British Columbia Forage Fish Spawning Survey Methodology for Academics and Qualified Environmental Professionals

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TABLE OF CONTENTS

1.0 MATERIAL CHECKLIST

1.1 Fieldwork Checklist

1.1.1 Beach Station Establishment[1]

- ☐ Beach Station Survey Datasheet/clipboard
- ☐ 30 m measuring tape
- ☐ Pencils
- ☐ Compass
- ☐ GPS Unit
- ☐ Location codes document

1.1.2 Sample Collection

- ☐ Data sheets/clipboard
- ☐ CHS map of sample area
- ☐ Pencils
- ☐ Tide tables (current and previous day)
- ☐ Camera
- ☐ Thermometer
- ☐ Measuring tape x2 (30 m)
- ☐ Telescoping leveling rod
- ☐ 1 metre stick
- ☐ Clinometer/hand site level
- ☐ GPS unit
- ☐ Scoop (500mL)
- ☐ 4 litre Sample containers
- ☐ Sample tags
- ☐ Sediment Grain Card

1.1.3 Sample Processing

Sieving Process

- ☐ 5-gallon bucket with holes in the bottom
- ☐ Sieves – 4.0 mm, 2.0 mm, 0.5 mm
- ☐ Water buckets
- ☐ Water pitcher (optional)
- ☐ Plastic tub(s)
- ☐ Sample jar(s)
- ☐ Nylon brush
- ☐ Hose for water
- ☐ Sediment Composition tags

Vortex Process

- ☐ 68 litre tote
- ☐ Bilge pump with hose and quick connectors
- ☐ Nylon stocking and an elastic
- ☐ Blue Bowl with stands
- ☐ 0.5 mm sieve
- ☐ 12 V marine battery
- ☐ Shims
- ☐ Turkey baster
- ☐ Big plastic spoon
- ☐ Small plastic spoon
- ☐ Rubber spatula
- ☐ Wash bottle (optional)
- ☐ Stockard's solution
- ☐ MSDS Sheet for Stockard's solution

1.2 Laboratory Checklist

- ☐ Dissecting microscope
- ☐ Petri dishes/Bogorov tray
- ☐ Small spoon
- ☐ Pipette
- ☐ Fine point forceps
- ☐ Corresponding datasheets
- ☐ Vials
- ☐ Stockard's solution
- ☐ MSDS Sheet for Stockard's solution

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[1] Beach Station Establishment only needs to happen once per beach station – the very first visit.

2.0 HOW TO SAMPLE – STEP BY STEP

2.1 Beach Station Establishment

When establishing new beach stations for the first time, certain beach characteristics and location details need to be recorded as part of the Coastal Forage Fish Network (CFFN) data submission template. Utilize the *Forage Fish Beach Station Survey* Datasheet (Appendix 1) for this step.

2.1.1 Samplers

1. Record the name(s) of the sampler(s), organization affiliation, and date (YYYY/MM/DD) of the beach station establishment.
2. Lay out your 30 m measuring tape where the most suitable spawning habitat is observed, parallel to the shoreline.

2.1.2 Location Information

3. Use the *Forage Fish Sampling: Location Codes (Appendix 3)* to fill out the regional district and municipality and/or electoral area that the beach station falls within
4. Use the *Fisheries and Oceans Canada (DFO) Management Area (Appendix 4)* document, or their website, to fill out the DFO Management Area that the beach station falls within.
5. Record the beach name, beach station number, and beach ID. Your beach ID will be the next available number in your set, unique to your host organization. If you are unsure which ID numbers are available, please contact the CFFN Executive Team for clarification.

2.1.3 Indigenous Territories

6. Using https://native-land.ca/, record the Indigenous Territories the beach station falls within.

2.1.4 Beach Attributes

7. Using a compass, record the beach aspect and bearing from the midpoint of your 30m transect tape.
8. Using Google Earth™, record the fetch (km) and corresponding exposure of the beach.
   a. The maximum fetch distance is the longest horizontal distance over which wave-generating winds blow.
      i. Input the GPS location of the sample site into the map of choice (a georeferenced CHS map or Google Earth).
      ii. Use the measuring tool, determine the greatest distance over which wind can travel undisturbed.
      iii. Record the determined distance.
   b. A beach's exposure to wind and waves is reduced if there are landmasses or obstacles in the way. A beach's exposure is directly correlated to the fetch and can range from very protected, having landmasses in front of it, at less than 1 km, to very exposed and having nothing in front of it for more than 1000 km.
      i. Refer to the back of the datasheet to determine the exposure that corresponds to the maximum fetch distance determined in step 8a.

2.1.5 ShoreZone Information

9. If available, access ShoreZone mapping of suitable habitat for your beach station. Record if the mapping identified the beach as suitable forage fish spawning habitat. Access PhyIdent data through ArcGIS.

2.1.6 Site Assessment Information

10. If historical surveys have been completed at this beach station in the past, record who completed them and when they were completed.
11. Record the date(s) of the beach station establishment during winter and/or summer months where applicable.

12. Indicate the suitability of the sediment during the beach station establishment from physical observations, not predictive mapping models.
13. Record the lead person responsible for the beach station establishment by name or affiliated unique Staff ID value.

2.2 Field Preparation

2.2.1 Determining When to Sample

1. Sampling occurs in the upper third of the intertidal zone, selecting areas that contain the preferable sediment composition. This section must be exposed to sample.
2. The 'ideal sampling zone' is 2 m to 3 m above the Mean Low Low Water (MLLW) mark, which will vary based on area. It is good practice to plan your sampling at times when your 'ideal sampling zone' is exposed. For example, if your MLLW mark is 1.2 m, the 'ideal sampling zone' would be 3.2 m to 4.2 m; therefore, you would not want to go to the beach until the water level is at 3.2 m or lower.

2.2.2 Determining the Mean Low Low Water Mark

3. A Canadian Hydrographic Service (CHS) map for the area of interest will be required.
4. Each map has a variety of tidal information recorded on the front of the map in a box, under the map's title. It is in this box that you will find the "Mean Tide/LLW" measurement, which can then be used to determine the 'ideal sampling zone' for the region.

2.3 Site Assessment

1. Assess the area based on sediment type, with Pacific sand lance preferring medium sandy sediments 0.25 mm to 0.5 mm, with spawning also documented in coarse sand and fine pebble sediments 1.0 mm to 7.0 mm in diameter. Surf smelt prefer a sand and pea gravel combination, 1.0 mm to 7.0 mm. The landward boundary of the spawning area is the 'high tide mark', typically identified by a wrack (seaweed) line, and the seaward boundary is where there is a change in sediment type, becoming larger in size, or is simply at a lower elevation if there is no change in sediment type. *Note: See section 7.0, Best Practices, for images of preferable sediment types.*
2. Lay out the 30 m measuring tape through the middle of the suitable substrate for forage fish spawning habitat/activities.

2.4 Calculating Tidal Elevation

1. Using the 'Calculating Tidal Elevation' portion of your data sheet, work through the following steps.
2. Record your beach station number.
3. Using your leveling rod and clinometer/hand site level, you will determine the elevation change.
   a. One sampler holds the leveling rod at the edge of the water while the other stands at the measuring tape and looks through the clinometer at the leveling rod.
   b. When looking through the clinometer, determine where the zero value (percentage or degrees) aligns with the leveling rod – this will be your elevation change. *Note: Depending on the slope of the beach and the distance of the water from your 30 m measuring tape, you may need to take multiple measurements to determine the total elevation change; therefore, you would fill out A, B, C, and D on your datasheet, as needed.*
4. **Record the time at the waterline!** In other words, record the time when you are taking your <u>last</u> elevation change measurement, as this will be the time you use to determine height of water relative to chart datum from the tide chart.
5. In the 'Subtract Eye Height' column, record the height in which you used the clinometer (i.e., did you use the 1 m post or stand and measure from eye height). You must subtract the height at which you recorded from <u>for every</u> elevation change measurement that you took.

6. Subtract the eye height from the elevation change and record in the 'Elevation Difference' column. Each calculated difference should be recorded and totaled at the bottom of the column.
7. Record the elevation of the tide under the 'Tide Level (Tide Table)' column at the time the last elevation change was recorded. *Note: Use Environment Canada's tide charts for the area nearest your sample site (www.tides.gc.ca).*
8. Finally, calculate and record the 'Elevation Relative to Chart Datum' value by adding the 'Tide Level (Tide Table)' and the total 'Elevation Difference' values. This calculation determines where the 30 m measuring tape is in elevation relative to Chart Datum.
9. If the tidal elevation is 2 m to 3 m above the Mean Low Low Water (check your CHS map) for the region, then you are within the 'ideal sampling zone' for Pacific sand lance and surf smelt spawning. If not, adjust your 30 m measuring tape as is required, ensuring that you move it based on vertical elevation and not a horizontal distance. ***Note: The 2 m to 3 m above Mean Low Low Water is not the principal determinant of a sample site. If the sediment appears favourable outside of the 'ideal sampling zone', feel free to sample just make note of the elevation and surrounding characteristics under the "Comments" section on your data sheet.***

2.5 Filling out the Forage Fish Spawning Beach Survey Datasheet

2.5.1 Samplers
1. Record the sampler's name(s) and affiliated organization, if applicable.
2. Record the date and time of the sample collection, as well as the identification number/name of the camera that you are using to take photos.

2.5.2 Location & High Tide Events
3. Record the beach name (or 2-3 letter code), beach station number, and beach ID value (if available) of your sample station.
4. Use the corresponding tide tables to identify the "Last High Tide," referring to the most recent high tide event, and "Second Effective High Tide," which refers to a high tide that occurred the previous day that reached an elevation greater than or equal to the last high tide. Record the date, time, and elevation of each respective event, if applicable.
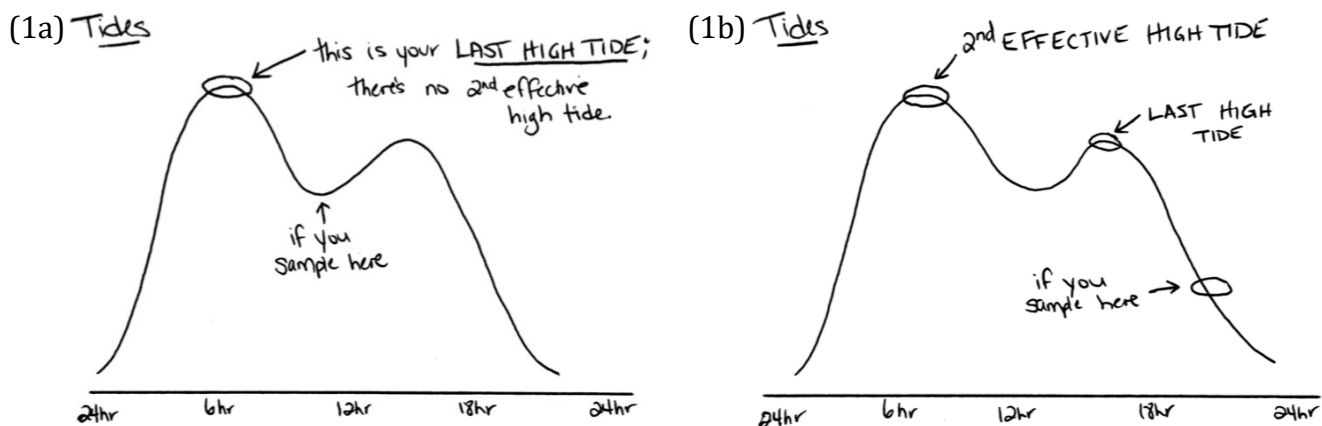

Figure 1. Explanation of tides that occurred prior to the time of sampling: (1a) last high tide, and (1b) second effective high tide (MABRRI, 2018).

2.5.3 Current Conditions
5. Record the current weather conditions including the clouds, wind, and wave conditions.
6. Use the closest weather station to your location to record the air temperature, wind direction, and wind speed. Remember that winds are named after the direction they are coming from. *Note: Weather Underground (wunderground.com) is a useful website/app to use. Additionally, any locally accurate weather stations for your area can be used to record the current conditions.*

7. Using the thermometer, record the temperature of the water at the deepest depth you can reach safely.

2.5.4 Episodic Events

8. Prior to or after the sample collection, determine if there has been a storm event in the last week. *Note: Weather Underground (wunderground.com) is a useful website/app to use. Additionally, any locally accurate weather stations or buoys for your area can be used to record the conditions experienced in the last week.*

9. If there has been a storm event, record the duration of the event, including the dates and times at which it occurred, as well as the maximum wind speed and total precipitation that resulted from the event. *Note: Storm events can quickly alter a beach and may impact the dispersal of spawning events.*

10. Identify if there is evidence of beach wrack harvesting occurring at the sample site (i.e., all-terrain vehicle tracks on the beach, beach wrack found on the road parallel to the beach, etc.). *Note: This is only relevant when it is large-scale removal, meaning large vehicles are being brought onto the beach, which could disturb the eggs in the sediment if work was being conducted at the same time the forage fish were spawning.*

2.5.5 Site Attributes

11. Beach slope is determined using a clinometer. Ensure you are recording the actual value of the slope (in degrees) and the range in which it falls within.
    a. Each sampler stands 2.5 m on either side (landward and seaward) of the 30 m measuring tape to determine the slope. Record the slope of the beach (in degrees) on the data sheet. *Note: Refer to section 6.0 for how to use a clinometer.*

2.5.6 Sediment Sample Collection

12. Record your beach station number, sample number, and time at which you are sampling. *Note: Each beach station represents up to 300 m of beach. Therefore, if a beach has suitable sediment expanding greater than 300 m in length, it may be necessary to establish additional beach stations.*
    a. An individual beach station can have multiple samples if different beach elevations or sections appear to be suitable for spawning habitat. *Note: Sample areas are only 30 m x 5 m; therefore, there is a possibility that more than one sample can be taken.*

13. Record the lat/long coordinates at the 15 m mark of the 30 m measuring tape using a GPS unit.

14. Using the 'Field Observation Sampling Codes', found on the back of the datasheet or your sediment grain scale card, choose the <u>dominant</u> beach sediment type and record in the 1° (primary) beach column. If there is a 2° (secondary) beach sediment present, identify the type and record in the corresponding column. Any additional mix of sediments present in the sample area can be included as written text in the comments section at the bottom of the datasheet. The sediment type should be approximated using the sediment grain size card.

15. Using the 'Field Observation Sampling Codes', identify the character of the backshore, which refers to how impacted the area above the beach station is due to human development.

16. With the second tape measure, measure the width of the potential forage fish spawning habitat. The width typically stretches from the highest tide mark (either last high tide or second effective high tide), usually determined by a wrack line, approximately 0.5 m in vertical elevation below the foreshore features (log line, dune grass, etc.), down to the area that has a notable change in sediment. *Note: If the beach has completely uniform sediment from top to bottom, the width will extend only a few metres in vertical elevation.*

Figure 2. Identifying the 'width' of the beach that is suitable for forage fish spawning activities in the upper intertidal zone.

17. The length of the potential forage fish spawning habitat is referring to the distance along the beach that contains the suitable sediment. Use a GPS unit to mark a waypoint at either end of the potential spawning habitat and using a georeferenced map or Google Earth, measure the distance between them to get the length value. *Note: If the length of potential spawning beach is greater than 300 m it is ideal to establish a second beach station.*

18. Record the "Landmark Object" that you have chosen to measure your 30 m measuring tape from. The object must be a permanent, unmovable object at the top of the beach, along the backshore.

19. You will measure the distance between the 30 m measuring tape, at the 15 m mark, and the chosen landmark. Be sure that the measurement is perpendicular to the measuring tape. Record this measurement in the 'Landmark Distance (m)' column. *Note: Sometimes the landmark does not line up with the 15 m mark. Therefore, be sure to measure the distance of the landmark to the measuring tape perpendicularly. Record in the comment section where on the measuring tape the landmark was measured from and what end of the beach the 0 m mark is located. For example, 'the landmark was measured from the 24 m mark and the 0 m mark was at the west end of the beach.'*

20. Fill in the tidal elevation of your 30 m measuring tape that was determined at the beginning of this process if it has not changed. If you have moved the measuring tape from the original position, be sure to record the accurate elevation.

21. Using the 'Field Observation Sampling Codes', record how shaded the sample site is. *Note: This measurement considers a seasonal and daily average for the site.*

22. There are 3 sediment samples that can be collected, offering up to 5 possible records:

  a. A 'Bulk' ("B") sample is a 4 L sediment sample that is collected when no eggs are evidently present at the site. This is the most common type of sample to be collected.
  b. A 'Scoop' ("S") sample requires the collection of approximately 500 mL of sediment. This method is used when egg masses are visible on the beach. This will ensure species identification and minimal collection of eggs, reducing the overall impact.
  c. An "eDNA" ("E") sample requires a small collection using a separate methodology and prior agreement. This collection method identifies any environmental DNA of the targeted species in the collection.
  d. You may collect "Bulk" and "eDNA" ("B & E") samples in one sampling instance.
  e. You may collect "Scoop" and "eDNA" ("S & E") samples in one sampling instance.

23. The 'Smelt' and 'Sand Lance' columns require you to pick up a handful of sediment and look through it carefully to see if you are able to visualize any eggs before collection.
24. Each site requires six photos to be taken, including one of the completed sample tag, one of the sediment next to an object for size comparison (use the sediment grain card), one of the beach backshore, beach right, beach foreshore, and beach left. Ensure that you move, as necessary, to get representative photos of the foreshore and backshore. If multiple samples are collected at a single beach station only the photo of the sample tag and sediment are required for each subsequent sample. *See section* **2.6 Sample Collection** *for how to complete a sample tag.*
25. Finally, include any additional comments regarding the site(s) or objects/wildlife you observed at the site in the "Comments" section at the bottom.

2.6 Sample Collection

1. Fill out a sample tag, including the date, location (beach code), sample station, and sample number.
2. You will need a 4 L plastic container, a filled-out sample tag, and the 500 mL scoop.
3. Your sample area is 30 m by 5 m – therefore, it runs down the entire length of your 30 m measuring tape and 2.5 m on either side of it, towards the foreshore and backshore.
4. Place the sample tag into the 4 L sample container. The sample tag will follow the sample from this point forward, all the way to the lab analysis.
5. Using the scoop and container, you will collect 4 L of sediment from the sample area, identifying the most ideal sediments along the measuring tape to collect. Be sure to collect a representative sample, spreading out along the measuring tape where the sediment is being collected; collect approximately half of the sample from above the measuring tape and the other half from below. *Note: This is biased sampling. Density counts are not being determined from this sampling method, simply presence and non-detection.*

Figure 3. Sample tag.

Figure 4. Sampling requires the collection of a 4 L sediment sample: (4a) and (4b) depict a sample container that is not filled to 4 L, while (4c) and (4d) show what a full sample container should look like.

6. Rinse the scoop <u>after every sample</u> you collect to avoid cross contamination between samples.
Note: If bulk samples cannot be processed immediately, they should be stored in 0.5 °C to 7 °C, such as a fridge, for up to 7 days; this will aid in reducing the rate of decomposition and egg mortality.

2.7 Sample Processing

It is possible to complete the next steps either in the field or back at the office and/or laboratory, each requiring specific equipment:

2.7.1 Sieving in the Field

1. You will need a 5-gallon bucket with holes drilled in the bottom, three stackable sieves (4.0 mm, 2.0 mm, and 0.5 mm), a water bucket, a wash bucket, a sample jar, and sediment composition tags.
2. First, ensure that the sieves are stacked in the appropriate order from largest to smallest with the smallest being on the bottom. Then place the sieves on top of the 5-gallon bucket and pour your sample into the top sieve. Transfer the sample tag into the sample jar and ensure that this stays with the sample throughout the rest of the processing.
3. This is a two-person job – the first person will be collecting water to pour over the sample while the second person is responsible for shaking the sediment through the sieves.
4. Once the sample is fully washed through the sieves, transfer the sample from the 0.5 mm sieve into the wash bucket, this is the sample that you will process using the vortex method. *Note: The sediment left in the 4.0 mm and 2.0 mm sieves can be disposed.*
5. On a sediment composition tag, record the approximate composition of material found in each sieve. Ensure you have filled out the beach station, processing date, and processor name(s).
6. Ensure you clean the sieves using the nylon brushes, and rinse out the buckets after each sample, to avoid cross contamination between samples.

2.7.2 Sieving at the Office/Laboratory

7. Follow the same method as stated above in "Sieving in the Field," but instead of one person collecting water to pour over the sample, a hose can be used to wash the sample through while the other person shakes the sieves.
8. Ensure that you have collected the sample from the 0.5 mm sieve in a wash bucket, as well as clean the sieves and 5-gallon bucket between each of the sieving events.

2.7.3 Vortex Method[2]

9. Ensure the nylon stocking is secured around the bilge pump using an elastic.
10. Fill the 68 L tote with 3 to 4 buckets of water, the hose, or until it is half full.
11. Put the tote lid back on and feed the bilge pump through the smaller hole, ensuring that the alligator clips and the flex hose stick out and the pump is fully submerged.
12. Rest the 0.5 mm sieve over the larger hole and place the blue bowl on top of that. Make sure that the sieve and blue bowl are as level as possible – use shims to level it if necessary.

Figure 5. Research assistants processing sieving sediment samples.

Sediment Composition
Sample:
Date:
Processor:

Sediment Size	Approx. %
>4.0mm	
>2.0mm	
>0.5mm	
<0.5mm	

Figure 6. Sediment Composition tags.

(7a)

Figure 7a – Valve, Blue Bowl, Flex hose, Tote lid, 0.5mm sieve, Water, Pump, Nylon mesh, Pump plug, 18 gal. tote

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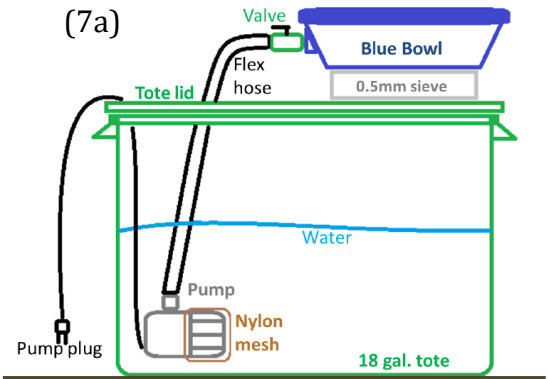
[2] Vortex method instruction discussed below is adapted from WDFW's published methods (Dionne, 2015), which can be found here: https://wdfw.wa.gov/publications/02022

13. Connect the bilge pump's hose to the blue bowl. Before you attach the battery clamps to the 12 V battery, ensure that the valve on the blue bowl is open – it should never be closed when the pump is running, it will cause the hose to burst. *Refer to section 5.0 to build a vortex kit of your own if you do not have one.*
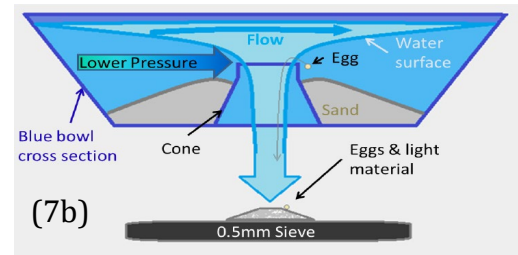

Figure 7. Vortex method explanation: (7a) vortex kit set-up and (7b) how the vortex is generated (Dionne, 2015).

14. Attach the battery clamps to the battery and allow the blue bowl to fill with water. *Note: Always connect the positive cable first, followed by the negative cable.*
15. Add the sediment sample to the blue bowl. The water should be approximately 1 to 2 cm from the top of the bowl after the sediment has been added.
16. Add the entire sample to the blue bowl, ensuring that you rinse out the wash bucket as well. *Note: If you have a large sample that will overflow the raised centre, process in multiple portions.*
17. Once the sample is in the bowl, use the spatula and small spoons to agitate the sediment starting at the centre and moving the sediment towards the outer rim, for 3 minutes – this will release the lighter materials, such as eggs and organic matter. These lighter materials will be carried by the water vortex through the raised centre and be collected in the sieve below.
18. After agitation, let the water run for once minute, allowing the vortex to collect the last material.
19. When you are ready to shut off the bilge pump, you will need to close the valve attached to the blue bowl and disconnect the battery clamp <u>simultaneously</u>. Closing the valve will ensure that sediment doesn't get sucked back into the bilge pump. *Note: Always remove the negative cable first, then the positive cable.*

20. Using the baster, collect the sediment that is directly beside the raised centre of the blue bowl. This action will ensure that any final organic materials that didn't make it over the rim will be included in the sample.

Figure 8. Depicting how to agitate the sediment in the blue bowl.

21. Wash the final sample that was collected in the 0.5 mm sieve, into a sample jar. *Note: Try to limit the amount of water entering the sample jar, you should have enough to cover the sample.*
22. Add the Stockard's solution[3]:
    a. Using a pipette, do your best to remove the top layer of water in the sample jar.
    b. In a well-ventilated area and wearing gloves and safety glasses, add enough Stockard's solution to cover the sediment sample.
    c. The sample can then be stored at room temperature until it can be analyzed.
23. Don't forget to wash your sieve with the nylon brush and wash out all your buckets. Finally, clean the nylon stocking that is covering the pump to ensure that all the sediment is washed off.

Note: If you are processing on the beach with salt water, flush your bilge pump with fresh water <u>as soon as possible</u>, as salty, marine water will take a toll on the equipment over time.

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[3] It is up to your group if you will be adding Stockard's solution to the sample; it will likely depend on the group's access to the appropriate equipment and disposal facilities. If you are not able to use Stockard's solution, it is best to have the samples looked at within seven days of processing.

3.0 LABORATORY ANALYSIS

1. Each sample should be analyzed separately, ensuring no cross contamination.
2. Using a small spoon, take a very small amount of your sample and spread it thinly in a petri dish or throughout the channel of a Bogorov tray. Creating a single layer, rather than a thick layer of sediment, along the bottom of the petri dish is the best technique and will reduce the possibility of missing eggs.
3. Examine the entire sample using the dissecting microscope.
4. Whenever you think that you have found an egg, use a pipette to transfer it gently into another petri dish.
5. Be sure to separate all the eggs that you find from the sediment for further analysis. If there are eggs present, you will document:
   [1] the species,
   [2] the number of each species,
   [3] the alive to dead ratio of each species, and
   [4] the developmental stage.
   If there are more than 100 eggs, you are only required to stage the first 100. All this data is to be documented on the data sheet.
6. After analysis, the eggs that are found will be preserved in Stockard's Solution. Be sure you are in a ventilated area and are wearing the appropriate safety gear. You will pipette the solution from the bottle into the sample vial with the eggs; you only need enough solution to cover the eggs.
7. Record sample identification information and tape it to the outside of the vial. Be sure to record:
   *[1] Date sample was **collected,***
   [2] Beach name and station where sample was collected,
   [3] Name of person who analyzed the sample,
   [4] Species and corresponding number of eggs found.

