

Galiano Island

Surf smelt and Pacific sand lance

Beach Spawning Habitat Suitability Assessments



Quelus' Village, Penelakut Tribe (Dionisio Point Provincial Park), rocky shoreline, Galiano Island -

Prepared for the Islands Trust and Islands Trust Fund

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Surf smelt and Pacific sand lance
Spawning Habitat Suitability Assessments

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1.0 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 focuses 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.

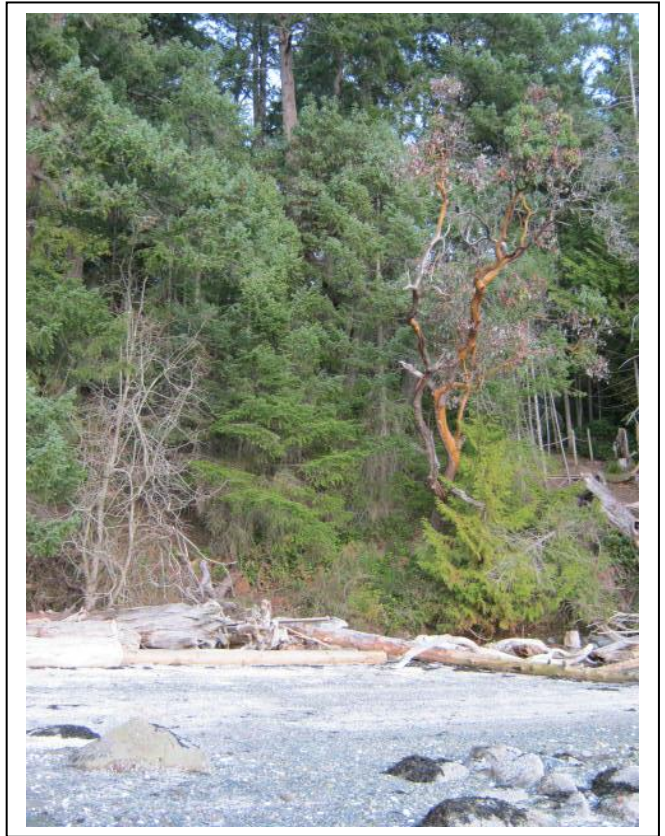
Numerous fish, seabird, and marine mammal populations are in precipitous decline in British Columbia and scientists have started to look at the link between forage fish biomass reduction and these declining populations.

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.

1.2.1 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



Overhanging Shade Vegetation
Photo: RC de Graaf

marine shoreline vegetation to the water's surface (Brennan and Culverwell 2004).

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.

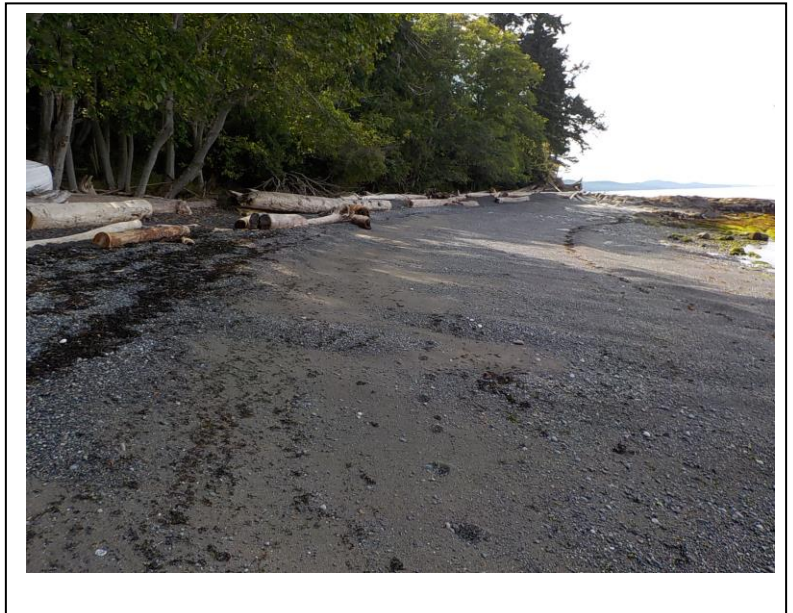
Diverting storm-water through pipes and ditches that empty directly into banks or onto beaches is another cause of erosion. It is easier and less damaging to the environment to re-route storm water into municipal infrastructure or into “rain gardens”. When inspecting shoreline edges, consider the natural 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.

2.0 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 hexapterus*). 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 spawning habitat is vulnerable to impacts from shoreline development. Beaches with natural erosion processes supplying appropriate sized gravels and 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.

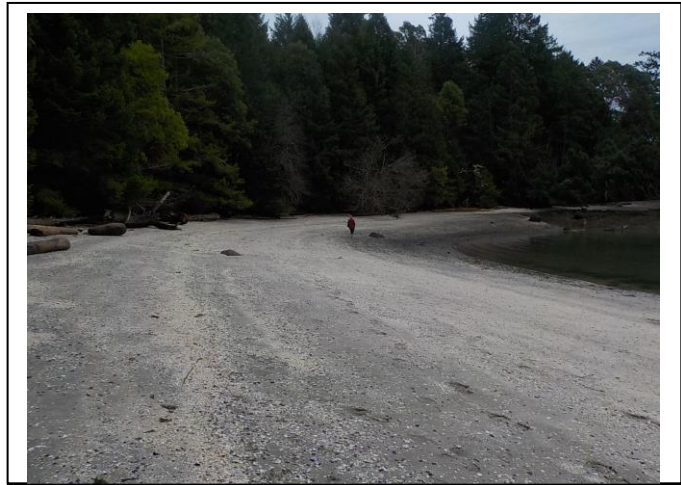


South of Pebble Beach Reserve
East Coast Pocket Cove, Galiano Island
Photo: RC de Graaf

3.0 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.



Montague Harbour Provincial Marine Park – suitable spawning habitat
West coast Galiano Island – Photo: RC de Graaf

3.2 Sediment Characteristics

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 embryo 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 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 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.

4.0 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). Pacific sand lance spawning 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 been undertaken by 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.



Surf smelt in spawning condition
Wreck Beach, BC
Photo: Kalup George

5.0 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).

5.1 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.

5.2 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).

5.3 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.

6.0 Introduction to the Beach Spawning Forage Fish Habitat Assessment

6.1 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 Galiano 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.

Galiano Island surveys took place on September 26, 2015, February 10-17, and May 27-30, 2016. A small number of beach units were reassessed on July 2 and 3, 2016.

6.2 Area Surveyed

The entire coastline of Galiano 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.

The Penelakut Tribe granted permission to access shorelines under their jurisdiction.

7.0 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 and model analysis.

7.1 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 layers (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.

7.2 GPS/GIS Methodology

7.2.1 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 D).

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.

7.2.2 Digitizing Spatial Data and Map Production

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

8.0 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 were 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.

9.0 Galiano Island – Geomorphic Setting and Beach Shoreline Types

Wave exposure regimes (fetch and energy) for Galiano Island range from low (sheltered west coast areas) to high (south, east and north coasts). The west coast is more protected from high fetch due to the presence of islands (Thetis, Penelakut, and Salt Spring), having lower wave exposures relative to the east coast which is directly exposed to dominant northwesterly and southeasterly winds and long fetch in the Strait of Georgia. Sections of the south coast are exposed to southwesterly storm winds and Active Pass tidal currents. The north coast is mainly exposed to strong tidal forces of Porlier Pass, strong northwesterly storm winds and the long fetch of the Strait of Georgia (deGreeff 2011). Galiano Island's dominant geomorphic system is rocky shorelines. Small sections of Galiano's south and west coast represent a beach geomorphic system with accretion shorelines and independent drift cells. Net sediment drift along Galiano's shores is northward (deGreeff 2011).

Along the majority of Galiano's exposed south, east and north rocky shores, small volumes of sediment are maintained between isolated and disjunct rocky headlands in small pocket coves along erosional shores.

Along sections of Galiano's southwest and west shores, 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).

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.

10. Results

10.1 Statistical Analyses

In total, 67 (sixty-seven) beach units comprised of unconsolidated sediments were assessed (Table 1). Principal Component Analysis using PRIMER-E and beach metrics, including grain-size analyses, assessed fifty-nine (59) beach units with 80% similarity to known positive beaches in BC and Washington State and were classified as “suitable spawning habitat” (Figure 1A-H). Fifty-one (51) of these beach units had continuous habitat and eight (8) had discontinuous habitat.

Eight (8) beach units failed statistical analyses, the same beach units with non-conforming grain-sizes, and were classified as “not suitable spawning habitat” (Figure 1A-H). A list of beach units identified in the map Figures 1A-H is provided in Appendix A.

Table 1: Galiano Island Beach Units - Suitable Forage Fish Spawning Habitat

	Count	Total	Length (m)	Percentage of Shoreline Perimeter
Habitat	59		5,062.10	6.73%
Not Suitable	8		580.18	0.77%
Total Beach Units		67		
Total Length (meters)			5,642.22	
Habitat				
Continuous	51		4,039.17	5.37%
Discontinuous	8		1,022.87	1.36%
Perimeter Distance of Galiano Island			75,202 m	

10.2 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. Fifty-nine (59) beach units showed grain-size frequencies curves that were within 80% and higher similarity to known positive spawning beaches (Appendix B, Appendix C, Figures 2-7). The grain-size frequencies of eight (8) samples did not meet the statistical standards of the analysis.

