Lasqueti Island
Surf smelt and Pacific sand lance
Spawning Habitat Suitability Assessments

Chris & Doug's Beach – Lasqueti Island
Photo: RC de Graaf

Prepared for the Islands Trust Fund and Pacific Salmon Foundation

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Dr. Connie Haist’s well-packed
forage fish support vehicle
Photo: RC de Graaf

1. Introduction

The term "forage fish" refers to small schooling fishes that are prey for larger animals. Forage fish, or "feeder fish", include species such as herring, anchovy, sardines, capelin, smelt and sand lance. This study focusses on beach spawning forage fish: Pacific sand lance and surf smelt.

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 to as the most important fish in the North East Pacific due to this species role as forage for marine fishes, seabirds and marine mammals (Robards 1999). Surf smelt are also important prey for marine predators. Surf smelt are managed by the 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 Role of forage fish in marine ecosystems

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 blue-listed coastal cutthroat trout. Both juvenile and adult Chinook and Coho feed on a high percentage of Pacific sand lance.

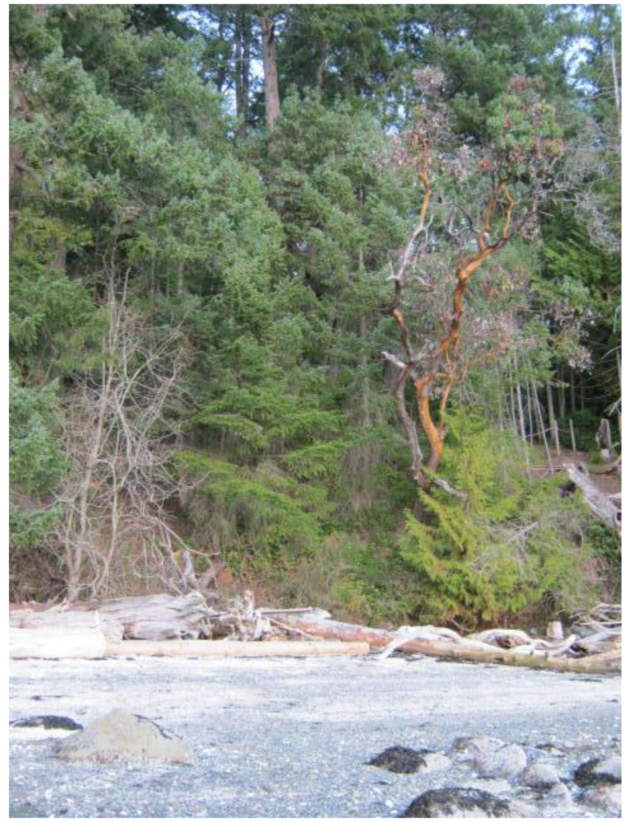
Numerous fish, seabird, and marine mammal populations are in precipitous decline in British Columbia and scientists have started to look at the link between forage fish biomass reduction and these declining populations.

1.2 Connections to other valued ecosystem components

Forage fish depend on nearshore habitats for their survival during several critical life-history stages. 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. Backshore components provide sediment sources, marine riparian vegetation and nutrients necessary to create and maintain beach habitats.

1.3 Protecting the ecosystem services of Marine Riparian Vegetation

Marine riparian vegetation, gravel/sand beaches and good water-quality are important to the health of these spawning areas. A healthy Surf smelt/Pacific sand lance spawning beach has an intact marine riparian buffer zone, overhanging shade vegetation, a supply of pebble and sand and clean water. Shade from overhanging shoreline vegetation keeps summer Surf smelt eggs moist. Removing shoreline vegetation increases temperatures within the spawning gravels; and on hot summer days, Surf smelt egg mortality is high (Penttila 2001, Rice 2006). 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 and water quality. Land-owner education and expanded biological surveys are all central to protecting these beaches. Careful site planning and guidance can protect shoreline habitats.



Marine Riparian Vegetation - Photo: RC de Graaf

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).

Overhanging Shade Vegetation
Photo: RC de Graaf

Marine riparian vegetation provides ecological benefits as well as a net benefit to property owners as a free “ecosystem service” limiting erosion and stabilizing slope soils. Trees and shrubs absorb large volumes of rain water and filter pollutants. Vegetation removal may cause large sediments loads to enter the ocean limiting light for eelgrass growth and clogging fish gills. A vegetative corridor is an effective, low-cost measure to reduce storm-water runoff and shoreline erosion.

Too often “wave attack” is singled out as causing shoreline banks to erode resulting in falling trees and slumping shoreline slopes. More often, the cause is actually simpler and much easier to control. Marine riparian vegetation loss is often a major contributing factor to or cause of shoreline erosion. Removing trees and shrubs in favour of a lawn near the high water mark can increase land slumping, run off and shoreline bank erosion. Maintaining even a narrow corridor of natural trees and shrubs, even integrated with horticultural landscaping, is an effective way of managing water-run off and mitigating shoreline erosion. Trimming and limbing trees rather than removal adds habitat and absorbs rain-water.

Diverting storm-water through pipes and ditches that empty directly into banks or onto beaches is another cause of erosion. It is easier and less damaging to the environment to re-route storm water into municipal infrastructure or into “rain gardens”. When inspecting shoreline edges, consider the natural protection from nearby islets/islands and rocky headlands that limit winds and reduce wave exposure. Often land owners chose to armour water-front properties when nature has already provided ample protection from most wind and storm events. Soft-sediment (gravel and sand) beaches and logs are an efficient and natural “sea” defence as they dissipate wave energy through their movement, unlike hard, vertical seawalls/riprap that can only displace wave energy causing sediment scour, degradation of beaches. Armouring failure places homes and infrastructure at risk.

Foreshore areas lacking vegetation and overhanging vegetation could benefit by restoring vegetation. Overtime, restoration of shrubs and trees (eg alders, arbutus, and maple) along the shoreline edge provides overhanging shade for summer Surf smelt embryos, insect prey for juvenile salmonids and benefits land-owners by stabilizing shoreline sediments. This is particularly important on land forms of eroding cliff/bluff and bank habitats. With careful site planning, shoreline vegetation and other landowner values, such as views, can be maintained.

2. Beach Spawning Forage Fish Habitat

Beach spawning forage fish of commercial, recreational and ecological value in the Strait of Georgia are capelin, surf smelt (*Hypomesus pretiosus)* and Pacific sand lance (*Ammodytes personatus)*. The Washington Department of Fish and Wildlife has conducted extensive surveys in Puget Sound and produced maps of spawning habitat (Penttila, D. 2007). Washington State surveys have been conducted since 1972 (Penttila 2001b). Unfortunately critical spawning habitat of these two forage fishes has not been mapped by government agencies 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 sand are an optimal state for spawning surf smelt and sand lance. Of primary importance for spawning is the mixture of gravels and sand. Extant backshore vegetation and marine riparian zones maintain natural soil erosion rates, filter storm water, and overhanging shade increases the survivability of spawned embryos.

Overhanging shade vegetation and backshore marine riparian vegetation - Marshall's Beach – Lasqueti Island - Photo: RC de Graaf

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. Pacific sand lance spawn may also be found on the sand flat edge near the beach slope (Penttila 2001b, Penttila 2007, de Graaf unpublished data); however, this area of the intertidal has been sparsely sampled.

3.2 Sediment Characteristics

Powder Flask Cove, Lasqueti Island
LIFFT Team surveying in progress
Photo: C. Haist

Both surf smelt and Pacific 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). Generally, 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). Pacific 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). Full analysis of the Penttila data set (2001c) shows a wide range of spawning sediments including coarse pebble/sand beaches greater than 2.6 cm. Recent findings in British Columbia reveal that Pacific sand lance embryos are also found in beaches bearing a high percentage of coarse pebble greater than 2.6 cm (de Graaf unpublished data). Pacific 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 Pacific sand lance embryos can be found throughout a beach drift cell and all zones (erosion, transport and accretion) (de Graaf, unpublished data, presented at American Fisheries Society Conference Sept 2011). Over 40 years of government sponsored surveys in Puget Sound and surveys 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

Sediments characterizing spawning habitats are typically of fine sediment (sand/pebble) distributed on the beach faces (upper intertidal) of soft-sediment landforms such as pocket coves, bluff-backed beaches and barrier beaches. These finer sediment bands often transition into lower (seaward) bands of cobble zones before the beach face transitions into the lower profile beach terrace (flat), or mid-intertidal zone. The width of the spawning deposition zone (commonly referred to as the B1 component) is variable and can range from 0.5 m to over 10 m in width dependent on geomorphic setting.

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, this same pattern has been detected (de Graaf unpublished data). Pacific 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 communities working with the author through the BC Shore Spawners Alliance (BCSSA), a project of the BC Marine Conservation and Research Society. In the Islands Trust Area, communities are presently undertaking spawning surveys with the BCSSA as the Gulf Islands Forage Fish Initiative.

5.0 Spawning Beaches

On Lasqueti Island, the Lasqueti Island Forage Fish Team determined the presence of summer and winter spawning Surf smelt and Pacific sand lance; and these results were accessed and verified by Sea Watch Society and Salish Sea Biological.

Winter spawning Surf smelt were confirmed at Chris & Doug Beach and summer spawning Surf smelt at Chris and Doug Beach and West Conn Bay. Pacific sand lance spawning beaches were confirmed for Chris & Doug, Marshall's and Matheson's beaches. 1-embryo beaches were confirmed for Pacific sand lance at Maple Bay beach and East Sandy Cove (Figure 1A-H). Established survey standards (Washington State and British Columbia) stipulate that results of 1-embryo beaches show evidence of spawning activity but are not conclusive to categorize the beach as a spawning beach until further embryos are detected. Nearby shorelines of the Sunshine Coast, sampled by Friends of Forage Fish Sunshine Coast, also confirms the presence of winter and summer spawning Surf smelt and Pacific sand lance as well as Powell River beaches that are positive for winter spawning Surf smelt and Pacific sand lance (de Graaf, unpublished data).

6.0. 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).

6.1 Shoreline Modification

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. Marine shellfish aquaculture in foreshore areas can affect beach spawning forage fish habitat. 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 Pacific sand lance is known to burrow. Vehicles operating directly on top of spawning areas can directly destroy embryos or change habitat by affecting sediment through compaction and reduced motility.

6.2 Marine Riparian Vegetation Habitat Modification

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. Removal of backshore vegetation alters soil natural erosion rates, water absorption, and nutrient flows to marine shorelines.

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

6.3 Sea Level Rise

Of all nearshore habitats, marine shorelines are the most at risk not only to rising sea levels but to how humans respond to this threat (Krueger 2009, Martin 2015, Whitman 2014). Beaches are dynamic shore forms, shifting in response to sediment and water flows. Changing sea levels affect the extent to which beaches retreat landward. Hard revetments (seawalls etc.) at or near the high water line prevent natural retreat of beaches landward. The term “coastal squeeze” applies to marine shoreline habitats that will be diminished or lost as these habitats are blocked from landward retreat due to coastal development and threatened seaward by rising sea levels. Upper beach areas are degraded or lost as increased erosional energy coarsens sediments, and beaches narrow in width (Dethier 2016, Shipman 2009). Most at risk are upper intertidal zones, beach berms and beach faces. As Surf smelt spawn on beach faces, the upper most part of the intertidal zone, their spawn is most at risk of loss. Sixty-six percent (66%) of Surf smelt embryos are deposited in the upper zone of beach faces (Quinn 2012, Whitman 2014). Spawn deposition zones of Pacific sand lance are also on the beach face (Penttila 1995). How management authorities respond to sea level rise has implications not only for forage fish species, but hundreds of predatory species and reliant fisheries.

7. Introduction to the Beach Spawning Forage Fish Habitat Assessment

7.1 General Introduction

To refine the study area, sediment maps were 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 Lasqueti Island. Unconsolidated sediments include silt, mud, sand, and gravels. Shore-units of consolidated sediment (rock) were also reviewed to ensure that no suitable habitats were present.

7.2 Area Surveyed

Lasqueti Island assessments took place on October 1, 2, 3, 2015, June 7, 8, 28, 29, and 30, 2016. No major storm activity was noted for the Strait of Georgia during the time of the surveys.

The entire coastline of Lasqueti Island was surveyed by foot and boat. Unconsolidated sediments consist of gravel (pebble, cobble and boulder), mud and silt areas. Areas of consolidated sediment (rocky shorelines) were surveyed to ensure the absence of any fine sediment accretions. All beach units of unconsolidated sediments were surveyed by foot to ascertain potential sites for detailed assessment.