3.1 Species

There are four potential fish species that you are likely to see when sampling, including:

3.1.1 Pacific Sand Lance (Ammodytes personatus)

- Eggs are 0.8 mm to 1.0 mm in diameter
- Have multiple sand grains attached
- Not completely round
- Milky colour
- There is 1 large oil droplet in the yolk
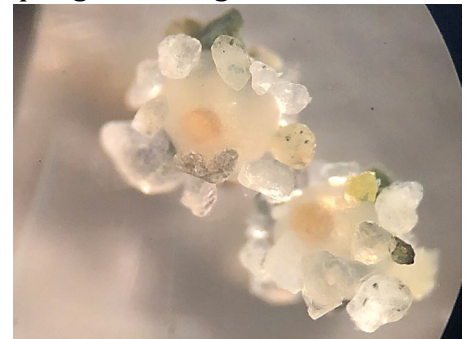
Figure 9. Pacific sand lance eggs.

3.1.2 Surf Smelt (Hypomesus pretiosus)

- Eggs are 1.0 mm to 1.2 mm in diameter
- The egg will only be attached to the sediment at a single point, where the membrane has ruptured and folded back, exposing an adhesive attachment point, called the 'peduncle'
- Non-self-adhesive – do not attach to other eggs
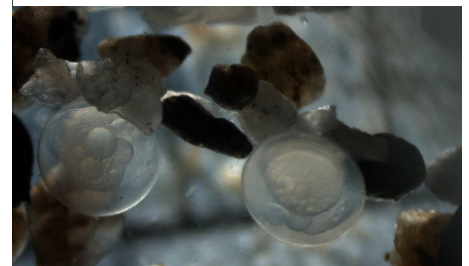
Figure 10. Surf smelt eggs (Brian Koval, Peninsula Stream Society, 2019).

3.1.3 Rock Sole (Lepidopsetta bilinear)

- Perfect sphere
- Very transparent
- Does not attach to sediment – no attachment sites
- Non-adhesive
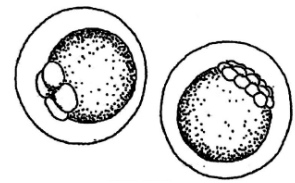
Figure 11. Rock sole eggs (Moulton & Penttila, 2006).

3.1.4 Pacific Herring (Clupea pallasii)

- Eggs are 1.3 mm to 1.5 mm in diameter
- Almost entirely spawn on marine vegetation
- They have a distinct shell attachment sites
- Often found in layers or clumps
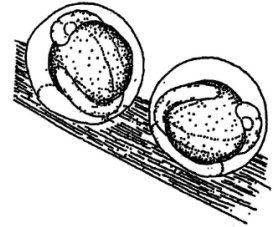
Figure 12. Pacific herring eggs (Moulton & Penttila, 2006).

3.2 Alive-to-Dead Ratio

Forage fish eggs that are <u>alive</u> will have a discernable embryo in a life stage event that can be determined by comparing it to your "Embryological-Stage Categories" sheet (refer to "Development Stages").

Forage fish eggs that are <u>dead</u> will appear opaque-white, lack a discernable embryo, be covered in fungus, collapsed, or appear empty (refer to image below).
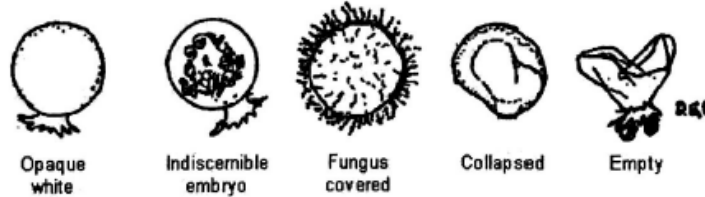
Figure 13. Depiction of forage fish eggs in dead or damaged states (Moulton & Penttila, 2006).
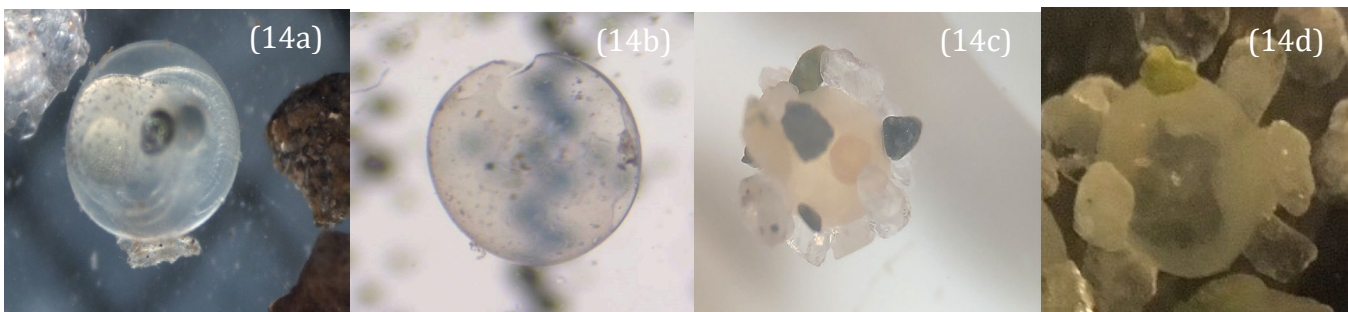
Figure 14. Eggs that are alive vs hatched/dead. Figures (14a) and (14b) show surf smelt eggs alive and hatched, respectively (Brian Koval, Peninsula Stream Society, 2019). Figures (14c) and (14d) show Pacific sand lance eggs alive and hatched, respective.

3.3 Development Stages

Developmental stage drawings have been provided for two of the four potential species, with the Pacific sand lance being very similar to the Pacific herring developmental stages.

3.3.1 Pacific Herring

As there are no composites for Pacific sand lance eggs, the Pacific herring diagrams are to be used as a guide when identifying development stages, as they have been noted to be similar to the Pacific sand lance development.
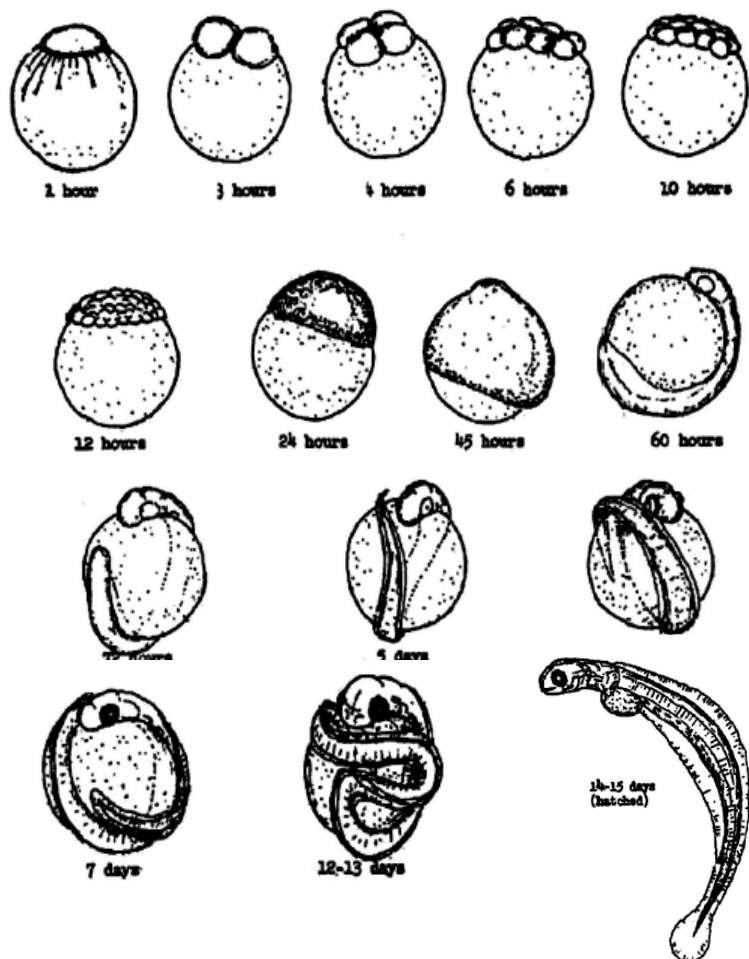
Figure 15. Pacific herring developmental stages (Moulton & Penttila, 2006).

3.3.2 Surf Smelt

Time line

1-5 Hours

"I-CELL-MORULA": very fresh eggs, 1-cell to roughly 30 cells

6-12 Hours

"BLASTULA": granular-caps through start of gastrulation

14-20 Hours

"GASTRULA": yolk=plug stage through start of neurulation

1-2 Days

"ONE-HALF COIL": distinct notochord axis to $^7/_8$ coil embryo

3-5 Days

"ONE-COIL": nose nearly to tail tip to 1-¼ coil, more or less, eyes white

6-7 Days

"ONE AND ONE-HALF COIL": more or less, preserved eyes gray

10 Days

">ONE AND ONE-HALF COIL": to 2+ coil, preserved eyes black to slightly metallic

13-14 Days

"LATE EYED": preserved eyes metallic, ventral gut spots are dashes, tight fit in shell, includes loose larvae hatched during preservation

Figure 16. Surf smelt developmental stages (Moulton & Penttila, 2006).

3.4 Egg Validation Process

Whenever eggs are detected in samples, they will need to be confirmed by an expert prior to submission of results to the database.

1. Using a dissecting microscope, take photos of the eggs that were found. *Note: Be sure that the photos are very clear, otherwise they are very difficult to confirm. It is best to take multiple photos, one with a light source from below and one with a light source from above. Having a measurement scale in the background is preferred.*
2. Photos should be uploaded to the Coastal Forage Fish Network's egg identification/validation Google™ Drive whereby cross-validation occurs from all members. *Note: If you are a host organization without access to the drive, contact the CFFN Executive Team to gain access to the Google™ Drive.*
3. Once confirmation has been received, this data can be uploaded into the Strait of Georgia Data Centre or be used in reporting.
4. Save/file a copy of the email with the datasheets to ensure that you have the confirmation on hand, if it is ever requested.

4.0 DATA MANAGEMENT

All forage fish data should be submitted to the Pacific Salmon Foundation's Strait of Georgia Data Centre, an open-access database hosted by the University of British Columbia. All data with regards to forage fish in the Salish Sea will be stored in this database, allowing for anyone interested in the data to access it. You can access the database from this link: http://sogdatacentre.ca/.

If you are unsure who to contact with regards to data submission or formatting, contact the CFFN Executive Team for data submission templates, data dictionary, and submission deadlines.

5.0 BUILDING A VORTEX METHOD UNIT
5.1 Materials Required

5.1.1 For Vortex
- ☐ 68 litre tote with lid
- ☐ Water bucket
- ☐ Blue bowl concentrator
- ☐ An adjustable hose valve
- ☐ 750 to 1000 GPH submersible electric water pump
- ☐ Alligator clips
- ☐ Nylon stockings and an elastic
- ☐ 60 cm length of ¾" corrugated hose
- ☐ ¾" male hose fitting
- ☐ 2 x ¾" hose clamps
- ☐ Quick connect hose fittings
- ☐ 0.5 mm Sieve
- ☐ Wash tub

- ☐ Shims
- ☐ Rubber spatula
- ☐ Large plastic spoon
- ☐ Small plastic spoons
- ☐ Baster
- ☐ Nylon brush
- ☐ Wash bottle (optional)
- ☐ Metal hangers (optional)
- ☐ 12 V marine battery

5.1.2 For Construction
- ☐ Box cutter
- ☐ Permanent marker
- ☐ Electrical tape

5.2 Material Preparation

5.2.1 Body of the Vortex

1. Cut two holes in the tote's lid: one smaller one in the top corner for the flex hose and battery clamps to come out of and one larger round one that the 0.5 mm sieve will sit on. You will have to customize this hole to ensure that your sieve will not fall through. *Note: It is suggested you draw the holes with a marker prior to cutting, ensuring that the holes will not be too big.*

Figure 17. Depicting how to cut the holes in to vortex kit lid (Dionne, 2015).

5.2.2 Bilge Pump Preparation

2. Connect the bilge pump to one end of the corrugated hose using one of the hose clamps.
3. Insert the ¾" male hose fitting into the other end of the corrugated hose and secure it with the second hose clamp.
4. Add one of the quick connector fittings to the male hose fitting on the corrugated hose.
5. Using pliers, attach the alligator clamps to the bilge pump cables. Be sure to connect the clamps to the appropriate cables.
6. Stretch the nylon stocking over the pump's water intake and secure in place with an elastic. The stocking ensures that if any eggs are lost in the tote, they will not pass through the pump and into the blue bowl, potentially cross contaminating samples if multiple are being processed. *Note: Be sure the nylon stocking is tight, so the stocking does not get sucked in when the pump is turned on.*

Figure 18. Bilge pump preparation: (18a) identifies the materials that will be required to prep the bilge pump and (18b) depicts how the bilge pump should look when put together.

5.2.3 Blue Bowl Concentrator Preparation

7. Add the second quick connector fitting to the blue bowl concentrator.
8. Prepare 'legs' for the blue bowl by cutting the metal hangers with wire cutters and folding the ends of the metal hangers back. *Note: The blue bowl concentrators come with 'legs', however they are typically too small and result in the blue bowl slipping off the sieve. Therefore, it is recommended to build these longer 'legs' to ensure the sample being processed does not slip off.*
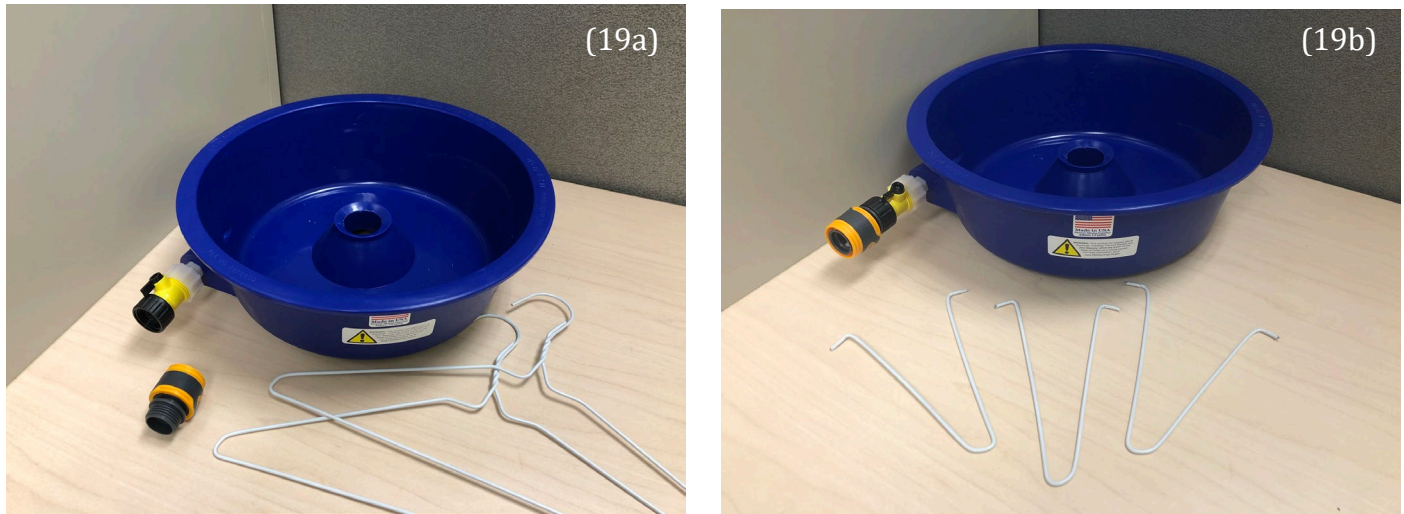
Figure 19. Blue bowl concentrator preparation: (19a) identifies the materials that will be required to prep the blue bowl and (19b) depicts how the blue bowl should look when put together.

5.3 Assembly

1. On a level surface, fill the tote half full of water, place the bilge pump in the tote, and secure the tote's lid, feeding the alligator clamps and corrugated hose through the "pump hole."
2. Set the 0.5 mm sieve over top of the "water return hole" and stack the blue bowl on top of the sieve, extending the 'legs' so it sits level.
3. Attach the corrugated hose to the blue bowl using the quick connector fittings. The final product should appear like Figure 19.
4. Follow the sediment processing details in section 2.6 'Sample Processing – Vortex Method'.
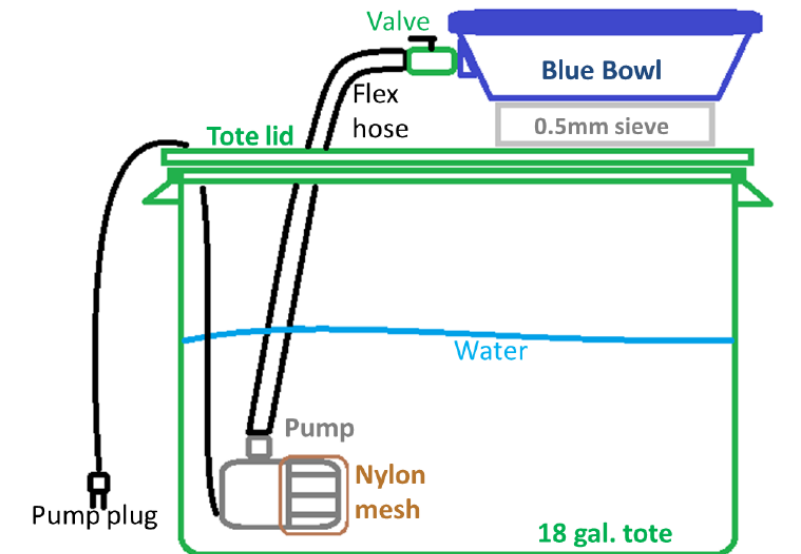
Figure 20. How to set up a vortex kit set-up (Dionne, 2015).

6.0 HOW TO USE A CLINOMETER

1. Partner up and stand at the same elevation a few metres apart and facing each other.
2. Hold the clinometer up to your dominant eye. Keep both eyes open and look through the sight lens.
3. While holding the clinometer up to your eye, line the static crosshair up with the zero. When aligned, use your other eye to note what part of your partners body the crosshair intersects (i.e., chin, nose, etc.).
4. Now have the taller partner stand 2.5 m on the foreshore side of the 30 m measuring tape; the shorter partner stand 2.5 m on the backshore side of the measuring tape.
5. Look through the clinometer at your partner and locate the same reference point (i.e., chin, nose, etc.) that was designated in step 3.
6. At this point you can either determine the slope in degrees (using the left side), or in percent (using the right side).

Figure 21. Clinometer (TrekkInn, n.d.).

7.0 BEST PRACTICES

7.1 Identifying Suitable Sediment

When selecting spawning habitat, different species of forage fish have different preferences for different sediment types. It is not uncommon that there is a lot of broken shell material mixed in with the sand and gravel. <u>Do not try</u> to avoid the shell materials as forage fish eggs can attach to the shells, as they are the same size as their favourable sediments.
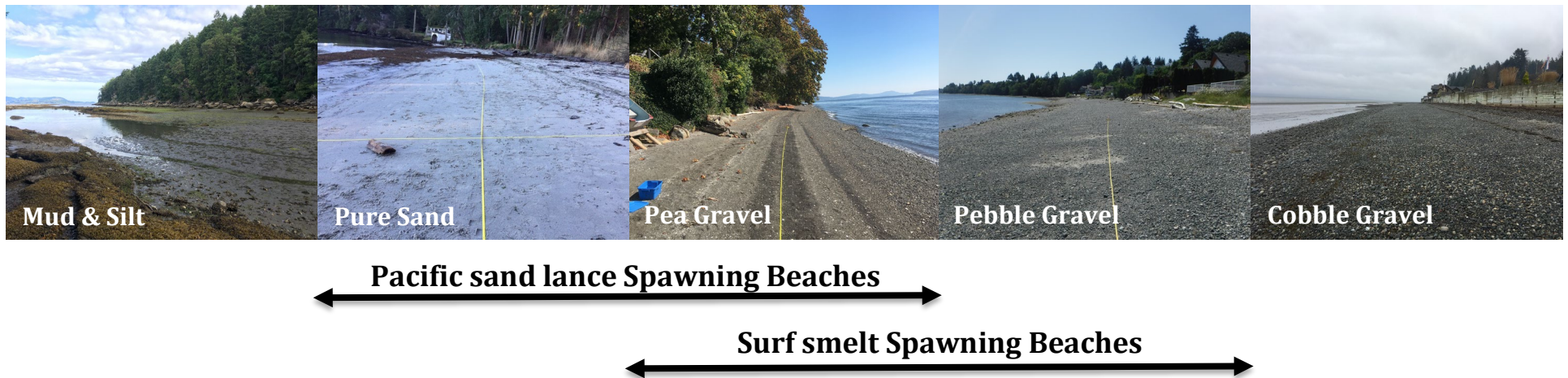
Figure 22. Identifying which beaches are preferable for Pacific sand lance and surf smelt to use for spawning.

7.1.1 Suitable Sediment: Pacific Sand Lance (PSL)

Pacific sand lance spawn from November to mid-February and prefer medium sand 0.25 mm to 0.5 mm in diameter, with spawning also documented in coarse sand and fine pebble sediments from 1.0 mm to 7.0 mm in diameter.

Figure 23. Pure sand: preferable sediment for PSL spawning (to scale).
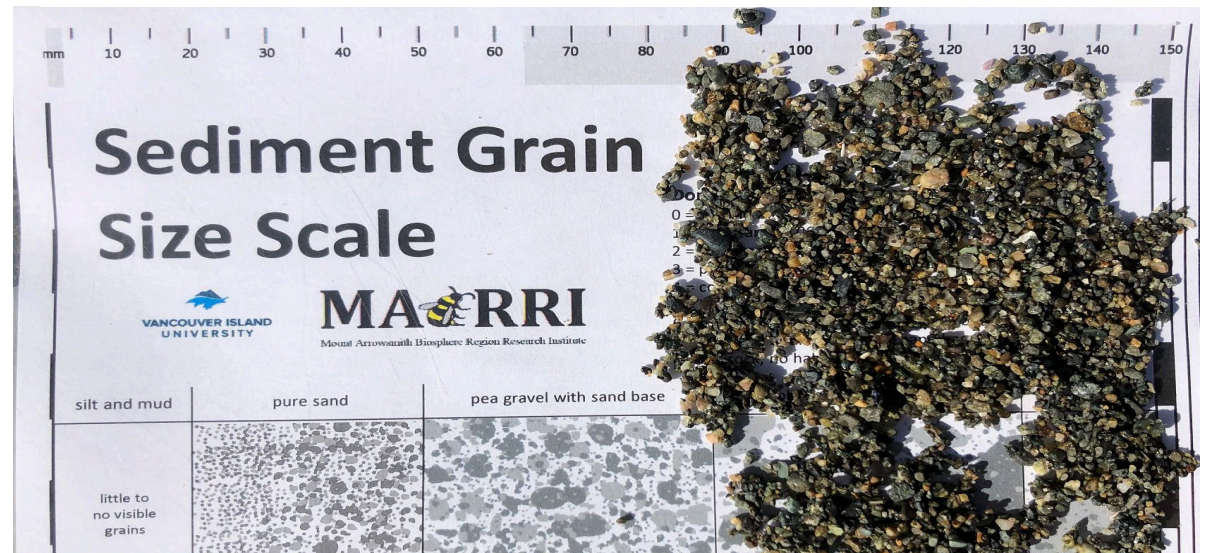
Figure 24. Pea gravel with sand base: preferable sediment for PSL spawning (to scale).

7.1.2 Suitable Sediment: Surf Smelt (SS)

Surf smelt spawn have been found to spawn year-round in coarse sand to fine pebble sediment mixes ranging from 1.0 mm to 7.0 mm in diameter.
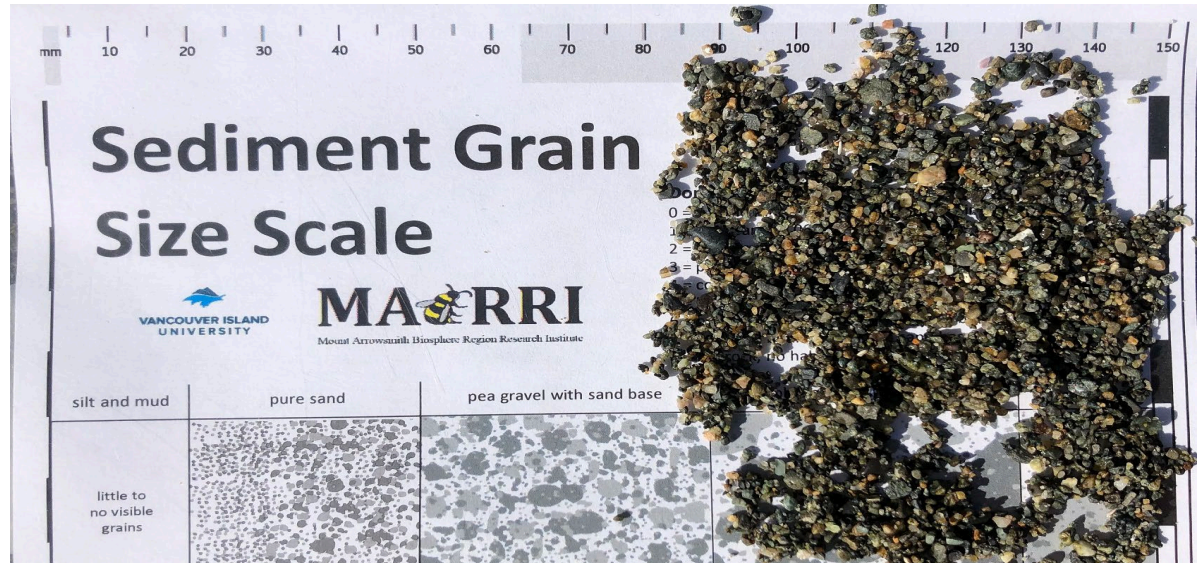
Figure 25. Pea gravel with sand base: preferable sediment for SS spawning (to scale).
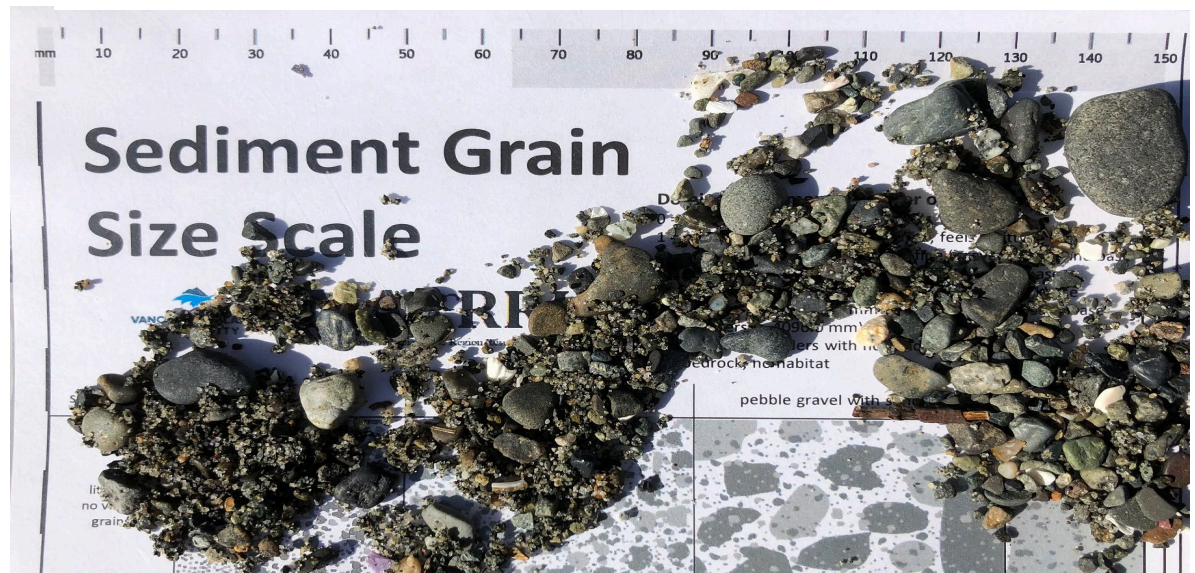
Figure 26. Pebble gravel with sand base: preferable sediment for SS spawning (to scale).

