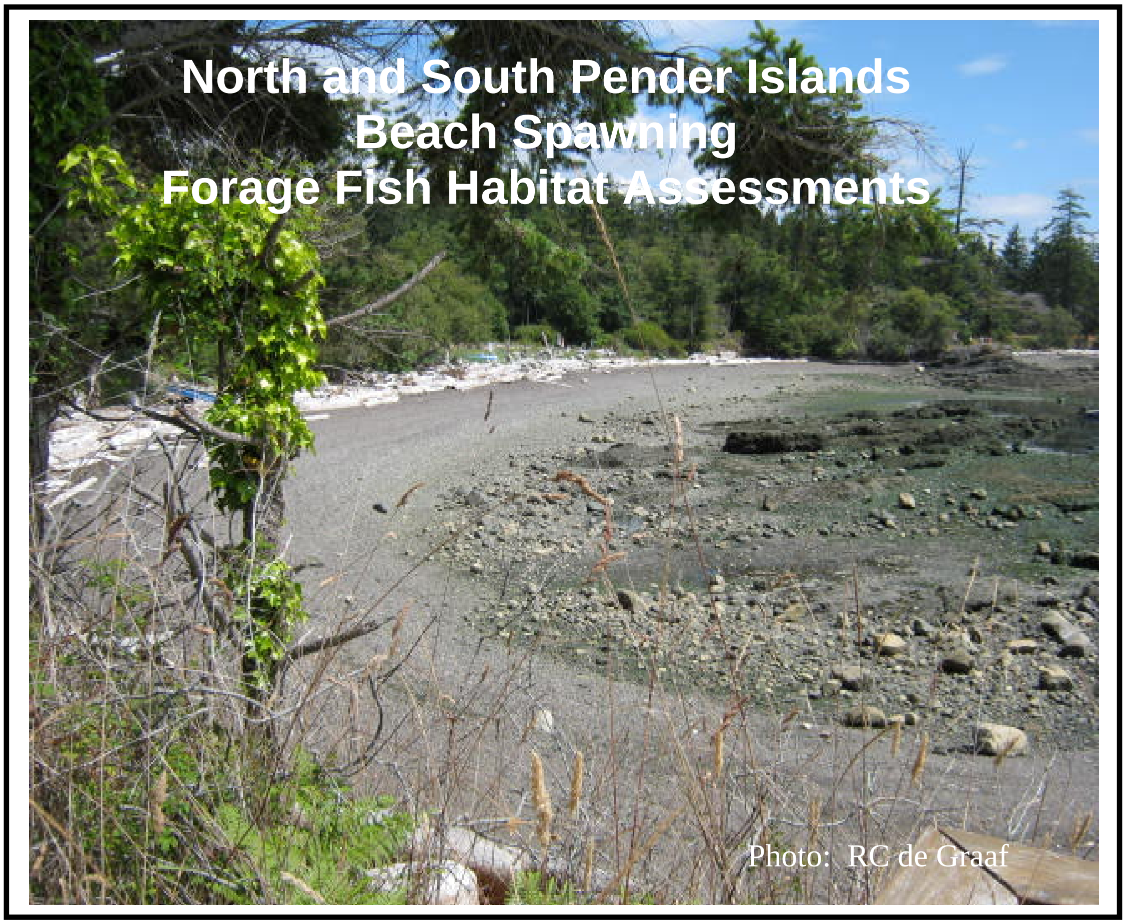


Prepared for the Islands Trust Fund

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# Beach Spawning Forage Fish Habitat Assessments
# North and South Pender July/Aug 2012

## CONTENTS

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## 1. Introduction

Beach spawning forage fish are a critical prey source for hundreds of marine predators in the Strait of Georgia. Pacific sand lance are often referred as the most important fish in the North East Pacific due to its unique role as forage to marine fishes, seabirds and marine mammals (Robards 1999). Surf smelt are also important prey to marine predators. Surf smelt are managed by Department of Fisheries and Oceans under the Surf Smelt Management Plan for commercial and recreational fishers and their population abundance in the Strait of Georgia is declining (Therriault et al 2002). Surf smelt and Pacific sand lance spawning habitats are protected under Section 35 of the Federal *Fisheries Act*.

### 1.1 Critical forage for marine ecosystem function

Pacific sand lance and surf smelt are important to the recovery of marine species at risk (from Humpback and Killer whales to Marbled Murrelets); the marine survival of salmon (such as Chinook and Coho); and the survival of provincially listed coastal cutthroat trout. Both Chinook and Coho feed on sand lance both as juveniles and as adults.

Numerous fish, seabird, and marine mammal populations are in precipitous decline in British Columbia; and scientists have started to look at the link between forage fish biomass reduction and these declining populations.

### 1.2 Connections to other valued ecosystem components

Forage fish depend on nearshore habitat for their survival. Herring spawn on marine vegetation such as eelgrass and seaweeds; and Pacific sand lance and surf smelt spawn high up the beach near the log line. Like numerous fish species, surf smelt and Pacific sand lance also require subtidal areas such as kelp forests for rearing.

## 2. Beach Spawning Forage Fish Habitat

Beach spawning forage fish of commercial, recreational and ecological value in the Strait of Georgia are the capelin, surf smelt (*Hypomesus pretiosus)* and Pacific sand lance (*Ammodytes hexapterus)*. The Washington Department of Fish and Wildlife has conducted extensive surveys in Puget Sound and produced maps of spawning habitat (Penttila, D. 2007). Approximately 10% of Puget Sound beaches are used by surf smelt for spawning and 10% are used by Pacific sand lance (Penttila 2007). Unfortunately critical spawning habitat of these two forage fishes has not been mapped in British Columbia.

Surf smelt and Pacific sand lance depend on a healthy nearshore and beach habitat, and they are vulnerable to impacts from shoreline development. Beaches with natural erosion processes supplying appropriate sized gravels and extant marine riparian zones are an optimal state for spawning surf smelt and sand lance. Of primary importance for spawning is the mixture of gravels and sand.


## 3. Spawning Habitat Characteristics

### 3.1 Intertidal Elevation

The highest densities of embryos found to date have been in the upper beach slope between the high water seaweed wrack zone and the low high water seaweed wrack zone. Consistently, mixed embryo stages are found in samples taken from +1.5 m to +4.5 m above chart datum and can be found at the highest extent of the maximum high tides Sand lance also spawn on the sand flat edge near the beach slope (Penttila 2001b, Penttila 2007, de Graaf unpublished data). This area of the intertidal has been sparsely sampled.

### 3.2 Sediment Characteristics

Both surf smelt and sand lance embryos can be found on certain beaches in the same beach sediment sample collected along the upper beach slope. Surf smelt are reported to spawn in sediments of fine “pea pebble”/sand to coarse pebble/sand beaches with the bulk of the pooled data set having material of 1-10 mm; although full grain size spectra show numerous sample sets with a wide range of pebble/sand including coarse pebble greater than 2.6 cm (Penttila 2001c).

Surf smelt do not spawn in coarse sand beaches without pebble due to the unique attachment pedestal of the osmerid egg (they are gravel-dependent spawners). Sand lance are reported to spawn in sediments of coarse sand/pebble with the bulk of the pooled data set (67%) having material of a median grain size of 0.2 – 0.4 mm and a portion of the data set (25%) being gravel-coarse sand from 1 – 7mm (Penttila 2001c; 2007). Recent findings in British Columbia reveal that sand lance embryos are also found in beaches bearing a high percentage of coarse pebble greater than 2.6 cm (de Graaf unpublished data). Sand lance embryos are found throughout the range of surf smelt bearing sediments as well as coarse sand. Pacific Sand lance do not spawn on fine silt and cobble (Penttila 2007). In British Columbia, both surf smelt and sand lance embryos can be found throughout a beach drift cell in the erosion, transport and accretion zones (de Graaf, unpublished data, presented at American Fisheries Society Conference Sept 2011). Over 40 years of government sponsored surveys in Puget Sound and carried out by Mr. Penttila has yielded important data on the spawning habitat of these two species. With recent attention to surveys in the Strait of Georgia and the outer coast of Vancouver Island, our understanding of beach spawning habitat types has increased.

### 3.3 Beach Biophysical Characteristics

Beaches in British Columbia bearing surf smelt and Pacific sand lance spawning sites are typically of sand/pebble in the upper component of the beach slope, a cobble component seaward, followed by a sand or mud flat toward the low tide zone. The width of the sand/pebble component (commonly referred to as the B1 component) is variable and can range from 0.5 m to over 10 m in width.

## 4. Spawning Seasons

Surf smelt are known to spawn year round in Puget Sound and also have distinct winter and summer spawning stocks (Penttila 2007). In British Columbia, summer and year round spawning beaches have been detected (de Graaf unpublished data). Sand lance spawning is from Nov – January with incubating embryos detected into February (30-45 day fall/winter incubation period). Data compilation for spawning periods for regions of British Columbia has begun due to the extraordinary effort of 30+ communities working with the author through the BC Shore Spawners Alliance (BCSSA). In the Islands Trust Area, communities are presently undertaking spawning surveys with the BCSSA as the Gulf Islands Forage Fish Initiative.

## 5. Threats to Beach Spawning Forage Fish Habitat

Shoreline modifications can negatively impact the nearshore marine food web in numerous ways, but are a primary threat to surf smelt and sand lance spawning beaches (Penttila 2007).

Many human activities impact and alter marine shorelines either through disruption of the sediment drift cell or by physical alteration of the beach, including: piers, pilings, docks, jetties, groins, breakwaters, riprap, seawalls and others. Diversion of sediment-bearing streams through culverts can also starve beaches of spawning sediment. Many of these activities render beaches unusable for spawning. These shoreline modifications can also limit sediment exchange in the shallow subtidal where sand lance are known to burrow.