Marshall’s Beach – Lasqueti Island
Photo: RC de Graaf

8.0. Methods

Forage Fish Habitat Assessments –
Assessing Suitable Forage Fish Spawning Habitat

Actual forage fish spawning beaches are determined after comprehensive embryo surveys (Moulton and Penttila 2001). In the absence of such comprehensive embryo surveys, beaches may be classified as having attributes suitable for Surf smelt/Pacific sand lance spawning habitat following field assessments.

8.1 General Methodology

A habitat suitability model is based on the observed response of an animal to specific environmental attributes (Robinson et al 2013). Specific environmental attributes (abiotic or “physical” variables) of the tested habitat patches are assessed as to their similarity to known habitat types. The Forage Fish Habitat Suitability Assessment (FFHSA) 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 units and grain-size samples assessed. These data are used to predict the suitability of beach units relative to beach units observed to be spawning habitat for spawning activity by Surf smelt and Pacific sand lance. Additional variables are measured to assess human activities that may have directly modified the foreshore or adjacent backshore areas and evaluated as to “stressors” on beach habitats. Assessments are conducted by experienced beach spawning forage fish biologists/technicians.

Physical variables from suitable beaches are compared to a database of habitats that were monitored using spawning surveys (over 2 years) for 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 suitable 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 probability can be assigned to each beach unit measured. Beaches are assigned as being suitable spawning habitat for Surf smelt, Pacific sand lance, or both Surf smelt/Pacific sand lance. Beach units assessed in the field but failing statistical analysis are assigned as “Not Suitable Spawning Habitat”. Beach units not assessed were assigned as “Not Spawning Habitat" in the field and were comprised of mud, silt, rock or shallow pebble veneers over rock.

For shoreline property owners undertaking works that may impact fish and their habitat, a project review by the Department of Fisheries and Oceans (DFO) may be required. In the absence of a two-year spawning survey, a FFHSA can provide a good indication of suitable surf smelt and sand lance habitat for use by landowners and other agencies responsible for shoreline management.

A description of the survey methodology has been provided to the Islands Trust/Islands Trust Fund and is available upon request for the purposes of verifying the validity of the data collection and analysis.

8.2 GPS/GIS Methodology

8.2.1 Spatial Data Specifications

A Trimble Juno 3B receiver was used to acquire spatial data. GPS data were post-corrected using Path Finder Office software. GPS data were collected according to the GPS Specifications provided by the Islands Trust as part of this contract (Appendix G).

If positional fixes with the Trimble Juno 3B at the desired level of accuracy were not possible due to satellite interference caused by land forms such as sea cliffs, feature data were digitized by the GIS technician from ortho-photographs provided from the Islands Trust and reviewed by the author.

8.2.2 Digitizing Spatial Data and Map Production

Maps of line segments were produced by digitizing spatial data following the protocol in Appendix H.

9.0 Project Limitations

The project was limited to assessing beaches as suitable spawning habitat for two species of beach spawning forage fish, Surf smelt and Pacific sand lance. Data for this study was compiled before major fall/winter storm events. The methods used in a forage fish habitat suitability 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 having physical variables suitable for spawning, but it does not confirm the presence or absence of spawning activity.

10.0 Lasqueti Island – Geomorphic Setting and Beach Shoreline Types

Wave exposure (fetch and energy) regimes for Lasqueti Island ranged from very low to high. The north coast is protected in the lee of Texada, having lower wave exposures relative to southern coastlines directly aligned with south easterly winds (de Greeff 2011). Lasqueti Island coastlines are dominated by two geomorphic systems: rocky shorelines and beaches.

Along Lasqueti's exposed southern rocky shores, small volumes of sediment are maintained between isolated and disjunct rocky headlands in small pocket coves along erosionary shores.

Pocket Cove (Old House Bay), rocky shoreline,
Lasqueti Island south coast - Photo: RC de Graaf

Along Lasqueti's protected northern beaches, large volumes of sediment are transported in complex drift cells from eroding land forms (bluffs and banks) and freshwater streams creating larger, connected bluff-backed and barrier beaches along accretionary shorelines (Shipman 2008). Net sediment drift along these beach systems is northward (Gulf Islands Shoreline Mapping, 2011).

Barrier beach (Boot Point), beach shoreline,
Lasqueti Island north coast – Photo: RC de Graaf

It is useful to consider the geomorphic context of sediment delivery/transport systems when assessing stressors from backshore/foreshore uses that may degrade sediment delivery to the shoreline. For example, due to the limited volume of sediment available along rocky coasts, pocket beaches are particularly sensitive to backshore/foreshore modification. Barrier beaches are sensitive to interruptions in lateral, or littoral drift along shorelines.

11.0 Results

11.1 Statistical Analyses

In total, 40 beach units comprised of unconsolidated sediments were assessed (Table 1). Principal Component Analysis using PRIMER-E and beach metrics, including grain-size analyses, assessed thirty-four (34) beach units with 80% similarity to known positive beaches in BC and Washington State and were classified as "suitable spawning habitat" (Figure 1A-E). Twenty (20) of these beach units had continuous habitat and fourteen (14) had discontinuous habitat. Six (6) beach units failed statistical analyses, the same beach units with non-conforming grain-sizes, and were classified as "not suitable spawning habitat". A list of beach units identified in the map Figures 1A-E is provided in Appendix A.

Table 1: Lasqueti Island Beach Unit Statistical Analyses

	Count	Total	Length (m)	Percentage of Shoreline Perimeter
Total Beach Units Assessed		40		
Total Length (meters)			3588	
Habitat	34		3080	3.6%
Not Suitable	6		508	0.6%
Habitat				
Continuous	20		1217	
Discontinuous	14		1863	
Perimeter Distance of Lasqueti Island			86,868	

Not Habitat: Pocket Coves

The Lasqueti Island round-island survey classified 62 pocket coves that presented beach faces of cobble/boulder substrates and classified as not potential spawning habitat (Appendix B). These beach units were not mapped using Trimble GPS protocol but were catalogued using hand-held Garmin and photographed.

Areas representing degraded or destroyed habitat, where significant shoreline modifications have buried or eroded beach habitat, were noted at False Bay and Maple Bay. At False Bay, adjacent to the ferry terminal parallel to the restaurant, a significant portion of the beach has been converted for commercial uses. Other changes to False Bay include the wharf facility, large barge loading/unlading infrastructure. At Maple Bay, a section of the western shoreline leased for shellfish aquaculture has multiple rock groins and bouldering across the beach face significantly altering sediment transport.

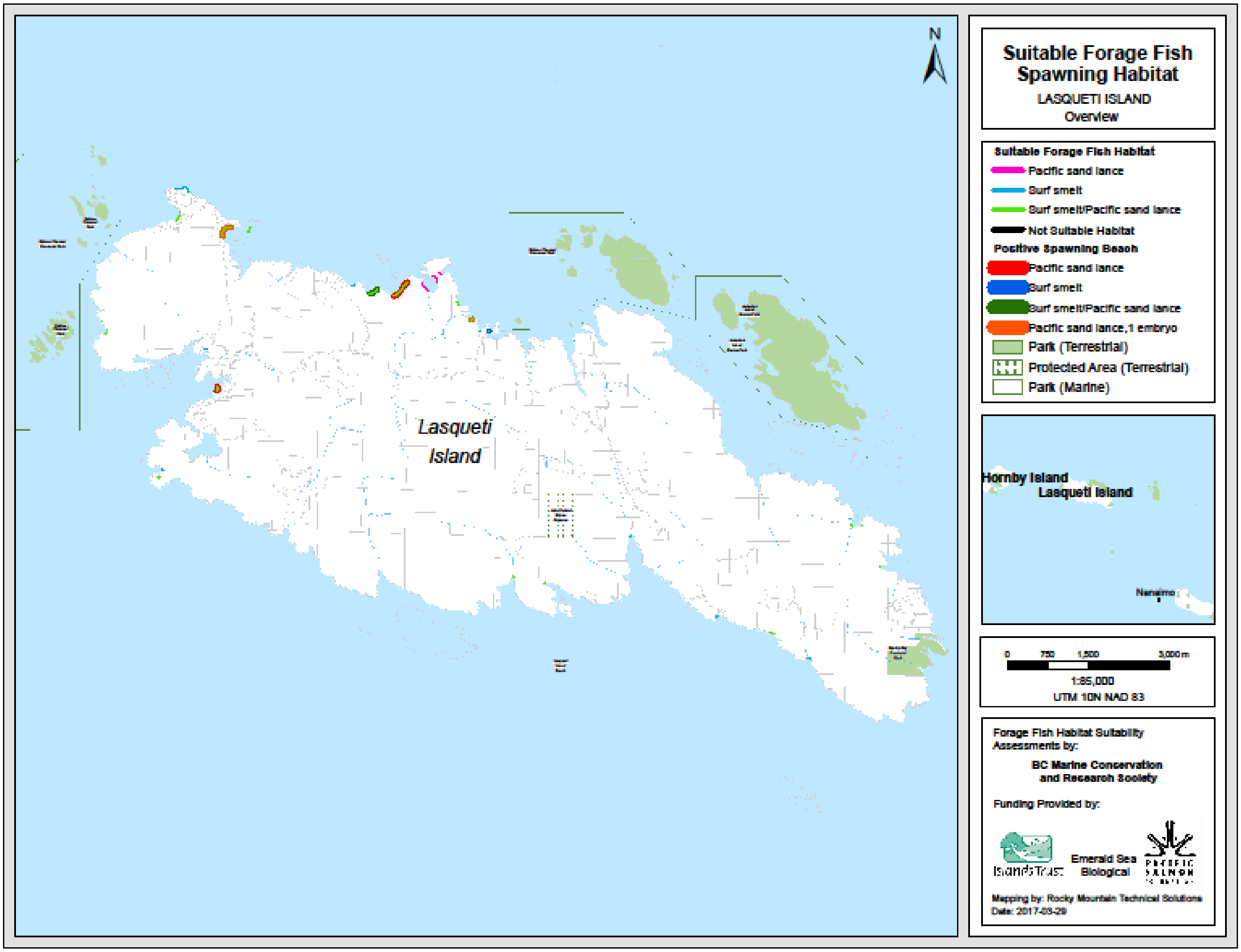
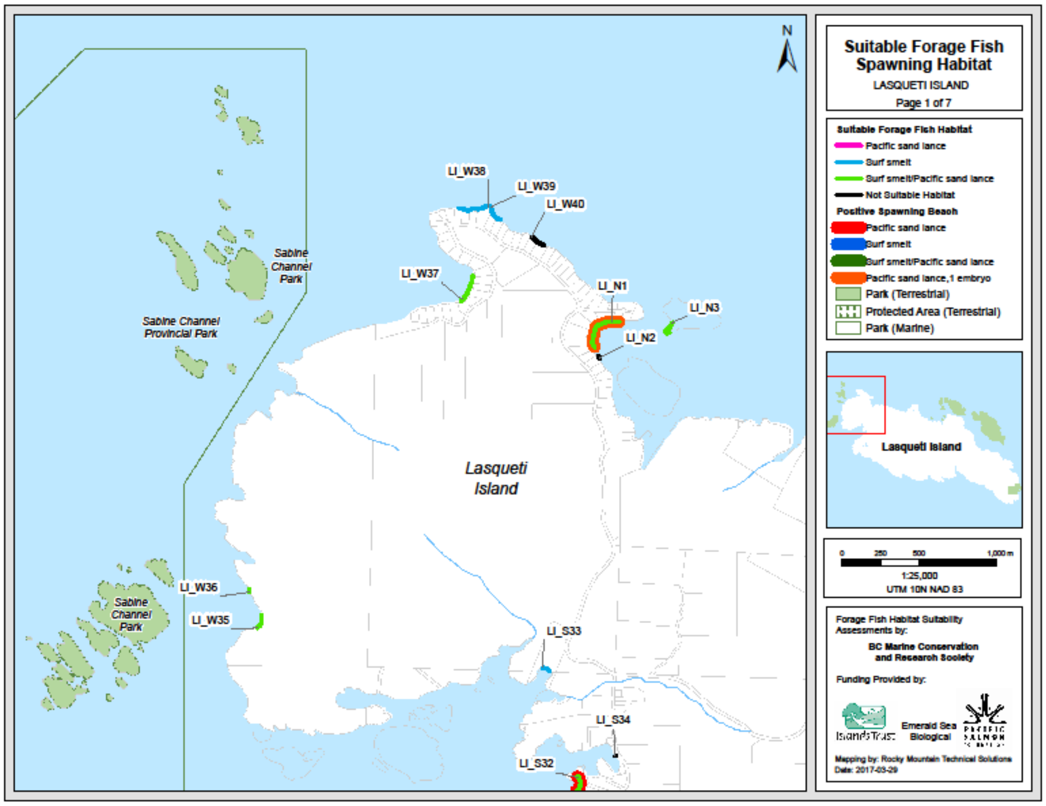


