DOCUMENTING PACIFIC SAND LANCE (*Ammodytes hexapterus*) SPAWNING HABITAT IN BAYNES SOUND AND THE POTENTIAL INTERACTIONS WITH INTERTIDAL SHELLFISH AQUACULTURE

DRAFT FINAL

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1.0 INTRODUCTION

1.1 BACKGROUND

Shellfish aquaculture in Baynes Sound has occurred since the early 1900's and includes both Pacific oyster (*Crassostrea gigas*) and Manila clam (*Venerupsis philippinarum*) culture (MSRM 2002). Currently, Baynes Sound produces approximately 50% of BC's total cultured harvest of shellfish (MSRM 2002). Recognizing the economic potential of this industry, the BC government announced the Shellfish Development Initiative in November 1998, whereby the government would work with the industry and communities to identify areas for shell aquaculture expansion. In response to concerns expressed by local residents and other resource users over the potential expansion, the BC Ministry of Sustainable Resource Management (MSRM) suspended the processing of new shellfish aquaculture tenures applications in 2001, and initiated The Baynes Sound Coastal Plan for Shellfish Aquaculture (formerly the Baynes Sound Shellfish Aquaculture Action Plan). MSRM has been leading a multi-jurisdictional project team whose agencies are responsible for different components of the plan.

The plan covers the area shown in Figure 1 and includes Baynes Sound north of Chrome Island (southern tip of Denman Island) and Mapleguard Point (Vancouver Island) to Comox Harbour, excluding Sandy Island Marine Park off the northern tip of Denman Island. The objectives of the coastal plan are:

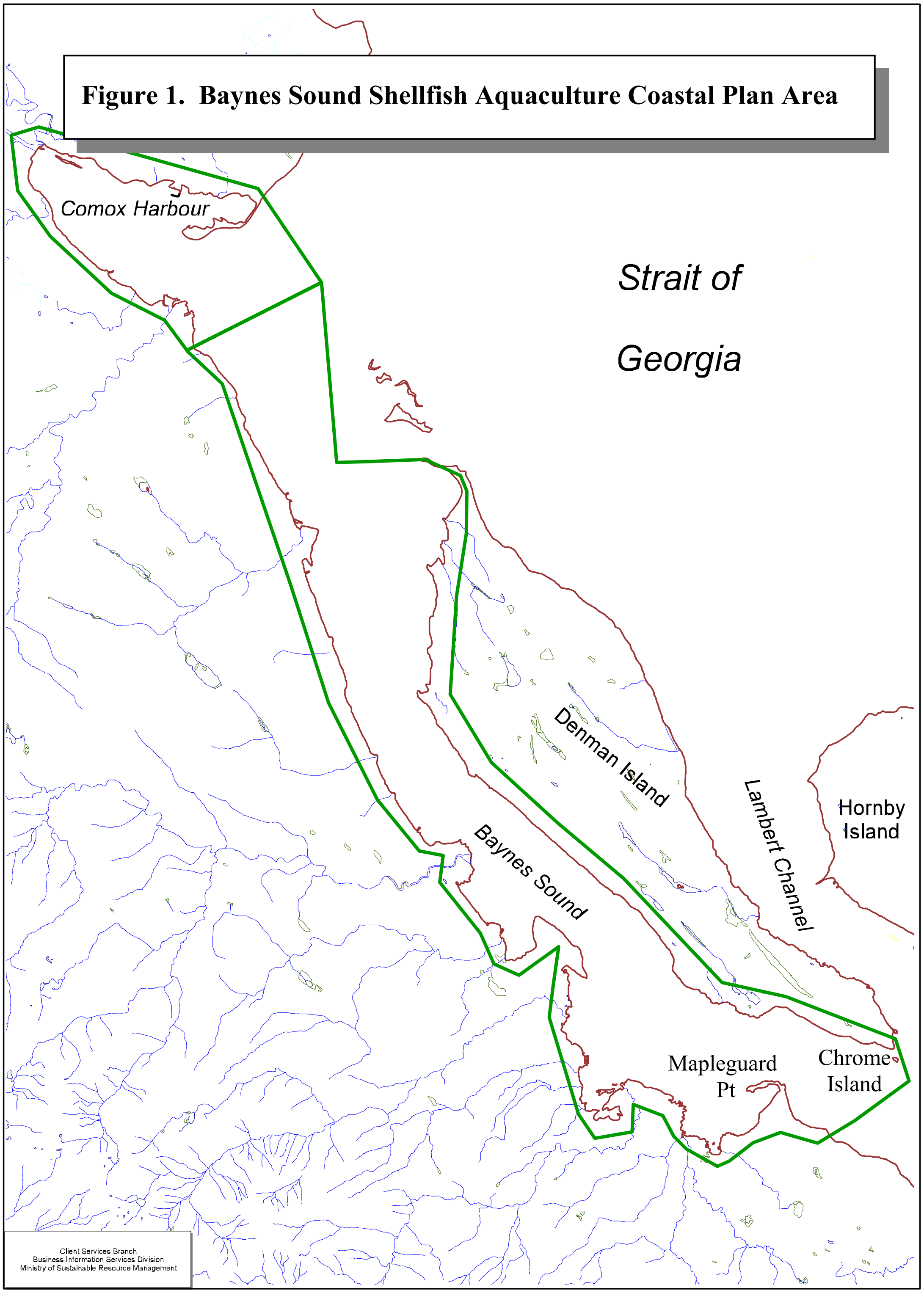
1. to identify whether any additional areas within Baynes Sound are suitable for further aquaculture development,
2. to address concerns of upland residents, other fisheries resource users and the aquaculture industry by documenting problem areas and developing management tools where required, and,
3. to ensure that, if any shellfish aquaculture expansion occurs, that it does so in an environmentally sustainable fashion.

The desire of the province is to balance the social, environmental, and economic perspectives of stakeholders within the planning process which involves, among other things, public consultation and an environmental analysis of potential impacts of shellfish aquaculture in Baynes Sound. In 2002 MSRM engaged Archipelago Marine Research Ltd. to provide information to enhance the environmental science perspective of the Baynes Sound coastal planning process, by:

1. systematically summarizing existing Baynes Sound environmental information,
2. assessing potential environmental effects associated with shellfish aquaculture, and,
3. developing a resource management decision analysis framework (MSRM 2002).

The report (Emmett 2002) provides a summary of potential ecosystem interactions associated with both intertidal and off-bottom shellfish activity, and the effect and significance of these interactions based on severity, duration and extent of the potential impact. The focus of the environmental analysis was intertidal oyster and manila clam aquaculture with some consideration of off-bottom longline aquaculture (oysters and scallops). Most of the potential impacts of the identified shellfish aquaculture activities were considered to be of low to moderate risk of negative environmental impact, based primarily on the degree of severity of impact. However, there was recognition of some uncertainty in the decision making process regarding the assessment of the severity of impact, and that this uncertainty could be lessened with the inclusion of scientific information to fill identified data gaps.

Figure 1. Baynes Sound Shellfish Aquaculture Coastal Plan Area



One of the data gaps identified by Emmett (2002) is a lack of information on the location and habitat characteristics of beach spawning finfish such as the Pacific sand lance (*Ammodytes hexapterus*) and surf smelt (*Hypomesus pretiosus*). Intertidal beach spawners are vulnerable to impacts to upper intertidal habitats from various foreshore activities as they rely on ecologically functioning beaches to sustain their populations. Archipelago Marine Research Ltd. was engaged by MSRM to conduct a Pacific sand lance beach spawner survey in Baynes Sound with the following objectives:

1. to identify sand lance beach spawner sites and timing of spawning in Baynes Sound,
2. to document physical characteristics of beach spawner habitat in Baynes Sound and compare these characteristics to those documented in Puget Sound by the Washington State Department of Fish and Wildlife,
3. to use documented sand lance beach spawner data in Baynes Sound and Washington State to assess suitability of these sites for surf smelt spawning, as the physical characteristics of spawning habitat for surf smelt are similar to sand lance,
4. to sample existing aquaculture areas, particularly clam tenures, where the use of predator netting or harvesting activities have the potential to impact beach spawner habitat,
5. to sample areas which are identified as possible shellfish aquaculture expansion sites under the Baynes Sound Coastal Plan for Shellfish Aquaculture, and,
6. to document interactions between aquaculture activities and beach spawning activity in Baynes Sound.

1.2 SAMPLING APPROACH

1.2.1 Previous Studies

In Puget Sound, Pacific sand lance (*Ammodytes hexapterus*) spawn from November 1 to February 15 on intertidal beaches, particularly beaches formed of sand, smaller gravel and shell fragments (Moulton and Penttila 2000). The egg incubation period is approximately 4 weeks. Other beach spawning finfish (known as forage fish) spawn at similar times of the year in similar habitat and often on the same beaches. The seasonal spawning window for surf smelt (*Hypomesus pretiosus*) appears to be year around in Puget Sound while rock sole (*Lepidopsetta bilineata*) appear to spawn between December and March. Intertidal aquaculture activities (shore access, clam harvesting, and manipulation of predator nets) during the period of spawning and egg incubation has the potential to impact the spawning success of this important forage fish group.

Information on beach spawning of sand lance, surf smelt and rock sole in British Columbia is lacking. In the winter of 2002 students from Camosun College's Environmental Technology Program undertook a survey of potential spawning sites at selected southern Vancouver Island beaches, mostly in the Greater Victoria area. The students also sampled several beaches in the Baynes Sound area in December 2001. Pacific sand lance (*A. hexapterus*) eggs were found in a sample from Mapleguard Point (Deep Bay) collected on December 27th, 2001. No eggs were found in samples taken in the Courtenay River estuary and Goose Spit.

