Intertidal Spawning Forage Fish Beach Surveys

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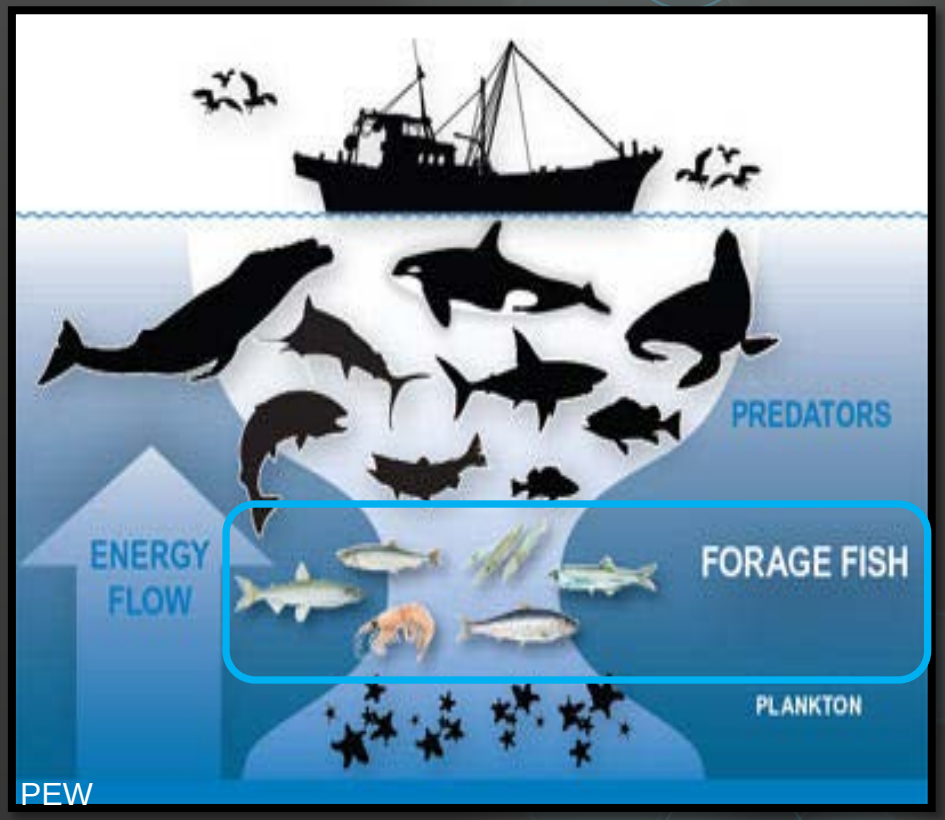
Forage fish are:

- An ecological, not necessarily genetic, group
- Generally small, abundant, schooling fish that occupy middle tier of food webs
- A vital conduit between primary producers and higher level marine/terrestrial consumers
- Commercially, recreationally, and culturally important around the world
- Currently account for over 1/3 of overall marine harvest by weight
- A valuable indicator species of ecosystem health



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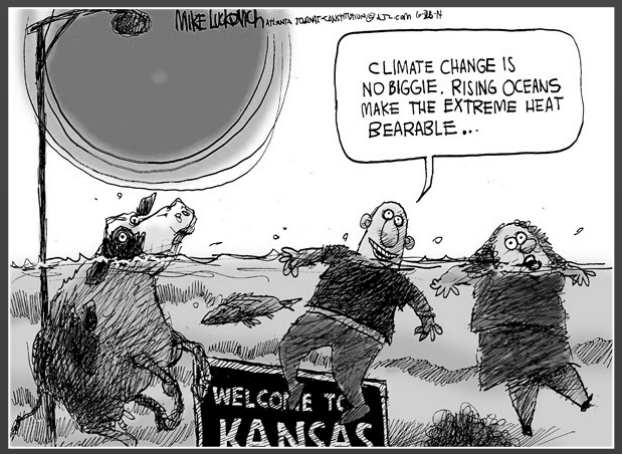
Challenges Facing Forage Fish

Forage fish are susceptible to:



Climate change

Over fishing

www.deviantart.com/art/Water-Pollution-49872

Poor water quality

Habitat Loss

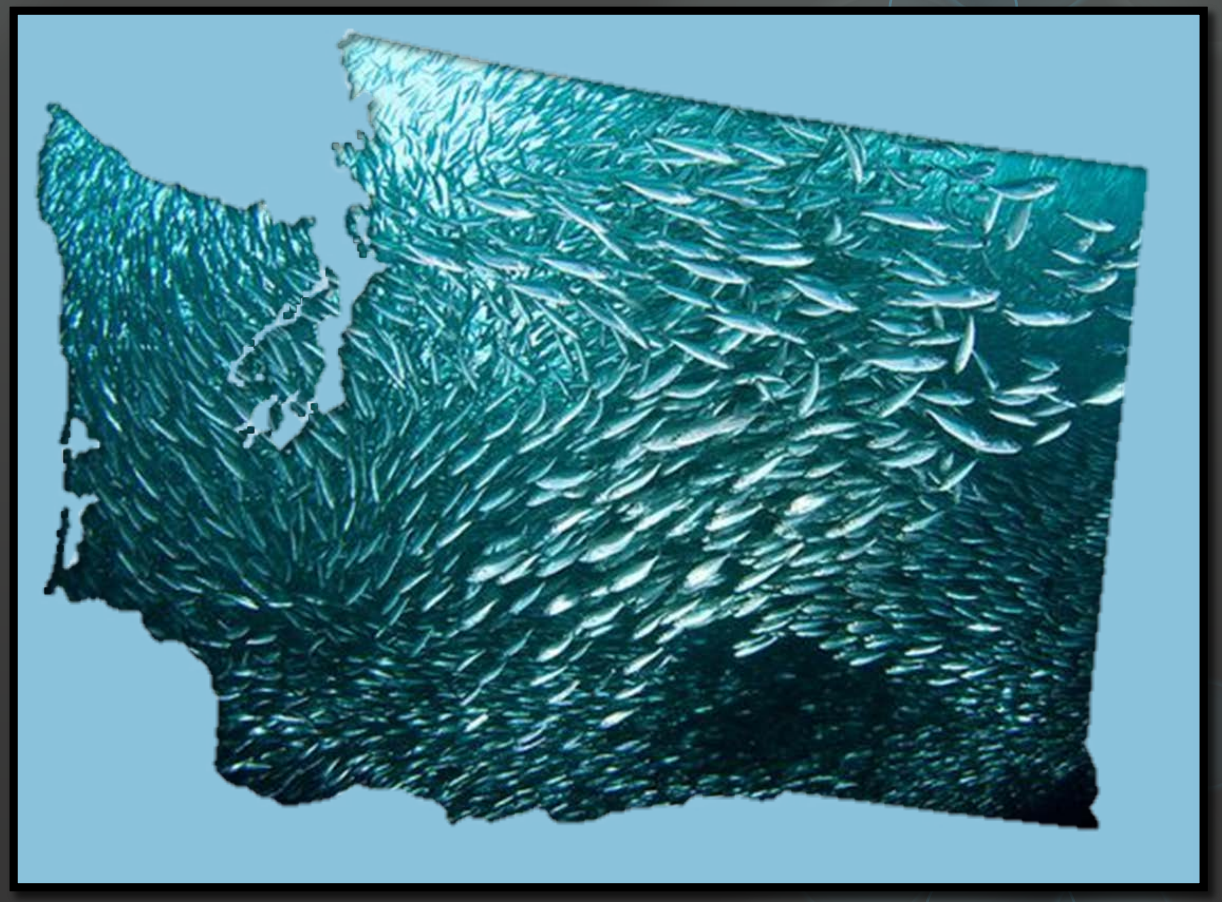
Common Marine Forage Fish of WA State

Spawning Habitat:

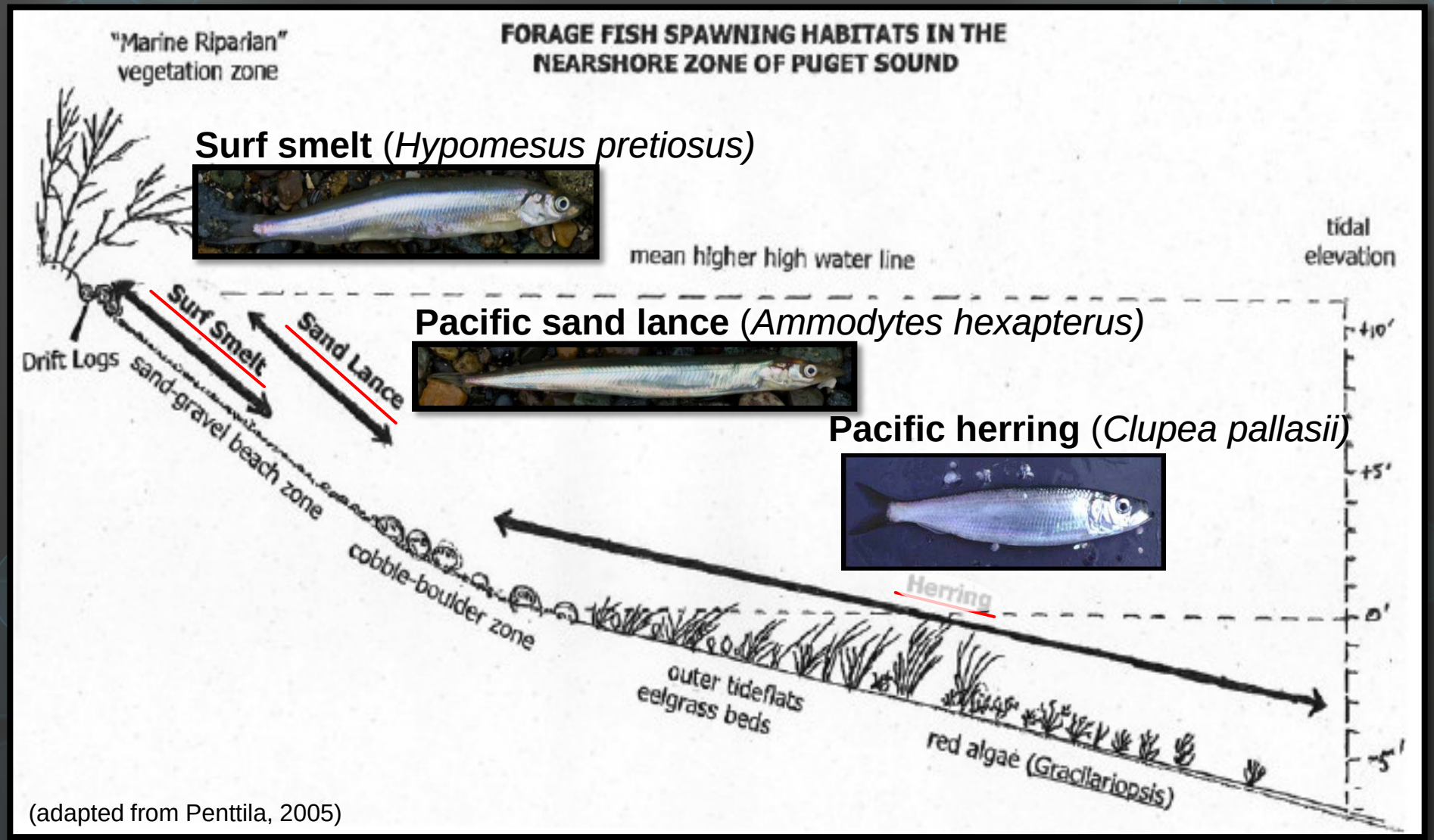
-Open water (pelagic)
- -Anchovy
- -Sardine

-River (anadromous)
- -Eulachon
- -Longfin Smelt

-Nearshore
- -Herring
- -Sand Lance
- -Surf Smelt



Nearshore Spawners:



(adapted from Penttila, 2005)

Sand Lance

- Spawn intertidally throughout Puget Sound during winter
- Utilize deep water sand waves
  - Little else known about life history, ecology
  - No population estimates or stoc delineation work to date
- Habitat protection
  - About 118 miles of spawning beach documented
  - Spawning habitat= no net loss (WAC 220-110)

Surf Smelt

- Spawn intertidally in Puget Sound Year round
  - North Sound, peak spawning in Summer
  - South Sound, Peak Spawning in Winter
  - Preliminary genetics indicates single Puget Sound population
  - Little known about life history, ecology away from beaches
- Habitat protection
  - About 266 miles of spawning beach documented
  - Spawning habitat = no net loss (WAC 220-110)

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**
  - **Spawn depth 1-10 cm (coincides with sediment)**
  - **Tend to spawn toward center of drift cells**
  - **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

Surf smelt spawning beach

- South Dugualla Bay, North Whidbey Island

Photo: D. Penttila

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**
  - **Tend to spawn toward distal ends of drift cells**
  - **Riparian shade not critical**
    - **Tend to spawn in winter**
    - **Tend to spawn lower on beach = more water coverage**
  - **Because they may spawn subtidally, beach surveys may not reflect total spawning area**

Spawning pit detail

- 6-10 inches in diameter
- Generated by motion of spawning aggregation

Photo: D. Penttila

Sand lance spawning beach

- Miller Bay Spit, Kitsap Co.
  - Note lack of vegetation, low slope, “muddiness”