Figure 1A: Lasqueti Island - Suitable Beach Spawning Forage Fish Spawning Habitats



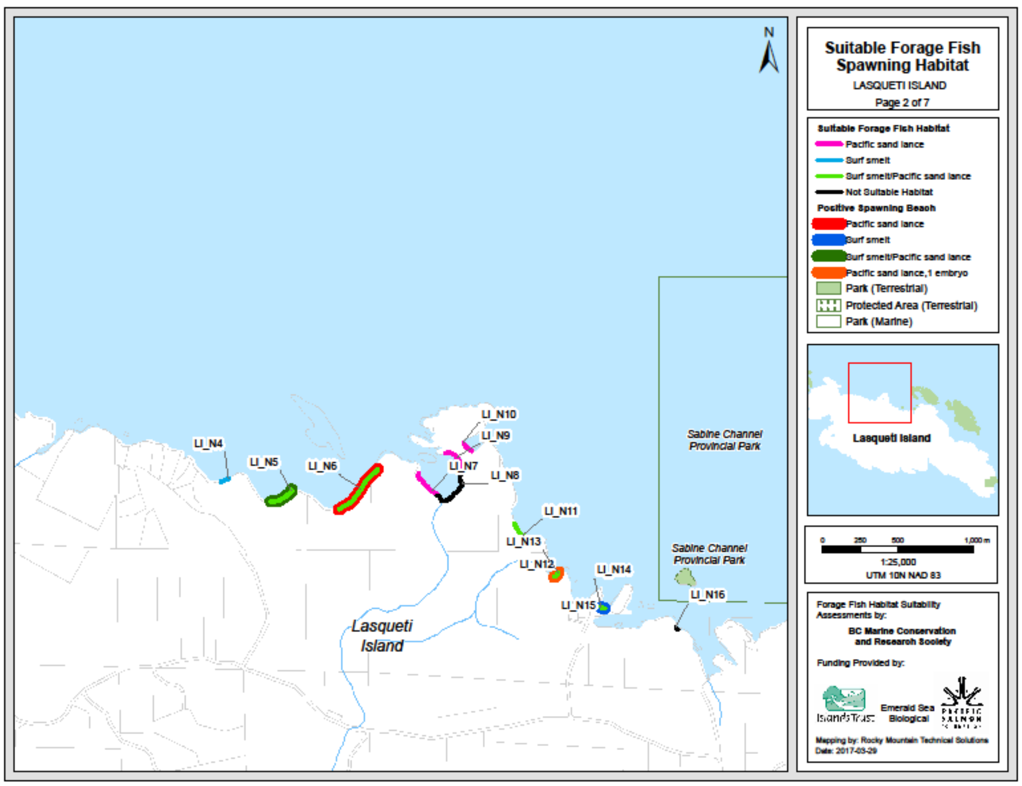
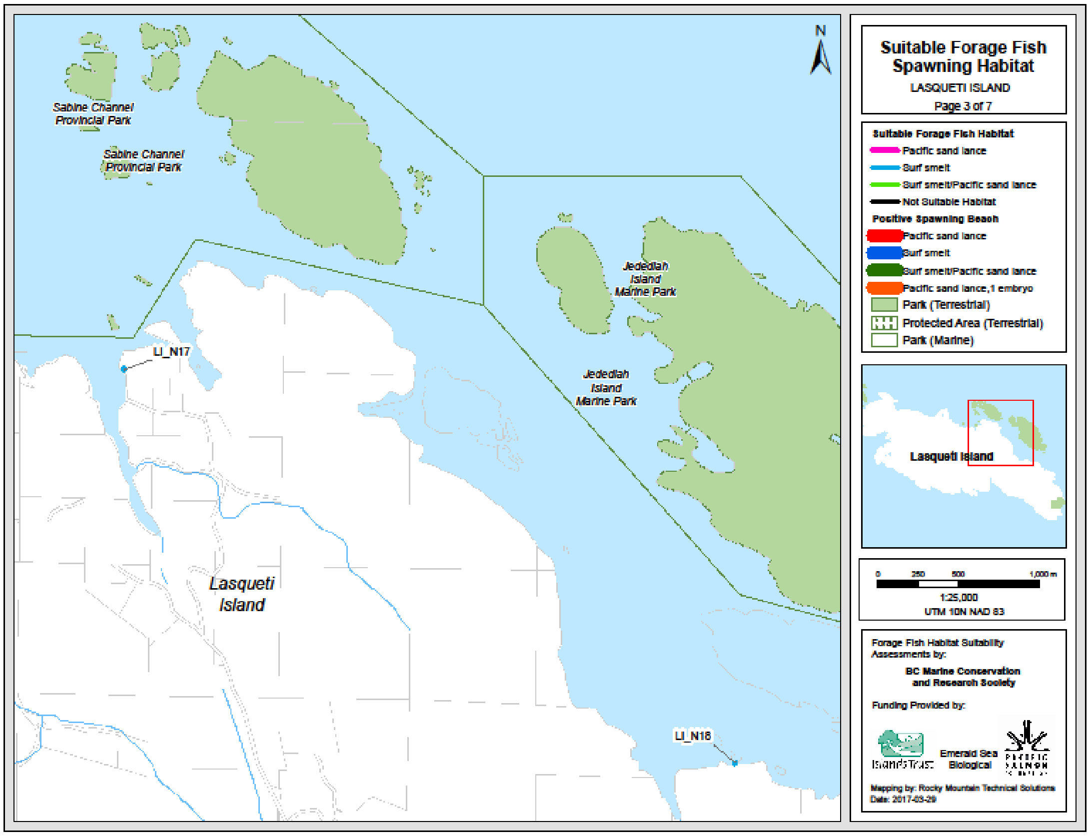


Figure 1B-C: Lasqueti Island - Suitable Beach Spawning Forage Fish Spawning Habitats



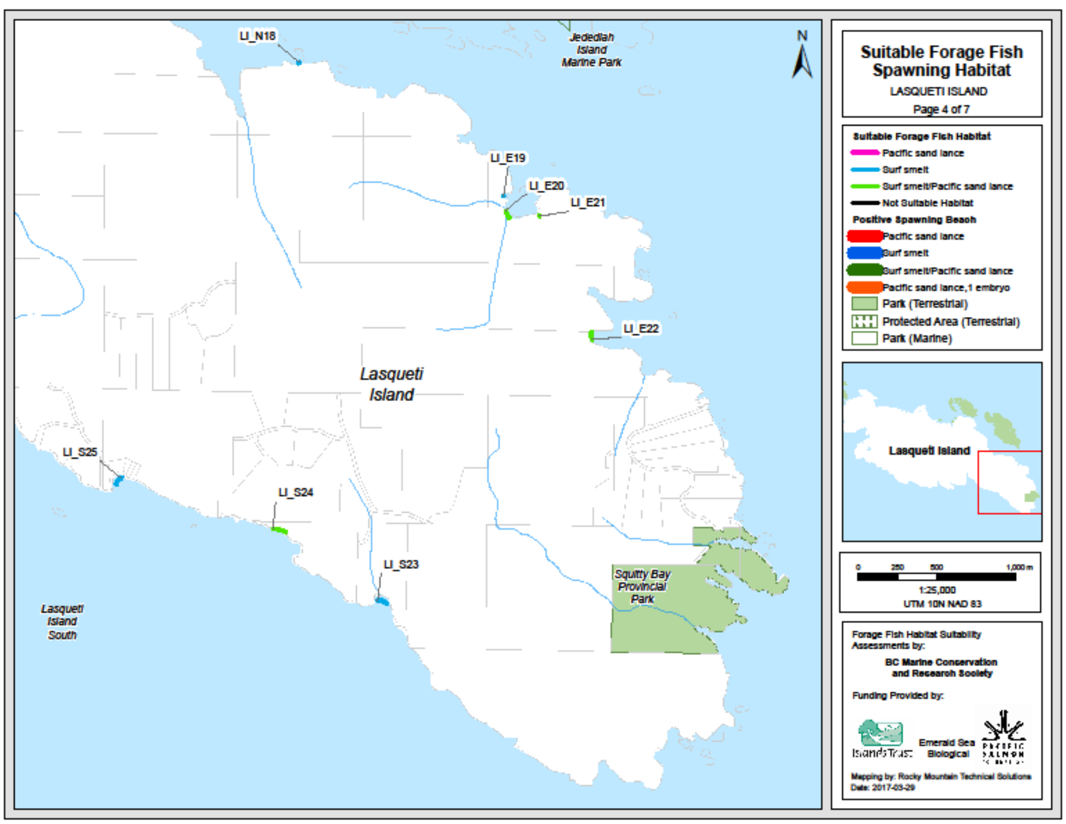
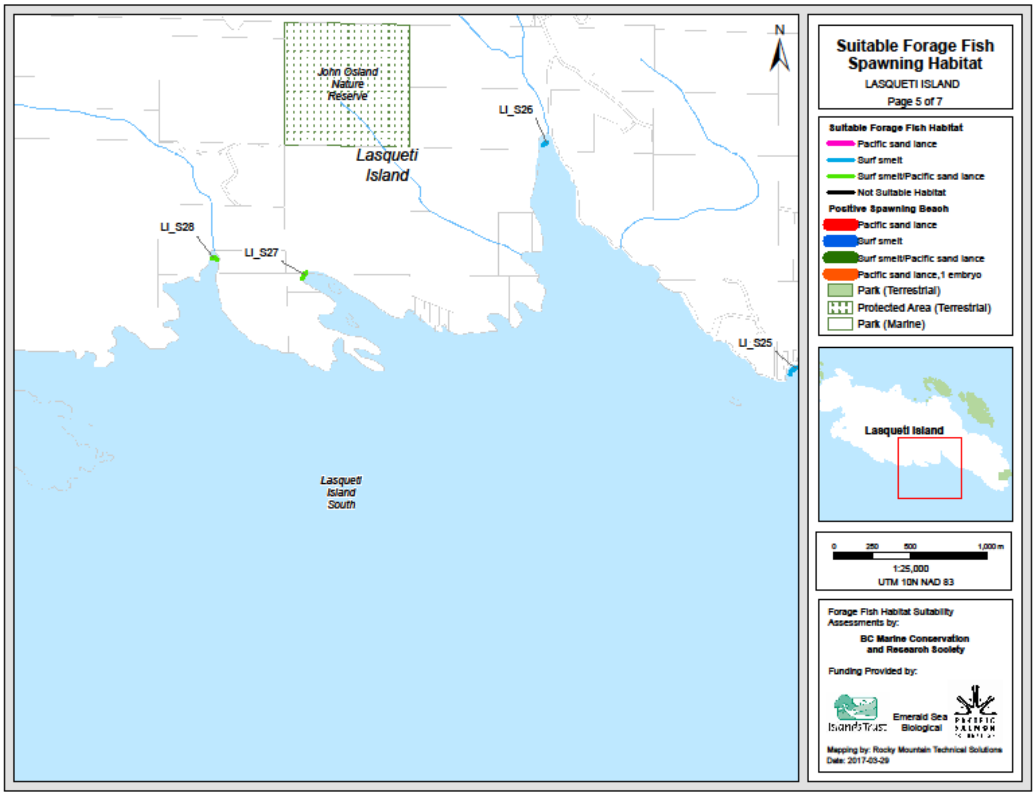


Figure 1D-E: Lasqueti Island - Suitable Beach Spawning Forage Fish Spawning Habitats