7.1.3 Unsuitable Sediments

Some of the sediments that beaches consist of are not suitable for Pacific sand lance and surf smelt to spawn on. Large cobble not ideal; although forage fish eggs can attach to this larger sediment, they are less likely to survive. Additionally, mud and silt is too fine and compact, making it difficult for respiration to occur and increasing the likelihood of egg smothering.
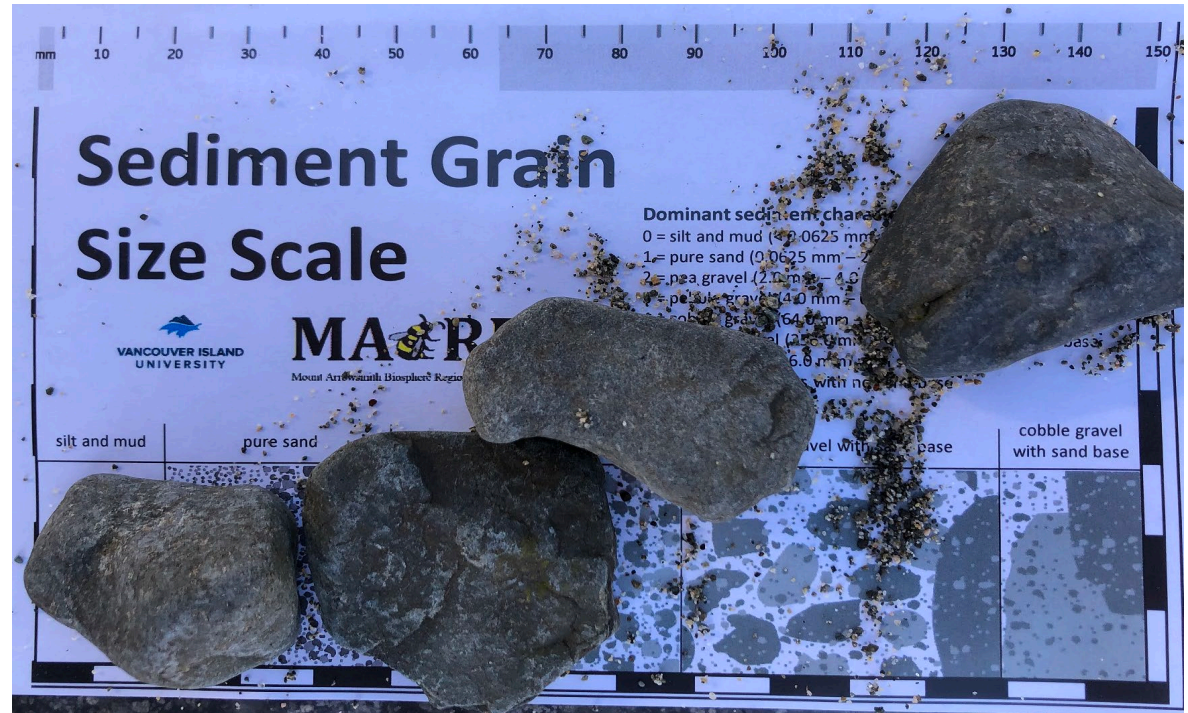
Figure 27. Cobble gravel with a sand base: unsuitable sediment for PSL and SS spawning (to scale).

7.2 Forage Fish Sampling Methods

A few things to consider when sampling:

- Select the most ideal looking sediment, sampling those sediments that are approximately 0.2 mm to 7.0 mm in diameter will provide you with the greatest potential of capturing a spawning event. This is biased sampling, but these protocols are used to determine where and when surf smelt and/or Pacific sand lance are spawning in British Columbia. Therefore, the data collected will indicate spawning presence or non-detection.
- When investigating a beach's sediment composition, be sure to move some of the top layer of larger sediment or seaweed out of the way to determine if:
    - o the ideal sediment identified on the surface is a few centimeters thick and not just a small layer situated overtop of larger cobble sediments; or,
    - o the not ideal sediment (i.e., larger cobble) identified does not have a layer of ideal sediment below it before moving on to the next beach. *Note: When sampling you can move the top layer of sediment and scoop the ideal sediment below. This can be done because when spawning occurs, the wave action moves the eggs around, allowing them to settle down under the larger sediment.*
- When collecting the sediment, do your best to get a representative sample of the entire sample area (30 m by 5 m). A simple way to do this is to mark the 15 m mark along the 30 m measuring tape and envision that your area is divided into 4 equal quadrats, each 15 m by 2.5 m (see below). By doing this you can collect approximately 25% of your sample from each section.
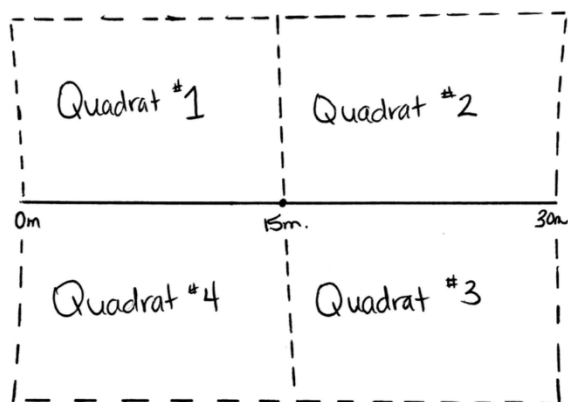
(28a)   (28b)

Figure 28. An example of how to visualize the sampling area to collect the representative sample: (28a) breaking the 30 m by 5 m into quadrats, and (28b) the quadrats drawn out on a beach.

Note: If a portion of your sample area has non-ideal sediment (bedrock, large cobble, mud, or silt), do your best to get an equal amount of sediment from each of the ideal sections.

7.3 Sample Processing

A few things to consider when processing your sample(s):

- When transferring the sample from the sieve to the wash tub in the field, pour the water through the back of the sieve and slowly rotate the sieve to ensure the entire sample has been transferred.

Note: When using a hose, it is still easiest to spray the sieve from the backside to transfer the entirety of the sample into the wash tub.

- When sieving in the field, you can use a water pitcher instead of a large water bucket to reduce physical ailments, as well as have better control of the water flow.
- If you still retain a very large sample after you have processed your sample through the sieves, it is best to <u>process the sample in multiple 'batches'</u> through the vortex kit; this will enable the greatest amount of the preferential sediments to be collected.
- When you have completed both processing steps, sieves and the vortex kit, and you are transferring your sample into a jar, it is best to first scoop the bulk of the sediment into the jar with a small spoon (rather than using water to coerce your sample into the jar). If you use water from the start, there is the potential that your jar will overflow, which may result in losing some of your sample.
- Be sure to clean all your gear between samples (i.e., sieves, blue bowl, buckets, baster, spoons, etc.) to prevent cross contamination.
- If you use salt water to process your sample, be sure to rinse all of your gear with fresh water as soon as possible, including flushing the bilge pump.

7.4 Laboratory Analysis

A few things to consider when analyzing your sample(s):

- Drawing grid lines or a set of circles on the bottom of the petri dish can aid in distinguishing where in the petri-dish you have already looked. A Bogorov tray with 1.0 mm etchings throughout the channel can greatly improve analysis.
- When putting sediment into the petri dish or Bogorov tray to analyze, be sure to only put in a very small amount to make a single layer of sediment. If sediments are stacked on top of one another, processing them takes longer and it is less likely that you will see the eggs mixed in amongst the sediment.
- Look for movement in the petri dish or Bogorov when moving it around. The eggs sway in the water when the dish is moved around, whereas the sediment will remain steady.
- When you think you have found an egg, use the forceps to gently squeeze it – this will ensure that it is not a rock or a piece of plastic.
- If the sample is not in preservative, be sure to keep it in a cool place (i.e., fridge) and analyze your samples <u>within seven days</u>.
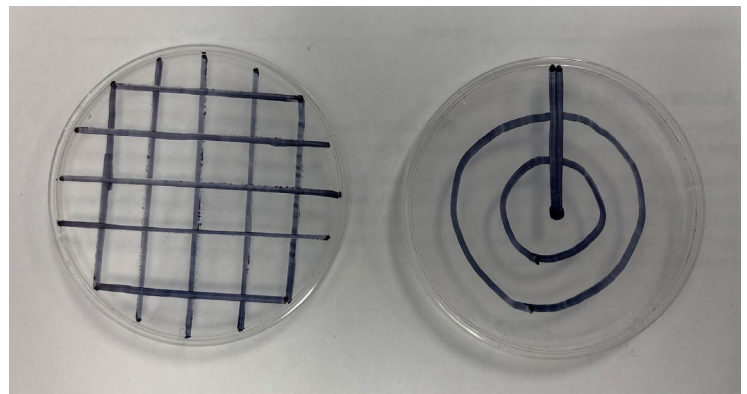
Figure 29. Petri dishes with grid lines and circles to aid in analysis process.

Figure 30. Bogorov tray with 1.0 mm grid etched in channel.

7.5 How to Safely Use Stockard's Solution

Although Stockard's solution is more potent than ethanol, there are some benefits to using it. It is recommended that Stockard's solution be used because ethanol can bleach and desiccate the eggs, making species identification difficult. Additionally, when the eggs are preserved in Stockard's solution than can be stored for years and can be used for educational purposes.

Therefore, there are a few things to consider when using it:
- Ensure to have the MSDS sheet on hand,
- Recommended to have WHMIS training,
- Be sure to be in a well-ventilated space (i.e., outside, fume hood) and wearing gloves and safety glasses when using the solution,
- Use a pipette to transfer the Stockard's solution into the jar or vial in a controlled fashion,
- When filling the sediment or eggs, only add enough solution to fully cover them, and
- Ensure disposal of Stockard's solution in the appropriate location according to the MSDS sheet

8.0 REFERENCES

A variety of documents and resources were used to produce this manual, including:

Dionne, P. (2020). Personal communication.

Dionne, P. (2015). Vortex method for separation of forage fish eggs from beach sediment. Washington Department of Fish and Wildlife, 1-14.

Fisheries and Oceans Canada (DFO). (2002). Surf smelt: Stock status report B6-09(2002). Retrieved from https://waves-vagues.dfo-mpo.gc.ca/Library/345799.pdf

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Meisel Rock Products. (2015). Sand and gravel uses. Retrieved from http://www.meiselrockproducts.com/sand-and-gravel-uses/

Moulton, L.L. & Penttila, D.E. (2006). San Juan County forage fish assessment project: Field manual for sampling forage fish spawn in intertidal shore regions. Retrieved from the Washington Department of Fish & Wildlife.

Robards, M.D., Piatt, J.F., & Rose, G.A. (1999). Maturation, fecundity, and intertidal spawning of Pacific sand lance in the northern Gulf of Alaska. *Journal of Fish Biology, 54,* 1050-1068.

Robinson, C. (2020). Personal communication.

Swanpark. (2019). White pea gravel. Retrieved from http://swanpark.site/white-pea-gravel/

Thuringer, P. (2003). Documenting Pacific sand lance (Ammodytes hexapterus) spawning habitat in Baynes Sound and the potential interactions with intertidal shellfish aquaculture. Retrieved from https://www.for.gov.bc.ca/tasb/slrp/marine/south_island/baynes/docs/sandlance/baynes_sand lance_%20draftreport.pdf

Thuringer, P. (2017). Personal communication.

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APPENDIX 1: FORAGE FISH BEACH STATION SURVEY

Forage Fish Beach Station Survey

Samplers

Name(s)	
Organization	
Date (YYYY/MM/DD)	

Location Information

Region	Municipality	DFO Mngt Area
Geographical Landmass		
GPS Coordinates		
Beach Name	Beach Station #	Beach ID

Indigenous Territories (use native-land.ca)

Beach Attributes

Beach Aspect		Fetch (km)	
Beach Bearing		Exposure	

ShoreZone Information

Habitat Suitability Model	TRUE FALSE	PhyIdent	

Site Assessment Information

Other Surveys (who, when, etc)			
Winter Assessment Date (YYYY/MM/DD)		Winter Site Suitability	Staff (ID or Name)
		TRUE FALSE	
Summer Assessment Date (YYYY/MM/DD)		Summer Site Suitability	Staff (ID or Name)
		TRUE FALSE	

Region is determined using the *Forage Fish Sampling: Location Codes* document.

Municipality is determined using the *Forage Fish Sampling: Location Codes* document.

DFO Mngt Area is determined using the *Fisheries and Oceans Canada (DFO) Management Areas* document, or their website.

Geographical Landmass refers to the general landmass your beach station is on, such as *Vancouver Island, BC Mainland, Gabriola Island, Thetis Island,* etc.

Beach Name refers to the name your beach station is situated on, may write out name or use code.

Beach Station # refers to the station you are sampling on. A single beach station is representative of approximately 300 m of coastline. If this is a new beach, your station number would be 1. If you are identifying a second station on the same beach, your station number would be 2.

Beach ID is a unique numeric value assigned to this specific beach station. Host organizations have a set of numbers assigned to use, please contact CFFN Executive Team for details if unsure.

Indigenous Territories can be found using https://native-land.ca/. List the Indigenous Territories the beach station falls within.

Beach Aspect and Bearing are calculated using a compass, taken from the midpoint (15 m) of the transect facing perpendicular to the shoreline.

Fetch is the horizontal length over which wave-generating winds can blow with little to no disruption.

Exposure refers to how vulnerable the beach is to wave action.

Effective Fetch Range (km)	Wave Exposure Category
<1	Very Protected
1-10	Protected
10-50	Semi-Protected
50-500	Semi-Exposed
500-1000	Exposed
>1000	Very Exposed

Version: October 2024

APPENDIX 2: FORAGE FISH QEP SPAWNING BEACH SURVEY DATASHEET

2.1 Front of Datasheet

Forage Fish Spawning Beach Survey

Access Database ID:

Beach Name	Beach Station #	Beach ID

Samplers

Name(s)	
Organization	
Date (YYYY/MM/DD)	
Time (24hr)	
Camera ID	

Last High Tide

Time (24hr):	
Elevation:	
Date:	

2nd Effective High Tide

Time (24hr):	
Elevation:	
Date:	

Calculating Tidal Elevation

Station #		Elevation Change	Subtract Eye Height	Elevation Difference	Time	Tide Level (Tide Table)	Elevation Relative to Chart Datum
	A						
	B						
	C						
	D						
				Total			

Current Conditions

Weather Conditions	
Air Temp (°C)	
Wind Direction	
Wind Speed (km/hr)	
Water Temp (°C)	

Episodic Events (determined prior to or after sampling)

Has there been a storm event in the last week?   Yes   No

Storm Date(s)			
Maximum Wind Speed		Precipitation from Event (mm)	
Storm Category			

Evidence of beach wrack harvesting?   Yes   No

Site Attributes

Beach Slope	Flat (<5°)	Inclined (5°-20°)	Steep (>20°)	Slope of Beach (°):

Sediment Sample Collection

Sample Station #	Sample #	Time (24hr)	Lat/Long at Transect Midpoint (decimal degree preferred)	1° Beach	2° Beach	Backshore	Width (m)	Length (m)	Landmark Object	Landmark Distance (m)	Tidal Elevation	Shading	Sample Type	Surf Smelt	Sand Lance	Photo #

Comments:

Forage Fish Sample Lab Analysis

Sample Station #	Sample #	Species	# of Eggs	Alive:Dead	Comments (species, development stage, etc)

Processed by:

Analyzed by:

Version: September 2024

2.2 Back of Datasheet

Field Observation Sampling Codes

Calculating Tidal Elevation *(Step by step)*

1. Record the beach station.
2. Use a survey rod and clinometer/hand sight level (rested on a 1m post/at eye height) to determine the elevation change from the sample transect. Several measurements may be necessary due to the water line distance.
3. Subtract your eye height/1m from each "Elevation Change" measurements.
4. Record the time at the water line. This is important.
5. Record the "Tide Level (Tide Table)" from your tide chart (acquired from www.tides.gc.ca); it is the elevation at the time closest to the time recorded.
6. "Elevation Relative to Chart Datum" is equal to the Total "Elevation Difference" plus "Tide Level (Tide Table)". If the tidal elevation is 2m to 3m above the Mean Low Low water (acquired from CHS Marine Maps), the sample transect is within the typical tidal elevation for Pacific sand lance and surf smelt spawning. There is no need to change the elevation of the transect if it is within 1m of the ideal elevation.

Episodic Events refer to storm events that may be altering the beach structure, impacting forage fish spawning behaviour or egg distribution. *Note: All wind speeds exclude gusts.* (1 knot = 1.85km/hr)

Strong Wind Warnings	20 – 33 knots
Gale Warnings	34 – 47 knots
Storm Warnings	48 – 63 knots
Hurricane Force Wind Warnings	> 64 knots

Beach Slope is determined using a clinometer to measure the slope of the sample area width (5m).

1° Beach: Dominant/primary sediment character of the beach.

0 = silt and mud (<0.0625 mm, feels "slimy")
1 = pure sand (0.0625 mm – 2.0 mm, feels "gritty")
2 = pea gravel (2.0 mm – 4.0 mm, "fine gravel") with sand base
3 = pebble gravel (4.0 mm – 64.0 mm) with sand base
4 = cobble gravel (64.0 mm – 256.0 mm) with sand base
5 = boulder gravel (256.0 mm – 4096.0 mm) with sand base
6 = boulders (>4096.0 mm) with sand base
7 = gravel to boulders without sand base
8 = bedrock, no habitat
10 = organics (shell hash, drift vegetation)

2° Beach: Secondary sediment character of the beach. Use codes from 1° Beach, above.

Backshore: Integrity of backshore (up to 30m of high-water mark)

1 = natural, 0% impacted	4 = 75% impacted
2 = 25% impacted	5 = 100% impacted
3 = 50% impacted	

Width of the potential spawning substrate band to the nearest metre. Judged by character of substrate and presence of spawn, when possible.

Length of the beach up to 300 metres (150 metres on either side of the station).

Landmark Object: Note a landmark object in the backshore area that is parallel to the sample zone transect. This will be the object from which you measure the "Sample Zone" distance from. Ensure that the object chosen is a permanent structure.

Landmark Distance: Distance of sample zone transect to the landmark, in metres to the nearest 0.5 metre. This will be used to repeat a sampling event in the exact same location.

Tidal Elevation: This value can be transferred from the "Calculating Tidal Elevation" portion of the data sheet. This value is the "Tidal Elevation (Chart Datum)".

Shading: Amount of spawning substrate zone that is shaded, averaging over the entire length of the beach station. Consider the best interpretation for the entire day and season.

1 = fully exposed	4 = 75% shaded
2 = 25% shaded	5 = 100% shaded
3 = 50% shaded	

Sample Type: S = Scoop; B = Bulk; E = eDNA;
S + E = Scoop & eDNA; B + E = Bulk & eDNA
If eggs are visible to the naked eye, it is only necessary to take a single 500mL scoop of sediment to be processed. In all other cases a bulk sample is to be collected.

Smelt & Sand Lance: Subjective field assessment of spawn intensity apparent to the naked eye.
0 = no eggs visible
L = light, but apparent
M = medium, readily visible
H = heavy, broadly abundant
W = eggs observed in winnow

Photos: Take 6 photos standing at the centre of the sample transect.
*Photo 1: Completed sample tag
*Photo 2: Sediment w/scale at transect
Photo 3: Beach backshore
Photo 4: Beach right
Photo 5: Beach foreshore (towards water)
Photo 6: Beach left
*If multiple samples are collected at a single station, only photos 1 & 2 should be repeated for each sample.

***I certify that to the best of my abilities, the surveys recorded on this data sheet and the associated samples were collected and documented to the methodology instructed to me and the information I am providing are the true and accurate results of these surveys.

Lead Signature: _____

Version: September 2024

Appendix 3:

Forage Fish Sampling: Location Codes
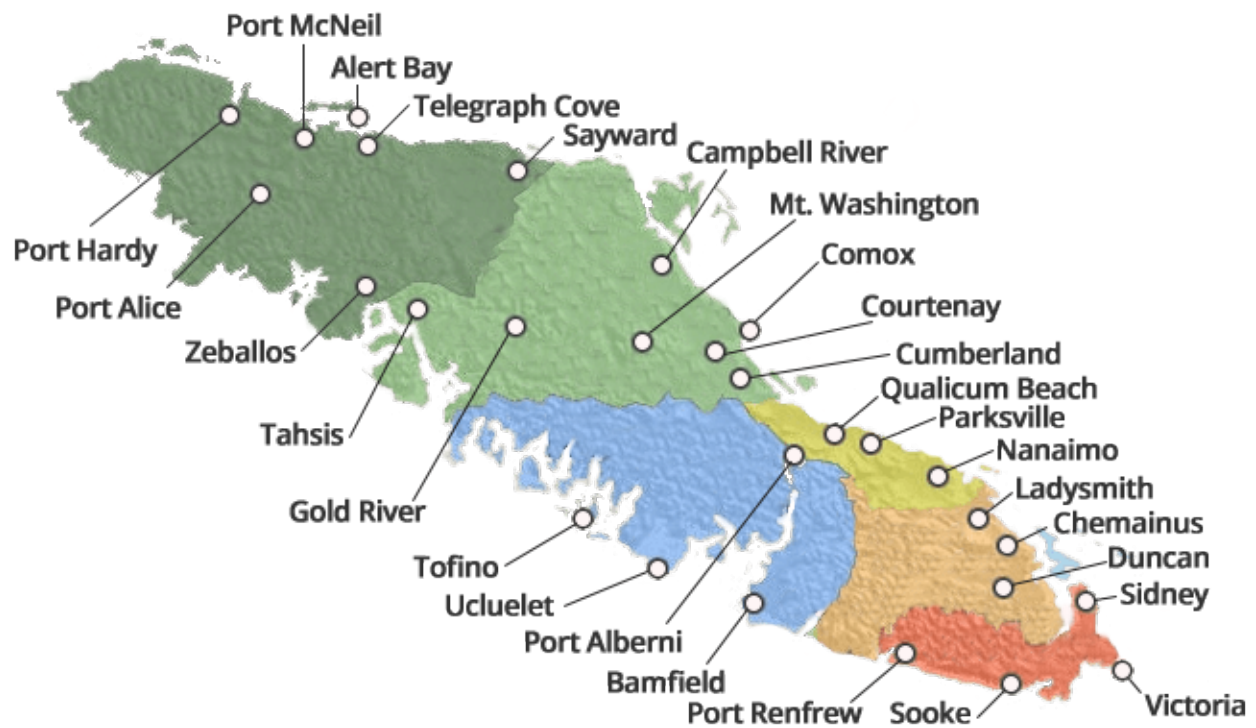
Developed by: Mount Arrowsmith Biosphere Region Research Institute (MABRRI)

May 2018
Revised: October 2024

TABLE OF CONTENTS

FIGURES

Forage Fish Sampling: Location Codes

Forage Fish Sampling: Location Codes

1.0 INTRODUCTION

'Forage fishes' is a term referring to species of small, schooling fishes that are an important food source for larger mammals, seabirds, and fish (Penttila, 2007). According to the BC Ministry of Environment, forage fish, also known as pelagic fishes, consist of numerous species, including: herring, anchovies, smelts, capelin, sardines, eulachon and sand lance (BC Ministry of Environment, 2014). These species are classified based on their ecological role in the marine ecosystem, rather than their taxonomy. Forage fish populations are declining globally, subsequently increasing adverse impacts culturally, ecologically, and economically (Mckechnie et al., 2014).

Although forage fish habitats are identified as critical fish habitat under the Canadian Fisheries Act, making them protected, BC has little data regarding the location and timing associated with these habitats (de Graaf, 2010). In response to this data gap, the Sea Watch Society developed the Forage Fish Program (FFP), which involves potential spawning site identification, as well as site surveying, mapping, and monitoring of two forage fish species within BC, surf smelt and Pacific sand lance (de Graaf, 2013). The FFP involves training volunteers and community groups along the coast of BC to identify potential spawning sites of these two species and offer monitoring of these locations (de Graaf, 2013).

In 2017, the Mount Arrowsmith Biosphere Region Research Institute (MABRRI) at Vancouver Island University was trained to use the "vortex method" by a Nearshore and Forage Fish Specialist from the Washington State Department of Fish and Wildlife. The MABRRI team monitors beaches along the coast, as well as trains citizen scientists to do the same in order to build the capacity of this project. Since 2017, other groups, including Peninsula Stream Society, have begun monitoring and training citizen science groups to further expand this initiative's capacity and range. By regularly monitoring the beaches, this initiative aims to reduce the current data gap that exists regarding forage fish spawning habitat along the Vancouver Island and Gulf Island coastlines.

MABRRI created this quick reference document, in addition to the "Fisheries and Oceans (DFO) Canada Management Areas: Vancouver Island" document, in order to aid in the standardization of data collection and data referencing. Codes for locations across the entirety of Vancouver Island and the Gulf Islands were created in order to retrieve site specific data in a timely fashion. Each site that is sampled will have a corresponding code that includes the regional district of Vancouver Island, the municipality and/or electoral area, and the beach (Figure 1). This document includes the codes that were assigned to each regional district, municipality, and electoral area.

Region	Municipality	DFO Mngt Area

Figure 1. Location data as seen on beach station survey datasheet (Appendix 1).