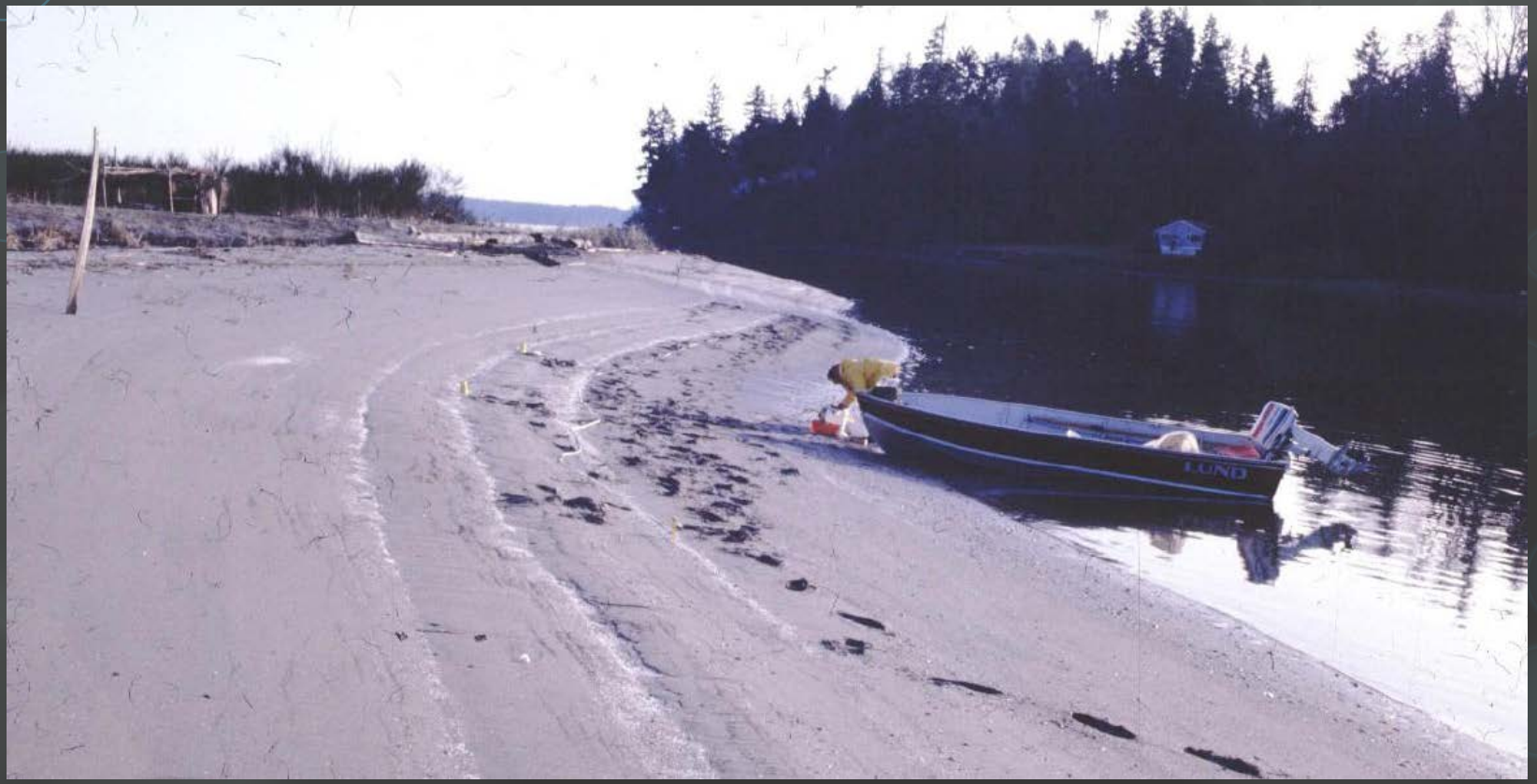


Photo: D. Penttila

Planning:

Goals of spawning beach surveys

- Presence/absence surveys for new spawning areas, or to verify known sites
- Quantitative evaluations of spawn abundance and specific timing
- Scientific evaluations of site preference, correlated variables, genetic structure of populations, etc.
- Regulatory assessments

Planning:

Beach surveys

- Survey site selection can be driven by:
  - Exploratory investigation for presence
  - Nearshore construction permits (HPA application)
  - Comparison with historic work, or convenience
  - *Exact location depends on species of interest, sample processing varies based on question*
- Survey timing
  - Spawning season varies by species and region
  - Sample at lowest feasible tide, be sure the water level will be below the preferred spawning elevation when you sample
  - Seasonal issues arise; may need night sampling
- **Before sampling the goal should be clear.**

Planning:

Collection Permits

Any forage fish beach survey not under direction of WDFW staff requires a Scientific Collection Permit (Bruce Baker, WDFW) or a written Memorandum of Understanding (Phillip Dionne, WDFW).

Please send data for completed surveys to WDFW

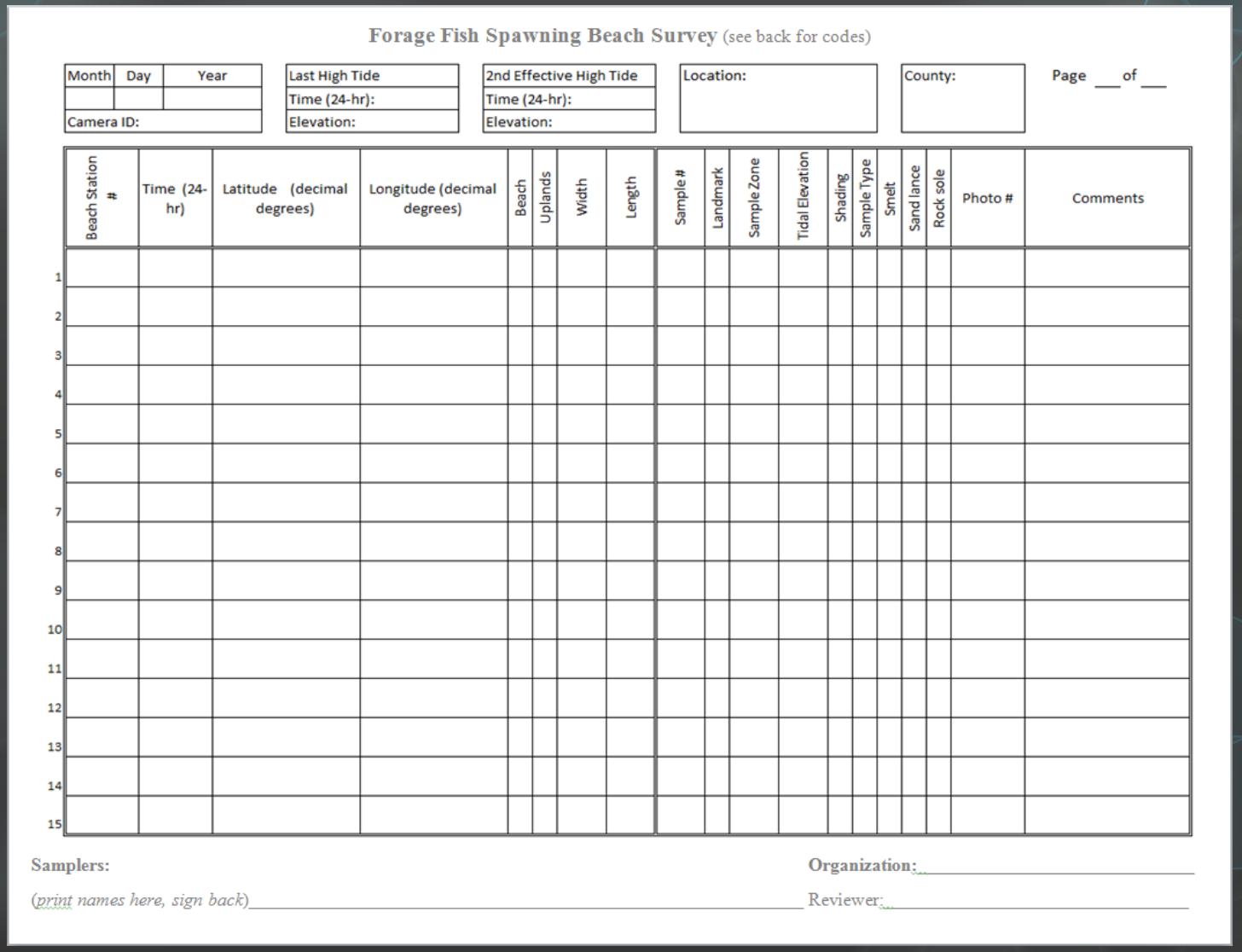
If sampling more than one site

- Be sure to rinse your sample gear between samples to avoid false positives
- Be mindful to not transport invasive or aquatic nuisance species *http://wdfw.wa.gov/ais/*

All images from Google

Data Sheet:

- Use the codes provided on the back
- Mark every field



Forage Fish Spawning Beach Survey (see back for codes)

Month	Day	Year
Camera ID:		

Last High Tide
Time (24-hr):
Elevation:

2nd Effective High Tide
Time (24-hr):
Elevation:

Location:

County:

Page ___ of ___

	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:

(print names here, sign back)

Organization:

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 1st 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 the these surveys.**

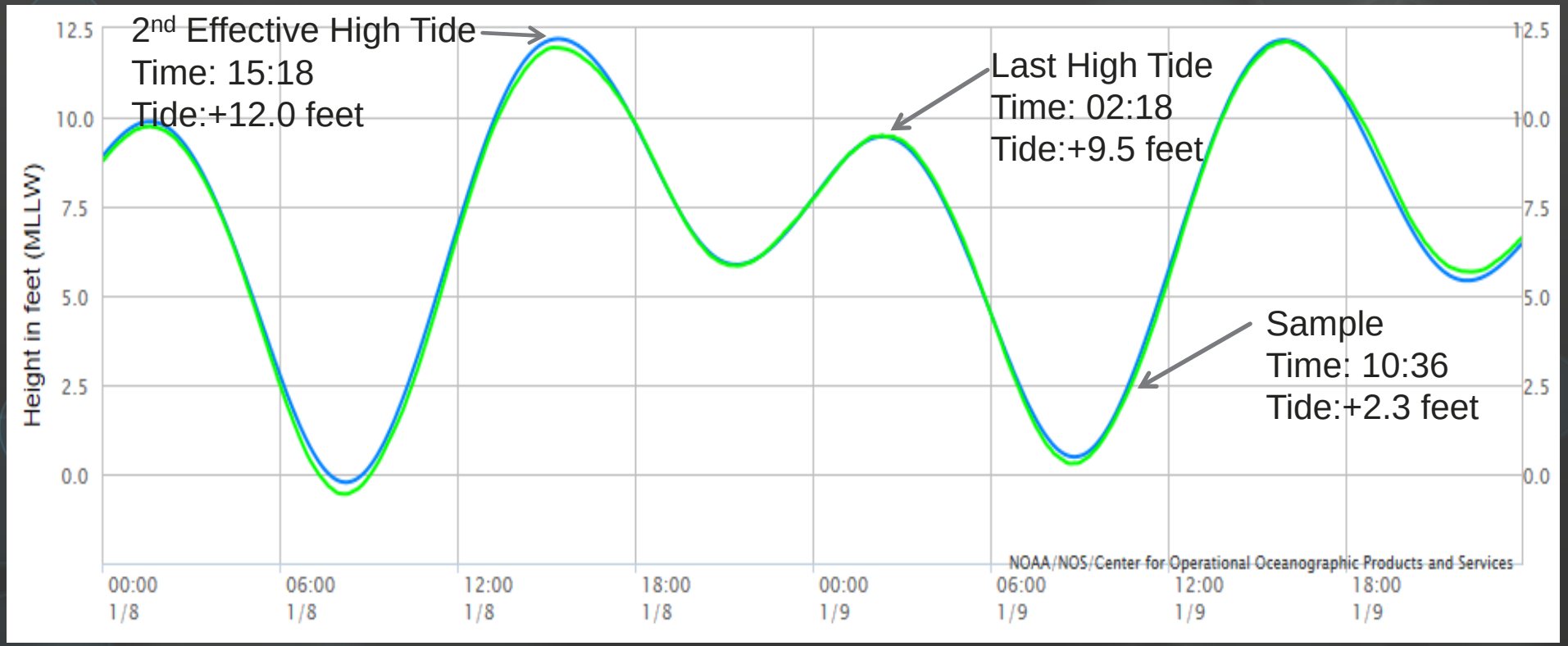
Lead Signature: _____

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.



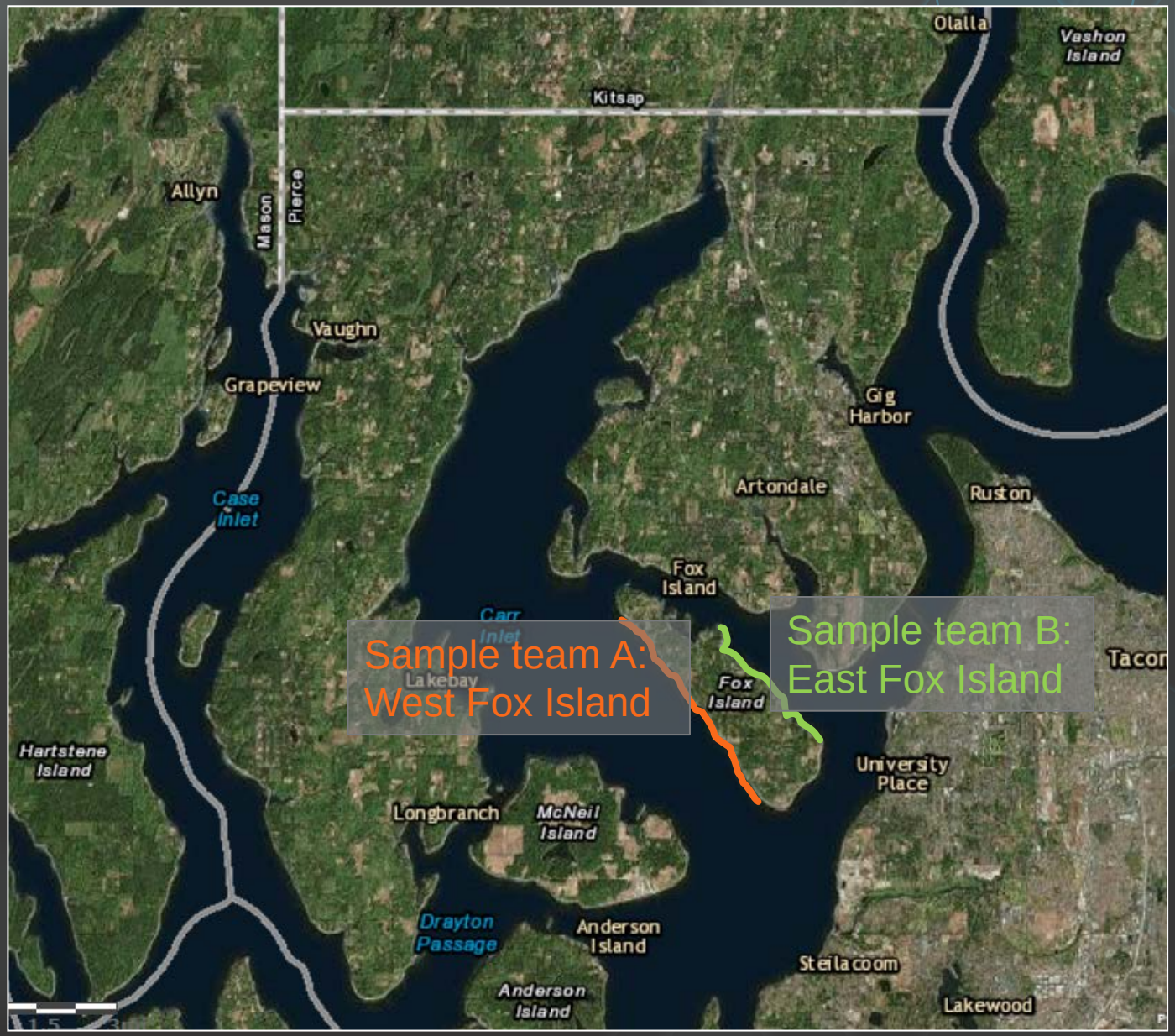
http://tidesandcurrents.noaa.gov/waterlevels.html?id=9447130

Location:

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

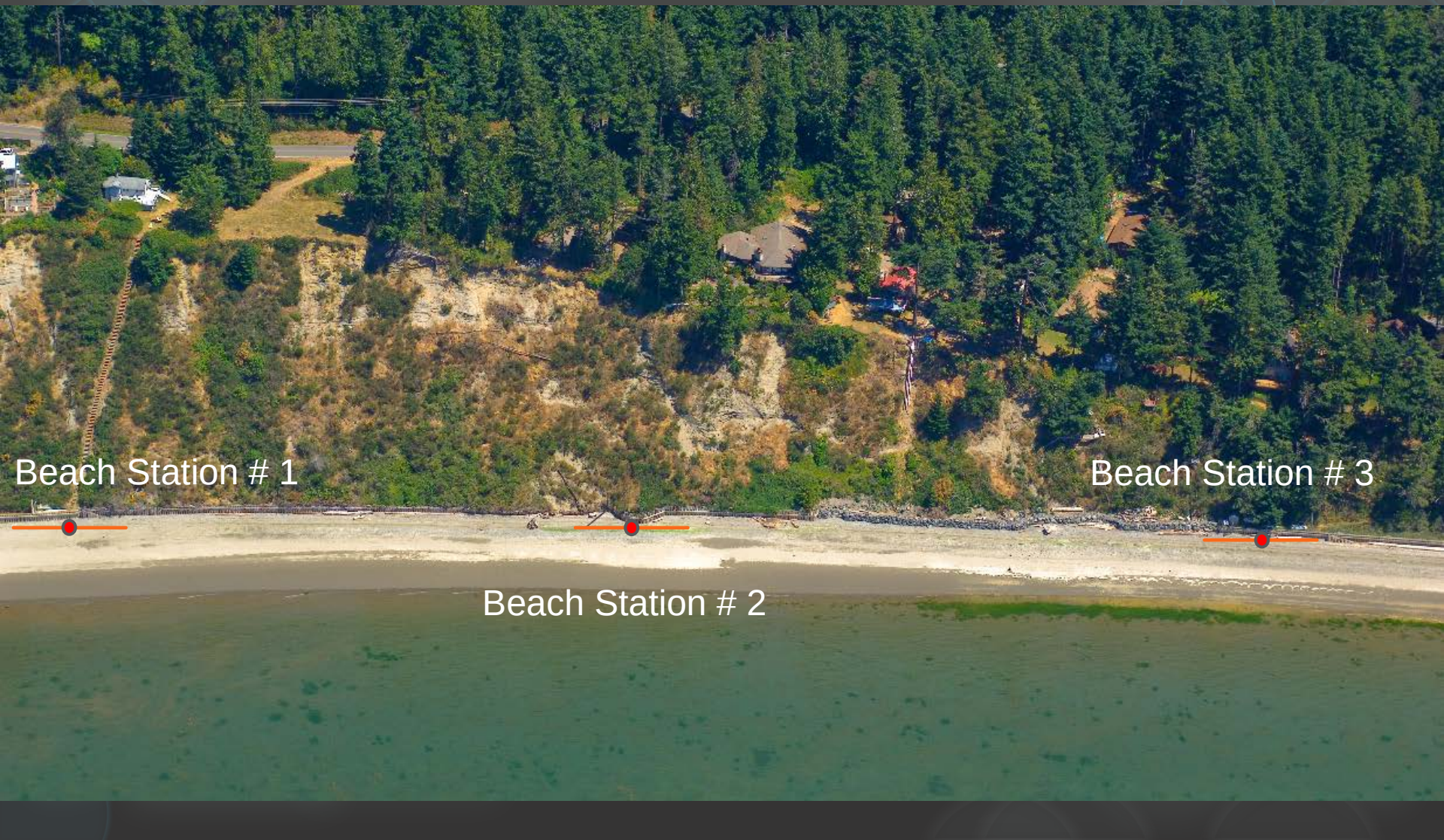
The name of the inlet, island, beach, etc. are all fine locations.

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:

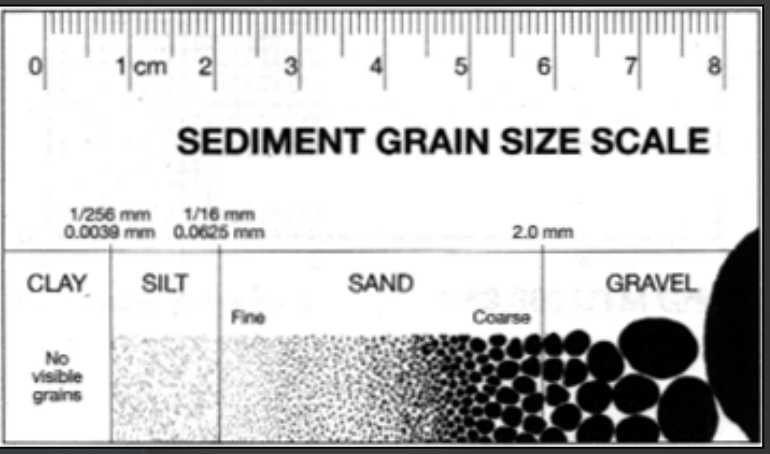
- Each 100 stretch of beach sampled receives its own sequential station #.
- The coordinates should be recorded at the center of the station.



Beach: 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	*No description*		
7	boulder w/ sand	>10.1	>256
8	boulder w/ gravel		
9	bed rock, no habitat		



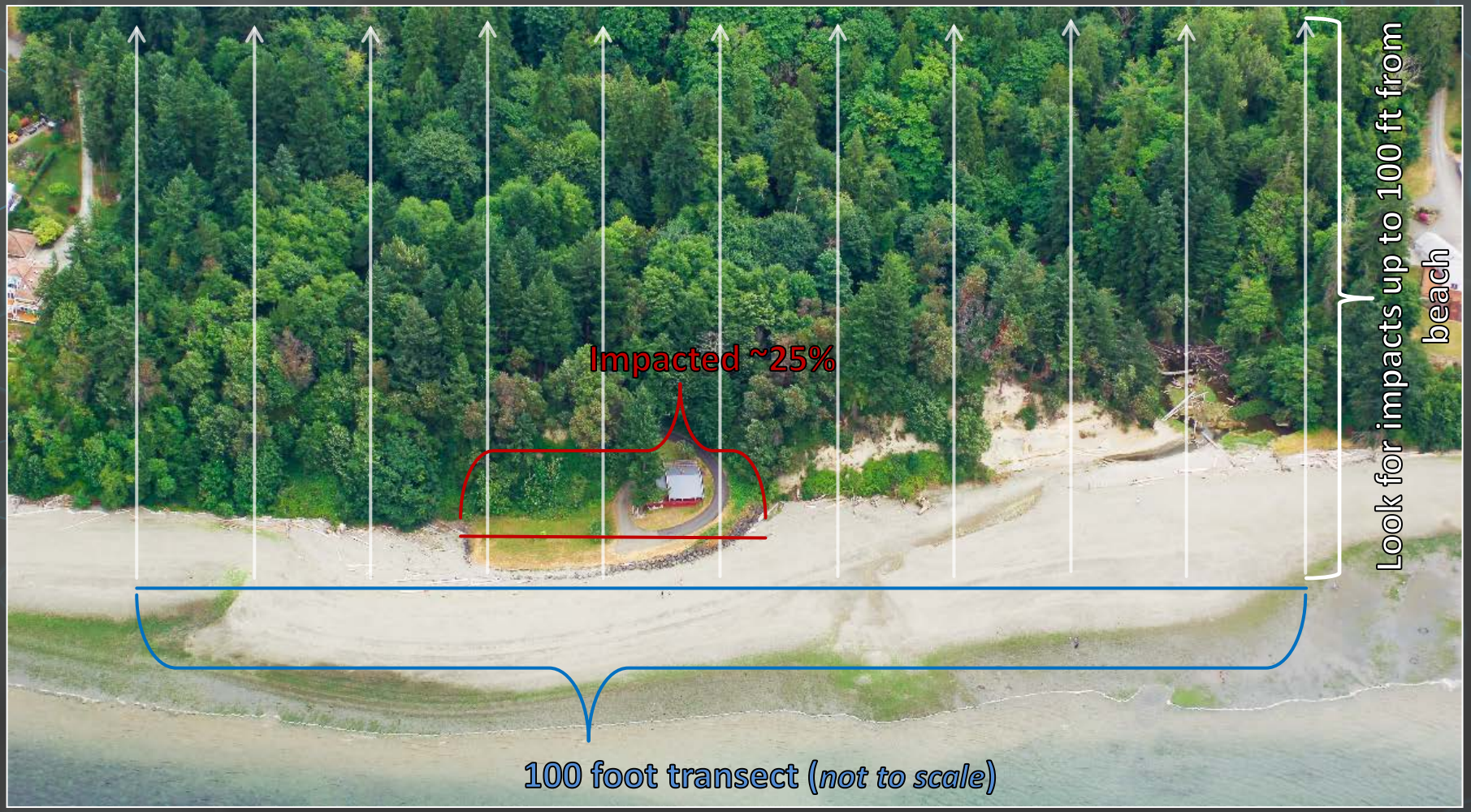
Tennis ball (5) = 2.7 inches; 69mm

Dime (4) = 0.7 inches; 18mm

Drinking straw (3)= 0.24 inches; 6mm

Tooth pick (2) = 0.08 inches; 2mm

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

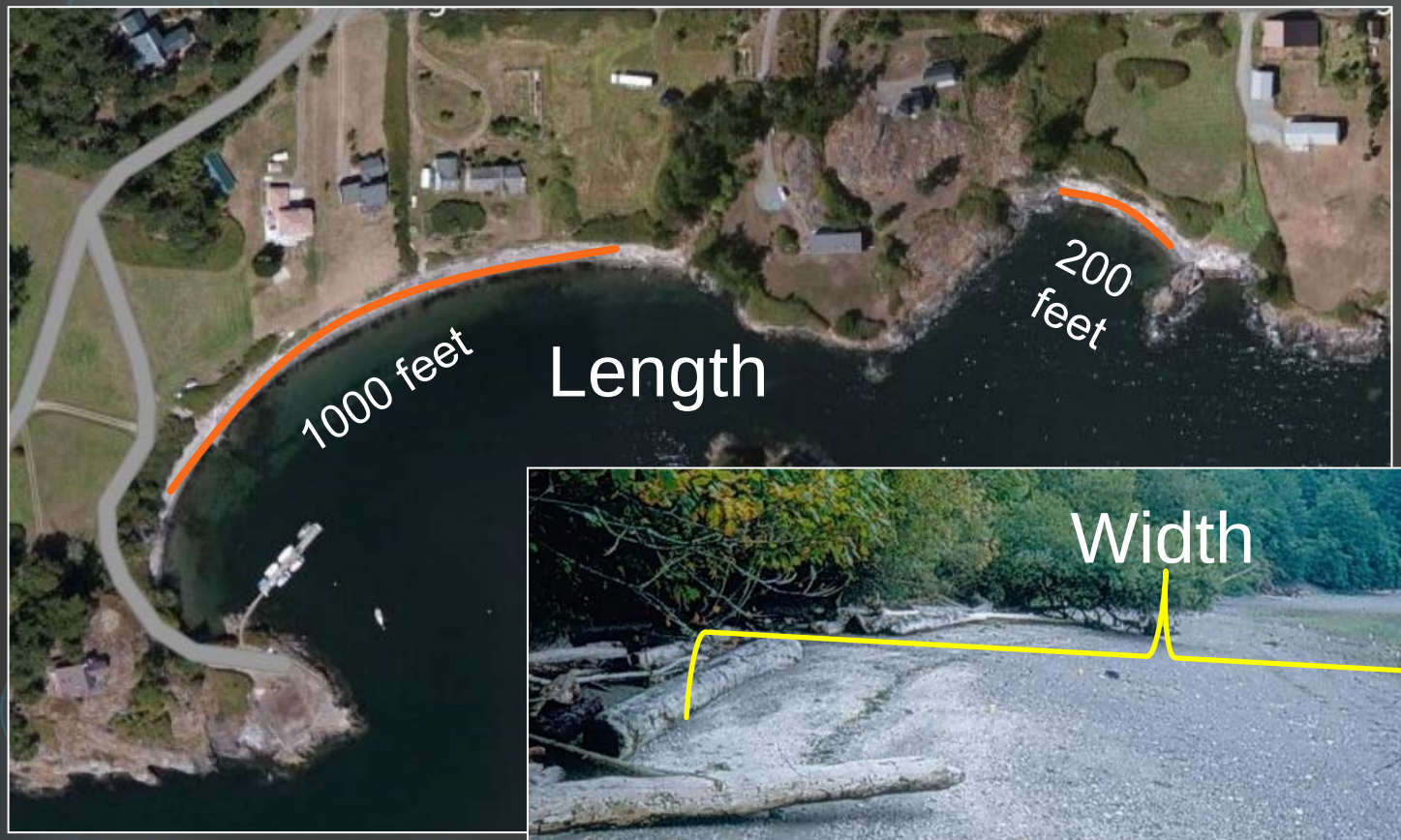


Uplands: Assess the nature (natural or impacted) of the uplands for 50 feet on either side of the center of your sample by looking up to 100 feet landward of the beach. Impacts include human disturbances such as buildings, roads, bulkheads, clear cuts, etc.

Record the impact as the approximate % of the length of the 100 ft. transect that has visible impacts within 100 ft. of the beach.

Length and Width

- Length: The total distance (up to 1000 feet) in either direction in which the substrate continues to look suitable for potential spawning
- 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. Includes: 1) down beach from last high tide; 2) up beach from last high tide; 3) down beach from 2nd to last high tide; 4) down beach from upland toe; and 5) up beach from the waterline at the time noted.

