version of the WDFW Intertidal Forage Fish Spawning Habitat Survey Protocol. Our greatest success is in training and empowering citizen scientists to conduct surveys using a standardized protocol. In this effort, we have engaged more than 32 volunteers who conducted surveys weekly or bi-weekly for an average of 1-3 hours at three sites. We conducted a total of 74 surveys and collected 119 samples from February 2013 to May 2014. Due to the high frequency of sampling during 2014, the majority of 2014 samples have not yet undergone lab analysis. To remedy this and further assist our partners in achieving the goals of this project, CSC members and other citizen scientists received training from WDFW and WDNR personnel on July 28, 2014 on how to perform lab analysis of samples. This training was attended by 15 citizen scientists. While we did not reach all of our targets, the goals and objectives of the program were still met with some success. The citizen-science volunteers are committed to continue the collection of samples and assist WDFW and WDNR in their efforts to monitor all beaches in South Puget Sound. To date, sampling continues to occur at the primary sites on a bi-monthly basis.

Introduction

Nisqually Reach Aquatic Reserve Forage Fish Beach Survey (FFBS), in cooperation with existing surveys, started in February of 2013 on Anderson Island and in April of 2013 on the mainland as part of the Nisqually Reach Aquatic Reserve Citizen Stewardship Committee (NRARCSC) monitoring program and in

general has continued on a weekly to bi-weekly basis. This project was developed and designed by the NRARCSC with assistance from the Washington Environmental Council (WEC), the Nisqually Reach Nature Center (NRNC), and in association with the Washington Department of Natural Resources (WDNR) and Washington Department of Fish & Wildlife (WDFW). The survey is a continuation of surveys conducted by WDFW and Puget Sound Corps (PSC) staff and utilizes a modified version of established WDFW protocols. The purpose of the program is to determine when and where of Pacific sand lance (*Ammodytes hexapterus*) and surf smelt (*Hypomesus pretiosus*) spawn. The Quality Assurance Project Plan (QAPP) for this study was approved in June, 2013 (Grilliot & Joyce, 2013). Therefore, the data from this project covers a one-year sampling from June 2013 to May 2014. However, to add context to these results, data gathered under guidance from PSC prior to June 2013 are discussed.

The Nisqually Reach Aquatic Reserve (NRAR) is part of the WDNR Aquatic Reserves Program and was designated as a reserve in 2011. The reserve's Management Plan was released in September 2011 and is based on extensive studies that preceded the designation (WDNR, 2011). Figure 1 shows the boundaries of the aquatic reserve in association to the geographic and manmade features and Figure 2 shows a regional view of the area.

The reserve is an Educational, Environmental, and Scientific Reserve. The NRAR encompasses approximately 14,826 acres of state-owned DNR-managed tidelands and bedlands. The ownership of surrounding and adjacent lands adjoining the reserve is diverse. This includes state parks; the Nisqually National Wildlife Refuge; local park districts; and private, tribal, WDFW, Military, city, and county lands.

According to the Commissioner's Order (Goldmark, 2011) that created the reserve, the reason for its designation is "The confluence of oceanographic, estuarine, and riverine influence creates ecosystem conditions that result in highly productive habitat and extremely high species diversity." The order goes on to identify the importance of the habitat for the development of juvenile chinook and chum salmon as well as numerous other aquatic species. It also notes the importance of the area for foraging and breeding of seabirds and sea ducks.