The presence of overhanging vegetation in marine riparian zones is important for the ecological function of nearshore marine habitats providing insect prey for migrating fish (Levings and Jamieson 2001; Brennan and Culverwell 2004) and having a positive effect on summer surf smelt spawn survival (Penttila 2001a, Penttila 2007, Rice 2006). The loss of shade increases thermal stress and desiccation to incubating eggs as sediment temperatures rise resulting in increased mortality of buried eggs (Penttila 2007, Rice 2006). Vegetation buffers the drying effect of winds, and where beaches have lost riparian zones, eggs can also suffer a higher mortality than normal due to wind-induced desiccation effects.

Other threats to surf smelt and sand lance eggs include contamination from acute oil spill events and chronic oiling can result in 100% mortality of surf smelt eggs. Oiling from vessel operations near beaches can potentially cause mortality of incubating forage fish eggs (herring, sand lance, and surf smelt) (Penttila 2005).

## 6. Introduction to the North Pender and South Pender islands Beach Spawning Forage Fish Habitat Assessment

### 6.1 General Introduction

Over July 28 – August 4, 2012, surveys of unconsolidated sediment intertidal areas were conducted along North and South Pender shorelines. Data acquired by the author with the Pender Island Conservancy Association in 2010-2012 has also been incorporated into this report.

A sediment map was produced from the Coastal Resource Information Management System, DataBC (DataBC Catalogue 2013). The data layer used to produce the sediment map was the shoreline biophysical classification by repetitive shore type. All shore-units of unconsolidated sediments were investigated along the entire shoreline length of North and South Pender islands. Unconsolidated sediments include silt, mud, sand, and gravels.

## 6.2 Area Surveyed

The entire coastline of North and South Pender was surveyed with the exception of areas of consolidated sediment (rocky beaches, rock terraces etc.).

Areas surveyed included areas with drift cell attributes of erosional faces that graded into beach areas. These are areas with unconsolidated sediments of gravel/sand as well as mud/silt areas. Gravel is defined as pebble, cobble and boulder.

Areas of pebble and sand were assessed. Areas of mud/silt were assessed for the presence of upper bands of pebble and sand.

Negative beaches fall into three categories:

1. Areas with boulder or cobble on rock ramp were surveyed to ensure the presence/absence of pebble/sand bands. If areas of boulder and cobble did not yield pebble and sand, they were classified as "negative".

2. Areas of mud/silt may have a thin layer (veneer) of pebble and cobble. Due to the lack of motility of mud/silt areas, these are classified as "negative".

3. Pebble/sand beaches that failed to pass statistical analysis are also classified as "negative".

## 6.3 Project Limitations

The project was limited to assessing beaches as potential spawning habitat for two species of beach spawning forage fish, surf smelt and Pacific sand lance. Data are compiled after one visit to the beach in summer months. The methods used in a forage fish habitat assessment do not allow one to determine the presence or absence of spawning activity as sediments are not collected for nor screened for the presence of embryos. Spawning surveys are conducted over two spawning seasons (24 months) and follow strict protocols (Moulton and Penttila 2001). The project undertaken grades beaches as being "potential" spawning beaches, but it does not confirm the presence or absence of spawning activity.

# 7. Methods

## Forage Fish Habitat Assessments – Assessing Potential Forage Fish Spawning Habitat.

Actual forage fish spawning beaches are determined after a two-year embryo survey and the presence of two or more embryos in a sample (Moulton and Penttila 2001). In the absence of such comprehensive surveys, beaches may be classified as potential surf smelt/Pacific sand lance spawning habitat following a habitat assessment. The habitat assessment protocol used in this project, the Forage Fish Habitat Assessment, has been developed through a collaboration of forage fish biologists from British Columbia and Washington State. Due to the current transition of the Department of Fisheries and Oceans Habitat Program to the Fisheries Protection Program and numerous staff reassignments, the FFHA protocol vetting process has been stalled. Numerous Regional Districts in British Columbia have had shoreline areas assessed using this particular FFHA methodology for land-use planning decisions.

## 7.1 General Methodology

The FFHA entails a survey of habitat attributes for each area of unconsolidated sediments making up the upper component of intertidal beaches (beach berm/beach face and mid intertidal). Measurements are taken of physical variables of the beach as well as grain-size analysis. Additional variables are measured to assess human activities that may have directly modified the foreshore or adjacent backshore areas. Assessments are conducted by experienced beach spawning forage fish biologists/technicians.

Physical variables from potential beaches are compared to a database of habitats that were monitored using spawning surveys (over 2 years) and were positive or negative for spawning by surf smelt and/or Pacific sand lance in British Columbia and Washington State. The software program PRIMER-E, a multivariate statistical program, set at an 80% similarity threshold, is used to test potential beaches to this BC/WA database. The PRIMER-E software program is used extensively by ecologists to describe similarities and differences among biological communities, habitat types, or for monitoring biological communities and habitats.

Using statistical analyses, a statistical probability can be assigned to each beach measured. Beaches are assigned as being either surf smelt, surf smelt/Pacific sand lance, or Pacific sand lance. For shoreline property owners undertaking works that may impact the foreshore, a professional habitat assessment is required by the Department of Fisheries and Oceans (DFO). In the absence of a two-year spawning survey, a FFHA can provide a good indication of potential surf smelt and sand lance habitat for use by landowner and other agencies in shoreline management.

## 7.2 Specific Methodology

### 7.2.1 Forage Fish Grain-Size Profile Types

The FFHA uses a method developed by Mr. Dan Penttila (former Washington Department Fish and Wildlife Forage Fish Expert) and Ms. R de Graaf to examine sediment types. Surf smelt beach grain-size profiles are divided into five grain-size types. Pacific sand lance beaches are classified into three grain-size types. In winter months, surf smelt and Pacific sand lance embryos can be found in the same beach sediment sample. Mixed surf smelt/Pacific sand lance beaches have grain-size profiles classified by mixed, winter surf smelt and Pacific sand lance beach types. This is because of the overlap of the use of sediment sizes and beaches by the two species. Pacific sand lance beach Type 1 is similar to Surf Smelt Type 1 and 2. Pacific sand lance beach Type 1 is a grain-size profile with coarser pebble that PSL Type 2 and Type 3. This grain-size type is common of beaches where surf smelt and Pacific sand lance spawn on the same beaches. It is also common of beaches where only Pacific sand lance spawn but have a high percentage of coarse pebble and lower percentage of small pebble and sand.

The standard beach types are fully described in the FFHA methodology. When the FFHA methodology evaluation process is completed by the Department of Fisheries and Oceans, complete details and a manual will be available.

### 7.2.2 Grain-Size Analysis and Statistical Testing

A series of 14 US standard sieves are used to divide 2 L of sediment into grain-size classes. Sediments were dried and weighed and percentage of weight in each sieve recorded. Cumulative frequency curves are generated. Cumulative frequency curves of North and South Pender island beaches being tested are compared to the Grain-Size Types using similarity tests (Kolmogorov-Smirnov) to a threshold of 80%.

### 7.2.3 Beach Metrics

The beach is assessed for sediment depths, widths, length, erosion sources, beach character, beach slope, overhanging shade vegetation, marine riparian vegetation, modification of foreshore and backshore and the presence of structures that modify both foreshore and backshore zones (Moulton and Penttila 2001; Therriault et al. 2002). The average depth of sediment is determined over three measurements taken along the beach unit (de Graaf and Penttila 2006). The width of the spawning zone is measured as the area of potential spawn deposition to the nearest 10 centimetres at the time of the survey (Moulton and Penttila 2001; de Graaf and Penttila 2006). The length of spawning sediments is measured as the length of the beach composed of appropriate unconsolidated sediments. Beach character is the sediment character of the upper beach and ranges from mud to boulder (Moulton and Penttila 2001). The slope of the upper beach is measured in degrees using a clinometer. Marine riparian overhanging shade is classified into percentage of the length of the beach unit (Moulton and Penttila 2001). The presence or absence at a beach unit of marine riparian vegetation is noted and categorized according to vegetation category. Vegetation categories are grasses, shrubs and trees and combinations of these categories (de Graaf and Penttila 2006). Modification of the foreshore is categorized as the presence of structures that may impede sediment movement, either from land-based erosion sources (bluffs, banks, creeks, rivers) or across the shore (Moulton and Penttila 2001). Modification of the foreshore is measured by a percentage of the total length of the beach unit being impacted (Moulton and Penttila 2001). The presence or absence of modification to the backshore region is noted (up to 30 meter landward of the high water mark) (de Graaf and Penttila 2006). Photo-logs for each beach consist of photos of backshore, marine riparian zones, foreshore, and sediment bands (Moulton and Penttila 2001).

### 7.2.4 Statistical Analyses of Beach Metrics:

A database of positive and negative beaches from British Columbia and Washington State is used to assess the probability that a beach would support forage fish spawning. Beach metrics are used in a Principal Component Analysis using PRIMER-E software. Beaches that cluster with known positives are tested for similarity. A threshold of 80% or greater has been successful in other forage fish habitat assessments where beaches were tested for and found to bear embryos. Beaches that cluster with known negatives are still entered into Grain-Size frequency curve analysis. Beach metrics of negative beaches commonly overlap with positive beaches. This is a reminder that models lack other variables important to the fish that we do not measure or cannot measure.

