MusselWatch Expansion Pilot Study

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Washington Department of Fish and Wildlife

Agenda for Mussel Watch Pilot Expansion Study
Technical Workshop, 5/24/2012, Sand Point, WA

1:00 – 1:30 Mussel Watch Pilot Study - Scope of Work (15-20 min)

- Background and Brief refresher of study goals/objectives
- Geographic scope
- Station selection criteria

1:30- 3:45 Study Design Elements

- Sample timing – when should we sample mussels? (30-45 min)
  - SCMRC seasonal study
  - Seasonality of contaminant inputs
  - Mussel biology
- Naturally Occurring vs. Caged Mussels (1–1.5 hr)
  - What factors are most important to control in this study?
  - Pros/Cons of each method

3:45-4:15 Washington MW data Summary (2004-2011) (20-30 min)

- Data compatibility issues - how labs report data (qualifiers, non-detects)
- Procedures for estimating contaminant totals (Total PCBs) and summations (Sum PAHs)
- Analyte lists and what to include in summations (diagnostic analytes?)
- Anticipate comparisons with other media (sediments)?

Mussel Watch Expansion in 2012-14

Short Term (Project) goal: evaluate extent and magnitude of contamination of nearshore biota in Puget Sound.

Companion DNR study: "*Outfall assessment and the effects on critical nearshore habitats*"

Funded EPA's National Estuary Program (NEP), for Puget Sound Recovery

Granted via WDFW/DNR as Lead Organization for Marine and Nearshore Habitat Restoration and Protection Crosscutting project
(April 2012 –March 2014)

Mussel Watch Expansion… beyond

Long term goal: establish status & trends monitoring for toxics in Puget Sound nearshore biota

- a new tool in the PSEMP toolbox to fill the nearshore gap
  - additional indicator for the *Toxics in Biota* Vital Sign
  - generate additional recovery goals for the nearshore

- provide S&T monitoring for new NPDES permitting (2015?)
  - Coordinate w/ sediment S&T
  - Coordinate w/ shellfish (seafood) safety programs

- fill specific needs
  - Oil spill baseline/NRDA
  - Effectiveness monitoring
  - S&T related to specific inputs (e.g.,outfalls)

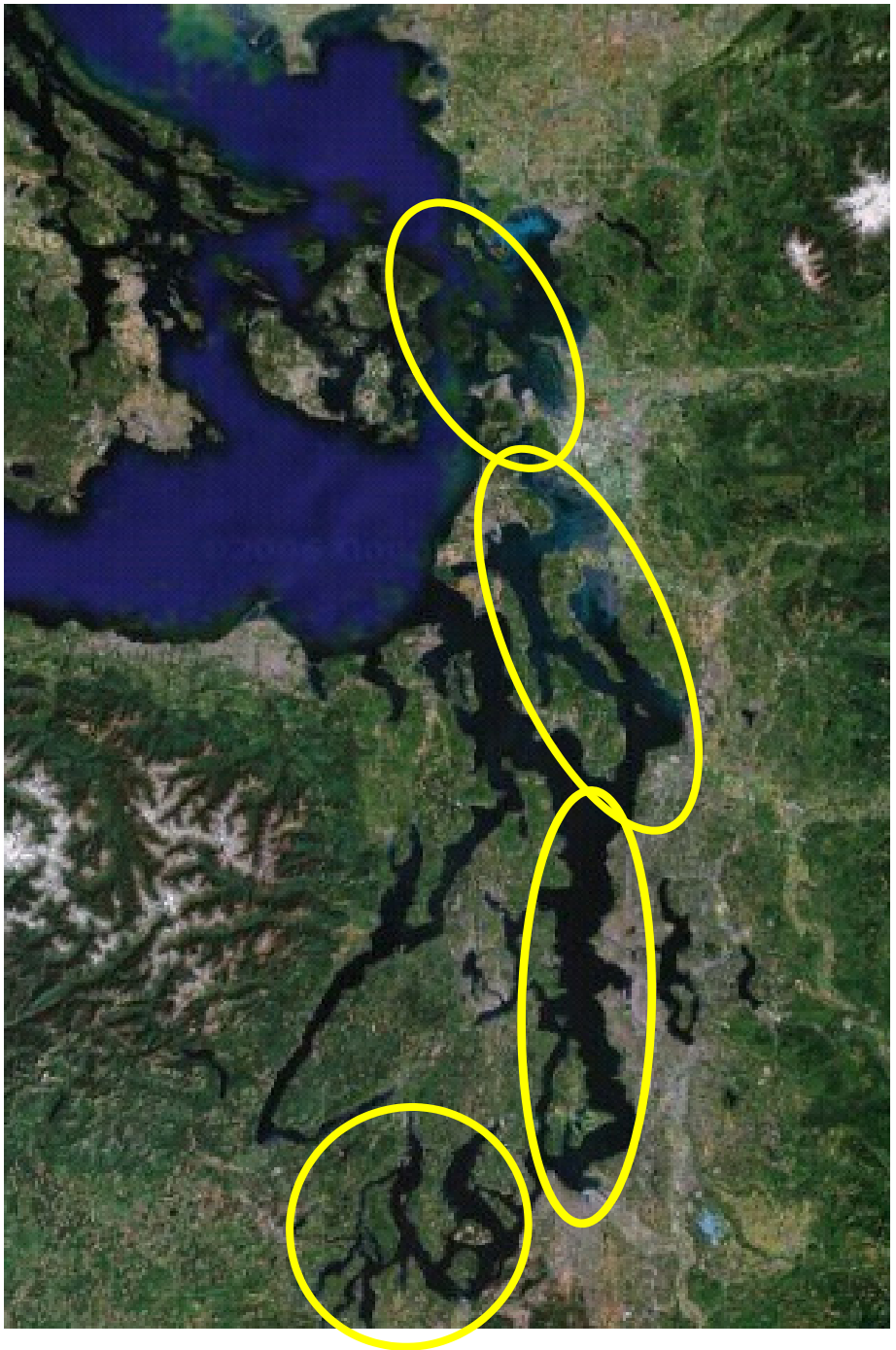
- continue compatibility with NOAA MW program

Geographic Scope for Pilot Study

- Southern Puget Sound
- Central Puget Sound
- Whidbey Basin
- Bellingham Basin

Depending on availability of funds, additional water bodies could be included:

- Strait of Georgia
- Strait of Juan de Fuca
- Admiralty Inlet
- Hood Canal
- San Juan Archipelago



Station selection criteria (60 sites for pilot study)

Short term (pilot study)

- Based on as complete coverage of area as possible
- Representative sampling for obvious, large scale conditions
    - Cities
    - Large marinas
    - Large outfalls
    - WWTPs
    - Rural shorelines

- Co-locate mussel sites with
    - eelgrass study
    - input from WDFW Oil Spill Team to cover areas of high priority for baseline/Natural Resource Damage Assessment

Station selection criteria (for long-term program)

Long term program

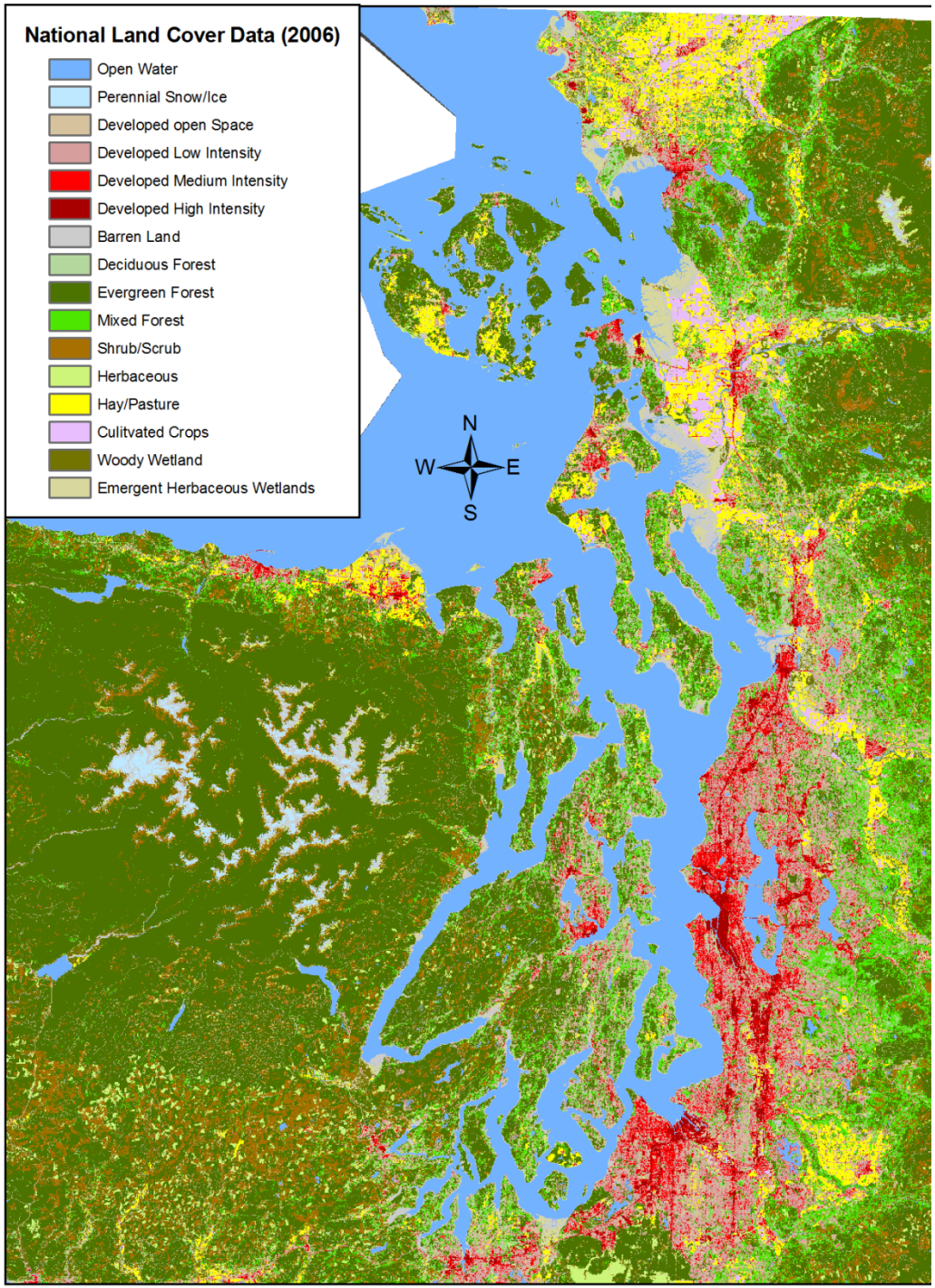
Area stratified by upland land-use with strata initially relating to degree of impervious surfaces.

Minimum of three impervious surface strata (low, med, high) within which replicate sample sites may be assigned.