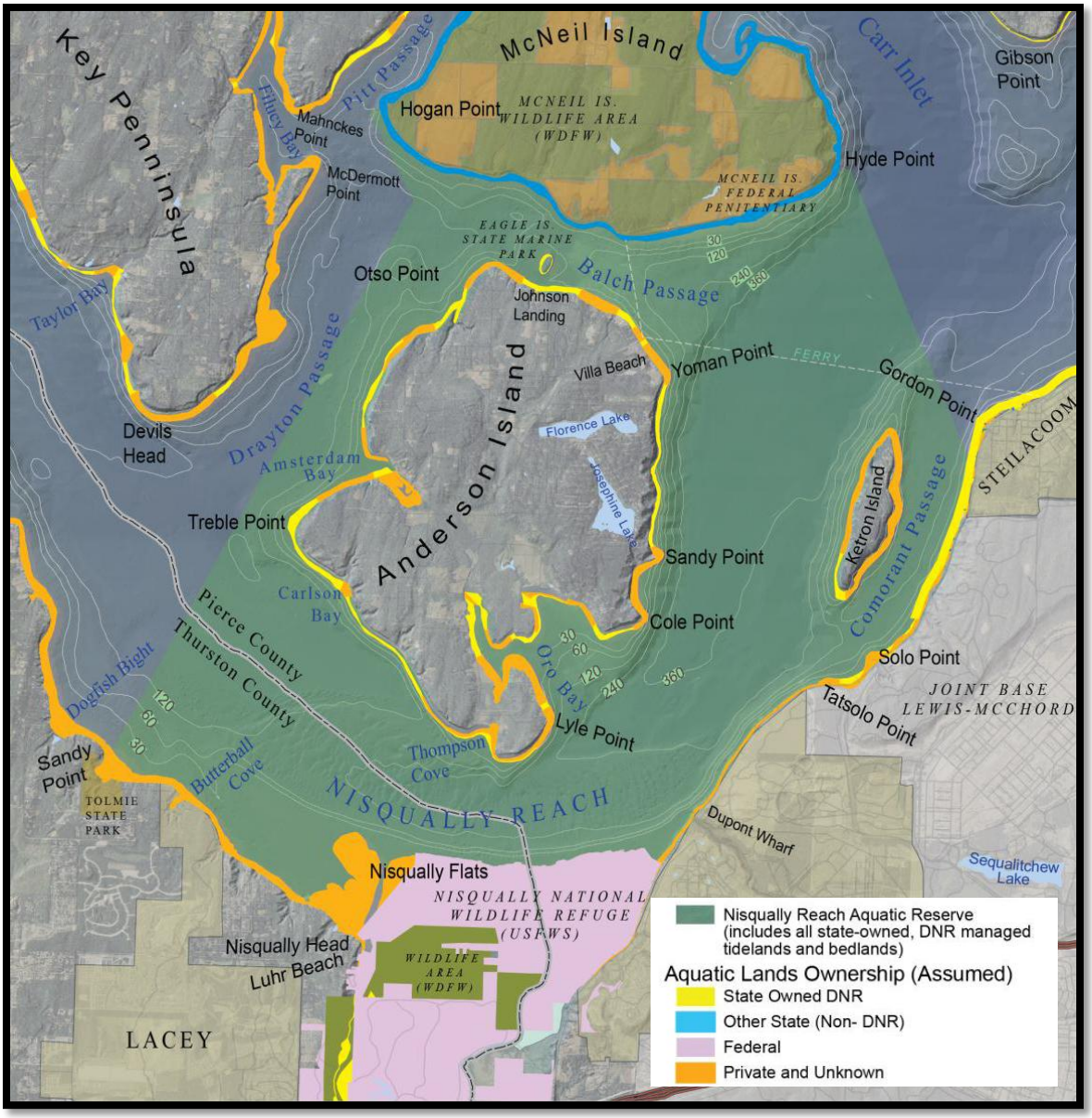

Figure 1: Map of the Nisqually Reach Aquatic Reserve boundaries. Source: DNR, 2011.

The management plan (WDNR, 2011) for the Nisqually Reach Aquatic Reserve identifies five management goals:

1. Preserve, restore, and enhance aquatic nearshore areas including intertidal and subtidal ecosystems with a special emphasis on native habitats for forage fish, salmonids, and marine birds.
2. Protect and restore the functions and natural processes of nearshore ecosystems in support of the natural resources of the reserve.
3. Promote stewardship of riparian and aquatic habitats and species by supporting and providing opportunities for outdoor education, scientific research including citizen science, and interpretive studies.

4. Promote sustainable management of traditional recreational (e.g., boating, water skiing, fishing), commercial (e.g., marinas), and cultural uses in the aquatic reserve in a manner consistent with the other goals and objectives for the reserve.
5. Support the recovery and protection efforts for federal and state threatened, endangered and sensitive species, species of special concern and their habitats.

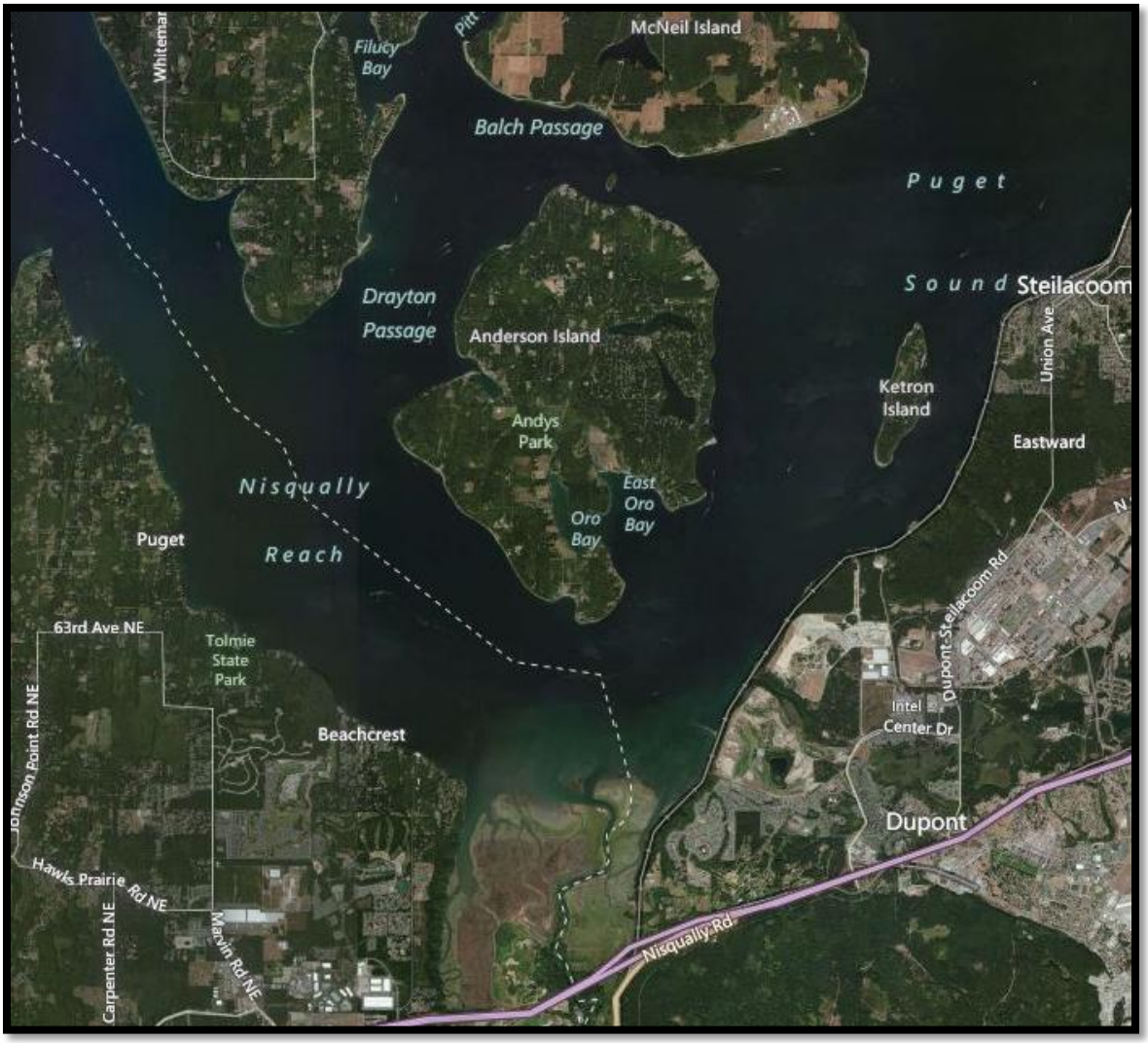

Figure 2: The Nisqually Reach Aquatic Reserve and surrounding areas. (Source: Bing maps)

This monitoring program was developed to address these goals.

In the development of the 2012-13 Action Agenda, the Puget Sound Partnership established a near-term action for forage fish in Marine Protected Areas, including the aquatic reserves (PSP, 2012)

> *B3.1 NTA 1: Marine Protected Area Effectiveness. By June 2014, PSP, in collaboration with WDFW and DNR will identify the threats, coverage gaps, and conservation concerns addressed by existing Puget Sound marine protected areas and assess the potential effectiveness of these MPAs to protect threatened species and habitats, including rockfish and forage fish.*

The importance of forage fish in the Puget Sound ecosystems has long been recognized. WDFW (1998) established a policy (POL-C3012) on the management of forage fish that requires management policies based on monitoring data. A poster by Pierce, et al (2012) summarizes much of the past sampling of forage fish in Puget Sound.