2.0 REGIONAL DISTRICT OF MOUNT WADDINGTON (RDMW)

2.1 Municipalities

PH - District of Port Hardy

Figure 3. District of Port Hardy.
Source: Google Maps Imagery (2017)
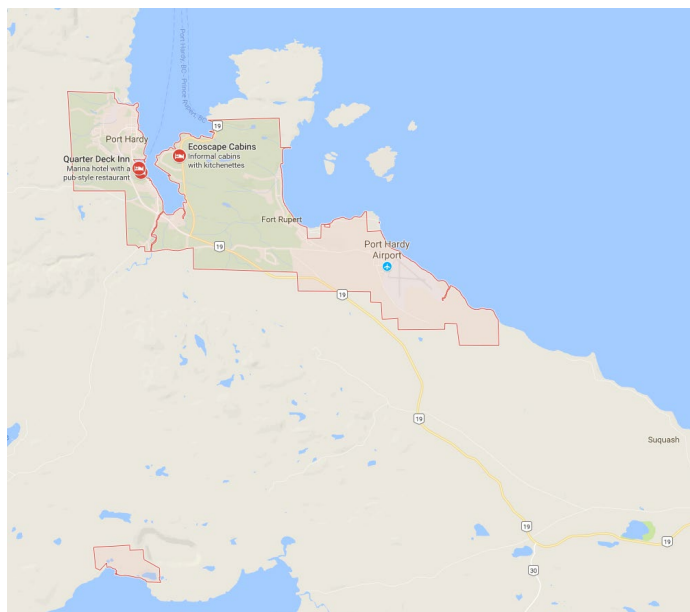
Figure 2: District of Port Hardy. Source: Google
Maps Imagery (2017)

Figure 4: District of Port Hardy.
Source: Google Maps Imagery (2017)

PM – Town of Port McNeill
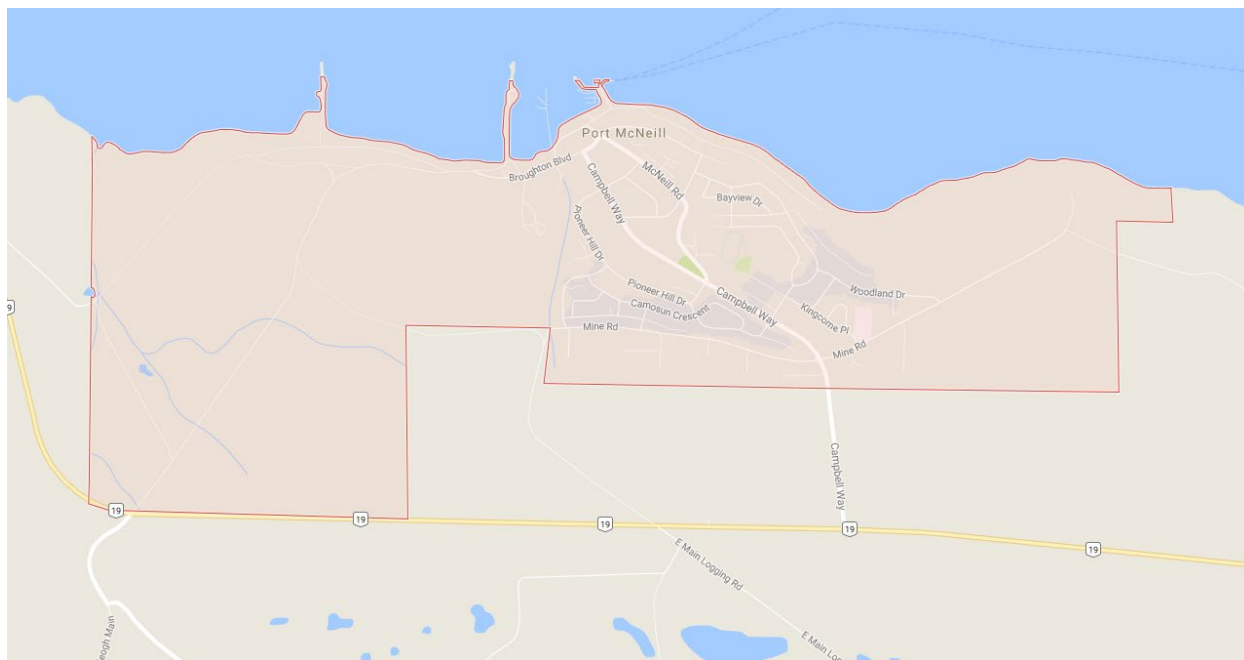
Figure 5: Town of Port McNeill. Source: Google Maps Imagery (2017)

Forage Fish Sampling: Location Codes

PO – Village of Port Alice   AB – Village of Alert Bay

Figure 6: Village of Port Alice.
Source: Google Maps Imagery (2017)
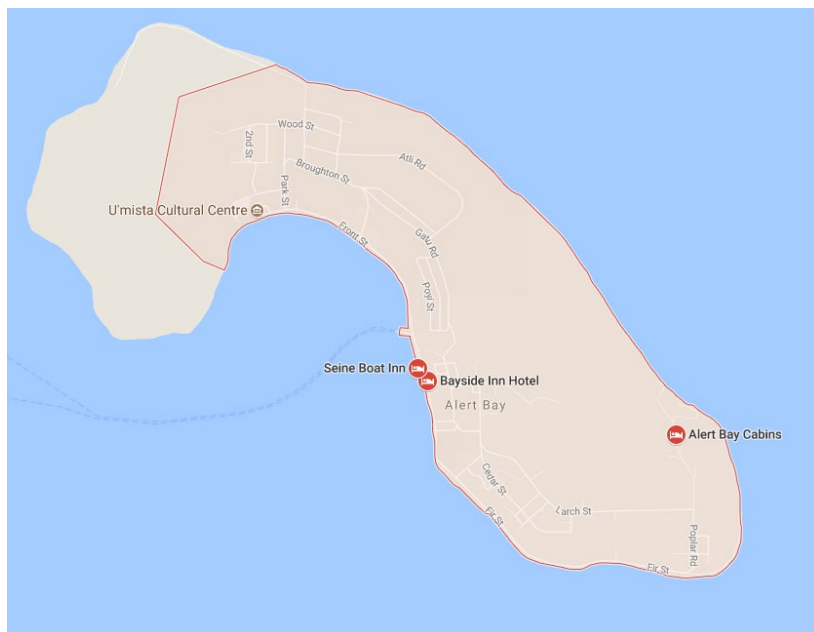
Figure 7: Village of Alert Bay.
Source: Google Maps Imagery (2017)

2.2 Electoral Areas

Figure 8: Electoral Areas of the Regional District of Mount Waddington.
Source: Regional District of Mount Waddington Website (2017)

3.0 STRATHCONA REGIONAL DISTRICT (SRD)

3.1 Municipalities

ZE – Village of Zeballos

TA – Village of Tahsis

Figure 9: Village of Zeballos.
Source: Google Maps Imagery (2017)

Figure 10: Village of Tahsis.
Source: Google Maps Imagery (2017)

GR – Village of Gold River

SA – Village of Sayward

Figure 11: Village of Gold River.
Source: Google Maps Imagery (2017)

Figure 12: Village of Sayward.
Source: Google Maps Imagery (2017)

Forage Fish Sampling: Location Codes

CR – City of Campbell River
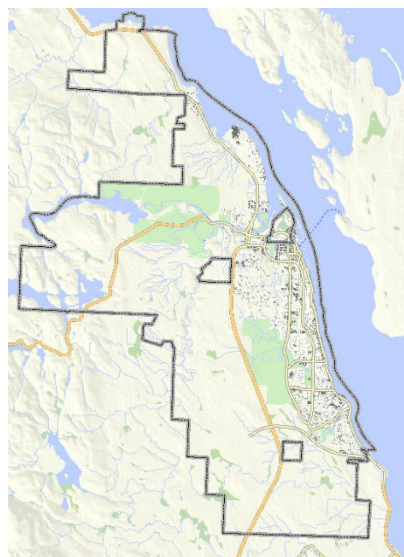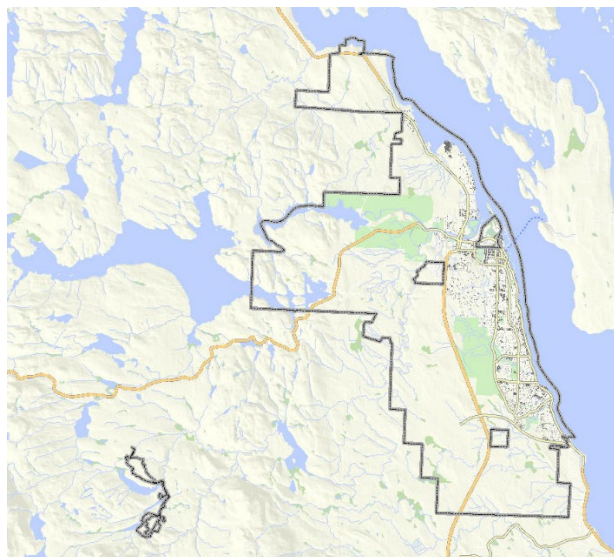
Figure 15

Figures 13 – 15: City of Campbell River.
Source: City of Campbell River Website (2017)

Figure 14

3.2 Electoral Areas
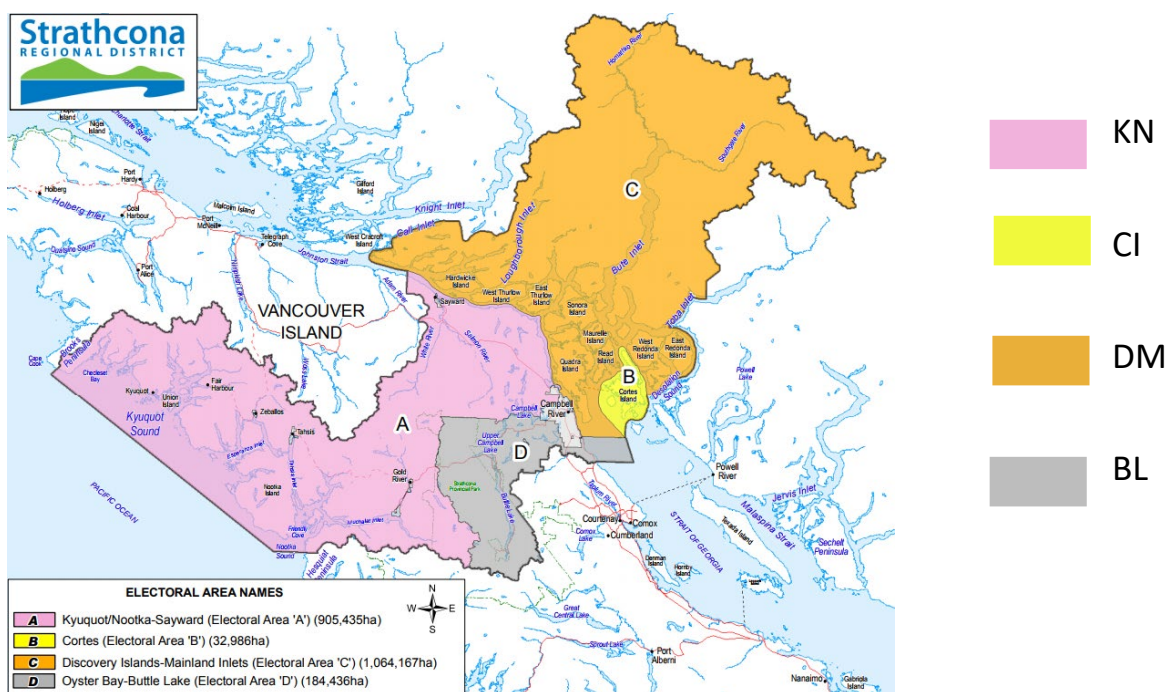
Figure 16: Electoral Areas of Strathcona Regional District. Source: Strathcona Regional District Website (2013)

4.0 COMOX VALLEY REGIONAL DISTRICT (CMVRD)

4.1 Municipalities

CU – Village of Cumberland
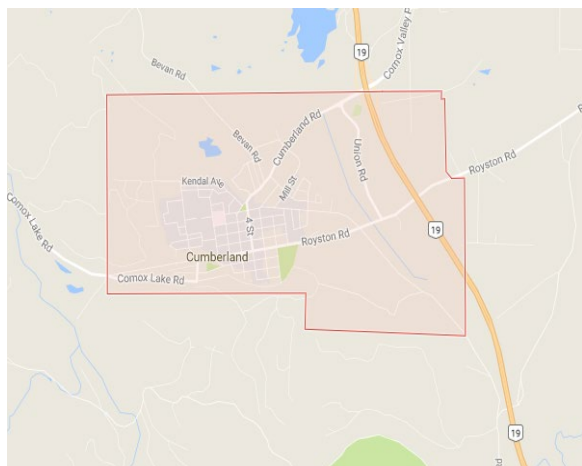
CM – Town of Comox

Figure 17: Village of Cumberland.
Source: Google Maps Imagery (2017)
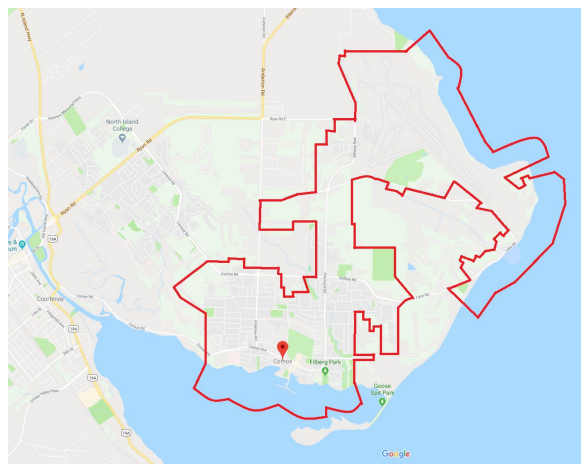
Figure 18: Town of Comox.
Source: Google Maps Imagery (2017)

CT – City of Courtenay

Figure 19: City of Courtenay.
Source: City of Courtenay Website (2015)

4.2 Electoral Areas
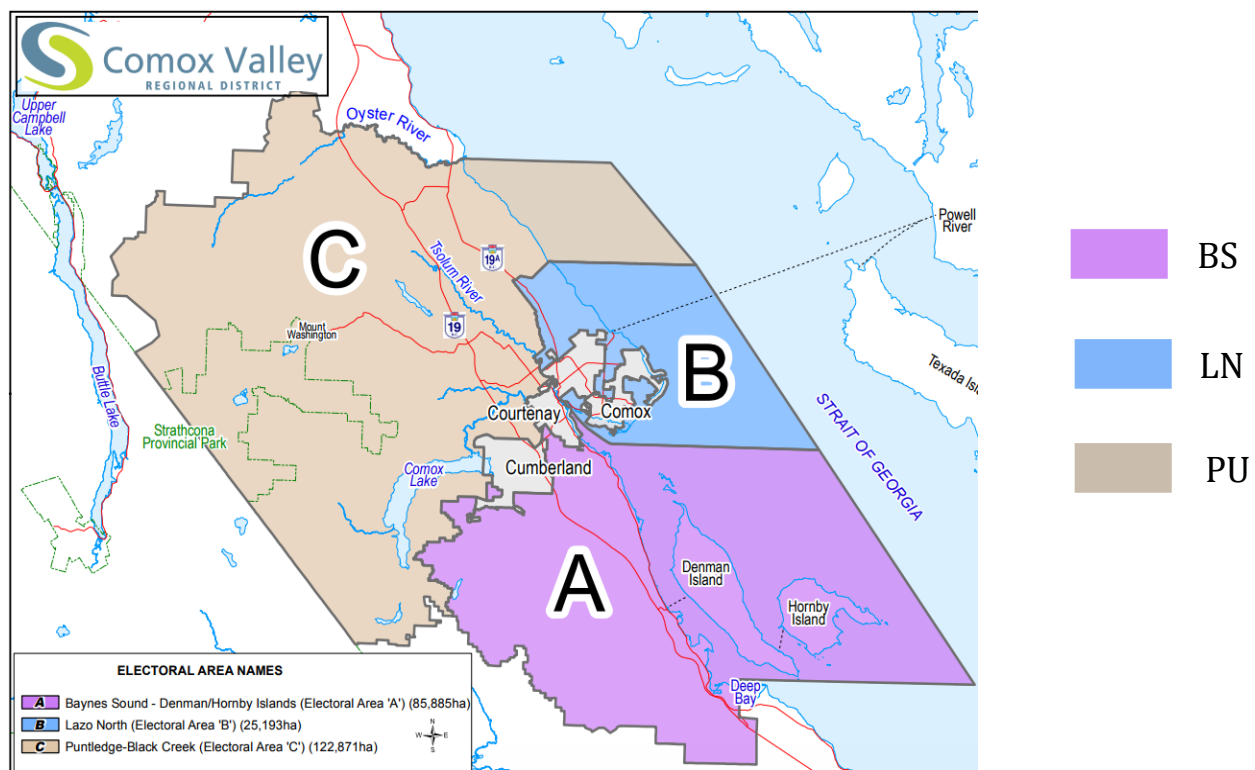
Figure 20: Electoral Areas of Comox Valley Regional District.
Source: Comox Valley Regional District Website (2017)

5.0 ALBERNI-CLAYOQUOT REGIONAL DISTRICT (ACRD)

5.1 Municipalities

TO – District of Tofino

Figure 21: District of Tofino.
Source: Google Maps Imagery (2017)

UC – District of Ucluelet
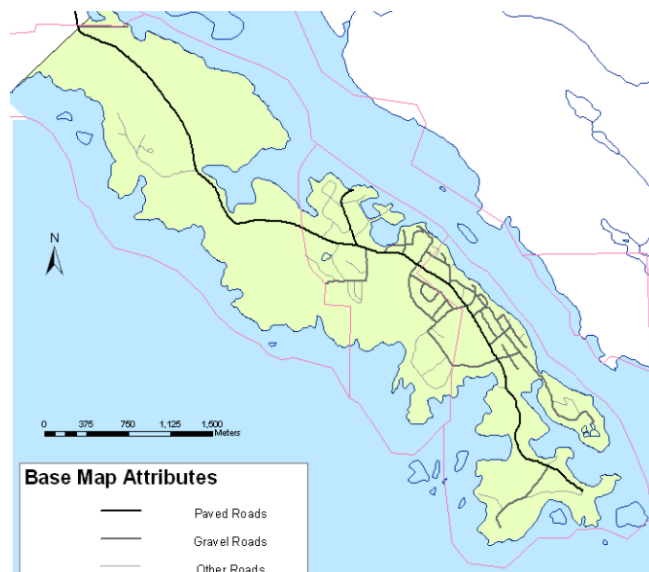
Figure 22: District of Ucluelet.
Source: University of British Columbia's Department of Geography (2005)

CP – City of Port Alberni
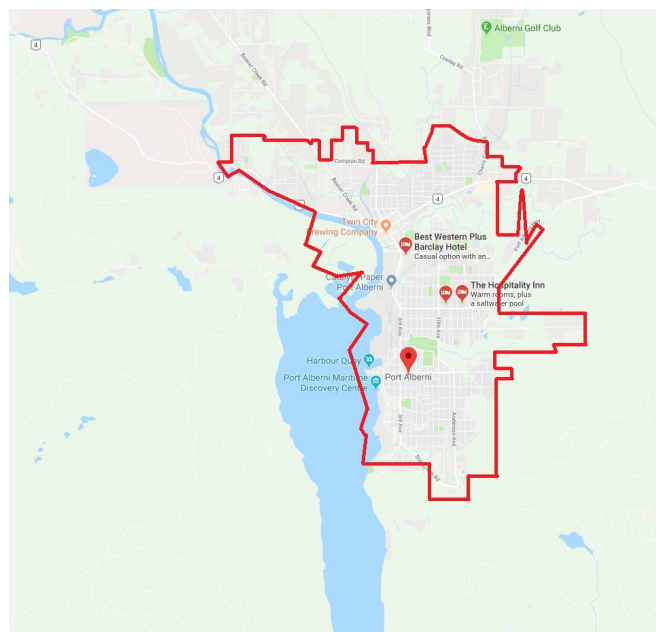
Figure 23: City of Port Alberni.
Source: Google Maps Imagery (2017)

5.2 Electoral Areas
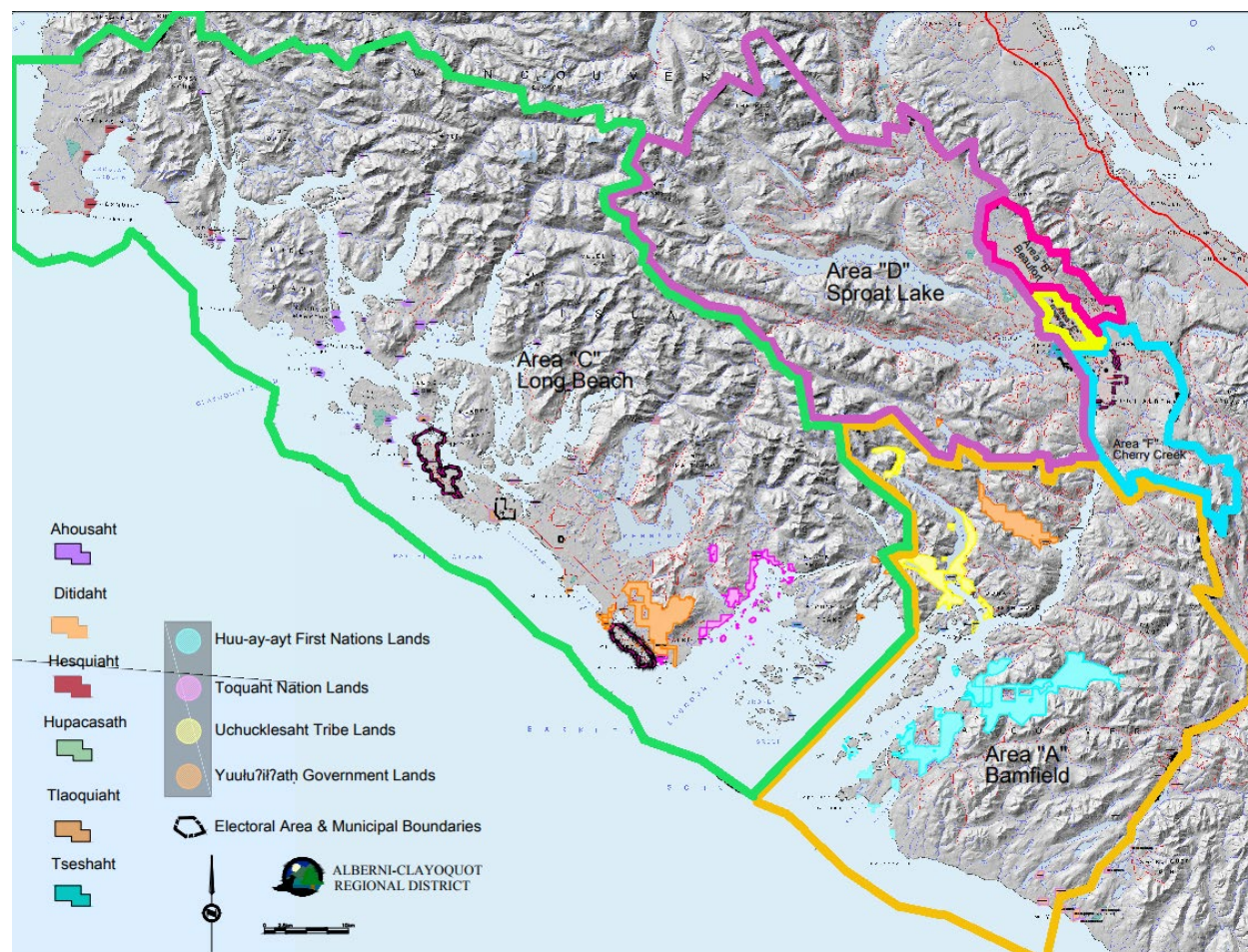
Figure 24: Electoral Areas of the Alberni-Clayoquot Regional District.
Source: Alberni-Clayoquot Regional District Website (2017)

6.0 REGIONAL DISTRICT OF NANAIMO (RDN)

6.1 Municipalities

NA – City of Nanaimo

PK – City of Parksville
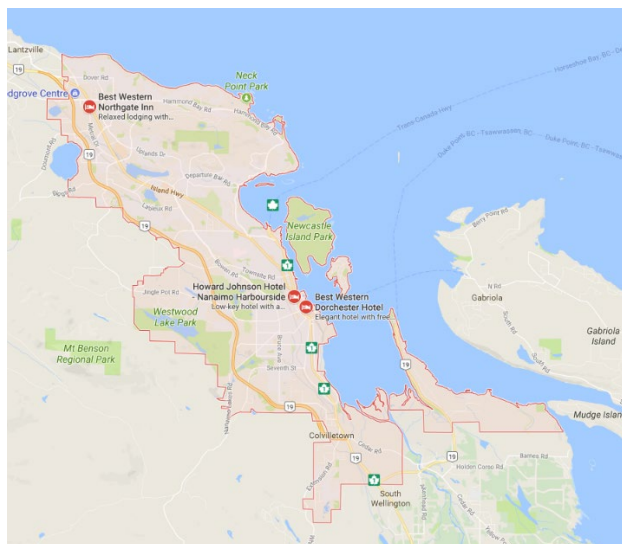
Figure 25: City of Nanaimo.
Source: Google Maps Imagery (2017)
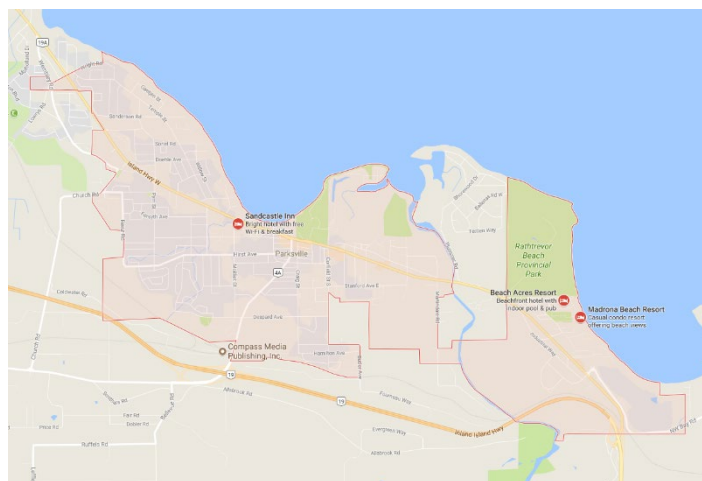
Figure 26: City of Parksville.
Source: Google Maps Imagery (2017)

QB – Town of Qualicum Beach
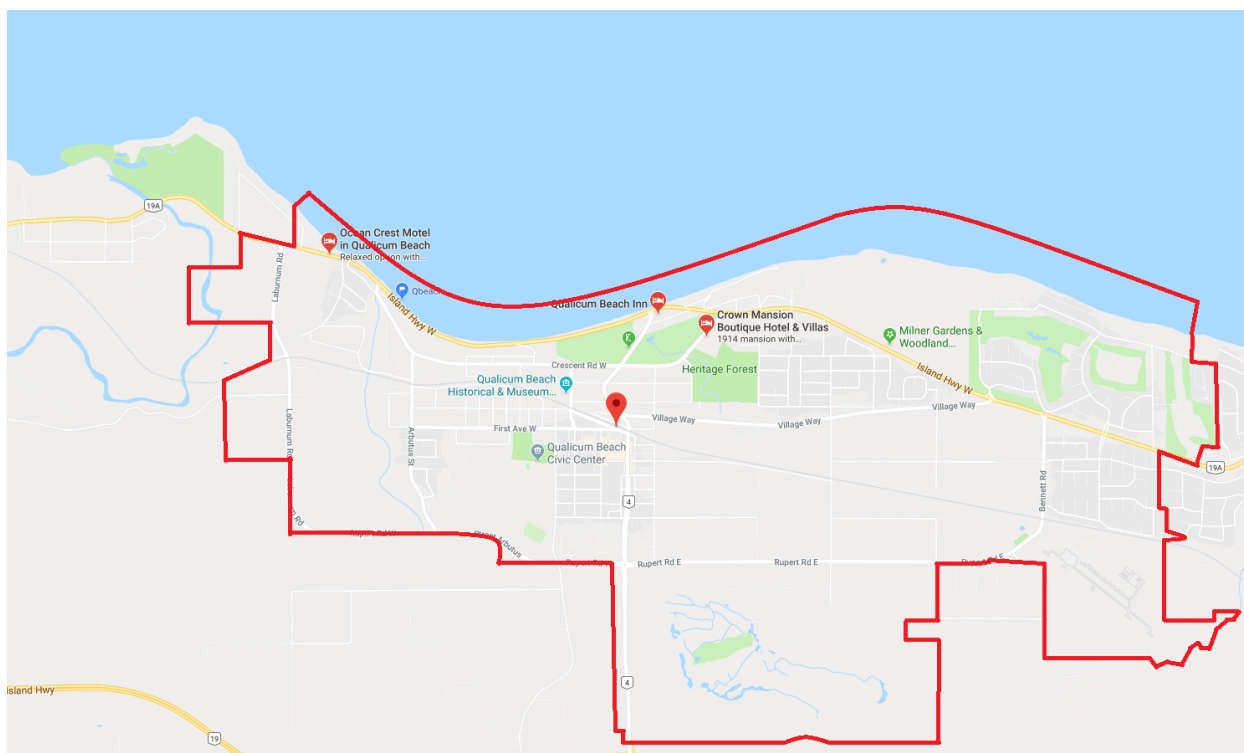
Figure 27: Town of Qualicum Beach. Source: Google Maps Imagery (2017)