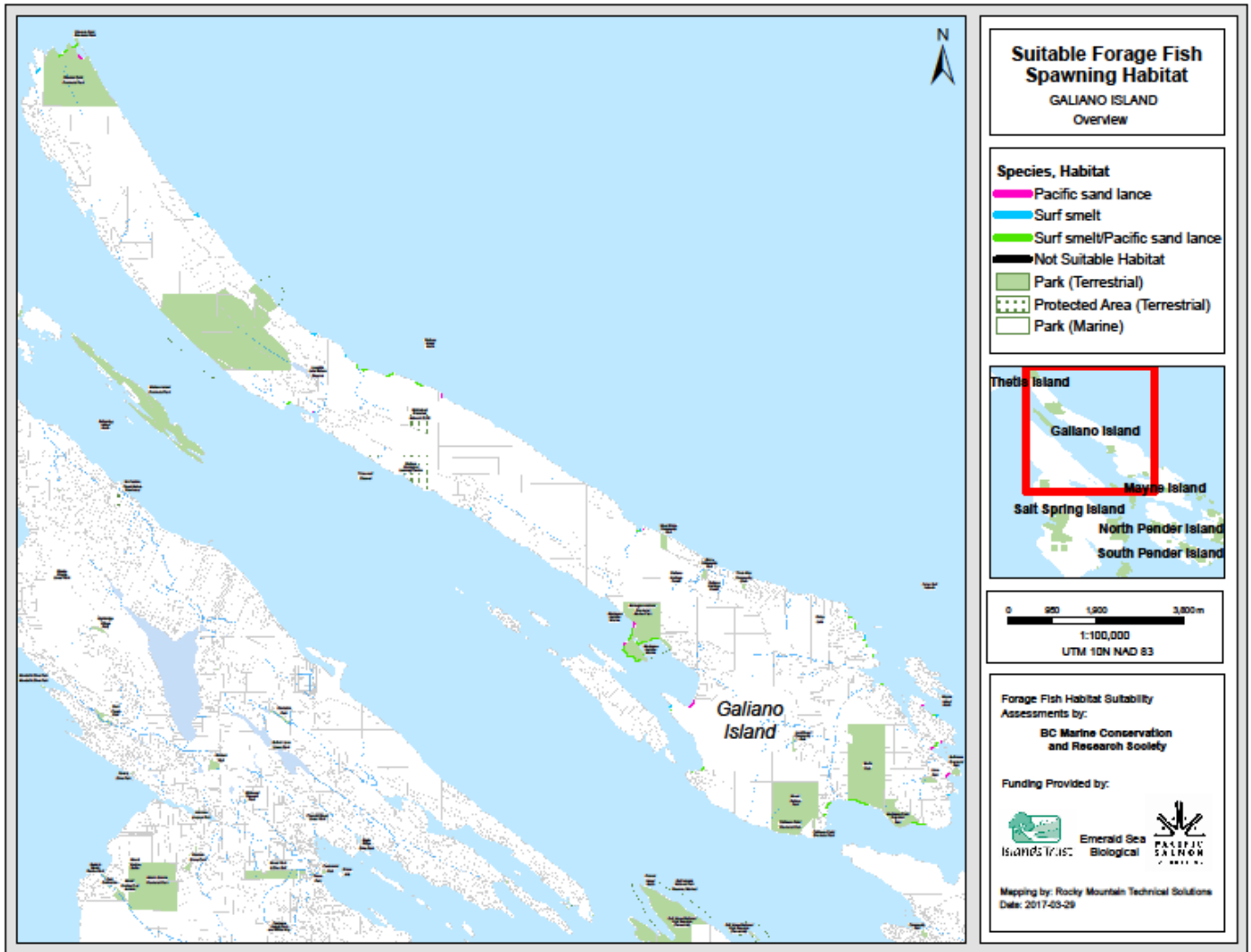


Figure 1A: Suitable Forage Fish Spawning Habitats – GALIANO ISLAND

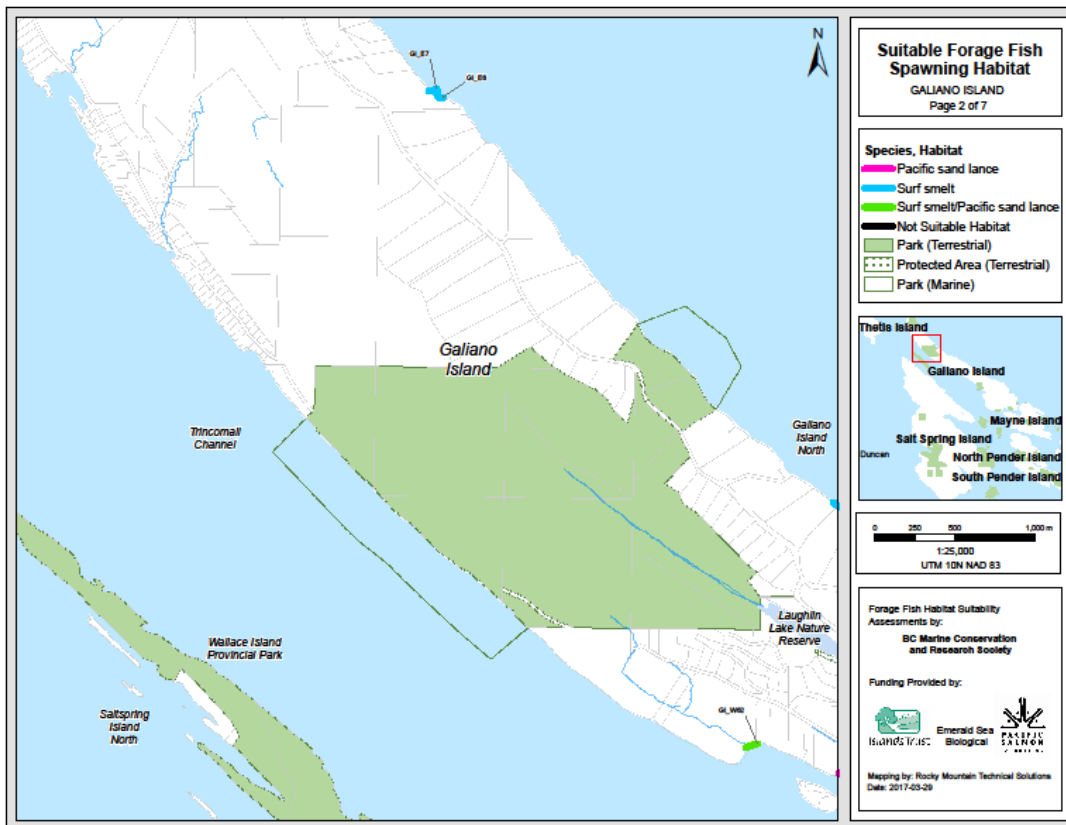
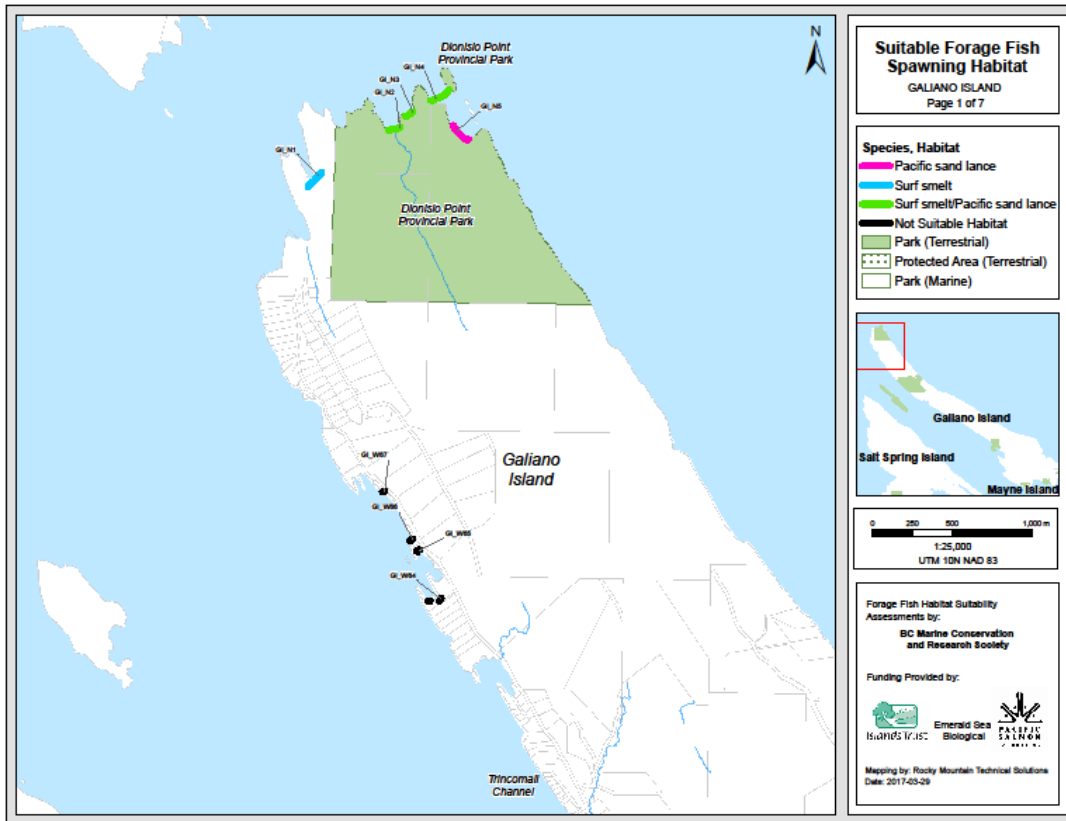


Figure 1B-C: Suitable Forage Fish Spawning Habitats – GALIANO ISLAND

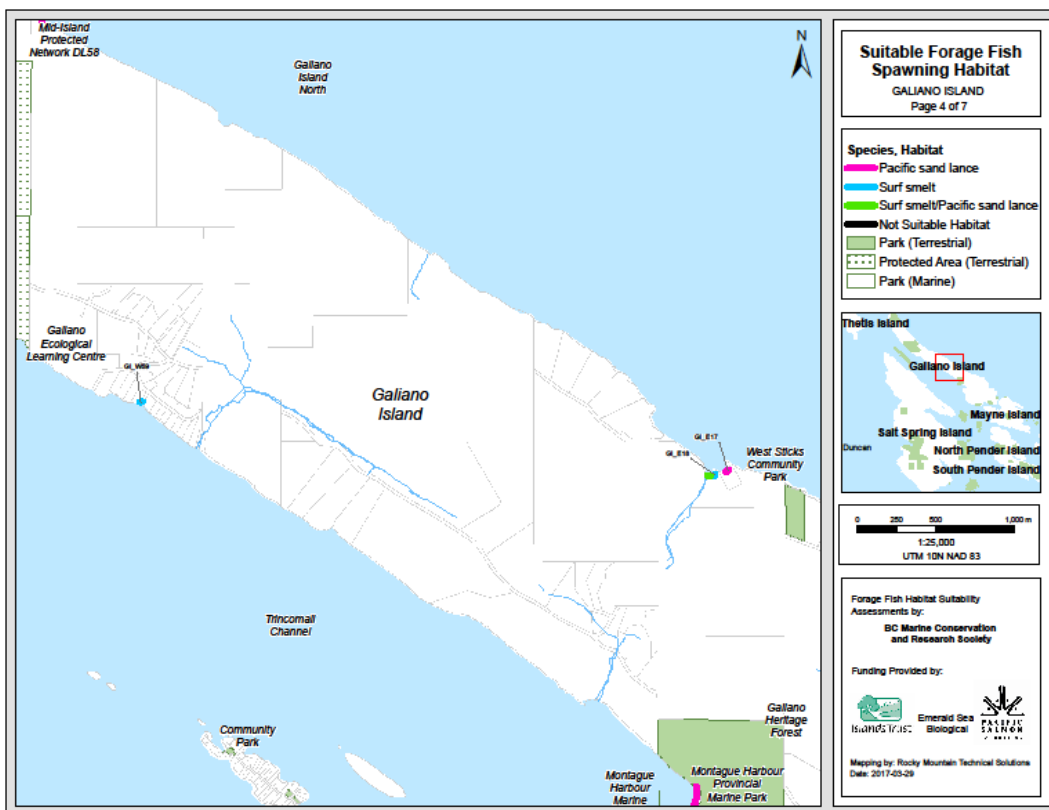
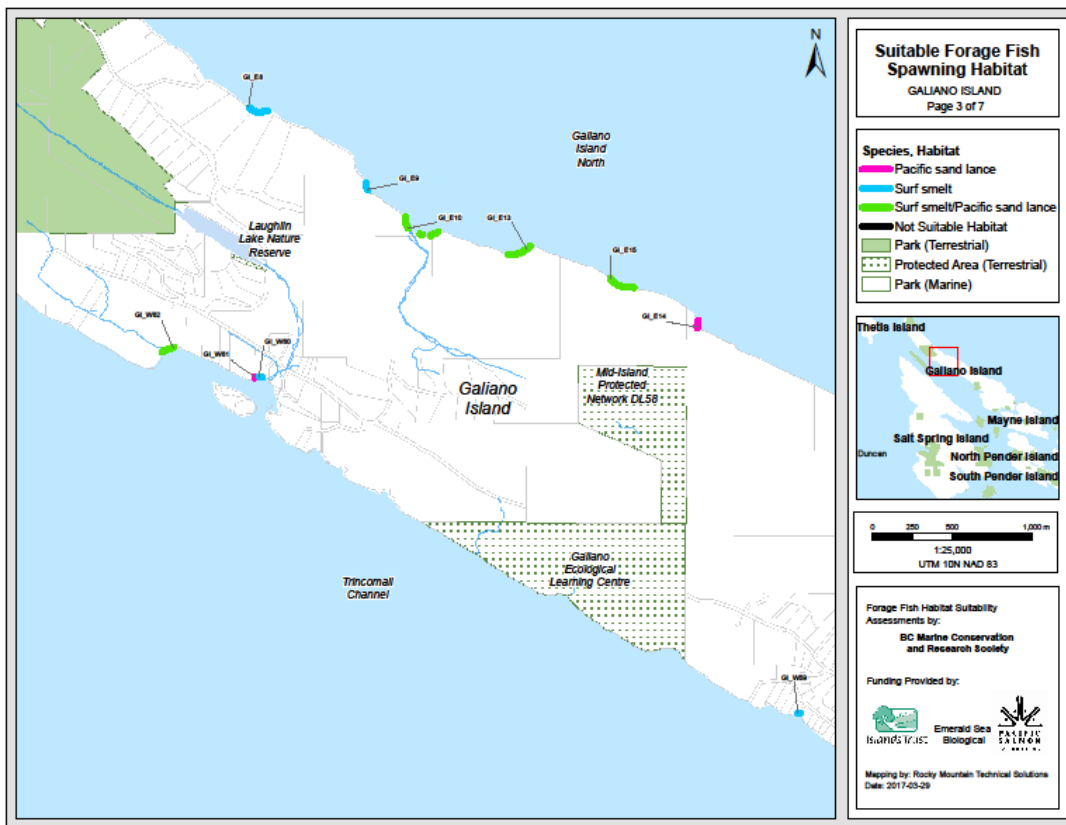


