

Nearshore Forage Fish Survey

MRC Training, Padilla Bay Dec. 9, 2021

Phillip Dionne, Lisa Hillier, & Kate Olson

Washington Department of Fish & Wildlife

Marine Fish Science Unit



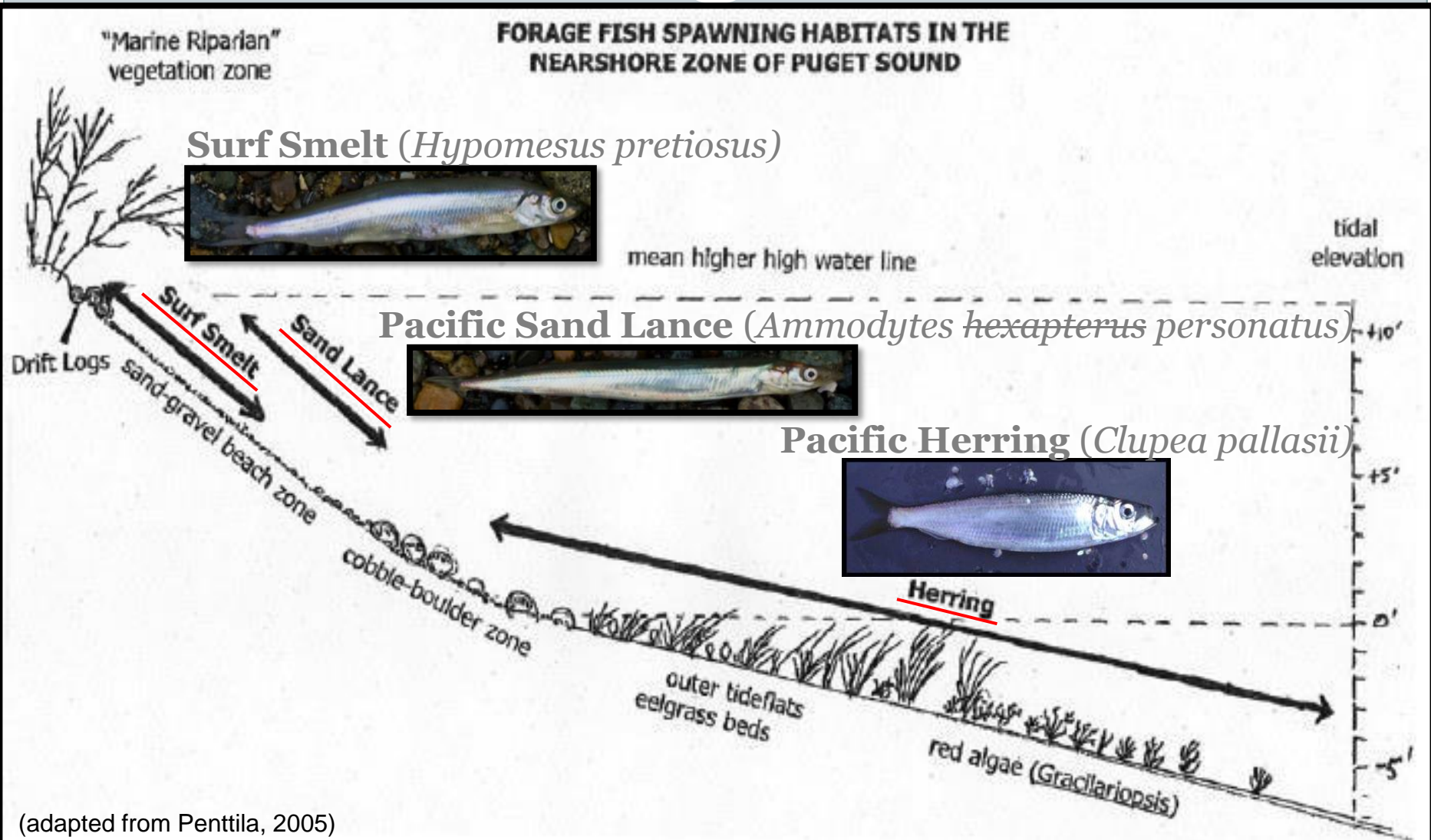
Overview



- **Habitat characteristics**
 - Surf smelt
 - Sand lance
- **Beach survey data**
 - Collect and record data
- **Sample processing**
 - Reduce sample w/ sieves and vortex
- **Lab analysis & egg ID**
 - Find eggs and determine species
- **Wrap up**



Nearshore Spawners:



(adapted from Penttila, 2005)

Surf Smelt Spawning beach attributes

- **Surf smelt (and night smelt?):**
 - **Spawn from +7 ft tidal elev. to extreme high water**
 - **Prefer sand/gravel mix, most sediment in 1-7 mm diameter size range**
 - **Riparian shade is critical, especially in summer**
 - **Helps regulate temperature and relative humidity**
 - **Beyond basic requirements spawning is limited by access to beach; fairly widespread**



Surf Smelt spawning beach



- South Duguala Bay, North Whidbey Island



Photo: D. Penttila

Surf smelt



Sand Lance Spawning beach attributes

- **Sand lance:**
 - **Spawn from +5 ft up to MHHW (and subtidally?)**
 - **Prefer sand, most sediment in 0.2-0.4 mm diameter size range**
 - **Riparian shade not critical**
 - **Spawn in winter**
 - **Tend to spawn lower on beach = more water coverage**



Sand Lance spawning beach



- Miller Bay Spit, Kitsap Co.



Sand Lance Eggs



A photograph showing a collection of small, silvery forage fish, likely anchovies or sardines, scattered on a white surface. The fish are of various sizes and are surrounded by dark, dried seaweed or kelp. The text "Forage Fish Surveys" is overlaid in a blue, outlined font across the center of the image.

Forage Fish Surveys

Surf Smelt & Sand Lance spawn on the beach,
so that's where we look for their eggs.



Beach survey planning



COLLECTION PERMITS?

SITE SELECTION?

**BEACH ACCESS
PERMISSION?**

SAMPLE TIMING?

Beach survey planning



- **When to sample?**

- When the tide is at or below +7' (MLLW) Seattle equivalent for Surf Smelt, or +5' for Sand Lance.

Tidal Range (i.e. Greatest Diurnal Range) = MHHW - MLLW

$$\frac{\text{Local Tidal Range}}{\text{Seattle Tidal Range}} \times 7' = \text{Lower elevation boundary}$$

$$\frac{14.5'}{11.36'} \times 7' = 8.9' \text{ near Olympia}$$

Beach survey planning



- **When to sample?**

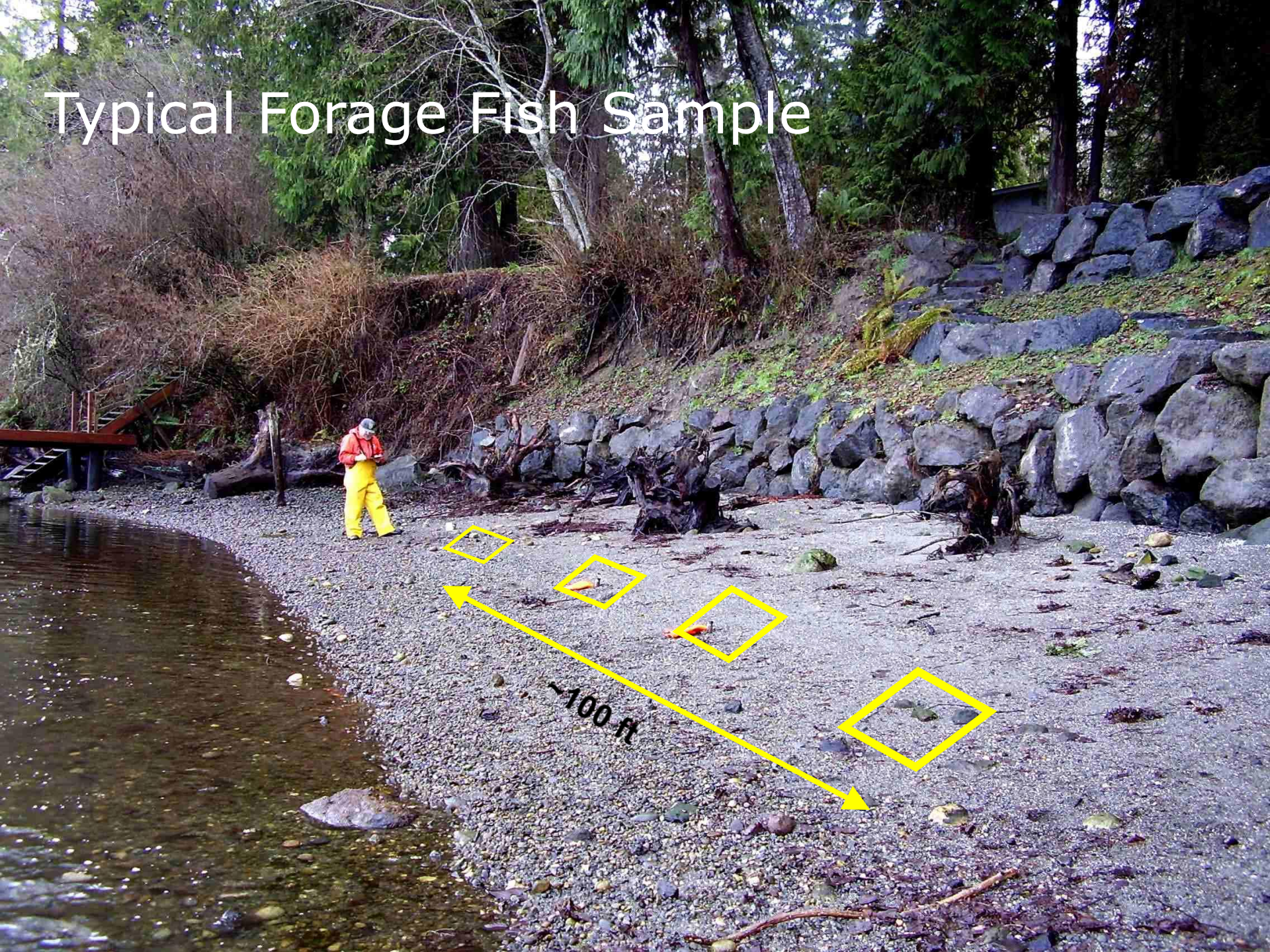
- When the tide is at or below +7' (MLLW) Seattle equivalent for Surf Smelt, or +5' for Sand Lance.

Tidal Range (i.e. Greatest Diurnal Range) = MHHW - MLLW

$$\frac{\text{Local Tidal Range}}{\text{Seattle Tidal Range}} \times 7' = \text{Lower elevation boundary}$$

$$\frac{9.79'}{11.36'} \times 7' = 6.03' \text{ near Point Roberts}$$

Typical Forage Fish Sample



Collecting a bulk substrate sample

- Along the sediment band, take several scoops at 4 areas about 10m (33 feet) apart
 - Scoop the top 1-2 inches of sediment, place in bag
 - Each sample should fill the bag to about $\frac{1}{2}$ to $\frac{2}{3}$ full
- Other bands may be sampled as a new sample with a **new** bag
 - Higher for smelt, lower for sand lance.