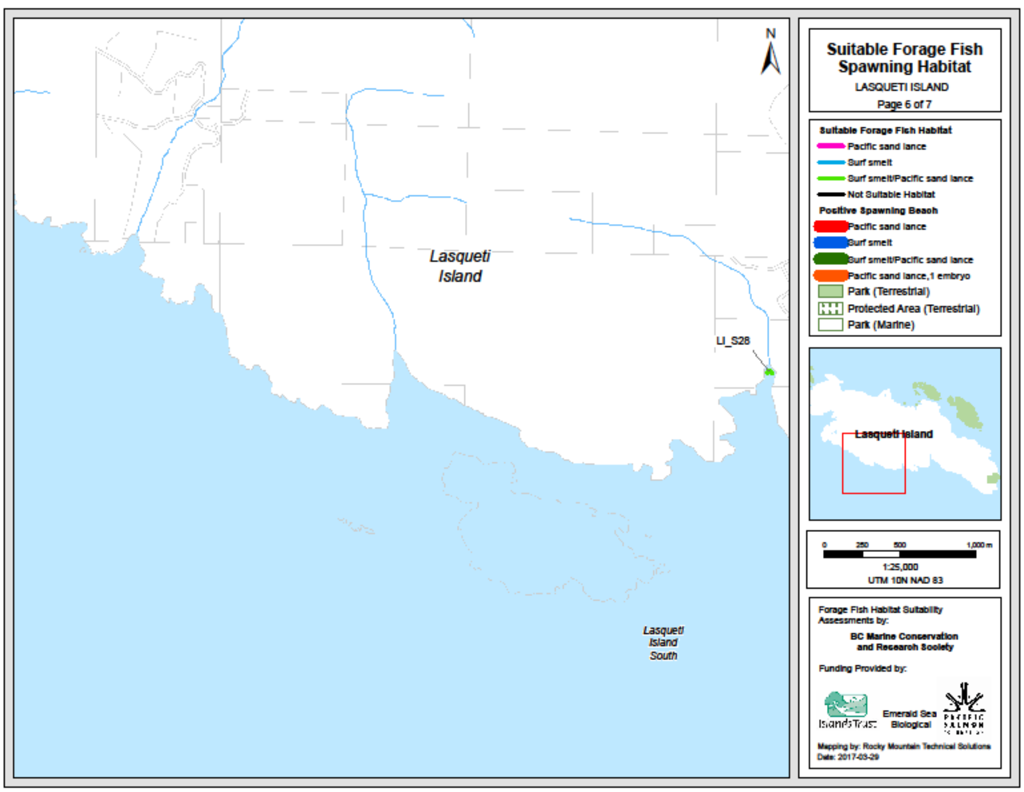


Figure 1F-G: Lasqueti Island - Suitable Beach Spawning Forage Fish Spawning Habitats

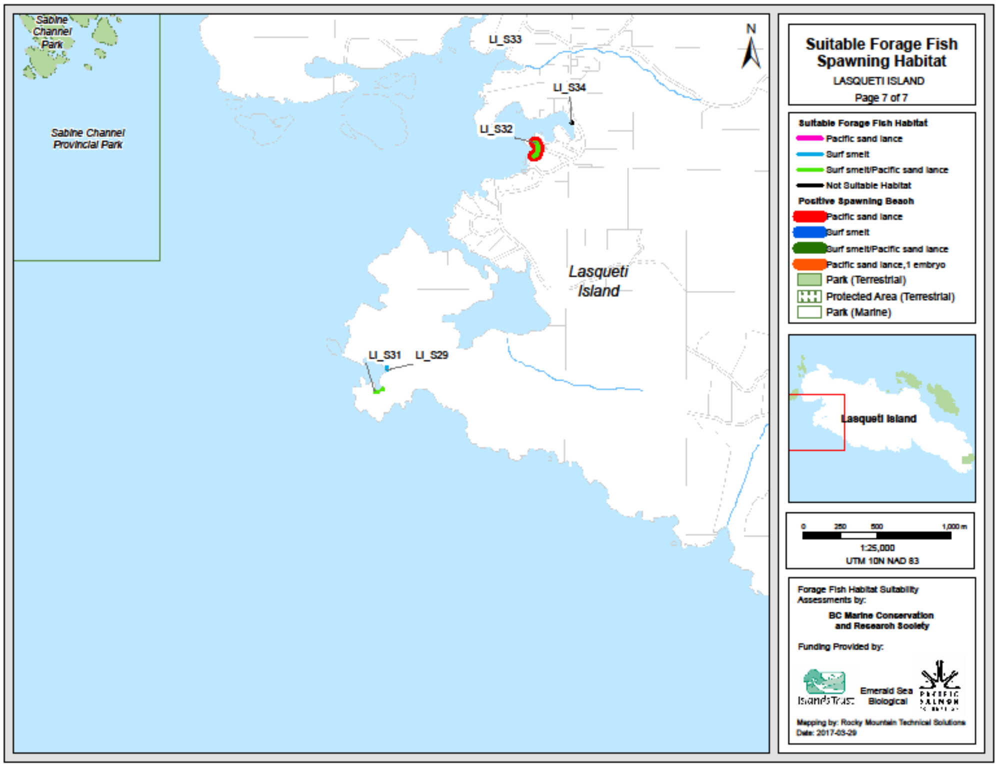


Figure 1H: Lasqueti Island - Suitable Beach Spawning Forage Fish Spawning Habitats

11.2 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. Thirty-four (34) beach units showed grain-size frequencies curves that were within 80% and higher similarity to known positive spawning beaches (Appendix C and D, Figures 2-7). The grain-size frequencies of six (6) samples did not meet the statistical standards of the analysis.

11.3 Length of Suitable Forage Fish Spawning Habitat

The total shoreline perimeter of Lasqueti Island is 86.6 kilometers. Suitable forage fish spawning habitat comprised 3.1 kilometers (3,080 m) or 3.6 percent (3.6%) of the Lasqueti Island shoreline perimeter (Table 2). Of the suitable forage fish spawning habitat, 22.6% (696.7 m) suitable for Surf smelt spawning; 15.4% (474.5 m) is suitable for Pacific sand lance spawning; and 62.0% (1908.4 m) as suitable for surf smelt/Pacific sand lance spawning habitat (Table 2).

Table 2: Lasqueti Island – Classification of Suitable Forage Fish Spawning Beach Units

	SS	PSL	SS/PSL	Total (m)
Count	12	3	19	
Length (m)	696.7	474.49	1908.41	3079.6
Length Percentage	22.6%	15.4%	62.0%	100.0%
Shoreline Perimeter Percentage	0.8%	0.6%	2.2%	3.6%
Perimeter Distance				86,868

SS - Surf smelt

PSL - Pacific sand lance

11.4 Suitable Forage Fish Spawning Habitat Beach Types

Of the 34 suitable spawning beaches, 3 were classified as Pacific sand lance, 12 as Surf smelt, and 19 as mixed Surf smelt/Pacific sand lance spawning habitat (Table 3). Of the Pacific sand lance beaches, grain size analyses assessed 3 as Type 3 Pacific Sand lance habitat. Of the Surf smelt beaches, grain size analysis assessed 4 as Type 1, 2 as Type 2, 1 as Type 3, and 5 as Type 5 Surf smelt beaches. Of the mixed Surf smelt/Pacific sand lance beaches, grain size analysis assessed 9 as Type 1; 8 as Type 2; 1 as Type 3, and 1 as Type 4 Surf smelt beaches (Appendix C and D, Figures 2-7). The majority of grain-size types, 28 (82%) are coarser grain-sizes (Types1-2 and 5) with only 6 (18%) being of finer grain-sizes, which is consistent with the dominant geomorphic systems and wave energy regimes of Lasqueti Island.

Table 3: Lasqueti Island - Beach Units Grain-Size Types

Category	SS Count	PSL Count	SS/PSL Count	Row Totals
PSL TYPE 1				
PSL TYPE 2				
PSL TYPE 3		3		3
SS TYPE 1	4		9	13
SSTYPE 2	2		8	10
SS TYPE 3	1		1	2
SS TYPE 4			1	1
SS TYPE 5	5			5
Totals	12	3	19	34

11.5 Geographic Position of Suitable Forage Fish Spawning Beaches

11.5.1 Geographic Position

Dividing Lasqueti Island into north, south, west and east coast lines, 14 suitable beach units are located on the north coast; 11 suitable beach units are located on the south coast; 5 suitable beach units on the west coast; and 4 suitable beach units on the east coast (Table 4).

Table 4: Lasqueti Island Coast Line - Suitable Forage Fish Spawning Beach Units

	SS	PSL	SS/PSL	Total
North	4	3	7	14
South	5		5	11
West	2		3	5
East	1		3	4
Total				34

11.5.2 Geomorphic habitat types

Reflecting the geomorphological systems of Lasqueti Island (Section 9.0), of the 34 suitable beach units, along the wave-exposed shores of south, southeast, 15 are pocket coves. Along the northwest shore, an area of medium wave exposure (deGreeff 2011), 2 are pocket coves and 3 are barrier beaches. Along the wave-protected northern shore, 6 are pocket coves and 8 barrier beaches (Appendix A).

11.6 Foreshore Modification

Modification of the foreshore is classified as a percentage of the length of the beach unit that has been altered from a natural state by structures that would impede movement of sediments either to or across the beach.

The level of foreshore modification on Lasqueti Island is low. Twenty-seven (27) of the beach units had unmodified shorelines and seven (7) were modified (79% and 21% respectively). Of the seven (7) modified beach units, five (15%) were 1-25% impacted; 1 (3%) was 51-75% impacted; and 1 (3%) was 75-100% impacted (respectively) (Table 5).

Table 5: Lasqueti Island Beach Units - Foreshore Modification

	0% impact	1-25% Impact	26-50% Impact	51-75% Impact	76-100% Impact	Total
Count	27	5		1	1	34
Percentage	79.0%	15.0%		3.0%	3.0%	100.0%

11.7 Foreshore and Backshore Structures

Of the seven (7) suitable forage fish spawning beach units with modified foreshore zones, the presence of sediment impeding structures were classified and enumerated. In total ten (10) structures were classified into four (4) categories (Table 6).

Wooden seawall and riprap boulders along shore-line – Lasqueti Island – Photo RC de Graaf

Of the suitable spawning beach units, 23, 68% had modified backshore zones (alteration of the backshore within 30 metres of the high-water mark).

Within the backshore zone, eighteen (18) structures were classified into 7 categories, other than buildings. Buildings were not present on the foreshore. Buildings (cabins, houses, sheds, etc.) are not enumerated but only classified as present or absent. All other individual structures were numerated. The total number of beach units having structures includes buildings. Buildings were present at 19 beach units (56%) and 15 beach units (44%) had no buildings (Table 6). Of the 15 beach units with no backshore buildings, three had structures (roads and fences).

Combining zones, some beach units had multiple structures on the foreshore and backshore. 1 beach unit had 4 structures, 1 beach unit had 3 structures, and 3 beach units had 2 structures. Five beach units had hard armouring below or at the high water mark (seawalls or riprap boulders) and four had boat ramps, structures known to cause beach erosion.

Table 6: Lasqueti Island Beach Units – Foreshore and Backshore Structures

		Foreshore		Backshore		
Category		Count	Percent-age	Count	Percent-age	No. Beach Units Buildings Present
Building						19
Boat Ramp		4	40	1	6	
Boat House		0		2	11	
Dock/Wooden Pier		0		0		
Seawall		2	20	2	11	
Riprap		3	30	0		
Groyne		0		0		
Storm Water Outfall		0		0		
Stairs		0		1	6	
Road to beach		1	10	7	39	
Parking Lot				1	6	
Culvert						
Other				4	22	
Total Number of Structures		10	100	18	100	
Total Number of Beach Units	34					
Number of Beach Units with structures		7		22		
Number of B Units with structures (excluding buildings)				13		

N.B. A single beach unit may have structures in the foreshore and backshore as well as buildings present.

11.8 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. In general, of the beach units assessed as being suitable for spawning by Surf smelt or Pacific sand lance, 32% (11 beach units) had no overhanging shade habitat and 68% (23 beach units) had overhanging shade habitat. Of the 23 suitable beach units with overhanging shade habitat, 47% (16 beach units) had 1-25% overhanging shade; 9% (3 beach units) had 26-50% overhanging shade; 12% (4 beach units) had 51-75% overhanging shade; 0% had 76-100% overhanging shade (Table 7). Thirty beach units (88%) had overhanging shade coverage between 0-50%, and four beach units (12%) had overhanging shade coverage greater than 50%.