A symposium on forage fish was also was also held in September 2012 (Liedtke, 2013) that both summarized current work and presented new research. One of the conclusions of the symposium was that

> *"The lack of a reliable, and stock-specific, abundance estimate is a large data gap for most forage fish species in the Salish Sea. It is difficult to assess whether forage fish populations are stable, growing, or declining without a baseline population estimate and a means of assessing abundance on a relevant time scale. Herring are the only forage fish species in Puget Sound that are regularly monitored (by WDFW), and the group recommended that future effort be more balanced across all forage fish species."*

Pacific sand lance and surf smelt spawn in the course to fine gravel of the upper intertidal zone, depositing eggs in specific, although overlapping, zones. Forage fish beach spawning surveys have been recognized as a reliable way of monitoring forage fish spawn abundance and determining critical spawning habitat sites (Moulton and Penttila, 2001).

Additional details regarding the development and design of the program are given in the QAPP *Intertidal Forage Fish Spawning Surveys in Washington Department of Natural Resources Aquatic Reserves* (Grilliot & Joyce, 2013).

Goals and Objectives

The goals of the intertidal forage fish-spawning survey are to:

- Collect time-sensitive baseline data throughout the reserve.
- Document changes over time in forage fish usage of the beaches using established methods that will provide data comparable across reserves and monitoring years.
- Add to the existing WDNR Aquatic Reserve database on forage fish spawning beach locations.

The objectives of this project are to:

- Train and empower citizen scientists in conducting surveys using a standardized protocol.
- Implement the surveys on a regular and consistent basis.
- Create a sustainable, locally operated structure to continue this work after the end of this grant.

Sampling Design and Procedures

The sampling design follows the WDFW Intertidal Forage Fish Spawning Habitat Survey Protocols, Procedures for Obtaining Bulk Beach Substrate Samples (Penttila, 2011). Slight modification of the protocol has been made in steps 9 and 10 to eliminate the need to use preservatives when possible. The protocol is shown in Appendix B. Once the samples were collected, labeled, and stored, they were transferred to WDNR staff for analysis.

Surveys were conducted weekly on Anderson Island at a private beach in the Amsterdam Bay area and monthly to bi-weekly at Luhr Beach and Tolmie State Park. Bi-weekly surveying at Luhr Beach and

Tolmie State Park began in February of 2014. A total of four samples were collected during each survey from February 2014-May 2014: two from Luhr Beach and two from Tolmie State Park. This sampling frequency was designed to accomplish two objectives—to provide ample opportunity for volunteers to gain experience conducting surveys and to increase our chances of finding any eggs that may have been present. The general procedure is to establish and document the location of the sampling transect (Figure 3), collect samples along the transect (Figure 4), sift the samples through a series of sieves (Figure 5) and use a winnowing technique to separate the lighter material (Figure 6). The eggs, if any, and other light material, is then scooped into a plastic jar, labeled, stored, and eventually transferred to WDNR staff for lab analysis.

Figure 3: Recording data along the transect.

Figure 4: Collecting a sample.

Figure 5: Sieving a sample

Figure 6: Winnowing a sample.

Narrative of the field research

The intention of the surveys is to aid WDNR PSC and add capacity to their efforts. PSC conducts their monthly surveys at two sites that are not currently surveyed in the NRAR FFBS. The PSC collects 10 samples from Andy's Marine Park and Riviera Beach. Monthly FFBS at Luhr Beach and Tolmie State Park were conducted starting in April 2013, but due to logistic and personnel problems, the sampling schedule was inconsistent with no surveys conducted in June and from September to January 2014. Sampling resumed in February 2014 with the transition to a new coordinator. With the new coordinator came capacity to increase volunteer recruitment and conduct surveys on a routine schedule. Surveys were usually conducted twice a week at Luhr Beach and Tolmie State Park from February 2014 onward. This high frequency of surveying was meant to achieve multiple goals. One being to provide volunteers more opportunities to become experienced with the survey and the second being to increase the probability of sampling where eggs may be present. Amsterdam Bay was surveyed once in February 2013 and not surveyed again until November. It was not until February of 2014 that surveys were conducted weekly. Sampling was generally conducted in the upper and middle portions of the potential spawning area which may have increased the chances of collecting surf smelt eggs rather than sand lance eggs. Samples were sieved and winnowed at NRNC instead of in the field for easier and faster processing.

Training

Two training sessions were conducted to engage citizens in the NRAR forage fish sampling. Volunteers were recruited from a wide variety of backgrounds via outreach by the NRARCSC. The first training session was held in March 2013 attracted twenty volunteers; the second training session was held in January 2014 and attended by eight volunteers. The NRNC's forage fish coordinator joined both WDNR & WDFW PSC crews on subsequent occasions for additional training and practice in 2014. Additional training was provided to new volunteers on an as-needed basis. Initial training was provided by Emily Rhoades and Jennifer Soper (PSC, WDNR), and entailed classroom introduction and field/lab sampling practice. Volunteers were introduced to the target species and the protocols used in the field

investigation via a PowerPoint presentation by trained staff from the center and the PSC during both of the training sessions. Since February 2014, volunteers who participated in this project have been trained in the field by Terence Lee. Terence has led or assisted with all surveys at Luhr Beach and Tolmie State Park. On two occasions, Terence assisted the Anderson Island survey team to ensure compliance with survey protocol. On July 28, 2014 WDFW staff (Kira Kranzler) and WDNR PSC members (Geoffrey Mayhew, Kirsten Miller, Michelle Bahnick) conducted a training sessions on how to perform lab analysis of forage fish samples. This training involved 15 volunteers and one Washington Conservation Corps crew member who was job shadowing.

Results

The results of this study are the first observations for a multi-year study and the majority of 2014 samples still await laboratory analysis. Therefore, the results are primarily descriptive of the collection of samples and field observations and are not intended to be used in statistical analysis of forage fish spawning.