Recording Data

- Use the codes provided on the back
- Mark every field
- The “Camera ID” is for your reference to know which device your photos are on
- Indicate the organization you represent and who assisted you

Forage Fish Spawning Beach Survey (see back for codes)

Month	Day	Year	Last High Tide	2nd Effective High Tide	Location:	County:	Page ___ of ___
			Time (24-hr):	Time (24-hr):			
Camera ID:			Elevation:	Elevation:			

Beach Station #	Time (24-hr)	Latitude (decimal degrees)	Longitude (decimal degrees)	Beach Uplands	Width	Length	Sample #	Landmark	Sample Zone	Tidal Elevation	Shading	Sample Type	Smelt	Sand lance	Rock sole	Photo #	Comments
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	

Samplers: _____ Organization: _____
(print names here, sign back) Reviewer: _____

Field Observation Sampling Code

Beach: Sediment character of the upper beach (particle size range in inches)

- 0 = mud (<0.0025)
- 1 = pure sand (0.0025-0.079)
- 2 = pea gravel (0.079-0.31, "fine gravel") with sand base
- 3 = medium gravel (0.31-0.63) with sand base
- 4 = coarse gravel (0.63-2.5) with sand base
- 5 = cobble (2.5-10.1) with sand base
- 7 = boulder (>10.1) with sand base
- 8 = gravel to boulders without sand base
- 9 = rock, no habitat

Uplands: Character of the uplands (up to 100 ft. from high water mark)

- 1 = natural, 0% impacted (no bulkhead, rip-rap, housing, etc.)
- 2 = 25% impacted
- 3 = 50% impacted
- 4 = 75% impacted
- 5 = 100% impacted

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

Length: Length of the beach up to 1,000 feet (500 feet on either side of the station).

Landmark: landmark for determining sample zone where collection occurs

- 1 = down beach from last high tide mark
- 2 = up beach from last high tide mark
- 3 = down beach from second to last high tide mark
- 4 = down beach from upland toe
- 5 = up beach from waterline at the time noted

Sample Zone: Distance of sample zone transect parallel to the landmark, in feet to the nearest ½ foot. Used to determine the tidal elevation of the spawn deposit.

Tidal Elevation: Determined in the office using location and time data provided.

Shading: Shading of spawning substrate zone, averaged over the 100 foot station and best interpretation for the entire day and season

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

Sample Type: S=Scoop; V=Visual; B=Bulk; E=Elevation; C=Core; 3=3S-Bulk

Smelt, Sand Lance, Rock Sole: 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 site photos standing at the center of the site, and record the file number of the 1" photo in the 6 photo series.

***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, then only photos 1 and 2 need 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 in accordance with WDFW approved protocols, and the information I am providing are the true and accurate results of these surveys.**

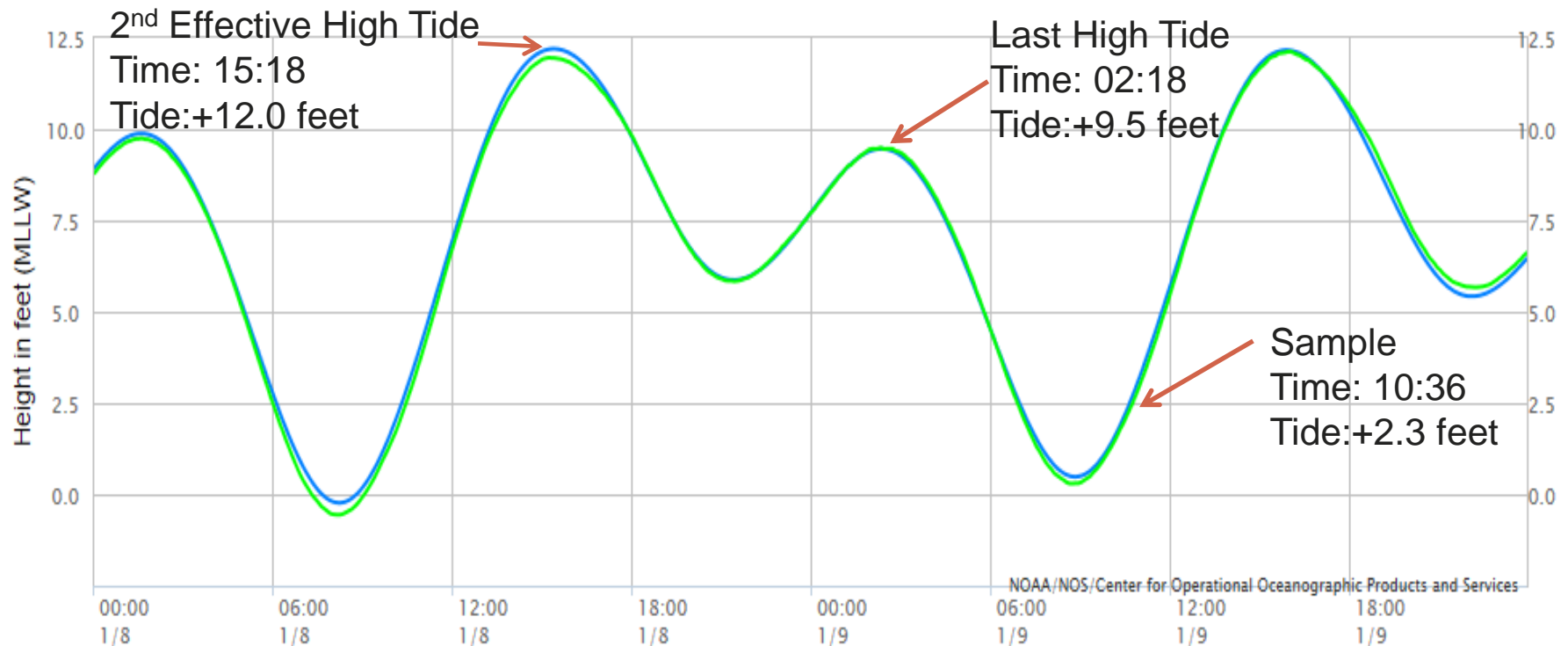
Lead Signature: _____

Field observation sampling codes:

- Use only the codes provided
- Be aware of the units of measurement
- Don't forget to sign the bottom

Tide Elevations

- Record the last and 2nd effective high tide time and elevations before your survey.
- Record the time of your survey in the field, then record the tide elevation when you return to the office.



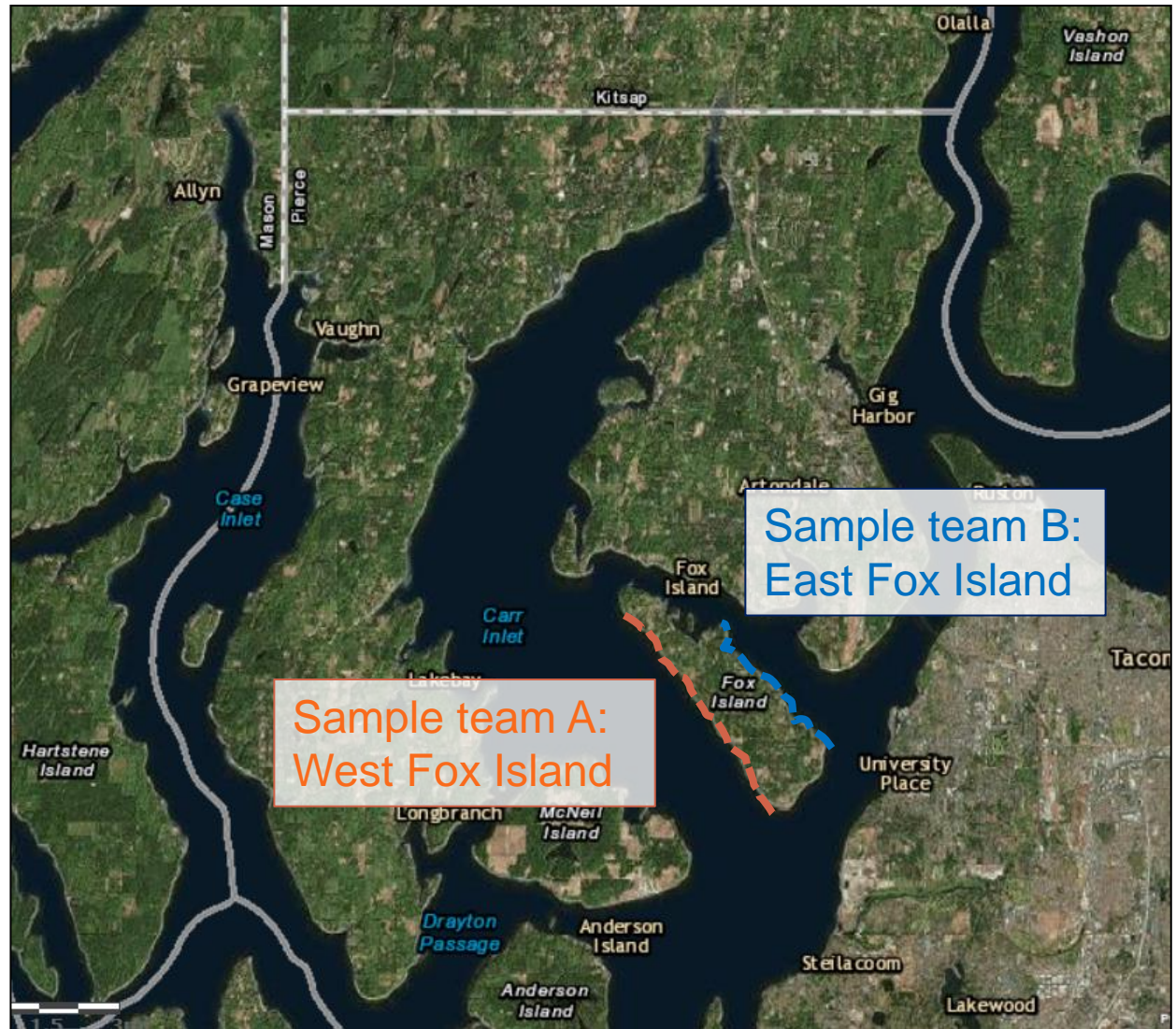
Location:

The location name should be a common name for the area to be sampled.

The name of the inlet, island, beach, etc. are all fine locations.