1.2.2 Sampling Strategy

The general approach to sampling the Baynes Sound area was to select sites fitting the following designations:

A. *Aquaculture Sites* – sites with active aquaculture operations (including clam netting) with upper beach substrate considered suitable for sand lance spawning. These sites would be sampled in both the upper intertidal zone and immediately adjacent the clam netted area.
B. *Aquaculture Opportunity Sites* – sites identified by the Baynes Sound Coastal Plan for Shellfish Aquaculture as opportunity sites for future intertidal aquaculture operations. If suitable, both upper beach areas and the potential clam culture area were to be sampled.
C. *Reference Sites* – sites with no ongoing or planned intertidal aquaculture operations which were considered the most likely sand lance spawning sites in or near the Baynes Sound Plan area.

Incorporating reference sites into the sampling strategy was done to better address the question, "Do sand lance spawn in the Baynes Sound area?" In addition if sand lance spawning was documented at the reference sites, we would be better able to physically characterize these sites and contrast them with the aquaculture and opportunity sites.

A meeting was held with the BC Ministry of Sustainable Resource Management to identify priority areas for sampling. The priority areas included western Denman Island, Deep Bay, Fanny Bay and Base Flats, where clam netting currently exits, as well as the Restricted Expansion and/or Future Analysis management areas (MSRM 2002) north of Buckley Bay on Vancouver Island.

Given these priority areas, a review of available physical information for Baynes Sound was conducted using:

A. a map (Figure 2) and descriptions (Table 1) of eight intertidal habitat types identified in an earlier foreshore planning process (Howes and Thompson 1983), and
B. aerial video and a database with physical shore zone attributes (MSRM 2003) classified using the provincial shore zone mapping protocol (Howes *et al*. 1984).
C. air photos provided be the BC Ministry of Agriculture, Fish and Food (B. Carswell, pers. comm.) of the Baynes Sound area taken at low tide in June 2001.

This physical information was contrasted with a review of correlation data between the Washington State Department of Fish and Wildlife beach spawning data and the Department of Natural Resources shore zone data (Harper and Ward 2001).

From this review 27 possible sampling sites were identified in or adjacent to the Baynes Sound Plan area. A reconnaissance was conducted November 1-3, 2002 to select approximately 15 sites from the 27 possible sites identified from the physical information review, current aquaculture activity and site accessibility (from either upland or by boat). Fourteen sites were selected; three reference sites, nine existing aquaculture sites with clam tenure sites and two opportunity sites (see Figure 3 and Section 2.1).

1.2.3 Limitations of the Approach

It is important to note several limitations of both the scope of this project and the sampling strategy. The intent of the project was not to conduct a synoptic (comprehensive) survey of Pacific sand lance spawning locations, timing and habitat in Baynes Sound or to estimate the biomass of spawners. Spawning areas cannot be easily identified by visual observations due to the small size of the eggs (<1mm) and the tendency for these eggs to adhere to sand grains and disperse after spawning. Therefore the results of this project should not be expected to identify all beach spawning areas in Baynes Sound or to conclude definitively that if no eggs were sampled at all sites, that sand lance do not spawn in Baynes Sound.

During the systematic sampling of beaches in the Puget Sound between 1972-2000 (Penttila 2000a), surf smelt spawning has been documented all year round. However, information on the timing and location of surf smelt spawning in British Columbia is sparse (Therriault et *al*. 2002, D. Hay pers. comm.), and documentation has been primarily in the summer months. Therefore, as with sand lance, the results of this project should not be used to conclude definitively that surf smelt spawn or do not spawn in Baynes Sound. However, the summary of physical characteristics from sites sampled in Baynes Sound and data from Washington State can be used to evaluate the potential for surf smelt beach spawning activity in Baynes Sound.

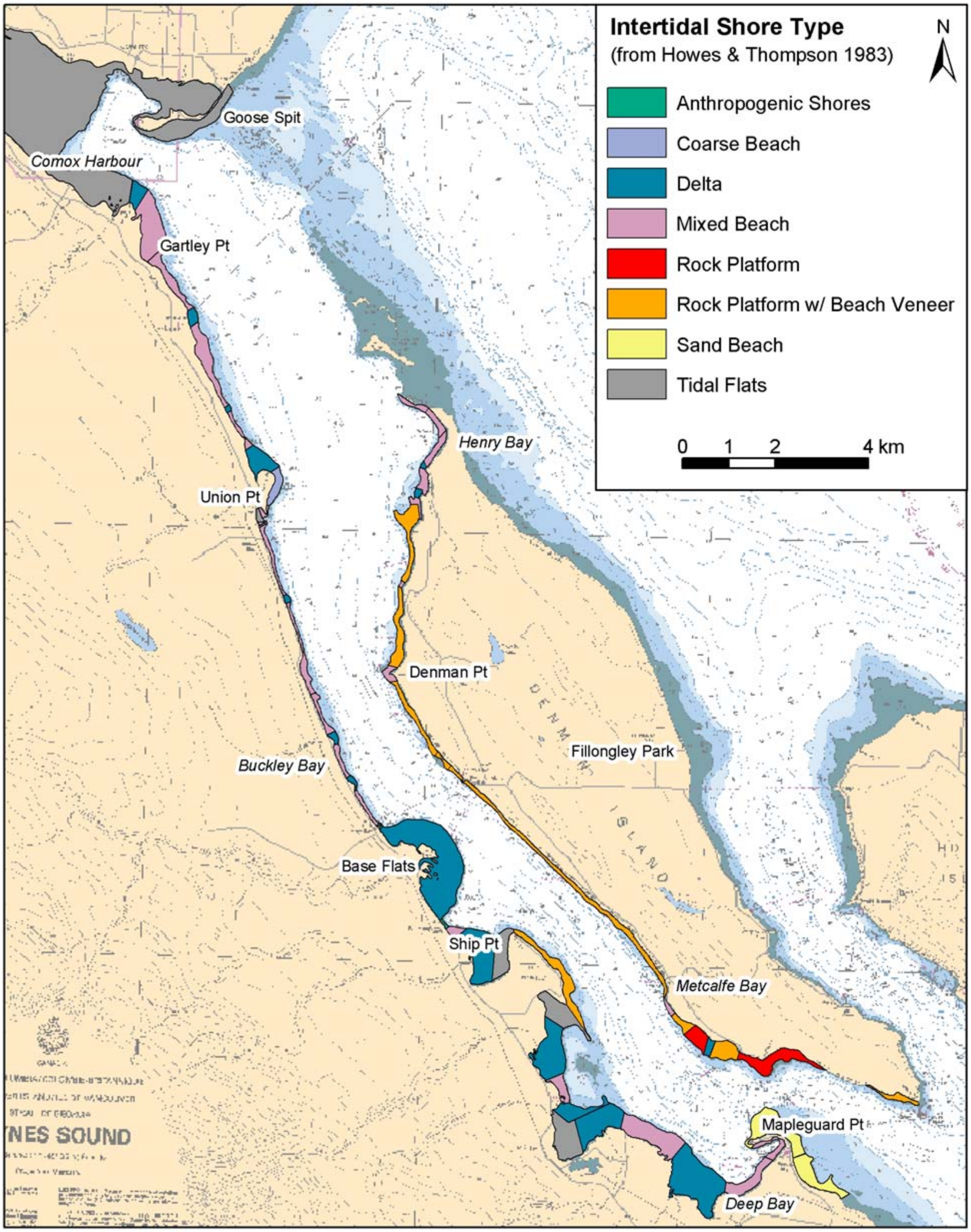


Figure 2. Intertidal Shore Types (Howes and Thompson 1983)

Table 1. Description of Intertidal Shore Types (from Howes and Thompson 1983)

SHORE TYPE	DESCRIPTION
Anthropogenic Shores	Man-made or man-modified features including docks, boat ramps, marine, and ferry terminals as well as areas where material has been moved (dredged) or deposited (e.g., rip-rap, breakwater, coal slag pile).
Rock Platform	A level or gently sloping bedrock surface. Rock platforms in the study area have low gradients (slopes <5^{o}) with local relief less than 1m. They are usually devoid of sediment (<20% cover). Intertidal widths range from 10 - 20m (intermediate) to >50m (very broad).
Rock Platform with Beach Veneer	Rock platforms overlain by beach sediments less than 1m thick. Beach materials are variable and consist of mixtures of sand and gravels. The degree of beach cover varies spatially and seasonally but usually ranges from 20 to 60%. Intertidal width ranges from 20 - 50m (broad) to >50m (very broad).
Delta	An accumulation of silt, sand, and gravels deposited at the mouth of a river or stream. Deltas in this study area have low gradients (slopes <5^{o}), are fan-shaped and dissected by single or multiple river channels. Approximately one-third of the deltas have salt marshes in their upper intertidal zone. The supratidal zone of several of the units are made up of raised deltas (i.e., delta deposits that are no longer forming). Intertidal width ranges from 20 - 50m (broad) to >50m (very broad).
Tidal Flats	A flat surface slopes (<5^{o}) made up mixtures of mud and sand. Tidal flats in the area are found in sheltered bays; salt marshes sometimes occur within the upper intertidal zone of the flat. Intertidal widths are very broad (>50m).
Sand Beach	A beach composed primarily of sand particles but may contain up to 20% coarse materials (pebbles, cobbles and boulders). Minor amounts of shell hash and wood particles may be associated with the clastic sediments. Intertidal widths range from 20 - 50m (broad) to >50m (very broad).
Mixed Beach	A beach composed of poorly sorted mixtures of sand and gravels (pebble, cobble, and boulder). Intertidal widths range from 10 - 20m (intermediate) to > 50m (very broad).
Coarse Beach	A beach composed of gravel-sized materials (pebbles, cobbles and boulders) which may have a minor portion of sand (<20%). Intertidal widths vary from 0 - 10m (narrow) to >50m (very broad).