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

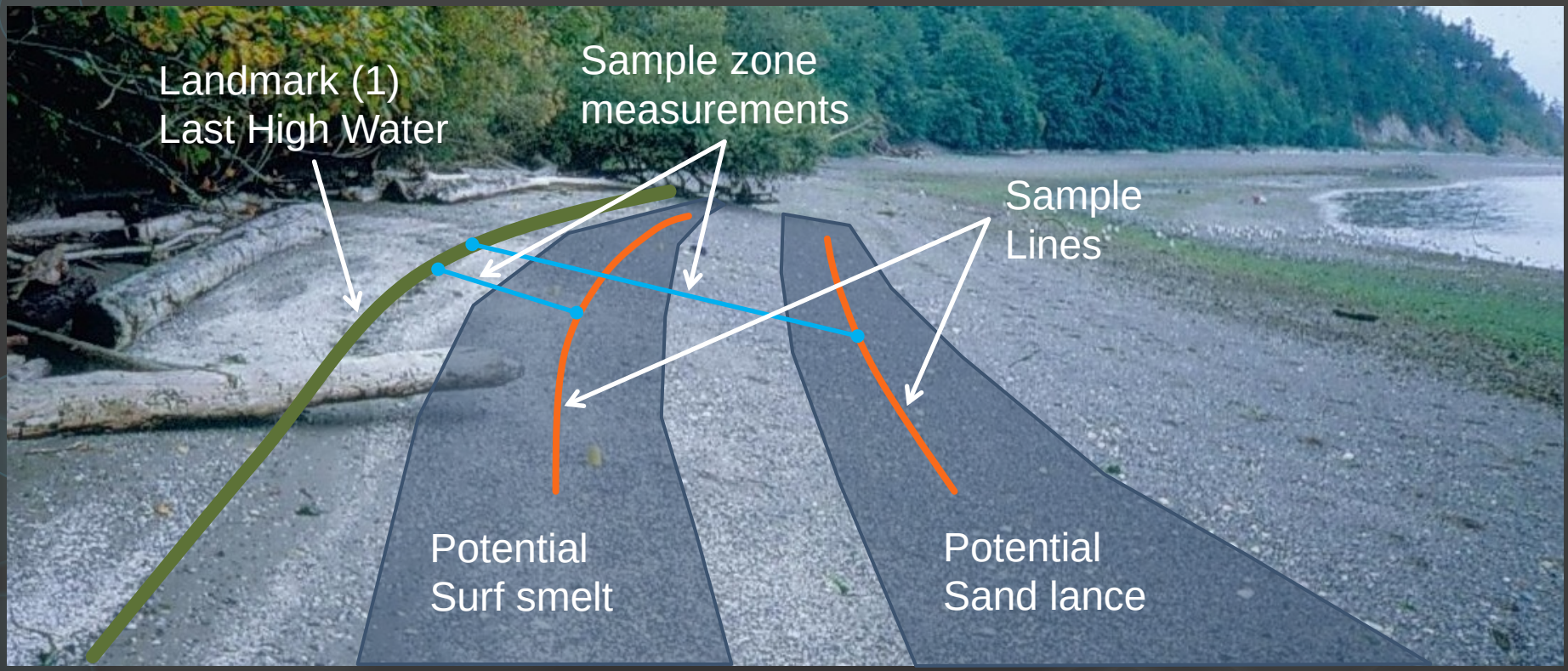


Photo: D. Penttila

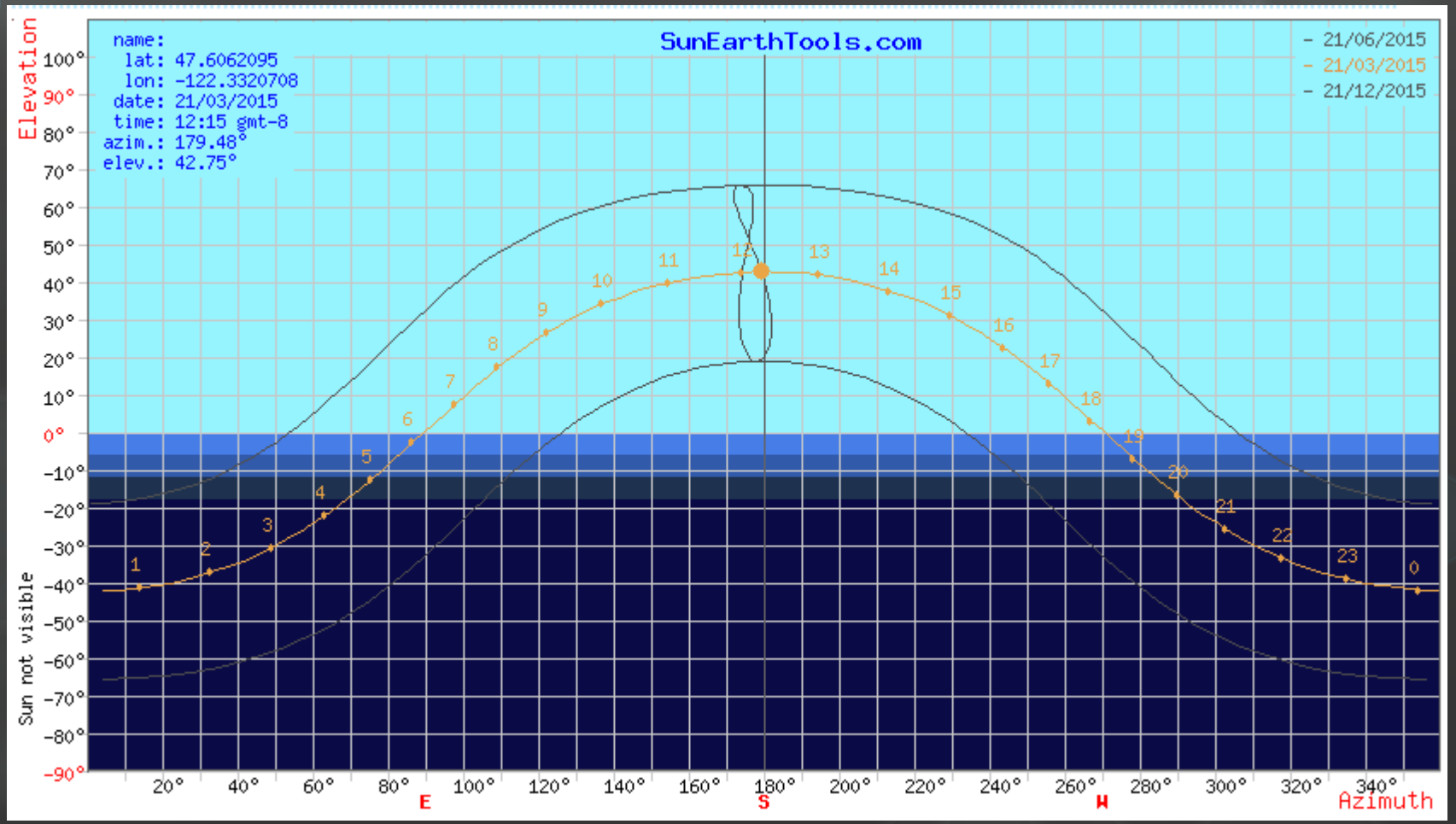
Shading: Estimate the average percent of a day that the 100 foot line you are sampling would be shaded during the current season.

Elevation of sun above horizon:

Winter: ~20º

Spring fall: ~43º

Summer: ~65º



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.

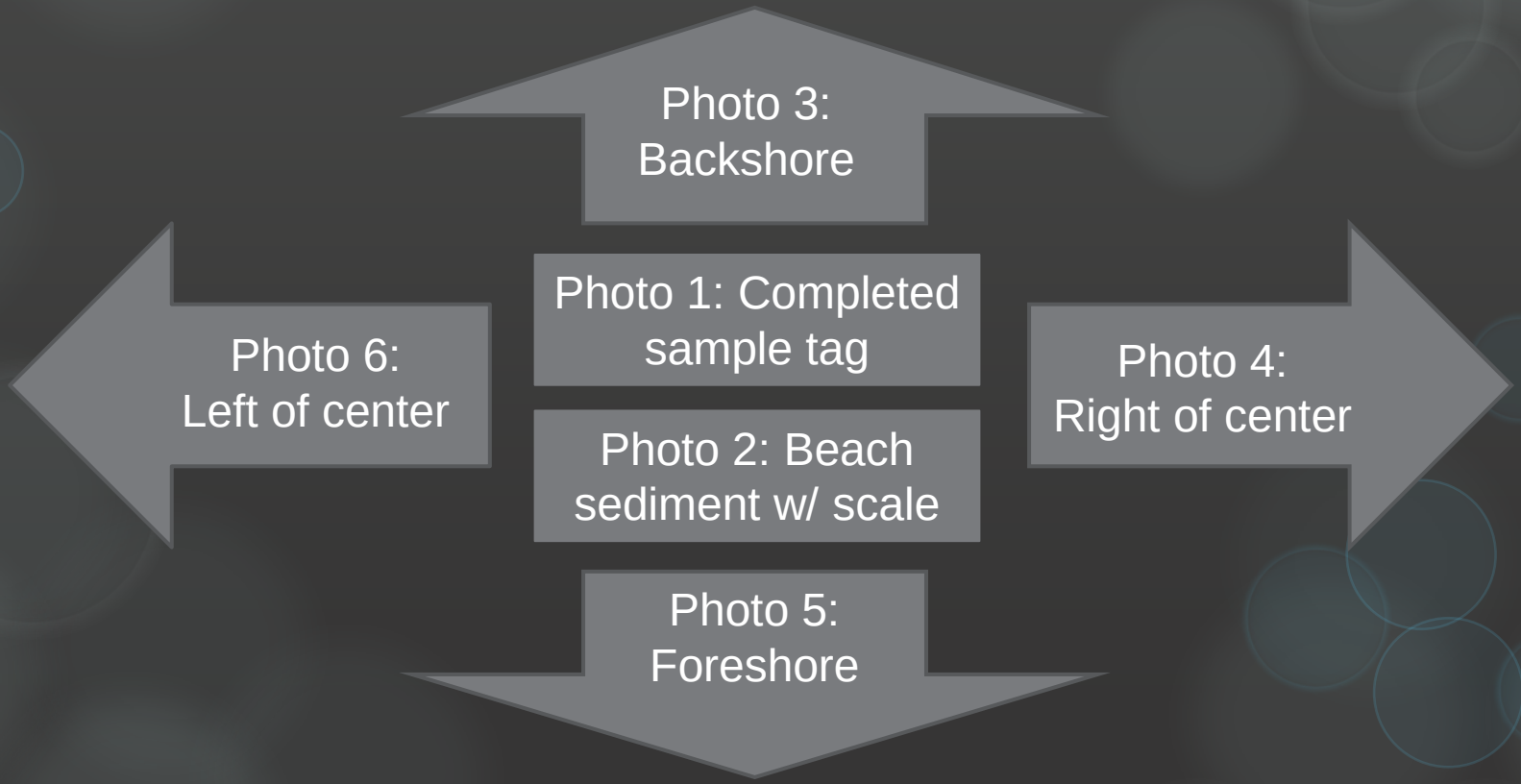
0= no eggs observed; L= light but visible; M= medium; H= heavy;
W= eggs only observed during/after winnowing

Photos:

Photos should take 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.

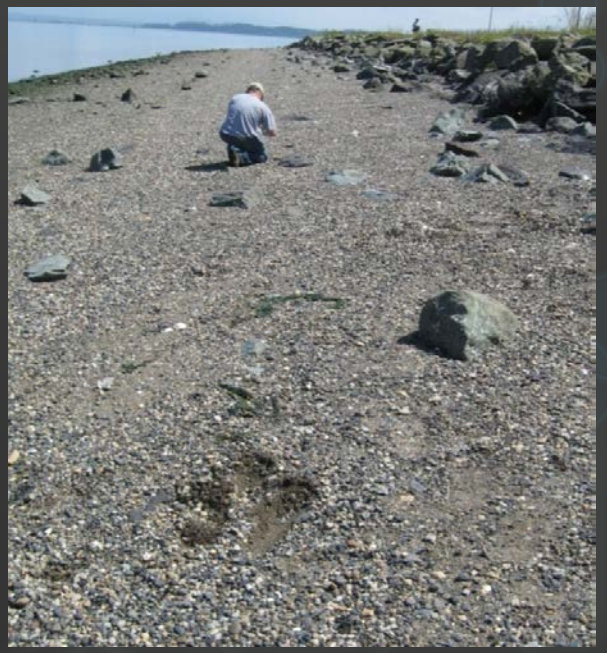
Photos will always be taken in the same order and named sequentially with the name of the photo 1 recorded in the “Photo #” field.




Bulk Sample Collection

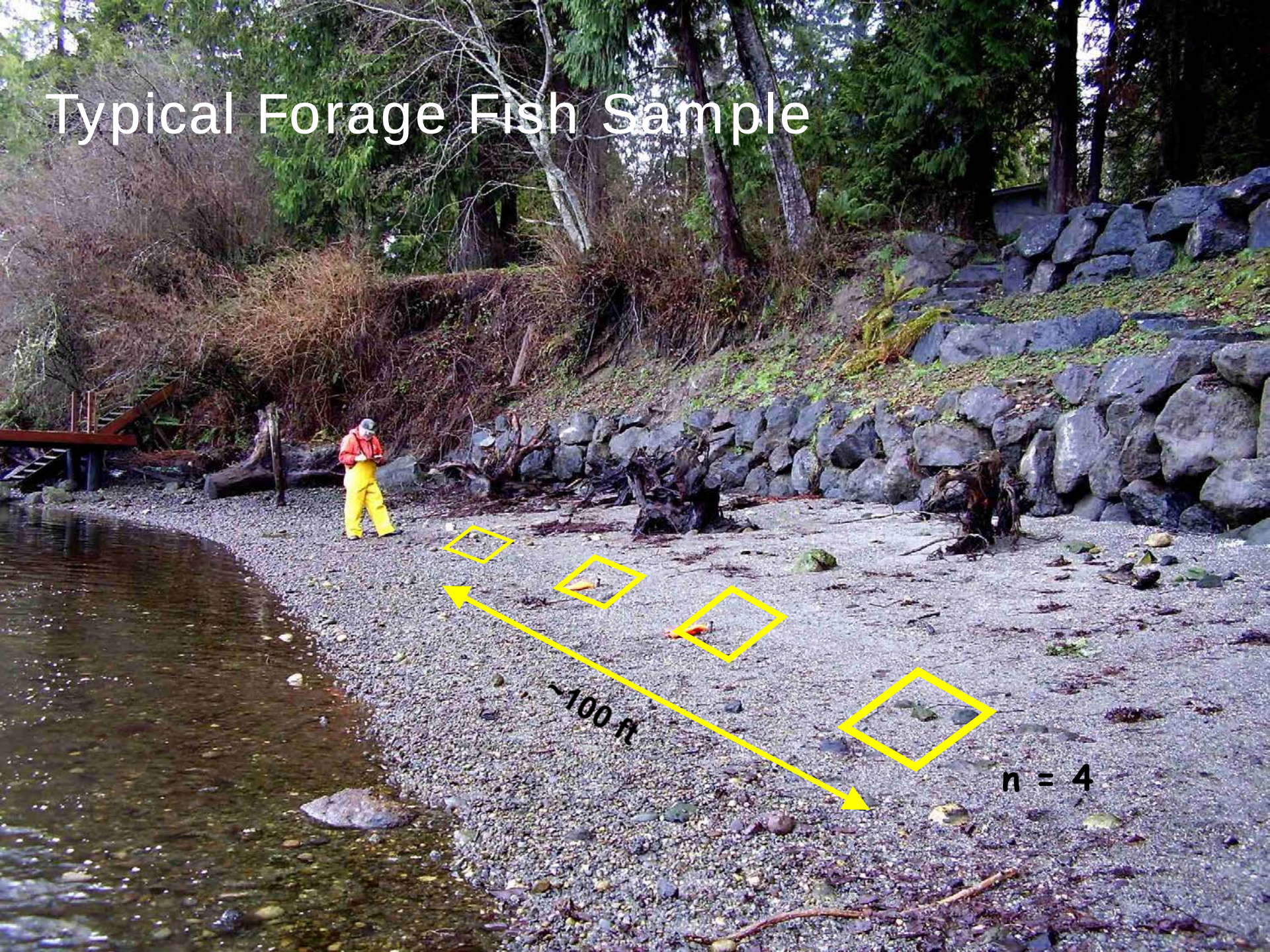
Collecting a bulk substrate sample

- 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 ½ to $^{2}/_{3}$ full
- Other bands may be sampled as a new sample with a **new** bag
  - Higher for smelt, lower for sand lance.