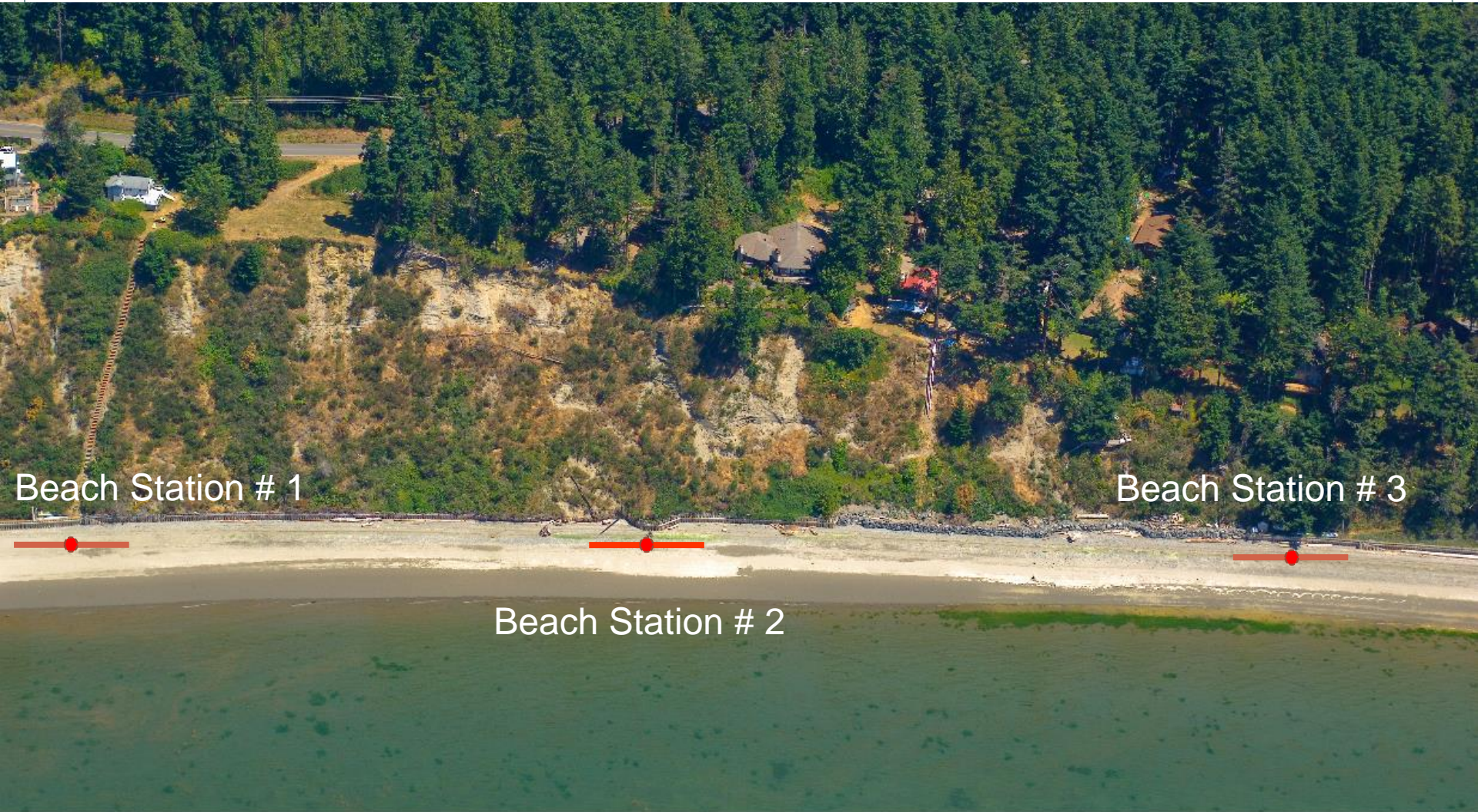
Note: 2 surveys collected on the same date should *not* have the same location.

-This could lead to confusion when matching samples in the lab.



Beach Station # and Lat/Long:

- Each 100' stretch of beach sampled receives its own sequential station #.
- The coordinates should be recorded at the center of the station.



Beach Station # 1

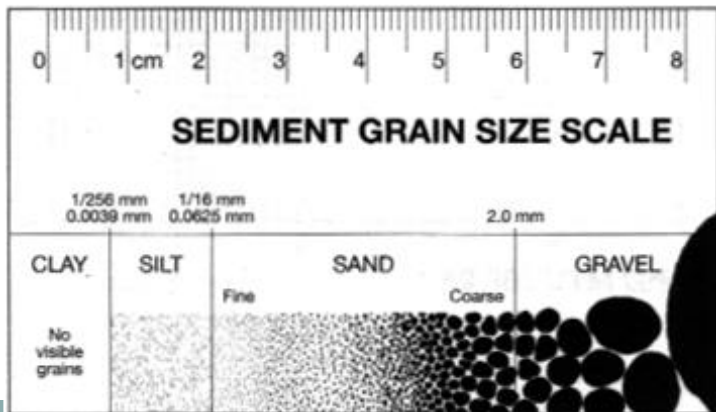
Beach Station # 3

Beach Station # 2

Beach: Sediment character of the upper beach

- Select the code that best describes the sediment on the upper 1/3 of the beach where you will collect your sample
- Use only the codes provided

Code	Description	Inches	millimeters
0	mud	<0.0025	<0.062
1	sand	0.002 - 0.08	0.062 - 2.0
2	fine gravel w/ sand	0.08 - 0.32	2.0 - 8.0
3	medium gravel w/ sand	0.32 - 0.63	8.0 - 16.0
4	coarse gravel w/ sand	0.63 - 2.52	16.0 - 64.0
5	cobble w/ sand	2.52 - 10.1	64.0 - 256
6	<i>No description</i>		
7	boulder w/ sand	>10.1	>256
8	boulder w/ gravel		
9	bed rock, no habitat		