Table 1 shows the dates of sampling at each location and Figure 7 shows the frequency and quantity of received for analysis from June 2013 to May 2014. Sampling was variable for two reasons: sampling was conducted more frequently during periods when spawning was expected while logistic issues also caused some planned sampling to be missed. There were several periods when surveys were not conducted due to lack of volunteers, lack of leadership, and/or tides.

Figure 8 shows the locations on Amsterdam Bay, Luhr Beach, Tolmie State Park, Mallard Cove, and Bee Dee Beach where samples were collected.

For 2014, 25 volunteers contributed 170 hrs towards training and 60 surveys. In 2013, eight volunteers spent 61 hrs receiving training and conducting 14 surveys. In addition to volunteer NRARCSC time, the NRNC Forage Fish Coordinator, Terence Lee (January 2013- present), spent 140 hrs coordinating efforts in the NRAR. No fish eggs for either sand lance or surf smelt were observed in any of the analyzed samples. However, most of the samples obtained in 2014 have not yet been analyzed.

Table 1: Forage fish survey sites and sampling dates.

	Luhr Beach	Tolmie State Park	Amsterdam Bay	Mallard Cove	Bee Dee Beach
Feb 2013			2/7/13		
April 2013	4/23/13	4/24/13			4/23/13
May 2013	5/20/13	5/21/13			
July 2013	7/27/13	7/29/13			
Aug 2013	8/12/13				
	8/23/13				
Nov 2013			11/5/13		
			11/12/13		
			11/19/13		
Dec 2013			12/3/13		
Feb 2014	2/16/14	2/16/14	2/4/14		
	2/19/14	2/23/14	2/11/14		
	2/23/14		2/18/14		
			2/25/14		
Mar 2014	3/1/14	3/1/14			
	3/5/14	3/5/14	3/4/14		
	3/8/14	3/8/14	3/11/14		
	3/14/14	3/14/14	3/18/14		
	3/19/14	3/16/14	3/23/14		
	3/21/14	3/19/14			
	3/28/14	3/21/14			
		3/28/14	4/1/14	4/8/14	
April 2014	4/4/14	4/4/14	4/8/14		
	4/10/14	4/10/14	4/22/14		
	4/16/14	4/12/14	4/29/14		
	4/25/14	4/20/14			
	4/30/14	4/25/14			
		4/30/14			
May 2014	5/3/14	5/3/14	5/7/14		
	5/8/14	5/8/14	5/27/14		
	5/15/14				
	5/31/14				

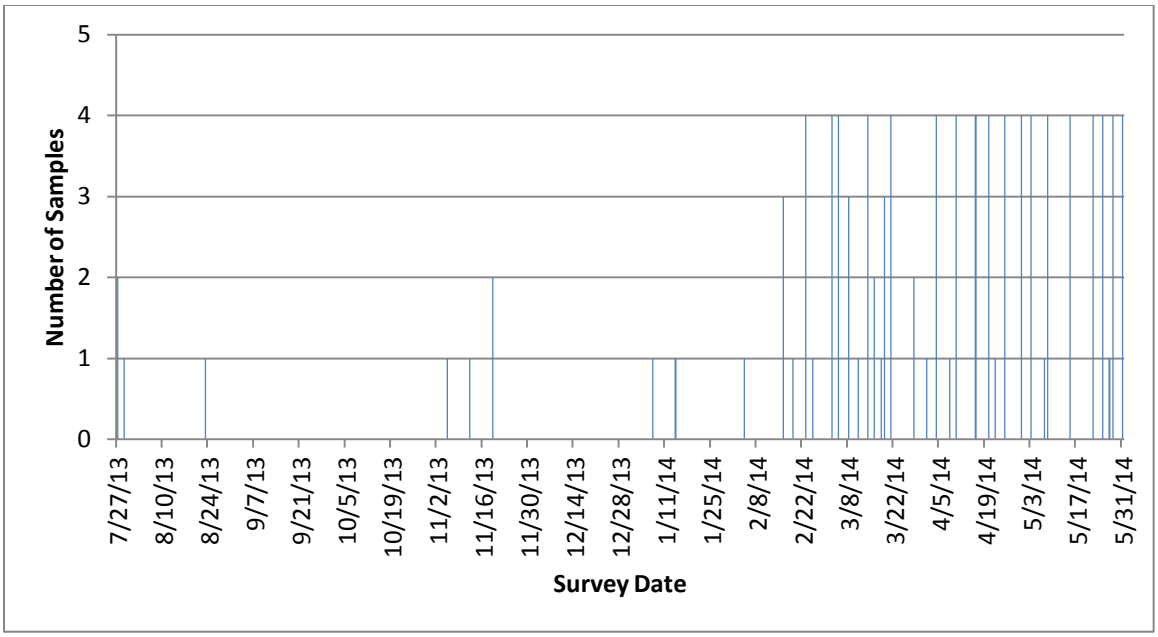

Figure 7: Sampling frequency and quantity from June 2013 to May 2014.