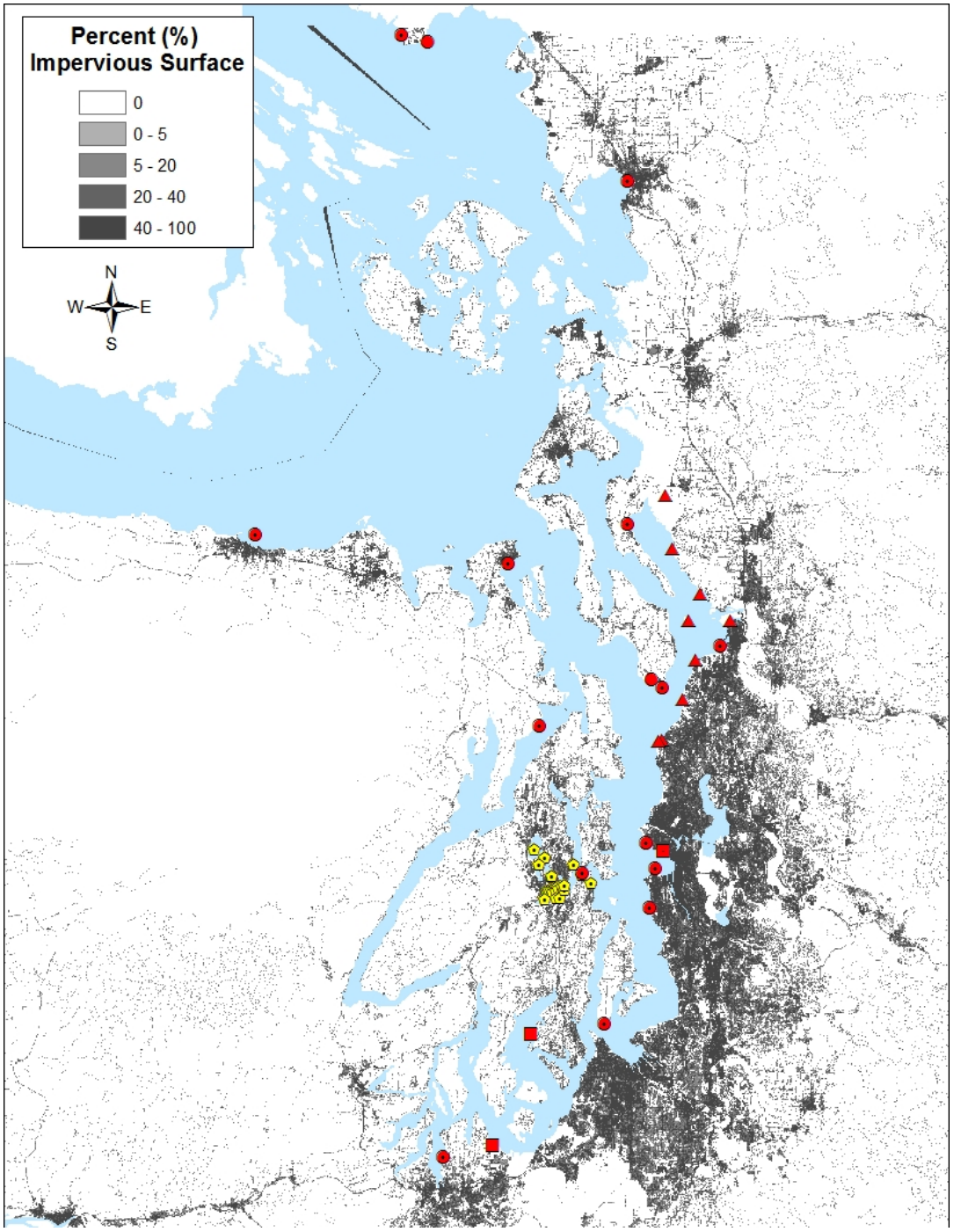
Selection informed by pilot study: sites with potential contaminant "meso" point-sources may also be included as separate strata, e.g.,:

- major stormwater outfalls
- marinas
- Combined Sewer Overflow (CSO) outfalls
- WWTPs

Assessment (NRDA) baseline monitoring, and areas that have been predicted to be at high risk of damage from spills


National Land Cover Data (2006)
Open Water
Perennial Snow/Ice
Developed open Space
Developed Low Intensity
Developed Medium Intensity
Developed High Intensity
Barren Land
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub/Scrub
Herbaceous
Hay/Pasture
Culitvated Crops
Woody Wetland
Emergent Herbaceous Wetlands
N
W
E
S

Current Mussel Locations
NOAA
SCMRC
ENVVEST



MW Pilot Expansion Study Technical Meeting

Mussel Watch Pilot Expansion Study - Scope of Work

- Brief refresher of study goals/objectives
- Geographic scope (map)
- Station selection criteria and need to co-locate stations

Study Design Elements

- **Sample timing** – when should we sample mussels? (30-45 min)
  - SCMRC seasonal study
  - Seasonality of contaminant inputs
  - Mussel biology
- Naturally Occurring vs. Caged Mussels -
  - What factors are most important to control in this study?
    - Placement of sites
    - Timing of collection
    - Other issues?
  - Pros/Cons of each method

Washington MW Summary (2004-2011) update

- Data compatibility issues - how labs report data (qualifiers, non-detects)
- Common procedures for estimating contaminant totals (e.g., Total PCBs)
- Analytes to include in summations (e.g., Sum PAHs)
- Anticipate comparisons with other media?
- Diagnostic analytes/ratios?

Snohomish County Seasonal Study

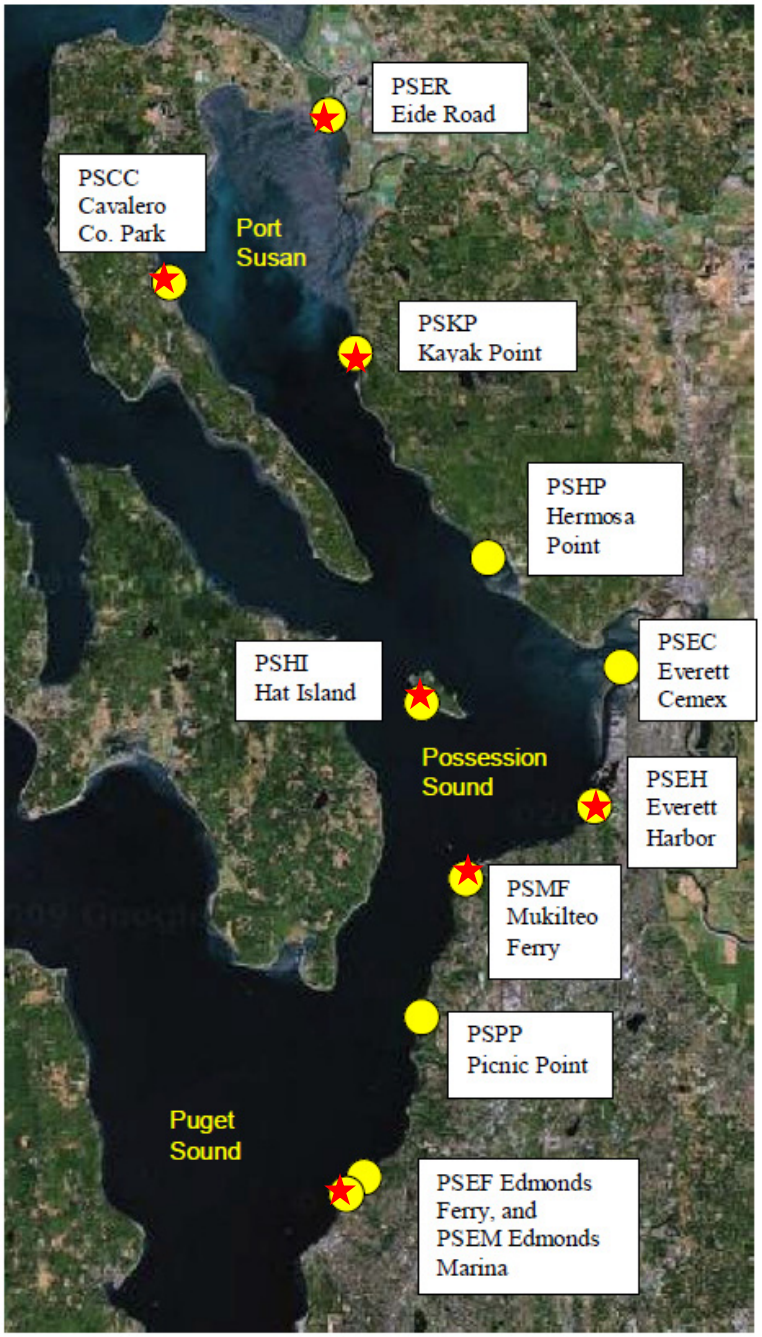
- Wet Season (winter) 2006, 08, 09
- Dry Season (summer) 2007, 08
- Seven sites around Snohomish County
- Winter > summer for PCBs, DDTs and PAHs
- Winter somewhat > summer for chlordanes
- Equivocal for HCHs, HCB and most metals measured

Snohomish County MW Sites

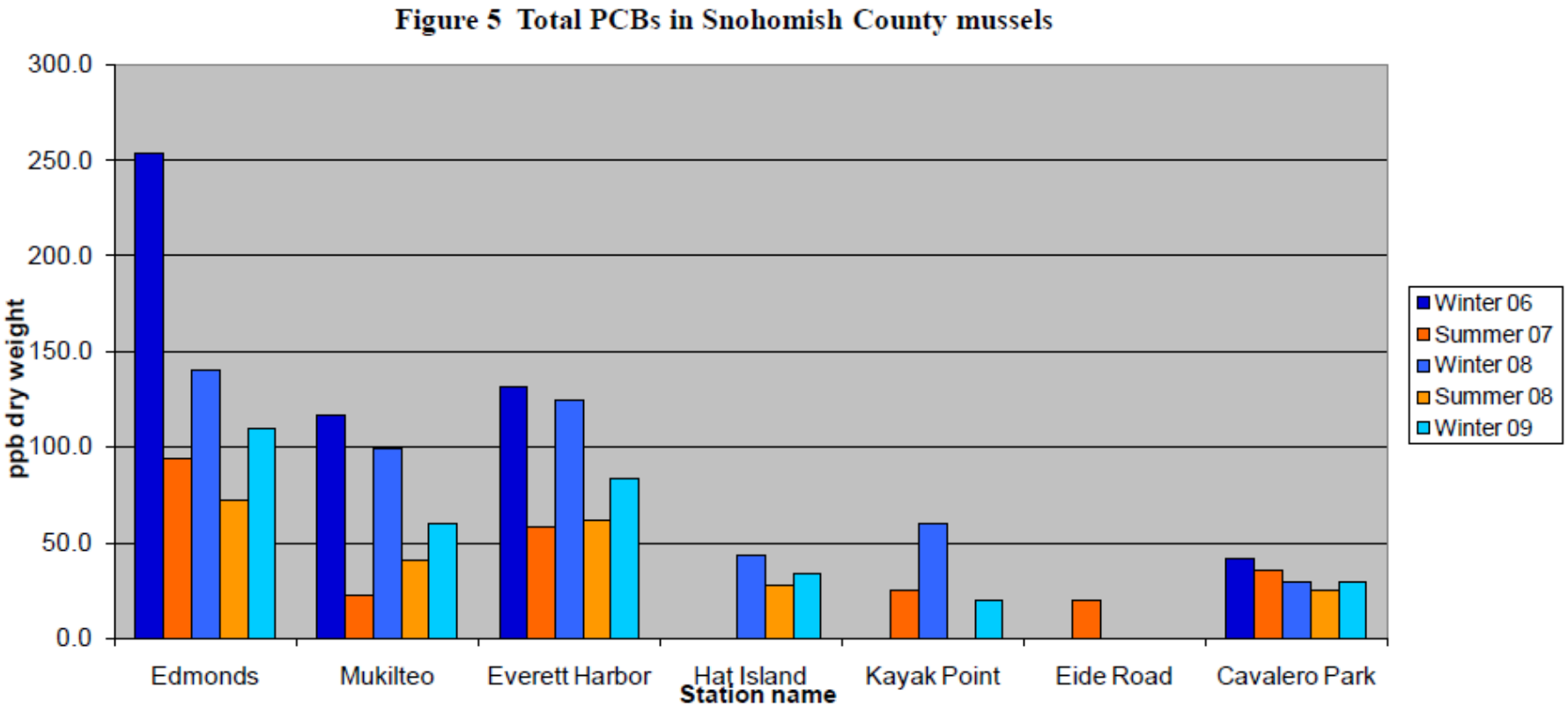
(seasonal study sites – red stars)