Tennis ball (5) = 2.7 inches; 69mm



Dime (4) = 0.7 inches; 18mm



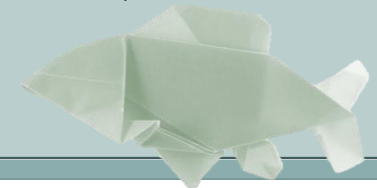
Diameter of Pen (3) = 0.32 inches; 8mm

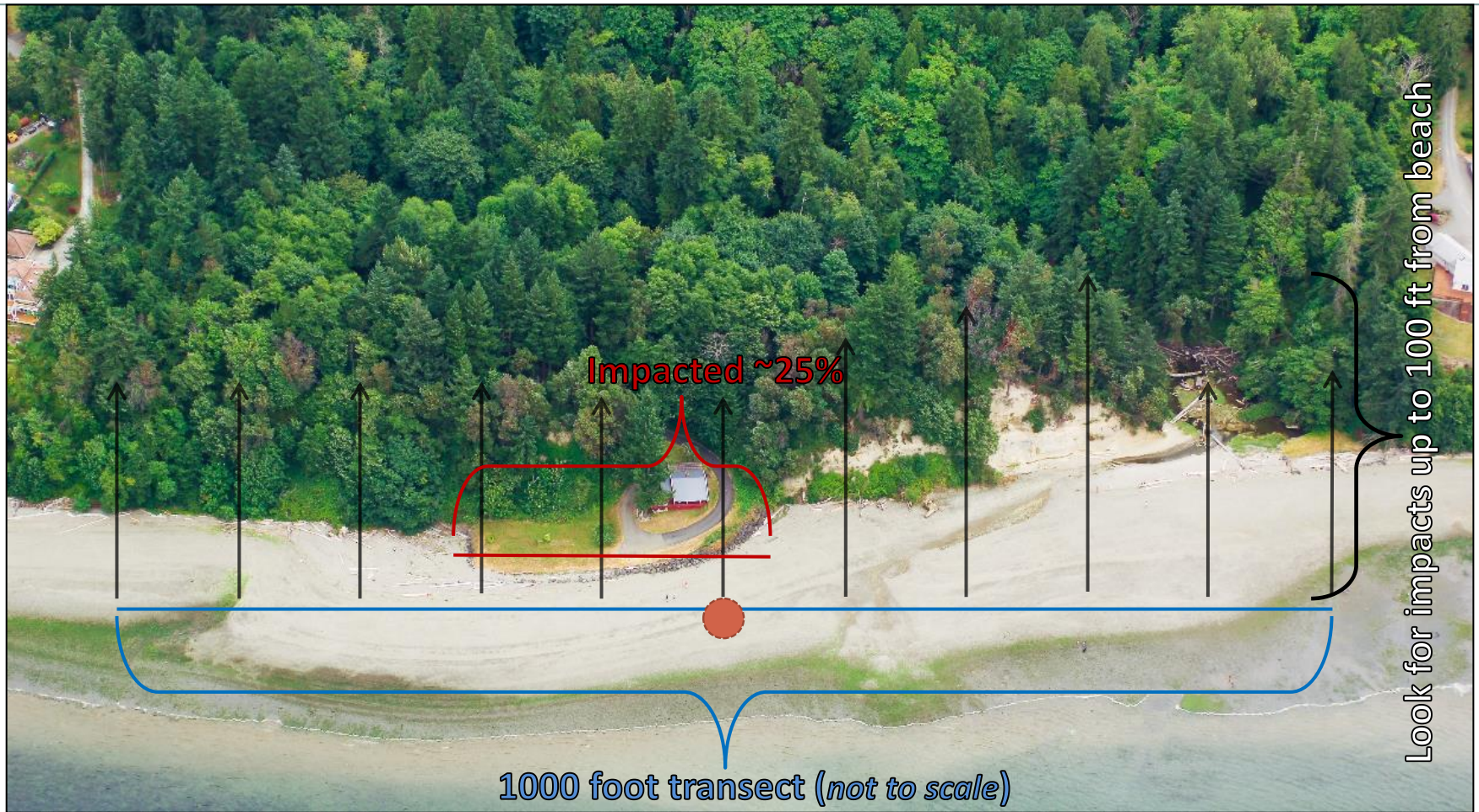


Diameter of Toothpick (2) = 0.08 inches; 2mm



Thin sheet of paper (1) = 0.003 inches; 0.07mm

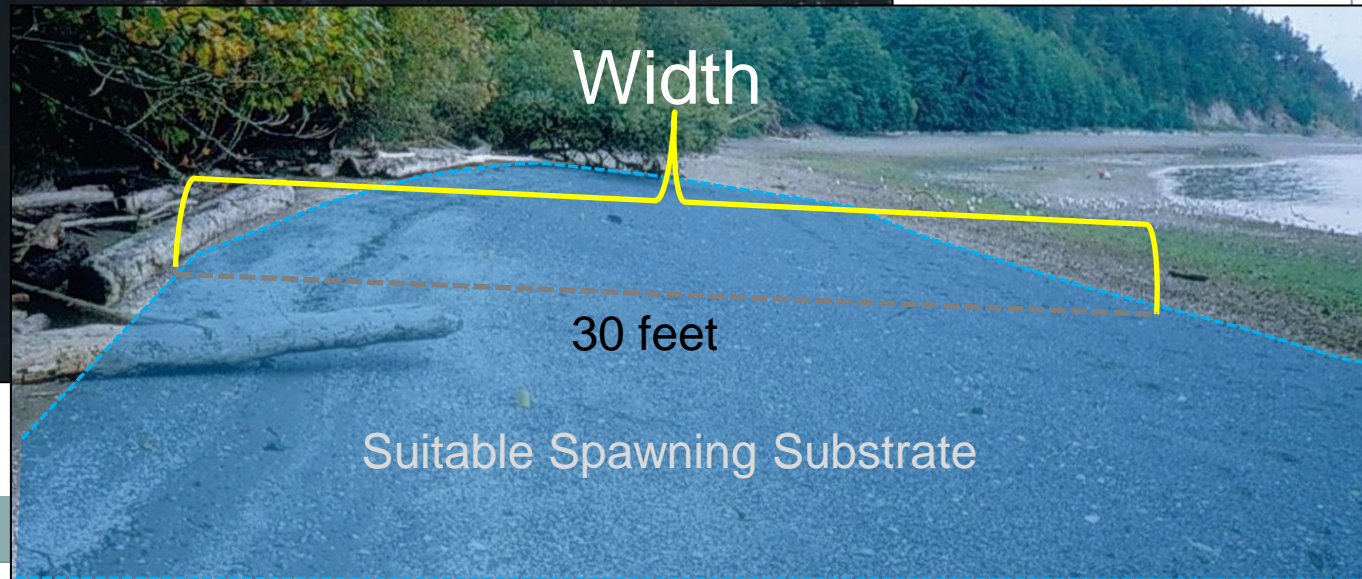
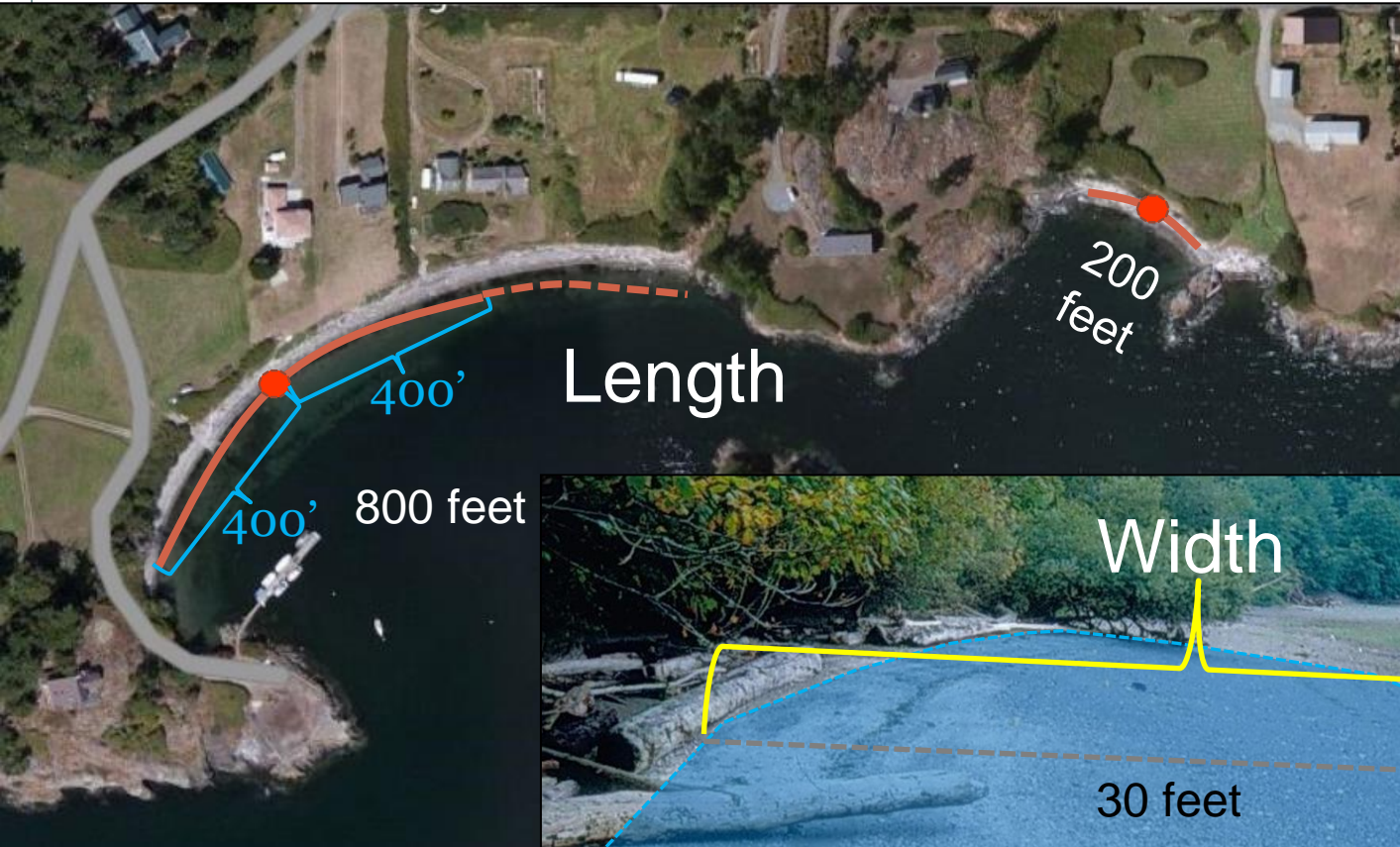




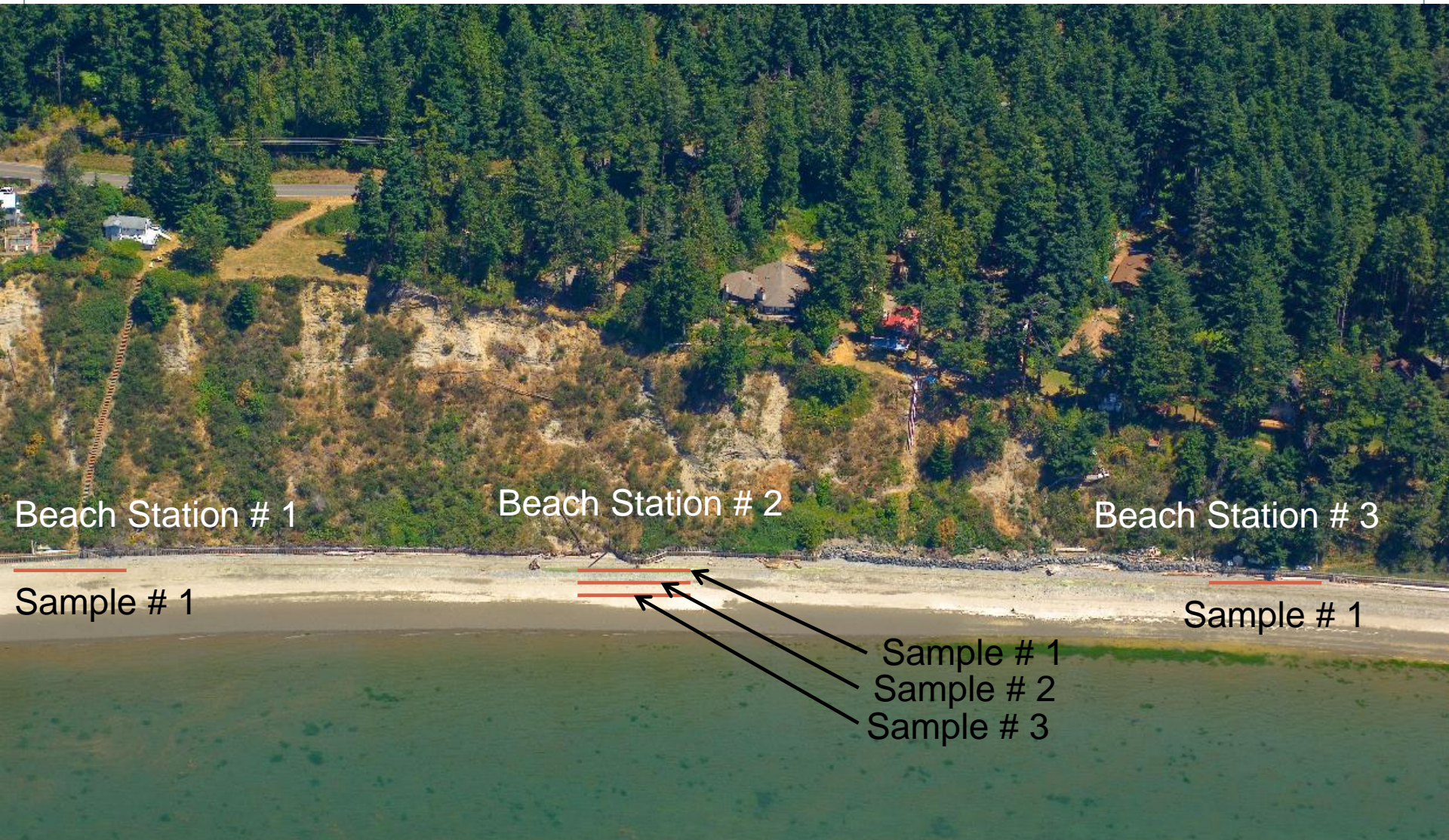
Uplands: Assess the nature (natural or impacted) of the uplands for 500 feet on either side of the center of your sample by looking up to 100 feet landward of the beach. Impacts include large human disturbances such as buildings, roads, bulkheads, clear cuts, etc. Record the impact as the approximate % of the length of the 1000 ft. transect that has visible impacts affecting the beach.

Length and Width

- Length: The total distance in which the substrate continues to look suitable for potential spawning (up to 500' either side of center point, x 2)
- Width: Width of potential spawning substrate



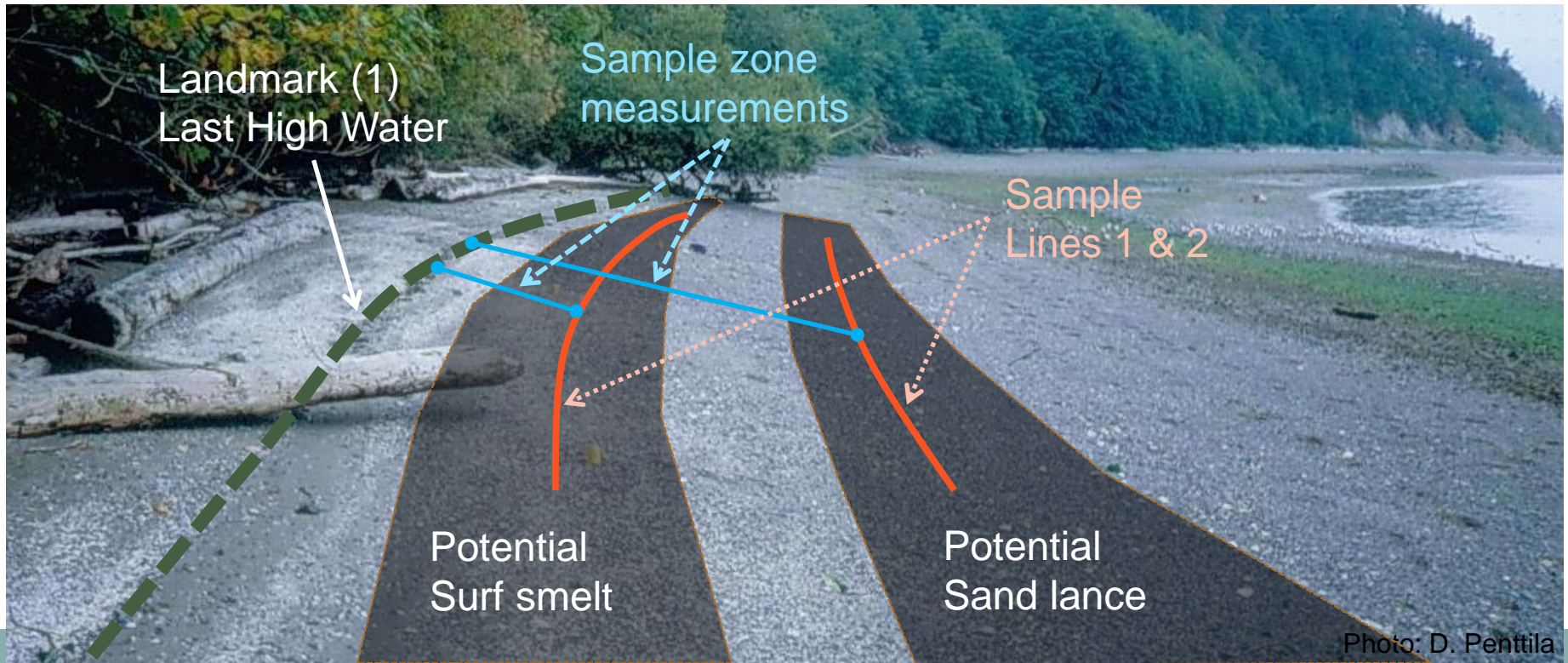
Sample #: There can be multiple samples collected at the same beach station, and the beach station information can remain the same for each sample.



Landmarks and Sample Zones

Landmark: One of five references to be used to measure from to record where on the beach your sample is located.