### 7.2.5 Habitat Coverage:

Beaches are categorized as having continuous sediment bands or discontinuous sediment bands. If the beach sediment bands are interrupted by bands of unfavorable habitat, they are scored as discontinuous if the interruption is less than 100 m. If the interruption is greater than 100 m, the area is assessed as separate beach units.

# 8. Results

## 8.1 North Pender

### 8.1.1 Statistical Analyses

In total, 82 beach areas were assessed. Principal Component Analysis using PRIMER-E and beach metrics clustered 54 beaches within 80% similarity to known positive beaches in BC and Washington State. 50 of these beaches had continuous habitat and 4 had discontinuous habitat. 32 beaches were comprised of unconsolidated sediments such as mud, silt, cobble that are not suitable as spawning habitat (Figure 1: North Pender Map of Assessed Potential Forage Fish Spawning Beaches).

### 8.1.2 Grain-Size Analyses

Grain-size analyses were used to test for likelihood of beaches to support spawning. All grain-size frequencies curves were classified to Type curves. All of the 54 beaches showed grain-size frequencies curves that were within 80% and higher similarity to known positive spawning beaches (Appendix A, Figures 3-8).

### 8.1.3 Length of Potential Forage Fish Spawning Habitat

The total length of potential spawning habitat is 4,469 meters and classified as 500 m specific to Pacific sand lance (11 %), 62 m specific to surf smelt (1.4%), and 3907 meters as mixed surf smelt/Pacific sand lance spawning habitat (87.6%) (Table 1).

Table 1: Classification of N Pender Potential Forage Fish Beach Types

| | PSL | SS | SS/PSL | Total |
|---|---|---|---|---|
| Length (m) | 500 | 62 | 3907 | 4469 |
| Length Percentage | 11% | 1.40% | 87.60% | 100% |

PSL - Pacific sand lance
SS - Surf Smelt

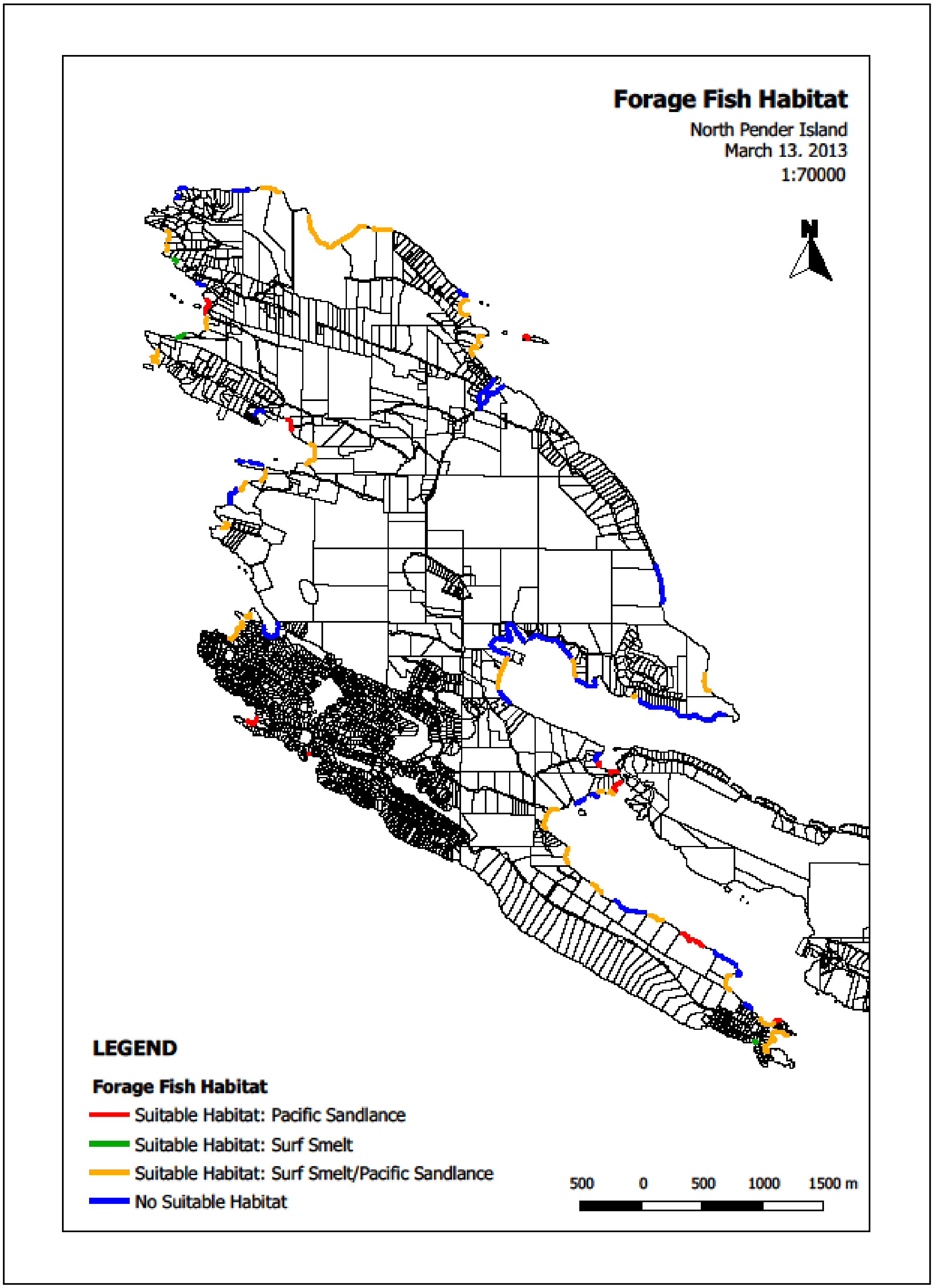


Figure 1: Potential Beach Spawning Forage Fish Spawning Habitats – North Pender

### 8.1.4 Potential Forage Fish Spawning Habitat Types

Of the 54 potential spawning beaches, 13 were classified as Pacific sand lance, 3 as surf smelt, and 38 as mixed surf smelt/Pacific sand lance spawning habitat (Table 2). Of the Pacific sand lance beaches, grain size analysis assessed ten (10) as Type 1 and three (3) as Type 3 Pacific Sand lance beaches. Of the surf smelt beaches, grain size analysis assessed two (2) as Type 1 and one (1) as Type 2 Surf Smelt beaches. Of the mixed surf smelt/Pacific sand lance beaches, grain size analysis assessed twelve (12) as Type 1; twelve (12) as Type 2; nine (9) as Type 3, and five (5) as Type 4 Surf Smelt beaches (Appendix A).

Table 2: North Pender Grain-Size Types

| | PSL | SS | SS/PSL |
|---|---|---|---|
| PSL TYPE 1 | 10 | | |
| PSL TYPE 2 | | | |
| PSL TYPE 3 | 3 | | |
| SS TYPE 1 | | 2 | 12 |
| SSTYPE 2 | | 1 | 12 |
| SS TYPE 3 | | | 9 |
| SS TYPE 4 | | | 5 |
| SS TYPE 5 | | | |

### 8.1.5 Foreshore Modification

Modification of the foreshore is classified as a percentage of the length of the beach that has been altered from a natural state by structures that would impede movement of sediments either to the beach or along the beach. Thirty (30) of the beaches had unmodified shorelines and twenty-four (24) were modified. Of the 54 beaches, 55% were in a natural state; 26% were 1-25% impacted; 6% were 26-50% impacted; 6% were 51-75% impacted; and 7% were 75-100% impacted (30, 14, 3, 3, and 4 respectively)(Table 3).

Table 3: Foreshore Modification - North Pender

| | 0% impact | 1-25% Impact | 26-50% Impact | 51-75% Impact | 76-100% Impact |
|---|---|---|---|---|---|
| Count | 30 | 14 | 3 | 3 | 4 |
| Percentage | 55 | 26 | 6 | 6 | 7 |

### 8.1.6 Foreshore and Backshore Structures

Of the 24 potential forage fish spawning beaches with modified foreshore zones, sediment impeding structures were classified as nine (9) vertical seawalls, five (5) riprap revetments; two (2) stairways to the beach; one (1) foreshore cement infill revetment; seven (7) boat ramps; four (4) wooden piers/docks spanning the intertidal zones; one (1) boat; two (2) boathouses; and one (1) building (Table 4).

Of the potential spawning beaches, 42, or 78%, had modified backshore zones. Backshore structures, comprised thirty-seven (37) homes; one (1) seawall; one (1) riprap retaining wall; six (6) stairways to the beach; one (1) wooden pier/dock spanning the intertidal zone with footings in the backshore; and two (2) boathouses (Table 4). Backshore structures that may negatively impact beaches by disrupting sediment transport were calculated as a percentage of total structures after removal of homes. (Table 4).

Table 4: Foreshore and Backshore Structures - North Pender

| | Foreshore Count | Foreshore Percentage | Backshore Count | *Backshore Percentage |
|---|---|---|---|---|
| Building | 2 | 6 | 37 | |
| Boat Ramp | 7 | 21 | | |
| Boat | 1 | 3 | | |
| Boat House | 2 | 6 | 2 | 18 |
| Dock/Wooden Pier | 4 | 12 | 1 | 9 |
| Seawall | 9 | 27 | 1 | 9 |
| Riprrap | 5 | 15 | 1 | 9 |
| Infill | 1 | 3 | | |
| Stairs | 2 | 6 | 6 | |
| Total | 33 | | 48 | |

*[houses] removed

### 8.1.7 Overhanging Shade Vegetation

Marine riparian overhanging shade is classified into percentage of the length of the beach unit with tree branches overhanging the spawning zone. Trees are, generally, located above the high water mark and subject to removal by property owners. Of the 54 beaches, 20% of the beaches had no overhanging shade; 35% had 1-25% overhead shade; 30% had 26-50% overhanging shade; 11% had 51-75% overhanging shade; 4% had 76-100% overhanging shade (11, 19, 16, 6, and 2 respectively)(Table 5).