Figure 1D-E: Suitable Forage Fish Spawning Habitats – GALIANO ISLAND

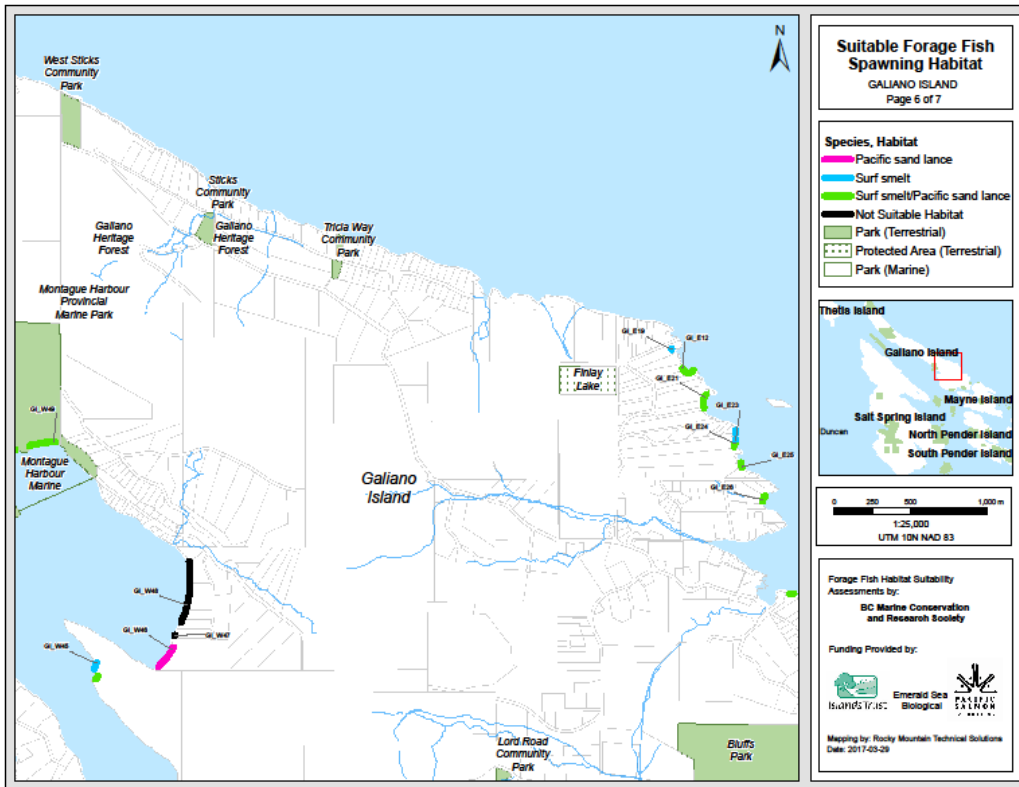
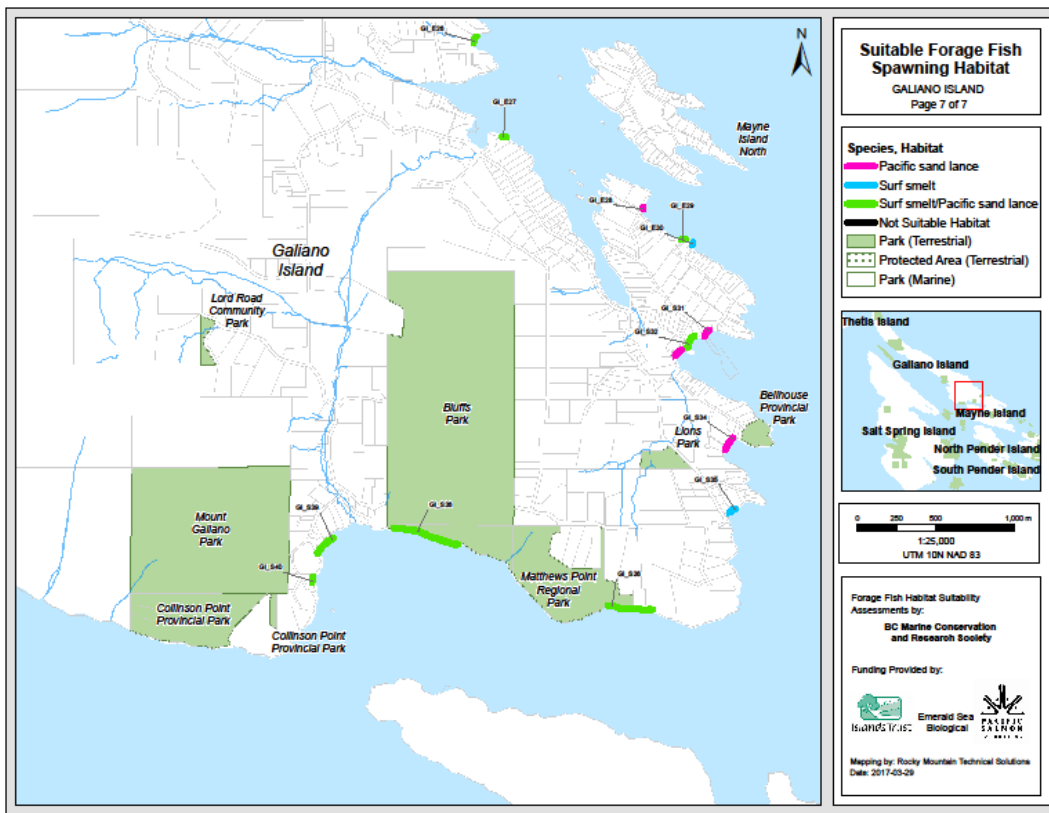


Figure 1F-G: Suitable Forage Fish Spawning Habitats – GALIANO ISLAND

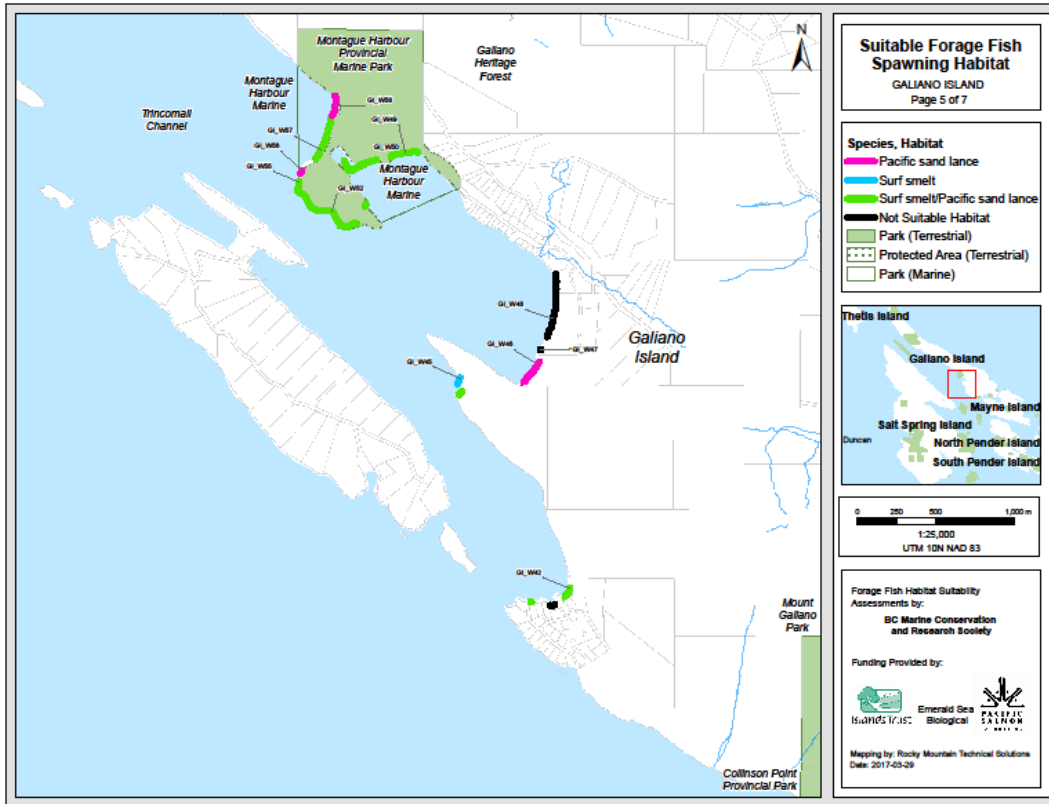


Figure 1H: Suitable Forage Fish Spawning Habitats – GALIANO ISLAND

10.3 Length of Suitable Forage Fish Spawning Habitat

The total shoreline perimeter of Galiano Island is 75.2 kilometers (75,202 m). Suitable forage fish spawning habitat comprised 5.0 kilometers (5,062.10 m) or 6.73% percent of the Galiano Island shoreline perimeter (Table 1).

Of the suitable forage fish spawning habitat, the shoreline perimeter is comprised of 15.8% (802.29 m) suitable for Pacific sand lance spawning; 12.4% (629.46 m) suitable for Surf smelt spawning; and 71.7% (3,630.29 m) as suitable for Surf smelt/Pacific sand lance spawning habitat (Table 2).