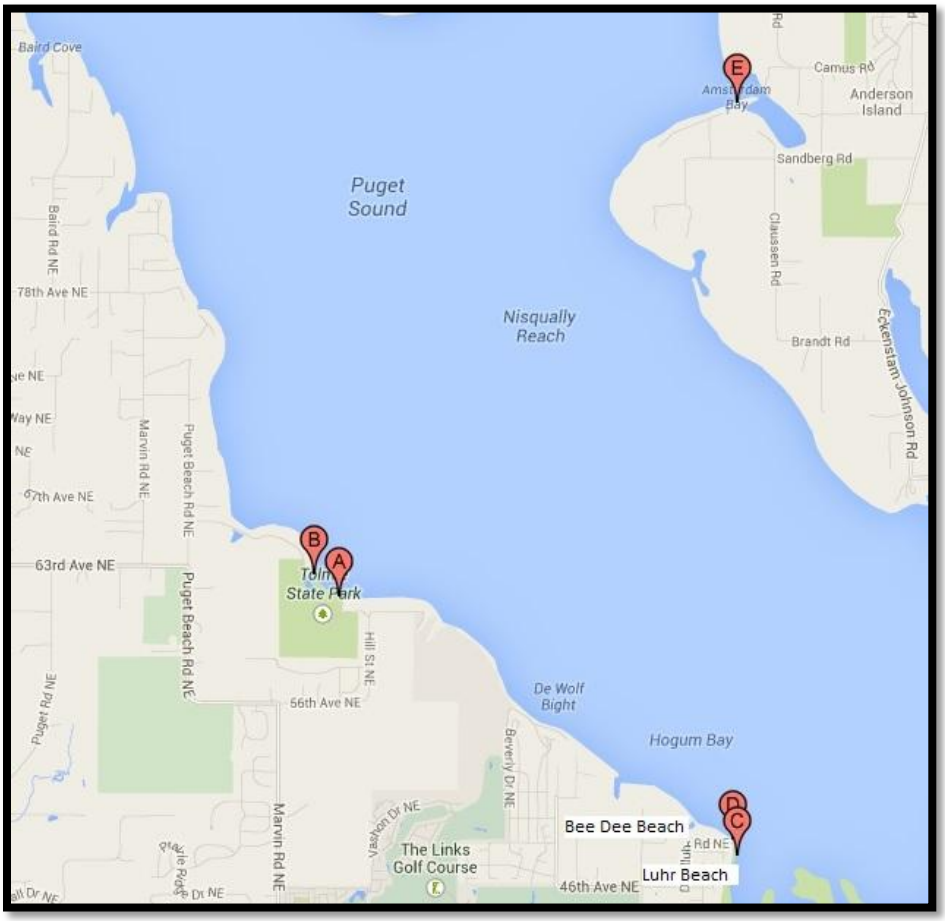

Figure 8: Location of survey sites.

Discussion

The NRARCSC decided in 2013 to start forage fish surveys after being given a presentation from the PSC. A major determining factor for selection was that WDFW had an established and well-tested protocol for the collection and preservation of the samples and PSC would provide assistance and training on the established sampling procedures. Additionally, two other aquatic reserve Citizen Stewardship Committees, Fidalgo Bay and Smith and Minor Islands, chose this for a research project. The surveys address sampling gaps by providing supplemental data to verify previous findings and new data on spawning distribution and timing. Our first year of sampling was marked by challenges that prevented us from achieving our goals. Despite this, we persevered and continued to monitor knowing that help would be on the way. The previous coordinator was a volunteer unable to commit fully to the demands of the duties and responsibilities associated with the position. In 2014 with monies garnered through an NEP grant and General funds from Nisqually Reach Nature Center, we hired a dedicated scientific research technician to assist with this project. This resulted in a significant boost to the project that solidified its foundation and started to generate the proposed outcomes.

The main sampling sites were Luhr Beach sample 2, Tolmie State Park sample 1, and Amsterdam Bay sample 1. These appear to be good potential spawning habitat for forage fish and were already part of the WDFW and WDNR sampling sites. Surveys conducted prior to QAPP approval, while not a part of the analysis, were intended to further train and increase confidence of NRARCSC members. This extra time spent practicing the field protocols produce highly trained CSC members who can assist NRNC, WDFW and DNR with a high freqency or year round monitoring of local beaches. As sampling continued under the accepted QAPP the NRNC scintific tecnition helped to guide, cordinate, and provide onsite QA/QC for volunteers involved with this monitoring effort.

At Luhr Beach, the combination of a high, vegetated bank, northern exposure, and a pea gravel/sand mix in the upper tidal elevation of the beach seem to provide ideal spawning habitat for surf smelt. However, the site is a public beach with people walking on this stretch of beach. The section of Luhr Beach where sample 1 is collected from generally does not appear to be good habitat, primarily due to the large gravel size that dominates the beach. (Moulton and Penttila, 2001) Despite this, we have sampled this part of the beach in order to determine whether or not spawning occurs here.

Similarly, the area where sample 2 is collected at Tolmie State Park also appears to be marginal habitat for surf smelt spawning for several reasons. First of all, this is a high traffic area. Secondly, it is nearly pure sand except for a small patch of coarse sized gravel. And last, the sample zone is completely exposed, with virtually no shade and has an eastern exposure. On the other hand, the section where sample 1 is collected seems to be the best potential spawning habitat of all the beaches surveyed in the aquatic reserve. A high and steep vegetated bank, northern exposure, and a pea gravel/sand mix in the upper tidal elevation of the beach are all found here. This is by far the shadiest site of all. It too, however, happens to be a very popular place for a walk and subsequently, the majority of the sampling area is often disturbed.

Amsterdam Bay is another promising site due to its substrate and northern exposure, although it is the most highly impacted area due to minimal shading, close proximity of houses, and high energy wave exposure.

The stated goals and objectives were met to the best of our capacity at the time. Surveying in 2013 was inconsistent due to not having an adequate project coordinator; surveying in 2014 has been consistent with NRNC hiring a scientific Technician/project coordinator in January 2013. The greatest challenge is to develop a core group of volunteers to conduct surveys on a regular basis. Having someone dedicated to coordinating forage fish research has been an instrumental part of our success for the 2014 surveys.

The first goal, to create a time-sensitive dataset of spawning is still in progress, as the majority of 2014 samples have yet to be analyzed. Otherwise, survey frequency since February 2014 has exceeded survey guidelines as outlined in the NRAR management plan (see Table 1). Analysis of 2014 samples should provide a clearer picture of spawning within the reserve as well as being a solid start towards completion of a baseline data set. Inconsistent sampling effectively eliminated the possibility of having a solid baseline data set for 2013, therefore 2014 data from February onward could be considered the effective start date for establishment of the baseline. As long as we continue with a sampling plan that follows that of the WDFW protocol and maintain consistent volunteer involvement, we will be on track to complete a baseline by spring of 2015. Additionally, given our current capacity, we are well positioned to continue surveying into the peak spawning season (fall/winter), which is the period for which we lack data. Efforts will be made to ensure that sampling is consistent during this time.

The second goal is to create a monitoring program that documents changes over time of forage fish usage of the beaches using established methods that provide data comparable across reserves and monitoring years. This program follows an established protocol to collect samples and is fully compatible with forage fish spawning data in other aquatic reserves and other locations. The monitoring program continues to gather samples. It will take substantial time to gather adequate data to detect changes in habitat use. Despite none of the samples collected and analyzed had any eggs, we are confident in the survey methodology and the ability to detect active spawning, especially during the peak spawning season. Several factors could explain why we did not find eggs. Primarily, we have a backlog of samples awaiting lab analysis. Additionally, it is possible that sampling was not representative of all areas used for spawning. We did focus our sampling efforts in the middle to upper portions of the suitable habitat, so it is possible that we missed any potential sand lance spawning lower on the beach. The final possibility is that these beaches are not used for spawning. Future sampling should document beach usage and changes from month to month, season to season, and year to year.