2.0 METHODS

Fourteen sites were sampled in Baynes Sound, at three to four week intervals from mid November 2002 until early February 2003. The sampling and analysis protocol used in Puget Sound by the Washington State Department of Fish and Wildlife (Moulton and Penttila 2001) for documenting spawning habitat was followed with some minor modifications to accommodate the project objectives, and included the following physical characteristics:

1. Tidal elevation - from direct measurements relative to chart datum,
2. Substrate composition - from qualitative observations and quantitative sediment sample grain-size analysis,
3. Exposure and direction of maximum wave fetch - from field and chart measurements, and
4. Shore unit classification data from existing aerial video classification data (MSRM-Decision Support Services).

2.1 RECONNAISSANCE

During the reconnaissance trip, preliminary notes of shoreline physical characteristics, photographs and GPS locations were collected. Following the completion of the reconnaissance trip, 14 of 27 possible sites were chosen and the tenure holders were contacted for permission to use their sites for sampling. Figure 3 shows the location of the 14 sample sites, distinguished as reference (ideal beach spawner habitat), aquaculture (existing lease with clam netting) and opportunity (potential expansion area) sites. Table 2 lists the sites and target sampling area.

Table 2. Beach Spawner Sampling Sites in the Baynes Sound area as identified in the November 01-03, 2002 reconnaissance survey

SITE DESIGNATION	SITE	TARGET SAMPLES	COMMENTS
Reference	Mapleguard Point	Upper Beach	Residential upland, sand lance eggs documented in December 2001
	Goose Spit	Upper Beach	Public Beach, north of DND
	Fillongley Park	Upper Beach	Provincial Park, good shore access
Aquaculture	Deep Bay	Upper Beach and Clam Netted Area	1 km hike, beach access
	Ship Point	Upper Beach and Clam Netted Area	Good shore access, good upper beach habitat
	South Base Flats	Upper Beach and Clam Netted Area	Good shore access
	North Base Flats	Upper Beach and Clam Netted Area	Good shore access
	North of Buckley Bay	Clam Netted Area	Clam net sample only, upper beach too coarse
	South Metcalfe Bay	Upper Beach and Clam Netted Area	Good shore access
	Metcalfe Bay	Upper Beach and Clam Netted Area	Good beach access
	Denman Point	Upper Beach and Clam Netted Area	North side of point
	Henry Bay	Upper Beach and Clam Netted Area	Good upper beach habitat
Opportunity	Gartely Point	Upper beach and possible clam habitat	Future Analysis management area
	Comox Harbour	Possible clam habitat	First Nation tenure interests

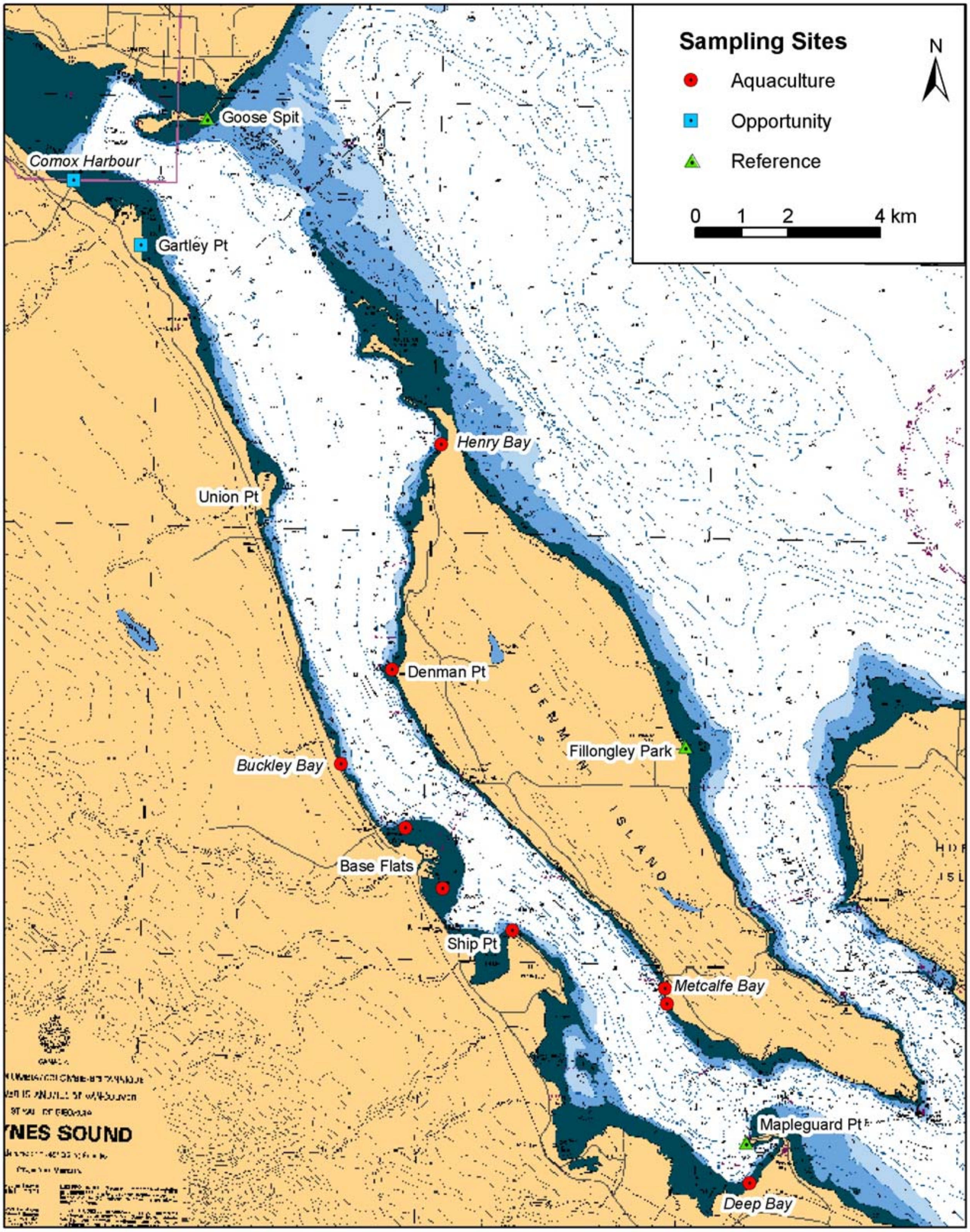


Figure 3. Beach Spawner Sampling Sites in the Baynes Sound Area

2.2 SAMPLING

Three 5 day field sampling trips were conducted; November 21-25, 2002, December 16 –20, 2002 and January 17 – 21, 2003. During each field sampling trip, a total of 25 beach spawn samples were taken from the 14 sites during the nightly winter low tides. A summary of the sampling analysis methodology is provided below. Further detail on the sampling and analysis protocol used by both WDWF and this sampling program are included in Appendix 1. The data sheet used to collect the site specific information is shown in Appendix 2a.

A final one-day field trip was conducted on February 5, 2003 at which time the two reference sites on Vancouver Island (Goose Spit and Mapleguard Point) were sampled and several daytime photographs of some of the sites were taken.

2.2.1 Field Component

A 30m transect (T1) was laid parallel to the shoreline within the upper intertidal zone. A composite beach spawn sample of four 500mL of sediment from the top 1.5 cm of substrate within 2.5m on either side of the transect was collected. For each of the aquaculture sites, a second transect (T2) was laid approximately two meters shoreward of the top of the predator net and sampled using the same method as T1. Each composite sample was then stored at a cool temperature overnight and sieved (using fresh water) through graduated screens (4mm, 2mm, 0.5mm) with the 0.5mm fraction retained for closer analysis the following day.

2.2.2 Laboratory Component

Between 300 to500ml of the 0.5mm fraction from each sample was examined for eggs using a winnowing technique. Certain samples were comprised of mostly sand and were not processed through the gradient of sieves; rather, the entire 2000ml were examined for eggs. The winnowing technique involved swirling sediment with a cover of water to bring the lighter fraction to the surface. This fraction included the beach spawner eggs, which tend to adhere to sand grains and fragments of shell. Each sample was winnowed once again to obtain approximately 100mL of lighter material. This material was independently examined by two observers to confirm presence or absence of any eggs. Eggs were then examined under a dissecting microscope for preliminary determination of species and placed in labelled vials with preservative (Stockard's solution) for subsequent ageing.

The number of eggs in each sample were enumerated, with the exception of one reference site (Mapleguard Point), where a sub-sample of the sediment was examined due to a higher density of eggs found.

2.2.3 Egg Identification and Ageing

A portion of eggs from each sample were separated from the sand grains and shell fragments and aged according to the eight embryological development stages shown in Appendix 3. All eggs were then sent to WDFW Marine Resources Division in La Conner, WA for species and age verification.

2.3 SITE PROFILES/BIOPHYSICAL INFORMATION

During the January 17 – 21, 2003 field trip, detailed intertidal biophysical information was collected along an across-shore transect from the higher high water mark (HHW) to the waterline at each of the 14 sample sites. Biophysical information included substrate composition, major invertebrate and algal species, distance (relative to the HHW) and elevation of each of the intertidal bands and intersection points (T1,T2, predator net) for each transect (see data sheet Appendix 2b). The bands were determined by changes in substrate, slope and/or marine vegetation. Elevations were corrected to chart datum using the predictive tide software (Tides and Currents Pro) for Comox (Goose Spit, Comox Harbour, Gartley Point) and Denman Island (all other sites). Although the focus for data collection was on physical characteristics of the site, vegetation cover was estimated using a percent cover of particular algal assemblages or species (e.g. foliose or filamentous red algae, rockweed, *Fucus* sp.). The presence of invertebrates was noted qualitatively, as present (P), common (C), or abundant (A). Substrate size was visually classified according to a modified Wentworth Scale:

Boulder (Bd)	>256mm
Cobble (Cb)	64 to 256mm
Pebble (Pb)	2 to 64mm
Sand (Sd)	0.2 to 2mm
Silt (Si)	<0.2mm
Shell (Sh)	variable

2.4 SEDIMENT COLLECTION AND GRAIN SIZE ANALYSIS

During the December 16 – 20, 2003 field trip, sediment samples were collected independently of the bulk spawn samples at each of the transects. Between 10 – 14 kg (wet weight) of substrate was collected at each site in two labelled ziploc bags, with half the sample collected along the shoreward side of the 30m transect, and the other half of the sample collected on seaward side of the transect. A total of 25 sediment samples were delivered to Thurber Engineering Ltd. in Victoria, BC on January 10, 2003 for grain size analysis.