Marine riparian vegetation may be absent due to soil conditions, the type of land form, or due to landscaping. Of the beaches with no overhanging shade, 18% had modified foreshore and 82% modified backshore zones; beaches with 1-25% overhead shade, 32% had modified foreshore and 79% modified backshore zones; beaches with 26-50% overhead shade had 38% modified foreshore and 75% modified backshore zones; beaches with 51-75% overhead shade had 50% modified foreshore and 83% modified backshore zones; and beaches with 75-100% overhead shade had 50% modified foreshore and 50% modified back shore zones (Table 5). In general, foreshore and backshore areas had significant losses of shade bearing trees.

Table 5: Overhanging Shade Vegetation - North Pender

| | Fully exposed | 1-25% Shade | 26-50% Shade | 51-75% Shade | 76-100% Shade |
|---|---|---|---|---|---|
| Count | 11 | 19 | 16 | 6 | 2 |
| Percentage | 20 | 35 | 30 | 11 | 4 |
| Foreshore Modified Percentage | 18 | 32 | 38 | 50 | 50 |
| Backshore Modified Percentage | 82 | 79 | 75 | 83 | 50 |

## 8.2. South Pender

### 8.2.1 Statistical Analyses

In total, 48 beach areas were assessed. 32 beaches were classified as being potential forage fish habitat and 16 as not potential. 30 of these beaches had continuous habitat and 2 had discontinuous habitat. Principal Component Analysis using PRIMER-E and beach metrics clustered all 32 beaches within 80% similarity to known positive beaches in BC and WA State. 12 beaches were comprised of unconsolidated sediments such as mud, silt, cobble that are not suitable as spawning habitat (Figure 2: South Pender Map of Assessed Potential Forage Fish Spawning Beaches).

### 8.2.2 Grain-Size Analyses

Grain-size analyses were used to test for likelihood of supporting spawning. All grain-size frequencies curves were classified to Type curves. All of the 32 beaches showed grain-size frequencies curves that were within 80% and higher similarity to known positive spawning beaches (Appendix A, Figures 9-12).

### 8.2.3 Length of Potential Forage Fish Spawning Habitat

The total length of potential spawning habitat is 3,098.3 meters and classified as 73 m specific to Pacific sand lance (2.4%), 461.3 m specific to surf smelt (15%), and 2,564 meters as mixed surf smelt/Pacific sand lance spawning habitat (83%) (Table 6).

Table 6: Classification of S Pender Potential Forage Fish Beach Types

| | PSL | SS | SS/PSL | Total |
|---|---|---|---|---|
| Length (m) | 73 | 461.3 | 2564 | 3,098.30 |
| Length Percentage | 2.40% | 15% | 83% | 100% |

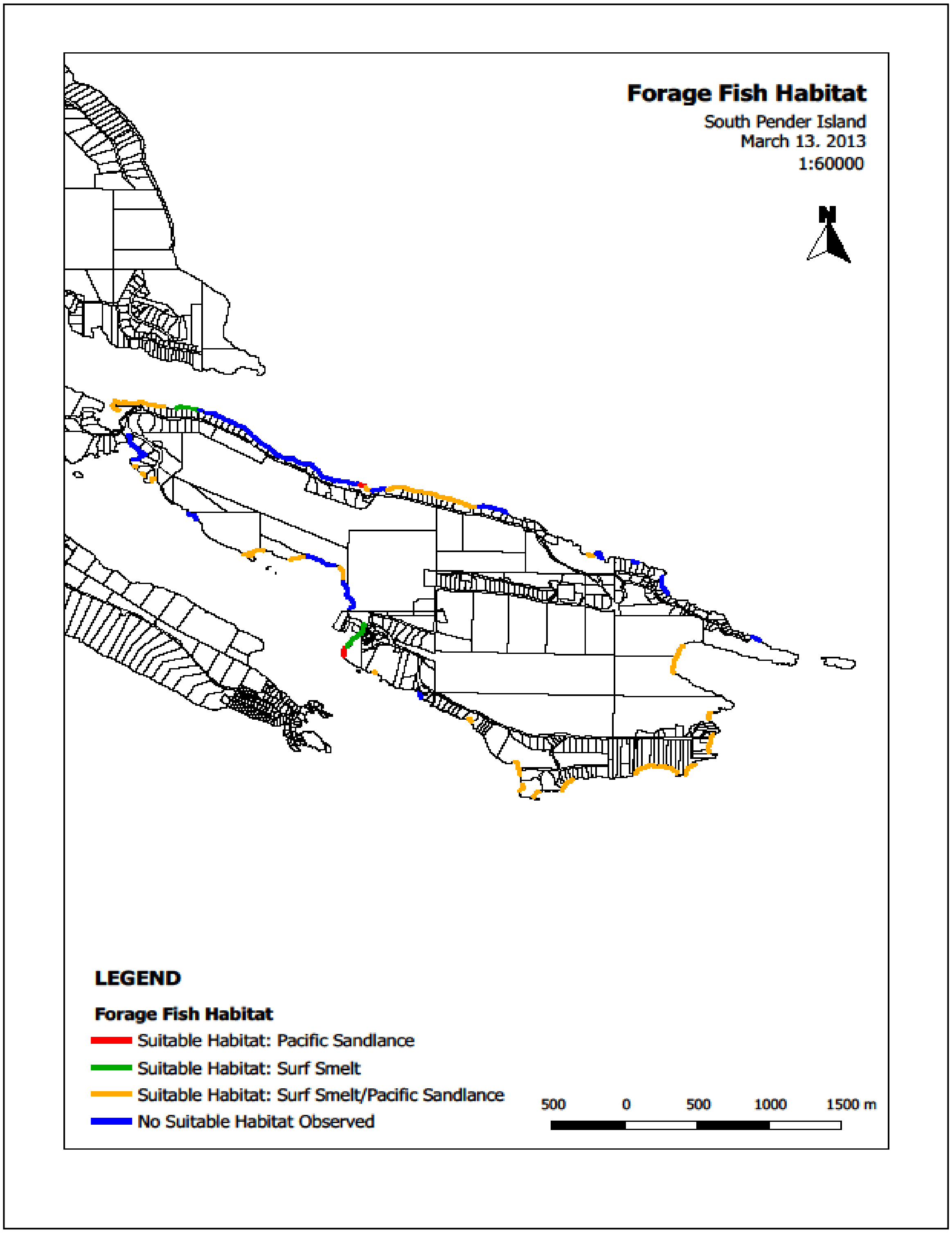


Figure 2: Potential Beach Spawning Forage Fish Spawning Habitats – South Pender

8.2.4 Potential Forage Fish Spawning Habitat Types

Of the 32 potential spawning beaches, 3 were classified as Pacific sand lance, 3 as surf smelt, and 26 as mixed surf smelt/Pacific sand lance spawning habitat (Table 7). Of the Pacific sand lance beaches, grain size analysis assessed three (3) as Type 1 Pacific sand lance beaches. Of the surf smelt beaches, grain size analysis assessed two (2) as Type 1 and one (1) as Type 2 Surf Smelt beaches. Of the mixed surf smelt/Pacific sand lance beaches, grain size analysis assessed nine (9) as Type 1; ten (10) as Type 2; seven (7) as Type 3 (Appendix B).

Table 7: South Pender Grain-Size Types

| | PSL | SS | SS/PSL |
|---|---|---|---|
| PSL TYPE 1 | 3 | | |
| PSL TYPE 2 | | | |
| PSL TYPE 3 | | | |
| SS TYPE 1 | | 2 | 9 |
| SSTYPE 2 | | 1 | 10 |
| SS TYPE 3 | | | 7 |
| SS TYPE 4 | | | |
| SS TYPE 5 | | | |

8.2.5 Foreshore Modification

Modification of the foreshore is classified as a percentage of the length of the beach that has been altered from a natural state by structures that would impede movement of sediments either to the beach or along the beach. Of the 32 beaches, 84% were in a natural state;

12.5% were 1-25% impacted; and 3.5% were 26-50% impacted (27, 4, and 1 respectively). No beaches were classified in the highest impact categories of 51-75% and 75-100% (Table 8).

Table 8: Foreshore Modification Categories - South Pender

| | 0% impacted | 1-25% Impacted | 26-50% Impacted | 51-75% Impacted | 76-100% Impacted |
|---|---|---|---|---|---|
| Count | 27 | 4 | 1 | 0 | 0 |
| Percentage | 84 | 12.5 | 3.5 | 0 | 0 |

### 8.2.6 Foreshore and Backshore Structures

Six potential forage fish spawning beaches had modified shorelines. Sediment impeding structures were classified as three (3) vertical seawalls, two (2) riprap revetments; one (1) stairway to the beach; two (2) piers/dock spanning the foreshore and one (1) outfall pipe. The marina at Poets Cove accounted for four foreshore structures and five residential properties accounted for five foreshore structures (Table 9).

Of the potential beaches, 18, or 56%, had modified backshore zones. The majority of the structures were homes. Other than homes, these consisted of one (1) riprap revetment and three (3) stairways (Table 9). Backshore structures that may negatively impact beaches by disrupting sediment transport were calculated as a percentage of total structures after removal of homes (Table 9).