Now that we have a staff scientific technician/ coordinator and good core of citizen scientists trained to collect samples and complete lab analyses, we are well prepared to increase the strength of our partnership with WDNR and WDFW. This collective effort will help us to understand when and where forage fish spawn in the Puget Sound. Although current sampling efforts are focused on looking for presence/absence of surf smelt and sand lance eggs, future sampling efforts will hone in on identifying preferred beach elevations for spawning. This effort would be complemented by potential work conducting surveys in partnership with WDNR and the US Geological Survey to study hydraulic processes within the reserve including drift cells and sediment transport/deposition. Doing so would allow us to identify the most likely spawning areas. Our staff and NRARCSC members are committed to continuing this survey. Continuation of this work is contingent upon further funding. Aside from funding, with a coordinator in place and a group of volunteers, NRNC is well positioned to continue these surveys. With

information provided here it is our intent to seek new monies to keep a strong coordinated effort to this end. This program not only generates useful data that augments state databases for scientific and shoreline policy management purposes, it also serves as an educational tool that reaches citizens throughout our community in an engaging manner by providing a deeper connection with the environment.

Completeness of the Survey

The QAPP for this program proposes a sampling schedule of monthly March-November and twice-monthly December –February. From February 2014 to May 2014, we sampled twice a week at both Luhr Beach and Tolmie State Park. Therefore, while February met the planned sampling regime and March-May exceeded the target, the survey schedule was not completed throughout the rest of the survey year. Table 1 shows the actual frequency of sampling. To complete the full survey protocol, the survey needs to be continued at least through January 2015.

Assessment of the feasibility of this study

This study has accomplished some of what it intended to do, engaging citizens in usable science, and connecting them in a richer way to the natural resources. It follows an established WDFW protocol that is followed by state agencies and citizen-science groups alike. Programs like this are paramount to connect citizens in conservation with state agencies like WDFW and WDNR. Continuation of the surveys will allow us to reach our goal of compiling enough data to establish a baseline and detect any trends.

The beaches currently surveyed account for a small portion of the nearly 39 miles of shoreline within the reserve. WDFW is currently working towards surveying the entire south Puget Sound, which is approximately 400 miles of shoreline on both public and private beaches. A fair amount of that shoreline within the NRAR is either private or only accessible by boat. Our eventual goal is to survey all the beaches in the reserve within the next two years to assist state agencies in their surveys of forage fish. There are numerous beaches on Anderson Island with potential spawning habitat; a scouting survey is necessary to determine which beaches would be good survey sites. A couple factors are currently limiting our ability to survey more beaches. Consistent volunteer availability and continued funding would allow us to continue surveying existing sites while expanding to others. The current coordinator will work to develop a core group of volunteers by recruiting new ones to replace those who have moved on to other engagements or become inactive. Ideally volunteers would sign up to conduct surveys on a regular schedule independent of direct supervision by the coordinator. Additionally, we currently have a backlog of samples waiting lab processing, so it would be prudent to analyze them before collecting even more samples. This backlog goes back to March of 2014. On July 28, 2014, NRNC in partnership with WDFW and WDNR hosted a training session on lab analysis of forage fish samples, with 19 citizen stewards attending. This is a huge step forward in giving NRNC the ability to fulfill its vision of doing a survey from start to finish. Lab processing of samples will commence in August 2014.

Recommendations

Since the goal of the survey is to determine the presence or absence of forage fish spawning, it may be prudent to conduct more intensive sampling to minimize the possibility of false negatives. There is an

inherent risk in sampling more often only from December to February, because there is no conclusive data to support when the exact peak spawning period occurs. There is a lack of complete information on forage fish life history for south Puget Sound. Since this is the case, it is another reason to conduct surveys that are more comprehensive. Although sand lance are known to sometimes use the same spawning habitat as surf smelt, their eggs are usually found lower on the beach (Kira Kranzler, personal communication, April 2, 2014). In order to increase the chance of detecting sand lance spawning, it would be prudent to collect samples at different elevations from each beach, especially those where forage fish spawning has been documented. These elevation surveys can also help identify areas that are consistently utilized by one or both species. This would allow us to determine if surf smelt and sand lance spawn regularly at various beaches. Because the condition of spawning habitat is documented, we can then go back and look for trends that may help explain existing patterns or any changes that may occur.

The experimental sample separation techniques currently being tested by WDFW and other collaborators are very promising and would be a significant improvement over winnowing, which has proven to be one of the more difficult steps in sample processing. All of these techniques involve centrifugal action to some degree. One of these methods is commonly referred to as the "blue bowl" method. The blue bowl is essentially a plastic pan that is similar in shape to a Bundt cake pan with a hole in the middle. There is another hole on the side for attaching a hose. After pouring a sample into the blue bowl, the hose is turned on, and eventually the water begins to swirl and create a vortex. The result is heavy material remaining in the pan and lighter material falling through the hole and into a sieve below. Compared with the traditional winnowing technique, the "blue bowl" method would not only save time, Stockard's solution, and water; it would greatly reduce the margin of human error involved.

Having a coordinator dedicated to implementing the forage fish program has been instrumental in rebuilding momentum. However, future success of this program hinges upon having a core group of volunteers who would ideally adopt a beach or beaches and conduct the field portion of surveys independently of the coordinator. At this time, a core group is still being developed. The lab portion of surveys has yet to begin in earnest and it too will require a core group of volunteers to keep momentum going and avoid a backlog of samples.

Conclusions

This program has come a long way since its inception and been successful in multiple aspects with useful data collected, many lessons learned, and good public engagement. Completion of the sample analysis and continued surveying may lead to complete success. Despite the fact that no eggs were found in any of the samples analyzed to date, this is a good example of the importance of consistent surveys over a time period of at least a year to rule out the possibility that the absence of eggs can be explained by a factor other than human error. It may also indicate that none of the beaches surveyed are used for spawning or that spawning is so limited that detection is highly improbable following the standard sampling protocol. Further surveys are necessary to make any definitive conclusions. Expansion to other beaches within the NRAR would help increase our knowledge about forage fish spawning while also allowing WDNR and WDFW to focus their survey efforts elsewhere in places not feasible or efficient for

NRNC to survey. The ongoing development and nurturing of a core volunteer group will allow us to achieve this goal. It is apparent to us that the presence of a paid coordinator is helpful to this end. In our study, even with the limited survey area, the data we collect will ultimately allow us to answer the basic questions of when and where surf smelt and sand lance spawn. With this report and the growth of this monitoring effort, we feel confident that we can garner monies through grants, membership dues, and private donations so the NRNC and the NRARCSC will be able to:

- Conduct surveys for additional years and expand beyond the original study area.
- Sample on a frequent basis and conduct other types of spawning surveys.
- Provide a more comprehensive account of local trends for surf smelt and sand lance spawning distribution.