The initial samples contained in two labelled plastic bags, were combined and either air or oven dried prior to splitting to a representative size for grain size testing. The dried sample was split to a mass appropriate for the maximum particle size in the sample in accordance with ASTM D-422 protocol. Sieve sizes used were 64mm, 32mm, 16mm, 8mm, 4mm, 2mm, 1mm, 0.5mm, 0.25mm and 0.063mm. Intermediate sieve sizes were used to lessen the weight of sediment on any one sieve. If required, silts and clays were washed using the 0.063mm sieve. Tabulated grain size analysis results (provided as a spreadsheet with percent retained/passing by grain size per sample) were supplied by Thurber and used to create graphical representations of the grain size content for each sample.

3.0 RESULTS

The 14 sites (Figure 3) were sampled for the presence of beach spawner eggs during three sampling field trips, November 20 – 24, 2002, December 16 – 20, 2002 and January 17 – 21, 2003. Two of the reference sites (Mapleguard Point and Goose Spit) were re-sampled on February 5, 2003. All samples were collected at night between 18:00 – 0300hrs with the exception of the February 5, 2003 sample, which was collected during daytime low tides (between 11:30 – 1600hrs). Table 3 summarizes the total number of samples taken at each site over the sampling period. Appendix 4 shows the transect locations (T1/T2) at each of the 14 sites. A total of 78 beach spawn samples, 42 at the upper transect (T1) and 36 at the lower transect (T2), were taken.

Table 3. Beach spawner sampling effort from November 20, 2002 to February 5, 2003

Site Designation	Site	Total Number of Spawner Samples	
		T1-upper intertidal	T2 – predator net
Reference	Mapleguard Point	4	n/a
	Goose Spit	8*	n/a
	Fillongley Park	3	n/a
Aquaculture	Deep Bay	3	3
	Ship Point	3	3
	South Base Flats	3	3
	North Base Flats	3	3
	North of Buckley Bay	n/a	6**
	South Metcalfe Bay	3	3
	Metcalfe Bay	3	3
	Denman Point	3	3
	Henry Bay	3	3
Opportunity	Gartely Point	3	3
	Comox Harbour	n/a	3

* two samples were taken from the upper intertidal zone due to the width of beach

** upper intertidal substrate was too coarse to sample; two samples were taken at the predator net, one shoreward of the net and one seaward.

3.1 Spawning Locations and Timing

Fish eggs were found within the upper intertidal zone samples (T1) at four of the 14 sites ; the three reference sites and one aquaculture site in Henry Bay on north western Denman Island. All eggs were confirmed to be Pacific sand lance eggs. No surf smelt or rock sole eggs were found. Table 4 summarises the location, timing and abundance of eggs found throughout the sampling period. Eggs were most abundant in the samples from Mapleguard Point. Eggs were found during all sampling trips at Mapleguard Point and Goose Spit, the two reference sites with the greatest amount of spawn, while lesser amounts were found during only one sampling trip at Fillongley Park and Henry Bay. Numbers of eggs reported are not quantitative in terms of numbers of eggs per square meter, however, enumeration of eggs per beach spawn sample (or sub-sample at Mapleguard Point) provides a relative index of spawn deposition at the sites sampled.

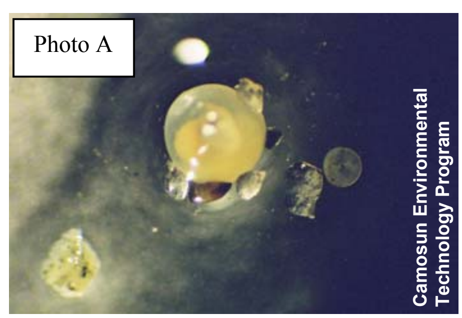
Table 4. Location, timing and abundance of eggs found in samples

SITE DESIGNATION	SITE	SAMPLE DATE			
		Nov 20-24, 2002	Dec 16-20, 2002	Jan 17-21, 2003	Feb 5, 2003
Reference	Mapleguard Point	39	>175**	>100**	
	Goose Spit	6	32	5	
	Fillongley Park		11		n/s*
Aquaculture	Deep Bay				n/s
	Ship Point				n/s
	South Base Flats				n/s
	North Base Flats				n/s
	North of Buckley Bay				n/s
	South Metcalfe Bay				n/s
	Metcalfe Bay				n/s
	Denman Point				n/s
	Henry Bay			2	n/s
Opportunity	Gartely Point				n/s
	Comox Harbour				n/s

* not sampled
** egg counts from 5% sub-sample

A total of 374 eggs were collected and preserved from all the samples, of which 239 were staged by the project team using the embryological development stages for surf smelt (Penttila 2000a, Appendix 3) as the developmental stages of Pacific sand lance eggs are similar to surf smelt (D. Penttila pers. comm.)

The species identification and development stages for all 374 eggs collected during the sampling period were confirmed in March 2003, by Dan Penttila, Fish Biologist at the Marine Resources Division of the Washington Department of Fish and Wildlife in La Conner Washington. Appendix 4 summarizes the number of eggs in each stage of embryological development by field trip and site. A total of 31 (8%) of the eggs were unfertilized, dead or too deteriorated to age. Between two and five development stages were identified at the reference sites during each sampling trip. Two development stages were identified at the earliest spawn at Mapleguard Point in November, 2002, with one stage indicating an approximate spawning date 8-10 days prior to the November 24, 2002. The latest spawn event also occurred at Mapleguard Point, with several eggs 5-7 days old recovered on January 16, 2003, indicating an approximate spawning date of January 9-11, 2003. Given an incubation period of 4 weeks (dependent on water and air temperature), these larvae would hatch February 6 – 8, 2003.



The diameter of a random sample of 68 eggs (18% of the total sample size) was measured to the nearest 0.1mm using a stage micrometer. The range in egg size was 0.8 – 1.0mm with a mean diameter of 0.9mm. Photo A shows a typical sand lance egg (1 ½ coil) with sand grains collected at Deep Bay on December 27, 2001.

Several small (0.5 – 1.5mm diameter) “unknown eggs” were collected at Henry Bay (T1), Metcalfe (T1)/South Metcalfe Bay (T1) and North Base Flats

(T2) during the December and January sampling trips. The unknown "egg" found at North Base Flats January 16, 2002 was too firm and sticky to be a fish egg and may be a plant seed (D. Penttila, WDFW, 2003). The small gelatinous egg (approximately 0.5mm diameter) found at Metcalfe Bay December 16, 2002 could not be identified by the WDFW Marine Resources Division and may be an invertebrate egg (D.Penttila, WDFW, D.Hay, pers. comm.). Several of the remaining unknown "eggs" were identified as droplets of conifer tree pitch, which are occasionally encountered within the upper intertidal beach samples from the Puget Sound Basin (D. Penttila , WDFW, pers. comm.).

Moulton and Pentilla (2001, p. 8) report that it is not uncommon to encounter non-egg objects that may be mistaken for beach spawner eggs or empty egg shells within upper intertidal samples. These non-egg objects may include "invertebrate eggs, algal fruiting bodies, flatworms and their egg cases, certain thecate or arenaceous foraminifera, decalcified gastropods, and fragments of annelid worm tubes". In addition, during the winnowing process, numerous mucous-coated clumps initially presented themselves as eggs but upon further examination, turned out to be coiled worms.

3.2 Tidal Elevations

At each site, tidal elevations were recorded at T1, T2 and the upper limit of the predator net (the aquaculture sites) and are summarized in Table 5.

Table 5. Tidal elevations (in metres relative to chart datum) of the intertidal transects (T1 and T2) and the upper limit of the predator nets at the aquaculture sites

Site Designation	Site	Elevation (m)			Profile Date
		T1	T2	Predator Net (upper limit)	
Reference	Mapleguard Point	4.0	n/a		17-Jan-03
	Goose Spit	4.3/4.1	n/a		15-Jan-03
	Fillongley Park	4.2	n/a		14-Jan-03
Aquaculture	Deep Bay	3.5	2.8	2.8	17-Jan-03
	Ship Point	4.6	3.0	3.0	16-Jan-03
	South Base Flats	2.8	3.4	3.1	16-Jan-03
	North Base Flats	3.1	1.9	1.9	16-Jan-03
	North of Buckley Bay	n/a	2.7	2.3*	16-Jan-03
	South Metcalfe Bay	4.5	2.6	2.5	14-Jan-03
	Metcalfe Bay	4.0	2.4	2.3	14-Jan-03
	Denman Point	4.4	3.1	3.0	14-Jan-03
	Henry Bay	3.8	2.9	2.9	14-Jan-03
Opportunity	Gartely Point	4.6	3.6		15-Jan-03
	Comox Harbour	n/a	3.3		15-Jan-03
Mean elevation		4.0	2.6	2.6	

*lower limit of predator net

The elevations at T1 ranged between 2.8m and 4.6m with the average elevation 4.0m. The elevation of the 5m wide sample zone at each site varied depending on the slope of the beach and was not directly measured (see across-shore profiles for each of the sites in Appendix 5).