Wet Season (winter)
2006, 08, 09

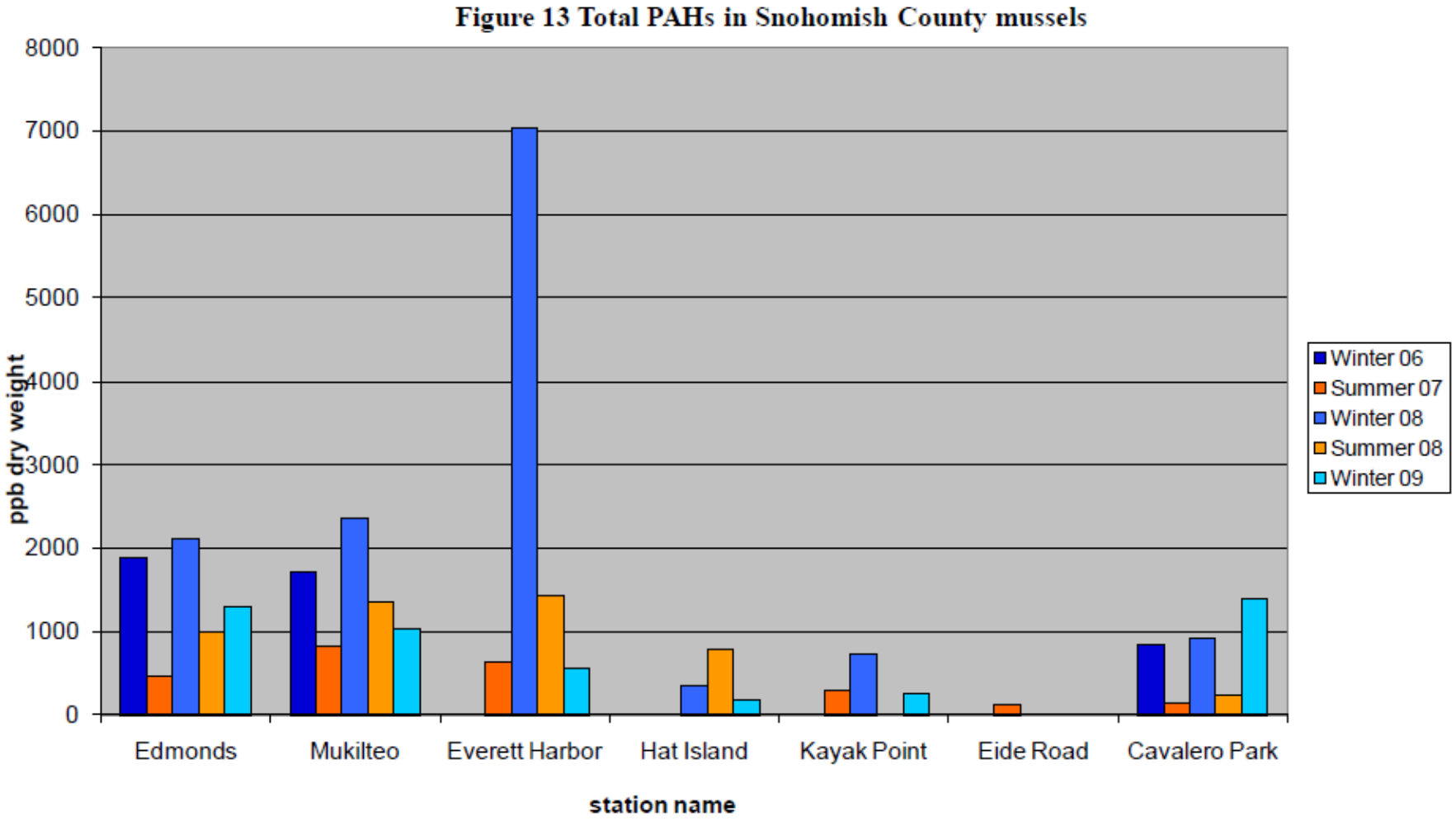
Dry Season (summer)
2007, 08



“Wet season samples are higher in T-PCB than dry season samples. Perhaps this could be explained by stormwater. However, it might also be associated with differences in T-PCB concentrations in surface and deep waters in Puget Sound.”

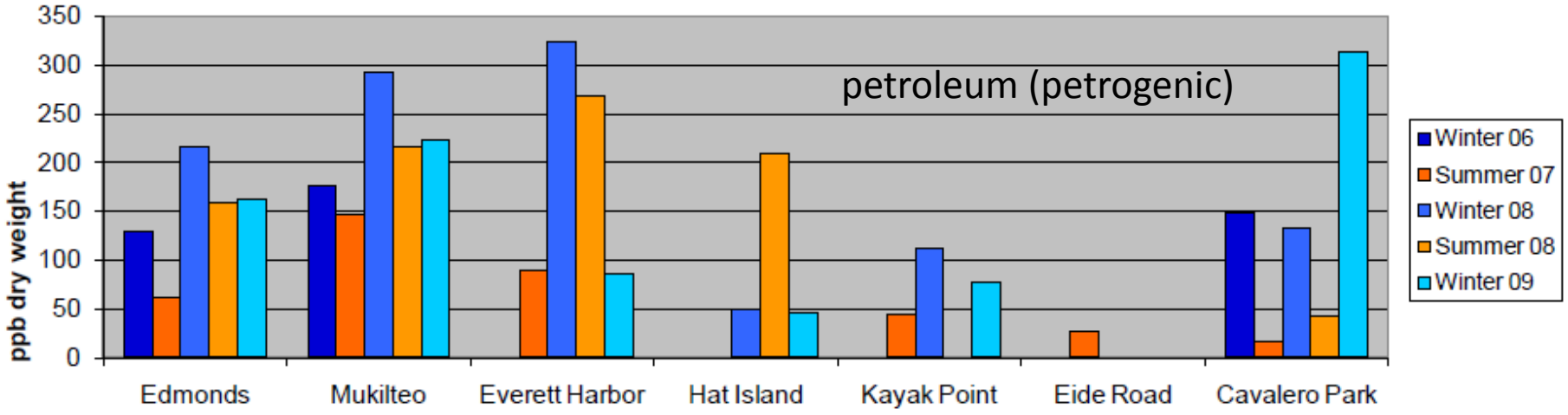


"PAHs also vary significantly with the season, indicating that storm water runoff is a significant source of PAHs. Wet season samples are between 2 and 10 times higher in total PAHs than the dry season."



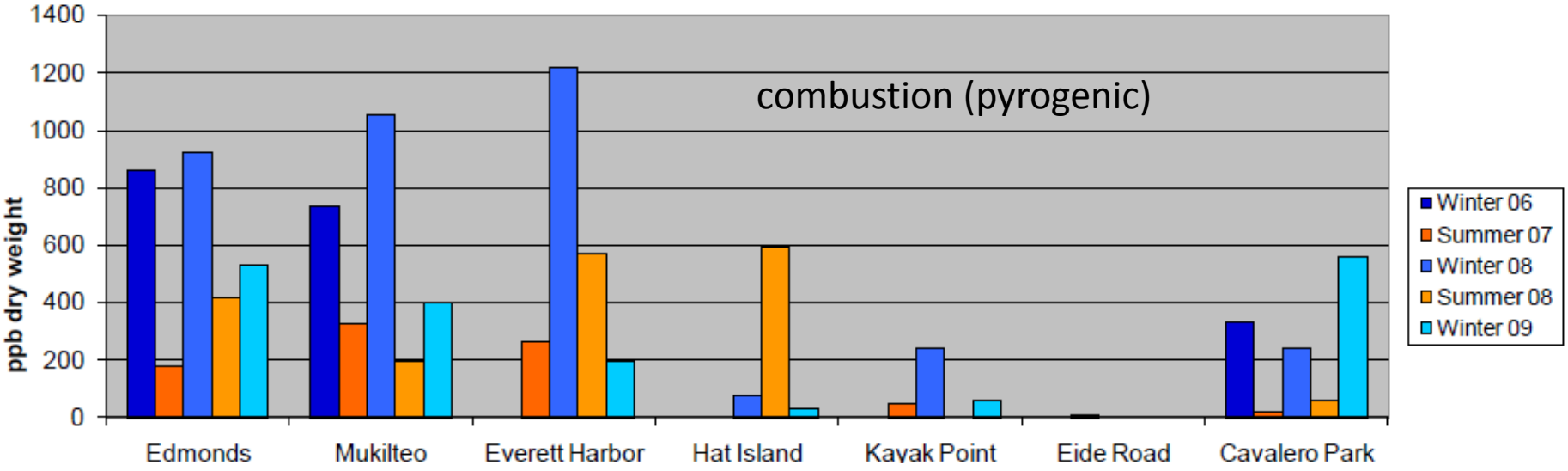
"L-PAH is the sum of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene and Anthracene."

Figure 15 Total Low Molecular Weight PAHs (LPAHs) in Snohomish County mussels

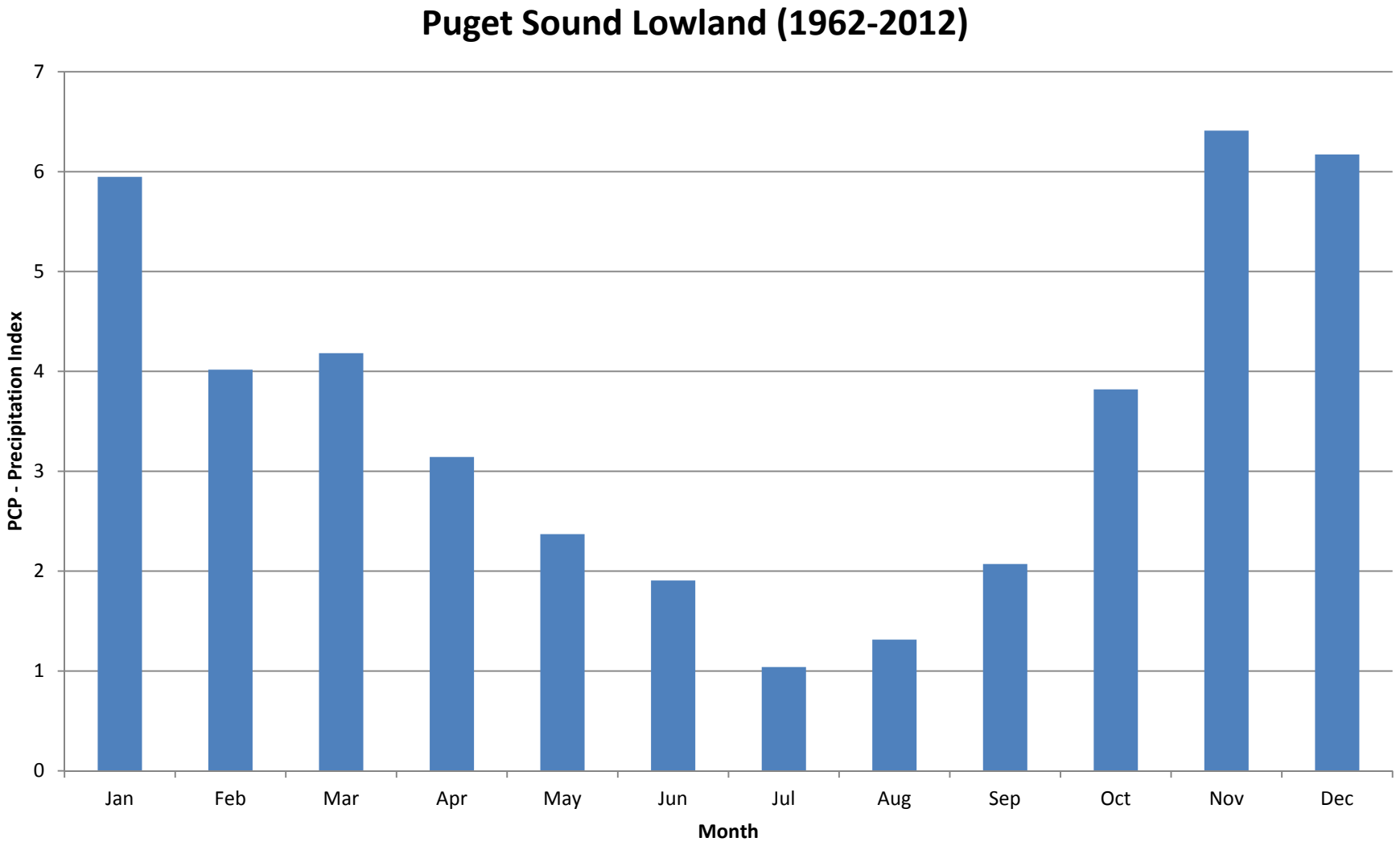


"H-PAH is the sum of Fluoranthene, Pyrene, Benz(a)Anthracene, Chrysene, Total Benzofluoranthenes, Benzo(a)Pyrene, Indeno(1,2,3-c,d)Pyrene, Dibenzo(a,h)Anthracene and Benzo(g,h,i)Perylene."