Photos: D. Noviello

Typical Forage Fish Sample



Screening the sample

- Stack sieves (bottom to top): 0.5 mm, 2 mm, then 4 mm
- Add ~⅓ to all of sample (depends on sample and sieve size), rinse thoroughly with hose or buckets of water
- Agitate constantly by hand




Photos: D. Noviello

Screening/winnowing the sample

- Ensure waste bucket has holes!
- Retain only sediment in 0.5 mm sieve, transfer to a square wash basin

Photos: D. Noviello

Isolating the “light-fraction”: winnowing method

Isolate the “light-fraction”

- Add ~1 inch water to basin (cover sediment)
- Roll/tilt/yaw vigorously to suspend and move lighter material to one corner
  - Similar to panning for gold, in reverse
- Tilt slowly to move water away, leaving deposit



Photos: D. Noviello

Collect “winnowed light-fraction”

- Use wide-mouthed sample jar to skim off upper ½-inch of deposit
  - May see eggs along edges of deposit
- Repeat panning process at least three times

Photos: D. Noviello

Isolating the “light-fraction”: vortex method

Vortex Method

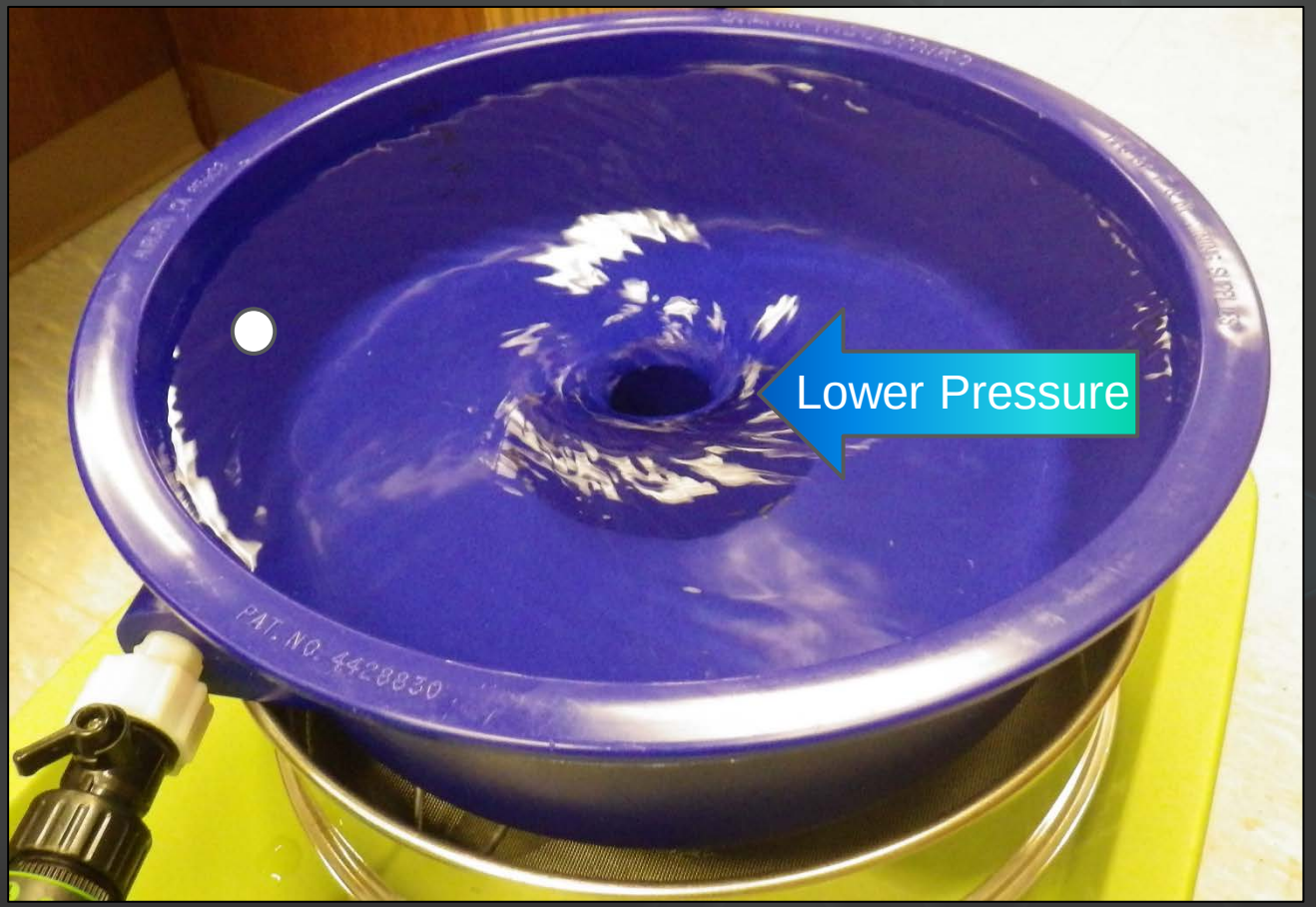
How it works:

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

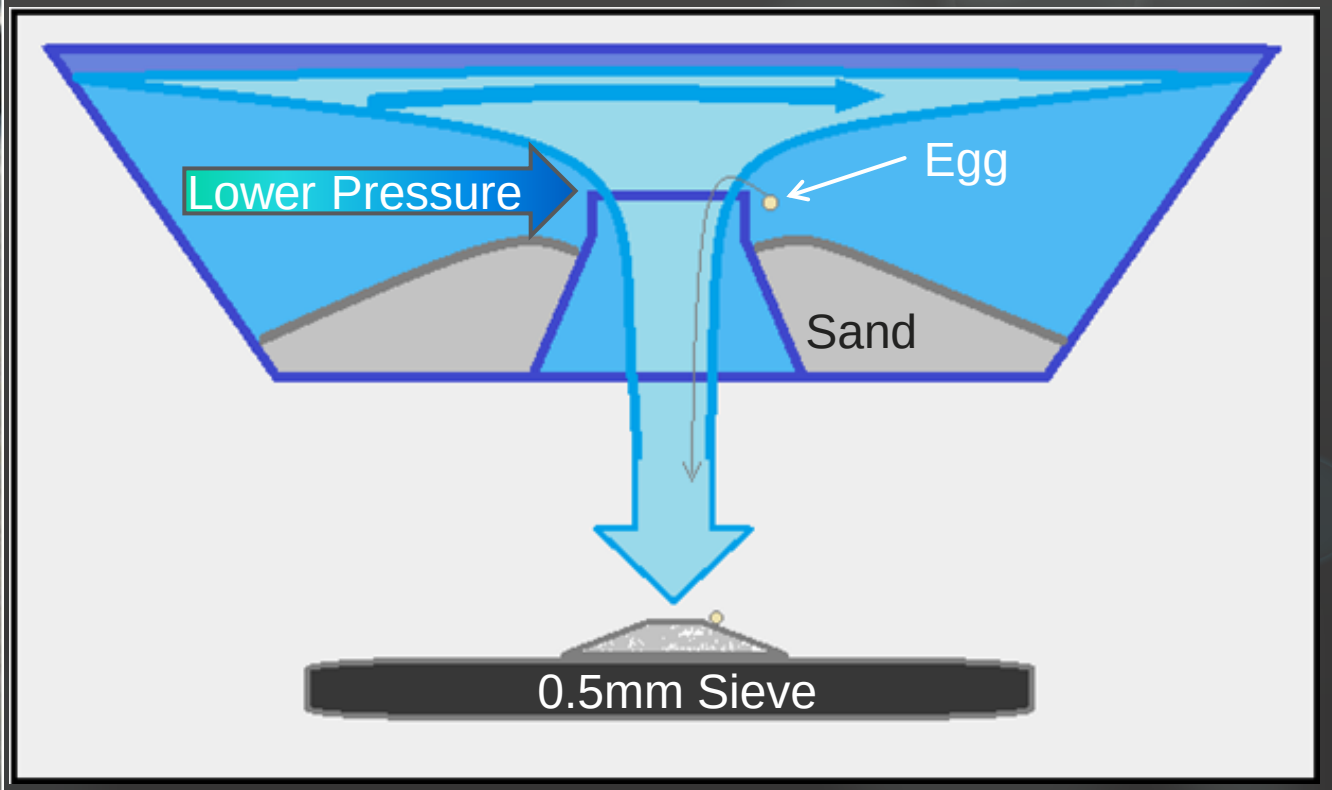


Vortex Method

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



Isolating the “light-fraction”: The vortex method

Set up:

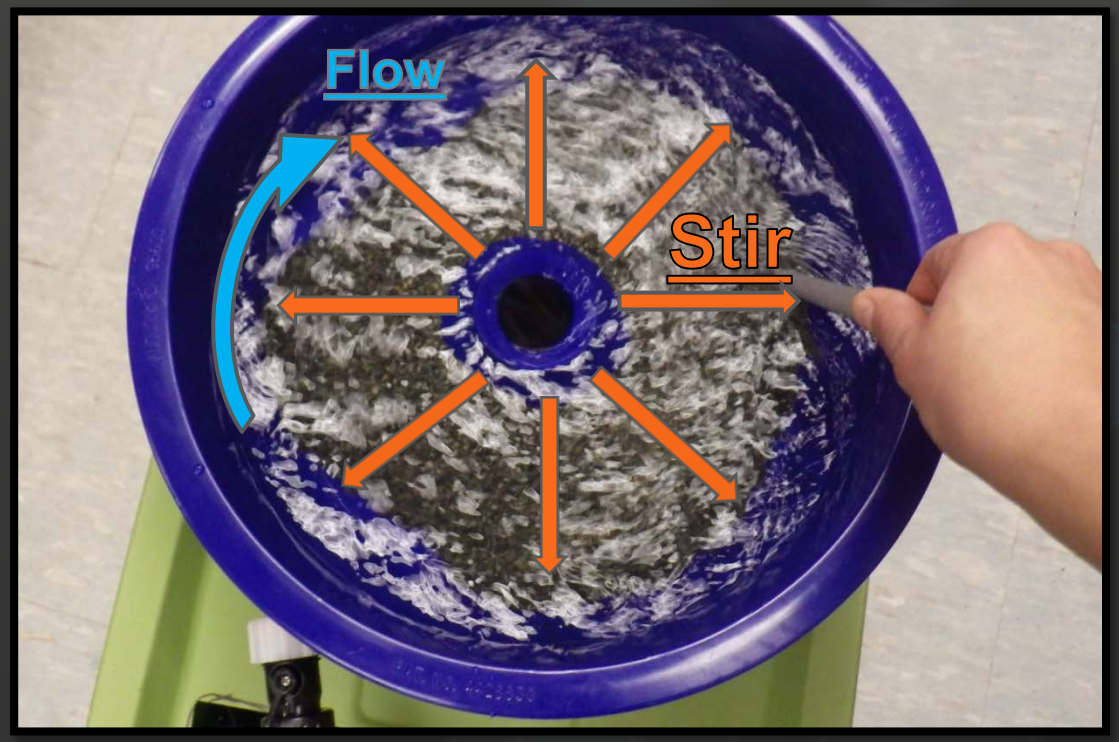
- Place the tote on a relatively level surface and remove the equipment from the tote
- Add enough water to the tote so that the pump is covered by several inches of water when connected
- Attach the tote lid, place the 0.5 mm sieve over the large hole, place the blue bowl on top of the sieve, and connect the pump to the bowl
- Use the shims to level the bowl if needed

Sample processing

- Open the valve about ½ way and turn on the power to the pump. *Note: the pump should not be left on with the valve closed as the hose may rupture.*
- Adjust the flow if needed to ensure that water is not overflowing the outer edge of the bowl.
- Add up to about 60oz of the sieved sediment to the bowl *Note: if you have more sediment you may need to divide the sample and repeat the process*
- Once the sediment has been added, open the valve all the way, or until the water is about 1cm-2cm from the edge of the bowl.

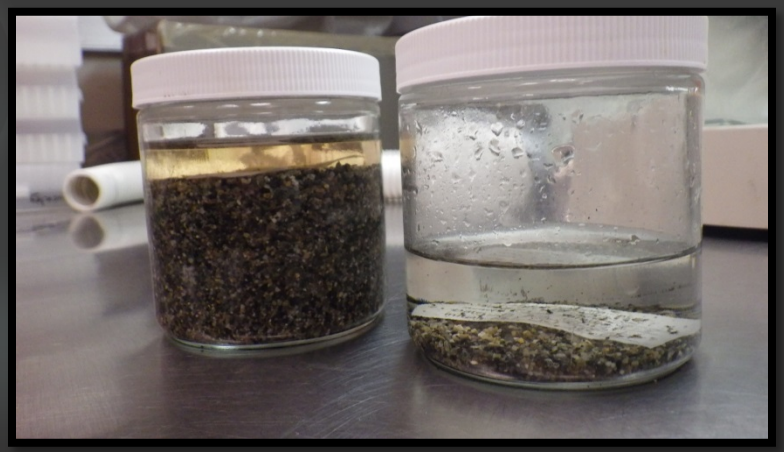
Sample processing

- Using a spoon, stir the sediment by sliding the spoon down the edge of the cone, across the bottom of the bowl, then up the side.
  - This will help ensure that eggs aren't being buried under the sand
- Stir for 1 to 3 minutes, then allow the bowl to run undisturbed for about 15 to 30 seconds before turning off the pump.
- Once the water has settled, examine the sediment immediately around the cone for eggs. If eggs are observed, skim them off with a spoon and add them to the sample jar.



Sample processing

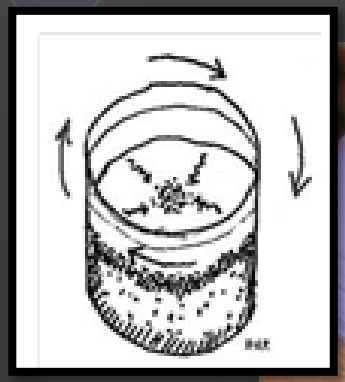
- Remove the blue bowl and with a aid of a wash bottle, rinse the material captured by the sieve into a sample jar.
- Once the light fraction is in the sample jar, strain off as much water as possible, and cover with preservative.