Sample Zone: The sample zone is the perpendicular distance from your landmark to the line of sediment sampled.



Shading: Estimate the average percent of the beach length you defined (up to 1000') that is 'shaded' by overhanging vegetation.



Sample Type:

The sample type codes indicate how the sample was collected and processed.

This training is for “Bulk” samples (B).



Surf Smelt/ Sand Lance/Rock Sole:

Indicate the relative abundance of eggs observed on the beach with the naked eye, or if eggs were observed during the winnowing process.

0= no eggs observed; L= light but visible; M= medium; H= heavy;
W= eggs only observed during/after winnowing

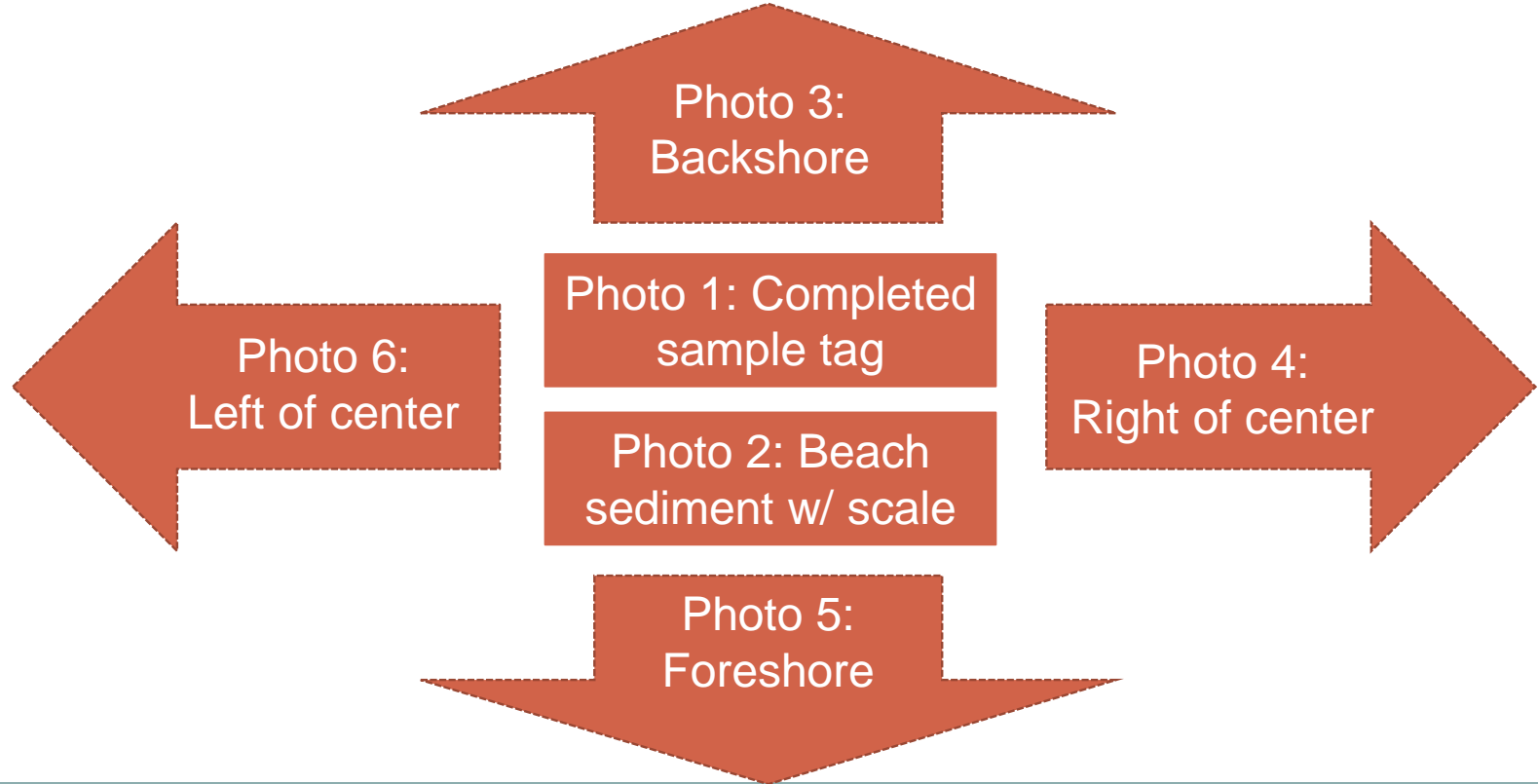


Photos:

Photos should be taken with a GPS enabled device that can record the time and coordinates of the photo.

There will be at least 6 photos taken at each beach station.

Photos will always be taken in the same order and named sequentially with the name of Photo 1 recorded in the "Photo #" field.



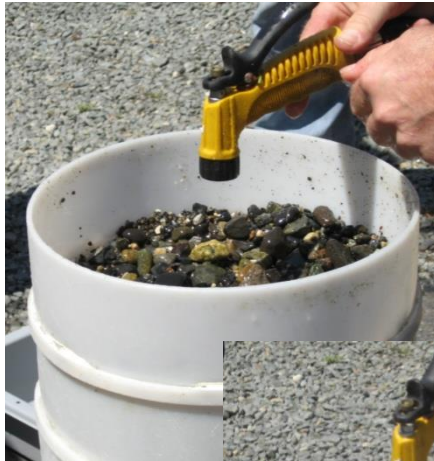
Sample Processing:



- **Sieve**
 - Reduce bulk sample to egg sized material
- **Isolating the light-fraction (winnowing)**
 - Reduce sieved sample to light material similar in density to eggs
- **Lab analysis**
 - Identify eggs in the sample

Sieving/winnowing the sample

- Ensure waste bucket has holes!
- Stack sieves (bottom to top): 0.5 mm, 2 mm, then 4 mm
- Retain only sediment in 0.5 mm sieve, transfer to a square wash basin



Photos: D. Novello

Isolating the “light-fraction”: winnowing method



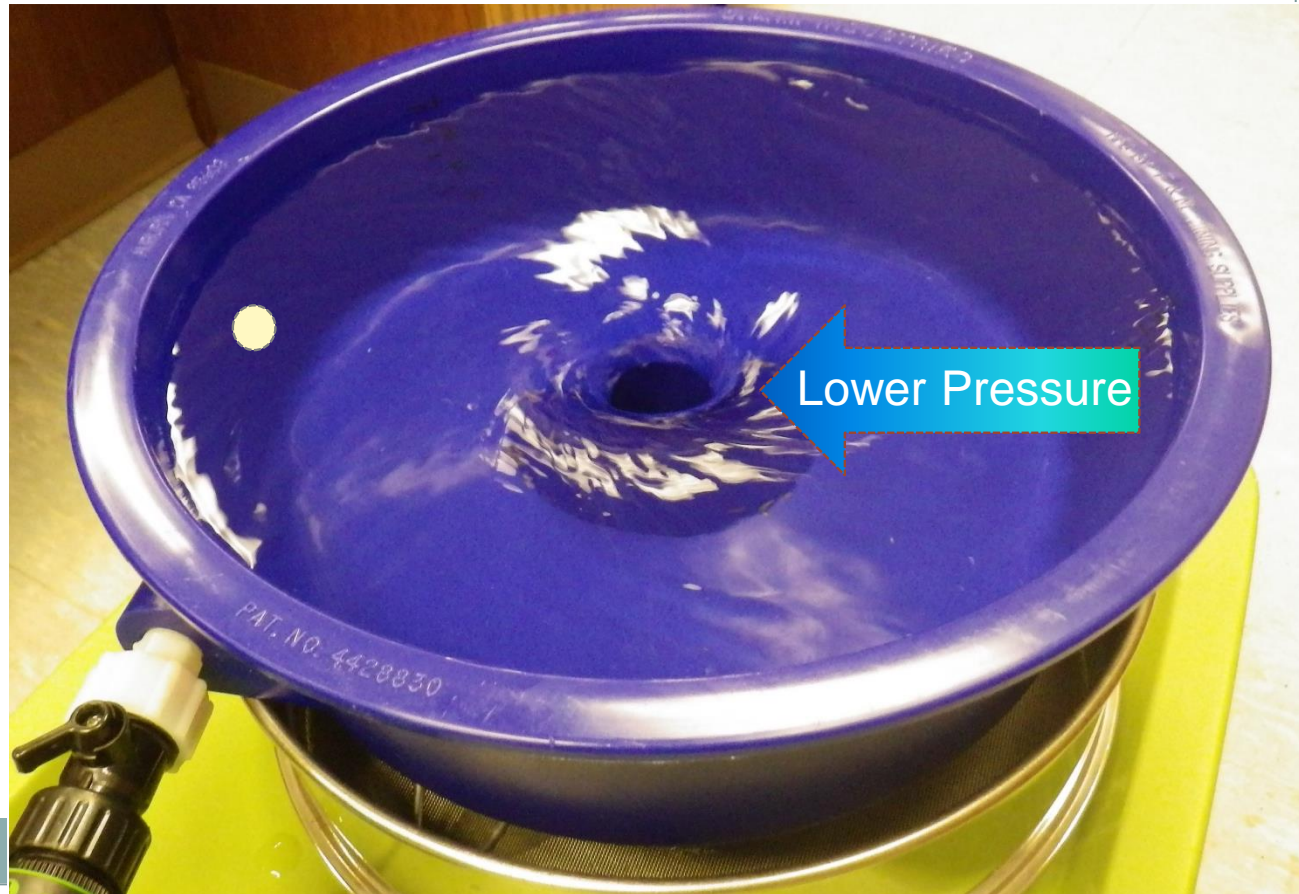
Vortex Method

How it works:



The movement of the water creates a pressure gradient

- Material moves from high pressure to low pressure in the middle



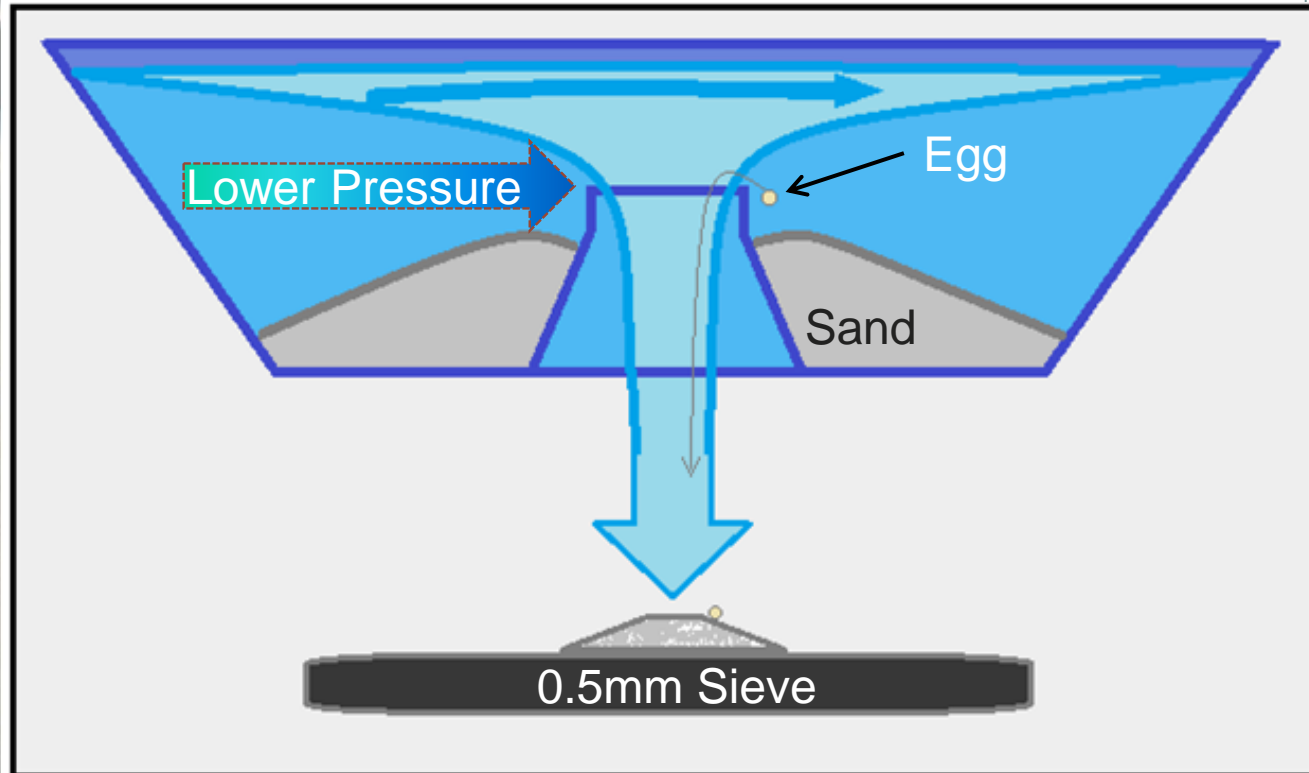
Vortex Method

How it works:



The movement of the water creates a pressure gradient

- Material moves from high pressure to low pressure in the middle
- The elevated cone in the middle reduces the amount of sand that leaves the bowl
- The sieve collects only the material large enough to be an egg



Smelt Egg Extraction Techniques



The image shows two glass jars with white lids on a metal surface. The left jar, labeled 'Winnow', contains a dark, granular substance at the bottom and a clear, yellowish liquid on top. The right jar, labeled 'Vortex', contains a clear liquid with a thin layer of dark granules at the bottom and a white, paper-like strip floating in the middle. The background is slightly blurred, showing a laboratory setting.

Winnow

Vortex

Lab Processing & Egg Identification



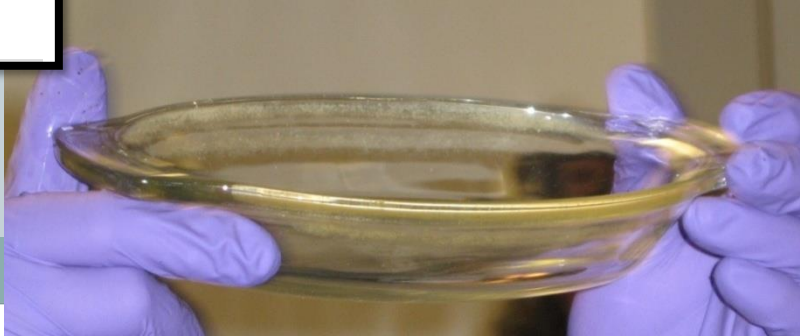
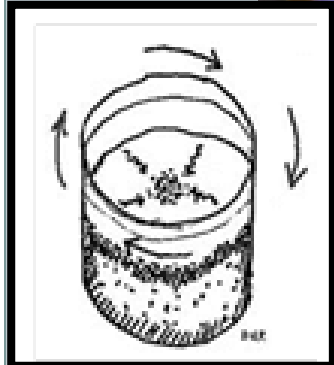
I'm right here!



Laboratory processing and analysis



- Generally, samples processed with the vortex method can be analyzed without further winnowing.
- Process the entire sample.



Egg Identification



What to look for to find eggs

- **Shape:** Eggs are mostly round
- **Size:** Eggs are generally between 0.75mm and 1.5mm
- **Color:** Depending on the condition of the egg, its age and whether it has been preserved, eggs can be clear, white, orange, yellow, or a combination of these
- **Movement:** Eggs are less dense than sand, so they will move more when the petri dish is moved
- **Texture:** Eggs are generally firm and rubbery when squeezed with forceps

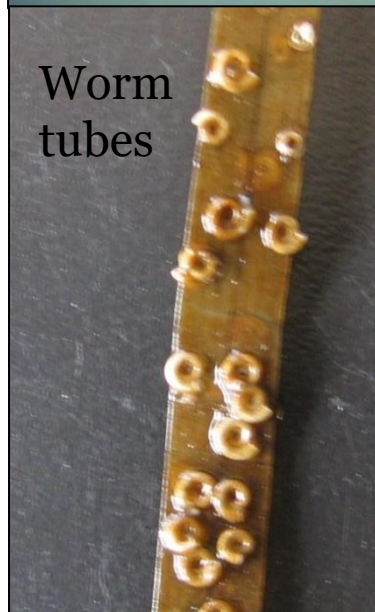
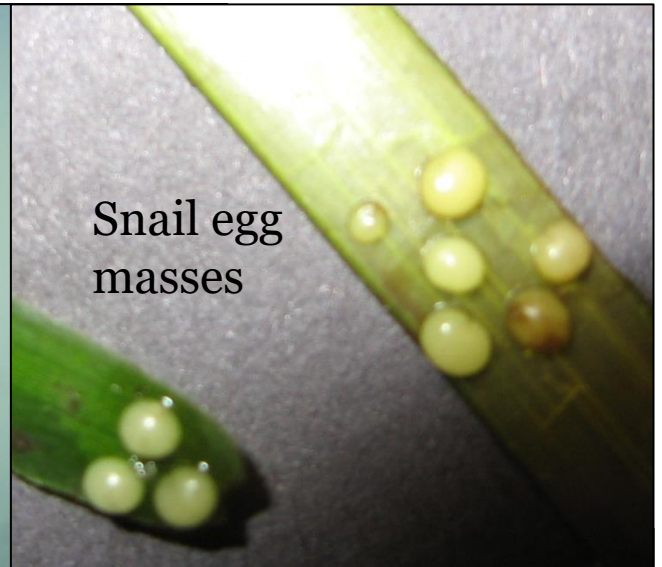
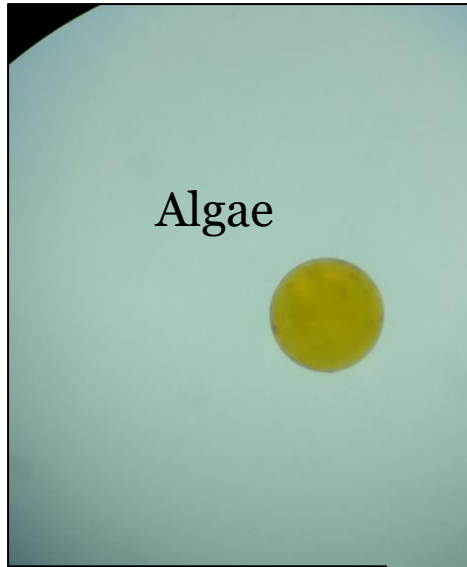


Egg Identification

Just because it's round, doesn't mean it's an egg.

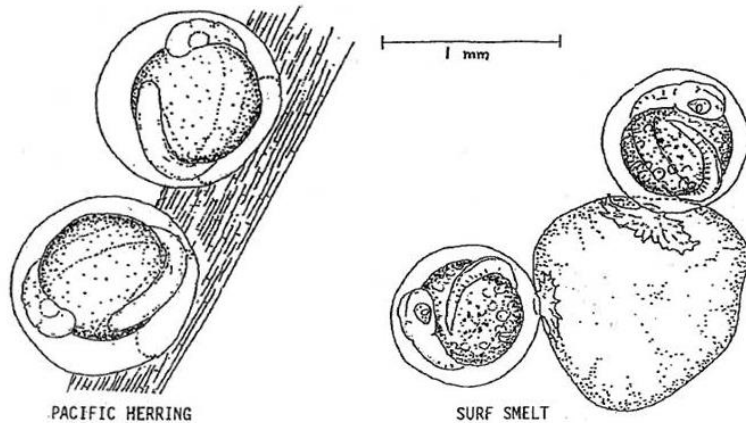
These are the species we typically encounter:

- Herring
- Surf Smelt
- Sand Lance
- Rock Sole



Identification guides

Forage Fish Eggs of Puget Sound

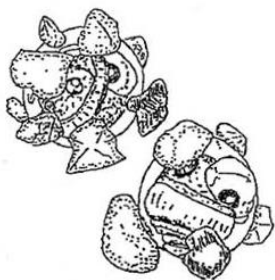


PACIFIC HERRING

almost entirely deposited on marine vegetation; distinct shell attachment sites; self-adhesive in layers or clumps.

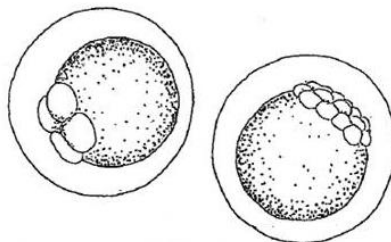
SURF SMELT

single pedestal-like attachment site; non-self-adhesive; entirely in beach sediment particles.



PACIFIC SAND LANCE

relatively small; multiple sand grain attachment sites; egg off-round/milky; 1 large oil droplet in yolk.



ROCK SOLE

egg perfectly spherical; very clear; no visible attachment sites; non-self-adhesive.

D&P

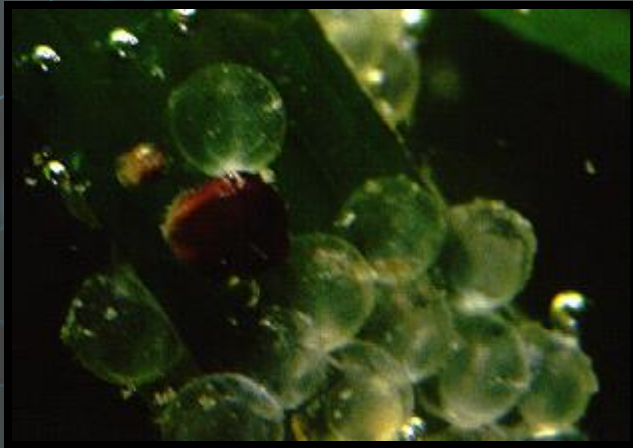
Embryonic Development Stages – Surf smelt



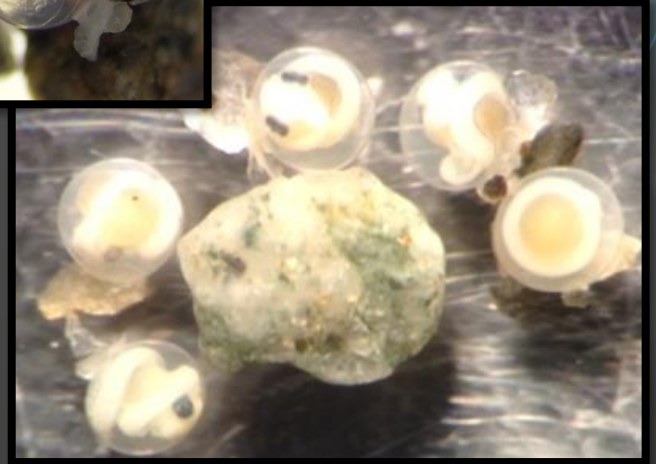
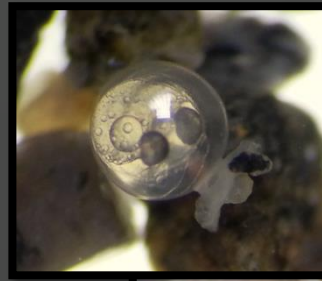
Newly Hatched Larva