Figure 16 Total High Molecular Weight PAHs (HPAHs) in Snohomish County mussels



National Climate Data Center



Peak spawning period for *Mytilus edulis* complex in Puget Sound is April - May (Kagley et al. 2003)

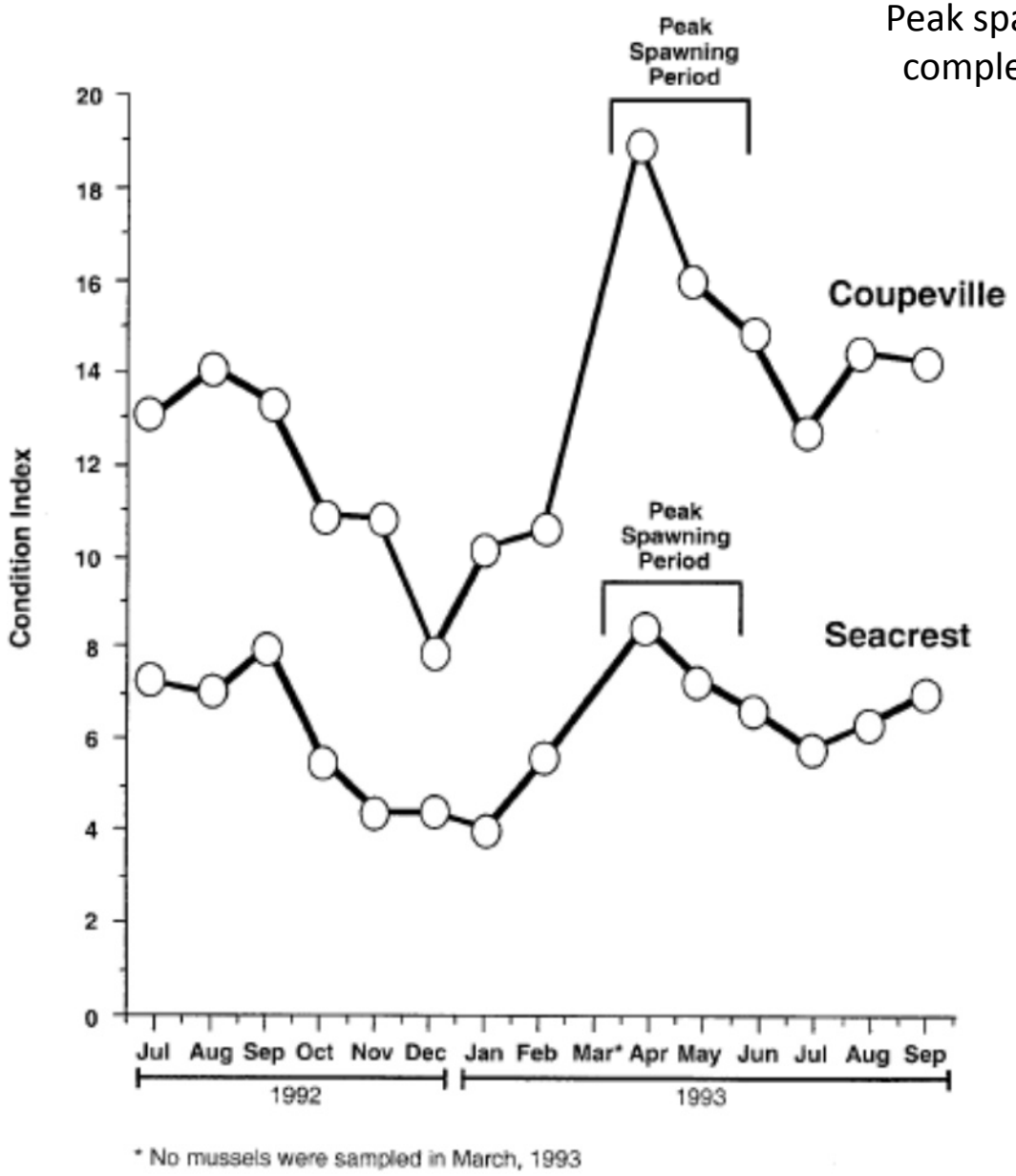
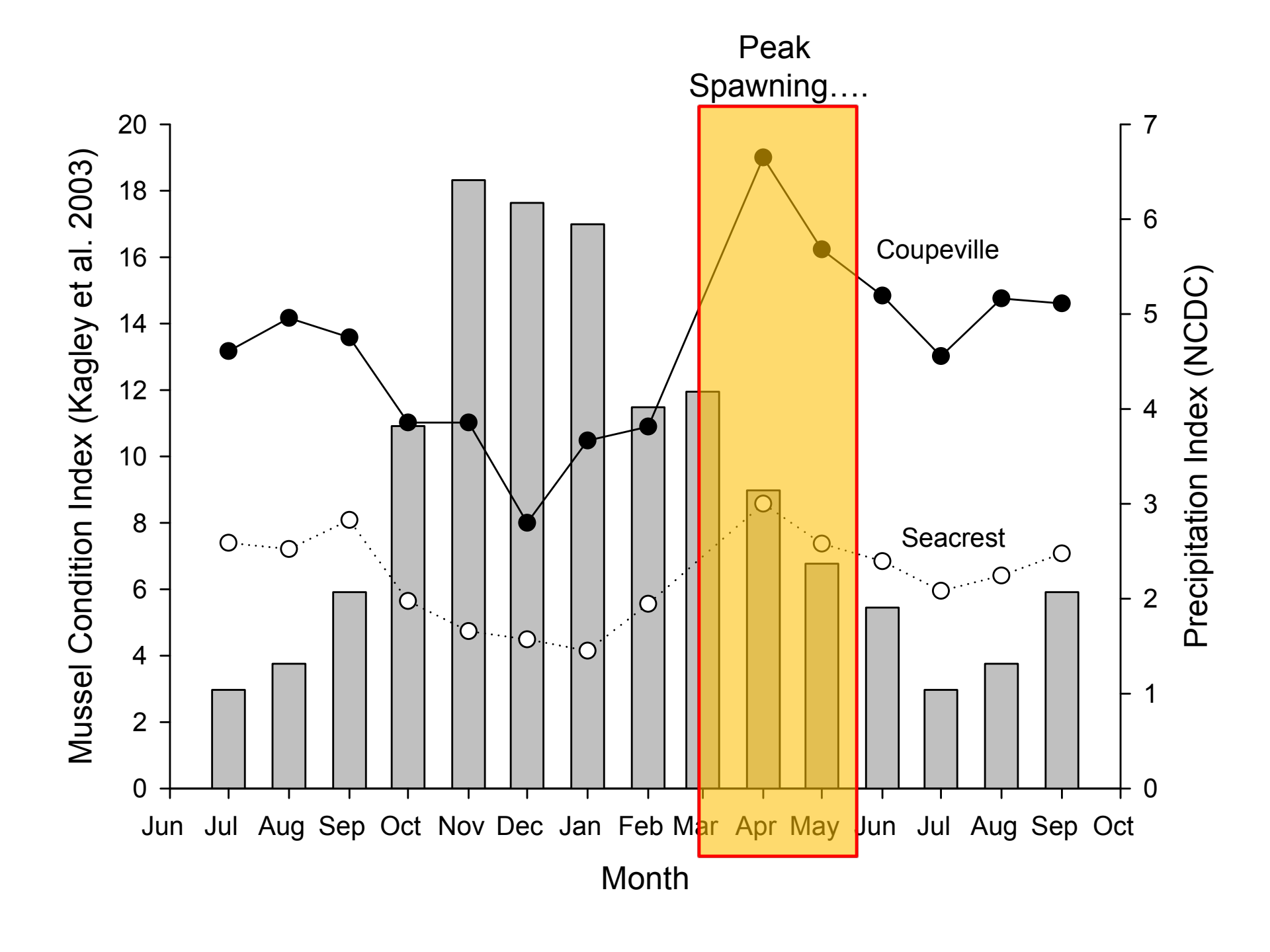
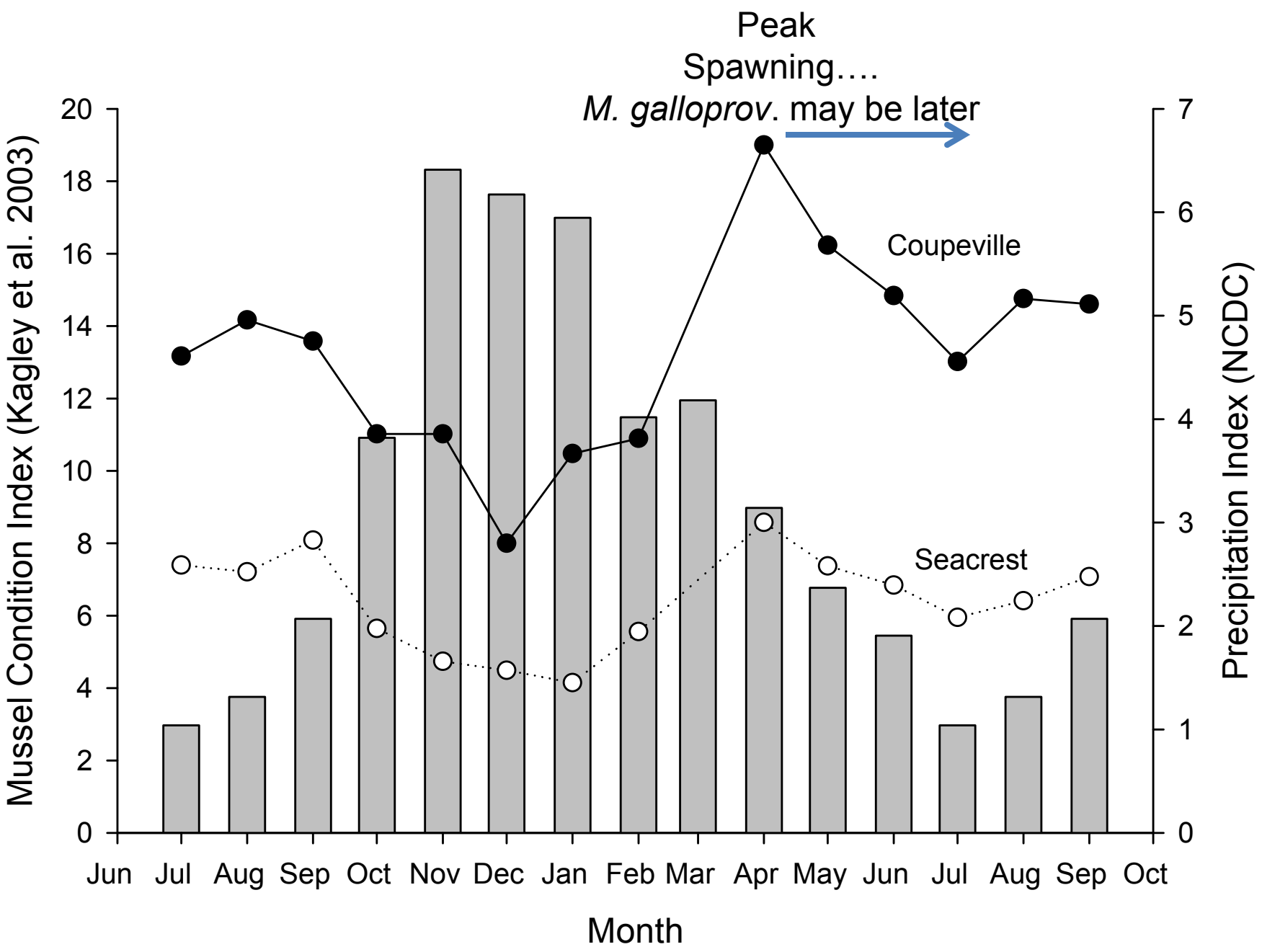


Fig. 2. Changes in the condition index of mussels (*Mytilus edulis* complex) from Coupeville and Seacrest (n = 25 per site, per month) from July 1992 to September 1993. The condition index is the somatic tissue wet weight (g)/(shell length [mm]) * 100


Peak
Spawning….
Coupeville
Seacrest
Mussel Condition Index (Kagley et al. 2003)
Precipitation Index (NCDC)
Month
0
2
4
6
8
10
12
14
16
18
20
0
1
2
3
4
5
6
7
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct


Peak
Spawning….
M. galloprov. may be later
Coupeville
Seacrest
Mussel Condition Index (Kagley et al. 2003)
Precipitation Index (NCDC)
Month
0
2
4
6
8
10
12
14
16
18
20
0
1
2
3
4
5
6
7
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct

MW Pilot Expansion Study Technical Meeting

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Characteristics required of an Indicator for large-scale S&T monitoring

1. Ubiquitous distribution
2. Single “species”
3. Consistent through time
4. Cost-effective (easily conducted) protocols
5. Easy to sample (volunteers?)