Elevations at T2 ranged between 1.9m and 3.6m over 11 sites with an average elevation 2.6m. The upper limit of the predator nets at the nine aquaculture sites ranged between 2.3m and 3.4m with an average elevation of 2.6m. There was no difference in mean vertical elevation between T2 and the upper limit of the predator net while the mean difference between T1 and T2 was 1.4m..

Sand lance eggs were found along T1 at elevations between 3.8 and 4.3m (+ 0.3m depending on the slope of the beach). According to Pentilla and Moulton (2002) spawning and incubation of eggs normally occurs 2-3m above mean lower low water (MLLW), with the lower limit approximately 1.5m above MLLW for sand lance spawn and 1.8m above MLLW for surf smelt, as gauged in the Seattle District (Penttila pers. comm.). The tidal datum used in the United States is Mean Lower Low Water and can differ from Canadian tidal datum (Lowest Normal Tide) by as much as one metre (Canadian Tides and Currents Table). Using the MLLW for Denman and Comox (1.2m, CHS Chart # 3527), the normal range of sand lance and surf smelt spawn should be between 3.2 and 4.2m relative to Canadian chart datum, with the lower limit of sand lance spawn at 2.7m and surf smelt spawn at 3.0m elevation. The elevation range of beach spawn recorded within the four sample sites in Baynes Sound is therefore consistent with the elevations reported in Washington State.

3.3 PHYSICAL CHARACTERISTICS

Physical characteristics of the shoreline in the vicinity of the sample sites are summarised below along with the site specific information documented during the field trips to Baynes Sound. A comparison of Washington State Shore-Zone and beach spawner data (from Harper and Ward 2001)is also described.

3.3.1 General

Information on the physical characteristics of the intertidal zone in Baynes Sound at the 14 sample sites is summarized in Table 6. The intertidal shore type (from Howes and Thompson 1983) and the provincial physical shore-zone coastal class and calculated exposure information is based on a unit of shoreline and is not site specific. As well, the unit boundaries mapped by Howes and Thompson (1983) and within the BC Physical Shore-Zone system are not the same. A total of eight intertidal shore types were used to describe 60 units (see Figure 3) within Baynes Sound by Howes and Thompson (1983) and 31 coastal classes (Howes et *al.* 1994) are used to describe 174 units in Baynes Sound using the BC physical shore-zone mapping system. However, although the unit boundaries are different, the general physical characteristics for each of the sample areas are consistent. Exceptions include Ship Point and Metcalfe Bay where the sample area is located on a boundary between two units. At Ship Point, the sample site is located on a gravel beach in a transition area between tidal flats (Howes and Thompson 1983) and a rock platform with a wide gravel beach (Howes et *al*. 1994). At the Metcalfe Bay site, there is a narrow gravel beach at the southernmost limit of the bay, with rock platform and beach north of the sample site. All of the unit based physical characteristics include beaches or tidal flats with a mixture of sand and/or gravel substrate.

Table 6. Comparison of shore-unit based and site-specific physical attributes in Baynes Sound from Howes and Thompson (1983), MSRM-Decision Services Branch and the field survey (November 2002 – February 2003)

DESIG-NATION	SITE	INTERTIDAL SHORE TYPE (HOWES AND THOMPSON 1983)	BC SHORE ZONE DATA (UNIT BASED*)			BEACH SPAWNER SURVEY (SITE SPECIFIC***)			
			UNITKEY	COASTAL CLASS**	CALCULATED EXPOSURE	EXPOSURE	MAXIMUM FETCH (KM)	ASPECT	
Reference	Mapleguard Point	Sand Beach	3949	Sand & gravel beach, narrow	Semi-protected	Protected	2	W	266°
	Goose Spit	Tidal Flats	4010	Sand & gravel flat or fan	Semi-exposed	Semi-exposed	100+	SE	119°
	Fillongley Park	not classified	4126	Sand & gravel flat or fan	Semi-protected	Semi-exposed	64	NNW	340°
Aquaculture	Deep Bay	Mixed Beach	3951	Sand & gravel beach, narrow	Semi-protected	Semi-protected	18	NW	321°
	Ship Point	Tidal Flat	3961	Platform with gravel beach, wide	Semi-protected	Semi-protected	26	SE	118°
	South Base Flats	Delta	3968	Estuaries	Protected	Protected	6	SE	118°
	North Base Flats	Delta	3969	Estuaries	Protected	Semi-protected	18	NNW	350°
	North of Buckley Bay	Mixed Beach	3971	Sand & gravel flat or fan	Semi-protected	Semi-protected	18	N	358°
	South Metcalfe Bay	Mixed Beach	4157	Gravel flat, wide	Semi-protected	Semi-protected	12	NW	315°
	Metcalfe Bay	Rock Platform w/ Beach Veneer	4156	Gravel beach, narrow	Semi-protected	Semi-protected	12	NW	313°
	Denman Point	Mixed Beach	4149	Sand & gravel flat or fan	Semi-protected	Semi-protected	15	NNW	331°
	Henry Bay	Mixed Beach	4144	Sand flat	Semi-protected	Semi-protected	15	NW	311°
Opportunity	Gartely Point	Mixed Beach	3982	Sand & gravel flat or fan	Semi-exposed	Semi-exposed	100+	E	116°
	Comox Harbour	Tidal Flats	3986	Sand & gravel flat or fan	Semi-protected	Semi-exposed	100+	E	116°

* physical data from aerial survey, Ministry of Sustainable Resource Management - Decision Support Services Branch
** detailed description of coastal class in Howes et *al.* 1994
*** measured from chart and field January, 2003

3.3.2 Washinton State- Shore Zone and Beach Spawner Data

Harper and Ward (2001) compared Washington State Department of Fish and Wildlife beach spawner data with the Washington Department of Natural Resources Shore-Zone data to see if any correlations existed that might be indicative of spawn habitat. Table 7a and 7b (from Harper and Ward 2001) show a correlation of shore type and the co-occurrence of sand lance and surf smelt spawning locations in Washington State. While the shore-type order is different between the two tables, almost 90% of spawning occurrence for both sand lance and surf smelt are on the same four shore types, with substrate comprised of sand and gravel.

Table 7a. Co-occurrence of Sand lance and Shore Types (from Harper and Ward 2001)

SHORE-TYPE	STATE-WIDE		SANDLANCE	
	km	*%*	*km*	*%**
wide S&G flat	393.7	8%	23.9	25%
sand flat	751.4	15%	23.0	24%
narrow S&G beach	642.4	13%	20.6	21%
narrow sand beach	565.5	11%	17.4	18%
wide sand beach	123.2	2%	5.7	6%
man-made permeable	329.6	7%	1.2	1%
narrow S&G flat	29	1%	1.2	1%
rock ramp w S&G beach	73.3	1%	0.7	1%
platform w S&G beach	28.7	1%	0.6	1%
estuary	868.0	18%	0.6	1%

% is based on 96km of 100% overlap shoreline of sand lance

Table 7b. Co-occurrence of Surf Smelt and Shore Types (from Harper and Ward 2001)

SHORE-TYPE	STATE-WIDE		SURF SMELT	
	km	*%*	*km*	*%**
narrow S&G flat	393.7	8%	86.0	28%
narrow sand beach	751.4	15%	68.7	23%
sandflat	642.4	13%	67.8	22%
wide S&G flat	565.5	11%	45.4	15%
wide sand beach	123.2	2%	14.6	5%
mudflat	329.6	7%	5.3	2%
wide platform w S&G beach	29	1%	4.4	1%
rock platform w sand beach	73.3	1%	3.8	1%
wide gravel flat	28.7	1%	1.9	1%
rock platform w S&G beach	868.0	18%	1.7	1%

% is based on 302km of 100% overlap shoreline of sandlance

According to comparisons made by Harper and Ward (2001), both sand lance and surf smelt spawn on shorelines with a range of wave exposures (sand lance-very protected to semi-exposed; surf smelt very protected to semi-protected as well as exposed). However, both species show a strong preference (>70%) for protected sites.

Figure 4a and 4b (from Harper and Ward 2001) show a comparison between the most commonly associated shore type and exposure combinations. The top 10 combinations explain 90% of the occurrences and the top four combinations explain 70% of the occurrences for both species.

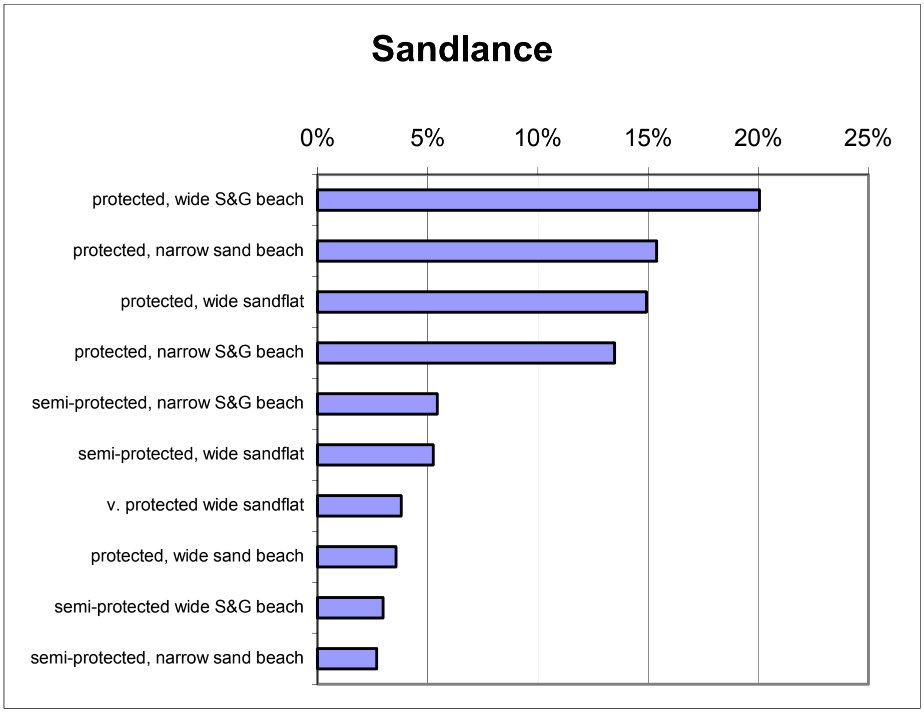


Figure 4a. Co-occurrence of shore-type/exposure with sand lance spawning(based on 96km of shoreline with 100% overlap) from Harper and Ward (2001)