Table 2: Galiano Island Beach Units -
Classification of Suitable Forage Fish Spawning Habitat by Species

	SS	PSL	SS/PSL	Total (m)
Count	14	11	34	59
Length (m)	629.46	802.29	3,630.29	5,062.10
Shoreline Perimeter Percentage	12.4%	15.8%	71.7%	100.0%

SS - Surf smelt

PSL - Pacific sand lance

10.4 Suitable Forage Fish Spawning Habitat Beach Types

Of the 59 suitable spawning beaches, 11 were classified as Pacific sand lance, 14 as Surf smelt, and 34 as mixed surf smelt/Pacific sand lance spawning habitat (Table 3). Of the Pacific sand lance beaches, grain size analyses assessed 11 as Type 3 Pacific sand lance beach type. Of the Surf smelt beaches, grain size analysis assessed 8 as Type 1, 3, as Type 2, 1 as Type 1, and 2 as Type 5 Surf smelt beach types. Of the mixed Surf smelt/Pacific sand lance beaches, grain size analysis assessed 5 as Type 1; 8 as Type 2; 8 as Type 3, and 13 as Type 4 Surf Smelt beach types (Appendix C, Figures 2-7). There were 11 pure sand beach types (PSL type 3) and the rest (48) were mixed pebble/sand beach types.

Although no spawning surveys have been undertaken, the author has been advised by numerous residents and members of the Penelakut Tribe that in summer Surf smelt have been seen spawning on the beaches of Quelus', Dionisio Point Park.

Table 3: Galiano Island Beach Units - Suitable Forage Fish Spawning Habitat by Grain-Size Types

Category	SS	PSL	SS/PSL
PSL TYPE 1			
PSL TYPE 2			
PSL TYPE 3		11	
SS TYPE 1	8		5
SSTYPE 2	3		8
SS TYPE 3	1		8
SS TYPE 4			13
SS TYPE 5	2		
Totals	14	11	34

10.5 Geographic Position and Geomorphology of Suitable Forage Fish Spawning Beaches

10.5.1 Geographic Position

Dividing Galiano Island into north, south, west and east coast lines, 4 suitable beach units are located on the north coast; 9 suitable beach units are located on the south coast; 20 suitable beach units on the west coast; and 25 suitable beach units on the east coast (Table 4).

Table 4: Galiano Island Beach Units - Geographic Position of Suitable Forage Fish Spawning Beach Habitat

	SS	PSL	SS/PSL	Total
North	1	1	3	5
South	1	3	6	10
West	3	4	12	19
East	9	3	13	25
Total	14	11	34	59

10.5.2 Geomorphic Habitat Types

Reflecting the geomorphological systems of Galiano Island, of the fifty-nine (59) suitable beach units, 3 (5.1%) are bluff-backed beaches (eg. Georgeson Bay), 9 (15.3%) are barrier beaches (eg. Montague Harbour/Dionisio lagoon), and 47 (93%) beach units are pocket coves (Appendix A).



Bluffs Park, suitable spawning habitat
Bluff-backed beach, South coast Galiano Island
Photo: RC de Graaf



Pebble Beach Reserve, Pebble Beach
East Coast Pocket Cove, Galiano Island
Photo: RC de Graaf

10.6 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 the beach or along the beach. Galiano Island has a low level of foreshore modification. Of the 59 beach units assessed as being suitable spawning habitat, 83% (49) of the beach units had unmodified shorelines and 17% (10) were modified. Of the ten (10) modified beach units, 6 (10.1%) were 1-25% impacted; 2 (3.4%) were 26-50% impacted, 1 (1.7%) was 51-75% impacted; and 1 (1.7%) was 75-100% impacted (Table 5).

Table 5: Galiano Island Beach Units -
Foreshore Modification Classification of Suitable Forage Fish Spawning Habitat

	0% impact	1-25% Impact	26-50% Impact	51-75% Impact	76-100% Impact	Total
Count	49	6	2	1	1	59
Percentage	83.1%	10.1%	3.4%	1.7%	1.7%	

10.7 Foreshore and Backshore Structures

10.7.1 Foreshore Structures

Of the fifty-nine (59) suitable spawning beach units, 10, 17%, had modified foreshore zones, the presence of sediment impeding structures were classified and enumerated (Table 6). Other structures encroaching on the foreshore, such as outfall pipes, were also classified and enumerated. No buildings were present on the foreshore. In total eighteen (18) structures were classified into 8 categories (Table 6).

Seven (7) beach units had one (1) foreshore structure, and five (5) beach units had two (2) foreshore structures.

Hard Armouring:

Four (4) beach units had hard armouring (seawalls, riprap), three (3) beach units had boat ramps, and one (1) beach unit had a groyne encroaching on the foreshore.

10.7.2. Backshore Structures

Of the fifty-nine (59) suitable spawning beach units, 32, 52% had modified backshore zones. In total thirty-two (32) structures were classified into eight (8) categories (Table 6). Buildings (cabins, houses, sheds, etc.) are not enumerated but only classified as present or absent. All other Individual structures were enumerated.

Buildings were present at twenty-five (25) beach units (Table 6). Eight (8) beach units had one (1) backshore structure, three (3) beach units had two (2) backshore structures, three (3) beach units had three (3) backshore structures, and two (2) beach units had four (4) backshore structures (Table 6).

Hard Armouring:

Four (4) beach units had hard armouring (seawalls, riprap), and one (1) beach unit had a boat ramp.

Table 6: Galiano Island Beach Units -
 Classification of Structures present in Foreshore and Backshore Zones

Category	Foreshore			Backshore		No. Beach Units Buildings Present
		Count	%	Count	%	
Building						25
Boat Ramp		3	17%	1	3%	
Boat House		0	0%	3	9%	
Dock/Wooden Pier		2	11%	0	0%	
Seawall		2	11%	4	13%	
Riprap		2	11%	2	6%	
Groyne		1	6%	0	0%	
Storm Water Outfall		3	17%	6	19%	
Stairs		4	22%	10	31%	
Road to beach		0	0%	4	13%	
Parking Lot		0	0%	2	6%	
Culvert		1	6%	0	0%	
Total Number of Structures		18		32		
Total Number of Beach Units	59					
Number of Beach Units with Structures		13		32		
Percentage Beach Units with Structures		22%		54%		

10.8 Overhanging Shade Vegetation

Overhanging-shade habitat is classified as the percentage of the length of the beach unit with tree or shrub branches overhanging the spawning zone. In this analysis, overhanging shade vegetation scores ranging from 0-50% indicates reduced shade habitat.

Marine riparian vegetation may be reduced/absent due to land use/landscaping, structures (ranging from buildings to hard armouring), the type of soils or land form (examples include bluffs and barrier beaches (including spits, lagoons, and barrier beaches with wide berms)).

Trees are, generally, located above the high water mark. During property development, trees are often removed. Bluffs may lack trees that provide overhanging shade habitat as these land forms are steep sloped and are composed of eroding sediments. Low-lying landforms such as lagoons and spits often have natural vegetation types of low shrub and grasses near the high-water mark and trees more landward or may be devoid of trees.

10.8.1 Overhanging Shade Vegetation Index

Of the fifty-nine (59) suitable beach units, six (6) of the beach units had no overhanging shade; twenty-one (21) had 1-25% overhanging shade; nine (9) had 26-50% overhanging shade; nine (9) had 51-75% overhanging shade; fourteen (14) had 76-100% overhanging shade (10%, 34%, 16%, 16%, and 24% respectively) (Table 7).

Beach units with overhanging-shade habitat scores of 0-50% represent a reduced habitat condition. Thirty-six beach (36) units, 61%, had reduced overhanging shade-habitat (0-50%); and twenty three (23) beach units, 39%, had overhanging shade-habitat of 51-100% (Table 7).

Table 7: Galiano Island Beach Units - Overhanging Shade Vegetation Index

	Fully exposed	1-25% Shade	26-50% Shade	51-75% Shade	76-100% Shade
Number of Beach Units	6	21	9	9	14
Percentage	10.2%	35.6%	15.3%	15.3%	23.7%
Foreshore Modified (Count) %	(3) 50%	(3) 14%	(2) 22%	(2) 22%	(2) 14%
Backshore Modified (Count) %	(2) 33%	(9) 43%	(7) 78%	(6) 67%	(8) 57%
Landforms Lagoon/Bluff (Count) %	(1) 17%	(4) 20%		(1) 11%	
	0-50% Shade		51-100% Shade		
Number of Beach Units	36		23		
Percentage	61%		39%		

10.8.2 Overhanging-Shade Vegetation and shoreline modification effects

The relationship between the reduction of overhanging-shade habitat due to modifications below and within 30 meters of the high water mark (foreshore and backshore zones) was assessed.

Of the six (6) suitable beach units with no overhanging shade, 50% had modified foreshore and 33% modified backshore zones; twenty (21) beach units with 1-25% overhead shade, 14% had modified foreshore and 43% modified backshore zones; beach units with 26-50% overhead shade had 22% modified foreshore and 78% modified backshore zones; beach units with 51-75% overhead shade had 22% modified foreshore and 67% modified backshore zones; and beach units with 75-100% overhead shade had 14% modified foreshore and 57% modified back shore zones (Table 7).

Thirty-six of the beach units (36) beach units had overhanging shade ranging from 0-50% and five (5) of these had shoreline armouring (Table 7 and Table 8). Twenty three (23) beach units had overhanging shade ranging from 51-100%, and two (2) of these had shoreline armouring (Table 7 and Table 8).

Table 8: Galiano Island Beach Units -
Overhanging Shade Index Relative to Shoreline Armouring

		Fully exposed (1)	1-25% Shade (2)	26-50% Shade (3)	51-75% Shade (4)	76-100% Shade (5)
All beach units:	59 beach units	6	21	9	9	14
All armouring (Fsh&Bsh)	7 beach units	1	3	1	1	1
Foreshore Armouring	3 beach units	1			1	1
Backshore Armouring	3 beach units		2	1		
Foreshore&Backshore Armour	1 beach unit		1			

Although the incidence of shoreline armouring is low, in general, modification of the shoreline below or within 30 meters of the high water mark (foreshore and backshore zones) resulted in reduced overhanging-shade habitat.

10.8.3. Overhanging Shade Habitat and Landform

On Galiano Island, of beach units classified as suitable for forage fish spawning habitat, lagoons represented three (3) beach units and bluff-backed beaches represented four (4) beach units. The lagoons were present in Montague Harbour and Dionisio Point parks and bluffs in Matthews point and Bluffs Park. These seven (7) beach units with lagoon/bluff land forms had unmodified foreshore and backshore zones with vegetation types in natural, unaltered form.

Of the six (6) suitable beach units with no overhanging shade, 1 (17%) had lagoon/bluff land forms; twenty (20) beach units with 1-25% overhead shade, 4 (20%) had lagoon/bluff land forms; and nine (9) beach units with 51-75% overhead shade, 1 (11%) had bluff land form (Table 7).

Of the thirty-six (36) beach units with low overhanging-shade habitat index scores (0-50%), five (5) beach units are lagoon/bluff-backed land forms with no foreshore/backshore modification. Of the twenty-three (23) beach units with high overhanging shade habitat index scores (51-100%), one (1) had bluff-backed land form (Table 7).