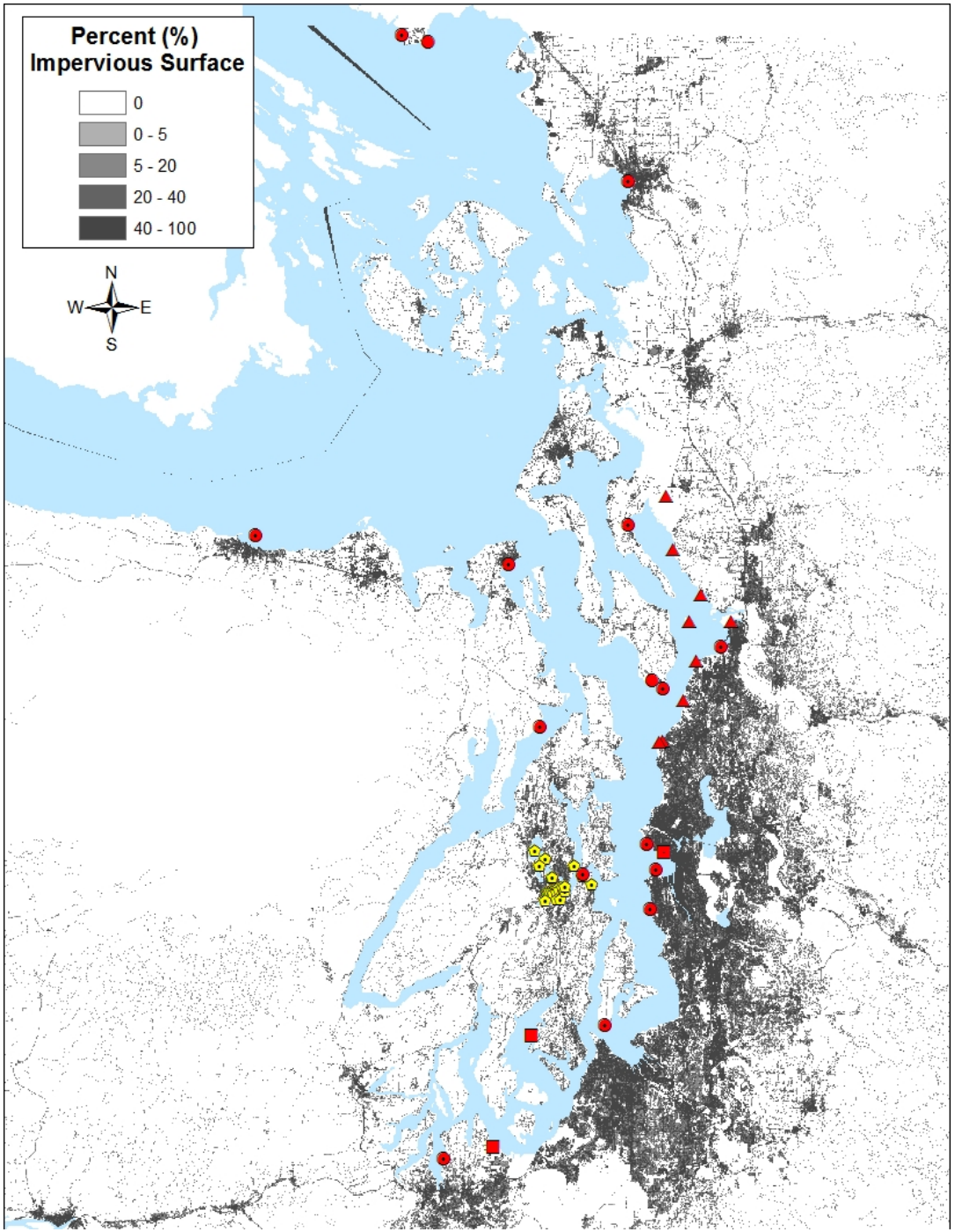
Design strategies to minimize variability and maximize statistical power

1. Equalize exposure time
   - Consistent tidal elevation
   - Consistent age (known-age, or est. age from size)
2. Minimize effects of reproduction
   - Equalize lipid content
   - Avoid variable loss of chemicals via gametes
3. Equalize life stage

Are mussels ubiquitous in PS?

- Mussels at MW, SCMRC, and ENVVEST sites
- Found at other sites
  - Info from DOH, DNR, WDFW, Tribes, volunteers
- Feasibility study for SWG
  - Mapped *potential* mussel habitat
  - Only examined UGA coastlines
  - DNR's *ShoreZone Inventory* – characterizes shoreline morphology, substrate, wave exposure and biota
  - Ecology's WA Coastal Atlas - orthophotos

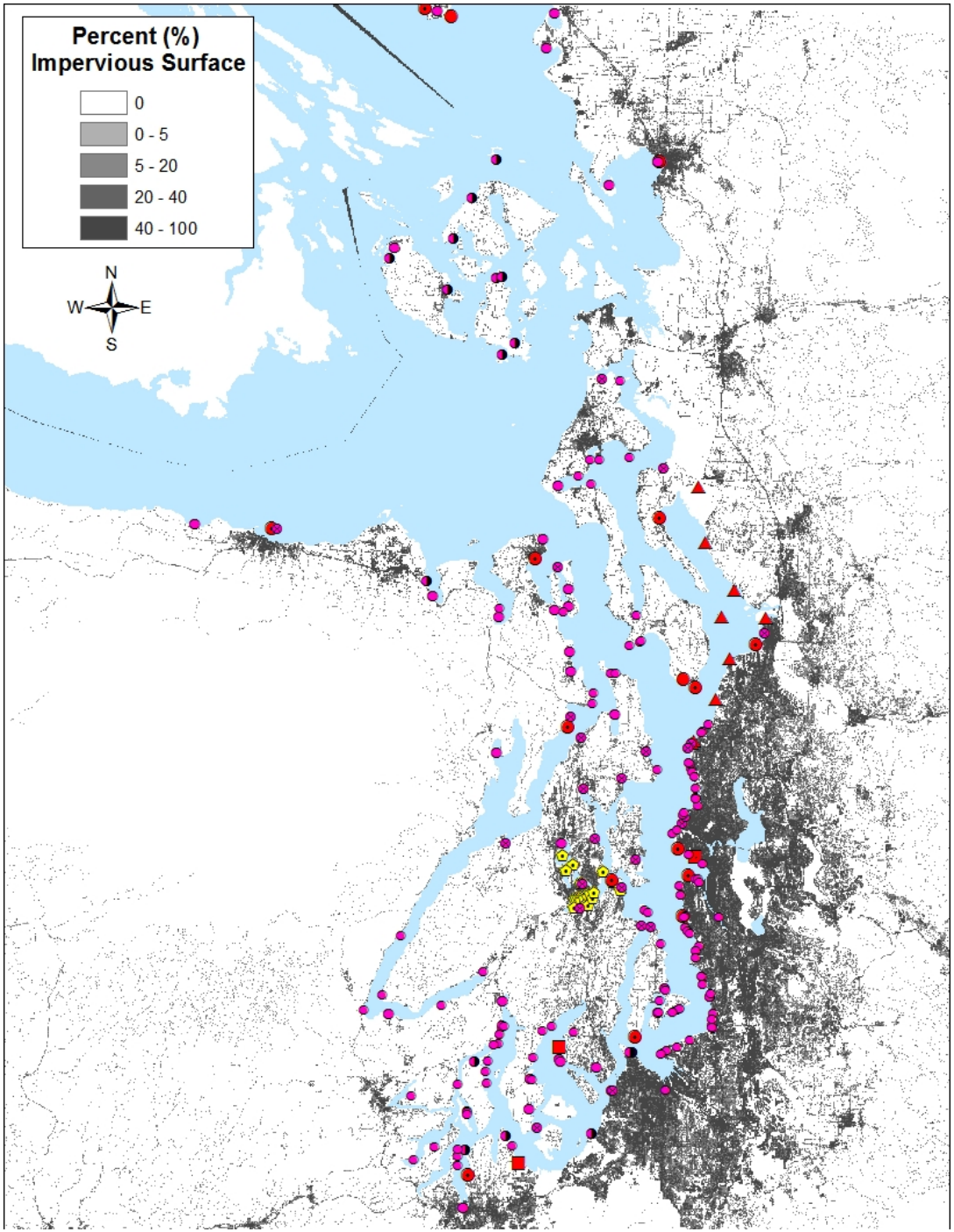
Mussels at MW, SCMRC, and ENVVEST sites



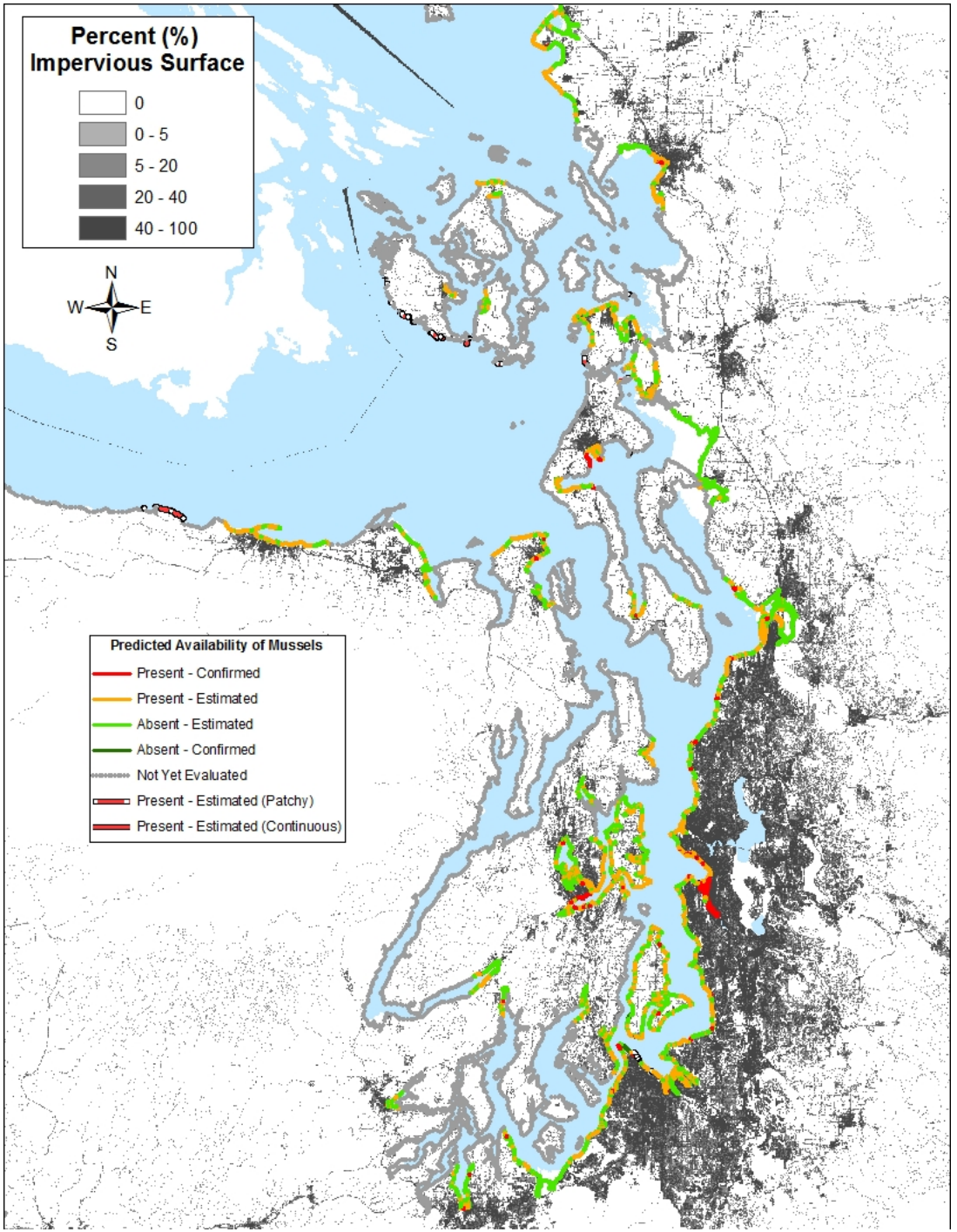
Mussels found at other sites in the past by:

DOH
- Native
- Caged
- Both

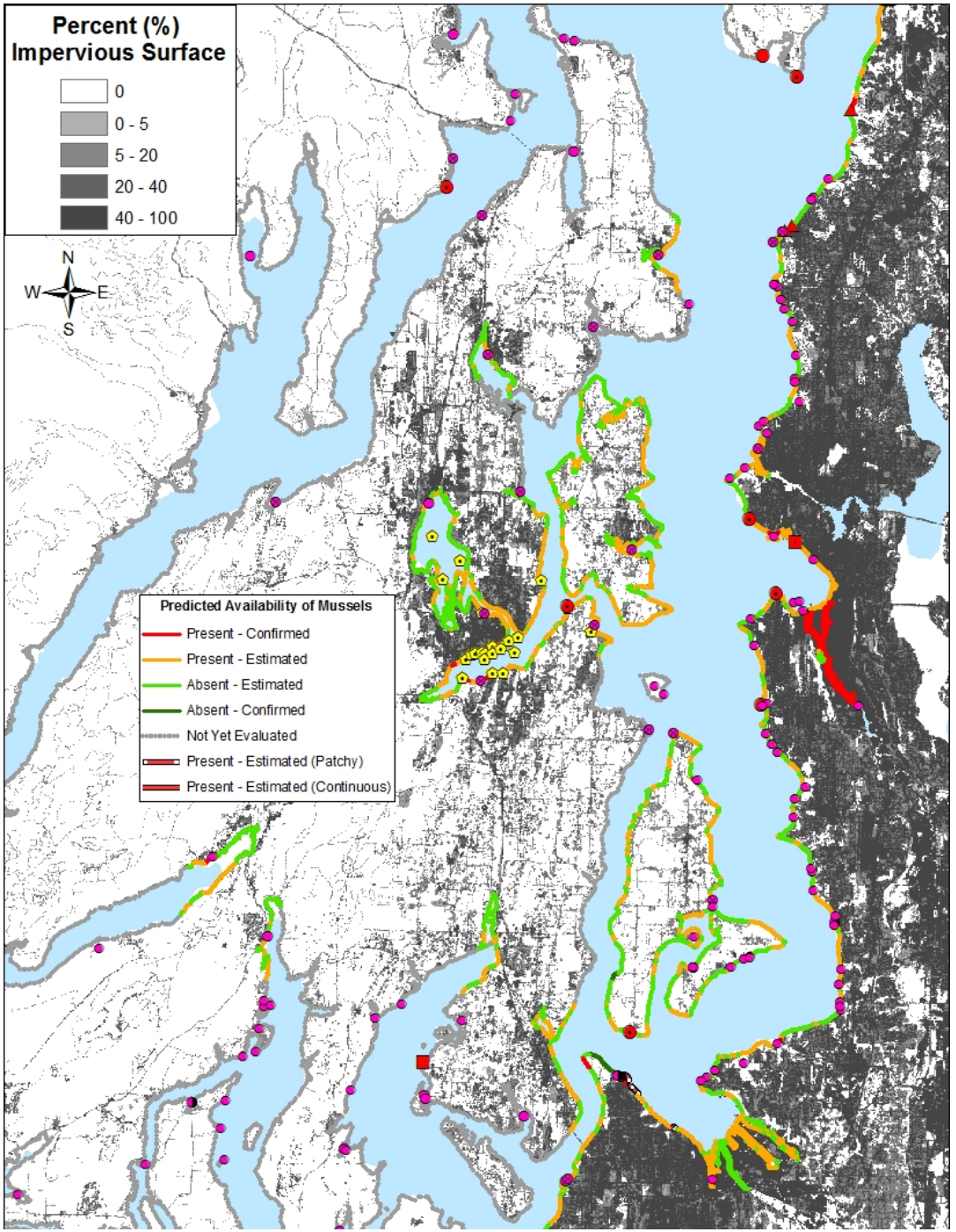
DNR
WDFW Oil Spill
WDFW Pt. Whitney
King County BEACH
Muckleshoot Tribe
Nisqually Tribe
SCALE study (minor)
Seattle Aquarium
Skokomish Tribe
Squaxin Tribe
Swinomish Tribe
UW Tacoma