Table 9: Foreshore and Backshore Structures South Pender

| | Foreshore Count | Foreshore percentage | Backshore Count | *Backshore Percentage |
|---|---|---|---|---|
| Building | | | 18 | |
| Boat Ramp | | | | |
| Boat | | | | |
| Boat House | | | | |
| Dock/Wooden Pier | 2 | 22 | | |
| Outfall Pipe | 1 | 11 | | |
| Seawall | 3 | 33 | | |
| RipRap | 2 | 22 | 1 | 25 |
| Stairs | 1 | 11 | 3 | 75 |
| Total | 9 | | 22 | |

*[houses] removed

### 8.2.7 Overhanging Shade Vegetation

Marine riparian overhanging shade is classified into percentage of the length of the beach unit with tree branches overhanging the spawning zone. Trees are, generally, located above the high water mark and subject to clearing by property owners. Of the 32 beaches, 38% of the beaches had no overhanging shade; 31% had 1-25% overhead shade; 16% had 26-50% overhanging shade; 9% had 51-75% overhanging shade; 6% had 76-100% overhanging shade (12, 10, 5, 3, and 2 respectively) (Table 10).

Overall, the percentage of overhanging shade vegetation is low. Marine riparian vegetation may be absent due to soil conditions, the type of land form, or due to landscaping. Of the beaches with no overhanging shade, 25% had modified foreshore and 58% modified backshore zones; beaches with 1-25% overhead shade, 10% had modified foreshore and 60% modified backshore zones; 26-50% overhead shade had 20% modified foreshore and 60% modified backshore zones; 51-75% overhead shade had 33% modified foreshore and 33% modified backshore zones; and 75-100% overhead shade, 0% modified foreshore and 100% modified backshore zones (Table 10). In general, areas of low foreshore modification have higher percentages of overhanging shade vegetation. Backshore development impact on degree of overhanging shade vegetation was variable.

Table 10: Overhanging Shade Vegetation - South Pender

| | Fully exposed | 1-25% Shade | 26-50% Shade | 51-75% Shade | 76-100% Shade |
|---|---|---|---|---|---|
| Count | 12 | 10 | 5 | 3 | 2 |
| Percentage | 38 | 31 | 16 | 9 | 6 |
| Foreshore Modification Percentage | 25 | 10 | 20 | 33 | 0 |
| Backshore Modification Percentage | 58 | 60 | 60 | 33 | 100 |

## 9. Summary and Recommendations

With approximately 7.5 kilometers of potential spawning habitat over 86 beaches, North and South Pender islands provide an excellent area to safeguard and protect these critical fish habitats. As stated in the introduction, marine shorelines are critical fish habitat not only for spawning surf smelt and Pacific sand lance, but also provide rearing grounds for juvenile salmonids. Habitats such as marine riparian vegetation, gravel/sandy beaches and high water-quality are important to maintain the health of these spawning areas. Key to maintaining and restoring these shoreline areas will be measures to limit physical structures that negatively affect sediment transport as well as actions that protect marine riparian vegetation. Education of land owners and an expanded spawning survey project are all central to protecting these beaches.

Marine riparian vegetation is a valued ecosystem component that provides benefits for human security and benefits to the ecosystem. Recent studies from Puget Sound and Squamish confirm the use of marine shorelines as rearing habitat for juvenile salmonids, such as Chinook. Dietary analyses show that up to 50% of the stomach contents of juvenile Chinook were composed of insect “windfall”, insects transported by winds from marine shoreline vegetation to the water’s surface (Brennan and Culverwell 2004). Marine vegetation is also important for the survival of summer surf smelt embryos. Foreshore areas on North Pender such as Clam Bay and Browning Beach could benefit by replanting tall vegetation. Overtime, restoration of trees at areas such as these would also provide overhanging shade for summer surf smelt embryos.

On North Pender, while the number of concrete seawalls affecting potential forage fish beaches was not high, there were some shoreline properties that had significant hardening. In light of future sea level change predictions, as well as shoreline development, pressures to harden shorelines will increase.

There are a generous number of beach access areas on North and South Pender and these are very important in areas of bluffs and high-banks. Designating beach access points benefits management of fragile slopes by reducing the need for private stairways. Overall, the stairways that were constructed down bluffs and high-banks were excellent and appeared to maintain vegetation within the stair footprint.

An area of concern on North Pender is Grimmer Bay. One section of the shoreline has a cluster of neighbouring shoreline properties serving as boat storage for derelict boats and the infrastructure of what may have been a former boat building business. All of these items are in the foreshore. Piles of paint cans, solvents and construction materials are stored inappropriately on the foreshore. Grimmer Bay also has a large seawall and concrete roadway extending to the shore. Recently the seawall was extended to protect an archeological site. Upland development along Grimmer Bay has also been extensive in some areas.

North Pender appears to have higher losses of marine riparian vegetation and overhanging shade vegetation and a higher foreshore modification impact level than South Pender. On North Pender, 44% of the beaches were impacted by structures that impeded the delivery of sediments to the beaches or the transport of sediments along the drift cell with only 16% (5 of 32) of the beaches being so impacted on South Pender. Also, on South Pender there were no foreshore modification classes noted above 51%. Commercial development on South Pender at Poets Cove accounted for a significant percentage of the foreshore structures documented (4 of 9 foreshore structures). Five residential properties accounted for one set of stairs, one seawall, two riprap structures and one pier/dock. On South Pender, backshore modification is generally correlated with land-use; residential land-use accounted for 15 of the 32 beaches. With the exception of a few properties, the majority of land-owners on both North and South Pender have maintained high levels of vegetation and had low levels of impact to the shoreline.

It should be noted that only potential forage fish beaches were inventoried for foreshore structures such as seawalls and private docks. There are a significant number of shoreline properties without unconsolidated sediment beaches that have private docks.

More generally, it was noted that bluffs are a common land form on North and South Pender. Protecting soils and vegetation on bluff tops is critical to managing erosion. A general perception is that wave forces are largely responsible for eroding bluffs. However, in some cases, it is actually human activities on bluff tops and high-bank land forms that contribute more to slumping bluffs and damage to residential properties. Both North and South Pender have a large number of properties located on bluff tops. Some land owners have responded by adding riprap or seawalls at the high water mark along their property lines which encroach on the foreshore (e.g. Irene Bay, N. Pender). Educating land owners about methods to reduce soil saturation by rain and storm water is a primary recommendation. Modification of bluff top activities would reduce the need for erosion protection at bluff toes, preventing damage to spawning habitat. Managing storm water, setting structures back from the edge, maintaining vegetation and using pervious gravels in driveways are all common ways of protecting bluff top properties. Controlling storm water runoff and reducing impervious surfaces is not just for the shoreline property owner but is part of good management throughout a watershed. Excellent resource materials for managing building on many land forms, including bluffs, are available on the Washington State, Department of Ecology website.

Throughout North Pender and South Pender, continued good stewardship of shoreline vegetation needs to be actively encouraged and could be formalized in regulation. Section 3.4.4 of the Islands Trust Policy Statement requires that local trust committees address protection of sensitive coastal areas in official community plans and regulatory bylaws. Section 3.4.5 requires that local trust committees address the planning for and regulation of development in coastal regions to protect natural coastal processes. Both the North Pender and the South Pender Official Community Plans have objectives to protect sensitive marine habitats. Potential forage fish spawning beaches are a sensitive nearshore habitat and protection measures for these beaches could be included in Land Use Bylaws and shoreline development permit areas. In creating regulatory protection mechanisms, there should also be consideration of bylaw enforcement.

Forage Fish Habitat Assessments can only grade beaches as to their spawning potential. FFHAs can overestimate actual spawning habitats. The actual presence or absence of spawning activity at beaches can only be determined after conducting spawning surveys according to establish protocols. Islands Trust communities are undertaking these spawning surveys. In the interests of effective land-use management, the Islands Trust and the Island Trust Fund would be well served to support these communities in the future.

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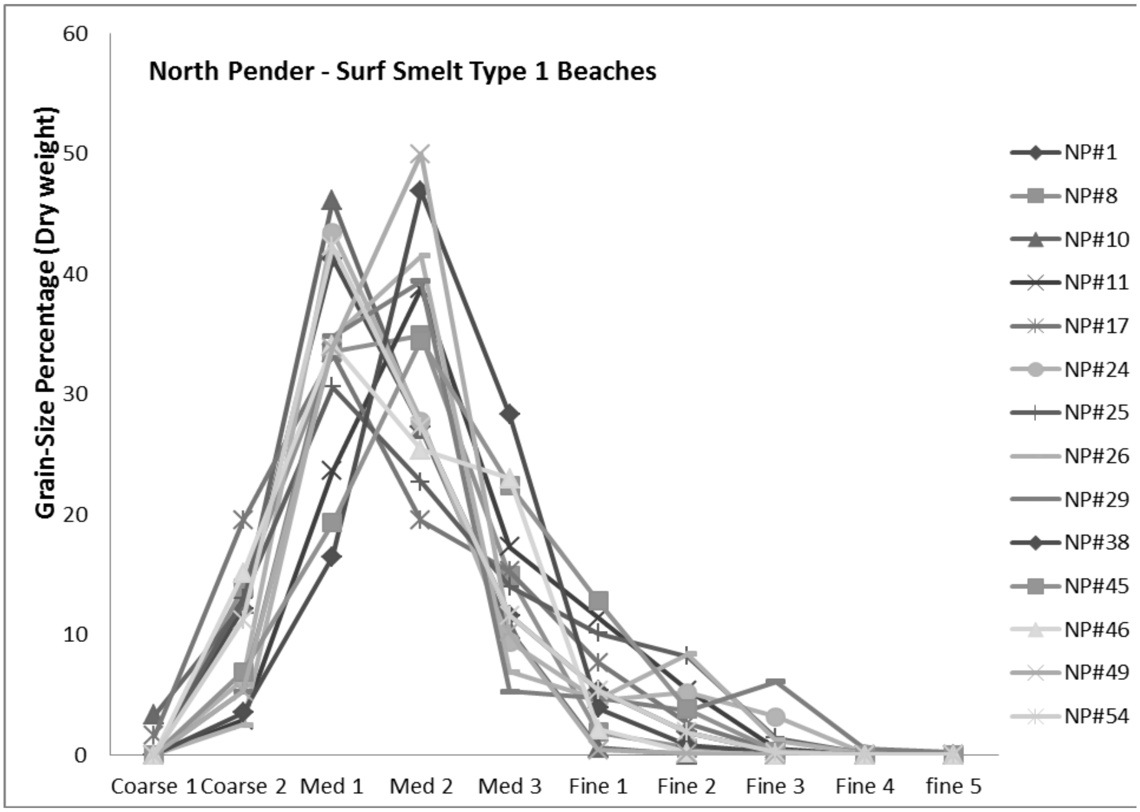