In summary, the reduction of overhanging-shade habitat is more closely associated with both foreshore and backshore modifications during property development than the presence of armouring and land forms such as lagoons and bluffs.

11.0 Summary

Galiano Island has a shoreline perimeter of 75.2 kilometers (75,202 m) and 5.1 kilometers of suitable spawning habitat for Surf smelt and Pacific sand lance. Galiano Island presents excellent opportunities to safeguard beach habitat for spawning forage fish and rearing habitat for juvenile salmonids.

Beaches in Trincomali Channel have a very large biomass of bivalves. As with neighbouring Thetis and Valdes Islands, Galiano Island west coast beaches contain a high volume of shell hash, and a few sites are pure “biogenic” beaches.

Galiano island shorelines are mainly rocky shorelines with numerous pocket coves. This is similar to neighbouring Thetis and Valdes islands. Barrier beach systems along drift cells were found in Georgeson Bay and Montague Harbour, both having bluffs providing sediment to shorelines. Lagoons are present at Montague Harbour and Dionisio Park.

Overall, foreshore beach unit conditions were excellent as only ten (10) beach units (17%) are impacted by foreshore modifications with seven (7) of these beach units having hard armouring (seawalls/riprap) below or at the high water mark (Tables 5, 6, and 8). Development within 30 meters of the high water mark (backshore zone) had a higher incidence with 32 (54%) beach units having modified backshore zones (Tables 5 and 6) and 36 (61%) with reduced overhanging-shade habitat (Table 7).

12.0 Mitigating Stressor Impacts and Planning Habitat Enhancement/Restoration

12.1 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.

12.2 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.

12.3 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.

12.4 Stressors and Enhancement/Restoration

12.4.1 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.

12.4.2 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

13.0 Recommendations

13.1 Geomorphic Setting

Sea level rise and changing marine conditions are affecting the resiliency of the Salish Sea. Understanding the geomorphic systems and processes forming beach habitat is important for land-use planning and effective conservation measures.

Barrier beaches and bluff-backed beaches were also present (Montague Harbour and Georgeson Bay). Galiano has a high number of pocket coves with suitable forage fish spawning habitat.

Barrier Beaches and bluff-backed beaches

Barrier beaches and bluff-backed beaches are sensitive to interruptions in lateral drift along shorelines and reductions in sediment transport to the drift cell. Bluff-backed beaches generally lack a berm, and barrier beaches exist seaward of storm berms.

Along the south coast, Georgeson Bay's bluff system contains two large bluff-backed beach units. The bluff-backed beaches provide extensive sediment inputs to beaches and shallow subtidal zones. These beaches are highly sensitive to clearing of vegetation and soil saturation levels along the bluff structure and shoreline structures at the base. Management of these fragile land forms should include close monitoring of site development, adequate setbacks from the edge, and prohibit any and all additions of structures at the base.

The beach units consisting of barrier beaches were primarily in Montague Harbour with its own drift cell. These beach units rely on sediment transport to accrete the beaches throughout the Park. Resisting armouring throughout the system of beaches will be critical to maintaining these beaches, particularly for future management options against rising sea levels and increasing storm activity.

Pocket Coves

Along all coasts, of the 59 beach units, 46 are pocket coves (79%) along erosional rocky shorelines. Sediments at pocket coves generally have high retention times, localized retention features (eg head lands) and localized sediment sources rather than reliance on drift cell processes. Pocket coves are generally well protected from wave energy due to the presence of rocky headlands. These beaches are sensitive to changes in sediment supply and/or transport as they have limited sediment inputs. These beach units are highly sensitive to causes of sediment erosion, from vegetation clearing to

foreshore structures such as boat ramps and hard revetments (seawalls and riprap boulders). Development affecting sediments within pocket coves should stress setbacks of infrastructure and vegetation management to reduced bank/berm erosion.

East coast pocket coves are highly wave exposed and largely nourished by northward, net sediment movement (eg Salamanca, Bodega, and Pebble). North, east and south coast pocket coves, exposed to seasonal high winds presently maintain a balance between sediment transport and limited sediment supply and, as such, are particularly vulnerable to sediment losses. Development setbacks, vegetation management, and if requested by land owners, utilization of bioengineering, or soft-shore methods for bank erosion mitigation are well-known, effective measures to protect both natural and built environments.



Proximity of infrastructure and vegetation removal near a fragile pocket cove
Galiano Island
Photo: R de Graaf

13.2 Public Access

Properly managed public access points to marine shorelines can be an asset for residents and visitors as they promote opportunities to connect with nature. Shoreline buffer zones or setback areas also provide the public with their legal access to Crown foreshore, a privilege often lost due to zoning and development to the high water mark. Buildings and shoreline modifications can hinder public access to beaches either due to overwater structures (piers/dock structures) or seawalls/rock revetments physically limiting access (Griggs 2010, Shipman et al 2010). Despite their ecological and ecosystem service values, marine shoreline corridors are under-represented in marine planning initiatives. Rarely are these backshore buffer areas implemented to provide wildlife corridors, protect shoreline ecological values, and act as storm berms as part of climate change adaptation measures.

On Galiano Island, the large number of beach access sites and forest reserves with marine shoreline areas provide exceptional public access to the shore. Pebble Beach Reserve provides a backshore corridor linking beaches within the Pebble Beach Reserve. Other beach access points to rocky shorelines lack routes above the high-water mark and only provide passage to pebble/sand beaches with lower tides and fair weather. Galiano Island's east coast is lightly populated and low-sloping backshores and marine forest types are stable and highly suitable for development of a "coastal, marine" hiking experience, something likely unique to the Gulf Islands and the Strait of Georgia. While providing a unique hiking experience, an east coast shoreline hiking corridor would protect marine shorelines and provide community benefits.

Walking trails along undeveloped marine riparian zones and/or shorelines in reserves could link present beach access points to pebble/sand beaches. Other pebble/sand beach units currently inaccessible due to current zoning could be linked through voluntary land-owner easements/covenants, regulated development setbacks, and land purchases so that significant gains can be made to protect marine riparian and beach habitats and providing public access. In the Cowichan Valley Regional District contiguous private, park and undeveloped lands were linked to provide a shoreline hiking experience.

A current possibility may be a corridors linking Sticks Allison beach access, the Galiano community forest land reserve and shoreline to Cook Cove's pebble beaches to provide a looping trail system. Off Gaylor Place, the backshore of Cook Cove appears to be a BC utility station where a shoreline easement or protected zone near to the Community Forest Lands may be viable. The Salamanca beach access provides a spectacular view point to the Strait of Georgia, but there is no backshore shoreline forest trail connection to nearby pebble pocket coves; and this could be accomplished with conservation covenants from private land owners.

North of Pebble Beach, access points to the shoreline are limited. A popular beach access, number 49, or "Consiglio Trail", provides access to a rocky cove with only intertidal passage to Bodega Beach. A backshore shoreline walk could connect Bodega Beach to beach access #50, or "Dewinetz Trail", to Pebble Beach Reserve.

With some effort, perhaps the entire east coast of Galiano could be linked from Salamanca to Dionisio Park via a protected, marine forest shoreline walk, ensuring protection of vital shoreline habitats, species diversity and security for residents from future rising sea levels.

13.3 Shoreline structures

Foreshore areas are the property of the Crown unless upland property owners secure a lease for a water lot or have “grandfathered” use of the foreshore through historical zoning (e.g. industrial land sites, commercial, recreational uses). Access to and alterations to the foreshore require permits and approvals at various government levels. Impacts of shoreline structures vary depending on their construction and site-specific factors such as backshore land forms and topography, soils/sediments, wave-exposure, fetch, and tidal currents.

Sea Level Rise and Coastal Squeeze:

On Galiano Island, the majority of beach units have a low incidence of armouring and backshore conditions favourable for landward transgression (eroding bluffs, low-moderate bank height and slopes). Safeguarding backshore and intertidal habitats against “coastal squeeze” builds resiliency during a period of sea level rise.

Armouring/Boat Ramps

Ten beach units classified as suitable forage fish spawning habitat had significant shoreline modifications below, at or near the high water mark impairing ecological function and shoreline processes (sediment supply/transport): including boat ramps, riprap armouring, seawalls, foreshore infills, and piers/docks. Seven beach units, all pocket coves, have hard armouring and will likely be partially or completely lost to sea level rise. Currently, five beach units showed reduced beach condition due to multiple stressors. No structures appear to block public access along shorelines. Beaches blocked by seawalls/riprap armouring cannot retreat landward and will be partially or completely lost as sea levels rise.

At two of these beach units, riprap armouring and seawalls placed below the high water mark encroaching on the foreshore has resulted in removal of fine sediments and exposure of cobbles, and evidence of wave scouring on the hard armouring. Impacts include reduced sediment supply, loss of berms and logs and burial of suitable spawning habitat. At one beach unit, riprap armouring below the high water mark does bury suitable spawning habitat but there was no apparent evidence of beach scouring as this pocket cove has rocky headlands which may protect the beach from wave energy.



Riprap armouring on foreshore Crown land and suitable spawning habitat. Evidence of wave scouring at hard armouring with exposure of cobble layer below spawning sediment. Galiano Island Photo: RC de Graaf

At three beach units, some beach units had significant shoreline modification at the high water mark and near complete or complete vegetation removals from the backshore. Multiple stressors, including vegetation losses, storm-water runoff, reduced sediment supply and scouring at the seawall/riprap toe has resulted in greatly reduced beach condition. These beach units are pocket coves and will likely continue degrading and be lost to sea level rise. At two of these beach units, hard armouring may have been employed due to ferry wakes rather than storm events as they have significant protection from Mayne Island.



Storm-water outfall pipe, riprap at the high water mark. South coast, Galiano Island Photo: RC de Graaf

Enhancement and restoration of these beach units can be achieved through vegetation restoration, managing storm water, and utilization of soft-shore engineering methods.

Three beach units have concrete boat ramps on the foreshore. One showed evidence of blocking lateral sediment transport due to its placement within the length of the beach unit along a barrier beach. Sediment transport should be restored by grading the height of the boat ramp so that it does not extend above the beach surface. The boat ramp would then require only seasonal maintenance of gravel accumulation, a management strategy more appropriate for protection of habitat within a Provincial Park. The second boat ramp structure extends from a boat house but is not blocking sediment transport as it is placed near the rock terrace at the distal end of a pocket cove. The third boat ramp structure did not show evidence of disrupting sediment transport as it does not extend above the beach sediment surface.

One beach unit had a groyne across the beach face located within the length of the beach unit. The groyne is composed of bags of cement likely protecting a buried utility cable. However, this pocket cove is protected within Payne Bay/Montague Harbour, and there was no evidence of changes to sediment conditions.

Piers and Docks

Galiano Island

At two beach units scored as suitable spawning habitat, piers spanned the soft sediment beach and support pilings are widely spaced with no blockage of lateral sediments evident [Sturdies Bay East (ferry) and South Wind Rd]. However, the pilings are treated with creosote, a toxic wood preservative.

Community docks (eg. Payne Bay) and shared public docks (eg Whaler's Bay, Montague Harbour, and Spanish Hills) currently appear to meet much of the community's needs and shared docks should be encouraged through local bylaws.