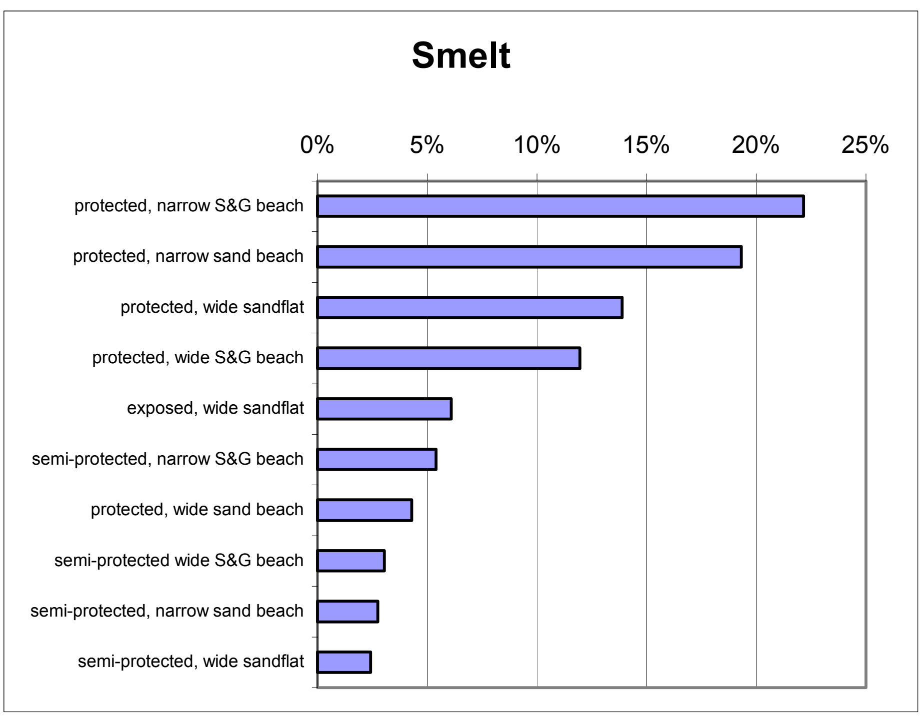


Figure 4b. Co-occurrence of shore-type/exposure with surf smelt spawning (based on 303km of shoreline with 100% overlap) from Harper and Ward (2001)

3.3.3 Site Specific Characteristics (November 2002 to February 2003)

The physical characteristics of each site are documented in Appendix 5 and include:

1. a site map with transect locations (T1,T2, and across-shore profiles),
2. a table summarizing the across shore banding information and general physical attributes (e.g., wave exposure, aspect, backshore features, and intertidal shading),
3. a vertical profile of the across-shore transect with elevations and transect positions, and
4. photographs showing the beach material and transect locations.

Based on maximum fetch (the distance over water that wind generates energy) estimates from field and chart measurements (January 2003) (Table 6) the exposure at the 14 sites are as follows:

- 4 semi-exposed sites,
- 8 semi-protected sites, and
- 2 protected sites.

Pacific sand lance eggs were found at two semi-exposed sites (Goose Spit, Fillongley Park), one semi-protected site (Henry Bay) and one protected site (Mapleguard Point). It is difficult to compare the associated shore type and exposure data between Washington State and Baynes Sound due to the small number of sample sites with spawn in Baynes Sound. However, the Baynes Sound data is consistent with Washington State data in that spawning occurs through a range of exposure categories.

There were some differences between the unit based exposure categories and the site specific exposures in that three of the 14 sites did not match in exposure categories (e.g., Mapleguard Point, see Table 6). Wave exposures in the physical shore zone data are calculated using fetch distances based on the unit (Harper *et al*. 1994), while the exposure reported in the site specific sample are based on maximum fetch from a point source. In the case of Mapleguard Point, the site specific sample was taken on the inside of the point (protected wave energy, see Figure 3) while the associated shore unit where the sample was taken extends along the outside of the point and the majority of the unit is semi-exposed.

Table 6 shows the direction of maximum exposure and the aspect for each sample site. There does not appear to be any correlation between aspect and presence/absence of eggs within the intertidal zone.

The beach slope within the upper intertidal (T1) sample area varies from 0.2^0 (Base Flats) to 8.9^0 (Ship Point, Fanny Bay), however, the slope of the beach at eight of the 12 sites ranges between 6.5^0 and 8.9^0 (mean = 7.9^0). There does not appear to be any correlation among slopes of the four sites where eggs were found in that the range of slopes at sites with spawn deposition (1.6^0 to 7.3^0, mean = 5.1^0) is similar to all sites. The beach slope at T2 was shallower, ranging between 0.8^0 and 3.6^0 (mean = 1.7^0).

There is some suggestion that vegetation overhanging the upper intertidal zone may provide beach spawner eggs some protection from desiccation, particularly during summer spawning. Shading in the upper intertidal zone from overhanging vegetation is present at five of the sites (35%). Trees including Douglas Fir (*Pseudotsuga menziesii*), Red cedar (*Thuja plicata*), Arbutus

(*Arbutus menziesii*) and shrubs including snowberry (*Symphoricarpos albus*) and Nootka rose (*Rosa nutkana*) which overhang the upper intertidal zone by up to 9m. However, there is no overhanging vegetation in the upper intertidal zone at any of the sites where eggs were found.

Modification to the immediate backshore ranged from 0% (forested) – 100% (farmland) and includes roads, parks (picnic areas), and residential development with seawalls (wooden, concrete). The immediate backshore at the four sites where eggs were found is a mixture of residential, forested/non-forested park (grassland, picnic areas) and roads.

Two of the three reference sites (Goose Spit and Mapleguard Point) are sand spits formed by alongshore drift processes. Sand lance spawn was considerably more abundant at these two sites that any other site sampled in the Baynes Sound area (Table 4). Spits, tombolos and beaches formed by these alongshore drift processes generally have sediments suitable for beach spawning fish (medium to coarse sand) and may be important physical features for these species.

3.4 Sediment Grain Size Analysis

The sediment grain size composition for each site is shown graphically in Appendix 6 (Figure 6.1 - Reference Sites, Figures 6.2 to 6.6 - Aquaculture Sites, Figure 6.7 – Opportunity Sites). Each graph depicts the percent material retained (by weight) by sediment size fraction grouped as silt (<0.63mm), sand (0.63 – 2mm), and gravel (2 – 64mm). The upper limit of 64mm corresponds to the maximum grain size for pebble size material. Photographic insets (Appendix 6) show the representative substrate sampled and provide a visual comparison for the bar graph data. A veneer (up to 1cm) of larger sized material (gravel/shell) was present at 16 of the 25 transects sampled (e.g., Denman Point (T1) and Henry Bay (T2), Appendix Figure 6.6).

There was no differentiation made between sand/gravel and fragments of shell material in the grain size analysis results. Based on visual (qualitative) estimates of shell fragment content in the sediment (not including whole shells), seven of the 14 sites had greater than 30% shell content. This is important to note as sand lance eggs are adhesive to both sediment and shell fragments of the appropriate size range.

Analysis of sediment grain size from 70 bulk beach spawn samples collected throughout the Puget Sound basin in Washington State from 1990 - 2000 has shown that 67% of the surface material collected on beaches containing sand lance eggs was medium sand within the 0.2 to 0.4mm size by weight (Penttila 2000b). Sand lance also spawned in material with more gravel and coarse sand (1-7mm in size) in 25% of the samples.

Sand lance eggs were found at five (two upper beach transects at Goose Spit) of the 25 transect locations sampled in Baynes Sound. Figure 5 and Figure 6 show the sediment size fraction distribution for the pooled data (mean percent retained by weight) for transect locations with sand lance eggs (n=5) and those without eggs (n=20). The pooled data indicates that sand lance tend to spawn on medium to coarse sand substrate as 50% of the sediment sampled was between 0.25 – 0.5mm (medium sand) and 30% between 0.5 – 2mm (coarse sand). If Henry Bay, a site where only two eggs were found, were excluded from the pooled data 60% of the sampled material is included within 0.25-0.5mm range. In contrast, the pooled sediment composition for samples without eggs (Figure 6) shows a distribution of size fractions with a higher percentage of coarser material (50% gravel) and finer material (10% silt and fine sand).

Figure 7 and Figure 8 show the sediment composition from pooled data (means) for upper intertidal samples (T1, n=10) and lower intertidal samples (T2, n=11) for the nine aquaculture sites and two opportunity sites. The lower samples contained a higher percentage of finer sediment, 3.6% silt and 12.4% fine sand material, compared to 0.7% silt and 2.2% fine sand in the upper samples. The upper samples were characterized by generally coarser material, with 73% gravel compared to 40% gravel in the lower samples. Sediment sampled at only two clam tenures (Ship Point, T2 and South Metcalfe Bay, T1). At Ship Point (T2) 42% of the sediment sample contained medium sand however, fine sand (30%) and silt (3.7%) content was much higher (see Appendix 7) than typical sand lance spawner substrate reported by Pentilla (2000b). According to pooled data from Puget Sound, only 4.4% of the surface substrate for typical sand lance spawn deposition is characterized by 0.1mm sized sediment (fine sand) and 0.4% by <0.1mm sized sediment (silt). The sediment composition for South Metcalfe Bay was almost identical to Fillongley Park (see Appendix Figure 6.1 and 6.5) which was comprised of coarser sand (41%) and fine gravel (49%).