Table 7: Lasqueti Island Beach Units – Overhanging Shade Vegetation Index

Category	Fully exposed	1-25% Shade	26-50% Shade	51-75% Shade	76-100% Shade
Count	11	16	3	4	0
Percentage	32	47	9	12	0
Foreshore not modified %	82%	81%	67%	75%	
Foreshore Modified %	18%	19%	33%	25%	
Backshore not modified%	18%	44%	0%	50%	
Backshore Modified %	82%	56%	100%	50%	

Marine riparian vegetation may be reduced/absent due to structures (ranging from buildings to hard armouring), land use/landscaping, the type of land form (examples include spits and lagoons), or soil conditions. Of the 11 suitable beach units with no overhanging shade, 18% had modified foreshore and 82% modified backshore zones; beach units with 1-25% overhanging shade, 19% had modified foreshore and 56% modified backshore zones; beach units with 26-50% overhanging shade had 33%

modified foreshore and 100% modified backshore zones; beach units with 51-75% overhanging shade had 25% modified foreshore and 50% modified backshore zones (Table 7).

Beach units of spits and lagoons rarely have overhanging shade vegetation, and three (3) beach units were of these land forms (Marine Island, Lennie's Lagoon East, and Lennie's Lagoon West). These land forms were not a significant factor in the analysis of overhanging shade habitat.

While Lasqueti Island has a low incidence of foreshore modification at 7 beach units (21%), backshore land use has resulted in 30 beach units (88%) with reduced overhanging shade habitat of 0-50% and reductions of marine riparian vegetation. Land clearing within close proximity to the high water mark, has resulted in significant reductions of overhanging shade and marine riparian vegetation.

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12.0 Summary

Relative to its shoreline perimeter length, Lasqueti Island has a small percentage of suitable spawning beaches for Surf smelt and Pacific sand lance. The shorelines are dominated by a high wave energy regime on the south and southeast coasts, and low-moderate wave energy regime on the north and northwest coasts. As predicted by the two geomorphic systems, the rocky shorelines of the south coast were comprised mostly of pocket coves and the beach shorelines of the north coast had a number of barrier beach land forms and pocket coves. With approximately 3.1 kilometres of suitable spawning habitat, there are excellent opportunities to safeguard and protect these critical habitats. Other than a small regional park at Boot Point, it does not appear that any of the suitable spawning beach habitats are protected within conservation/park zoning.

Of the islands surveyed to date, Lasqueti's shorelines and suitable spawning beaches are similar to that of Bowen Island. Suitable beaches were of coarser grain-size types with few pure sand beaches.

The level of foreshore shore modification on Lasqueti is low. Riprap and seawalls were present at two beach units due mainly to the presence of roads below or at the high water mark. Armouring at Boat Cove is at a shoreline that faces dominate south-easterly winds. However, foreshore armouring was present at pocket coves, and these land forms are sensitive to removal by erosion of their limited sediment supplies. Four beach units had boat ramps.

The 34 suitable beach units surveyed provide evidence that Lasqueti Island shorelines have a low occurrence of foreshore modification (21%, or 7 beach units) and moderate levels of backshore modification proximal to the shoreline (68%, or 23 beach units). Land forms of spits and lagoons rarely have overhanging shade vegetation (3 beach units). Reduction in the amount of overhanging shade vegetation and marine riparian vegetation at suitable spawning habitats is related to both backshore land use and foreshore modification. Thirty beach units (88%) had low-moderate levels of overhanging shade coverage (between 0-50% of beach unit length), and only four beach units (12%) had overhanging shade coverage greater than 50%; and no beach units had 76-100% shade vegetation.

As stated in the introduction, particular marine shorelines are critical fish habitat for spawning surf smelt and Pacific sand lance, and also provide rearing grounds for juvenile salmonids. Forage Fish Habitat Suitability Assessments (FFHSAs) can grade beaches as to their spawning suitability only.

Recommendations from this study have been evaluated with the goal of balancing changing oceanographic conditions (sea level rise), ecological values, public access/enjoyment of beaches, and shoreline property values. Recommendations should also promote local governance tools and community discussions that incorporate emerging engineering, biological and policy advances for shoreline protection and ecological/resource benefits.

13.1 Marine Shoreline Stewardship

Throughout the islands, good stewardship should be actively encouraged. In the absence of Provincial or Federal marine shoreline management planning initiatives that recognize and protect coastal processes supporting marine riparian and beach habitats, local governance tools can be employed to fill this gap in protecting vital habitats.

13.2 Local Governance:

As coastal resources, marine riparian vegetation and forage fish spawning beaches are sensitive nearshore habitats. 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. Coastal planning can assist by

- advocating building setbacks from the high water line as infrastructure protection to avoid armouring
- implementing shoreline buffers and
- Considering drift cell management for contiguous property owners.

Increasingly, regional districts in south coastal British Columbia are including marine shoreline protection measures in Official Community Plans, land-use bylaws and shoreline development permit areas (e.g. Cowichan Valley Regional District, City of Campbell River)

Landowner involvement in habitat protection is vital to any conservation strategy. Marine shoreline habitat protection requires specific management and mitigation measures due to the unique coastal processes forming these habitats and unique threats such as sea level rise and shoreline development. Providing practical tools will encourage effective marine shoreline stewardship as part of an integrated, local conservation strategy.

13.3 Marine Shoreline Protection and Climate Change Adaptation Toolkit for Landowners:

Landowners and local permitting officials are increasingly burdened with environmental protection as more senior governments divest themselves of this responsibility or, as in the case of marine shorelines, lack coherent and effective management policies and standards. Strengthening local governance through policy and bylaw implementation should be accompanied by a tool that property owners utilize to protect shoreline ecological values while meeting site-development permitting requirements. Such a landowner/stewardship “toolkit” could include:

- GIS-based tools (e.g. Islands Trust MapIT),
- local habitat inventories,
- checklists of local vegetation types,
- information on how to recognize evidence of and causes of erosion,
- available engineering assessments of slope stabilities,
- Site management of storm-water and soil stabilities,
- Islands Trust marine shoreline mapping,
- soft shore/bioengineering options to replace hard armouring (Green Shores for Homes),
- information on “green docks,”
- DFO timing windows of least risk,
- steps to enhance habitat and species biodiversity,
- sea level rise vulnerability information, and
- setback corridors according to emerging Provincial climate change adaptation and municipal sustainability/resiliency options

Utilized by the shoreline property owner to assist with site planning as well as preparing for permits, the toolkit would provide a standardized reporting format for permitting staff and could assist Islands Trust staff to track local targets for sustainable and resilient coastal community planning. A local “Marine Shoreline Protection and Climate Change Adaptation Toolkit” would serve as an incentive for multiple, neighbouring shoreline property owners to work together at the “shoreline drift cell” level to manage backshore processes (eg vegetation, soil and water management) and coastal sediment processes rather than numerous individual site plans. Local, place-based “best management practices” can be developed that will assist neighbouring land owners wishing to mitigate erosion, maintain healthy marine habitats, and adapt to local climate change stressors. As well, incentives for employing “soft” options (bioengineering) rather than hard armouring for shoreline erosion and sea level rise protection should accompany any local bylaw implementation (e.g. Green Shores for Homes). The toolkit can also highlight shoreline areas requiring enhancement and/or restoration.

13.4 Stressors and Enhancement/Restoration

13.4.1 Stressors:

Shoreline modifications can change habitats as well as public access/enjoyment of beaches. Deleterious changes to habitats can be termed "stressors". A stressor negatively impacts ecological function, poses a threat to future habitat/public values, and decreases public enjoyment/utilization of resources. Stressors can reduce the "ecosystem services" of the environment; for example, seawalls erode pebble/sand beaches reducing beach height, width and the wave- energy dissipating capacity of land-owners frontage, making infrastructure more vulnerable to negative storm impacts. Stressors can also limit the resiliency of coastal habitats to sea level rise. Restoration strategies can lead to effective solutions if grounded in cost-effective, community-supported regulatory tools. The following is a list of stressors applicable to marine shoreline habitats surveyed in this study, including emerging science dealing with rising sea levels and marine shorelines.

Stressors**:**

A. Shoreline Modifications

1. Hard armouring: seawalls, riprap, lock blocks and others
    - reduces public access to beach
    - removal of spawning habitat
    - interruption of sediment supply
    - increases beach erosion (sediment coarsening, beach profile changes)
    - reduces wave-energy dissipation capacity of high-intertidal beach
    - reduces marine riparian vegetation and overhanging shade habitat
    - Sea Level Rise(SLR) inundation ("coastal squeeze": habitat narrowing; sediment coarsening; beach profile changes)

2. Pier/Docks; Boat Ramps; Groins; Berms; Breakwaters; clearing foreshore
    - reduces public access to beach
    - blocks sediment supply/littoral drift
    - increases beach erosion (sediment coarsening, beach profile changes)

B. Vegetation Removals

- impairment of soil conditions (slope/shoreline stability, pollution filtering, storm water management)
- loss of overhanging-shade habitat
- loss of nutrient (prey) inputs for juvenile salmonids

Structures placed along shorelines can impede sediment delivery to shorelines either by blocking transport along the beach or blocking sediment transport from eroding land forms. Over time, beaches will lack sediment "nourishment" and will coarsen. Hard structures (seawalls, riprap boulders, retaining walls) have various impacts on the foreshore, but generally these can increase erosion due to wave-induced scouring. Overtime, fine sediments are scoured from the beach surface, slopes steepen, and sediments coarsen. Foreshore structures may also be placed directly on top of spawning habitat. The cumulative effects of shoreline structures have a detrimental impact on beach spawning forage fish habitat. Clearing cobbles and boulders from the foreshore changes beach profiles and changes sediment supply/delivery leading to altered habitat types.

Forage fish spawning habitat is vulnerable to the impacts of sea level rise. At sites with hard armouring placed below, at or near the high water mark (“natural boundary”) these structures cause a phenomena known as “coastal squeeze”. Hardening of the shoreline prevents the landward transgression of intertidal habitats and wave energy displacement degrades forage fish spawning habitat. As a result, the spatial area of suitable spawning habitats may be reduced or lost completely with increasing sea level rise due to the presence of hard armouring or foreshore infills.

13.4.2 Enhancement/Restoration

Generally, beach units suitable for forage fish spawning have active sediment inputs (at natural rates of erosion) and intact vegetative corridors (marine riparian vegetation zones). These are priority sites for protection of ecological values through shoreline setbacks (buffer zones), upland site planning, and water quality protection measures. These are also areas of high social and esthetic values. Numerous beach units can be enhanced for juvenile salmonid habitat and forage fish spawning habitat and reducing erosion simply by replanting vegetation, removing or modifying structures that may be blocking sediment drift, and managing storm water and pollution/nutrient inputs into marine habitats. Beach units can also be restored by removal of hard armouring and employing soft bioengineering methods that, depending on the local oceanographic conditions, can be less expensive and more effective in mitigating erosion. The following is a list of enhancement/restoration options relevant to the habitats surveyed.

Enhancement/Restoration:

A. Shoreline Modification

- shoreline development set backs
- soft engineering approaches for shoreline stabilization
- reducing/removal number of foreshore structures present on beach unit
- beach restoration/sediment nourishment

B. Vegetation Removals

- site management/planning

- marine riparian corridors
- trim vegetation for views
- replanting vegetation
- assessing role of invasive plant species

C. Beach Health and Climate Change Resiliency
- Removal of derelict structures
- Removal/replacement of creosote pilings
- Monitoring of upland septic systems
- Monitoring/mitigating oil/fuel fouling sources
- Monitoring storm water effluent
- Minimize docks (size and number) and implement “green dock” guidelines
- Site-management to adapt to rising sea levels

14.0 Specific Marine Shoreline Protection/Enhancement Recommendations

14.1 Shoreline Building Setbacks

Due to the low percentage of suitable spawning beaches relative to its shoreline perimeter, the high number of pocket coves, and actual spawning beaches, all the beach units could be managed by promoting shoreline setbacks. Shoreline Setbacks: Shoreline setbacks or corridors provide a buffer between the marine high-water mark and upland development. Shoreline setbacks are a highly effective tool to protect ecological values and human infrastructure. Undeveloped parcels and lands with any level of protected status should be reviewed for opportunities to provide these important high-water setbacks. Some Regional Districts on Vancouver Island have undertaken rezoning and regulatory tools within developed areas to provide such buffer zones. Private land owners can also be encouraged to create these corridors to promote not only ecological features but also protection from storms and sea level rise. Management of marine riparian vegetation and overhanging shade vegetation would be simplified if shoreline setbacks were implemented wherever possible.