Figure 3: North Pender – Surf Smelt Type 1 Beaches

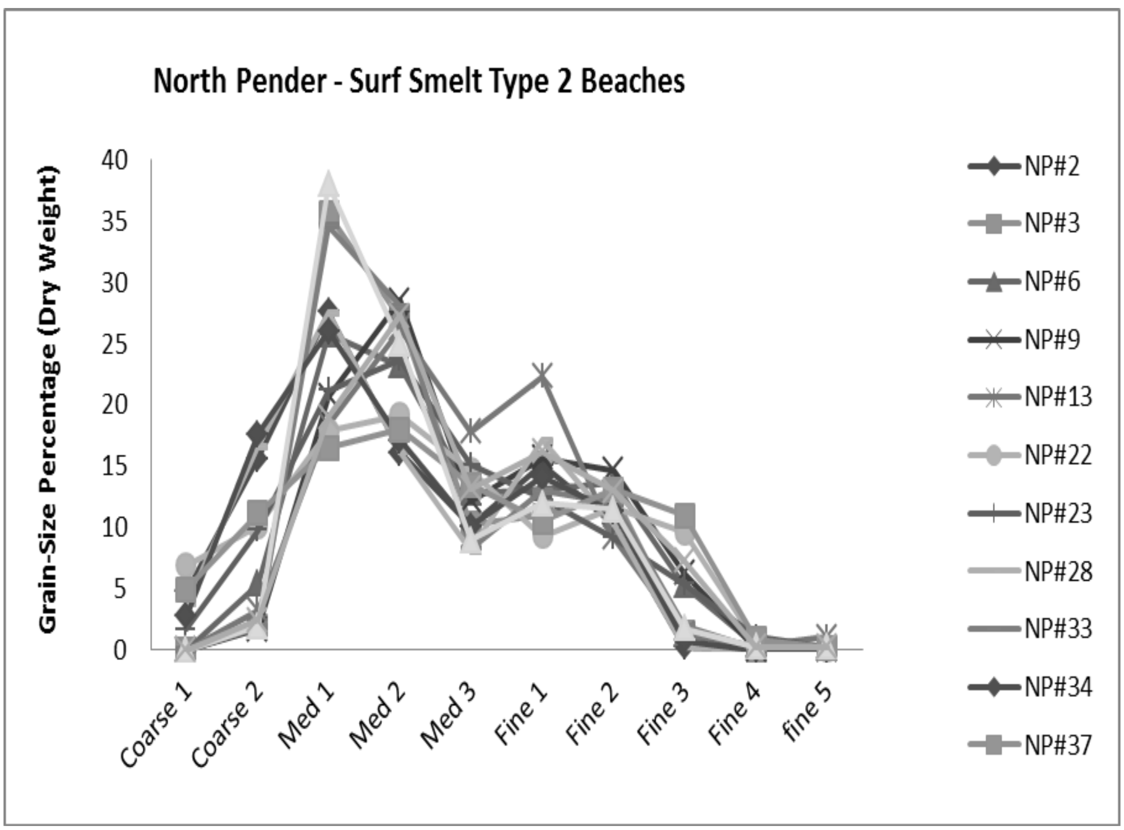


Figure 4: North Pender - Surf Smelt Type 2 Beaches

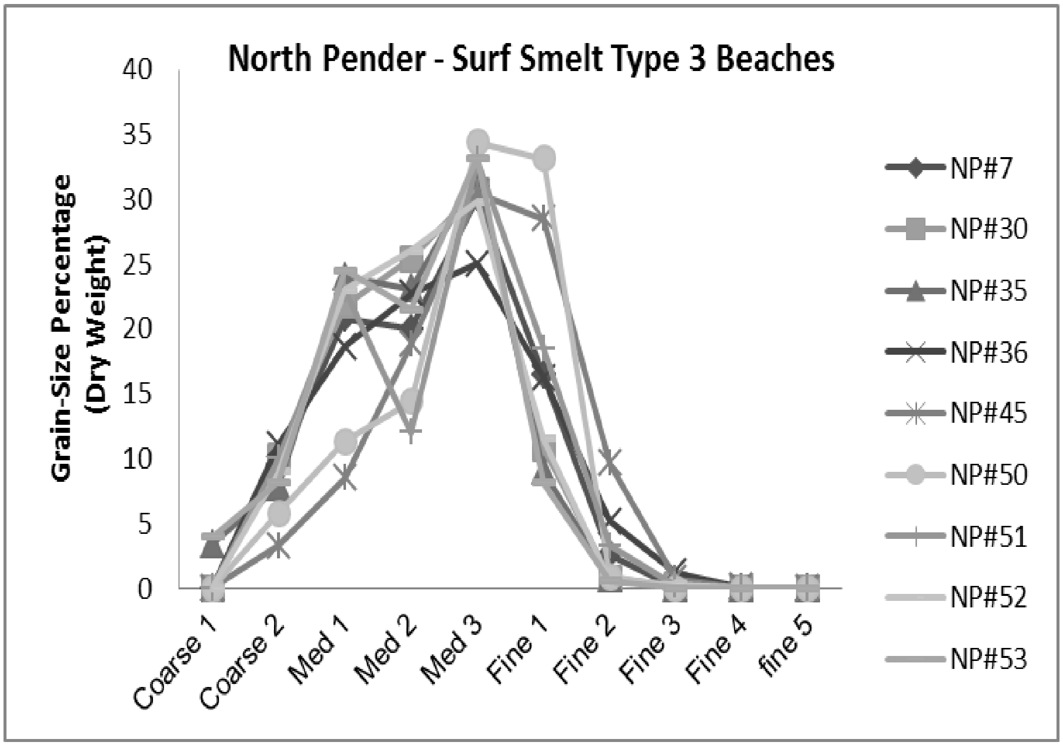


Figure 5: North Pender
Surf Smelt type 3 Beaches

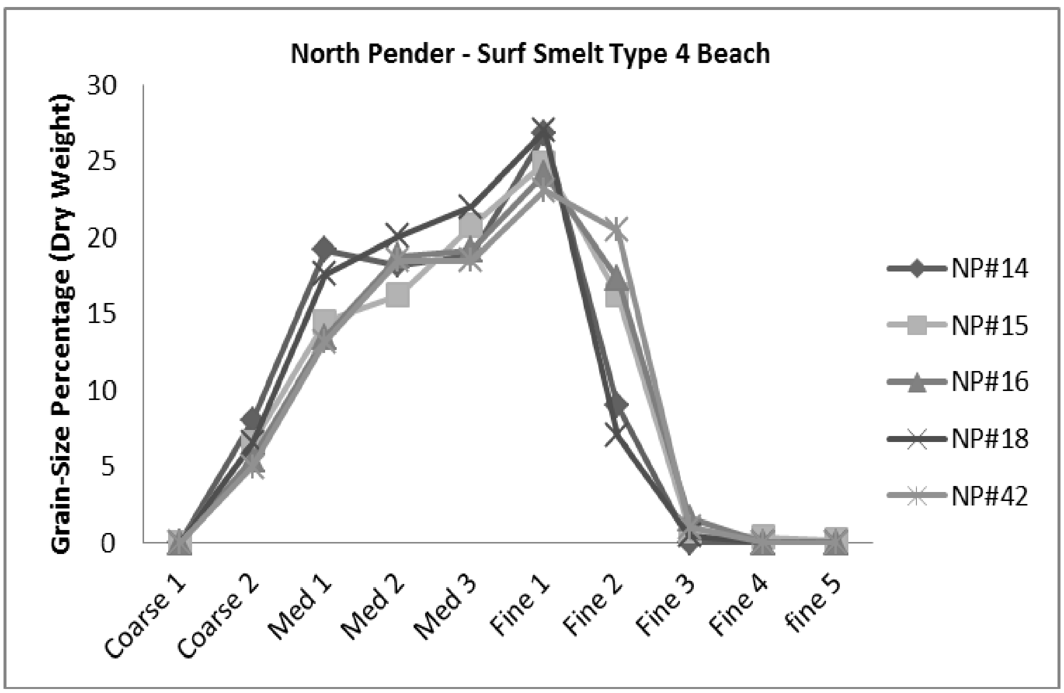


Figure 6: North Pender
Surf Smelt Type 4 Beaches

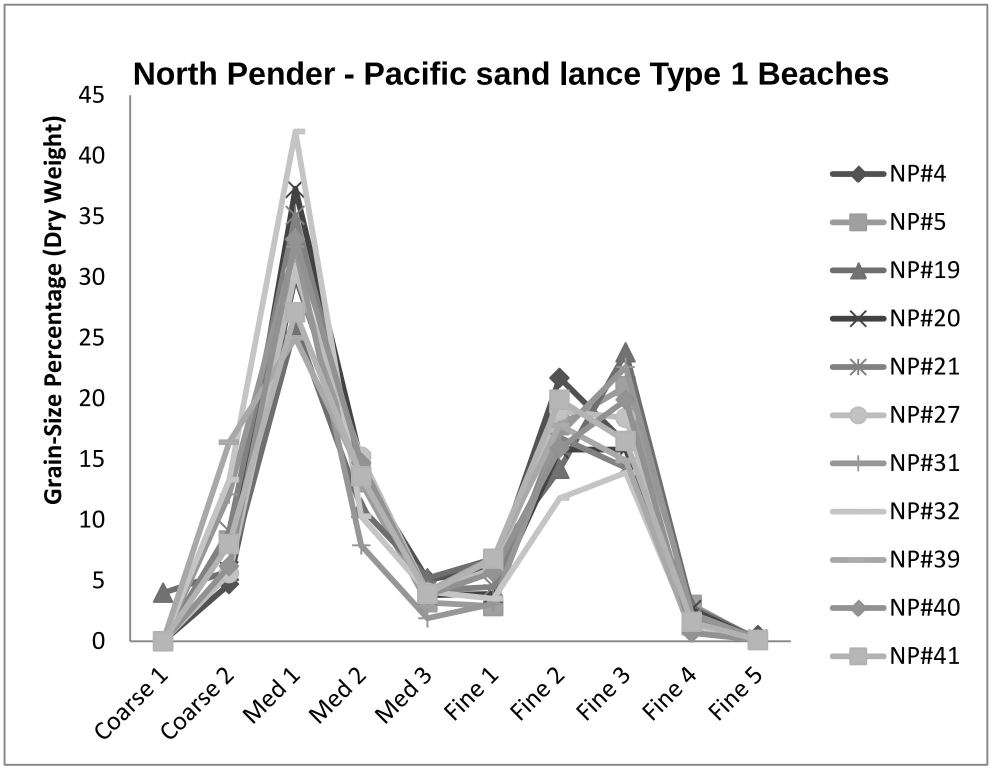


Figure 7: North Pender –
Pacific sand lance Type 1 Beaches

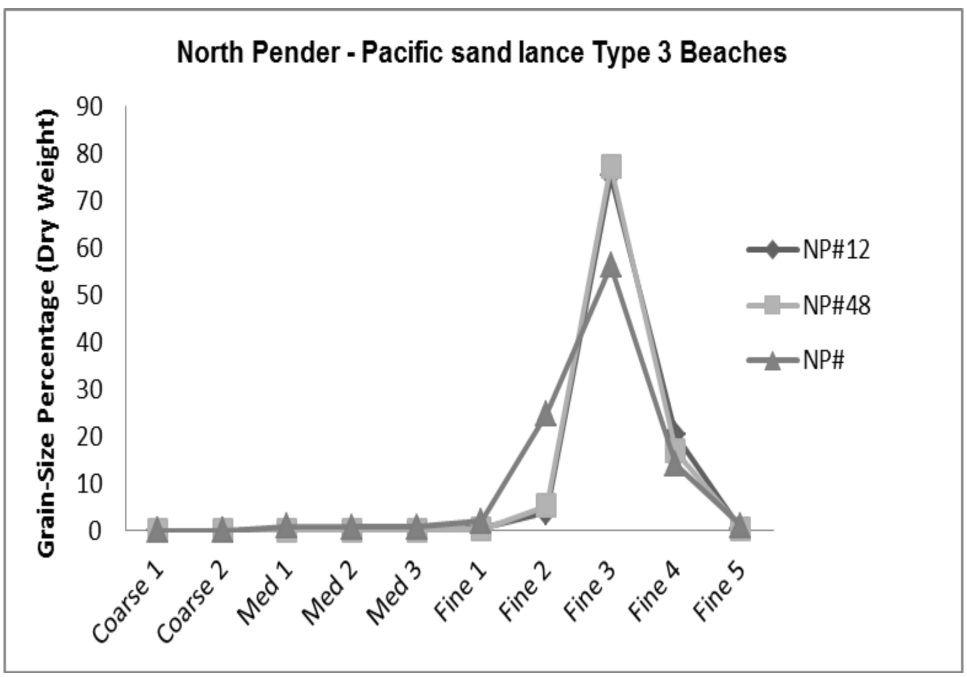


Figure 8: North Pender
Pacific sand lance type 3 Beaches

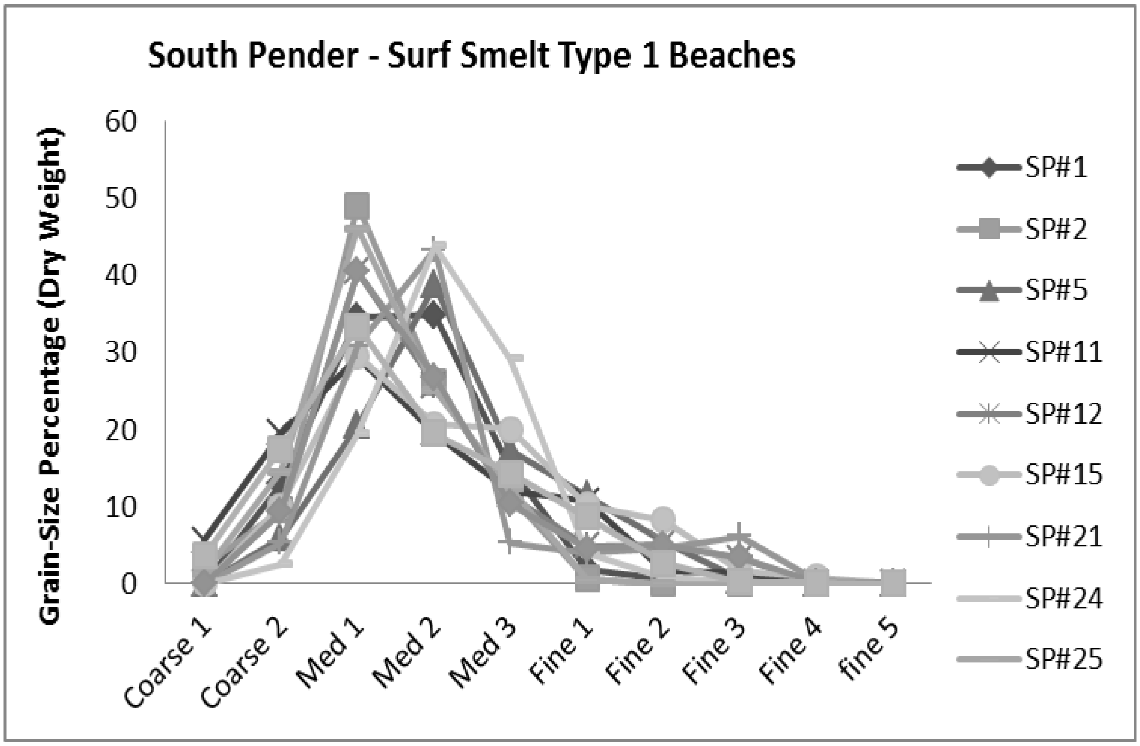


Figure 9: South Pender –
Surf Smelt Type 1 Beaches

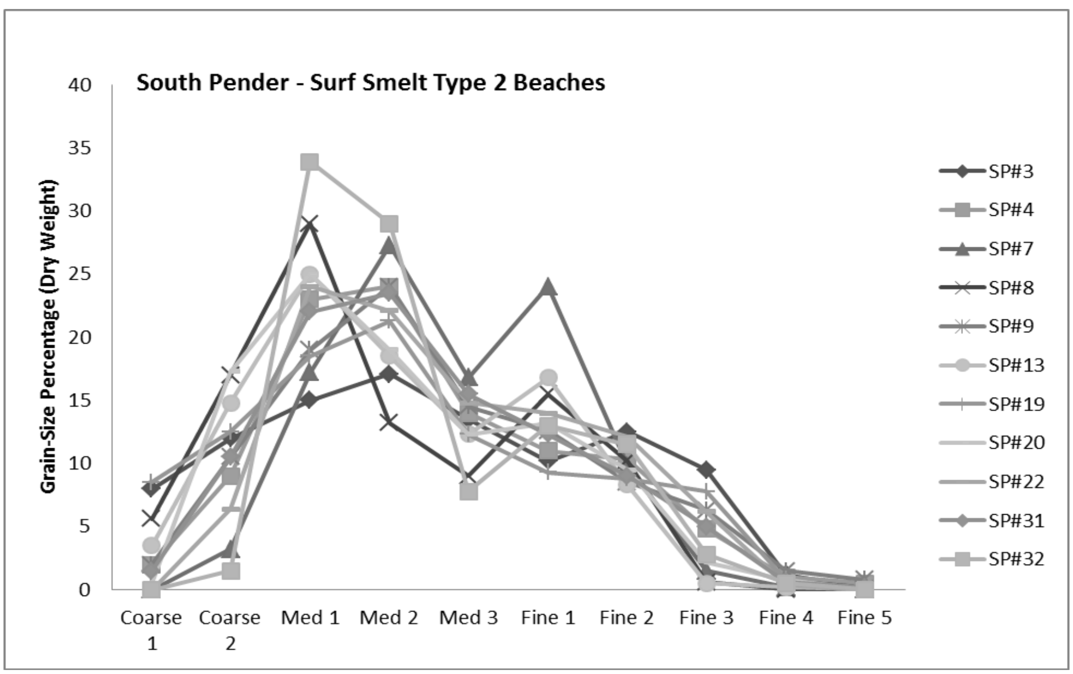


Figure 10: South Pender
Surf Smelt Type 2 Beaches

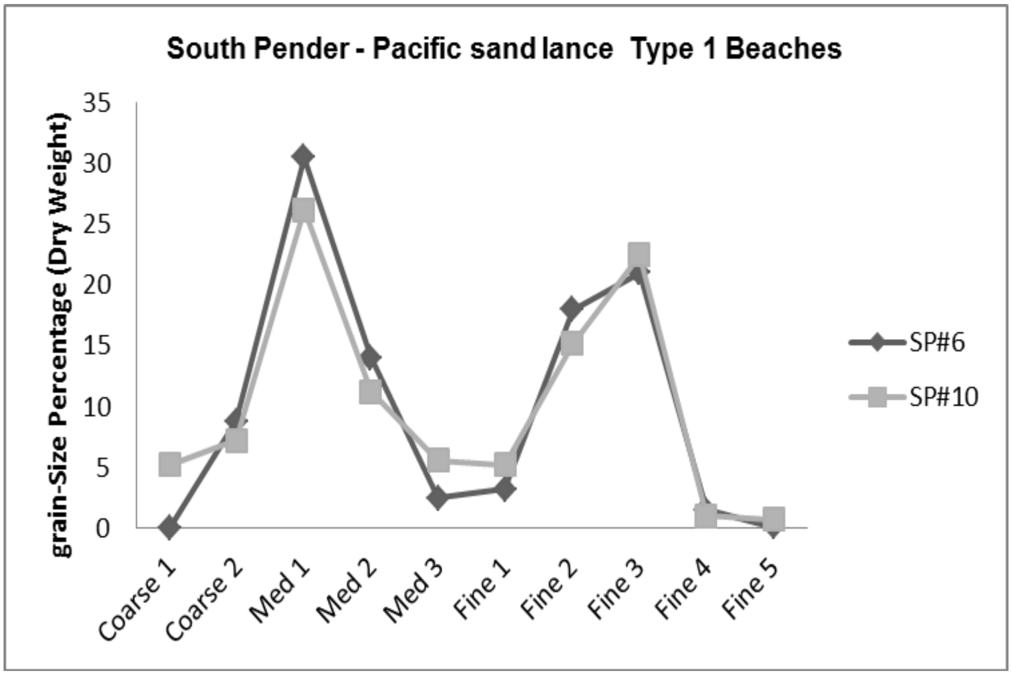


Figure 11: South Pender
Pacific sand lance Type 1 Beaches

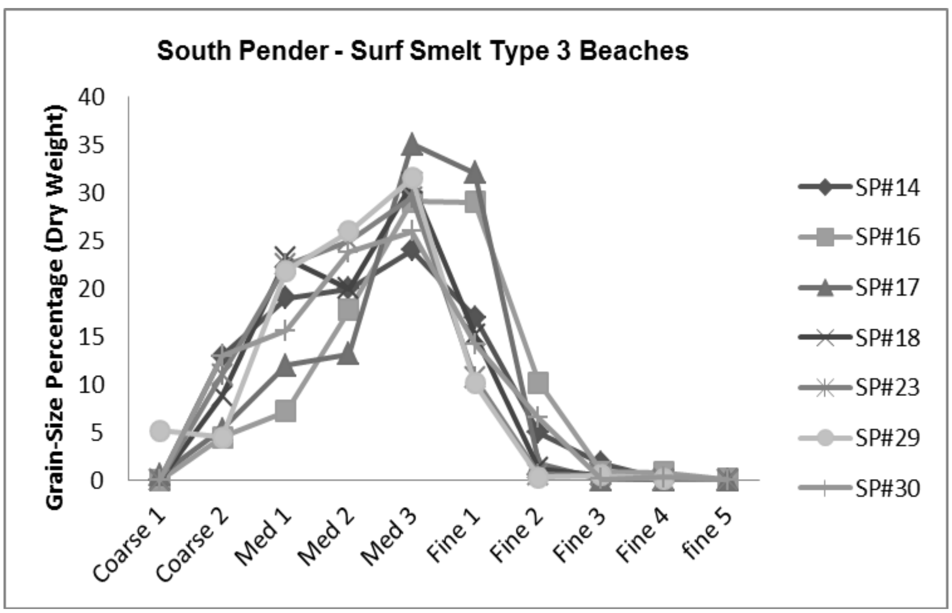


Figure 12: South Pender
Surf Smelt Type 3 Beaches

Appendix B

## Beach Type Classifications - North Pender

| | Surf Smelt Type 1 | | Surf Smelt Type 2 |
|---|---|---|---|
| Beach Number | North Pender Beach Name | Beach Number | North Pender Beach name |
| NP#1 | Stanley Pnt; Vassaleves | NP#2 | Stanley Pnt; Glass Beach |
| NP#8 | Stalker Rd | NP#3 | Bridges Rd Beach |
| NP#10 | James Pnt W side | NP#6 | Grimmer (Camelot) |
| NP#11 | James Pnt MacKinnon Rd | NP#9 | James Pnt S side |
| NP#17 | Panda Bay | NP#13 | Boat House Bay |