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Appendix A: Sampling Design and Procedures

The sampling design follows the WDFW Intertidal Forage Fish Spawning Habitat Survey Protocols, Procedures for Obtaining Bulk Beach Substrate Samples (Penttila, 2011). Slight modification to the protocol has been made in steps 9 and 10 to eliminate the need to use preservatives when possible. A description of the winnowing method is given in the QAPP (Grilliot & Joyce, 2013). The sampling protocol is as follows:

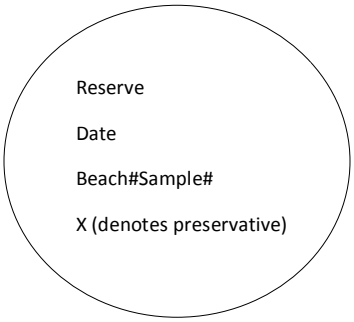
Note: Sampling should occur on the lowest tide practicable. Prior to sampling any site, consult tide tables to ensure you will be able to access the +7-9 (surf smelt) and +5-8 (sand lance) tidal height. It may also be necessary to obtain permission to access the beach from private or corporate landowners.

Procedure:

1. Upon arriving on the beach, fill out the header information on the attached data sheet. Do not fill in "Reviewed by." Before conducting the first sample, describe the character of the upland and beach environment using the codes provided on the back of the data sheet. For additional details on sample codes, see Moulton and Penttila (2001).
2. Identify a landmark from which you will measure the distance to the bulk substrate sample tidal elevation. Typical landmarks include the upland toe of the beach, the last high tide mark or wrack line, and the edge of the water.
3. Measure the distance from the landmark to the tidal elevation to be surveyed.
4. Stretch a measuring tape at least 100 feet along the selected tidal height. Note that beach contours may cause the landmark to be "wavy" and that the tape should remain a consistent distance from the landmark.
5. Standing at the 50-foot mark of the measuring tape, record a GPS fix on the data sheet.
6. Using a 16-ounce sample jar or large scoop remove the top 5-10 cm (2-4 in) of sediment from the location recorded in Step 5 above. Place the sediment in an 8 inch x 24 inch polyethylene bag or large, sturdy Ziploc. You may need to take two scoops to get sufficient sediment, depending on the coarseness of the beach.
7. Walk ten paces (single steps) along the measuring tape, repeat the sediment scooping action, and place the sediment in the bag. Move an additional ten paces and repeat. Move an additional ten paces, approximately to the end of the tape, and repeat. The bag should now have sediment from four locations along the tape and be at least ½ to ⅔ full. Place completed waterproof sample label in bag with sediment. Label should include reserve name, Beach# sample#, data, and sampler initials.
8. If additional transects, representing various tidal heights, along the beach are to be surveyed, place the sample bag in a cool, shady place and repeat the above procedures at these additional locations. If no additional samples will be taken, move on to wet sieving and winnowing the sample as described in the companion protocol *Procedures for recovering winnowed light fractions subsamples of forage fish egg-sized material from bulk beach substrate samples*.
9. Place each winnowed subsample in a sample jar, making sure threads are clean to ensure a tight seal. Label each jar (in pencil) with reserve name, date, and beach# sample#. If samples may not be transported within 24hours, the preservative Stockard's Solution may be added. If it is added, the closed jar should be inverted at least three times to be sure all the preservative is

distributed. When using Stockard's Solution, mark the jar with a large X to indicate a preservative has been used. See Figure 9 as an example of labeling.

Figure 9: Example of labeling sample jar.



10. Store sample collections in a cool location, making sure the samples are not frozen. Transport samples to WDNR or WDFW personnel for analysis within 24 hours of collection unless a preservative has been used.
11. If you have a camera, take several photos of the survey area showing sampling locations. Be sure to take photos from several perspectives (i.e., both up and down, as well as along, the beach). For each photo, record the cardinal direction you are facing on the data sheet in the comments field. For our purposes, one photo of the transect from either end is sufficient, but highly encouraged! Still important to record cardinal direction.

Appendix B: Nisqually Reach Aquatic Reserve Forage Fish Spawning Survey Protocol

Equipment and Materials

- Measuring tape (100 feet)
- Scooping mug
- Poly bags or lidded plastic buckets with handle
- Data sheets and sample labels
- Copy of sampling protocol
- Tide chart
- Pencil(s)
- Camera
- GPS
- Backpack
- Sieves
- Sieving bucket
- Dish pan
- Sample jars
- Stockard's solution
- Trash bags
- Knee boots(optional)
- Rain gear (optional)

Prior to Going into the Field

1. Sign up for a time and beach to be sampled.
2. Coordinate with your sampling partners to arrange meeting time and place.
3. Check the weather forecast and dress accordingly.
4. Gather equipment and materials.

Before you leave the parking lot

Meet with your team, and double check that you have all the equipment you need.

Agree on the beach segments you will be working on, and the approximate time limitations that you have, so you can be sure to finish collecting and winnowing the samples that you will gather. Decide on how far down the beach you will go, or if you have arranged for a one-way sample.

Begin filling out the data sheet:

1. Leave the **last high tide** field blank
2. Leave the **reviewed by** field blank.
3. The **location** is Luhr Beach or Tolmie State Park. In the event that you survey both beaches in the same day, write Luhr Beach/Tolmie State Park and also label them on the left margin.
4. Record today's **date**.
5. Write out first and last names for all **samplers**.

On the Beach

1. Walk to your sampling area and
    a. locate the last high tide mark if present or the next most prominent **landmark.** Typically, there is a line(s) of seaweed. In the event that one isn't present then the upload toe can be used or the water line if it is less than 100 ft from your sample area.
    b. Then look for a section of beach where there is suitable habitat and minimal or no footprints.
2. When you have selected a location, get out all your equipment and start your survey.