Forage Fish Sampling: Location Codes

LA – District of Lantzville
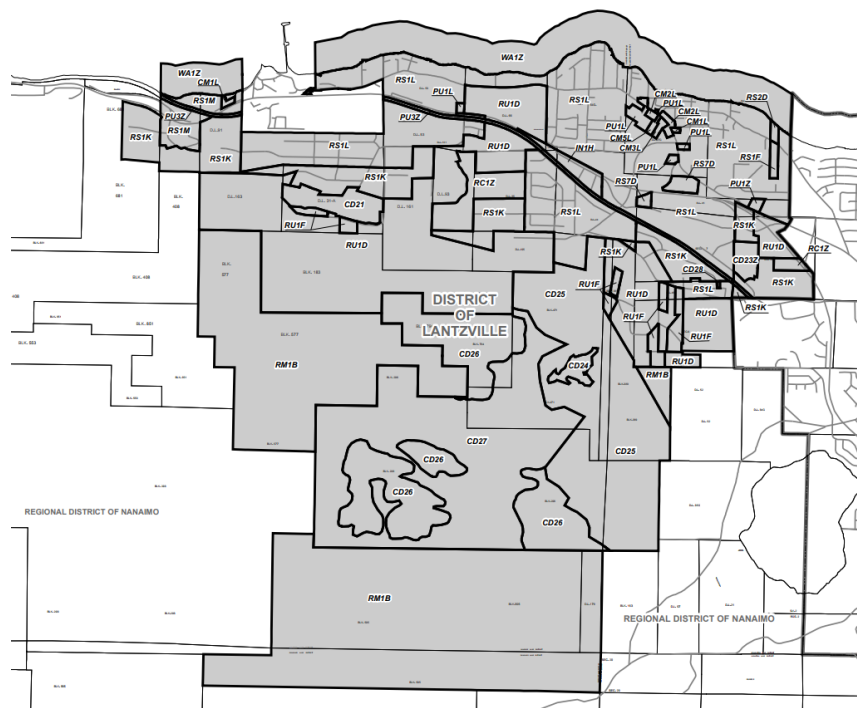
Figure 28: District of Lantzville. Source: District of Lantzville Website (2017)

6.2 Electoral Areas
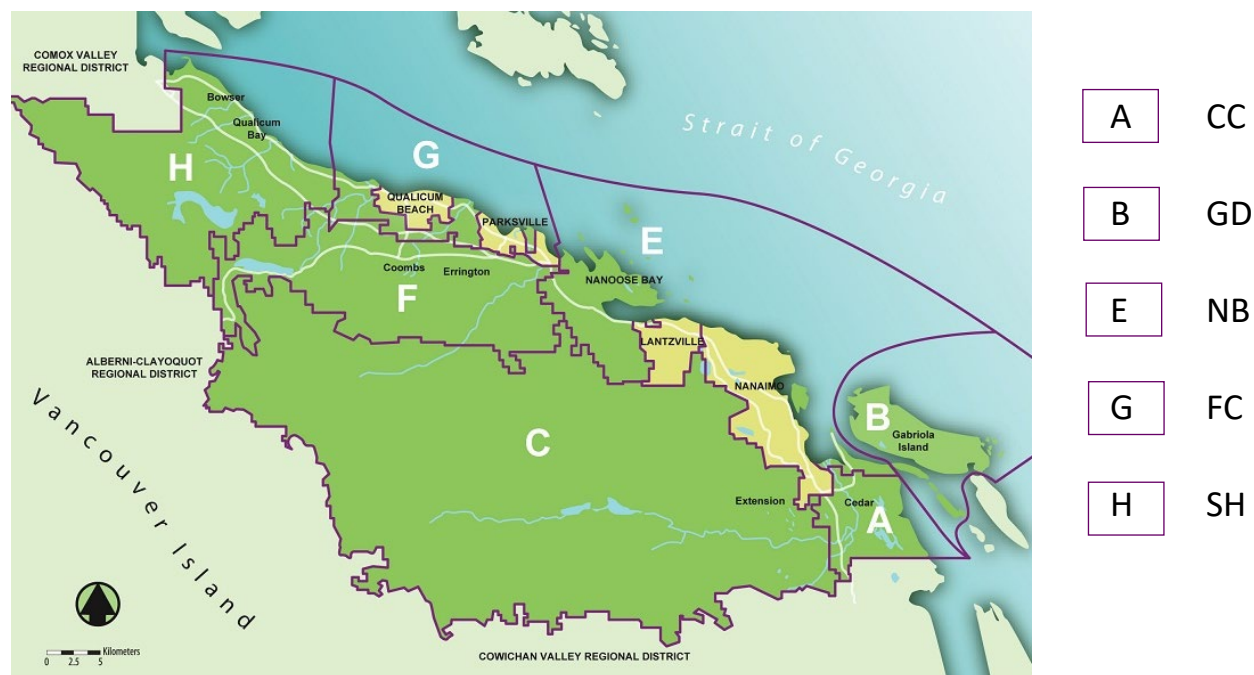
Figure 29: Electoral Areas of the Regional District of Nanaimo.
Source: Regional District of Nanaimo Website (2016)

7.0 COWICHAN VALLEY REGIONAL DISTRICT (CWVRD)

7.1 Municipalities

LS – Town of Ladysmith

NC – Municipality of North Cowichan

Figure 30: Town of Ladysmith.
Source: Google Maps Imagery (2017)
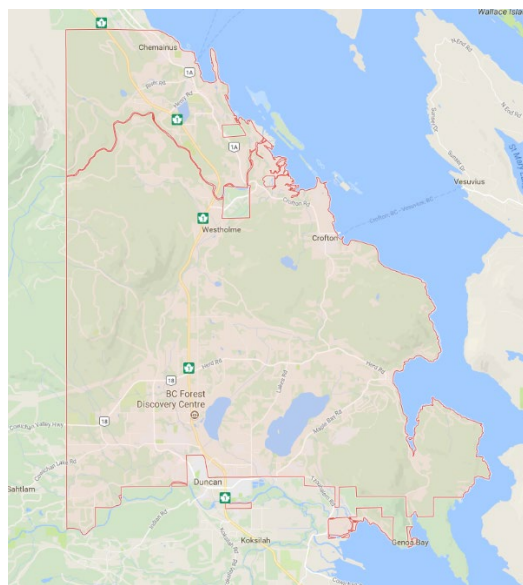
Figure 31: Municipality of North Cowichan.
Source: Google Maps Imagery (2017)

LC – Town of Lake Cowichan
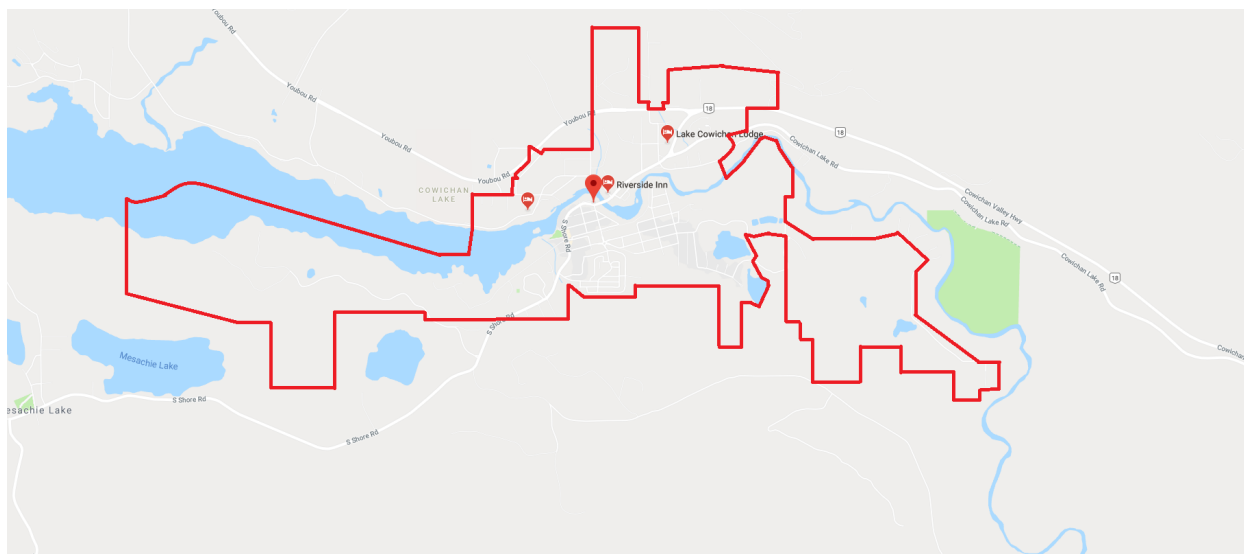
Figure 32: Town of Lake Cowichan. Source: Google Maps Imagery (2017)

Forage Fish Sampling: Location Codes

DU – City of Duncan
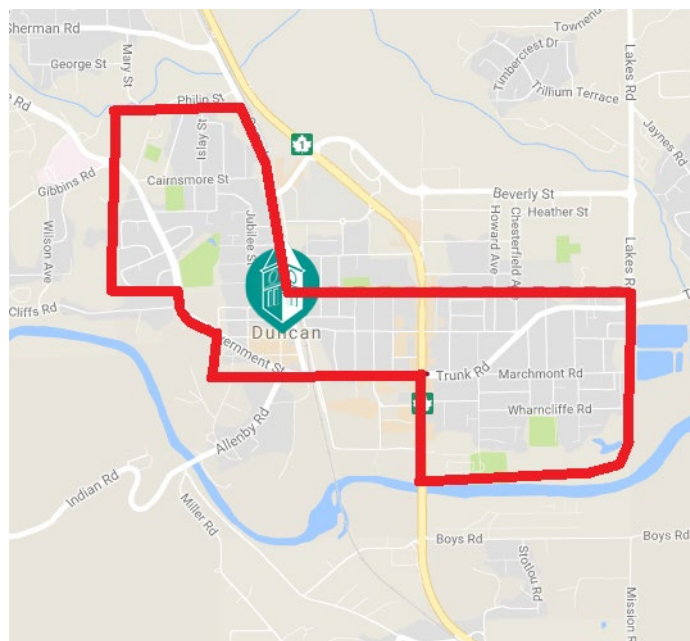
Figure 33: City of Duncan. Source: City of Duncan Website (2017)

7.2 Electoral Areas
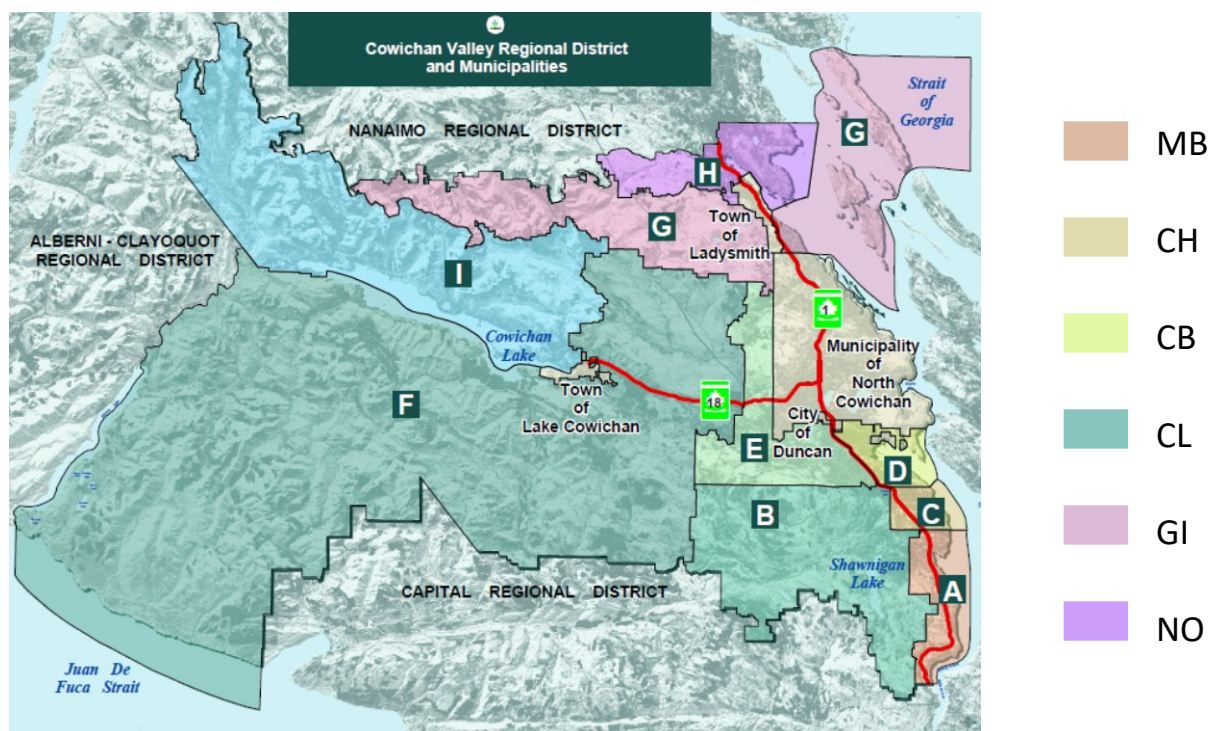
Figure 34: Electoral Areas of the Cowichan Valley Regional District. Source: One Cowichan Website (2014)

8.0 CAPITAL REGIONAL DISTRICT (CRD)

8.1 Municipalities

SI – Town of Sidney
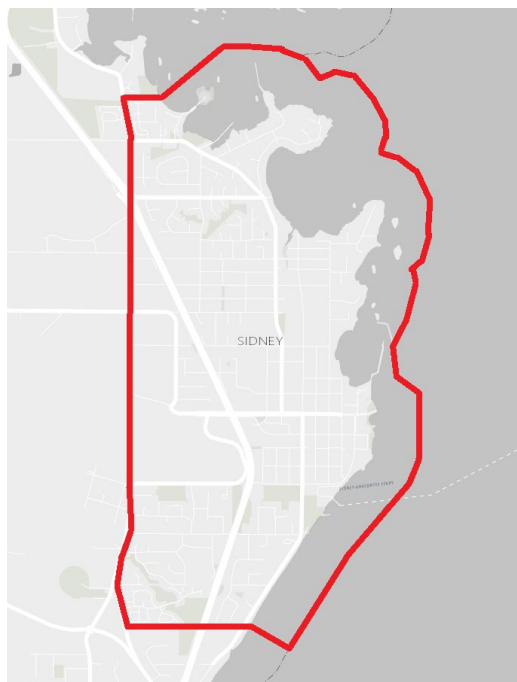
Figure 35: Town of Sidney.
Source: Capital Regional District
Website (2017)

CS – District of Central Saanich
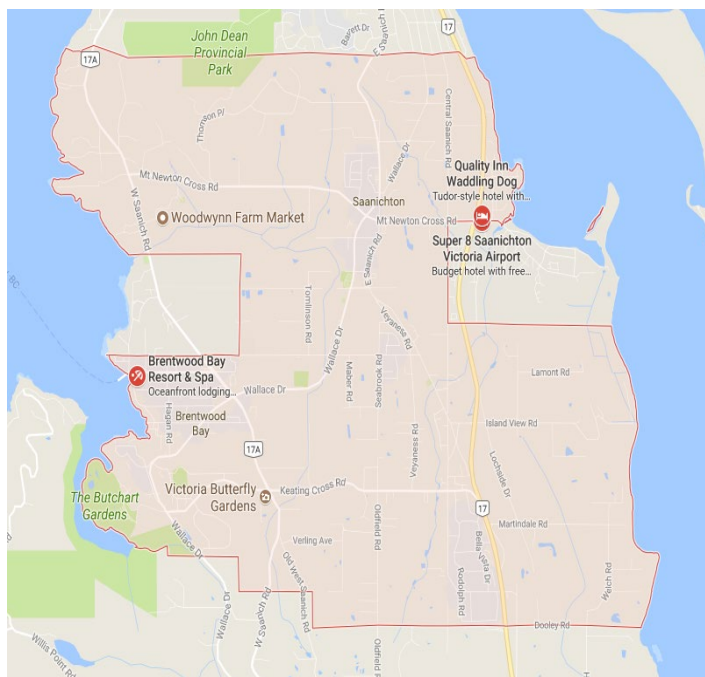
Figure 36: District of Central Saanich.
Source: Google Maps Imagery (2017)

NS – District of North Saanich
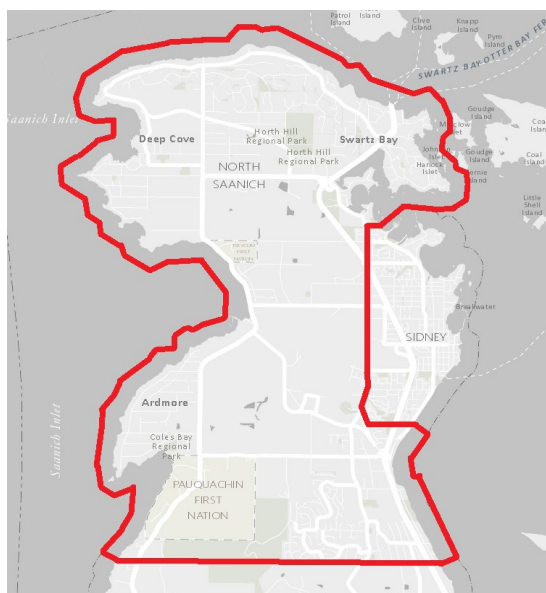
Figure 37: District of North Saanich.
Source: Capital Regional District
Website (2017)

HI – District of Highlands
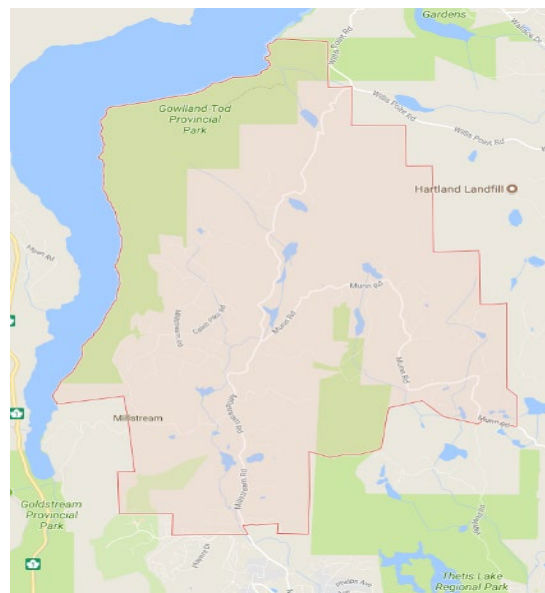
Figure 38: District of Highlands.
Source: Google Maps Imagery (2017)

Forage Fish Sampling: Location Codes

SN – District of Saanich

SO – District of Sooke
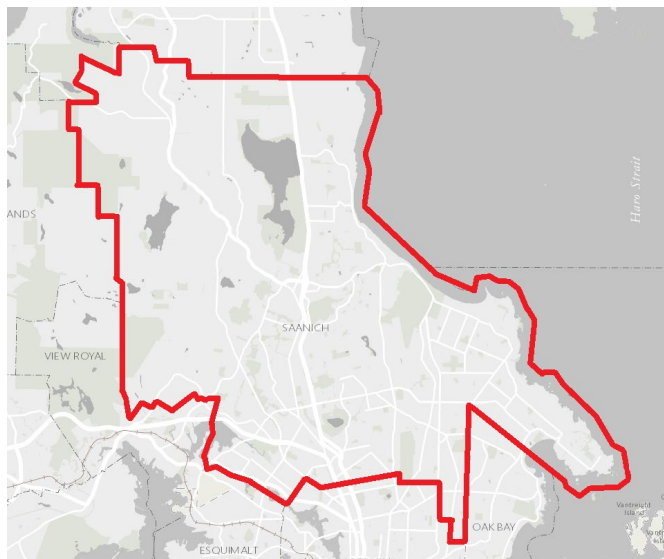
Figure 39: District of Saanich.
Source: Capital Regional District Website (2017)
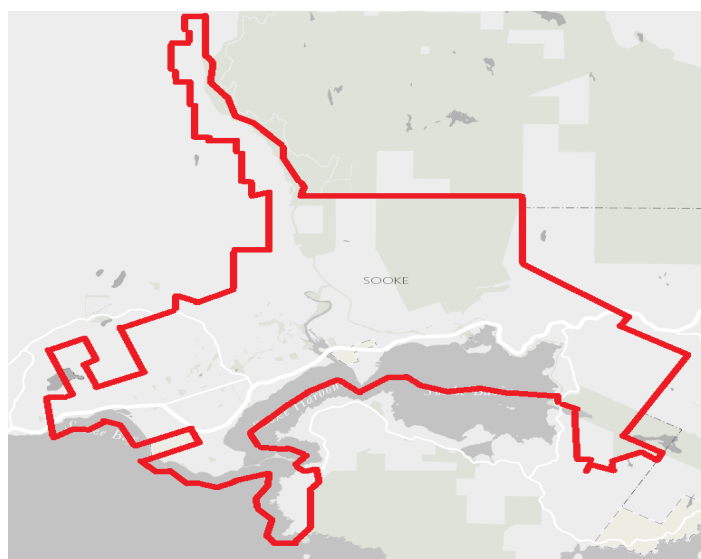
Figure 40: District of Sooke.
Source: Capital Regional District Website (2017)

ME – District of Metchosin
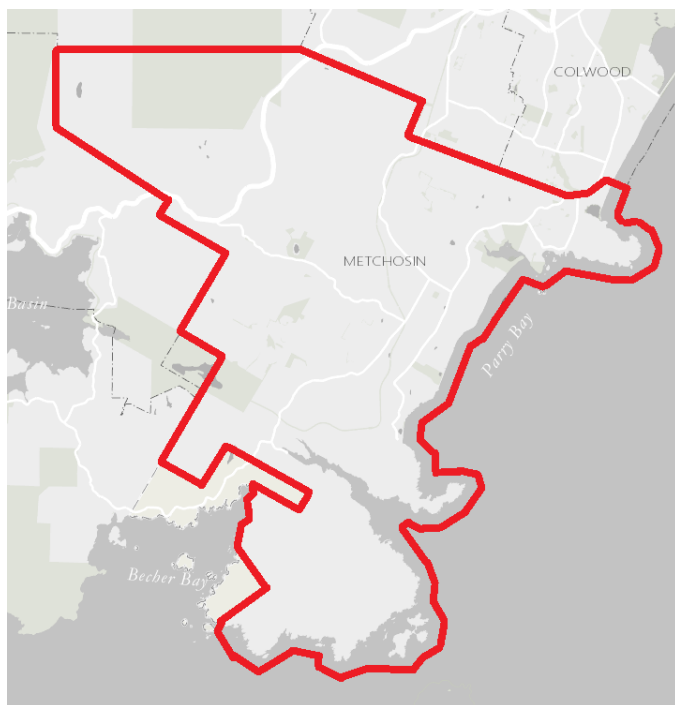
LF – City of Langford

Figure 41: District of Metchosin.
Source: Capital Regional District Website (2017)
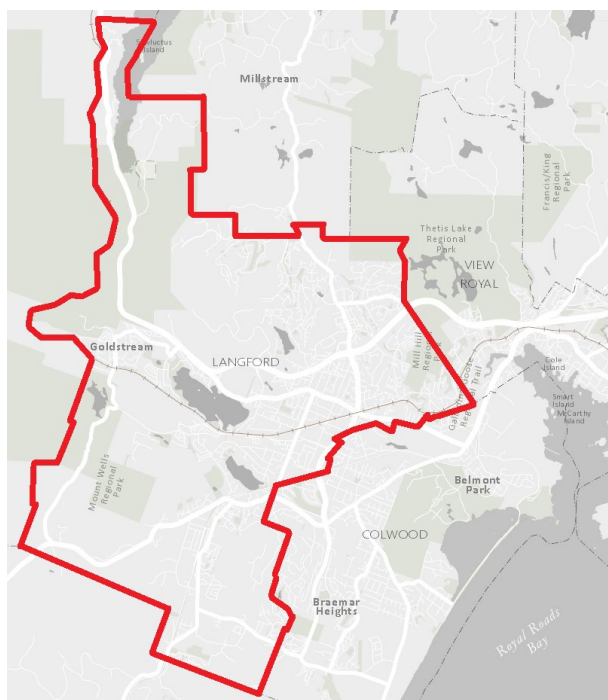
Figure 42: City of Langford.
Source: Capital Regional District Website (2017)

Forage Fish Sampling: Location Codes

VR – Town of View Royal
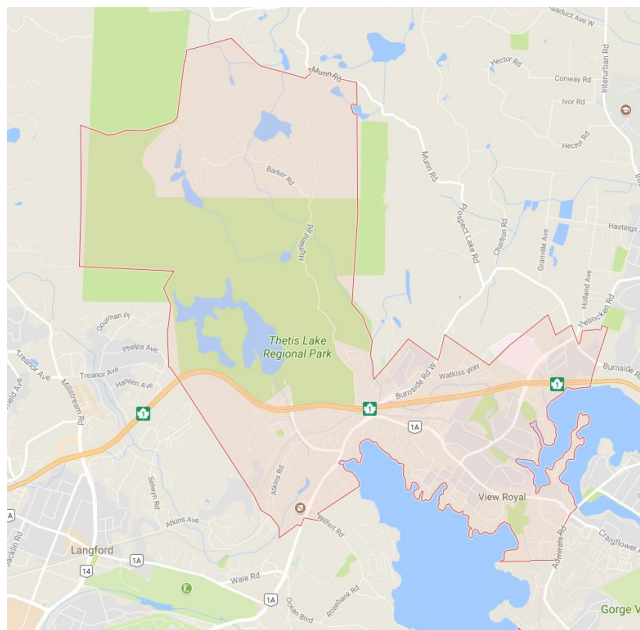
Figure 43: Town of View Royal.
Source: Google Maps Imagery (2017)