D&P

Egg Identification



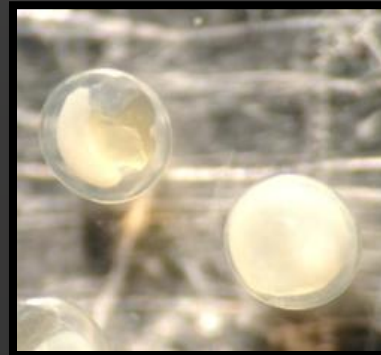
Herring eggs:
*Larger than SS.
Adhesive to
substrate and
each other,
usually in
clusters*



Surf smelt eggs: *larger than SL
and RS eggs; pedestal present;
sediment only attached to
pedestal side*



Sand lance eggs: *smaller than SS
and RS eggs; 'sticky' on all sides;
no pedestal*



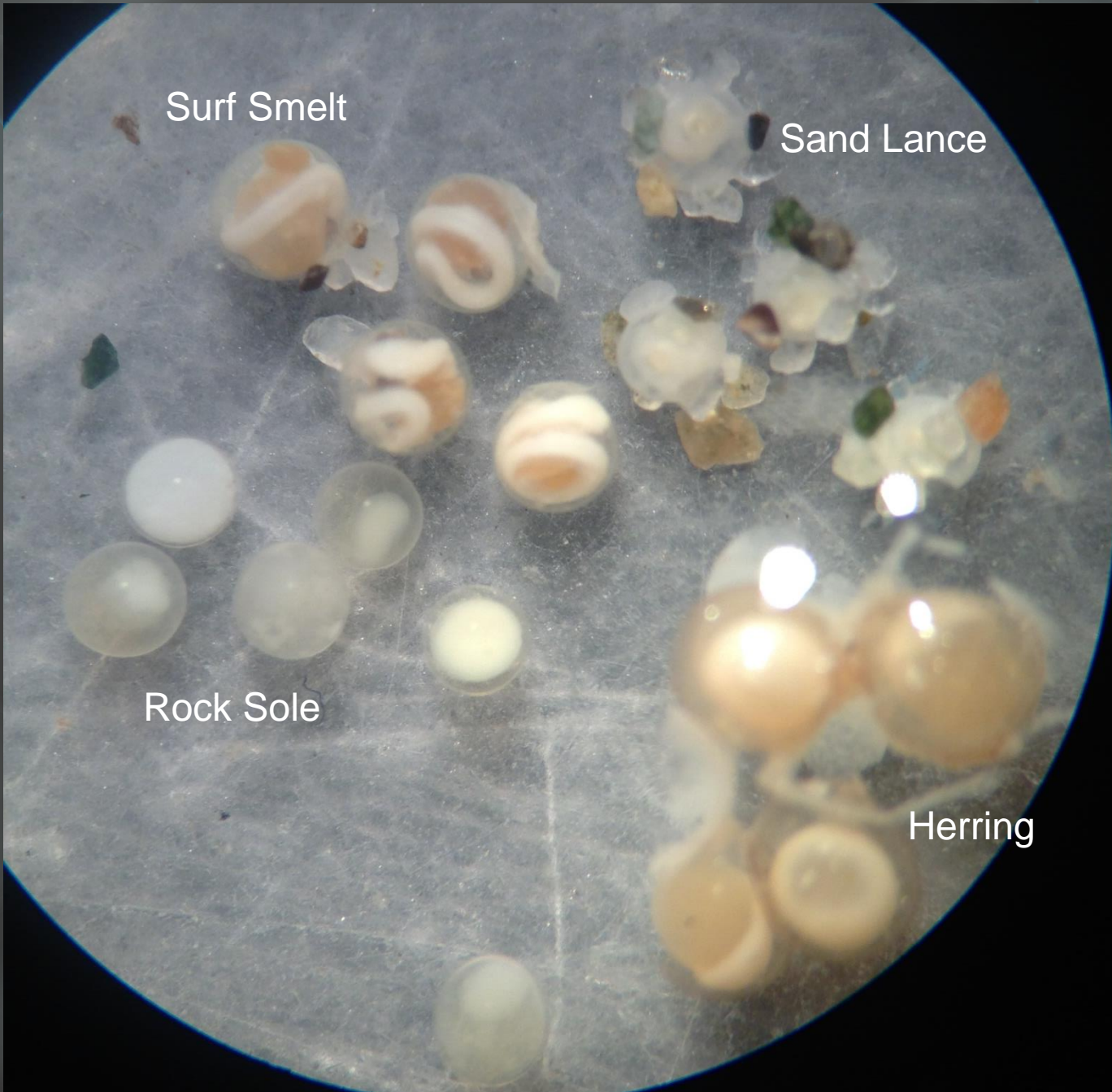
Rock sole eggs:
*smaller than SS
eggs but larger
than SL; no
sediment
attached; no
pedestal*

Surf Smelt

Sand Lance

Rock Sole

Herring



Sand Lance

0.79 mm

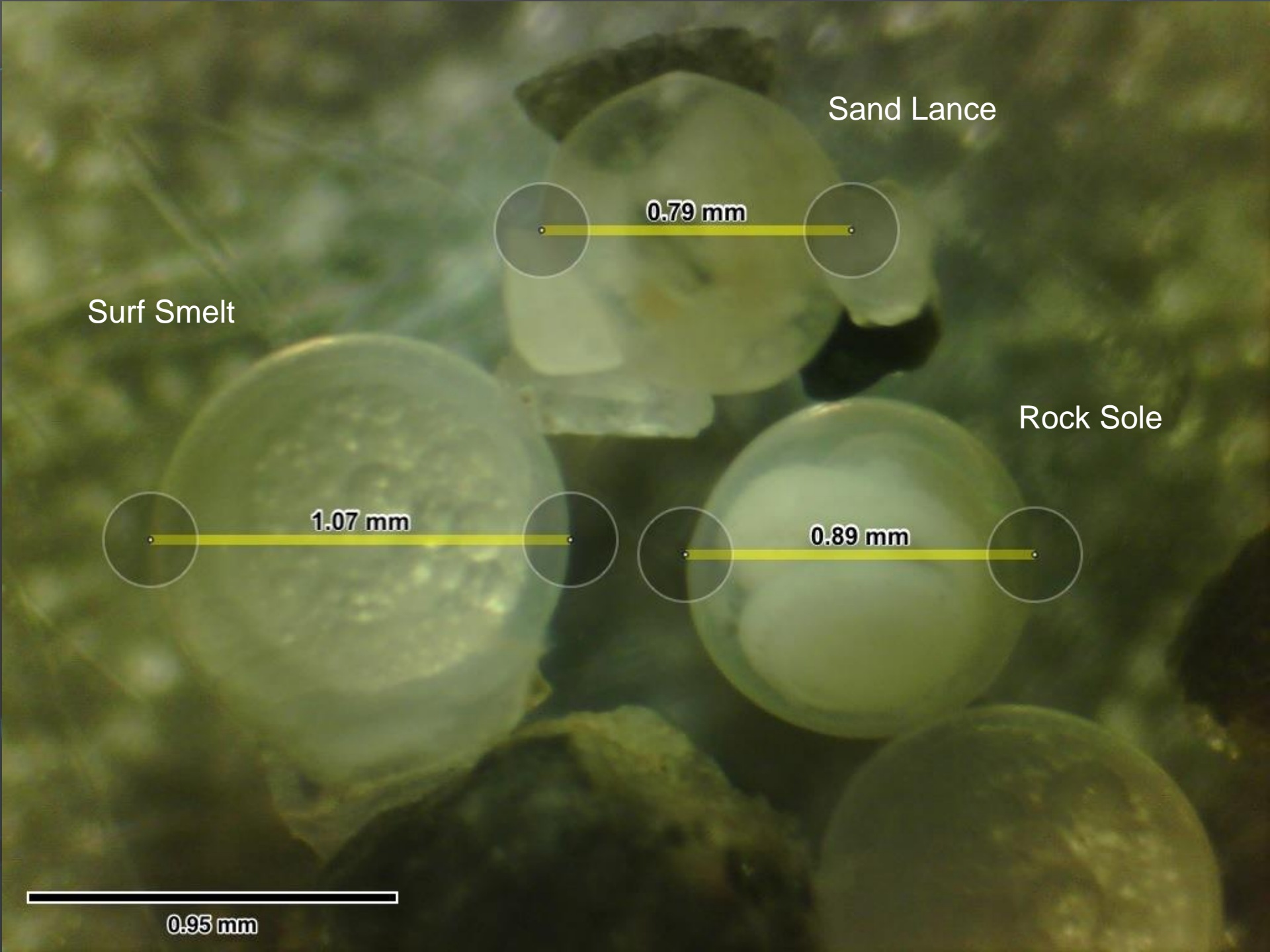
Surf Smelt

1.07 mm

Rock Sole

0.89 mm

0.95 mm



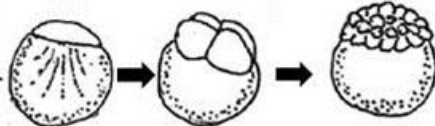
Rock Sole with Surf Smelt



Surf Smelt Embryological Stage Categories

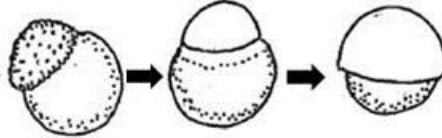
Two-week
Summer
Incubation
Time line

1-5
Hours



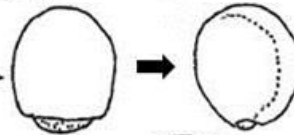
"1-CELL-MORULA": very fresh eggs,
1-cell to roughly 30 cells

6-12
Hours



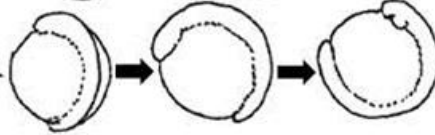
"BLASTULA": granular-caps through
start of gastrulation

14-20
Hours



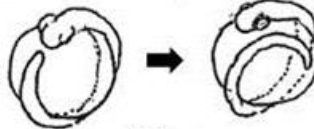
"GASTRULA": yolk=plug stage
through start of neurulation

1-2
Days



"ONE-HALF COIL": distinct
notochord axis to $\frac{7}{8}$ coil embryo

3-5
Days



"ONE-COIL": nose nearly to tail tip
to 1- $\frac{1}{4}$ 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



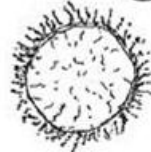
"Dead"



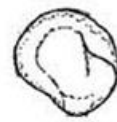
Opaque
white



Indiscernible
embryo



Fungus
covered

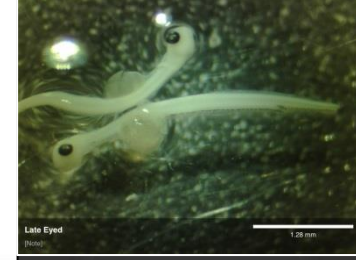
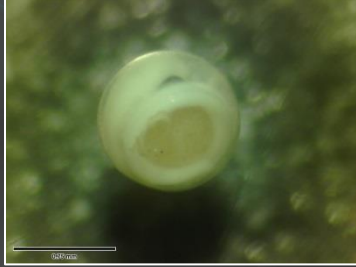


Collapsed



Empty

DEP.