3. Stretch the 100 ft. measuring tape out parallel to your landmark. Note that beach contours may cause the landmark to be uneven. If you encounter this situation, ensure that the tape remains a consistent distance from the landmark. The runner can set the GPS down next to the tape at the 50 ft mark and resume pulling out tape. Give the GPS time to get a reading; while it is doing so, begin filling out the data sheet.
4. To begin filling out the data sheet, enter the **beach number** according to the following: Luhr Beach is always beach number 1 and Tolmie State Park is always sample number 2.
5. Enter the **sample** number according to the following: The section of Luhr Beach south of the Nisqually Reach Nature Center is sample number 1. The section of Luhr Beach north of the boat ramp is beach sample 2. The section of beach at Tolmie State Park south and eastward of the creek is sample number 1. The area to the north of the creek is sample number 2.4. Enter the **time (24-hr)** (always use 24-hr time, f.ex. 8am= 08:00, 1pm = 13:00, 8pm=20:00, etc)
6. Standing at the midpoint of the tape, estimate the **length** of the beach 500 ft in each direction. If there is structure on the beach such as a bulkhead or boat ramp, estimate the distance to that structure.
7. Describe the character of the **uplands** and include in the comments what type of unnatural structure is within 1,000 ft of the high water mark.
8. See the codes for **shading**, noting that you are looking at the whole 1,000 feet of your station area (your 100-foot sample is in the beginning of this area). It is assessed over the course of an entire day, season, and year. Shadows from bluffs are not included; look at overhanging vegetation or shade from trees on the bank.
9. **Tidal elevation** is filled out by the analysis team in the office.
10. Scoop the top 1-2 inches (3-4cm) of sediment, picking spots with the best sediment (sand and small gravel) within the sample zone between the tape and the landmark, and place it in the bag. Take a second scoop above or below and parallel to the first. If there are large rocks that impede your ability to scoop, do not remove them, put them in the sample bucket/bag. If there is a layer of seaweed, peel it off carefully, inspect for eggs, and use your hand to brush off any sediment onto your targeted scooping area. Walk 10 paces between samples, and collect about 4 times so that the bag is ½ to 3/4 full.
11. Once you walk up to the GPS, record the **Latitude and Longitude** on your data sheet and then record a waypoint on the GPS.
12. At the end of the 100-foot segment take another picture looking back along the sample area. You can do this with people in the shot; also be sure to include as much of the beach profile as possible; capturing the landmark is important!
13. Fill out a sample label, put it in the bucket on top of the sediment, and tightly seal the lid.
14. Use the tape to simultaneously measure the **width** of the potential spawning substrate band and the **sample zone**.
15. Note any **comments** or clarifications you may have. Describe your landmark if you are unsure, or anything unusual or troubling.
16. If additional transects, representing various tidal heights, along the beach are to be surveyed, place the sample bag in a cool, shady place and repeat the above procedures at these additional locations. If no additional samples will be taken, move on to sieving and winnowing the sample

as described in the companion protocol *Procedures for recovering winnowed light fractions subsamples of forage fish egg-sized material from bulk beach substrate samples*.

17. Place each winnowed subsample in a sample jar, making sure threads are clean to ensure a tight seal. Label each jar lid (in pencil) with beach name, date, and beach# sample#. Preserve samples by adding enough Stockard's Solution to cover sediment by 1/4". The closed jar should be inverted at least three times to be sure all the preservative is distributed. When using Stockard's Solution, mark the jar with a large X to indicate a preservative has been used.

Appendix C: Acknowledgements and Volunteers

We thank Bookheim, Bob Lemon, and Tom Gries for their reviews and comments on this report.

Nisqually Reach Aquatic Reserve Forage Fish Surveys were made possible by volunteers and partners. The dedicated volunteers are listed in Table 2. These volunteers made it possible to conduct surveys frequently and as a result collect valuable data that will help inform future management policies at the state level.

Table 2: Program Volunteers

Volunteer	**Year(s)**
Luhr Beach/Tolmie State Park	
Daniel Hull	2013, 2014
Yvonne Shevalier, coordinator	2013
Terence Lee, coordinator	2013, 2014
Daniel Krenz	2013
TC Peterson, intern	2014
Wyatt Hersey, intern	2014
Anthony Doria	2013
Angelica Doria	2013
Matthew Anderson	2013
Deanna Donovan	2013
Kurt Shevalier	2013
Jacqueline Winter	2013, 2014
Tad Stein	2014
Bob Vadas Jr.	2014
Amanda Beaty	2014
Ross Skinner	2014
Samuel Kaviar	2014
Mary Verner	2014
Chris Montgomery	2014
Robert Barrett	2014
Martin McCallum	2014
Miranda Hoyle Dodson	2014
Leif Weff	2014
Blake Cantrell	2014
Manjit Nijjar	2014
Anderson Island	
Merry McNutt	2014
Connor McNutt	2014
Jerry Johannes	2014
Vivian Skanderberg	2014
Trace Skanderberg	2014

The project coordinator is grateful for the contribution of time, talent, and efforts of the following that made the project possible:

- Nisqually Reach Aquatic Reserve Citizen Stewardship Committee for adopting the project. Special thanks to Daniel Hull, chair, & Yvonne Shevalier, co-chair, for providing opportunity for sponsorship, for advice, and giving encouragement and appreciation throughout the year.
- Washington Environmental Council for support of the project through the National Estuary Program (NEP) of the United States Environmental Protection Agency (EPA) under assistance agreement PC-00J29801-0 to the Washington State Department of Natural Resources (WDNR). Maddie Foutch, coordination and support of the NRAR Citizen Stewardship Committee projects.
- The Washington State Department of Natural Resources Puget Sound Corps Crew: Geoffrey Mayhew, Kirsten Miller, Jackson Barnes, Emily Rhoades, Jaimie Liljegren, Michelle Bahnick, Heather Dalke, Jennifer Soper, Rose Whitson for support and partnership, providing training, sharing equipment and supplies, and answering questions.
- Washington State Department of Fish & Wildlife staff: Phillip Dionne and Kira Kranzler for support, training, and answering questions.
- Merry McNutt and Jerry Johannes for spearheading survey efforts on Anderson Island, coordinating volunteers on the island, and being a great source of inspiration to all of us by demonstrating what positive, like-minded folks can accomplish when they work together and dedicate themselves to making the world they live in a better place.