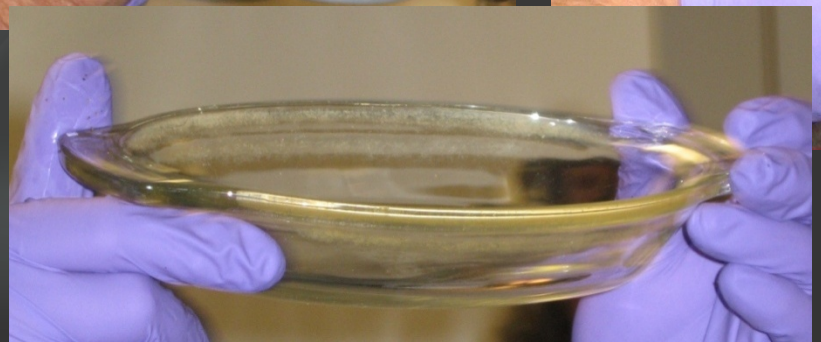


Lab Processing & Egg Identification

Laboratory processing and analysis

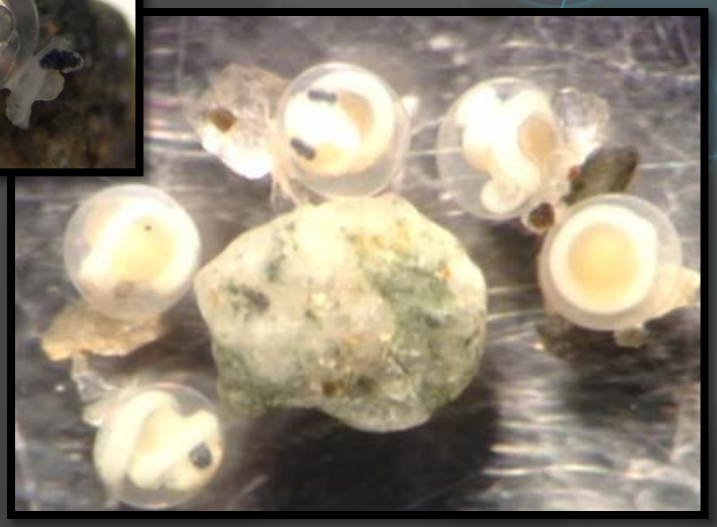
- For presence/absence, second panning/ winnowing may occur, then use microscope
  - If eggs found, stop. If not, continue to winnow until you are **certain** no eggs exist (at least 4 times)
- Repeat the process 4 times, or until eggs are found





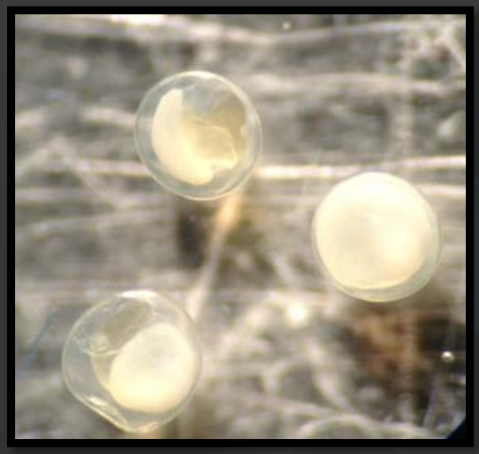
Photos: D. Noviello

Egg Identification

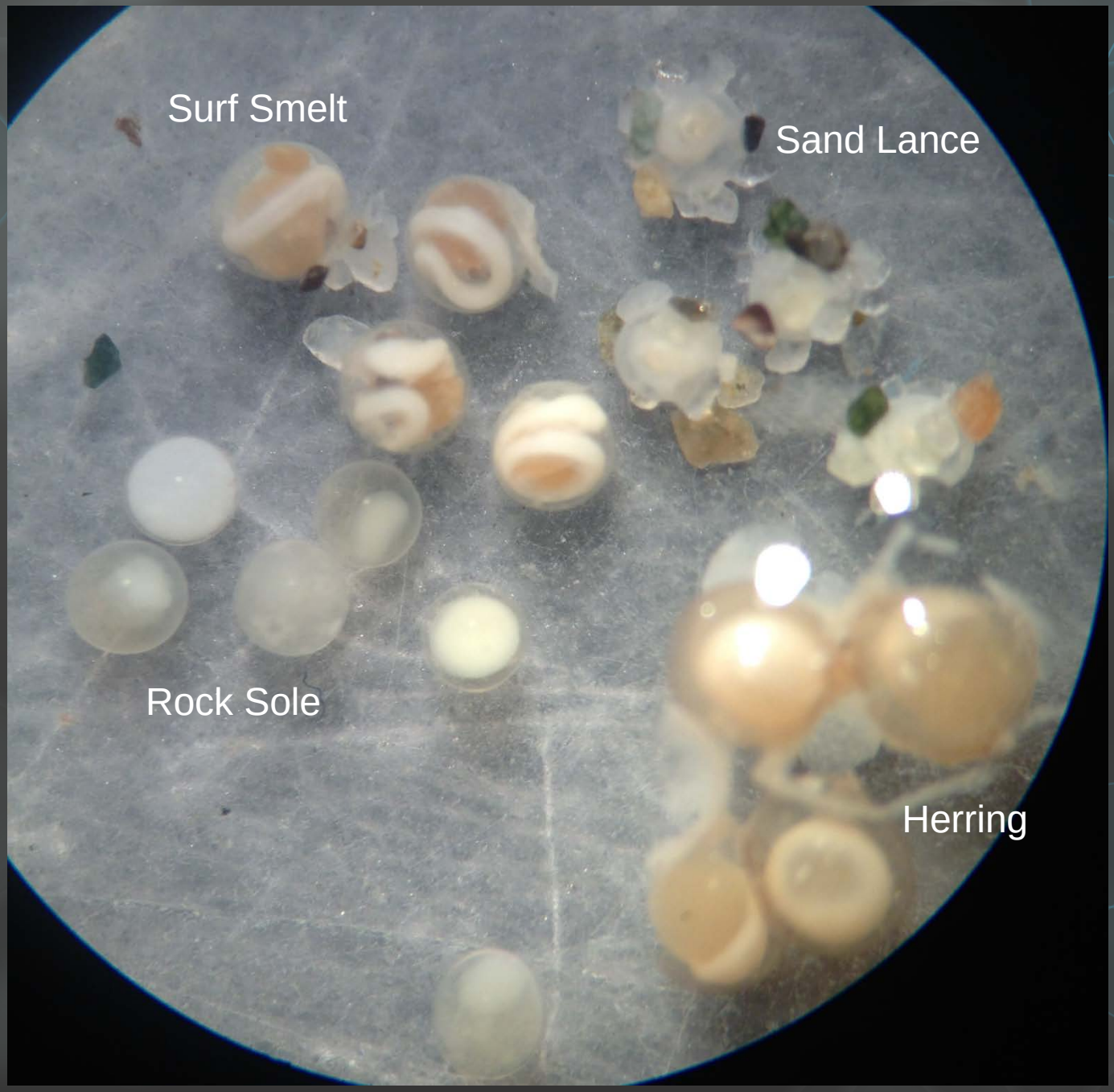


Surf smelt eggs: *larger than SL and RS eggs; pedestal present; sediment only attached to pedestal side*

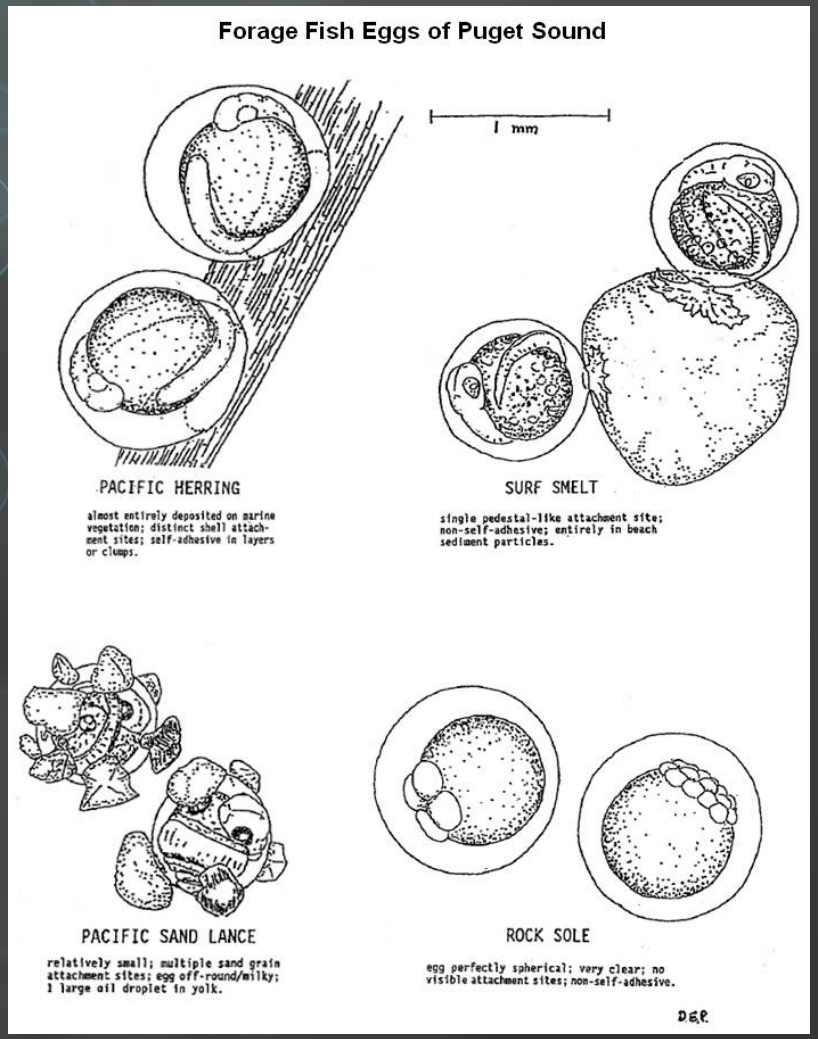
Sand lance eggs: *smaller than SS and RS eggs; 'sticky' on all sides; no pedestal*

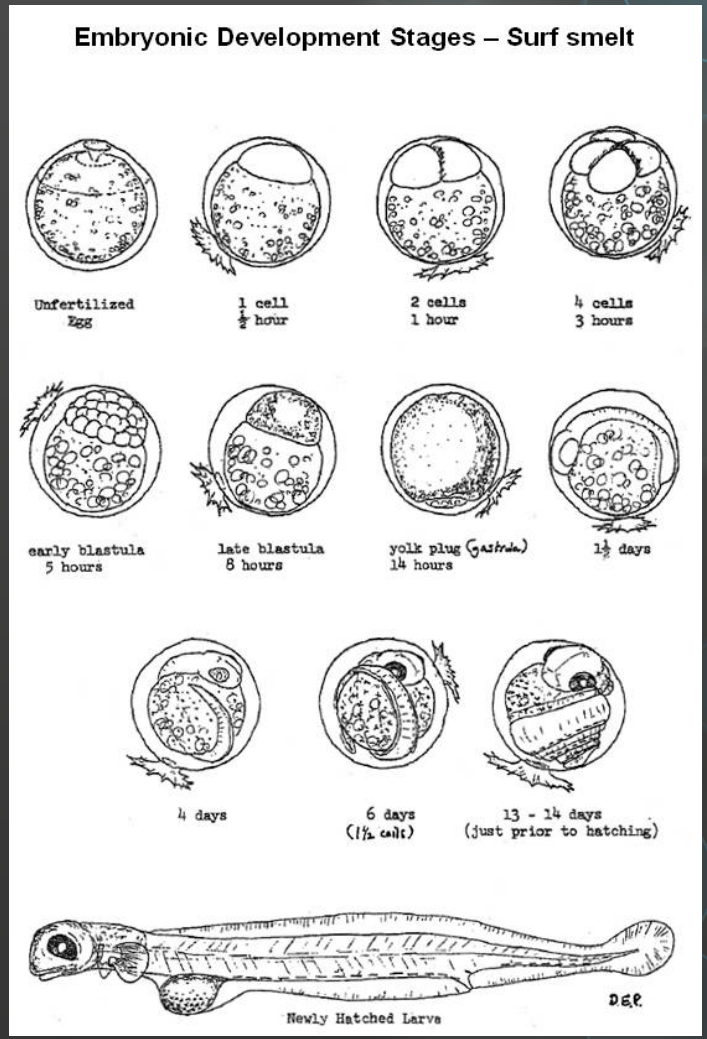


Rock sole eggs: *smaller than SS eggs but larger than SL; no sediment attached; no pedestal*


Surf Smelt
Sand Lance
Rock Sole
Herring

Identification guides

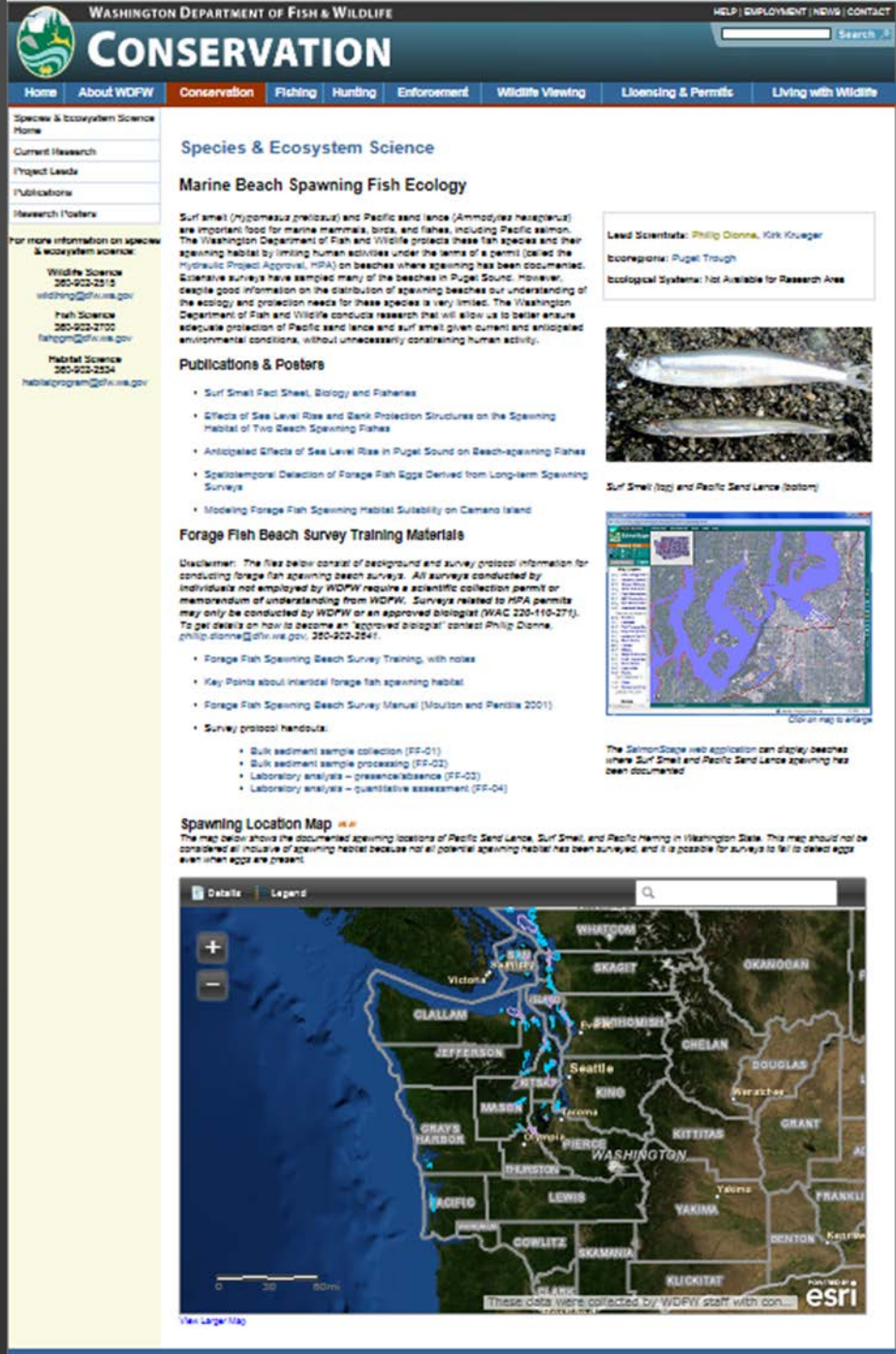




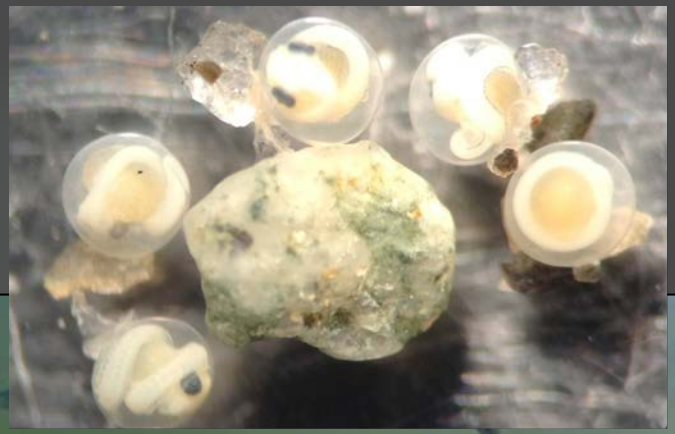
http://wdfw.wa.gov/conservation/research/projects/marine_beach_spawning/index.html