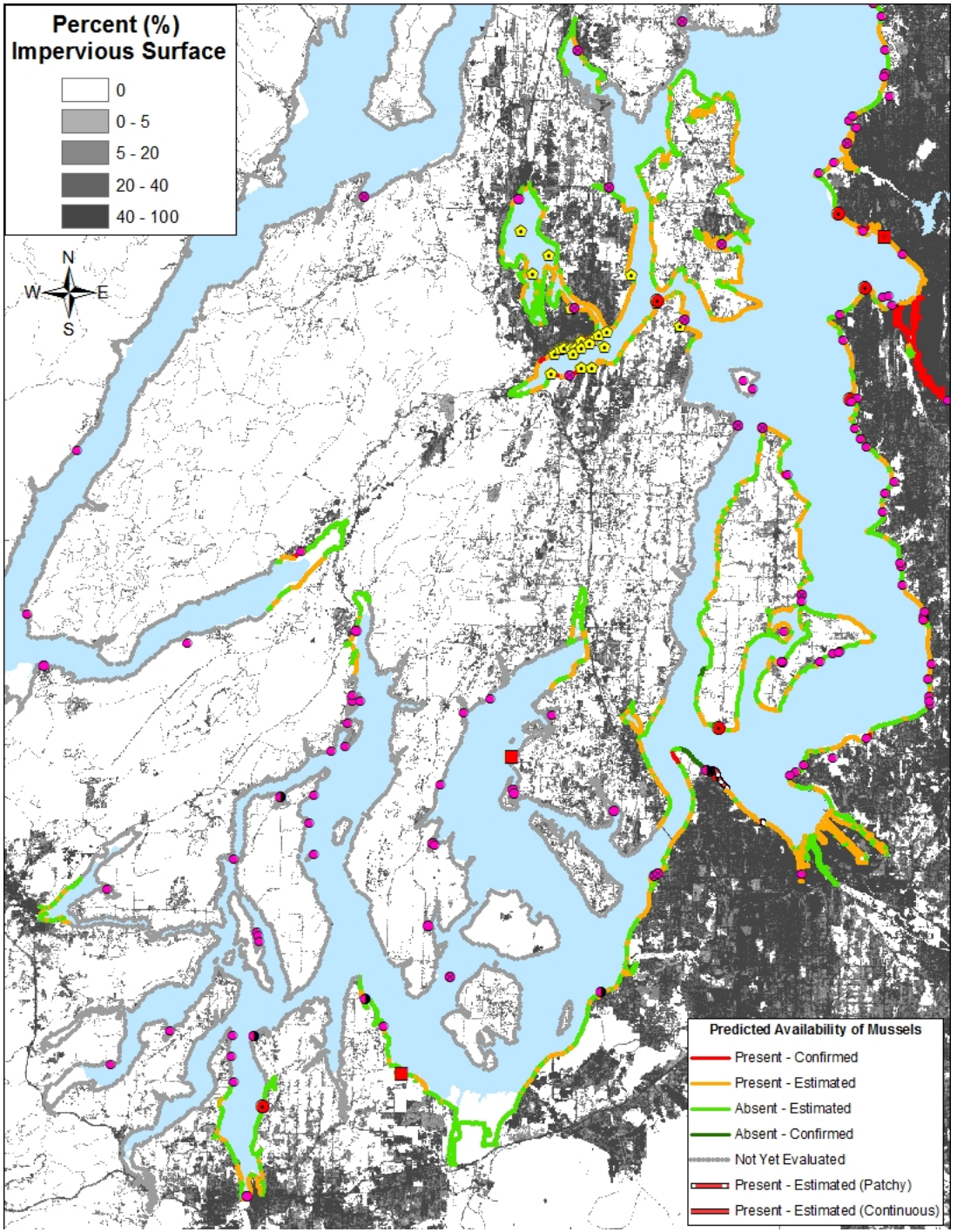
Map of *potential* mussel habitat (SWG Feasibility Study)



Kitsap
King

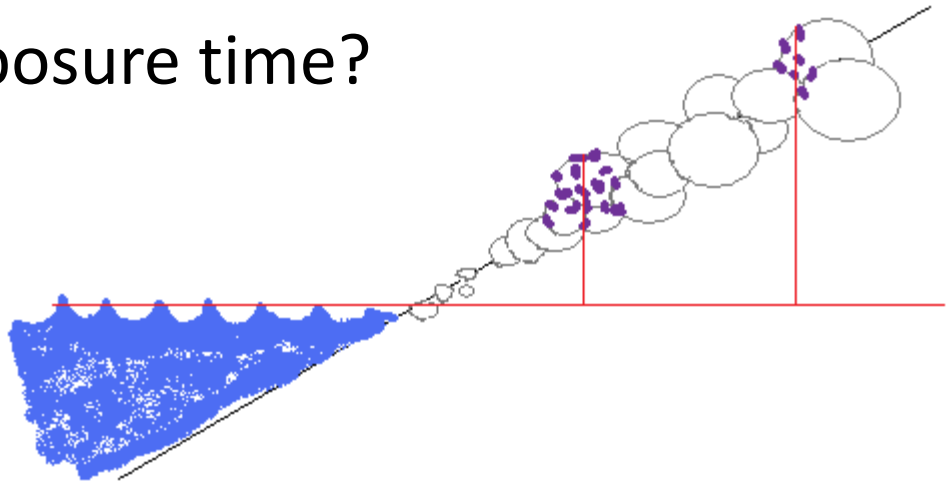

Percent (%)
Impervious Surface
0
0 - 5
5 - 20
20 - 40
40 - 100
N
W
E
S
Predicted Availability of Mussels
Present - Confirmed
Present - Estimated
Absent - Estimated
Absent - Confirmed
Not Yet Evaluated
Present - Estimated (Patchy)
Present - Estimated (Continuous)

Kitsap
Mason
Pierce
Thurston



At what tidal elevation are mussels collected?

- Figure from MW protocol - height of collection vs. highest distribution of mussels
- Often collecting from mid- to high intertidal zone, sometimes from low
- Differences in exposure time?



Species and Size?

- What species are collected?
  - *Mytilus trossulus*
  - *M. galloprovincialis*
  - Hybrids
  - *M. edulis*
  - *M. californianus*
- What size/age?
  - MW protocol requires for 2-3 inch (ideal size)
    - 2 - 3 inch long mussels: collect 50/station
    - ½ - 2 inch mussels: collect 100 – 150/station **(usual here)*
    - Less than ½ inch mussels: collect 150 – 200/station

Predictable Mussel Supply

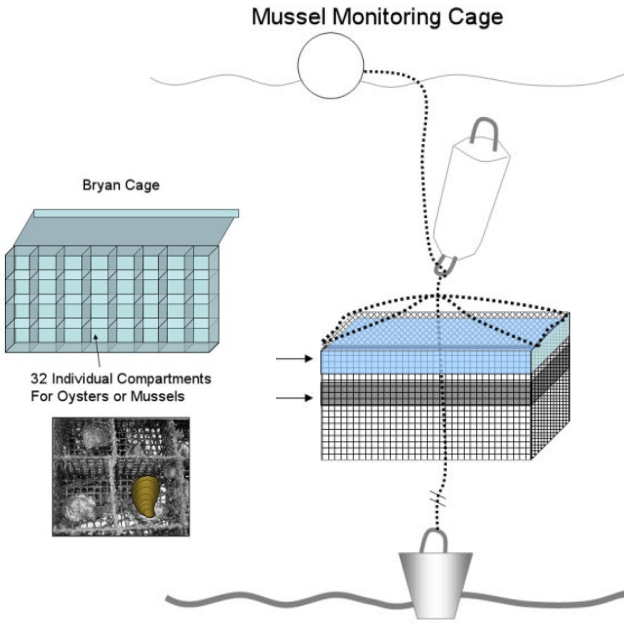
- Is the mussel supply consistent over time?
  - Sites lost (or moved) due to population decline or predation in various years
    - PSSS – Puget Sound, South Sound
    - PSMF – Puget Sound, Mukilteo Ferry
    - PSEM – Puget Sound, Edmonds Marina
    - PSKP – Puget Sound, Kayak Point
    - PSER – Puget Sound, Eide Road
    - PSCC – Puget Sound, Cavalero County Park
    - GHWJ – Gray's Harbor, Westport Jetty
    - WIPP – Whidbey Island, Possession Point
    - PRPR – Point Roberts, Point Roberts (1/3 sample this year)

Caged Mussels Studies

- Called “active biomonitoring”
- Literature review shows range of uses:
  - Small scale range
    - Superfund sites
    - Gradient studies
    - Effectiveness monitoring
    - Puget Sound - Michael Salazar (Applied Biomonitoring Inc.)
  - Large scale range
    - Status and trend studies
    - RINBIO (French Coast, 50 mgmt zones, 1996-2003, 106 cages)
    - Mytilos (6 nations, Mediterranean Sea, 123 stations, 2004-2006)

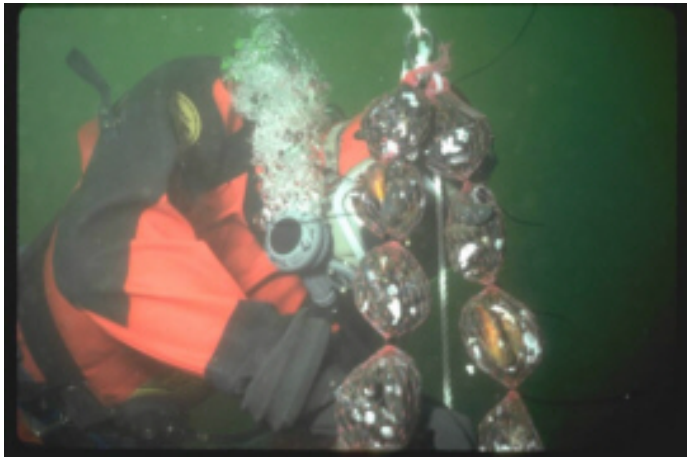
Small Scale Caged Studies

Contaminated sediments assessed at Harbor Island Superfund site in Puget Sound. Caged mussels deployed 1 m off the bottom and inspected by divers periodically. (Salazar)

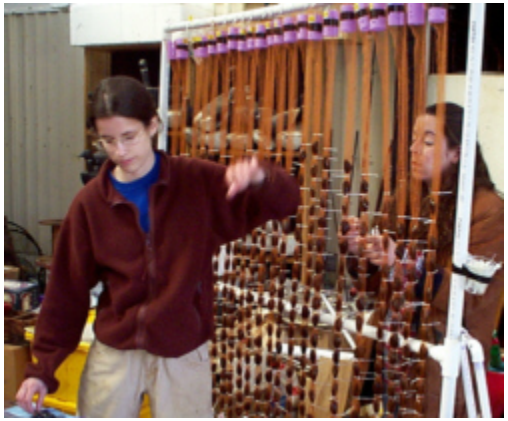


Shellfish Monitoring Network in the Southern Gulf of St. Lawrence (Fisheries & Oceans Canada)