CO – City of Colwood
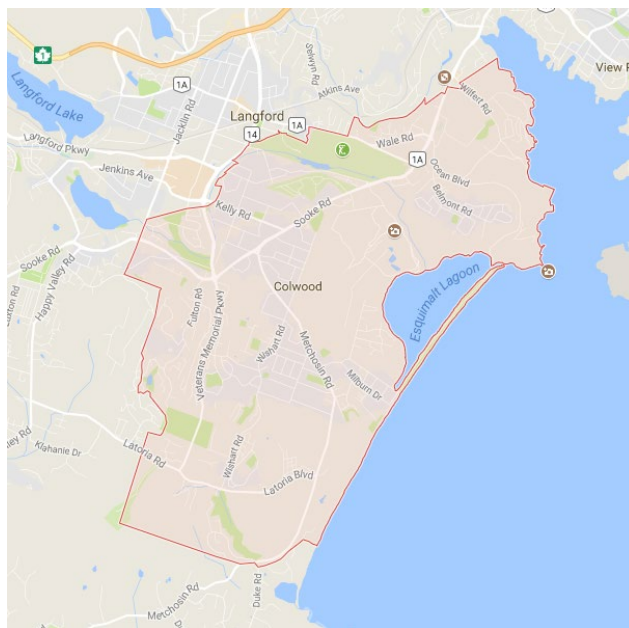
Figure 44: City of Colwood.
Source: Google Maps Imagery (2017)

ES – Township of Esquimalt

Figure 45: Township of Esquimalt.
Source: Capital Regional District Website
(2017)

OB – District of Oak Bay
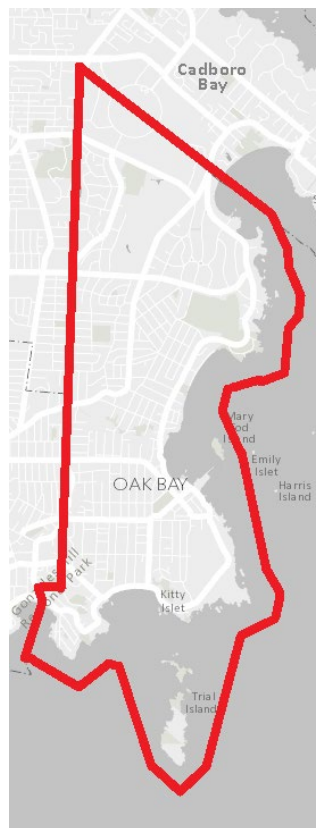
Figure 46: District of Oak Bay.
Source: Capital Regional
District Website (2017)

VI – City of Victoria

Figure 47: City of Victoria. Source: Capital Regional District Website (2017)

8.2 Electoral Areas

Figure 48: Electoral Areas of the Capital Regional District.
Source: Brian Laing Realtor Website (2012)

JF	SG	SS
Juan de Fuca	Southern Gulf Islands	Salt Spring Island

9.0 GULF ISLANDS (GI)

SS – Salt Spring Island Electoral Area

SG – Southern Gulf Islands Electoral Area

Figure 50: Southern Gulf Islands Electoral Area.
Source: Capital Regional District Website (2017)

Figure 49: Salt Spring Island Electoral Area.
Source: Capital Regional District Website (2017)
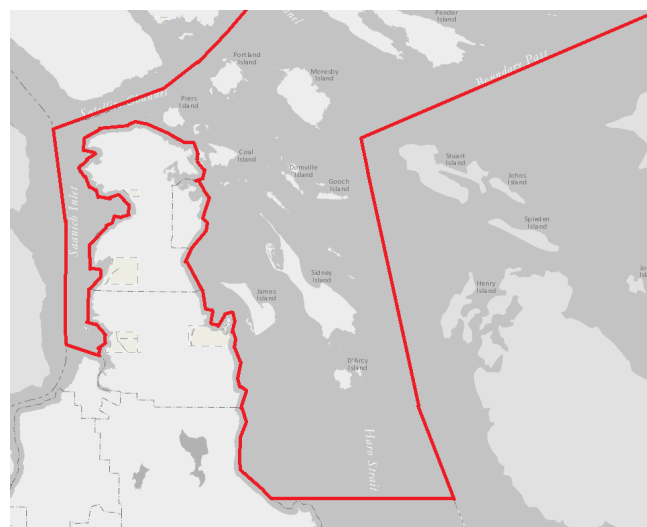
Figure 51: Southern Gulf Islands Electoral Area.
Source: Capital Regional District Website (2017)

10.0 POWELL RIVER REGIONAL DISTRICT (PRRD)

10.1 Municipalities

PR – City of Powell River

Figure 52: City of Powell River.
Source: qathet Regional District Mapping (2019)

10.2 Electoral Areas

A	PA
B	PB
C	PC
D	TI
E	LI

Figure 53: Electoral Areas of the Powell River Regional District.
Source: qathet Regional District Website (2018)

Page **55** of **88**

11.0 SUNSHINE COAST REGIONAL DISTRICT (SCRD)

11.1 Municipalities

GB – Town of Gibsons

SE – District of Sechelt
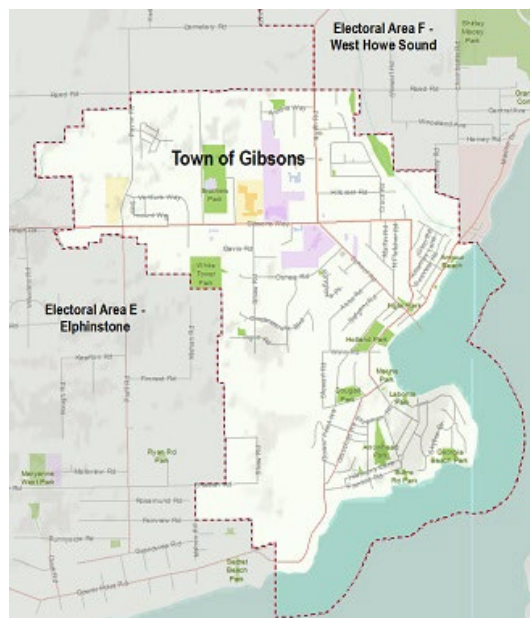
Figure 54: Town of Gibsons.
Source: Town of Gibsons Website (2015)
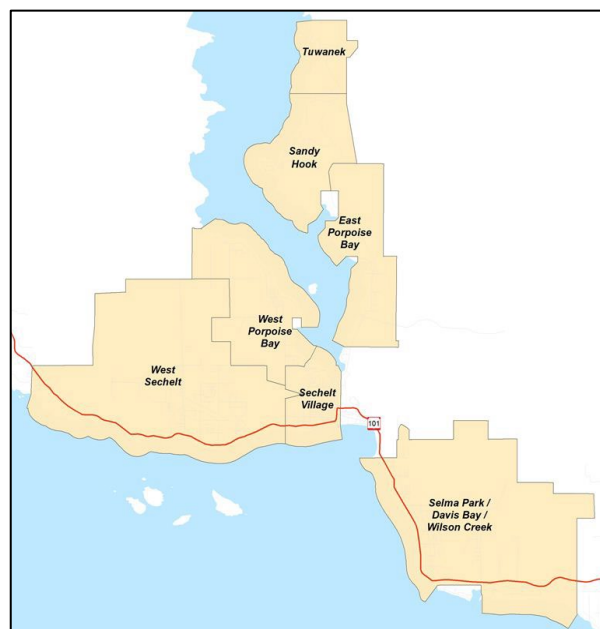
Figure 55: District of Sechelt.
Source: District of Sechelt Website (2019)

11.2 Electoral Areas
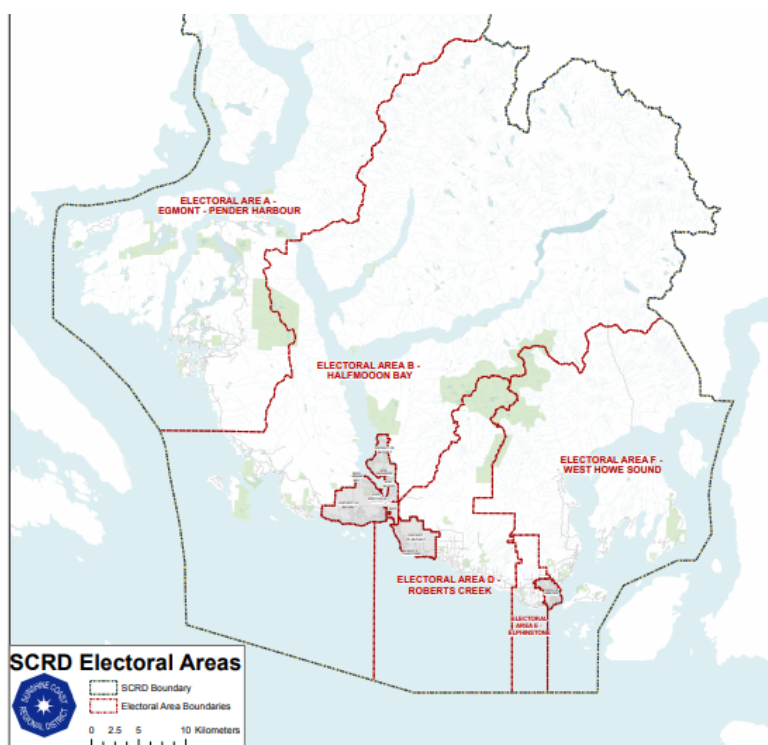
A	EG
B	HB
D	RO
E	EL
F	WH

Figure 56: Electoral areas of the Sunshine Coast Regional District.
Source: SCRD Website (2015)

12.0 METRO VANCOUVER REGIONAL DISTRICT (MVRD)

12.1 Municipalities

AN – Village of Anmore
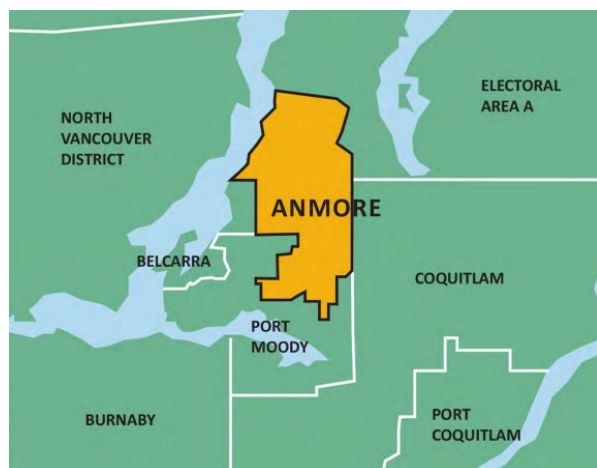
Figure 57: Village of Anmore.
Source: Village of Anmore Official Community Plan (2014)

BE – Village of Belcarra
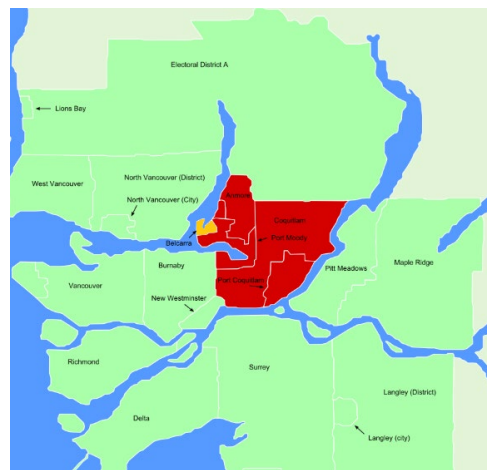
Figure 58: Village of Belcarra.
Source: Wikipedia (2019)

BI – Bowen Island Municipality
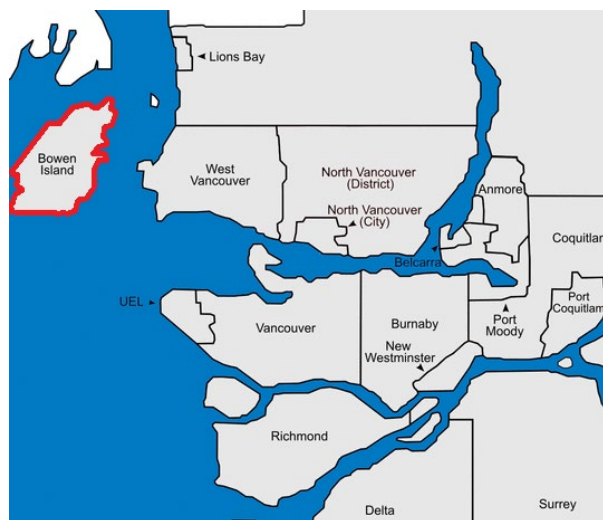
Figure 59: Bowen Island Municipality.
Source: Tourism Vancouver Website (2019)

BU – City of Burnaby
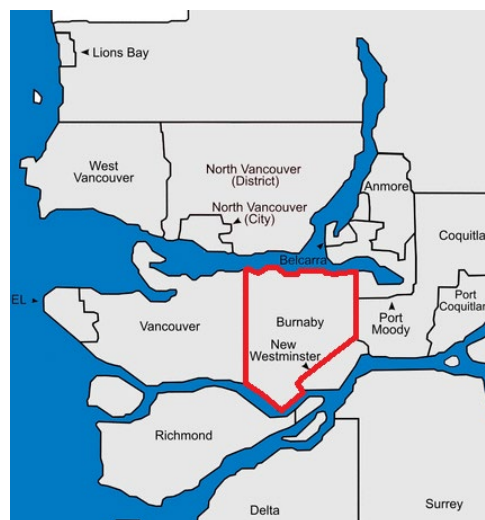
Figure 60: City of Burnaby.
Source: Tourism Vancouver Website (2019)

Forage Fish Sampling: Location Codes

DE – City of Delta
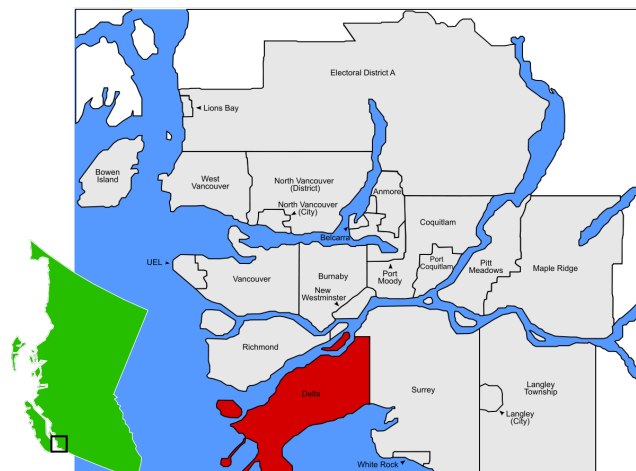
Figure 61: City of Delta.
Source: Wikipedia (2019)

DN – District of North Vancouver
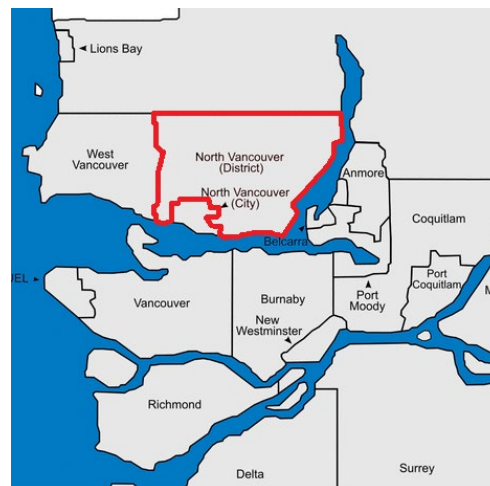
Figure 62: District of North Vancouver.
Source: Tourism Vancouver Website (2019)

LB – Village of Lion's Bay
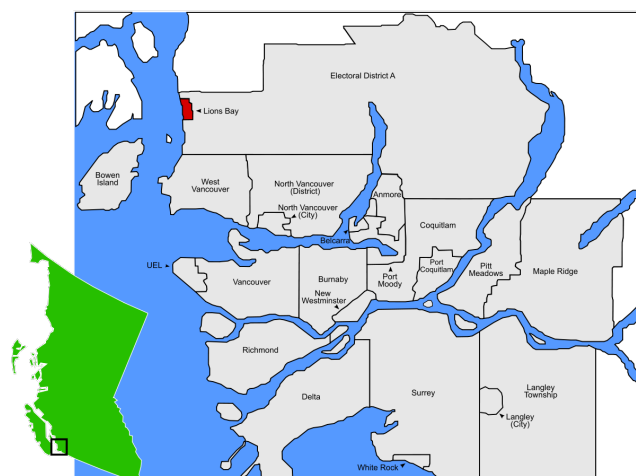
Figure 63: Village of Lion's Bay.
Source: Wikipedia (2019)

MR – City of Maple Ridge
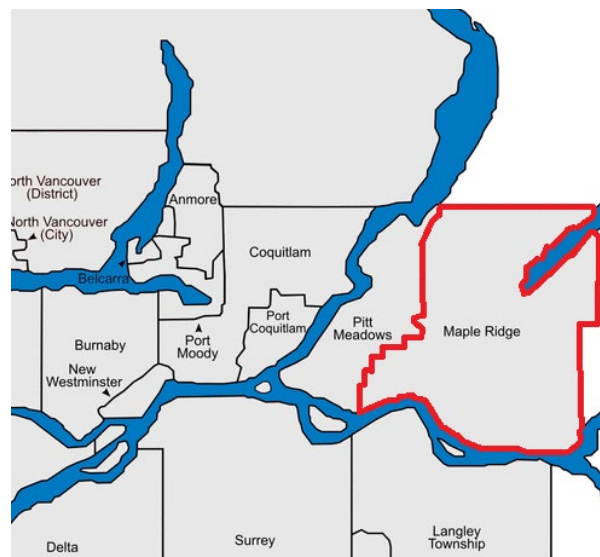
Figure 64: City of Maple Ridge.
Source: Tourism Vancouver Website (2019)

Forage Fish Sampling: Location Codes

NV – City of North Vancouver

Figure 65: City of North Vancouver.
Source: Tourism Vancouver Website (2019)

PY – City of Port Moody
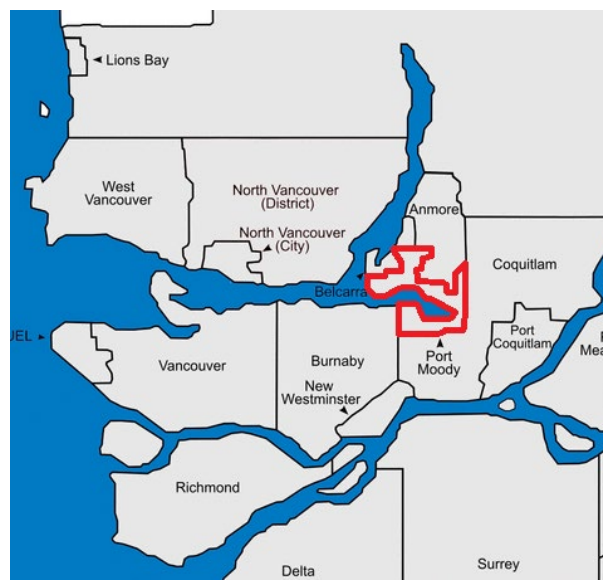
Figure 66: City of Port Moody.
Source: Tourism Vancouver Website (2019)

RI – City of Richmond

Figure 67: City of Richmond.
Source: City of Richmond Website (2018)

SU – City of Surrey
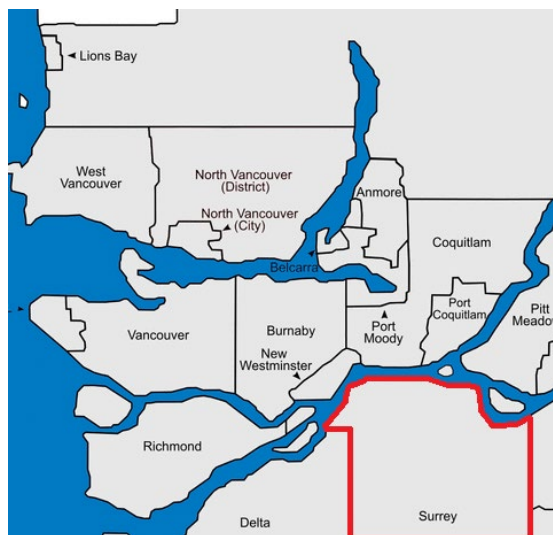
Figure 68: City of Surrey.
Source: Tourism Vancouver Website (2019)

Forage Fish Sampling: Location Codes

TS – Tsawwassen First Nation
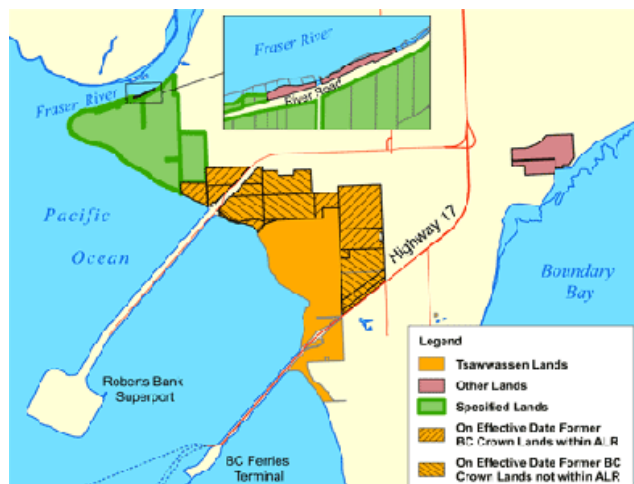
Figure 69: Tsawwassen First Nation land.
Source: Indigenous and Northern Affairs Canada
Website (2010)

VA – City of Vancouver
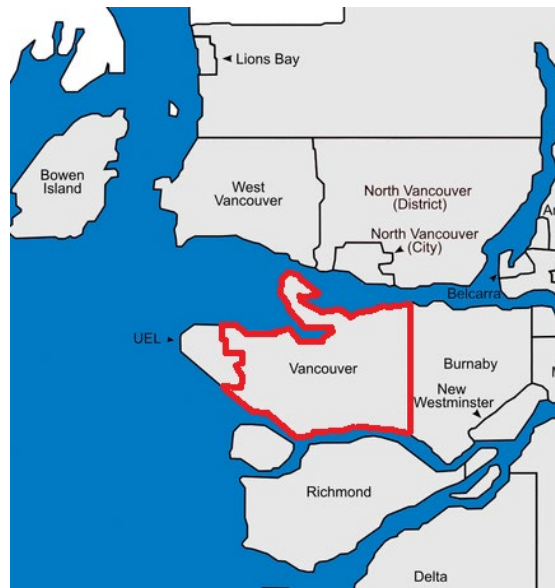
Figure 70: City of Vancouver.
Source: Tourism Vancouver Website (2019)

WR – City of White Rock

Figure 71: City of White Rock.
Source: White Rock Lifestyles Website (2019)

WV – District of West Vancouver

Figure 72: District of West Vancouver.
Source: Tourism Vancouver Website (2019)

12.2 Electoral Areas

MA – MVRD Electoral Area A
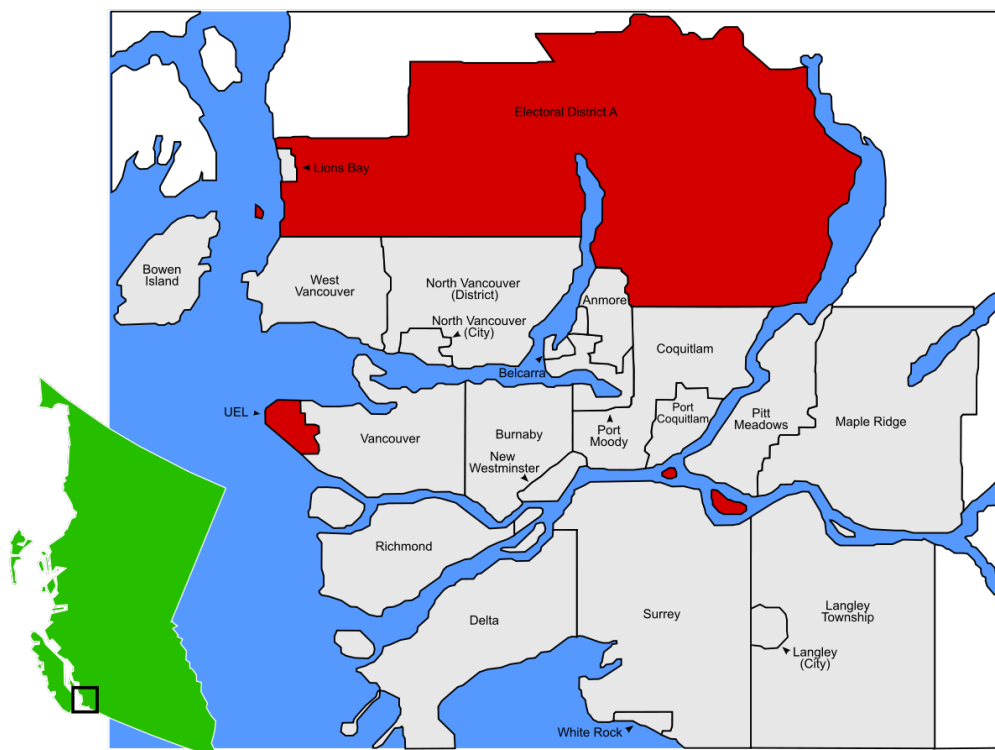
Figure 73: Electoral Area A in Metro Vancouver Regional District.
Source: Wikipedia (2019)

13.0 REFERENCES

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Pentilla, D., 2007. *Marine Forage Fishes in Puget Sound.* Prepared in support of the Puget Sound Nearshore Partnership. Technical Report No.2007-03. Published by Seattle District, U.W. Army corps of Engineers, Seattle, Washington.