| NP#24 | Peter Cove 2 | NP#22 | Wallace Point |
| NP#25 | Peter Cove 4 | NP#23 | Peter Cove 1 |
| NP#26 | Peter Cove 5 | NP#28 | Starvation Bay 2 |
| NP#29 | Starvation Bay 3 | NP#33 | Bedwell Harbour 2 |
| NP#38 | Canal South 1 | NP#34 | Bedwell Harbour 3 |
| NP#45 | nr Razor Pnt | NP#37 | pocket cove N Medicine |
| NP#46 | nr Hope Bay | NP#43 | Port Browning N2 |
| NP#49 | Bricky Bay | NP#44 | Port Browning N 1 |
| NP#54 | Peter Cove 3 | | |

| | Surf Smelt Type 3 | | Surf Smelt Type 4 |
|---|---|---|---|
| Beach Number | North Pender Beach Name | Beach Number | North Pender Beach Name |
| NP#7 | Grimmer (S of Camelot) | NP#14 | Roe Bay |
| NP#30 | Starvation Bay | NP#15 | Roeland |
| NP#35 | Bedwell Harbour 4 | NP#16 | Irene Bay |
| NP#36 | Medicine beach | NP#18 | Chart Rd |
| NP#45 | Welcome Bay | NP#42 | Browning Beach |
| NP#50 | Tracy Rd | | |
| NP#51 | Clam Bay 1 | | |
| NP#52 | Clam Bay 2 | | |
| NP#53 | North of Clam Bay | | |

| | Pacific sand lance Type 1 | | Pacific sand lance Type 3 |
|---|---|---|---|
| Beach Number | North Pender Beach Name | Beach Number | North Pender Beach Name |
| NP#4 | pocket nr Grimmer | NP#12 | Otter Bay; Niagara Rd |
| NP#5 | nr Grimmer Bay | NP#48 | Fance Islet |
| NP#19 | Thieves Bay 1 | | |
| NP#20 | Thieves Bay 2 | | |
| NP#21 | Boat Nook | | |
| NP#27 | Starvation Bay 1 | | |
| NP#31 | Bedwell Harb | | |