Bagged adult & juvenile mussels in plastic cutlery trays (Salazar)



Mussels moored 1-2 months (Mass. Water Resources Authority)



Compartmentalized bags attached to PVC frame and protected with predator mesh (Salazar)

Large Scale Monitoring - **Mytilos Project**

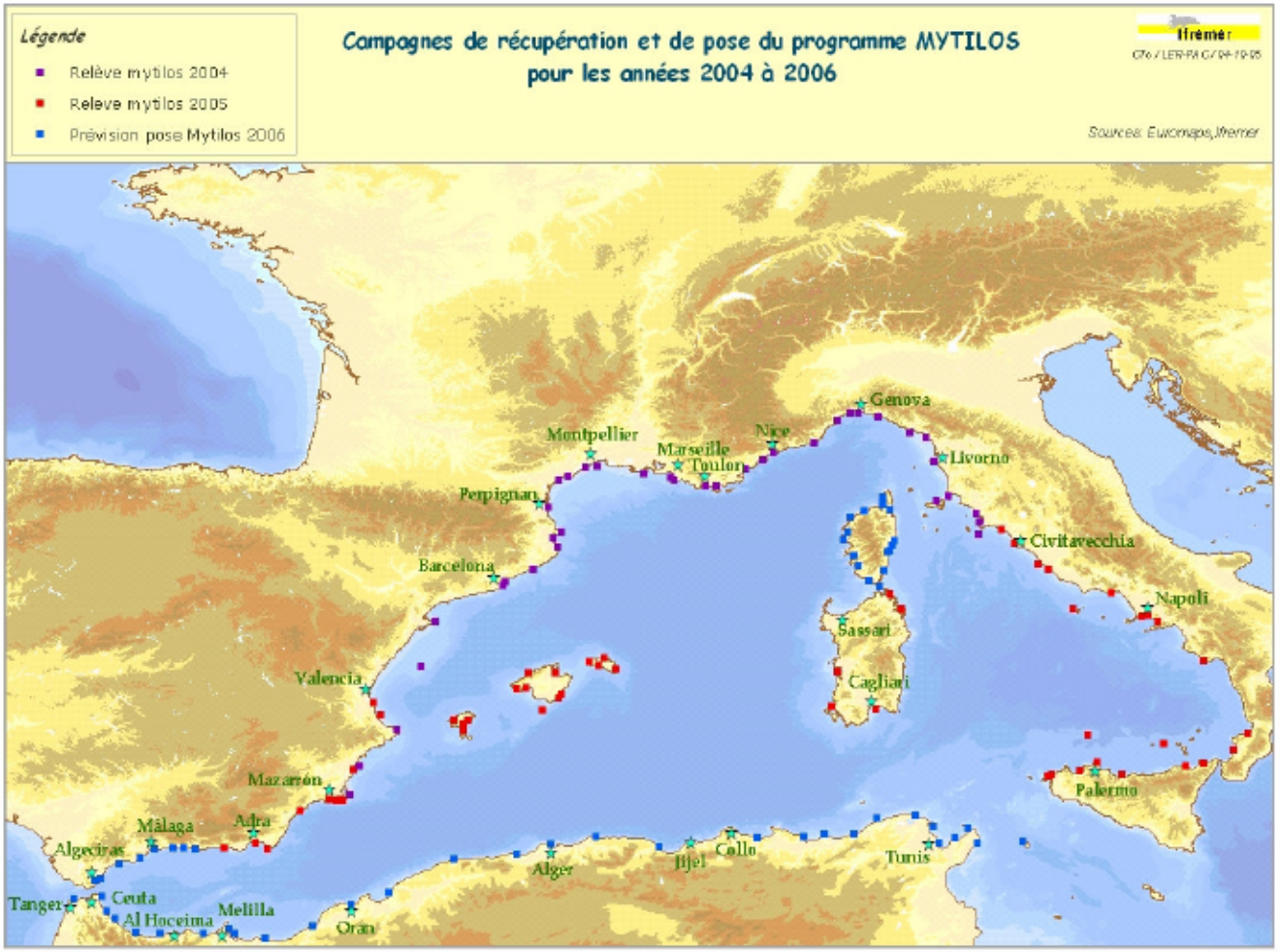
A monitoring network to evaluate chemical contamination at a large-scale level in the Mediterranean Sea

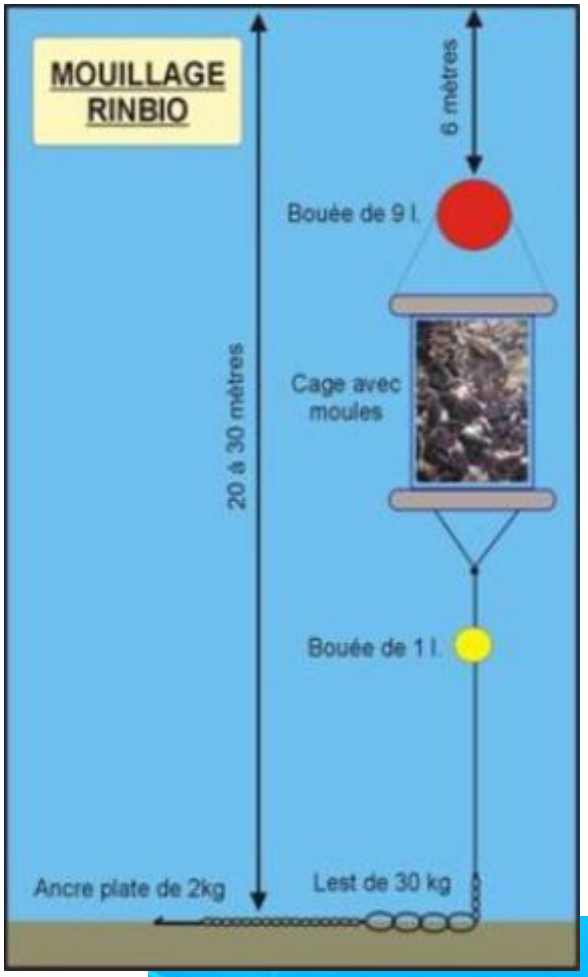
Not sufficient distribution of mussels along that coast - used caged mussels (active bio-monitoring)

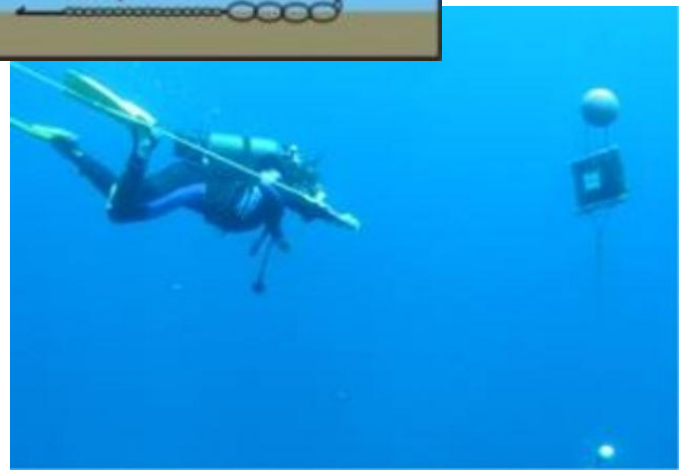
123 stations - Spain, France, Italy, North Tunisia, Algeria and Morocco

Sampled from 2004-2006

Figure 1. Map of stations




MOUILLAGE
RINBIO
6 mètres
Bouée de 9 l.
Cage avec
moules
20 à 30 mètres
Bouée de 1 l.
Ancre plate de 2kg
Lest de 30 kg



Mytilos methods:

- “Contaminant-free” source - aquaculture farm
- Single species, *(M. galloprovincialis)* adults
- Known age -- 18-24 months
- Select standard shell length (50 ± 5 mm)

- Mussels in polyethylene bags (cages) ~ 6 lbs per bag
- Bags suspended 6-8 meters (19-26 ft) from sea surface
- Anchored at bottom

- 123 stations (sampled in sets over 3 years)
- Placed at 20-40m (65-130ft) depth ranges, along coastal belt
- Immersed ~3 months (12 weeks), non-spawning season

Pros and cons of using **naturally occurring** vs. **caged/transplanted** mussels

Passive bio-monitoring with indigenous/wild mussels

Advantages

- Mussels already on location (logistically easier)
- Sampling costs minimal
- Less time-consuming (no measuring, deployment/retrieval)
- Readily comparable with National MW dataset
- Easy for volunteers to learn

Disadvantages

- Less statistical resolution power between sites (variability in species, age, size, vertical position)
- Exposure period and start condition unknown
- Distribution - sampling locations restricted to natural populations
- Loss of sites between years (pops. decline and/or disappear)
- Logistics - winter sampling after dark (low tide at night) difficult
- Need to find mussels (scout in advance)
- No growth measurements or mortality estimate possible (i.e. bioeffects)

Active bio-monitoring with caged/transplanted mussels

Advantages

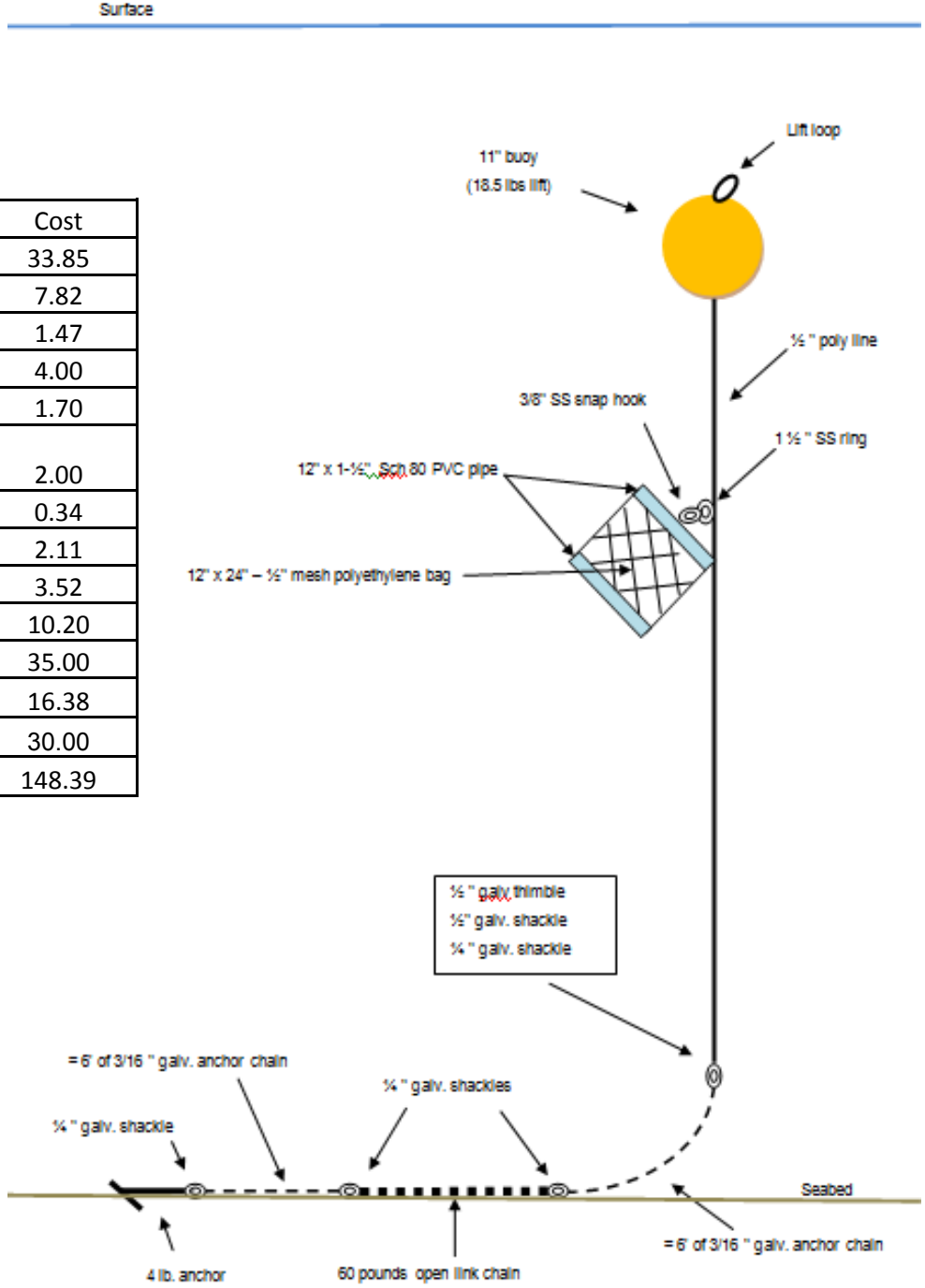
- Almost any sampling location possible
- Greater statistical resolution, uniform initial condition (species, age, size, vertical position)
- Exposure period known/clearly defined
- Bioeffects measurements possible (i.e. growth, mortality)
- Dependability of sites between years (reduced loss of sites from predation/pop. failure)
- Easier to co-locate sites with other studies (sediment, effectiveness monitoring, gradients)
- Winter sampling during daylight (no reliance on low tide)
- More interesting for volunteers, easy to learn?