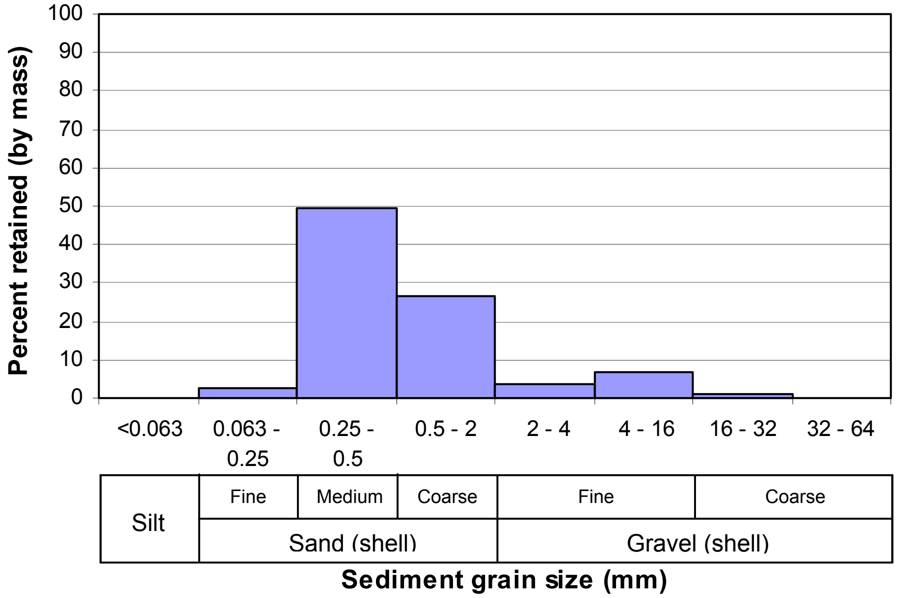


Figure 5. Pooled (mean percent retained by weight) sediment grain size composition for sites with sand lance eggs (n=5).

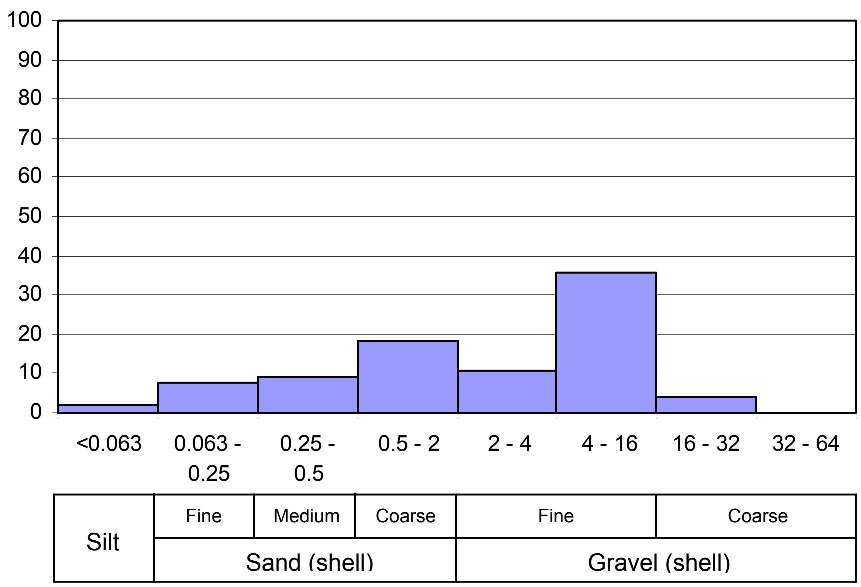


Figure 6. Pooled (mean percent retained by weight) sediment grain size composition for sites without sand lance eggs (n=20).

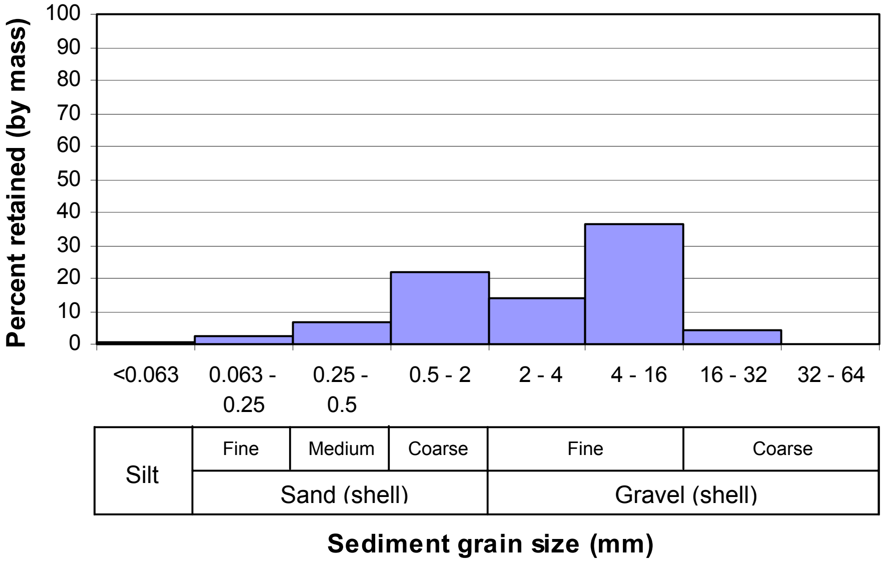


Figure 7. Pooled (mean percent retained by weight) sediment grain size composition for samples taken at T1 (upper) (n=10).

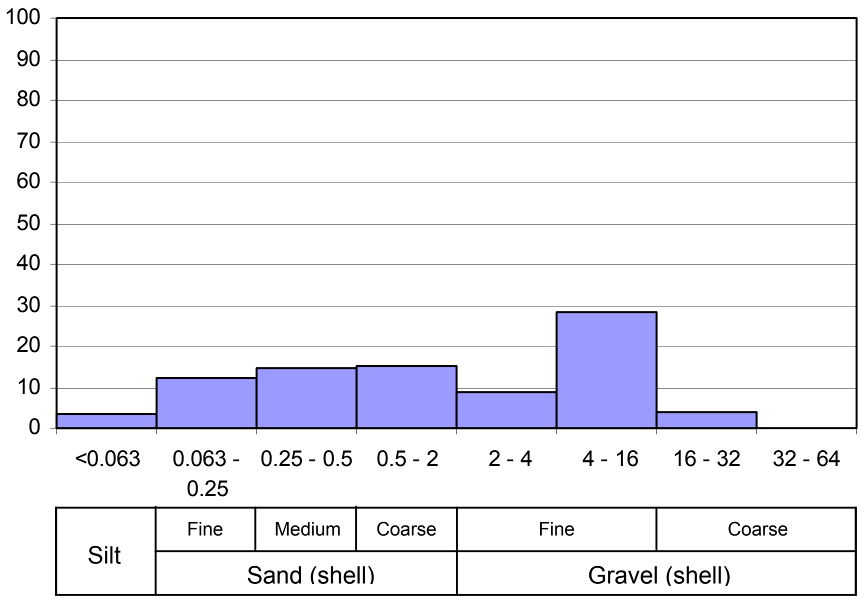


Figure 8. Pooled (mean percent retained by weight) sediment grain size composition for samples taken at T2 (lower) (n=11).

4.0 INTERACTIONS WITH INTERTIDAL SHELLFISH AQUACULTURE

4.1 REVIEW OF WASHINGTON STATE BEACH SPAWNER INTERACTIONS

The systematic documentation of forage fish spawning habitat in Puget Sound and San Juan County (Washington State) has led to the incorporation of habitat protection for Pacific sand lance, surf smelt and rock sole in state and county foreshore development permitting (administered through Washington Administrative Code (WAC) Hydaulic Rules). Foreshore development within or in close proximity to these habitats of special concern may be subject to restrictions on project design, type, location and timing under WAC. In Puget Sound, approximately 70% of the shoreline is privately owned and intensive use of clam netting occurs in the southern most region (G. Bargmann pers. comm.). Clam tenure holders must apply for a permit from the Washington Department of Agriculture in order to register a site as an aquatic farm. A Hydaulic Permit Approval (HPA) from Washington Department of Fish and Wildlife (WDFW) is not required for clam aquaculture as long as there are no structures built within the tenure such as perimeter berms or oyster long-line rafts (G. Bargmann pers. comm.).

Vertical elevation data collected during the beach spawn surveys in Puget Sound shows that the lower limit of the sand lance and surf smelt spawning zone (+1.5 and +1.8m relative to MLLW gauged in Seattle, WA) is slightly above the upper edge of the Manila clam farming zone. As a result clam culture activities, including placement of predator nets in the upper intertidal zone do not have a negative impact on spawning habitat. According to Penttila (2003), both clam netting and other shellfish culture-bag structures which have been deployed on a patchy basis in the southern most Puget Sound in the last 20 years, do not appear to have inhibited beach spawner activity within the upper intertidal zone at the same sites. Aside from an occasional report of mortalities of surf smelt gilled in loose sections of predator nets, he is not aware of any specific data on interactions between beach spawning forage fish and clam aquaculture activities. The main concern WDFW has with respect to shellfish aquaculture activities pertains to impacts to eelgrass and herring spawn habitat from the mechanical harvesting of Pacific oysters (D. Penttila pers. comm.), a practise that does not occur during shellfish aquaculture harvest in BC (Emmett 2002).