Overwater structures such as piers and docks have significant negative impacts including loss of public access along shorelines, interruption of sediment transport, shading causing reduction and elimination of submerged aquatic vegetation and creosote. Refitting of aging public dock facilities can

serve as a “green dock” pilot project by: minimizing the number of and size of docks, removal of creosote pilings and styrofoam floatation, and using light-penetrating panels.

While there are numerous private piers/docks on Galiano Island, piers and docks on areas not suitable for spawning forage fish (rocky shorelines and mud-based beaches) were not investigated. The majority of Whaler’s Bay, Spotlight and Saltery Cove is comprised of mud habitat and the impacts of the high number of docks and unelevated floats (floats resting on the beach surface) in this area was not investigated.

13.4 Vegetation Removals

Backshore zones (area within 30 meters of the high water mark) were modified at 32 (55%) of beach units. 35 beach units (60%) had reduced overhanging-shade habitat. Losses of overhanging-shade habitat were more commonly associated with property development/vegetation removals within backshore zones than due to hard armouring or lagoon/bluff land forms. Changes in backshore vegetation include both the character of the vegetation (grasses, trees and shrubs) and the width of the vegetative zone.

Shoreline bank erosion is highly associated with soil saturation due to losses of trees/shrubs. Along Galiano Island’s east coast, three beach units had impaired beach conditions and eroding shoreline banks. None of these three pocket coves had hard armouring. However, backshore vegetation was qualitatively classified as mainly lawns and structures included outfall pipes diverting storm-water onto the beach surface with evidence of slumping backshore surfaces, and eroding shoreline banks and beach surfaces eroded to the cobble layer.



Evidence of shoreline bank erosion and example of putative causes: storm-water run-off and backshore vegetation changes
Galiano Island, February 2016 - Photo: RC de Graaf

Enhancement and Restoration Measures:

Encouraging the retention of marine shoreline vegetation by 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.

One of the more cost-effective measures to protect shorelines from erosion is restoring lost vegetation along the bank and even a narrow fringe behind the bank. Natural trees/shrubs can be integrated with more horticultural species. Not only do trees and shrubs absorb large volumes of water, their extensive root systems maintain bank slopes and reduced erosion rates. Rain gardens are drainage ditches enhanced with water-loving plants and are popular in many urban areas adding habitat and assisting with storm-water management and local aquifer renewal. Paved roads and driveways contribute petroleum products to storm water. Storm water diverted from private residences to outfall pipes likely have significant pollution loads. The storm-water is better diverted to municipal water-treatment or to recharge local aquifers than to beaches and marine receiving waters.

13.5 Beach Health/Enhancement

Along the northern coast line under the jurisdiction of the Penelakut Tribe, the beaches are pocket coves. One was assessed as being suitable spawning habitat. However, over decades the small pocket cove was used by industry, boaters and there is evidence of it being used as a dump. While being a small pocket cove, it has complete forest cover, a wetland, stream, eelgrass and kelp. The beach however has imbedded glass, rusty debris and a shoreline bank with heavy deposit of garbage. Improving the quality of this small bay and pocket cove would also include subtidal removals of various types of industrial debris. However, with grants from the DFO Recreational Fishery Habitat Restoration fund, perhaps this bay could slowly be restored to benefit spawning herring, Surf smelt, juvenile salmon and recreational values.

One of Galiano's most important community assets is Sturdies Bay. The ferry terminal bounds a number of pocket coves and has an important public beach access to the foreshore. Cabins and seaside retreat accommodations overlook this picturesque bay with views of Mayne Island and the Strait of Georgia. Rocky shores, pebble/sand beaches, sand flats and eelgrass are all present in the

bay. Beach units assessed as providing suitable spawning habitat are impacted by seawalls and storm-water flows via outfall pipes impact the beach habitat. Impervious surfaces from the paved roads and ferry terminal all likely contribute petroleum products via storm water into the bay. Diverting these storm-water outfall pipes into a water treatment system as well as installation of a storm-water filter at the ferry terminal would solve the problem of reduced water quality due to oil/fuel contamination. Recently, Snug Cove on Bowen Island has improved water quality by treating water from the roadway/ferry terminal in a water filtration system.

Beach units scored as “not spawning habitat” included Saltery and Spotlight coves. These west coast coves are largely protected from wave energy and their entrances are bounded by rocky headlands/reefs. The beach units were largely not habitat due to shallow sediment deposits, limited sediment motility, and largely anoxic sediments bound with log/organic debris. Spotlight cove beaches are largely mud habitat with a thin layer of sand.

Both Saltery and Spotlight coves have abundant mud flats, eelgrass beds and bull kelp serving as habitat and rearing areas for invertebrates and fish species. Both coves still show the impacts of past industry and presently there are numerous piers/docks, seawalls and some unelevated docks that cover the mud flat and vegetation. Creosote pilings from these historical activities are still present in the foreshore, shallow subtidal, and even creosote logs are incorporated into wooden seawalls. Creosote pilings, particularly older treated logs, present a significant toxic risk as bioaccumulation of these “legacy toxins” move through the food web. Current levels of armouring may have cumulatively impacted habitat quality resulting in the degraded habitat quality. Fish and shellfish habitat could be enhanced at both Spotlight and Saltery Cove by removing historical infrastructure and when upgrading piers/docks, investigating “green dock” guidelines.

Where historical commercial/industrial land uses may have left structures such as bulkheads and infills, these should not be encouraged for present or future residential/recreational development if they negatively affect shoreline areas.

14.0 Potential Use of Data Set Provided

This report presents the forage fish spawning habitat maps only. Maps of overhanging shade vegetation, marine riparian vegetation, as well as specific foreshore structures and categories of foreshore/backshore modification can also be generated from the data provided as part of the project deliverables.

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 Galiano Island

GIS ID	Beach Number	Beach Name	Habitat Class	Sediment Distribution	Species Most Likely	Grain Size Type	Length (m)	Geo-morphic Habitat Type	Geo-graphic Position
1	GI_N5	Parry Lagoon	Suitable Habitat	Continuous	PSL	PSLT3	143.60	Pcvv	North
2	GI_E9	NCableBe	Suitable Habitat	Continuous	SS	SST2	43.91	Pcv	east
3	GI_E10	CableBe3	Suitable Habitat	Discontinuous	SS/PSL	SST3	80.54	Pcv	east
4	GI_E11	CableBe2	Suitable Habitat	Continuous	SS/PSL	SST3	21.99	Pcv	east
5	GI_E12	CableBe	Suitable Habitat	Continuous	SS/PSL	SST3	53.37	Pcv	east
6	GI_E13	PebbleBe	Suitable Habitat	Continuous	SS/PSL	SST3	154.3	Pcv	east
7	GI_E19	Salamanca1	Suitable Habitat	Continuous	SS	SST5	3.78	Pcv	east
8	GI_E12	Salamanca2	Suitable Habitat	Continuous	SS/PSL	SST2	92.26	Pcv	east
9	GI_E21	MorningBe	Suitable Habitat	Continuous	SS/PSL	SST4	105.96	Pcv	east
10	GI_E22	Harper1	Suitable Habitat	Continuous	SS	SST5	22.01	Pcv	east
11	GI_E23	Harper2	Suitable Habitat	Continuous	SS	SST2	2.57	Pcv	east
12	GI_E24	Harper3	Suitable Habitat	continuous	SS/PSL	SST4	34.46	Pcv	east
13	GI_E25	Linklater	Suitable Habitat	Continuous	SS/PSL	SST4	33.52	Pcv	east
14	GI_E26	Twiss	Suitable Habitat	Continuous	SS/PSL	SST4	44.94	Pcv	east
15	GI_E27	WhalersBy	Suitable Habitat	Continuous	SS/PSL	SST2	28.87	Pcv	east
16	GI_E28	Cain	Suitable Habitat	Discontinuous	PSL	PSLT3	21.30	Pcv	East
17	GI_E29	GulfDr1	Suitable Habitat	Continuous	SS/PSL	SST2	25.30	Pcv	East
18	GI_E30	GulfDr2	Suitable Habitat	Continuous	SS	SST1	18.17	Pcv	East
19	GI_S31	SturdiesByE	Suitable Habitat	Continuous	PSL	PSLT3	51.17	Pcv	South
20	GI_S32	SturdiesByW1	Suitable Habitat	Discontinuous	SS/PSL	SST3	88.27	Pcv	South
21	GI_S33	SturdiesByW2	Suitable Habitat	Continuous	PSL	PSLT3	60.57	Pcv	South
22	GI_S34	FarmHouseBy	Suitable Habitat	Continuous	PSL	PSLT3	91.64	Pcv	south
23	GI_S35	Burrill	Suitable Habitat	Continuous	SS	SST1	49.07	Pcv	south
24	GI_S36	MatthewsPnt	Suitable Habitat	Continuous	SS/PSL	SST1	294.52	Blb	south
25	GI_W44	PayneByN1	Suitable Habitat	Continuous	SS/PSL	SST4	35.49	Pcv	west
26	GI_W45	PayneByN2	Suitable Habitat	Discontinuous	SS	SST1	44.41	Pcv	west
27	GI_W46	SWinds1	Suitable Habitat	Continuous	PSL	PSLT3	171.45	Br	west
28	GI_W47	SWinds2	Not Suitable Habitat	nil	nil	nil	6.05	Br	west
29	GI_W48	SWinds3	Not Suitable Habitat	nil	nil	nil	413.75	Br	west
30	GI_W49	SMontague1	Suitable Habitat	Continuous	SS/PSL	SST4	177.39	Br	west
31	GI_W50	SMontague2	Suitable Habitat	Discontinuous	SS/PSL	SST3	274.17	Blb	west
32	GI_W51	Montague4	Suitable Habitat	Continuous	SS/PSL	SST4	18.24	Pcv	west
33	GI_W52	Montague5	Suitable Habitat	Continuous	SS/PSL	SST3	296.25	Br	west
34	GI_W53	Montague6	Suitable Habitat	Continuous	SS/PSL	SST4	61.73	Pcv	west