14.2 Shoreline Structures

14.2.1 Shoreline Erosion Mitigation

Lasqueti Island has a low proportion of suitable spawning habitat classified as having modified foreshores. Local governance tools can support this by encouraging and educating residents about protecting shorelines by implementing setbacks as part of adaptive management to storms and sea level rise. Residents concerned about protecting shorelines from erosion can be provided with incentives to explore “soft shore” or bioengineering options.

In light of future sea level change predictions and storm events, as well as shoreline development, threats/pressures to harden shorelines will increase. Seawall, riprap, and infills below the natural boundary should be removed or elevated foreshore/beach nourishment methods employed to re-establish and enhance forage fish spawning habitat.

Seawall and riprap armouring on foreshore – Lasqueti Island
Photo: RC de Graaf

A large number of Lasqueti's beaches are pocket coves. This geomorphic habitat type is highly sensitive to changes in sediment delivery and retention due to erosion as a result of backshore and foreshore development/modification.

14.2.2 Piers and Docks

At beach units suitable for forage fish spawning, there were no piers or docks. Areas in Spring Bay, Maple Bay, and Tucker Bay have a number of mooring cans/buoys. Shoreline-property owners at False Bay use the wharf and others use anchoring lines. It is hoped that this type of marine use continues into the future, although boat owners should be encouraged to use anchors and buoys with lines that are prevented from scouring the seabed at low tides.

As marine water-quality is an issue in False Bay, upgrades at the wharf facility could include replacement of creosote pilings and use of translucent panels or grating to provide light transmission to the subtidal areas.

14.2.3 Other foreshore alterations

One beach unit in Maple Bay had a section of the foreshore where cobbles/boulders were moved and used as upper-mid intertidal groins possibly for some aspect of shellfish aquaculture activity.

Stressors related to this activity are alteration of sediment/littoral drift and changes of beach profiles including degradation and loss of spawning habitat.

Foreshore moving/clearing of cobble and boulder resulting in changes to sediment sizes and beach slopes. Maple Beach – Lasqueti Island Photo: RC de Graaf

14.3 Marine Riparian Vegetation and Overhanging Shade Vegetation

Marine Riparian vegetation is abundant along Lasqueti's marine shorelines; however, there were reductions in overhanging shade vegetation along suitable forage fish habitat beach units. An analysis of foreshore modifications, land form and land use, revealed that backshore land-use was significant in the reductions of overhanging shade vegetation. It is likely that land-clearing within close proximity to the high water mark, has resulted in significant reductions of overhanging shade and marine riparian vegetation.

Encouraging stewardship practices that involve trimming tree branches and shrubs, rather than vegetation removal, will maintain nutrient subsidies to marine ecosystem as well as protect shorelines from accelerated rates of erosion. Vegetation replanting is also advised. As an example, one beach unit, Marshall's Beach, had 25% of its length with overhanging shade vegetation as 75% of the area immediately backshore of the berm is an agricultural field. Along this particular beach unit, there are no houses so restoring trees would not interfere with land-owners' viewscape and would improve ecological function as well as increase stability of the beach berm and reduce storm water runoff. Marshall's Beach is a Pacific sand lance spawning beach.

Backshore land-use resulting in reduction of overhanging shade vegetation – Marshalls Beach – Lasqueti Island – Photo: RC de Graaf

14.4 Public Access

Due to Lasqueti Island's remoteness, public access to beaches is not as serious an issue as it is on shorelines in more populated areas. There are many local roads to beautiful shoreline areas. A large number of beaches have no access either by private land holdings or otherwise.

14.5 Beach Health/Water Quality Enhancement

When repairing old piers/dock structures, minimizing the number of pilings, removing/eliminating creosote pilings, and following green dock guidelines will provide a positive benefit to marine habitats. Areas that have had vegetation losses can be enhanced by replanting.

False Bay contains suitable forage fish spawning and documented spawning habitat for Pacific sand lance and herring. Chronic oiling of the water is frequently evident. A large number of vehicles are parked along the public road on a significant slope. There does not appear to be a catchment at the base of the road to the government wharf. The Ministry of Transportation and Infrastructure should be engaged to work with the Islands Trust to ensure that a filter is placed at the base of the road to remove oil/fuel from entering these sensitive and productive marine waters. Bowen Island Municipality recently installed such a measure at Snug Bay.

15.0 Potential future uses of data provided

This report provides maps showing suitable spawning habitat for forage fish. Maps of overhanging shade vegetation, marine riparian vegetation, as well as foreshore structures and categories of foreshore/backshore modification can also be generated from the data provided to Islands Trust.

A sea level rise risk map can also be generated from these data to show beaches likely to be reduced or lost to rising sea levels due to “coastal squeeze” and changing land forms (lagoons and spits). The term “coastal squeeze” applies to marine shoreline habitats that will be diminished or lost as these habitats are blocked from landward retreat due to coastal development and threatened seaward by rising sea levels.

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Appendix A - Beach Units Lasqueti Island

GIS ID	Beach Number	Beach Name	Habitat Class	Sediment Distribution	Species most likely	Grain Size Type	Beach Unit Length (m)	Geomorphic Habitat Type	SPAWN DETECTED
22	LI_N1	MapleBy	habitat	Discontinuous	SS/PSL	SST1	295.08	Barrier beach	1-egg, PSL
23	LI_N2	MapleByS	not suitable	Continuous	none	Mud	22.09	Barrier beach	
24	LI_N3	Marine Island	habitat	Discontinuous	SS/PSL	SST2	112.40	Barrier beach	
17	LI_N4	EScottyBy1	habitat	Discontinuous	SS	SST5	61.75	Pocket cove	
25	LI_N5	ChrisDougBe	habitat	Continuous	SS/PSL	SST3	172.88	Barrier beach	SS,PSL
11	LI_N6	MarshallBe	habitat	Discontinuous	SS,PSL	SST1	384.74	Barrier beach	PSL
8	LI_N7	Lennies Lagoon3	habitat	Discontinuous	PSL	PSLT3	201.68	beach, lagoon	
9	LI_N8	Lennies Lagoon2	not suitable	Continuous	none	Mud	332.40	beach, lagoon	
10	LI_N9	Lennies Lagoon1	habitat	Continuous	PSL	PSL53	190.13	beach, lagoon	
18	LI_N10	WPnt1	habitat	Continuous	PSL	PSLT3	82.68	Pocket cove	
19	LI_N11	WPnt2	habitat	Discontinuous	SS/PSL	SST1	108.21	Barrier beach	
26	LI_N12	WSandyCv	not suitable	Continuous	none	Mud	28.73	Pocket cove	
27	LI_N13	ESandyCv	habitat	Continuous	SS/PSL	SST2	45.94	Pocket cove	1 embryo, PSL
28	LI_N14	WConnBy	habitat	Continuous	SS/PSL	SST2	27.41	Pocket cove	SS
12	LI_N15	MidConnBy	habitat	Continuous	SS	SST1	25.16	Pocket cove	
33	LI_N16	SteamshipLnd	not suitable	Continuous	none	Cb	20.31	Barrier beach	
20	LI_N17	ELongBy	habitat	Discontinuous	SS	SST5	13.45	Pocket cove	
43	LI_N18	AndersonBy	habitat	Continuous	SS	SST1	12.01	Pocket cove	
14	LI_E19	RouseBy3	habitat	Continuous	SS	SST5	8.66	Pocket cove	
13	LI_E20	RouseBy1	habitat	Continuous	SS/PSL	SST2	52.85	Pocket cove	
15	LI_E21	RouseBy4	habitat	Continuous	SS/PSL	SST1	5.28	Pocket cove	
4	LI_E22	WindyBy1	habitat	Continuous	SS/PSL	SST2	53.29	Pocket cove	
29	LI_S23	PowderFlaskCv	habitat	Continuous	SS	SST3	65.17	Pocket cove	

Appendix A - Beach Units Lasqueti Island

GIS ID	Beach Number	Beach Name	Habitat Class	Sediment Distribution	Species most likely	Grain Size Type	Beach Unit Length (m)	Geomorphic Habitat Type	SPAWN DETECTED
42	LI_S24	EaglePetes	habitat	Continuous	SS/PSL	SST1	86.46	Pocket cove	
30	LI_S25	KarlsBe	habitat	Discontinuous	SS	SST2	63.72	Pocket cove	
31	LI_S26	BoatCv	habitat	Discontinuous	SS	SST5	39.31	Pocket cove	
7	LI_S27	OldHouseBy1	habitat	Continuous	SS/PSL	SST1	51.26	Pocket cove	
32	LI_S28	RichardsonsBy	habitat	Discontinuous	SS/PSL	SST2	51.89	Pocket cove	
1	LI_S29	SusanCv1	habitat	Continuous	SS	SST5	18.09	Pocket cove	
2	LI_S30	SusanCv2	habitat	Discontinuous	SS/PSL	SST1	10.30	Pocket cove	
3	LI_S31	SusanCv3	habitat	Continuous	SS/PSL	SST1	26.17	Pocket cove	
6	LI_S32	Matheson	habitat	Discontinuous	SS/PSL	SST1	116.98	Pocket cove	PSL
21	LI_S33	OrchardBy	habitat	Continuous	SS	SST1	55.21	Pocket cove	
5	LI_S34	OldPostOff	not suitable	Continuous	none	Mud	6.87	Pocket cove	
39	LI_W35	FarmBy1	habitat	Continuous	SS/PSL	SST2	96.65	Pocket cove	
40	LI_W36	FarmBy2	habitat	Continuous	SS/PSL	SST2	21.39	Pocket cove	
41	LI_W37	SpringBy	habitat	Discontinuous	SS/PSL	SST4	189.23	Barrier beach	
36	LI_W38	BootPnt1	habitat	Discontinuous	SS	SST2	213.52	Barrier beach	
37	LI_W39	BootPnt2	habitat	Continuous	SS	SST1	120.65	Barrier beach	
38	LI_W40	BootPnt4	not suitable	Continuous	none	CB	97.57	Barrier beach	

Appendix B – Not Habitat Types, Pocket Coves, Lasqueti Island

Lasqueti Island - Not Habitat Pocket Cc

ID	Cv_No	Beach_unit	Line_segment	ID	Cv_No	Beach_unit	Line_segment
1	NH_N1	MarineIslE	not habitat	34	NH_SE34	OldHouseBy	not habitat
2	NH_N2	MapleBy	not habitat	35	NH_SE35	RichardsonBySE#1	not habitat
3	NH_N3	MapleBy	not habitat	36	NH_SE36	RichardsonBy	not habitat
4	NH_N4	ScottyByE#1	not habitat	37	NH_SW37	RichardsonBySW#1	not habitat
5	NH_N5	ScottyByE#2	not habitat	38	NH_SW38	JenkinsBay	not habitat
6	NH_N6	ConnBy#A	not habitat	39	NH_SW39	JenkinsBySW#A	not habitat
7	NH_N7	WPotterPnt#1	not habitat	40	NH_SW40	WeldonBySW#1	not habitat
8	NH_N8	WPotterPntA	not habitat	41	NH_SW41	WeldonBySW#A	not habitat
9	NH_N9	WPotterPnt#2	not habitat	42	NH_SW42	WeldonBy	not habitat
10	NH_N10	EPotterPntA	not habitat	43	NH_SW43	WeldonBySW#C	not habitat
11	NH_N11	ELongBay#1	not habitat	44	NH_SW44	WeldonBySW#D	not habitat
12	NH_N12	ELongBay#2	not habitat	45	NH_SW45	WeldonBySW#E	not habitat
13	NH_N13	WSkerryBy	not habitat	46	NH_SW46	SusanCv	not habitat
14	NH_N14	SkerryBy#A	not habitat	47	NH_W47	JlagoonS#A	not habitat
15	NH_N15	BohoAndersonBy#A	not habitat	48	NH_W48	JlagoonS#B	not habitat
16	NH_E16	AndersonBy#1	not habitat	49	NH_W49	FalseByPub	not habitat
17	NH_E17	NWindyBy	not habitat	50	NH_W50	CocktailCv	not habitat
18	NH_E18	SWindyBy	not habitat	51	NH_W51	FalseByW#1Jims	not habitat
19	NH_E19	WindyByE#1	not habitat	52	NH_W52	FalseByW#2	not habitat
20	NH_E20	WindyByE#2	not habitat	53	NH_NW53	FarmbyShumach1	not habitat
21	NH_E21	WindyByE#A	not habitat	54	NH_NW54	FarmbyShumach2	not habitat
22	NH_E22	SquittyE#1Daisys	not habitat	55	NH_NW55	FarmbyShumach3	not habitat
23	NH_E23	SquittyE#2	not habitat	56	NH_NW56	FarmbyShumach#AMarjorie's	not habitat
24	NH_E24	SquittyE#3	not habitat	57	NH_NW57	FarmbyShumach#BAerie	not habitat
25	NH_E25	SquittyE#4	not habitat	58	NH_NW58	FarmbyShumach4	not habitat
26	NH_E26	SETahiniCv	not habitat	59	NH_NW59	FarmbyShumachMarcie'sBe!	not habitat
27	NH_S27	PwdrflskE#1	not habitat	60	NH_NW60	BootPnt#A	not habitat
28	NH_S28	PwdrflskE#2	not habitat	61	NH_NW61	BootPnt#1	not habitat
29	NH_S29	PwdrflskW#1Inukshuk	not habitat	62	NH_NW62	BootPnt#2	not habitat
30	NH_S30	PwdrflskW#2Grant &Tracy	not habitat				
31	NH_SE31	BoatCvSE#1	not habitat				
32	NH_SE32	BoatCvSE#2	not habitat				
33	NH_SE33	BoatCvSE#3	not habitat				