14.0 QUICK SUMMARY OF LOCATION CODES

Alberni-Clayoquot Regional District – ACRD
Bamfield ACRD Electoral Area A - BF
City of Port Alberni – CP
District of Tofino – TO
District of Ucluelet – UC
Long Beach ACRD Electoral Area C - LO

Capital Regional District – CRD
City of Colwood – CO
City of Langford – LF
City of Victoria – VI
District of Central Saanich – CS
District of Highlands - HI
District of Metchosin – ME
District of North Saanich – NS
District of Oak Bay – OB
District of Saanich – SN
District of Sooke – SO
Juan de Fuca CRD Electoral Area – JF
Salt Spring Island CRD Electoral Area – SS
Southern Gulf Islands CRD Electoral Area – SG
Town of Sidney – SI
Town of View Royal – VR
Township of Esquimalt – ES

Comox Valley Regional District – CMVRD
Baynes Sound – Denman/Hornby Islands CMVRD Electoral Area A – BS
City of Courtenay – CT
Lazo North CMVRD Electoral Area B – LN
Puntledge-Black Creek CMVRD Electoral Area C – PU
Town of Comox – CM
Village of Cumberland – CU

Cowichan Valley Regional District – CWVRD
City of Duncan – DU
Cobble Hill CWVRD Electoral Area C – CH
Cowichan Bay CWVRD Electoral Area D – CB
Cowichan Lake South – Skutz Falls CWVRD Electoral Area F – CL
Gulf Islands – Saltair CWVRD Electoral Area G – GI
Mill Bay – Malahat CWVRD Electoral Area A – MB
Municipality of North Cowichan – NC
North Oyster – Diamond CWVRD Electoral Area H – NO
Town of Ladysmith – LS
Town of Lake Cowichan – LC
Metro Vancouver Regional District – MVRD

Forage Fish Sampling: Location Codes

Bowen Island Municipality – BI
City of Burnaby – VU
City of Delta – DE
City of Maple Ridge – MR
City of North Vancouver – NV
City of Port Moody – PY
City of Richmond – RI
City of Surrey – SU
City of Vancouver – VA
City of White Rock – WR
District of North Vancouver – DN
District of West Vancouver – WV
MVRD Electoral Area A – MA
Tsawwassen First Nation – TS
Village of Anmore – AN
Village of Belcarra – BE
Village of Lion's Bay – LB

Powell River Regional District – PRRD
City of Powell River – PR
Lasqueti Island PRRD Electoral Area E – LI
PRRD Electoral Area A – PA
PRRD Electoral Area B – PB
PRRD Electoral Area C – PC
Texada Island PRRD Electoral Area D – TI

Regional District of Mount Waddington – RDMW
District of Port Hardy – PH
RDMW Electoral Area A – RA
RDMW Electoral Area B – RB
RDMW Electoral Area C – RC
RDMW Electoral Area D – RD
Town of Port McNeill – PM
Village of Alert Bay – AB
Village of Port Alice – PO

Regional District of Nanaimo – RDN
Cassidy, Cedar, Yellow Point, South Wellington RDN Electoral Area A – CC
City of Nanaimo – NA
City of Parksville – PK
District of Lantzville – LA
French Creek, Dashwood, Englishman River RDN Electoral Area G – FC
Gabriola, DeCourcy, Mudge Islands RDN Electoral Area B – GD
Nanoose Bay RDN Electoral Area E – NB
Shaw Hill, Qualicum Bay, Deep Bay, Bowser, Spider Lake, Horne Lake RDN Electoral Area H – SH

Forage Fish Sampling: Location Codes

Town of Qualicum Beach – QB

Strathcona Regional District – SRD
City of Campbell River – CR
Coretes SRD Electoral Area B – CI
Discovery Islands – Mainland Inlets SRD Electoral Area C – DM
Kyuquot/Nootka-Sayward SRD Electoral Area A – KN
Oyster Bay-Buttle Lake SRD Electoral Area D – BL
Village of Gold River – GR
Village of Sayward – SA
Village of Tahsis – TA
Village of Zeballos – ZE

Sunshine Coast Regional District – SCRD
District of Sechelt – SE
Egmont-Pender Harbour SCRD Electoral Area A – EG
Elphinstore SCRD Electoral Area E – EL
Halfmoon Bay SCRD Electoral Area B – HB
Roberts Creek SCRD Electoral Area D – RO
Town of Gibsons – GB
West Howe Sound SCRD Electoral Area F – WH

Appendix 4:

Fisheries and Oceans Canada (DFO)

Management Areas

Imagery Gathered by: Mount Arrowsmith Biosphere Region Research Institute (MABRRI)

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TABLE OF CONTENTS

FIGURES

1.0 INTRODUCTION

'Forage fishes' is a term referring to species of small, schooling fishes that are an important food source for larger mammals, seabirds, and fish (Penttila, 2007). According to the BC Ministry of Environment, forage fish, also known as pelagic fishes, consist of numerous species, including: herring, anchovies, smelts, capelin, sardines, eulachon and sand lance (BC Ministry of Environment, 2014). These species are classified based on their ecological role in the marine ecosystem, rather than their taxonomy. Forage fish populations are declining globally, subsequently increasing adverse impacts culturally, ecologically, and economically (Mckechnie et al., 2014).

Although forage fish habitats are identified as critical fish habitat under the Canadian Fisheries Act, making them protected, BC has little data regarding the location and timing associated with these habitats (de Graaf, 2010). In response to this data gap, the Sea Watch Society developed the Forage Fish Program (FFP), which involves potential spawning site identification, as well as site surveying, mapping, and monitoring of two forage fish species within BC, surf smelt and Pacific sand lance (de Graaf, 2013). The FFP involves training volunteers and community groups along the coast of BC to identify potential spawning sites of these two species and offer monitoring of these locations (de Graaf, 2013).

In 2017, the Mount Arrowsmith Biosphere Region Research Institute (MABRRI) at Vancouver Island University was trained to use the "vortex method" by a Nearshore and Forage Fish Specialist from the Washington State Department of Fish and Wildlife. The MABRRI team monitors beaches along the coast, as well as trains citizen scientists to do the same in order to build the capacity of this project. Since 2017, other groups, including Peninsula Stream Society, have begun monitoring and training citizen science groups to further expand this initiative's capacity and range. By regularly monitoring the beaches, this initiative aims to reduce the current data gap that exists regarding forage fish spawning habitat along the Vancouver Island and Gulf Island coastlines.

MABRRI created this quick reference document, in addition to the "Vancouver Island Forage Fish Sampling: Location Codes" document, in order to aid in the standardization of data collection and data referencing. Codes for locations across the entirety of Vancouver Island were created in order to retrieve site specific data in a timely fashion. Each site that is sampled will have a corresponding code that includes the regional district of Vancouver Island, the municipality and/or electoral area, and the beach, as well as the DFO Management Area associated with it (Figure 1). This document includes the DFO Management Areas that influence Vancouver Island and the Gulf Islands.

Region	Municipality	DFO Mngt Area

Figure 1. Location data as seen on beach station survey datasheet (Appendix 1).

2.0 FISHERIES AND OCEANS MANAGEMENT AREAS: VANCOUVER & GULF ISLANDS

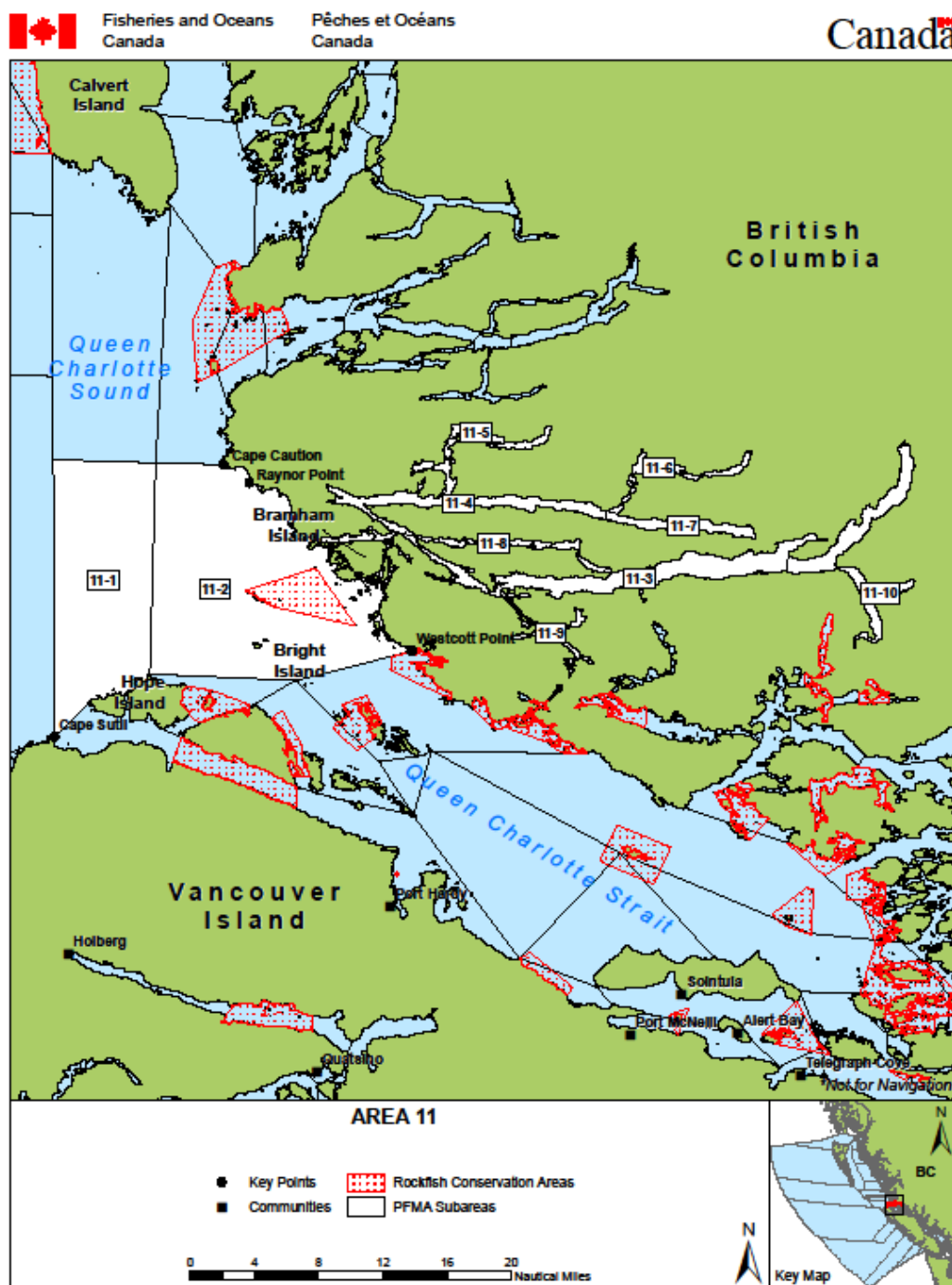### 2.1 Area 11: Cape Caution, Westcott Point

Figure 2. Cape Caution, Westcott Point DFO Management Area (DFO, 2017).

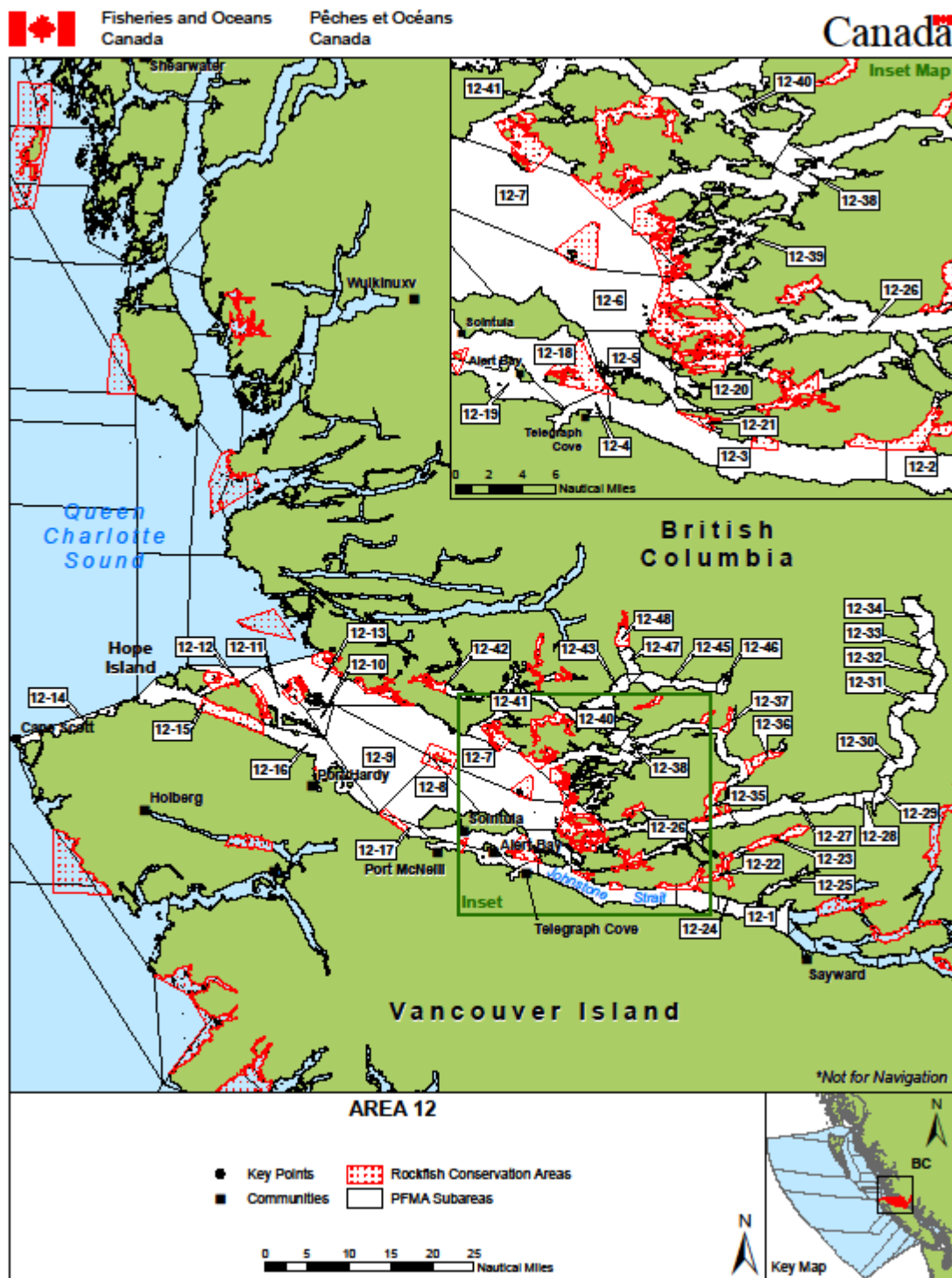## 2.2 Area 12: Northern Johnstone Strait

Figure 3. Northern Johnstone Strait DFO Management Area (DFO, 2017).

2.3 Area 13: Quadra Island, Cortes Island

Figure 4. Quadra Island, Cortes Island DFO Management Area (DFO, 2017).
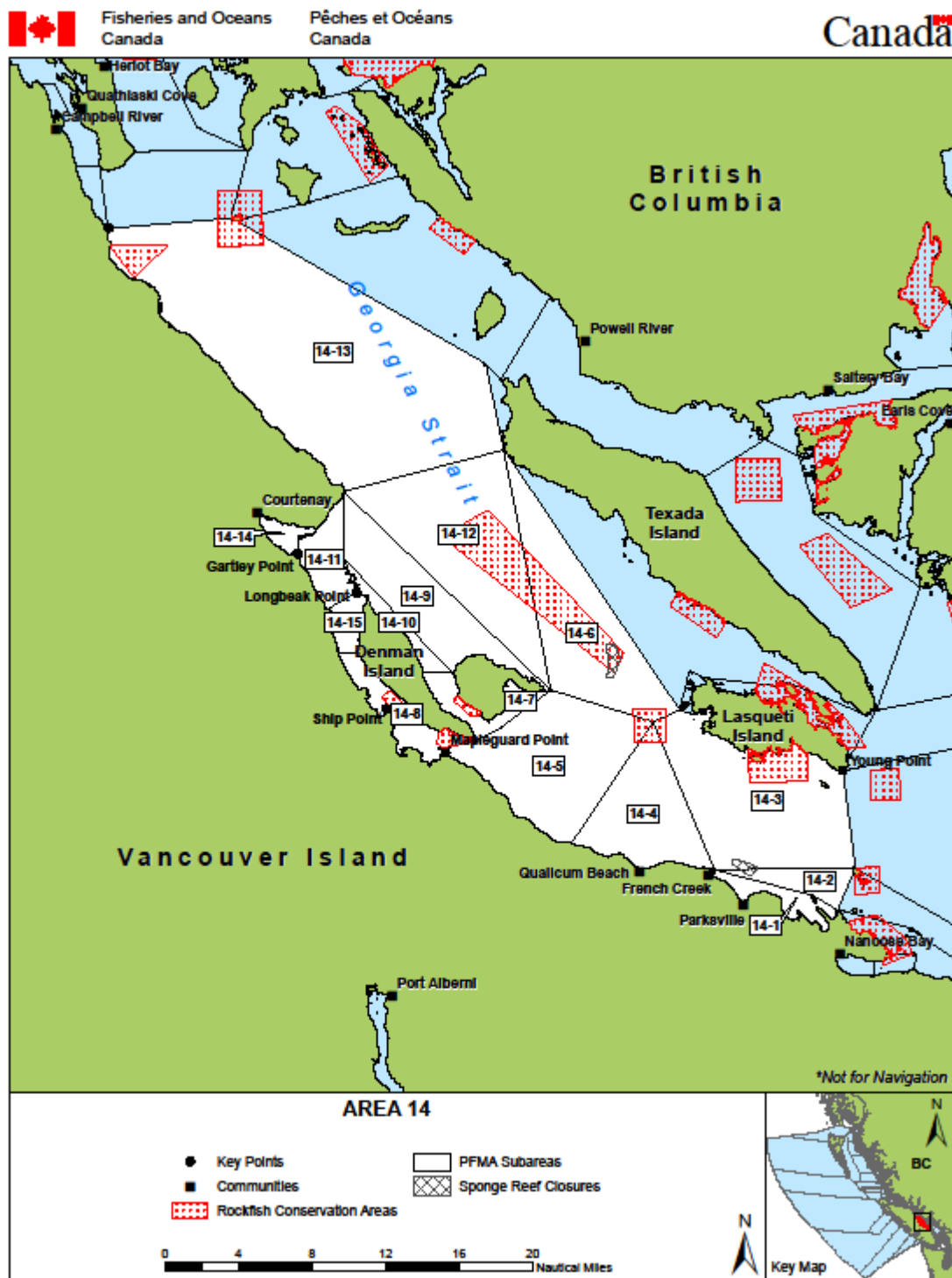
2.4 Area 14: Oyster River, Parksville

Figure 5. Oyster River, Parksville DFO Management Area (DFO, 2017).

2.5 Area 15: Brettell Point, Powell River

Figure 6. Brettell Point, Powell River DFO Management Area (DFO, 2017).

2.6 Area 16: Texada Island, Lasqueti Island, Jervis Inlet
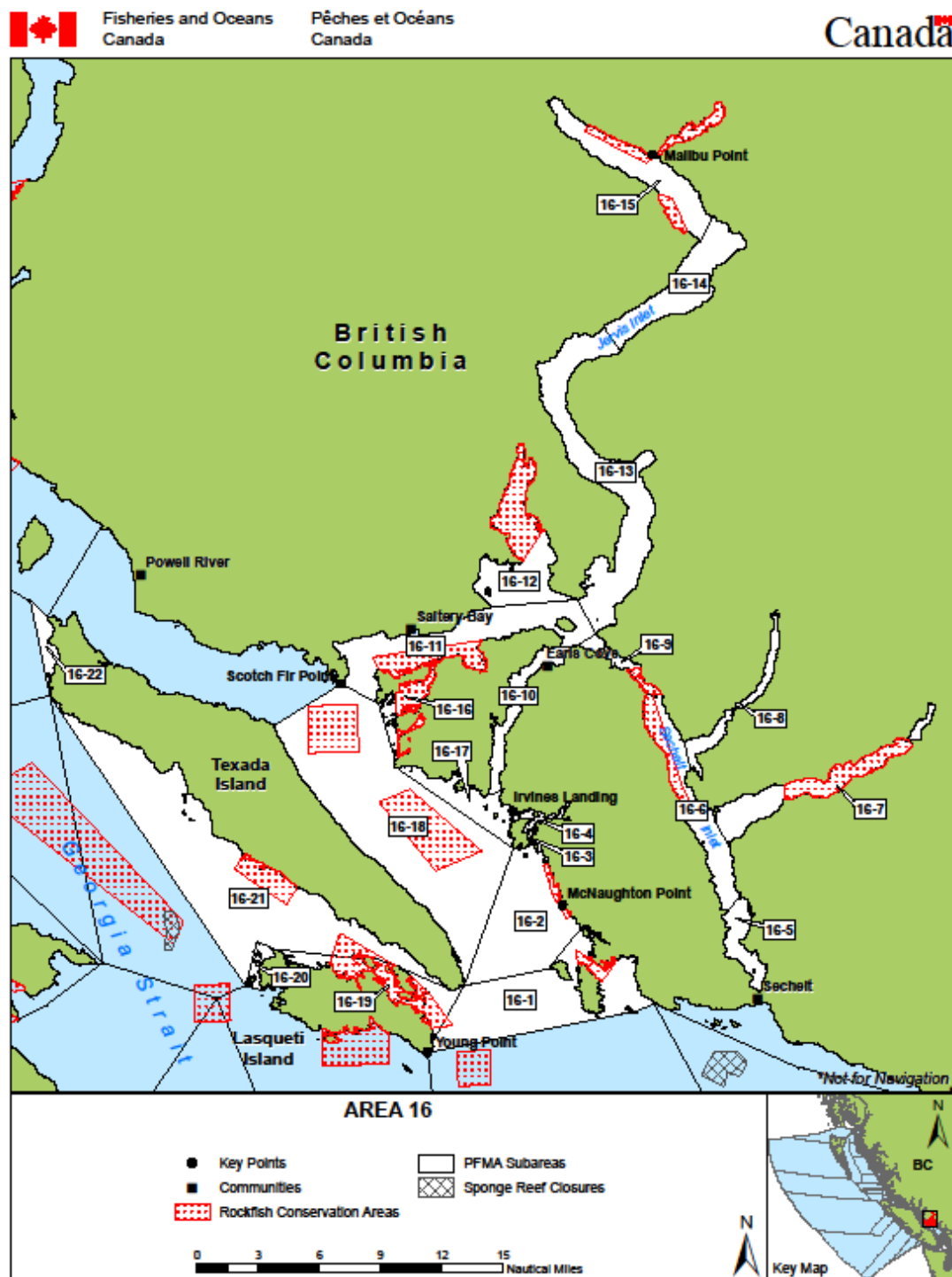
Figure 7. Texada Island, Lasqueti Island, Jervis Inlet DFO Management Area (DFO, 2017).
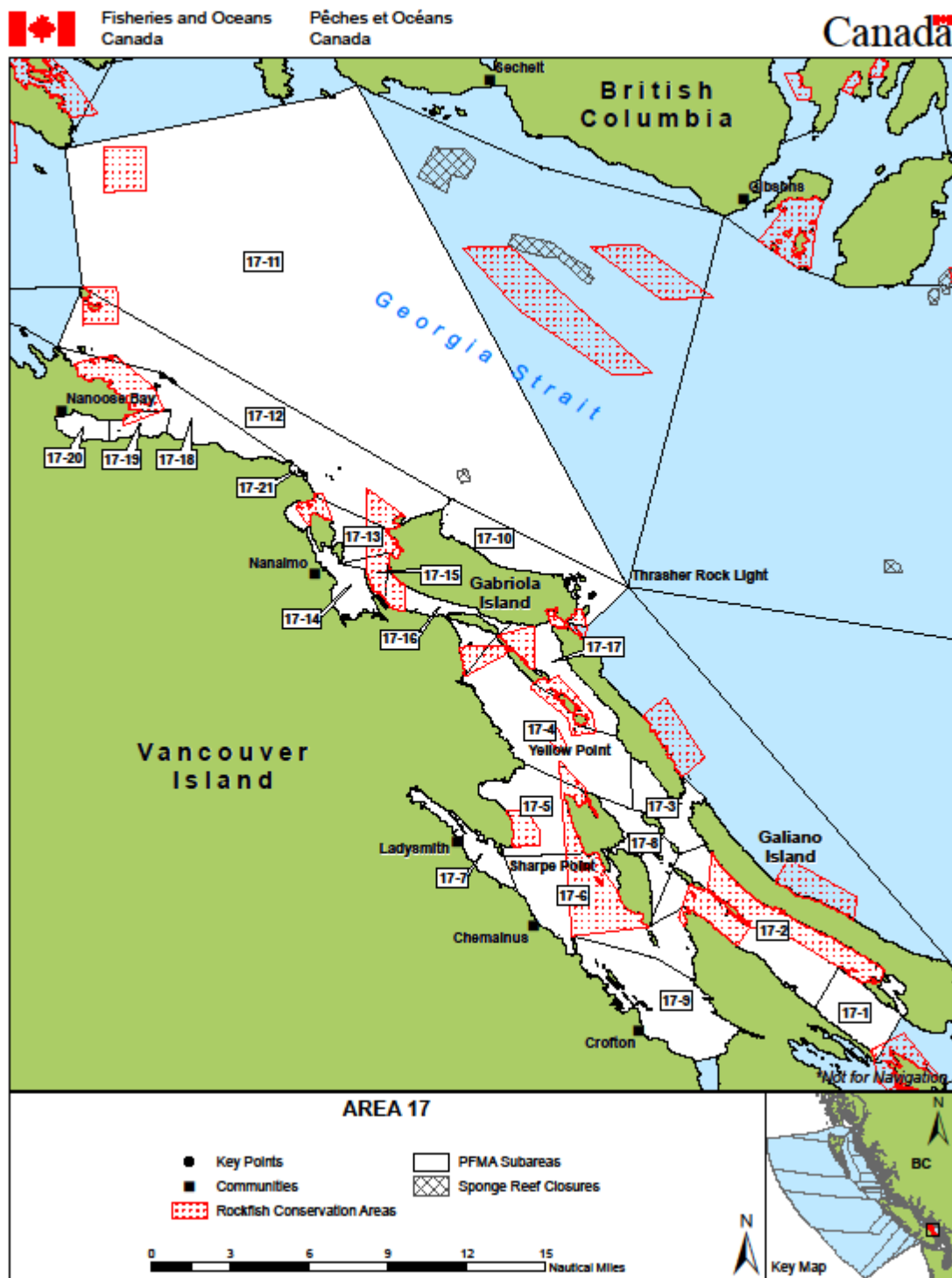
2.7 Area 17: Nanoose Bay, Galiano Island

Figure 8. Nanoose Bay, Galiano Island DFO Management Area (DFO, 2017).
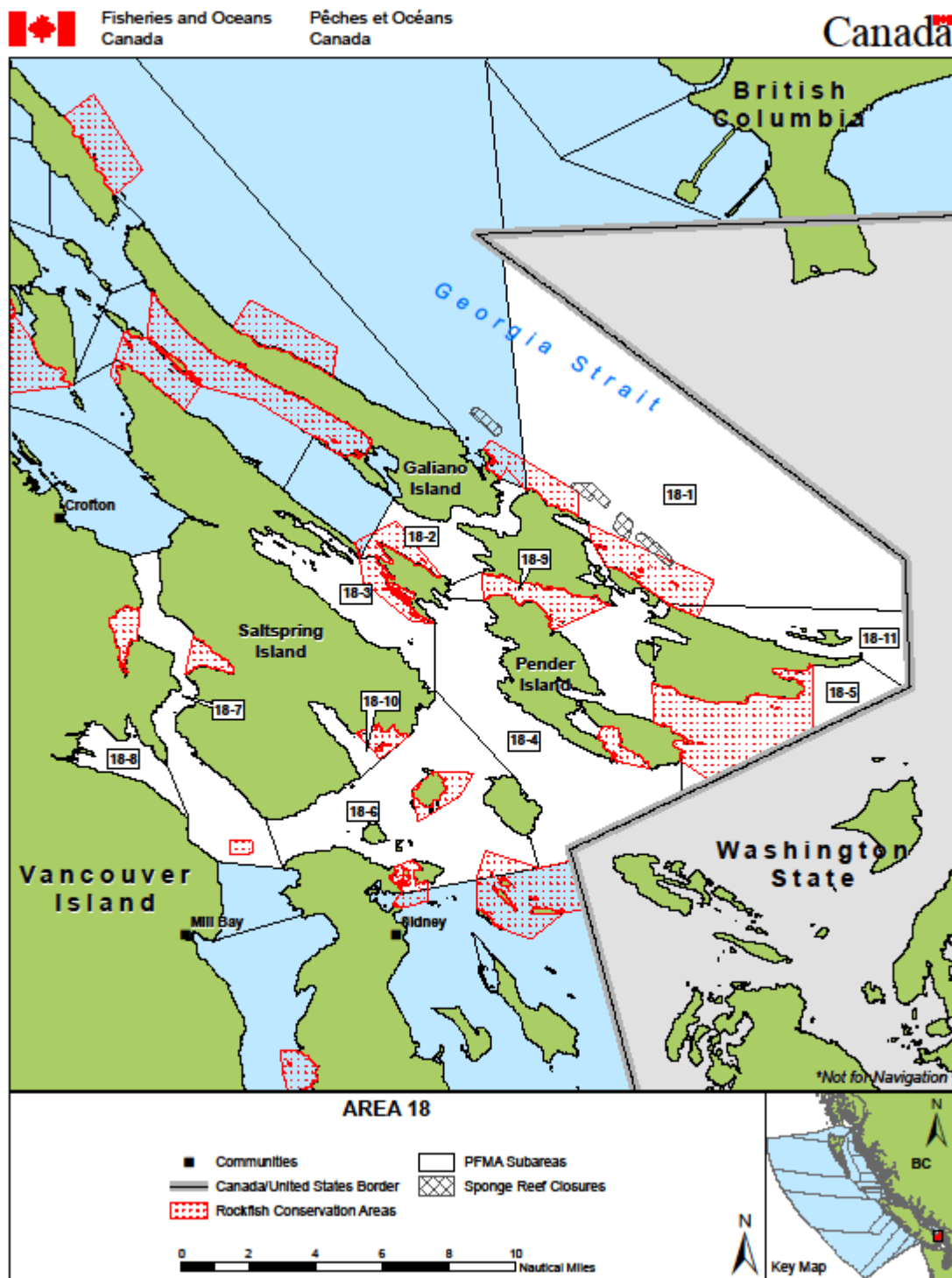
2.8 Area 18: Mayne Island, Saanich

Figure 9. Mayne Island, Saanich DFO Management Area (DFO, 2017).