4.2 BAYNES SOUND BEACH SPAWN INTERACTIONS

The potential for significant impact to finfish beach spawning activity during intertidal clam harvesting was identified as a data gap within Emmett's (2002) review of aquaculture activities and associated effects on the biophysical features in Baynes Sound. The results of the current study are consistent with data from Puget Sound, in that most of the predator netting at the sites that were sampled in Baynes Sound occur at an elevation below suitable beach spawning substrate (approximately +2.6m CD) which corresponds to the upper limit of the preferred growing range of Manila clams (+2.5m CD). Therefore, direct impacts from predator net placement in the intertidal zone appear to be minimal. Given the objectives of this project along with the time and budget constraints, across-shore sampling at regular intervals to determine the range of spawn on each of the egg bearing beaches was not conducted. However, given that the noted vertical elevation of sand lance eggs are consistent with vertical elevation data from Washington State, it is reasonable to assume that the lower limit of beach spawn activity is also consistent with beach spawn activity in Washington State.

Pacific sand lance eggs (11 to 100+) were found in the upper intertidal beaches at the reference sites in Baynes Sound which had greater than 50% composition of medium sand (0.25-0.5mm size) and less than 3% silt and fine sand content (from pooled data). Two of the reference sites, Mapleguard Point and Goose Spit, had considerably greater egg deposition (Table 4, Appendix Table 4) and a higher medium sand content (68% each, see Appendix Figure 6.1 and Appendix Table 7a) than the third reference site, Fillongly Park. At Henry Bay two eggs were found at the upper transect (T1) in January, 2003. The presence of eggs at this site, where sediment grain size distribution included 17% medium sand content as well as 18% fine sand, appeared to be an anomaly. Given that the preferred grain size for sand lance spawn habitat is consistent with results in Washington State, it appears that only one of the aquaculture sites has suitable substrate for sand lance spawn deposition (South Metcalfe Bay, T1). Although one aquaculture site sampled had medium sand content close to 50% (T2 at Ship Point, see Appendix Figure 6.2/Appendix 7), fine sand and silt content was 30% and 4% respectively, resulting in sediment composition with material too fine for sand lance and/or surf smelt spawning (Penttila 2000b).

The absence of surf smelt eggs in samples collected during the winter in Baynes Sound does not mean these fish do not spawn in the area. Documentation of surf smelt spawning in BC is very limited, mostly in the summer months, but surf smelt eggs were found in a sample taken by Camosun Environmental Technology students in Cordova Bay, Victoria in January 2002. In addition, surf smelt have been documented to spawn all year around in Puget Sound, WA.

Pooled sediment data in Puget Sound indicate that surf smelt spawn in gravelly sand, similar but slightly coarser material than used by sand lance. The bulk of the surface sediment by weight is between 1-10mm in size, with less than 0.5% silt and less than 5% fine sand content. Although surf smelt eggs were not found from November to February in Baynes Sound, sediment grain-size results from both surf smelt spawning locations in Puget Sound and beaches sampled in Baynes Sound, suggest that all, with the exception of one site, of the lower samples (T2) taken at either the aquaculture or opportunity sites would not support smelt spawning. This is based on the silt and sand content from the pooled data, which is 4% and 12% respectively for samples taken at T2. The sediment grain size composition of the sample taken at the predator net at South Base Flats appears to be suitable for surf smelt spawn. However, due to the high variation in substrate topography at this site (mixture of hummock, depressions and flats) and substrate composition (shell and finer sand/silt), it would be difficult to assess whether a large enough area with suitable substrate for spawning exits.

It has been suggested that capelin (*Mallotus villosus*), another beach spawner species in the smelt family (Osmeridae) with eggs approximately 1mm in diameter, could be utilizing gravelly upper intertidal beaches similar to surf smelt to spawn in the Strait of Georgia in BC. Capelin are not considered in Puget Sound as the southern extent of their range has been reported as Strait of Juan de Fuca, however, this distribution is based on one or two records (D. Hay and M.Busby pers. comm.). Capelin spawn in the summer in Alaska and during late fall (August/September) in BC (M. Busby pers. comm.) Historically, capelin have been found to spawn in the fall throughout the Strait of Georgia, but more recently, capelin have been found to be spring spawners and only in the northern Strait of Georgia (Johnson Strait) as well as Bute Inlet (D. Hay pers. comm.). As well, Pacific sand lance larvae (approximately 10-15cm larvae in March) were ubiquitous within historic larvae tows conducted for Pacific herring research in Baynes Sound in the late 1970's and early 1980's, but no capelin larvae were found in these tows (D. Hay pers. comm.).

4.3 Spawn Timing

Pacific sand lance spawning in Baynes Sound appears to occur from November to February, consistent with the timing window of November 1 – February 15 reported in Puget Sound. Embryological development of eggs recovered at Mapleguard Point during the November 21-25, 2002 sample period indicate that a spawning event had occurred 8-10 days previous, sometime between November 14-16, 2003. WDFW observations indicate that populations of this short lived species can fluctuate broadly in size over short periods of time (D. Penttila pers. comm.) and therefore, spawning frequency and abundance should not be expected to be consistent from year to year. Typically sand lance spawning events are sporatic and several may occur at close intervals as at Mapleguard Point. Slight differences in the character of the eye pigmentation possibly indicate that two closely–spaced broods were represented in the sample, and that the relatively large number of eggs recovered (100+ in 100ml of sediment sample in January, 2002), indicates that the original spawn deposit may have been quite dense and extensive (D. Penttila pers. comm.). Although we have a good indication of sand lance spawn timing window in Baynes Sound, we are not able to speculate on frequency of spawn over the period or the exact end of the incubation period after the January sample trip as egg incubation is dependent on water temperature. However, knowing that the approximate incubation period for sand lance is four weeks and the last spawn event from the survey was 5 – 7 days previous to January 16, 2003, we can assume these larvae will hatch around the first week in February.

4.4 Beach Access Considerations

Sand lance eggs were found in the upper intertidal zone within one meter of the higher high water mark. At some sites, this area may be used by vehicles to access aquaculture tenures. There is concern that beach access by vehicles could have an impact on spawning habitat, in that eggs would be crushed if present in the upper intertidal zone. In Puget Sound, regular vehicular activity on spawner beaches does not occur, primarily due to the fact that many of the upper intertdal sand and gravel beaches are only a thin veneer over glacial hardpan or clay and would become a soft mixture of clay not suitable for truck movement (D. Penttila pers. comm.).

Currently, the access to the existing aquaculture tenure in Henry Bay, where sand lance eggs were found, is by boat (J. Tarnowski pers. comm.). Although vehicle access to beach tenures is considered an activity that is required by operators, consideration for alternate access (via boat) should be examined for existing sites or new tenure applications with suitable material for sand lance or surf smelt spawn in the upper intertidal zone. This consideration is consistent with responses already tabled in the Baynes Sound Coastal Plan (MSRM 2002).

4.5 Other Considerations

The potential interactions between beach spawners and upper intertidal beach function are broader than intertidal shellfish aquaculture activities. Other upland activities and foreshore developments (such as vertical seawalls and bulkheads) have potential to impact ecosystem function in the upper intertidal zone of sand and gravel beaches. On sand and gravel beaches, the potential impacts of foreshore developments on beach spawner habitat should be considered. Some appropriate design considerations are provided by the Washington State Department of

Ecology Shorelines Program (see URL http://www.ecy.wa.gov/programs/sea/pugetsound/index.html ► building).

5.0 SUMMARY

Within the beach spawn sampling protocol from WDFW, it is recommended that beaches are consecutively sampled for two years before ruling out presence of spawn. However, the State of Washington has had an active program to survey and identify beach spawner habitat in Puget Sound since 1989, documenting locations and physical characteristics of 217 km (130 miles) of sand lance spawning habitat and 325 km (195 miles) of surf smelt spawning habitat. This information can be used to make several summary comments in respect to the findings in Baynes Sound. These include:

1. Pacific sand lance spawn in Puget Sound, Washington Sate, from November 1 – February 15. The data collected in Baynes Sound suggests a spawning window of mid-November to mid January. Knowing that the approximate incubation period for sand lance is approximately four weeks (dependant on water temperature), we can assume, based on our spawn data, that larvae will hatch by mid February.

2. Based on pooled data, sand lance eggs were collected from the upper intertidal beaches in Baynes Sound at the sites with >50% composition of medium sand (0.25 – 0.5mm) and <3% silt (<0.063mm) and fine sand (0.063 – 0.25mm). This is consistent with size fractions reported for sand lance spawning locations in Puget Sound.

3. Sediment composition at two of the reference sites (Mapleguard Point and Goose Spit) where the most eggs were recovered was comprised of 68% medium sand.

4. A small number of sand lance eggs (two in total) were found at an aquaculture tenure in Henry Bay in January, 2002. Given the sediment composition (18% fine sand), it is likely that the presence of these eggs at this site is an anomaly.

5. Substrate composition at the aquaculture and opportunity sites in both upper (Transect 1) and lower (Transect 2) sample locations would likely not support sand lance beach spawn deposition as content of fine material (silt/fine sand) is too high. One exception is at South Metcalfe Bay, where sediment grain size is very similar to material at Fillongley Park (reference site).

6. Based on data from Puget Sound surveys collected since 1989, the placement of clam predator nets in Baynes Sound at vertical elevations below approximately +2.6m relative to chart datum and associated clam harvest activities are likely below the spawning range of sand lance and surf smelt. In addition, at the vertical elevation of +2.6m, sediment composition generally contains a greater amount of fines than are found on a typical beach spawner site.

7. Although surf smelt eggs were not found throughout the winter sampling period in Baynes Sound, sediment grain size analysis from Baynes Sound contrasted with results from Puget Sound suggests suitable substrate is not present at all but one of the aquaculture and opportunity sites sampled.

8. Based on the sediment composition information from this project and previous data from Puget Sound, criteria can be developed with respect to assessing the suitability of upper intertidal beaches for beach spawning species and management practices associated with intertidal shellfish aquaculture, including beach access.

6.0 REFERENCES

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