Appendix C – Beach Spawning Habitat Type Classifications – Lasqueti Island

Pacific Sand lance - Type 3

Beach Number	Lasqueti Island Beach Unit	Grain Size Type	Suitable by Species	Spawning Beach	Sediment Distribution
LI_N9	LENNYSLAGOON1	PSLT3	PSL		Continuous
LI_N7	LENNIE3	PSLT3	PSL		Discontinuous
LI_N10	WESTPOINT1LLAGOON	PSLT3	PSL		Continuous

Surf smelt - Type 1

Beach Number	Lasqueti Island Beach Unit	Grain Size Type	Suitable by Species	Spawning Beach	Sediment Distribution
LI_S32	OrchardBy	SST1	SS		Continuous
LI_N1	MapleBy	SST1	SS/PSL	PSL 1 embryo	Discontinuous
LI_N6	MarshallBe	SST1	SS,PSL	PSL	Discontinuous
LI_N15	MidConnBy	SST1	SS		Continuous
LI_N11	WPnt2	SST1	SS/PSL		Discontinuous
LI_N18	AndersonBy	SST1	SS		Continuous
LI_E21	RouseBy4	SST1	SS/PSL		Continuous
LI_S30	SusanCv2	SST1	SS/PSL		Discontinuous
LI_S27	OldHouseBy1	SST1	SS/PSL		Continuous
LI_S31	Matheson	SST1	SS/PSL	PSL	Discontinuous
LI_W38	BootPnt2	SST1	SS		Continuous
LI_S24	EaglePetes	SST1	SS/PSL		Continuous

Appendix C – Beach Spawning Habitat Type Classifications – Lasqueti Island

Surf smelt - Type 2

Beach Number	Lasqueti Island Beach Unit	Grain Size Type	Suitable by Species	Spawning Beach	Sediment Distribution
LI_N3	Marine Island	SST2	SS/PSL		Discontinuous
LI_N13	ESandyCv	SST2	SS/PSL	PSL	Continuous
LI_N14	WConnBy	SST2	SS/PSL	SS 1 embryo	Continuous
LI_S28	RichardsonsBy	SST2	SS/PSL		Discontinuous
LI_S25	KarlsBe	SST2	SS		Discontinuous
LI_E20	RouseBy1	SST2	SS/PSL		Continuous
LI_E22	WindyBy1	SST2	SS/PSL		Continuous
LI_W34	FarmBy1	SST2	SS/PSL		Continuous
LI_W35	FarmBy2	SST2	SS/PSL		Continuous
LI_W37	BootPnt1	SST2	SS		Discontinuous

Surf smelt - Type 3

Beach Number	Lasqueti Island Beach Unit	Grain Size Type	Suitable by Species	Spawning Beach	Sediment Distribution
LI_N5	ChrisDougBe	SST3	SS/PSL	SS,PSL	Continuous
LI_S23	PowderFlaskCv	SST3	SS		Continuous

Appendix C – Beach Spawning Habitat Type Classifications – Lasqueti Island

Surf smelt - Type 4					
Beach Number	Lasqueti Island Beach Unit	Grain Size Type	Suitable by Species	Spawning Beach	Sediment Distribution
LI_W36	SpringBy	SST4	SS/PSL		Discontinuous

Surf smelt - Type 5					
Beach Number	Lasqueti Island Beach Unit	Grain Size Type	Suitable by Species	Spawning Beach	Sediment Distribution
LI_S26	**BoatCv**	SST5	SS		Discontinuous
LI_N4	EScottyBy1	SST5	SS		Discontinuous
LI_N17	ELongBy	SST5	SS		Discontinuous
LI_E19	RouseBy3	SST5	SS		Continuous
LI_S29	**SusanCv1**	SST5	SS		Continuous