| NP#32 | Nr Timbers | | |
| NP#39 | Canal South 2 | | |
| NP#40 | Shark Cove NE side bridge | | |
| NP#41 | Shark Cove  mid | | |

Appendix C

## Beach Type Classifications - South Pender

| | Surf Smelt Type 1 | | Surf Smelt Type 2 |
|---|---|---|---|
| Beach Number | South Pender Beach Name | Beach Number | South Pender Beach name |
| SP#1 | Ainsile Pnt 1 | SP#3 | Ainsile Pnt 3 |
| SP#2 | Ainsile Pnt 2 | SP#4 | Beaumont Mrn Park SW |
| SP#5 | Beaumont Mrn Park SE | SP#7 | nr RedMarker |
| SP#11 | South of Poets Cove | SP#8 | S of Mrn Park 1 |
| SP#12 | Tilly Pnt 1 | SP#9 | Poets Cove Marina |
| SP#15 | Tilly Pnt 4 | SP#13 | Tilly Pnt 2 |
| SP#21 | Canned Cod Bay | SP#19 | Brooks Pnt |
| SP#24 | Mortimor Spit 2 | SP#20 | Gowland Pnt |
| SP#25 | Mortimor Spit 3 | SP#22 | Camp Bay |
| SP#26 | Spender Coast nr Mortimor Spit 3 | SP#31 | S Pender mid E coast 4 |
| SP#27 | E of Mortimor Spit 2 | SP#32 | S Pender SE coast 5 |

| | Surf Smelt Type 3 | | Pacific sand lance Type 1 |
|---|---|---|---|
| Beach Number | South Pender Beach Name | Beach Number | South Pender Beach Name |
| SP#14 | Tilly Pnt 3 | SP#6 | Islet Mrn Park |
| SP#16 | Craddock Rd Beach Access | SP#10 | Day Beacon P Cove |
| SP#17 | Drummond N | SP#28 | S Pender mid E coast |
| SP#18 | Drummond S | | |
| SP#23 | Mortimor Spit 1 | | |
| SP#29 | S Pender mid E coast 2 | | |
| SP#30 | S Pender mid E coast 3 | | |