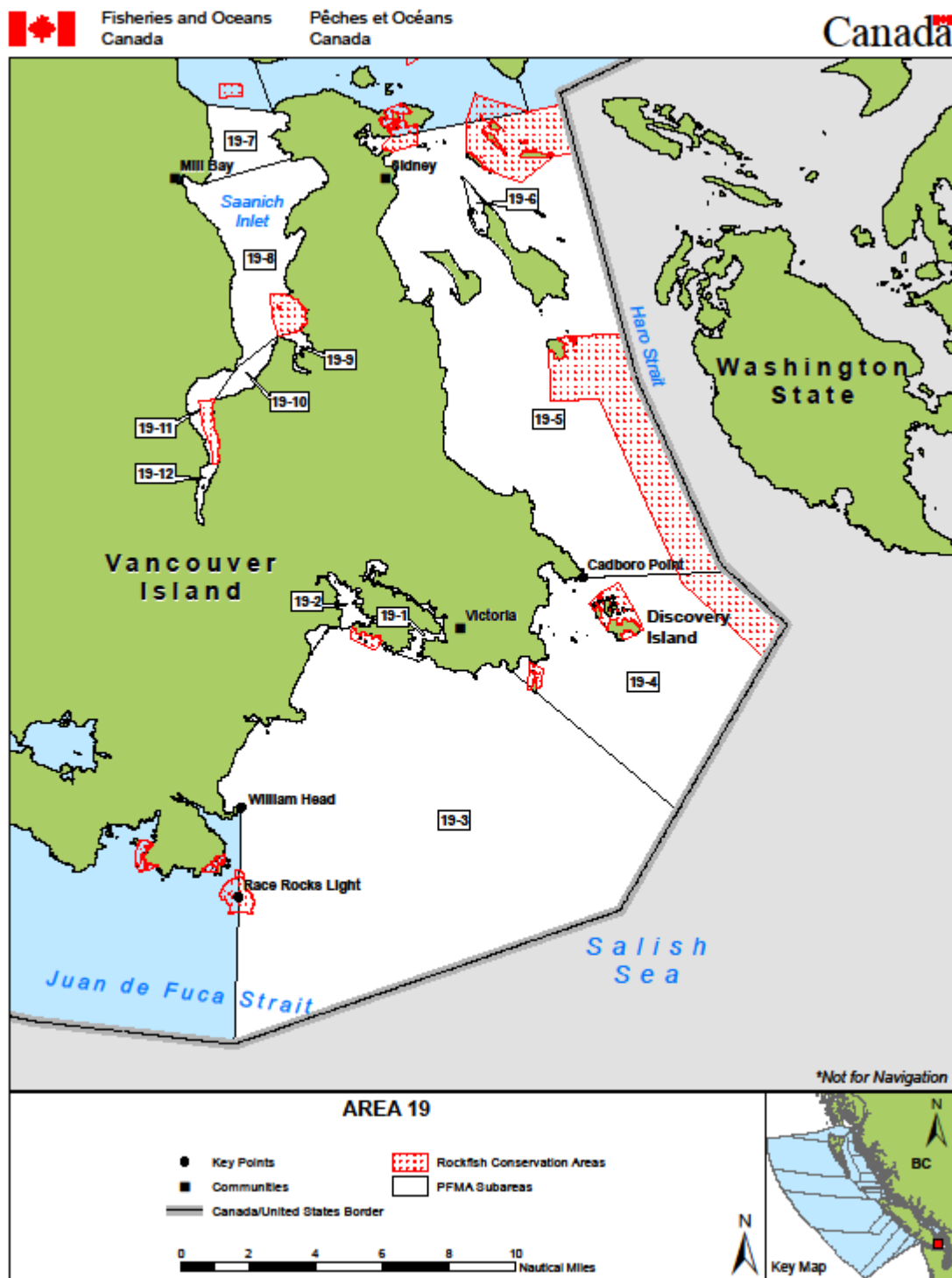**2.9 Area 19: Saanich, William Head**

Figure 10. Saanich, William Head DFO Management Area (DFO, 2017).

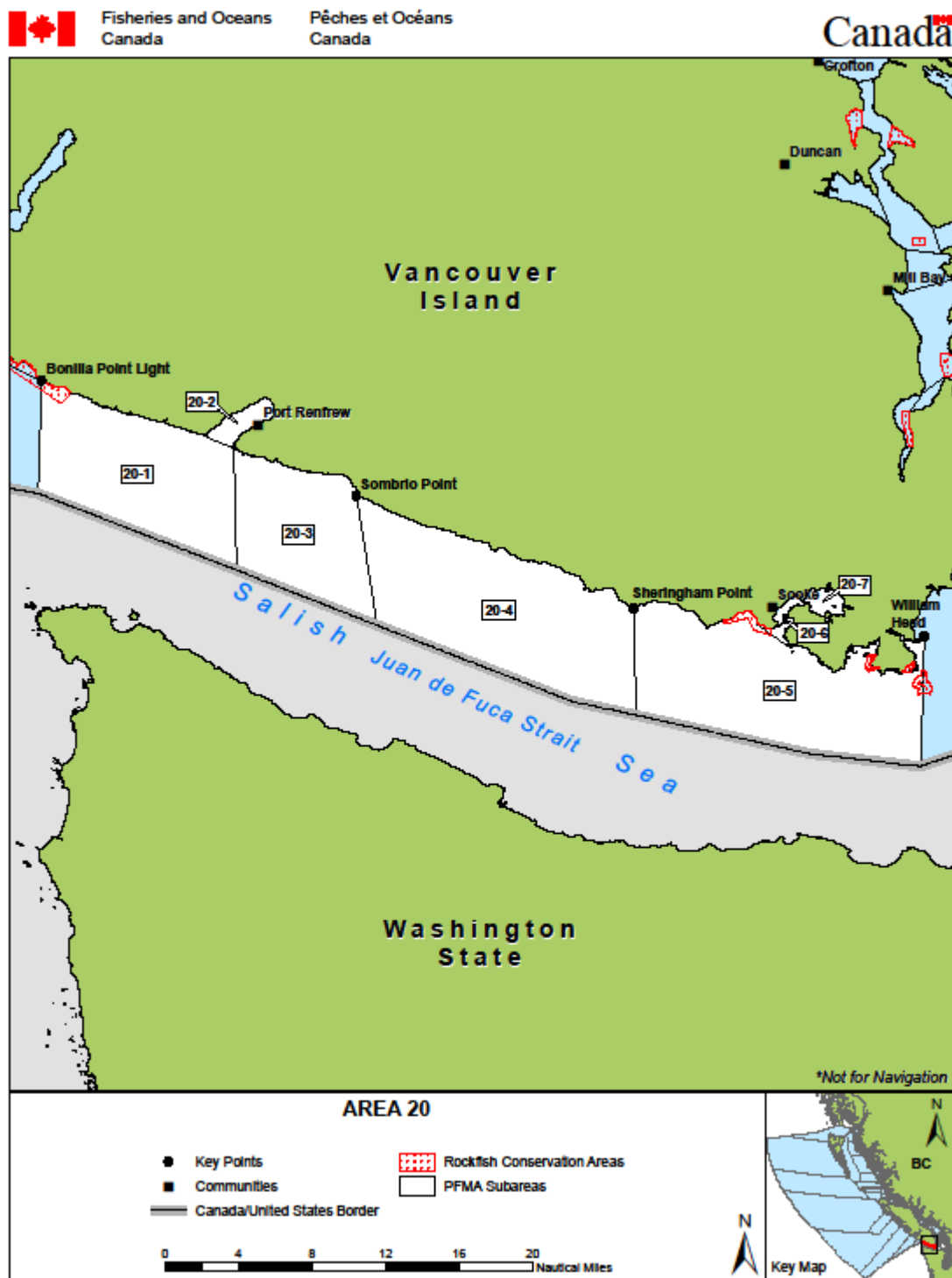## 2.10 Area 20: Sooke, Bonilla Point Lighthouse

Figure 11. Sooke, Bonilla Point Lighthouse DFO Management Area (DFO, 2017).

2.11 Area 21/22: Tzuquanah Point, Nitinat Lake

Figure 12. Tzuquanah Point, Nitinat Lake DFO Management Area (DFO, 2017).

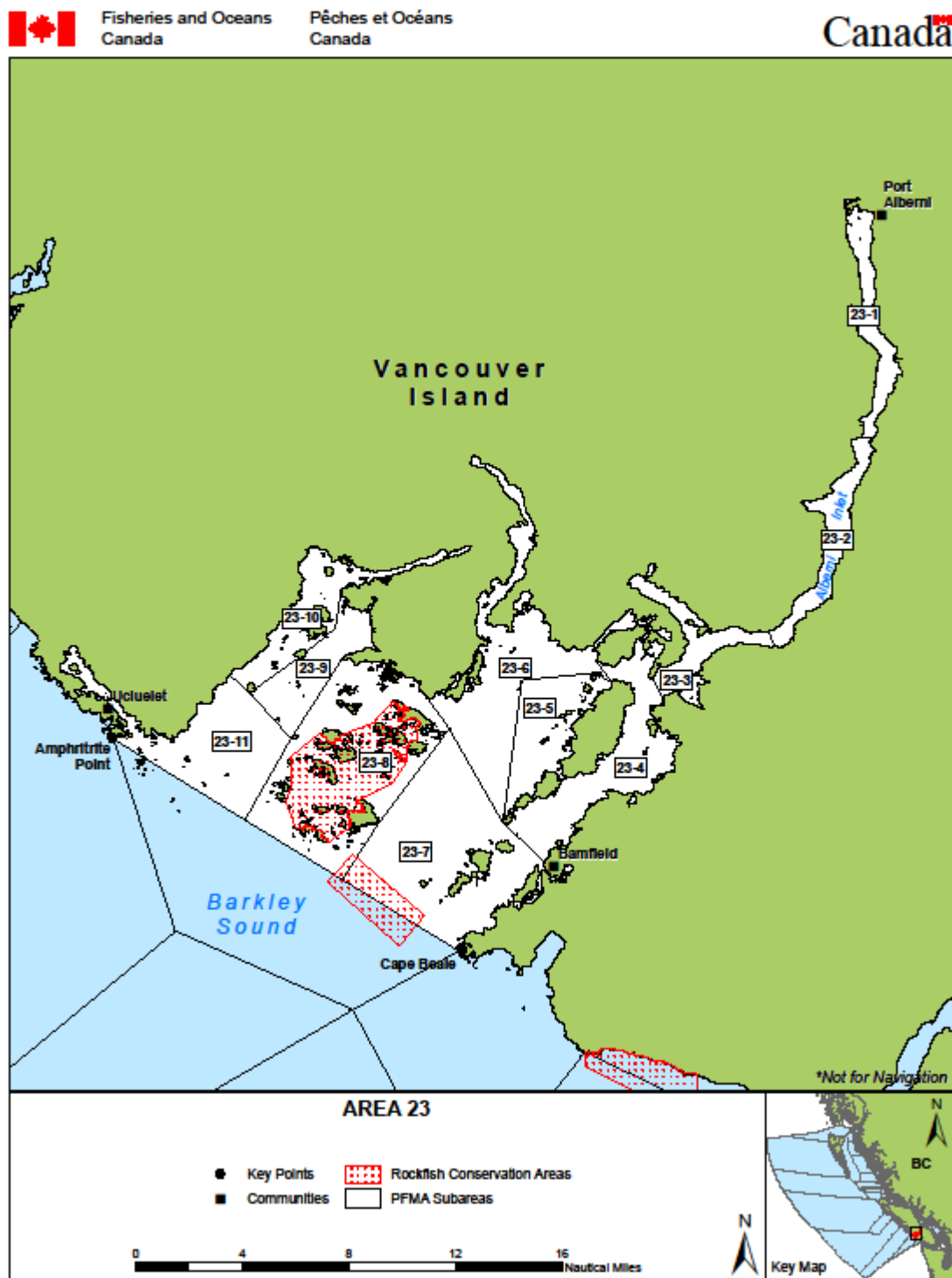## 2.12 Area 23: Cape Beale, Ucluelet

Figure 13. Cape Beale, Ucluelet DFO Management Area (DFO, 2017).
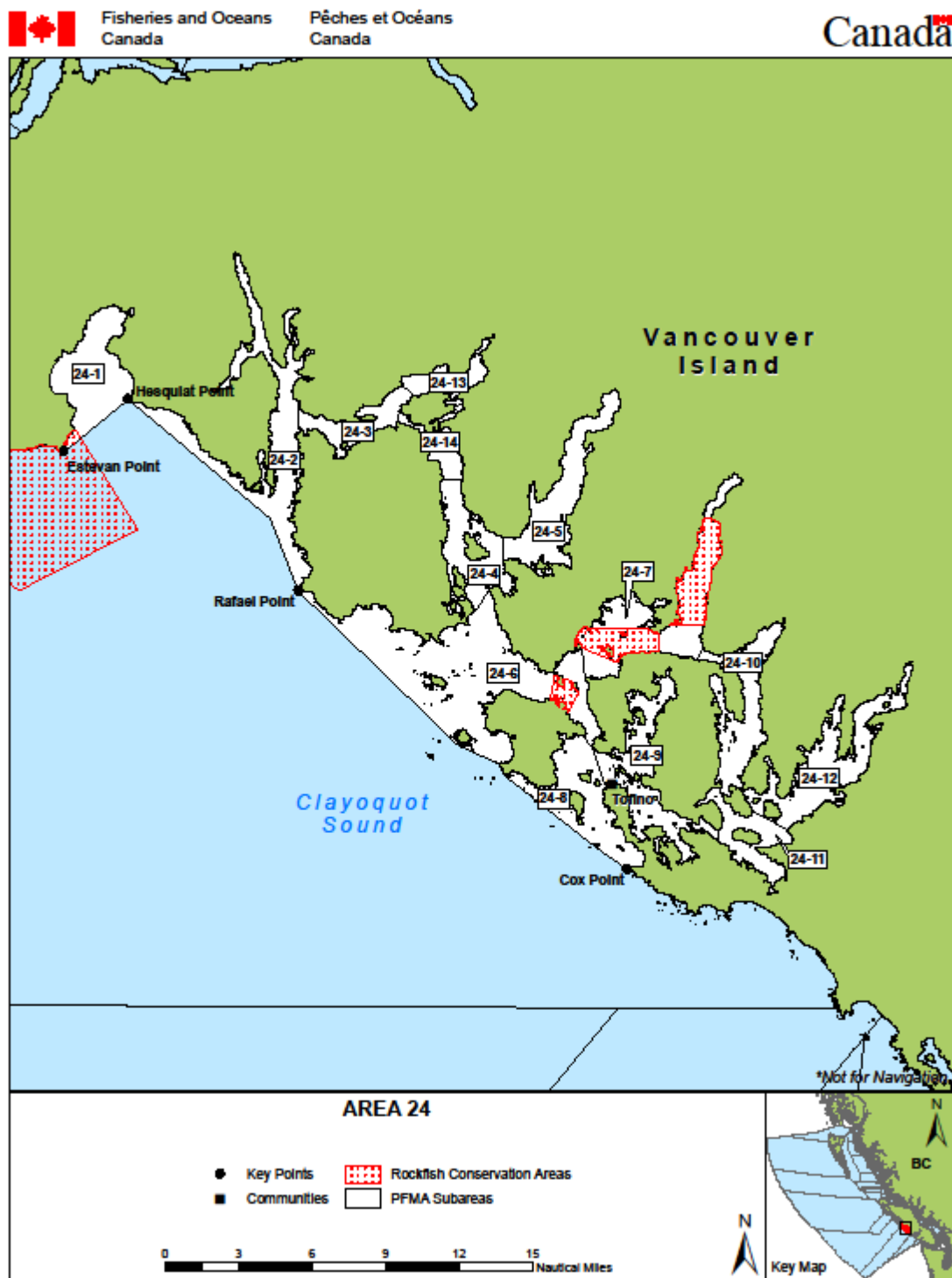
2.13 Area 24: Cox Point, Estevan Point

Figure 14. Cox Point, Estevan Point DFO Management Area (DFO, 2017).

2.14 Area 25: Nootka Sound, Esperanza Inlet

Figure 15. Nootka Sound, Esperaza Inlet DFO Management Area (DFO, 2017).

2.15 Area 26 Union Island, Solander Island

Figure 16. Union Island, Solander Island DFO Management Area (DFO, 2017).

2.16 Area 27: Solander Island, Lawn Point, Cape Scott

Figure 17. Solander Island, Lawn Point, Cape Scott DFO Management Area (DFO, 2017).
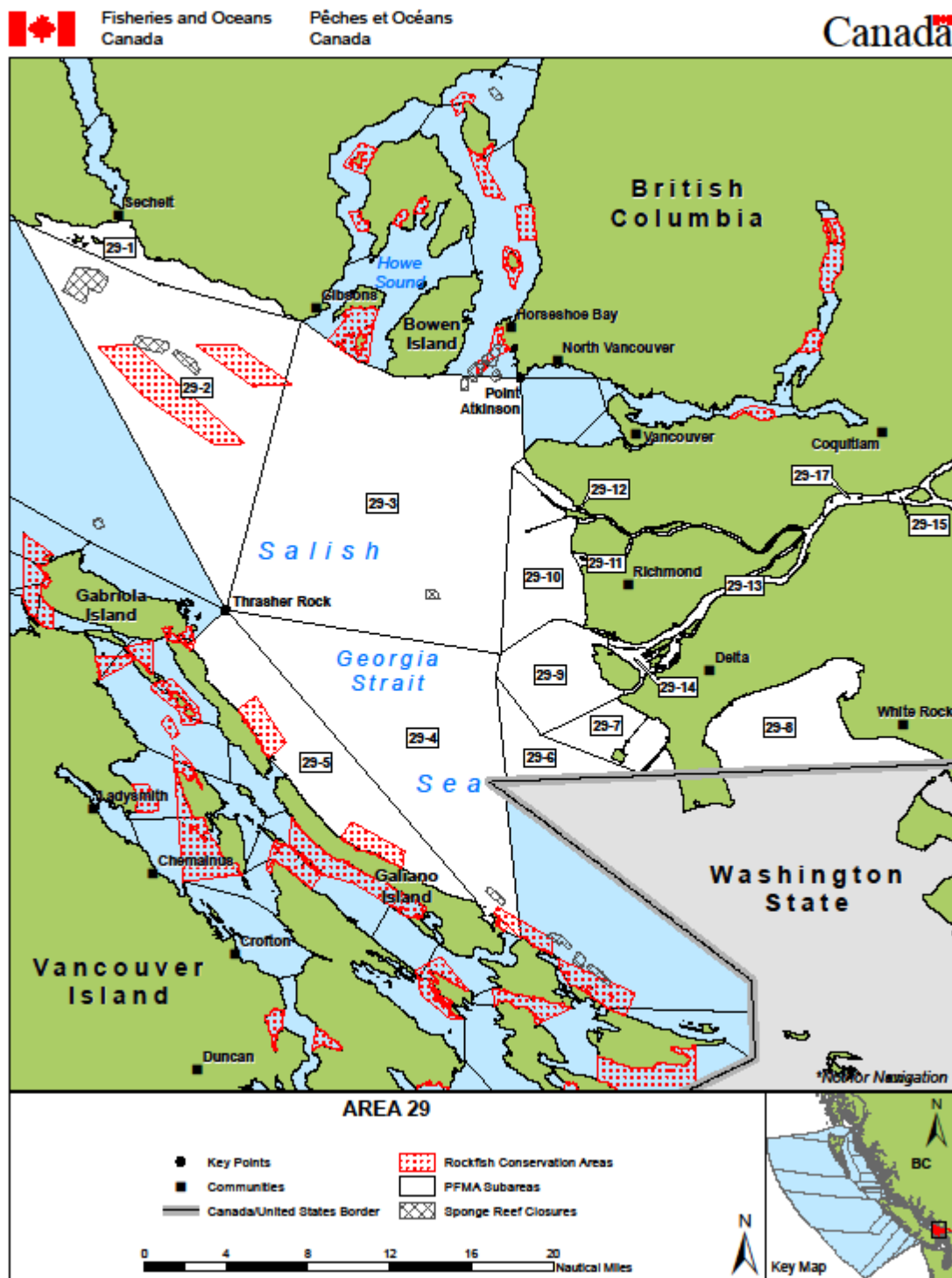
2.17 Area 29: Lower Georgia Strait

Figure 18. Lower Georgia Strait DFO Management Area (DFO, 2017).

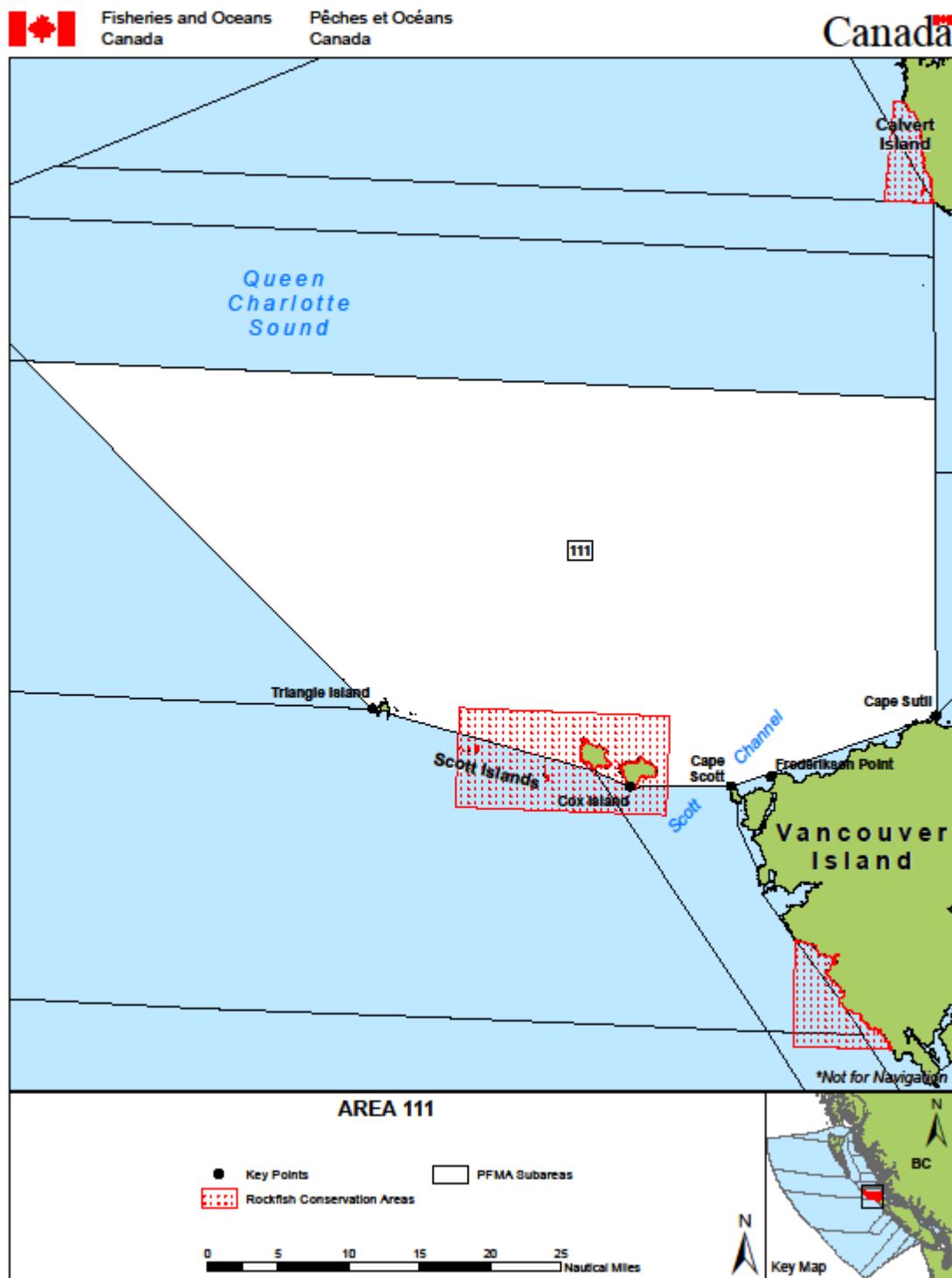## 2.18 Area 111: Open water north of Vancouver Island

Figure 19. Open water north of Vancouver Island DFO Management Area (DFO, 2017).

3.0 REFERENCES

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