Appendix A - Beach Units Galiano Island

GIS ID	Beach Number	Beach Name	Habitat Class	Sediment Distribution	Species Most Likely	Grain Size Type	Length (m)	Geomorphic Habitat Type	Geographic Position
35	GI_W54	Montague7	Suitable Habitat	Continuous	SS/PSL	SST4	101.11	Br	west
36	GI_W55	Montague8	Suitable Habitat	Continuous	SS/PSL	SST4	63.51	Br	west
37	GI_W56	Montague9	Suitable Habitat	Discontinuous	PSL	PSLT3	26.39	Br	west
38	GI_W57	NMontague10	Suitable Habitat	Continuous	SS/PSL	SST1	279.42	Br	west
39	GI_W58	NMontague11	Suitable Habitat	Continuous	PSL	PSLT3	128.37	Br	west
40	GI_N2	Maple Bay	Suitable Habitat	Continuous	SS/PSL	SST2	80.83	Pcv	North
41	GI_N3	Coon Bay	Suitable Habitat	Continuous	SS/PSL	SST4	59.50	Pcv	North
42	GI_N4	NPnt1_DionPk	Suitable Habitat	Continuous	SS/PSL	SST4	138.19	Pcv	North
43	GI_W65	SalteryCv3	Not Suitable Habitat	nil	nil	nil	36.76	Pcv	west
44	GI_W67	SalteryCv1	Not Suitable Habitat	nil	nil	nil	15.58	Pcv	west
45	GI_W64	SalteryCVS4	Not Suitable Habitat	nil	nil	nil	26.84	Pcv	west
46	GI_W63	SalterCVS5	Not Suitable Habitat	nil	nil	nil	12.86	Pcv	west
47	GI_E6	BodegaBeN1	Suitable Habitat	Continuous	SS	SST2	76.03	Pcv	east
48	GI_E7	BodegaBeN2	Suitable Habitat	Continuous	SS	SST1	51.83	Pcv	east
49	GI_E8	BodegaBe	Suitable Habitat	Continuous	SS	SST3	133.47	Pcv	east
50	GI_W61	RetreatCv2	Suitable Habitat	Continuous	PSL	PSLT3	29.1	Pcv	west
51	GI_E18	CookCove3	Suitable Habitat	Continuous	SS	SST1	13.01	Pcv	east
52	GI_W59	Ganner	Suitable Habitat	Continuous	SS	SST1	15.39	Pcv	west
53	GI_S35	BluffPark1	Suitable Habitat	Discontinuous	SS/PSL	SST1	76.29	Blb	south
54	GI_S36	BluffPark2	Suitable Habitat	Discontinuous	SS/PSL	SST4	366.14	Blb	south
55	GI_S39	GeorgesonByW1	Suitable Habitat	Continuous	SS/PSL	SST3	147.35	Pcv	south
56	GI_N1	Penelakut1	Suitable Habitat	Continuous	SS	SST1	131.95	Pcv	North
57	GI_E14	PebbleS1	Suitable Habitat	Continuous	PSL	PSLT3	58.02	Pcv	east
58	GI_E15	PebbleS2	Suitable Habitat	Continuous	SS/PSL	SST2	170.44	Pcv	east
59	GI_E17	CookCove1	Suitable Habitat	Continuous	PSL	PSLT3	20.68	Pcv	east
60	GI_E16	CookCove2	Suitable Habitat	Continuous	SS/PSL	SST2	17.08	Pcv	east
61	GI_S40	GeorgesonByW2	Suitable Habitat	Continuous	SS/PSL	SST1	43.37	Pcv	south
62	GI_W66	SalteryCv2	Not Suitable Habitat	nil	nil	nil	22.98	Pcv	west
63	GI_W60	RetreatCv1	Suitable Habitat	Continuous	SS	SST1	23.86	Pcv	west
64	GI_W42	PayneBy1	Suitable Habitat	Continuous	SS/PSL	SST1	74.33	Pcv	west
65	GI_W43	PayneBy2	Not Suitable Habitat	Discontinuous	SS	nil	45.36	Pcv	west
66	GI_W62	RetreatCv3	Suitable Habitat	Continuous	SS/PSL	SST2	80.68	Pcv	west
67	GI_W41	PayneBy3	Suitable Habitat	Continuous	SS/PSL	SST2	10.48	Pcv	west

Appendix B – Galiano Island - Beach Habitat Types by Grain Size

Pacific Sand lance - Type 3

Beach Number	Galiano Island Beach Unit	Grain Size Type	Suitable by Species	Sediment Distribution
GI_N5	Parry Lagoon	PSLT3	PSL	Continuous
GI_E28	Cain	PSLT3	PSL	Discontinuous
GI_S31	SturdiesByE	PSLT3	PSL	Continuous
GI_S33	SturdiesByW2	PSLT3	PSL	Continuous
GI_S34	FarmHouseBy	PSLT3	PSL	Continuous
GI_W46	SWinds1	PSLT3	PSL	Continuous
GI_W56	Montague9	PSLT3	PSL	Discontinuous
GI_W58	NMontague11	PSLT3	PSL	Continuous
GI_W61	RetreatCv2	PSLT3	PSL	Continuous
GI_E14	PebbleS1	PSLT3	PSL	Continuous
GI_E17	CookCove1	PSLT3	PSL	Continuous

Surf smelt - Type 1

Number	Beach Unit	Type	Species	Distribution
GI_E30	GulfDr2	SST1	SS	Continuous
GI_S35	Burrill	SST1	SS	Continuous
GI_S36	MatthewsPnt	SST1	SS,PSL	Continuous
GI_W45	PayneByN2	SST1	SS	Discontinuous
GI_W57	NMontague10	SST1	SS,PSL	Continuous
GI_E7	BodegaBeN2	SST1	SS	Continuous
GI_E18	CookCove3	SST1	SS	Continuous
GI_W59	Ganner	SST1	SS	Continuous
GI_N1	Penelakut1	SST1	SS	Continuous
GI_S40	GeorgesonByW2	SST1	SS,PSL	Continuous
GI_W60	RetreatCv1	SST1	SS	Continuous
GI_W42	PayneBy1	SST1	SS,PSL	Continuous
GI_S35	BluffPark1	SST1	SS,PSL	Discontinuous

Surf smelt - Type 2

Beach Number	Galiano Island Beach Unit	Grain Size Type	Suitable by Species	Sediment Distribution
GI_E9	NCableBe	SST2	SS	Continuous
GI_E12	Salamanca2	SST2	SS/PSL	Continuous
GI_E23	Harper2	SST2	SS	Continuous
GI_E27	WhalersBy	SST2	SS/PSL	Continuous
GI_E29	GulfDr1	SST2	SS/PSL	Continuous
GI_N2	Maple Bay	SST2	SS/PSL	Continuous
GI_E6	BodegaBeN1	SST2	SS	Continuous
GI_E15	PebbleS2	SST2	SS,PSL	Continuous
GI_E16	CookCove2	SST2	SS,PSL	Continuous
GI_W58	RetreatCv3	SST2	SS,PSL	Continuous
GI_W41	PayneBy3	SST2	SS,PSL	Continuous
GI_W62	RetreatCv3	SST2	SS,PSL	Continuous

Surf smelt - Type 3

Number	Beach Unit	Type	Species	Distribution
GI_E10	CableBe3	SST3	SS,PSL	Discontinuous
GI_E11	CableBe2	SST3	SS,PSL	Continuous
GI_E12	CableBe	SST3	SS/PSL	Continuous
GI_E13	PebbleBe	SST3	SS/PSL	Continuous
GI_S32	SturdiesByW1	SST3	SS/PSL	Discontinuous
GI_W50	SMontague2	SST3	SS,PSL	Discontinuous
GI_W52	Montague5	SST3	SS/PSL	Continuous
GI_E8	BodegaBe	SST3	SS	Continuous
GI_S39	GeorgesonByW1	SST3	SS/PSL	Continuous

Appendix B – Galiano Island - Beach Habitat Types by Grain Size

Surf smelt - Type 4

Beach Number	Galiano Island Beach Unit	Grain Size Type	Suitable by Species	Sediment Distribution
GI_E21	MorningBe	SST4	SS/PSL	Continuous
GI_E24	Harper3	SST4	SS/PSL	continuous
GI_E25	Linklater	SST4	SS/PSL	Continuous
GI_E26	Twiss	SST4	SS/PSL	Continuous
GI_W44	PayneByN1	SST4	SS,PSL	Continuous
GI_W49	SMontague1	SST4	SS,PSL	Continuous
GI_W51	Montague4	SST4	SS/PSL	Continuous
GI_W53	Montague6	SST4	SS/PSL	Continuous
GI_W54	Montague7	SST4	SS/PSL	Continuous
GI_W55	Montague8	SST4	SS/PSL	Continuous
GI_N3	Coon Bay	SST4	SS/PSL	Continuous
GI_S36	BluffPark2	SST4	SS,PSL	Discontinuous
GI_N4	NPnt1_DionPk	SST4	SS,PSL	Continuous

Surf smelt - Type 5

Number	Beach Unit	Type	Species	Distribution
GI_E19	Salamanca1	SST5	SS	Continuous
GI_E22	Harper1	SST5	SS	Continuous