“Dead” eggs



0.75 mm



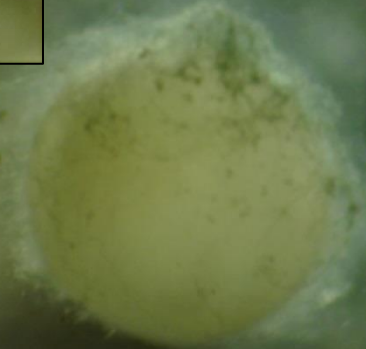
0.75 mm



0.75 mm

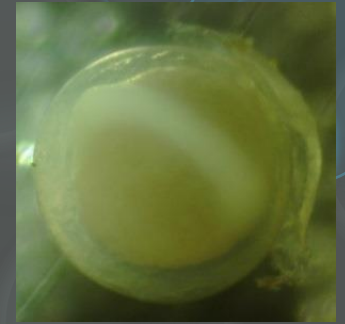
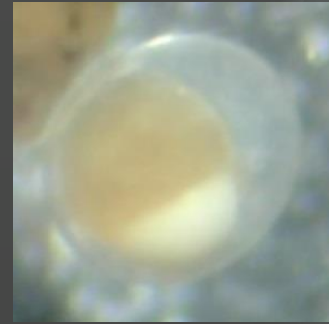


0.75 mm

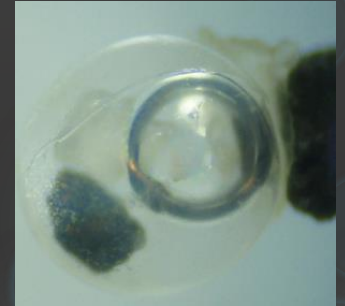
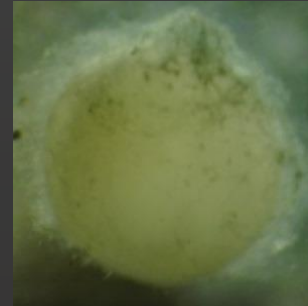
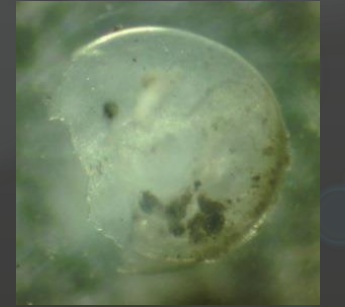
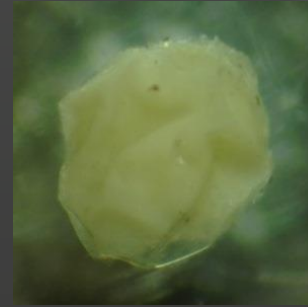
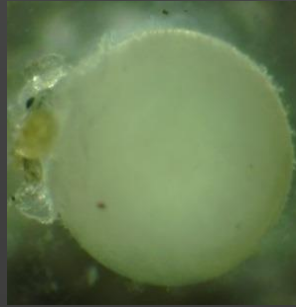


0.75 mm

“Live” eggs



“Dead” eggs



Lab Analysis Form

Sample Location: _____

Forage Fish Spawn Sample Analysis

Page ____ of ____

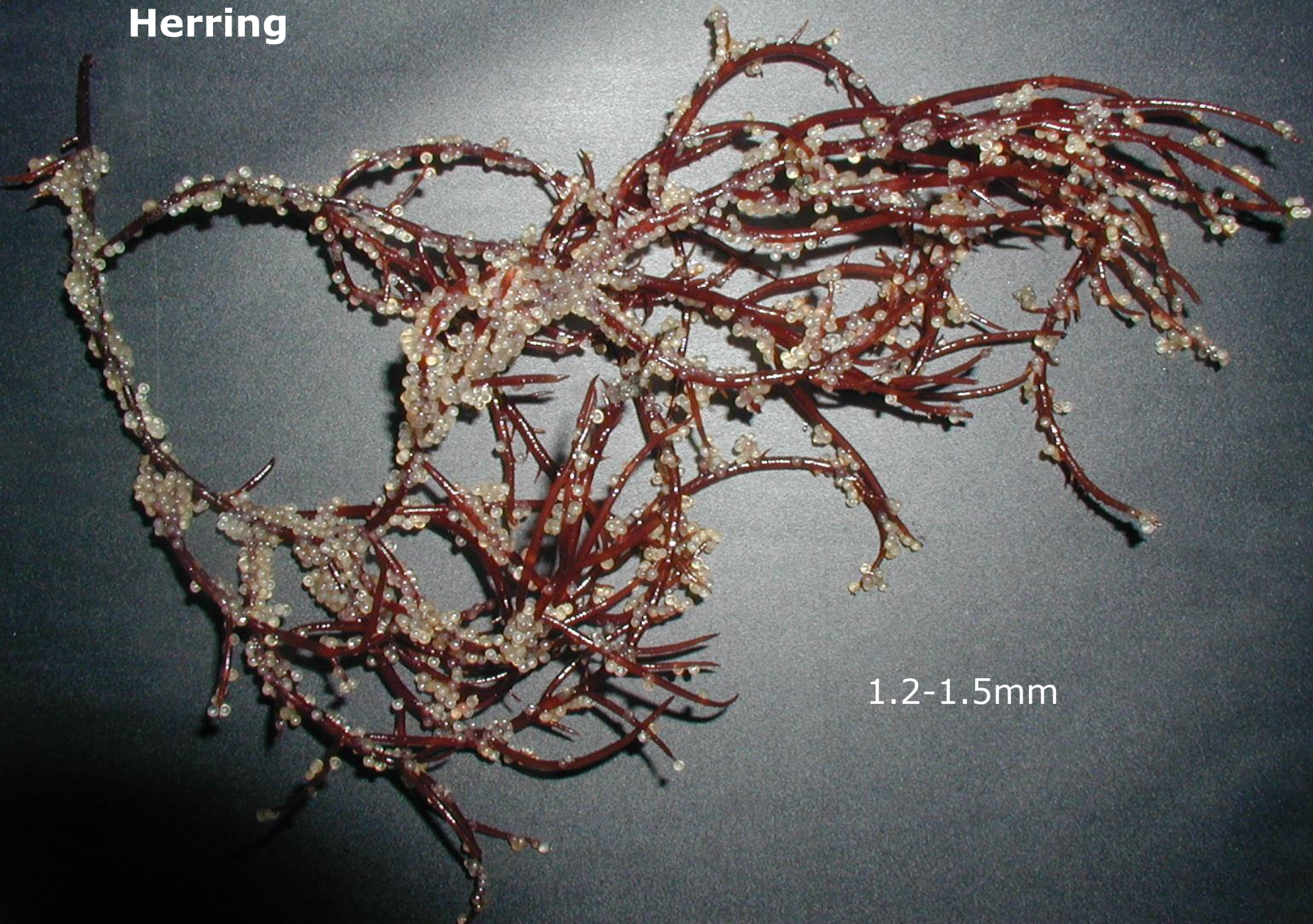
Date (mm/dd/yyyy): ____ / ____ / ____

Recorder _____

Beach Station #	Sample #	Species	1 cell to morula	Blastula	Gastrula	1/2 - 1 coil	1 coil	1 1/2 coil	>1 1/2 coil	Late eyed	Dead	# eggs	% Dead	Est. # brood	Comments
		SS													
		SL													
		RS													
		SS													
		SL													
		RS													
		SS													
		SL													
		RS													
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		SL													
		RS													

Collected By: _____

Herring



1.2-1.5mm

HERRING EGGS 3-2-04
ABOUT +3 TIDE LEVEL
COUNTRY CLUB BEACH
CAMANO IS



Not Herring Eggs

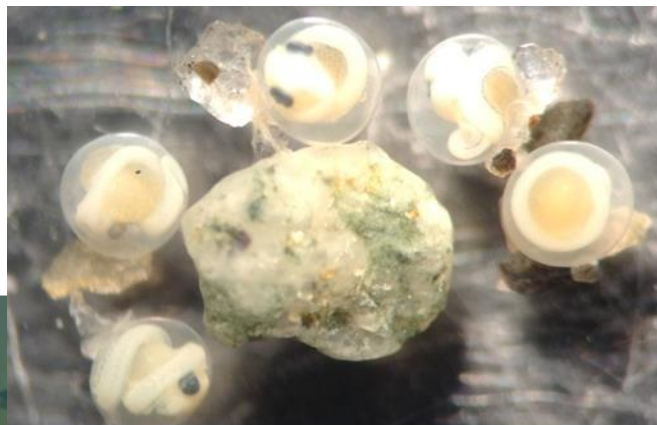
Not Herring Eggs



Not Herring Eggs



Questions?



Resources

- Web-based info available
 - Contains identification guides, and other materials.
 - Vortex Method:
<https://wdfw.wa.gov/publications/02022>
 - Field Manual:
<https://wdfw.wa.gov/publications/01209>
- Forage Fish Map
 - Interactive map of documented surf smelt and sand lance beaches
wdfw.wa.gov/conservation/research/projects/marine_beach_spawning/

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Species & Ecosystem Science

Marine Beach Spawning Fish Ecology

Surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexactylus*) are important food for marine mammals, birds, and fishes, including Pacific salmon. The Washington Department of Fish and Wildlife protects these fish species and their spawning habitat by limiting human activities under the terms of a permit (called the Hydraulic Project Approval, HPA) on beaches where spawning has been documented. Scientific surveys have sampled many of the beaches in Puget Sound, however, despite good information on the distribution of spawning beaches our understanding of the ecology and protection needs for these species is very limited. The Washington Department of Fish and Wildlife conducts research that will allow us to better ensure adequate protection of Pacific sand lance and surf smelt given current and anticipated environmental conditions, without unnecessarily containing human activity.

Publications & Posters

- Surf Smelt Red Sheet, Biology and Fisheries
- Effects of Sea Level Rise and Bank Protection Structures on the Spawning Habitat of Two Beach Spawning Fishes
- Anticipated Effects of Sea Level Rise in Puget Sound on Beach-spawning Fishes
- Spatiotemporal Detection of Forage Fish Eggs Derived from Long-term Spawning Surveys
- Modeling Forage Fish Spawning Habitat Suitability on Camano Island

Forage Fish Beach Survey Training Materials

Disclaimer: The files below contain background and survey protocol information for conducting forage fish spawning beach surveys. All surveys conducted by individuals not employed by WDFW require a scientific collection permit or memorandum of understanding from WDFW. Surveys related to HPA permits may only be conducted by WDFW or an approved biologist (WAC 220-110-274). To get details on how to become an approved biologist contact Philip Dianne, philip.dianne@doh.wa.gov, 206-202-2547.

- Forage Fish Spawning Beach Survey Training, with notes
- Key Points about Intertidal forage fish spawning habitat
- Forage Fish Spawning Beach Survey Manual (Moulton and Penttila 2001)
- Survey protocol handouts:
 - Bulk sediment sample collection (FF-01)
 - Bulk sediment sample processing (FF-02)
 - Laboratory analysis – presence/absence (FF-03)
 - Laboratory analysis – quantitative assessment (FF-04)

Spawning Location Map

The map below shows the documented spawning locations of Pacific Sand Lance, Surf Smelt, and Pacific Herring in Washington State. This map should not be considered all inclusive of spawning habitat because not all potential spawning habitat has been surveyed, and it is possible for surveys to fail to detect eggs even when eggs are present.

Details Legend

These data were collected by WDFW staff with con... esri