Appendix D: Beach Type Grain-Size Curves Lasqueti Island

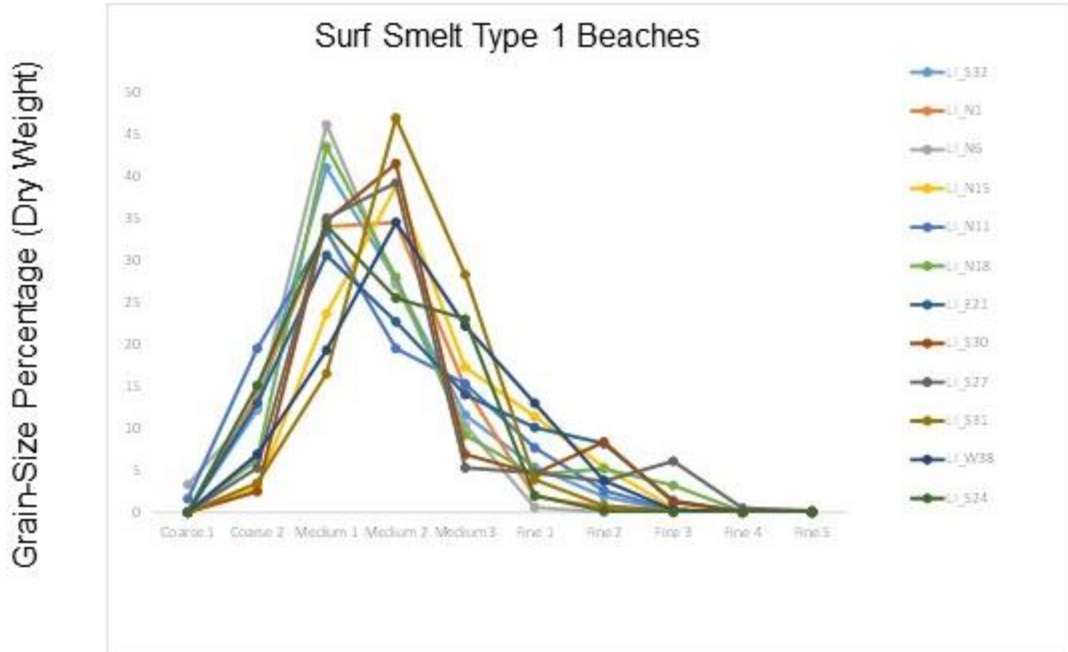

Figure 2 Lasqueti Island – Surf Smelt Type 1 Beaches

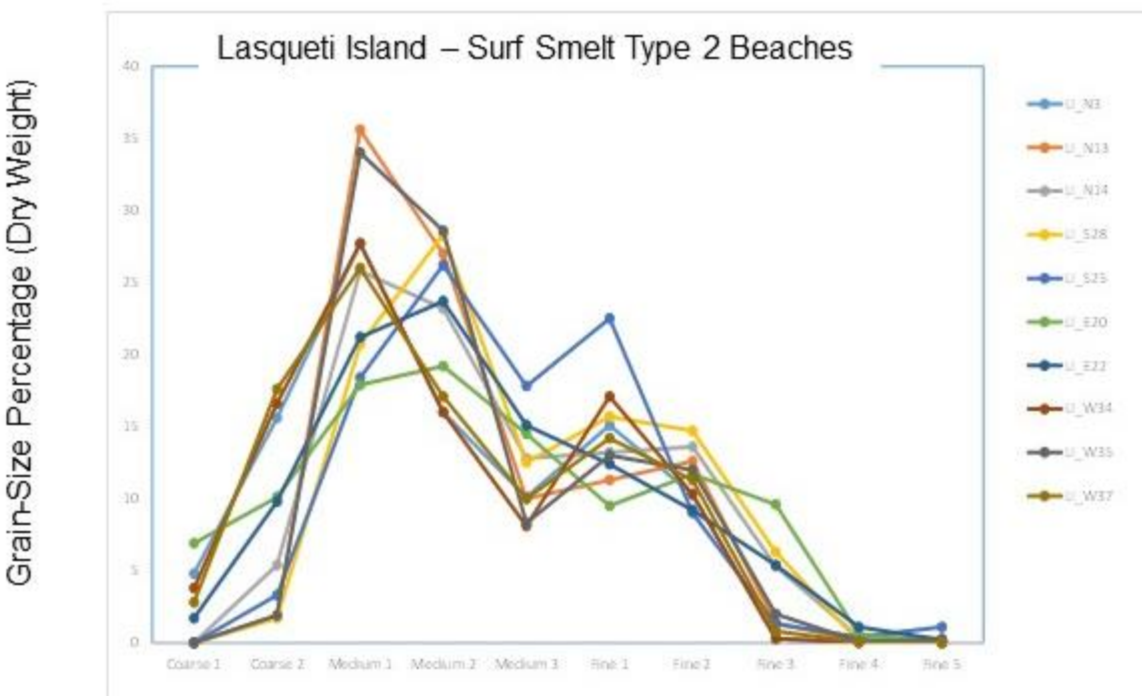

Figure **3** Lasqueti Island – Surf Smelt Type 2 Beaches

Appendix D: Beach Type Grain-Size Curves Lasqueti Island

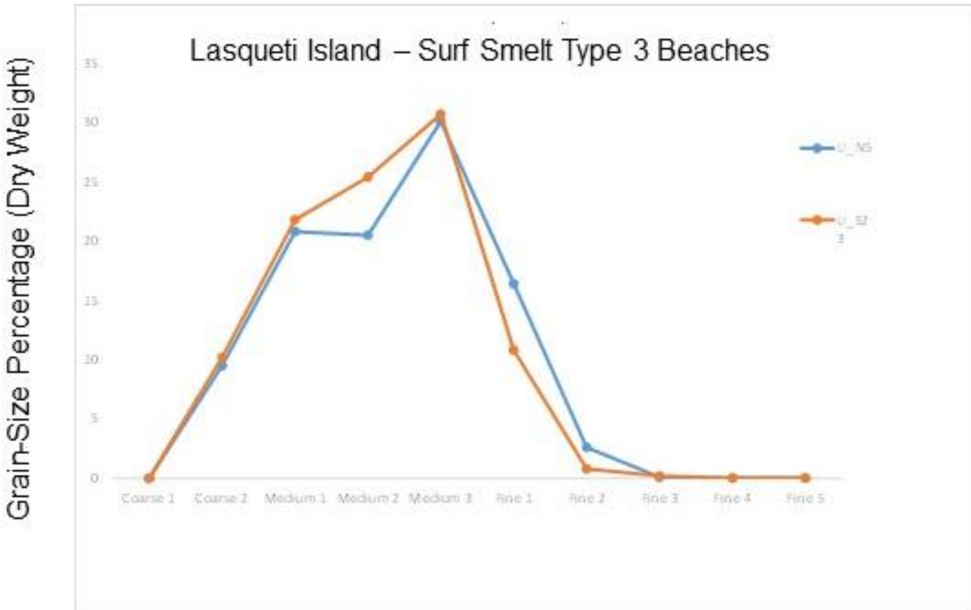

Figure **4** Lasqueti Island – Surf Smelt Type 3 Beaches

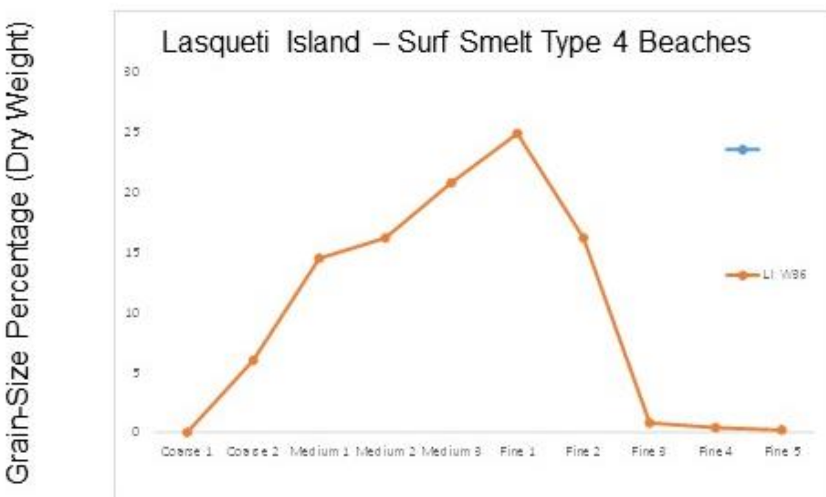

Figure **5** Lasqueti Island – Surf Smelt Type 4 Beaches

Appendix D: Beach Type Grain-Size Curves Lasqueti Island

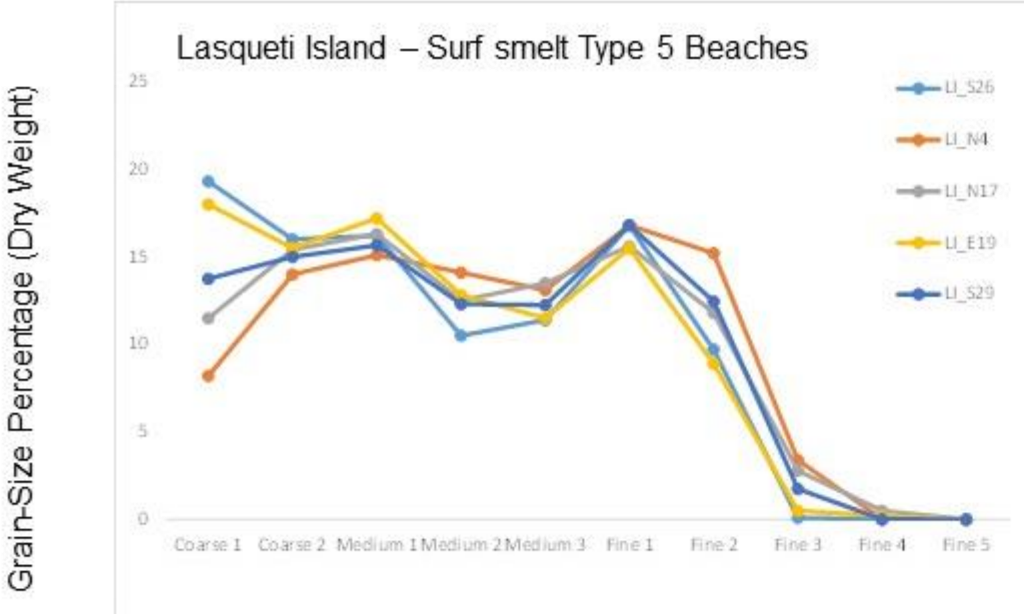

Figure **6**– Lasqueti – Surf smelt Type 5 Beaches

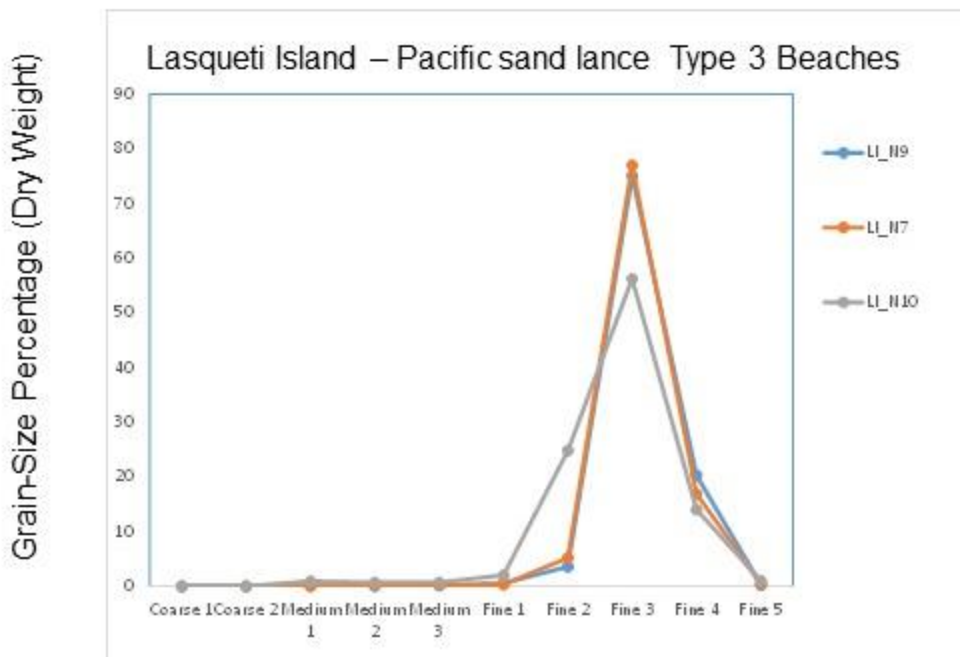

Figure **7**– Lasqueti – Pacific sand lance Type 3 Beaches

Global Positioning System Specifications

1. General Application

1.01

The target horizontal accuracy is 1 metre. The lowest acceptable horizontal accuracy is 5 metres, at the
95% confidence level. This applies to final map data after averaging (for point features), approximating
(for line features), and any editing.

1.02

All GPS receiver systems must be approved for use in stream mapping by Islands Trust GIS staff. Only
receiver models which have been tested and proven to be capable of meeting the above accuracy
specification in field conditions will be approved.

1.03

At least one person, who is responsible for the quality of the data, must act as a supervisor and have
completed GPS-specific training acceptable to Islands Trust GIS staff.

1.04

Field operators must be trained to the satisfaction of the supervisor, including GPS training and other
training as required.

2. Field Parameters and Procedures

2.01

All positions fixes must use at least four satellites. No height constraints can be applied.

2.02

The minimum elevation angle to satellites is 15 degrees above the horizon.

2.03

The maximum Dilution of Precision (DoP) is:

HDOP 5 (preferred in most cases)

PDOP 8

GDOP 10

VDOP 5 (only if elevations are required)

2.04

For standard static point features, occupation time must be at least 60 seconds AND there must be at
least 30 individual position fixes for each feature.

Appendix E: GPS/GIS Methodology

2.05

The maximum distance for point offsets is 25 metres. Directions must be accurate to 2 degrees and distances accurate to 1 metre. If the slope is over 10 percent and over 10 metres long, slope measurements (accurate to 5 percent or 3 degrees) must be made.

2.06

For all line (and polygon) features, all significant deflections and meanders of the feature must be mapped. Dynamic points recorded every 5 metres and static every 50 metres, or significant deflection.

2.07

For line (and polygon) features surveyed in dynamic mode, the majority of the individual position fixes must be no more than 5 metres apart. The maximum distance between successive position fixes is 10 metres.

2.08

The maximum distance for constant line offsets is 5 metres.

2.09

Supplementary traverses (using compass and chain) must begin (Point of Commencement) and end (Point of Termination) on static GPS point features or on survey control monuments of 1 metre or better accuracy.

2.10

Directions for supplementary traverses must be accurate to 2 degrees and distances accurate to 1 metre. If the slope is greater than 10 percent, slope measurements accurate to 5 percent or 2.5 degrees must be made. The maximum length of an individual traverse leg is 50 metres. There is no limit on the total length of a supplementary traverse.

2.11

Static features collected for start and end point of all sampling units. Static features will be meet collection and accuracy requirements as outlined in section 2.04.

2.12

Sampling unit feature descriptions refer to the centerline of B1 sediment component. Centerline changes of direction will be captured as static points every 50 meters or less. Centerline of features will be described between static points using dynamic mode. Dynamically collected transverses will not be required to meet static feature standards of accuracy.

2.05

The maximum distance for point offsets is 25 metres. Directions must be accurate to 2 degrees
and distances accurate to 1 metre. If the slope is over 10 percent and over 10 metres long, slope
measurements (accurate to 5 percent or 3 degrees) must be made.

2.06

For all line (and polygon) features, all significant deflections and meanders of the feature must be
mapped. Dynamic points recorded every 5 metres and static every 50 metres, or significant deflection.

2.07

For line (and polygon) features surveyed in dynamic mode, the majority of the individual position fixes
must be no more than 5 metres apart. The maximum distance between successive position fixes is 10
metres.

2.08

The maximum distance for constant line offsets is 5 metres.

2.09

Supplementary traverses (using compass and chain) must begin (Point of Commencement) and end
(Point of Termination) on static GPS point features or on survey control monuments of 1 metre or better
accuracy.

2.10

Directions for supplementary traverses must be accurate to 2 degrees and distances accurate to 1
metre. If the slope is greater than 10 percent, slope measurements accurate to 5 percent or 2.5 degrees
must be made. The maximum length of an individual traverse leg is 50 metres. There is no limit on the
total length of a supplementary traverse.

2.11

Static features collected for start and end point of all sampling units. Static features will be meet
collection and accuracy requirements as outlined in section 2.04.

2.12

Sampling unit feature descriptions refer to the centerline of B1 sediment component. Centerline
changes of direction will be captured as static points every 50 meters or less. Centerline of features will
be described between static points using dynamic mode. Dynamically collected transverses will not be
required to meet static feature standards of accuracy.

3. Data Processing and Mapping

3.01

All position fixes must be differentially corrected in real-time or post-processed. If position corrections
are used, the same set of satellites must be used at the reference station as at the field receiver.

3.02

Reference stations (real-time or post-processed) must be approved by Islands Trust GIS staff.

3.03

The maximum age of real-time corrections is 20 seconds from the time the observations are made at the
reference station to the time the computed corrections are applied at the field receiver.

3.02

All directions from compass observations must be corrected for declination before offset or traverse
computations. If applicable, correction for grid convergence must be made.

3.05

Supplemental traverses must close to better than 1 percent (1/100) of the total traverse distance plus
2.5 metres. Traverse misclosures over 2.5 metres total must be adjusted ("balanced") using the standard
compass rule method.

3.06

If true NAD 27 coordinates are required, NAD 83 coordinates must be converted using the Canadian
National Transformation, version 2 (NT v2).

3.07

If elevations are required, they must be converted from ellipsoidal to orthometric using the CRD Geoid
model HT 2.0.

3.08

If data in any other coordinate system (e.g. ground coordinates) are required, procedures acceptable to
Islands Trust GIS staff and the owner of the mapping must be used.

3.09

Any discrepancies between the GPS survey and existing mapping used as base maps must be resolved to
the satisfaction of Islands Trust GIS staff and the local agency(s) considered responsible for the mapping.

Appendix F: Digitizing Spatial Data and Map Production

Mapping Procedure for Suitable Forage Fish Habitat Beach Segments using Static and Dynamic GPS Features

Pathfinder Office

Export GPS point features and positions-not-in-features as two separate shapefiles using Pathfinder Office.

ArcGIS 10.1

1. Project the two GPS data shapefiles to NAD83 UTM 10N projection..
2. Create an empty polyline shapefile with NAD83 UTM 10N projection for the Forage Fish Habitat beach segments.
3. Connect static GPS features with a common *FILENAME* attribute using the Point to Line tool.
4. Re-shape the centerline between static feature points by snapping to dynamic feature points. Only start and end points with horizontal accuracy less than 5m are used for Forage Fish Segments that are Suitable Habitat.
5. Provide a preliminary *Line_Segmen* classification based on the data sheet provided by Ramona.
6. Finalize beach segment polylines and connect additional attributes.
7. Digitize any remaining 'Not Habitat' segments using ortho-photographs and ArcGIS digitizing tools at a scale of 1:5,000.
8. For segments with GPS end points which don't meet the accuracy standards, the segment end point is digitized using ortho-photographs at 1:5,000 scale. These segments have the attribute *Collection* =' Digitized'

Appendix G: Forage Fish Habitat Suitability Assessment Methods

Housed with the Islands Trust Fund and the author