Resources

- Web-based info available
  - Contains sampling protocols, identification guides, and other materials *wdfw.wa.gov/conservation/research/projects/marine_beach_spawning/*
- For training or consulting contact Phillip Dionne, WDFW, Habitat Science Division
  - Phillip.Dionne@dfw.wa.gov; 360-902-2641
- Forage Fish mapping to tool
  - Interactive map of documented surf smelt and sand lance beaches *wdfw.wa.gov/conservation/research/projects/marine_beach_spawning/*



Questions?



Further contact/training/support

- Web-based “refresher course” available
  - Contains presentation, sampling protocols, identification guides, and other materials
- Egg samples for ID, etc. can be sent to WDFW
- For training or consultation contact Phillip Dionne, WDFW, Habitat Science Division
  - Phillip.Dionne@dfw.wa.gov; 360-902-2641

Please send data for completed surveys to WDFW

Site overview and initial data

- Identify band of spawning gravel, record GPS coordinates, note landmark, and record attributes of beach/upland (see data form)

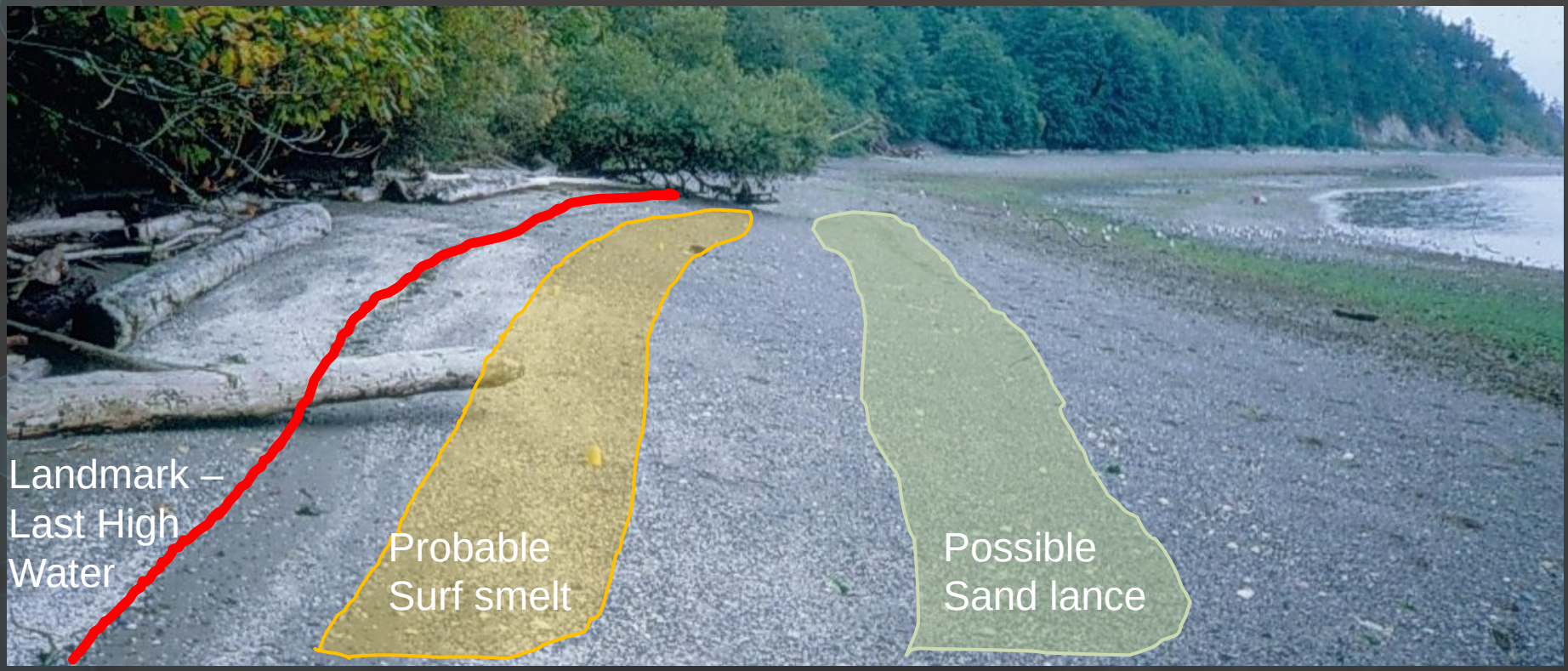
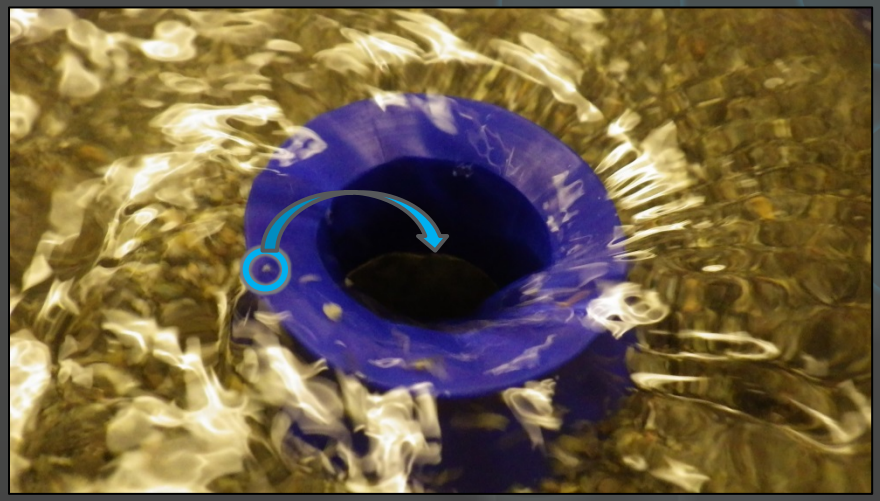


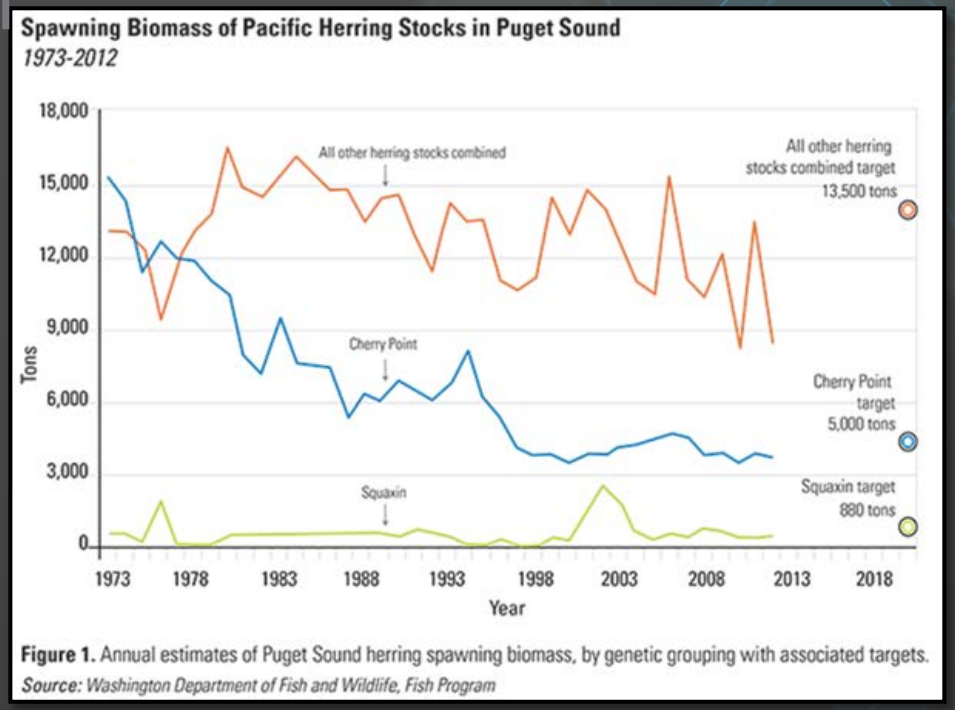
Photo: D. Penttila

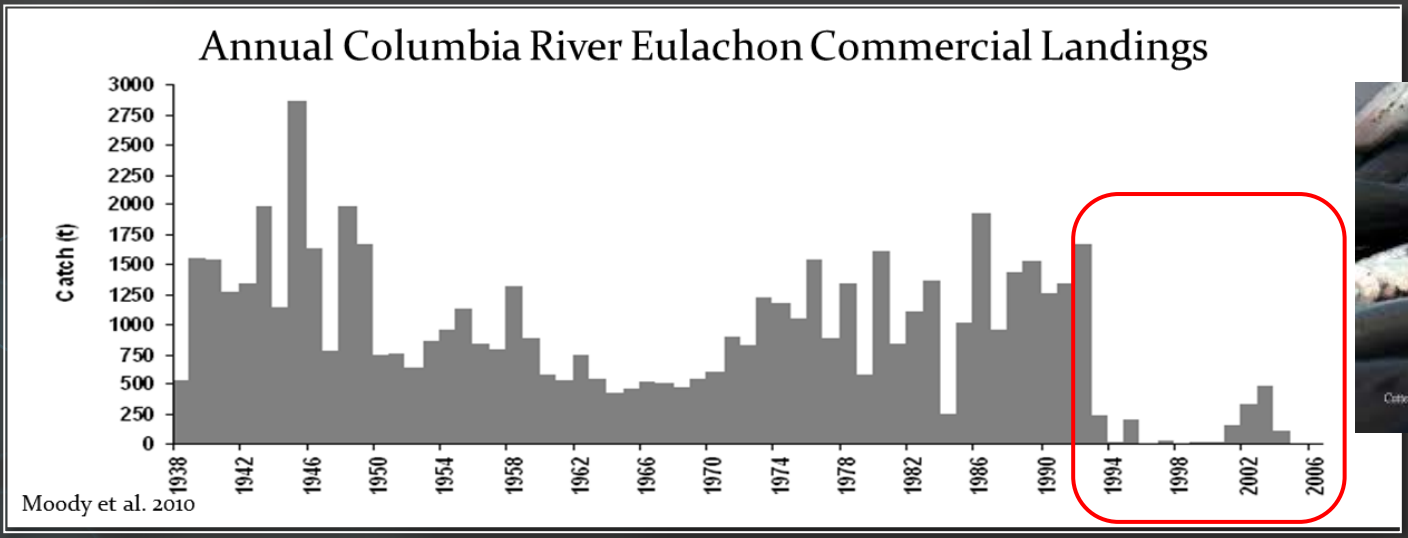


Trends in WA forage fish abundance

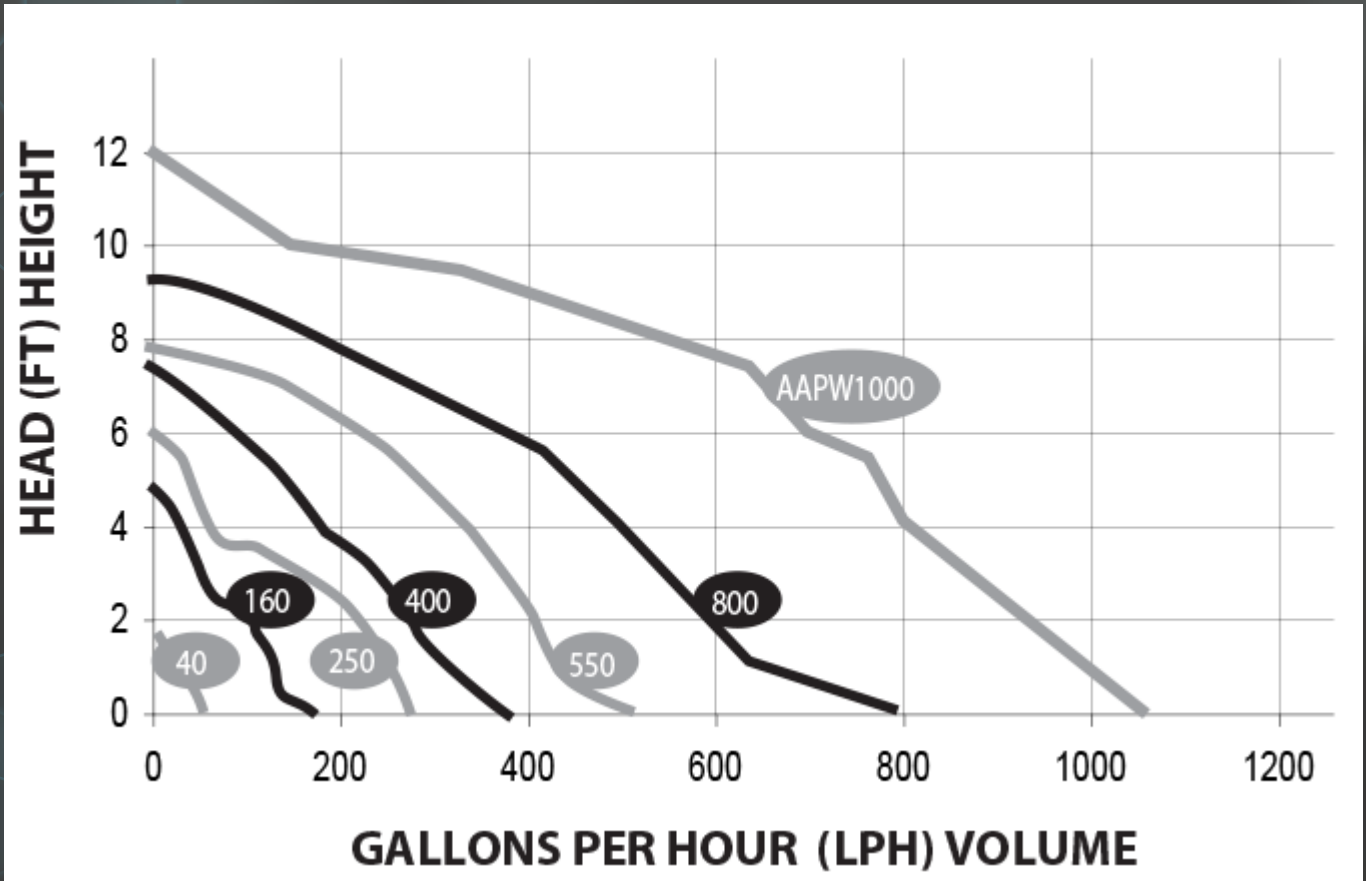
-Decline in herring stock and average size.