Appendix C

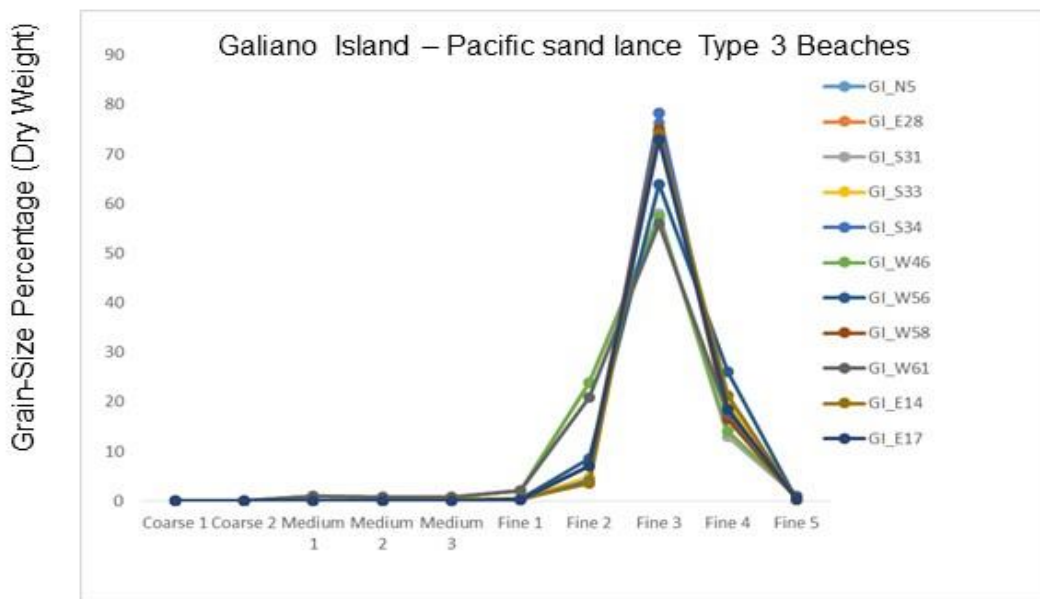


Figure 2– Galiano Island – Pacific sand lance Type 3 Beaches

Appendix C

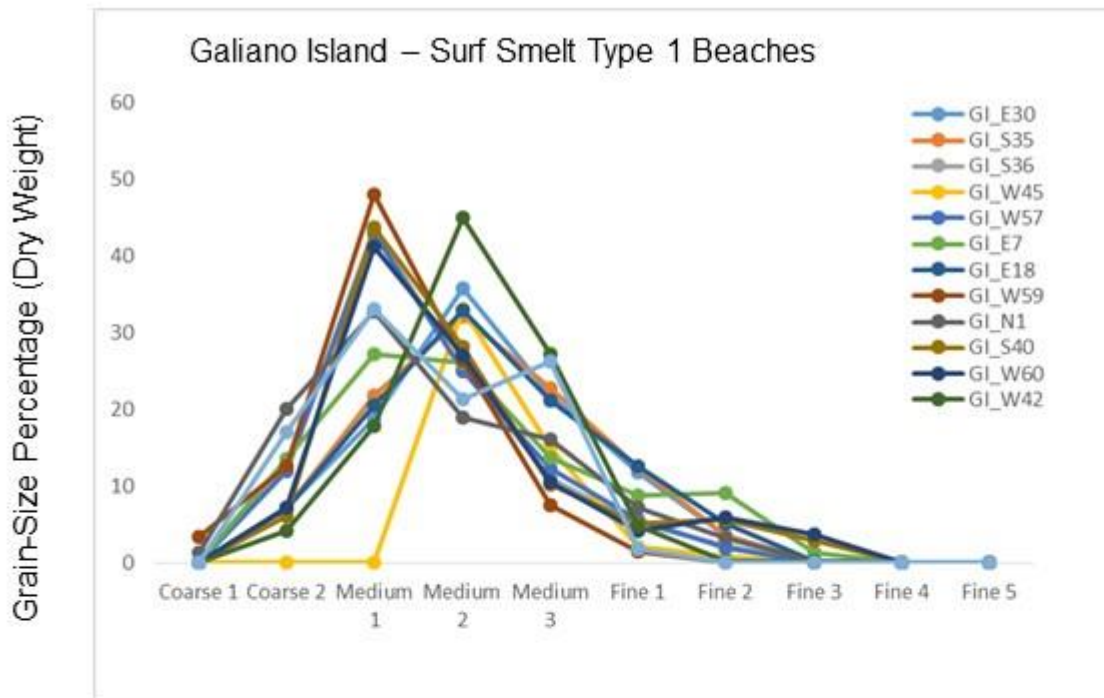


Figure 3 Galiano Island – Surf Smelt Type 1 Beaches

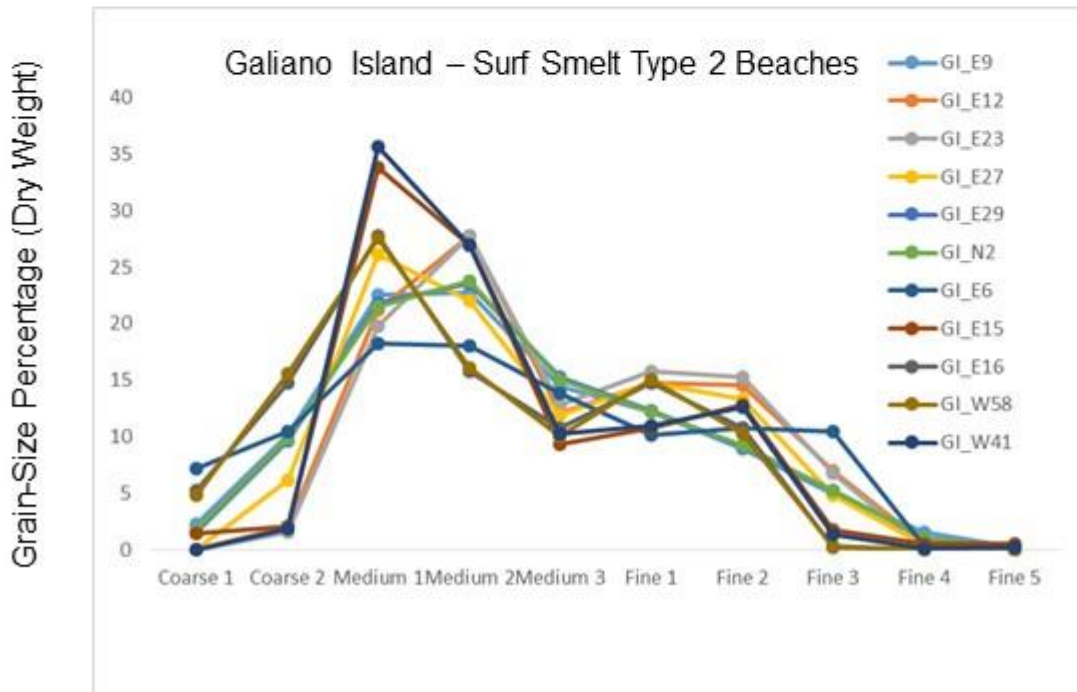


Figure 4 Galiano Island – Surf Smelt Type 2 Beaches

Appendix C

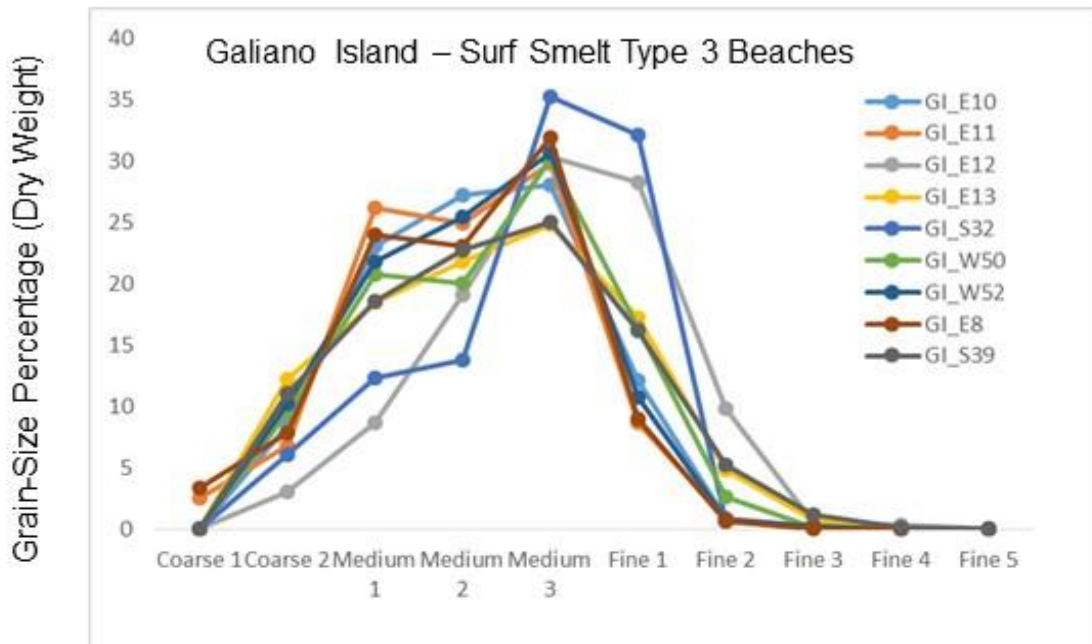


Figure 5 Galiano Island – Surf Smelt Type 3 Beaches

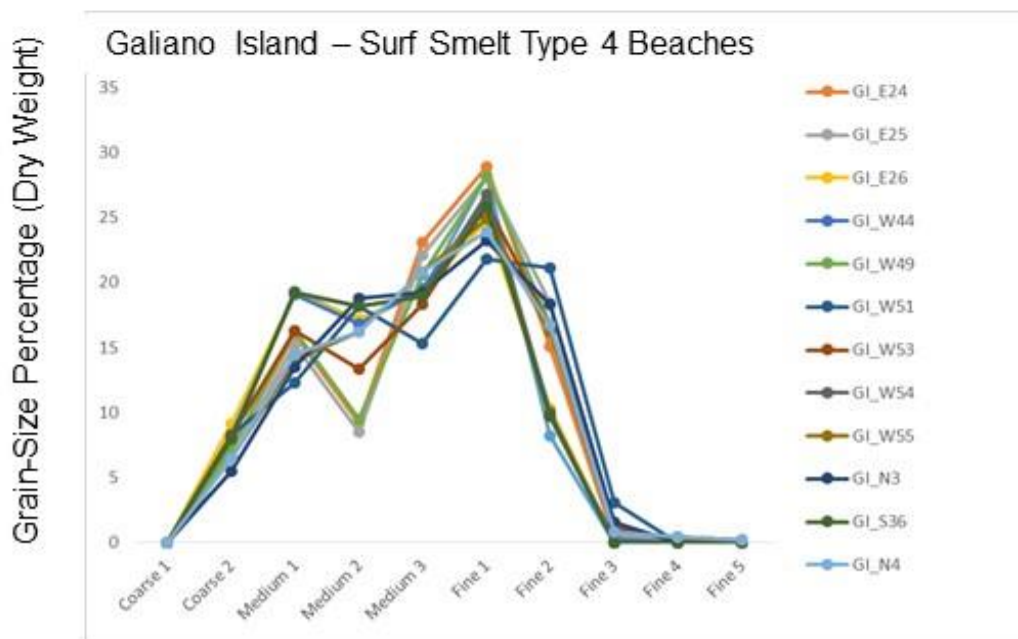


Figure 6 Galiano Island – Surf Smelt Type 4 Beaches

Appendix C: Galiano Island - Spawning Beach Habitat Types - Grain-Size Curves

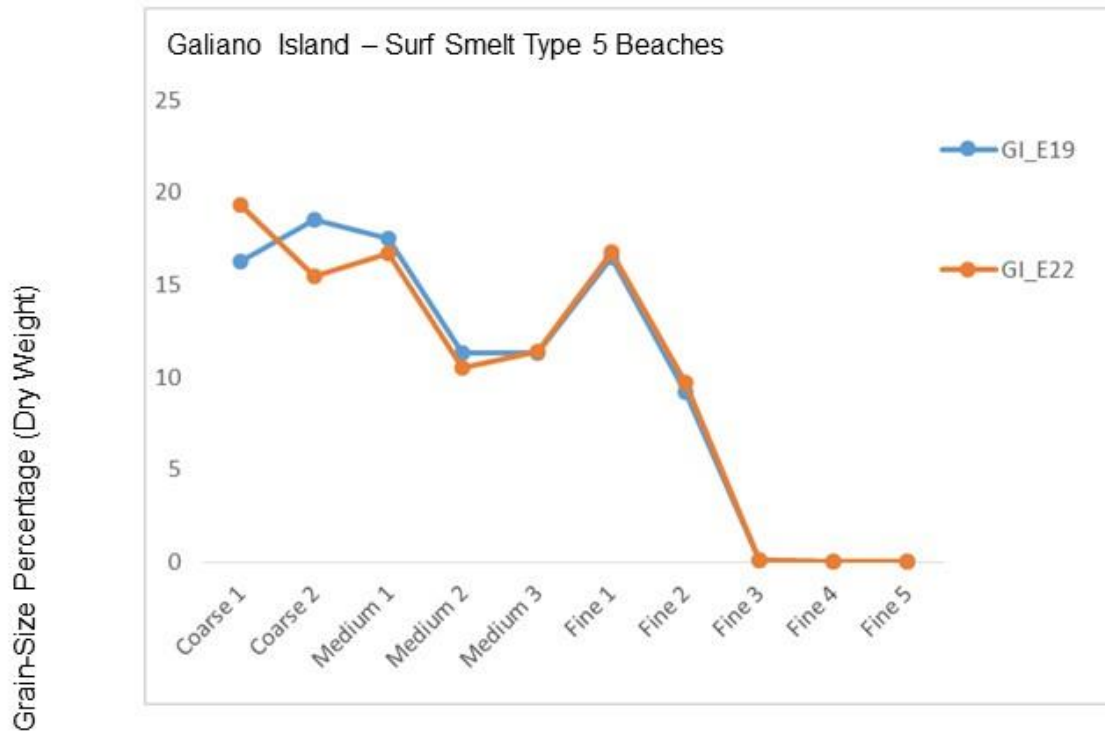


Figure 7 Galiano Island – Surf Smelt Type 5 Beaches

Appendix D: GPS/GIS Methodology

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 D: 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 collected 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 E: 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 F: Forage Fish Habitat Suitability Assessment Methods

Housed with the Islands Trust Fund and the author