-Eulachon listed as threatened under ESA.





Some notes on following protocols



WDFW Intertidal Forage Fish Spawning Habitat Survey Protocols

Procedures for obtaining bulk beach substrate samples

Field materials needed:

Measuring tape (100+ feet)
16-ounce plastic jar or large scoop
8 inch x 24 inch polyethylene bag (or large, sturdy ziplock)
Handheld GPS device
Tide table
Digital camera (optional)
Hypsometer (if available)
Data sheet (preprint on Write-in-the-Rain paper if possible)

Note: Sampling should occur on the lowest tide practicable. Prior to sampling any site consult tide tables to ensure you will be able to access the +7-9 (surf smelt) and +5-8 (sandlance) tidal height. It may also be necessary to obtain **permission to access the beach** from private or corporate landowners.

Procedure:

1. Upon arriving on the beach, fill out the header information on the attached data sheet. *Do not* fill in "Reviewed by." Before conducting the first sample, describe the character of the upland and beach environment using the codes provided on the back of the data sheet. For additional details on sample codes see Moulton and Penttila (2001)*.

2. Identify a landmark from which you will measure the distance to the bulk substrate sample tidal elevation. Typical landmarks include the upland toe of the beach, the last high tide mark or wrack line, and the edge of the water.

3. Measure the distance from the landmark to the tidal elevation to be surveyed. Note that linear measurements along the beach face serve as an index of tidal height but do not directly quantify *vertical* tidal height. If available, a hypsometer can be used to measure vertical sampling height.

4. Stretch a measuring tape at least 100 feet along the selected tidal height. Note that beach contours may cause the landmark to be 'wavy' and that the tape should remain a consistent distance from the landmark.

5. Standing at one end of the measuring tape, record a GPS fix on the data sheet.

6. Using a 16-ounce sample jar or large scoop remove the top 5-10 cm (2-4 in) of sediment from the location recorded in Step 6 above. Place the sediment in an 8 inch x 24 inch polyethylene bag or large, sturdy ziplock. You may need to take two scoops to get sufficient sediment, depending on the coarseness of the beach.

7. Walk ten paces (single steps) along the measuring tape, repeat the sediment scooping action, and place the sediment in the bag. Move an additional ten paces and repeat. Move an additional ten paces, approximately to the end of the tape, and repeat. The bag should now have sediment from four locations along the tape and be at least ½ to ⅔ full.

8. If additional transects, representing various tidal heights, along the beach are to be surveyed, place the sample bag in a cool, shady place and repeat the above procedures at these additional locations. If no additional samples will be taken, move on to wet sieving and winnowing the sample as described in the companion protocol "Procedures for recovering "winnowed light fractions" subsamples of forage fish egg-sized material from bulk beach substrate samples."

9. If you have a camera, take several photos of the survey area showing sampling locations. Be sure to take photos from several perspectives (i.e., both up and down, as well as along, the beach). For each photo, record the cardinal direction you are facing on the data sheet in the comments field.

* Moulton, L.L., and Penttila, D.E. 2001. Field manual for sampling forage fish spawn in intertidal shore regions. Field Manual, MJM Research and Washington Department of Fish and Wildlife, Lopez Island, WA. PDF available on request from Dayv Lowry at WDFW (dayv.lowry@dfw.wa.gov).

Original protocol by Dan Penttila, WDFW. Reformatted by Dayv Lowry, WDFW.

Forage Fish Spawning Surveys

Page ____ of _____

Reviewed by_____

Last high tide

Time (24-hr) | Elevation

Location | Day | Month | Year

SEE CODES ON BACK OF DATA SHEET

Beach Number	Sample Number	Time (24-hr)	Latitude (decimal degrees)	Longitude (decimal degrees)	Beach	Uplands	Landmark	Sample zone	Tidal elevation	Smelt	Sand lance	Rock sole	Herring	Width	Length	Shading	Comments

Samplers:_____

Version 2.0, July 2011

Field Observation Sampling Codes

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 1,000 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

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.

Smelt, Sand Lance, Rock Sole, Herring: subjective field assessment of spawn intensity apparent to the naked eye:
0 = no eggs visible
1 = very light, sparse
2 = light, but apparent
3 = light medium, visible
4 = medium, readily visible
5 = medium heavy, abundant
6 = heavy, broadly abundant
7 = very heavy, widespread
8 = eggs observed in the winnow

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). The value "C" may be assigned if surveyed beach is continuous with other potential sample sites.

Shading: Shading of spawning substrate zone, averaged over the 1,000 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

WDFW Intertidal Forage Fish Spawning Habitat Survey Protocols

Laboratory procedure for determining forage fish egg presence/absence from preserved "winnowed light fraction" beach substrate samples

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Laboratory materials needed:

Fume hood (alternatively, winnowed light fraction samples can be carefully washed before analysis)*
Latex or nitrile gloves*
Spoon
Oval microscope dish
Dissecting microscope with 10-20x power
Watchglasses/small Petri dishes
Fine-point (watchmakers) forceps
Data/tally sheets
Paper towels
Buckets/pans/sample jars (to collect waste, accumulated samples, etc.)

*Depending on the preservative used, samples may be toxic or carcinogenic. Take proper precautions.

Note*:* This procedure describes a second reduction of bulk substrate material collected during field sampling and is best used for determining spawn presence/absence. If detailed egg stage counts are needed, use the associated document "Laboratory procedure for counting and staging forage fish eggs."

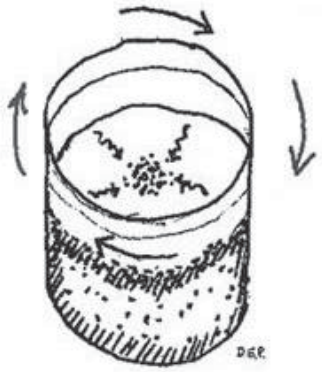
Procedure:

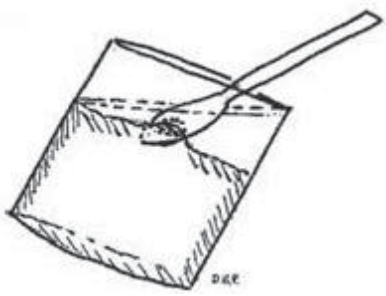
1. Stir "winnowed light fraction" sample jar contents with spoon.

2. Swirl jar in clockwise manner to impart rotation to fluid and surface layer of contents, causing light material to move to center of jar.

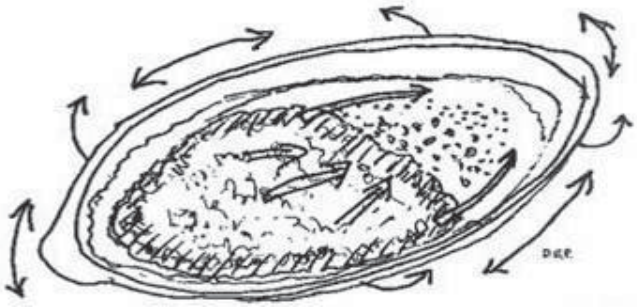
3. Carefully tilt jar. Slowly scoop center mound of light material with spoon into oval microscope dish.

4. Repeat steps 1-3 four times, accumulating about 400 grams of light material in microscope dish.

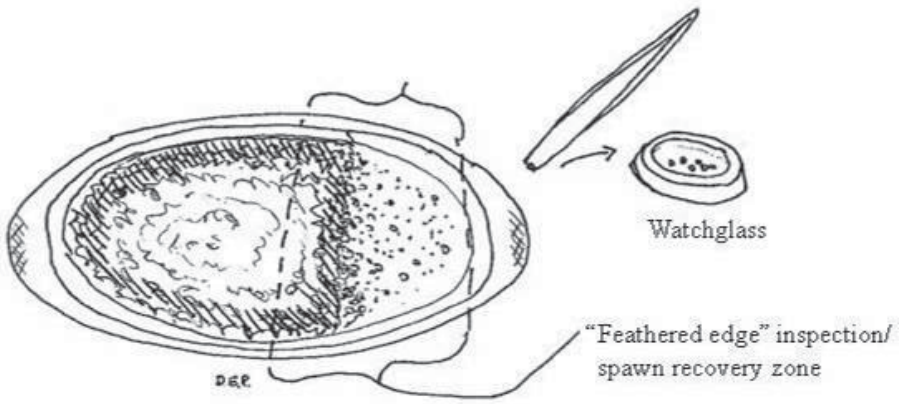




5. Add water to microscope dish. Swirl/tilt/yaw dish to suspend lightest material and concentrate it along feathered edge of the deposit in the dish.



6. Place dish on microscope stage. Inspect zone around feathered edge of deposit. Remove eggs to watchglass with forceps.



7. Reverse dish to redistribute sediment. Repeat steps 5+6 three more times, or until eggs cease to be detected around feathered edge of deposit. Species assignment may be made at this time or after completing processing (see attached egg identification guide).

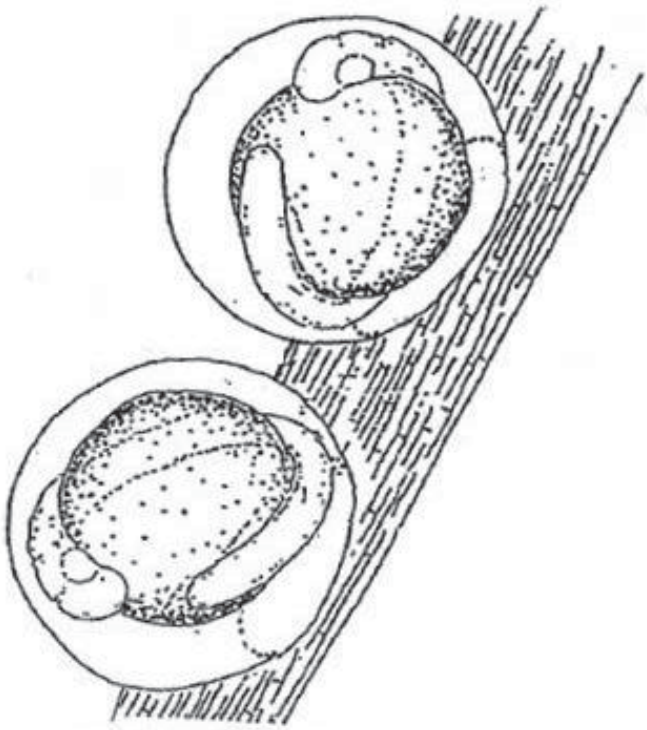
8. If steps 1-7 produce zero eggs, or only a single egg, repeat the procedure with a second sample of material from the same jar of "winnowed light fraction." The WDFW standard for documenting a spawning site for a given species is 2 eggs in a single "winnowed light fraction" sample.

9. Either preserve eggs for future counting and staging, or identify eggs in watchglass (see attached egg identification guide) to determine the species present.

10. Complete survey findings, as well as preserved egg samples if taken, should be sent to Dayv Lowry at Dayv.Lowry@dfw.wa.gov and/or WDFW, Habitat Program, 1111 Washington St SE, Olympia, WA 98501.

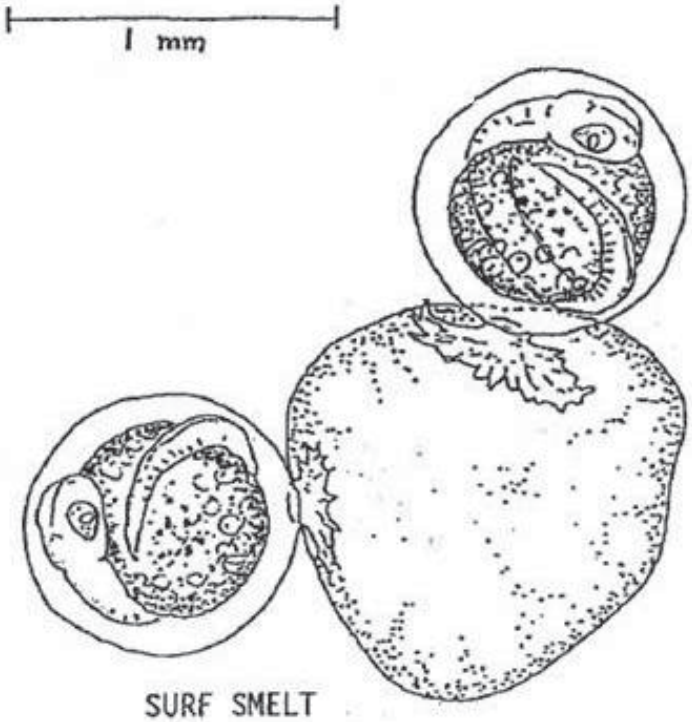
Original protocol by Dan Penttila, WDFW. Reformatted by Dayv Lowry, WDFW.

Forage Fish Eggs of Puget Sound



PACIFIC HERRING

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

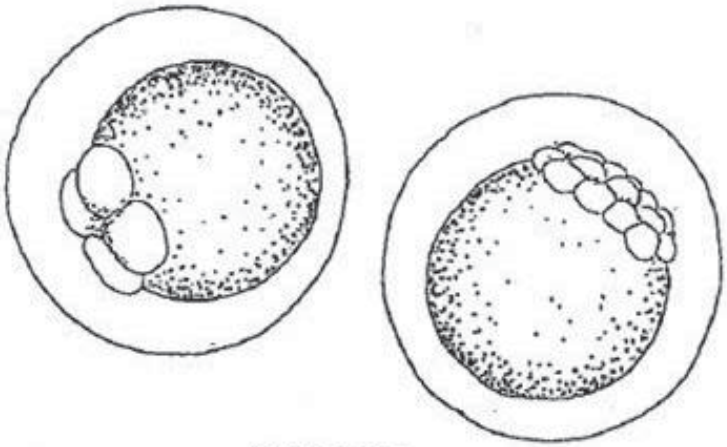


SURF SMELT

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.E.P.