Disadvantages

- Logistics more complex (cages, sorting/measuring, deploy/retrieve, permissions)
- Requires 3 months lead time
- Sampling costs higher
- Attrition of cages due to theft, storms (replicates needed)
- Study needed to determine comparability with National MW dataset
- Difficult to reconcile tidal elevation with proximity to shore

Cost estimate for caged mussels

Description	Count	Unit	Cost
Buoy	1	ea	33.85
1/2" polyethylene line	80	feet	7.82
3/8" SS ring	1	ea	1.47
3/8" SS snap hook	1	ea	4.00
1' x 1-1/2" Sch 80 PVC pipe	2	ea	1.70
12"x 24" - 1/2" polyethylene mesh bag	1	ea	2.00
1/2" galv. Thimble	1	ea	0.34
1/2" galv. shackle	1	ea	2.11
1/4" galv. shackle	4	ea	3.52
3/16" galv. Proof coil chain	12	feet	10.20
60 pounds 1" open link chain	7	feet	35.00
4 lb. danforth anchor	1	ea	16.38
M. trossulus: Penn Cove, 2.75 in	125	5 lb	30.00
Total			148.39



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Washington MW Summary (2004-2011) update (20-30 min)

- Data compatibility issues - how labs report data (qualifiers, non-detects)
- Common procedures for estimating contaminant totals (e.g., Total PCBs)
- Analytes to include in summations (e.g., Sum PAHs)
- Anticipate comparisons with other media?
- Diagnostic analytes/ratios?

Data Compatibility Issues:
how labs report data (qualifiers, non-detects)

TDI Brooks
"U" reported as 0
"J" is below MDL
-so what is reported for "J"?

Table 3. Data Qualifier Definitions.

Qualifier	Definition
B	Analyte detected in the procedural blank greater than 3X MDL
D	Diluted Value
I	Analytical interference
J	Analyte detected below the method detection limit (MDL)
NA	Not Applicable
U	Analyte not detected
X	Analyte <10X MDL
Y	Spiked level of analyte <50% of the native concentration
*	Outside QA limits, refer to narrative

Battelle – "U" reported as MDL

DATA QUALIFIERS:
c Exceeds DQO but meets contingency criteria of either:
1 SRM certified <10x MDL
2 Insufficient spiking level relative to native sample concentrations
3 Sample concentration <10x MDL
U Analyte not detected at or above the MDL, MDL reported *(same as "J" for TDI?)*
J Analyte detected above the MDL, but less than the RL
-- Not analyzed
NA Not applicable/available
N Spiked sample recovery outside QC criterion of 70-130%
NC Not Certified
& Accuracy result outside QC criterion of ≤20% PD
* Precision result outside QC criterion of <30%
NS Sample not spiked for this analyte
B Analyte detected in the method blank > RL and sample concentration < 10 times detected blank value
b Data are blank corrected using the batch specific procedural blank

Common procedures for estimating contaminant totals (e.g., Total PCBs, PAHs, etc.)

In an email from Dennis Apeti to Emily Whitney (3/13/2012):

"NOAA's approach to total organic calculation is also a bit complex because *the list of analytes has grown over the years making it difficult to truly compare historical data to current levels*. Thus few changes have occurred:

For PAHs and PCBs, we have designed *two approaches to total organic calculation* that work fine for us

-**For temporal assessment we still use PAHs 24 original compounds.**
-**PCBs Sum of 2x18 original congeners**

-**For current status assessment we basically use all the compounds that are being analyzed currently."**

Questions for us:

Sum 2x18 PCBs ok for estimate of "total PCBs" ?
Best "list" for Sum PAHs? (compare with NPDES needs?)
Sum PBDEs? (NOAA currently analyzes for 11 congeners)

Analytes in common (between MW, SCMRC, ENVVEST) for Current Status Summary Report

- Current status = mean values of contaminants (i.e. total PBCs, total PAHs) for last four winters
  - 2003/04 + 05/06 + 07/08 + 09/10 (+ five stations SC for 2011?)
  - Less years for PBDEs (see below)

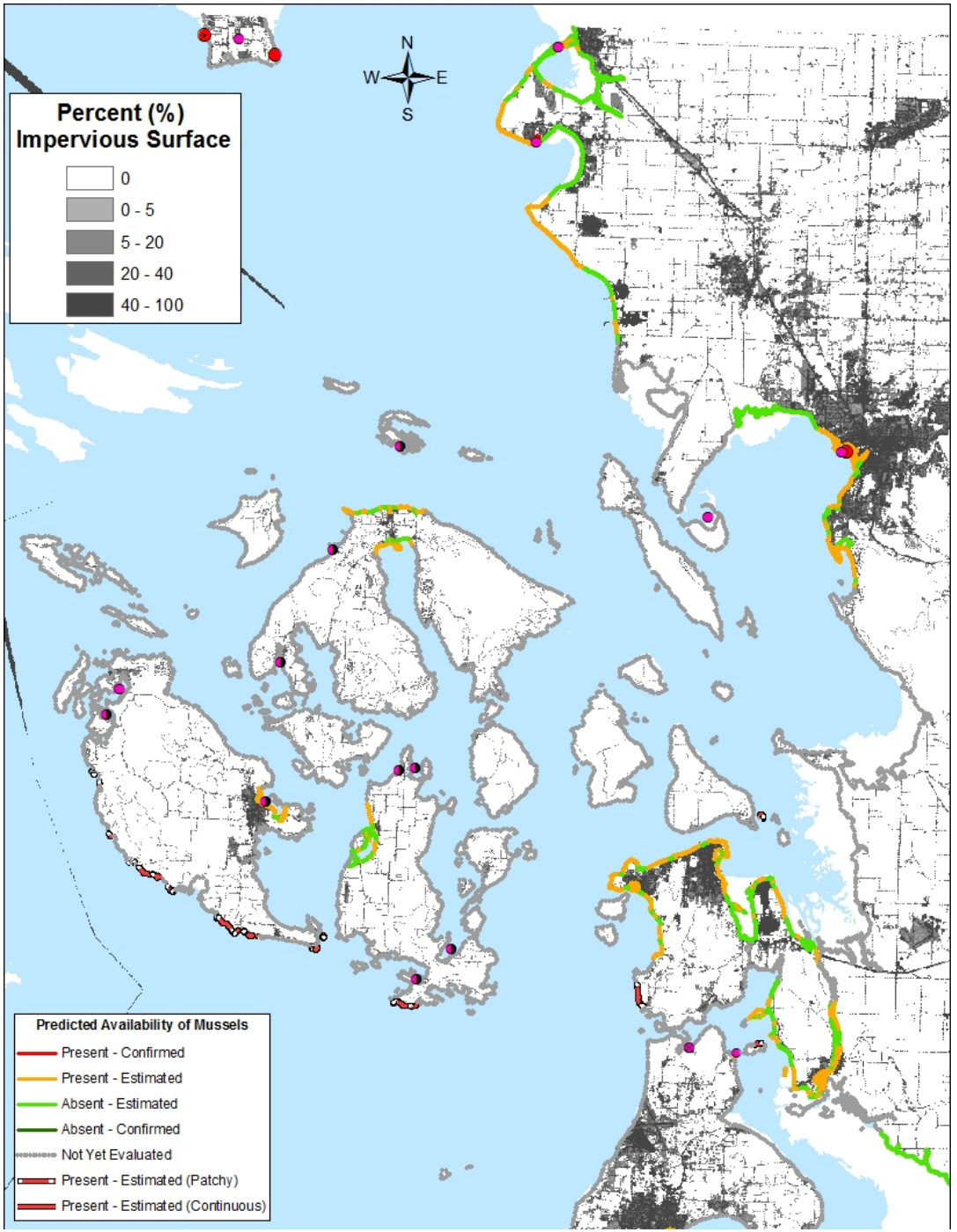
- For 1st tier analytes:
  - 18 PCB congeners in common (41 PSEMP, 41? MW, 24 ENVVEST)
  - 41 PAH analytes in common
    - 19 “parent” compounds + 21 homologues
  - 38 PBDE congeners in common
    - 2003/04 + 05/06 + 09/10 (+ five stations SC for 2011?)
    - No ENVVEST data
    - *Many* zeros in the TDI data (is/was the MDL too high?)
  - See Excel spreadsheets

Other Analysis/Data Issues

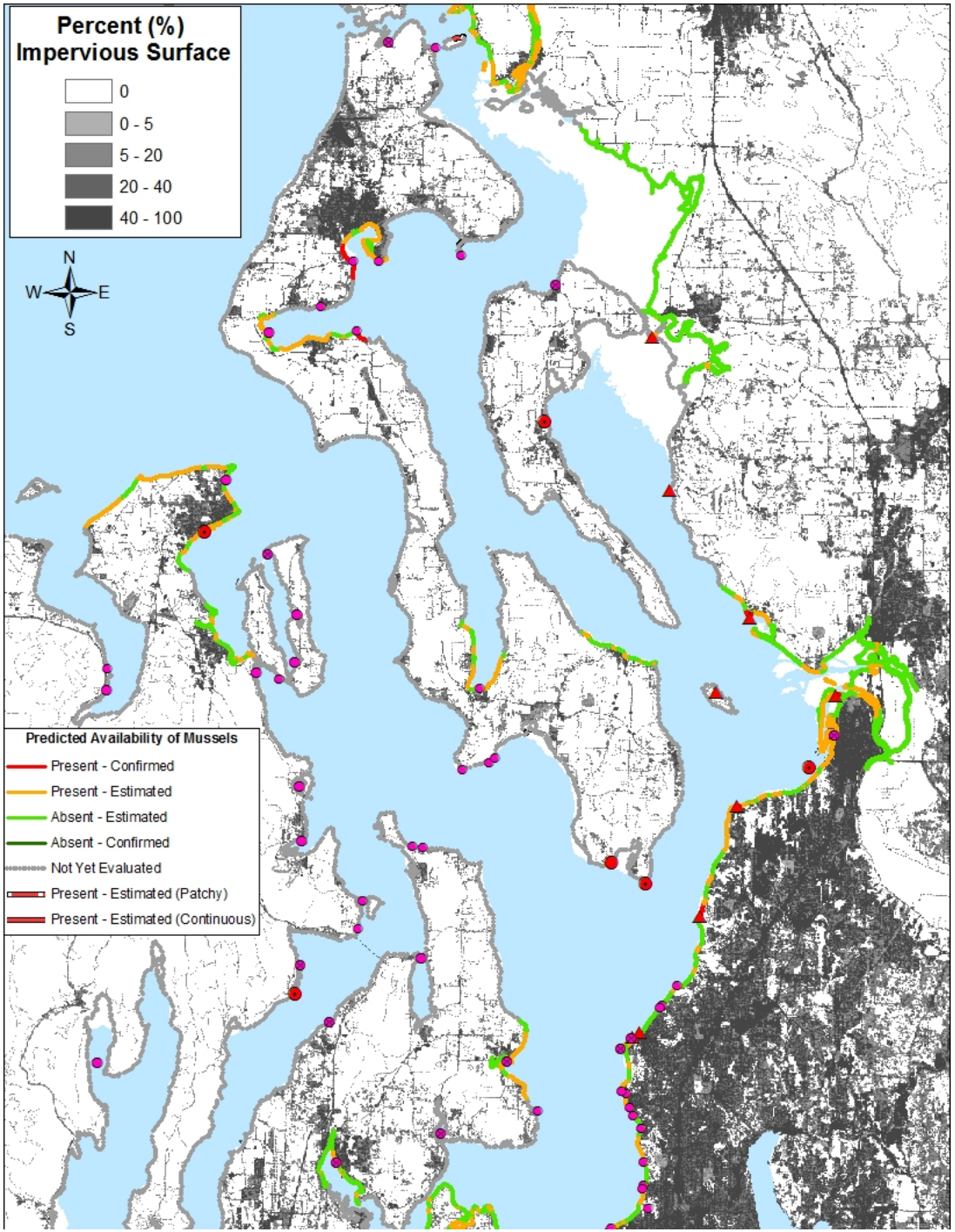
- Need to develop analyte list for this pilot expansion study
- Decide on analytes to include in summations
- Include diagnostic analytes/ratios?
- Anticipate comparisons with other media?
- No histopathology – Condition Index (CI) or Gonad Index (GI) determined in-house
- More?

End

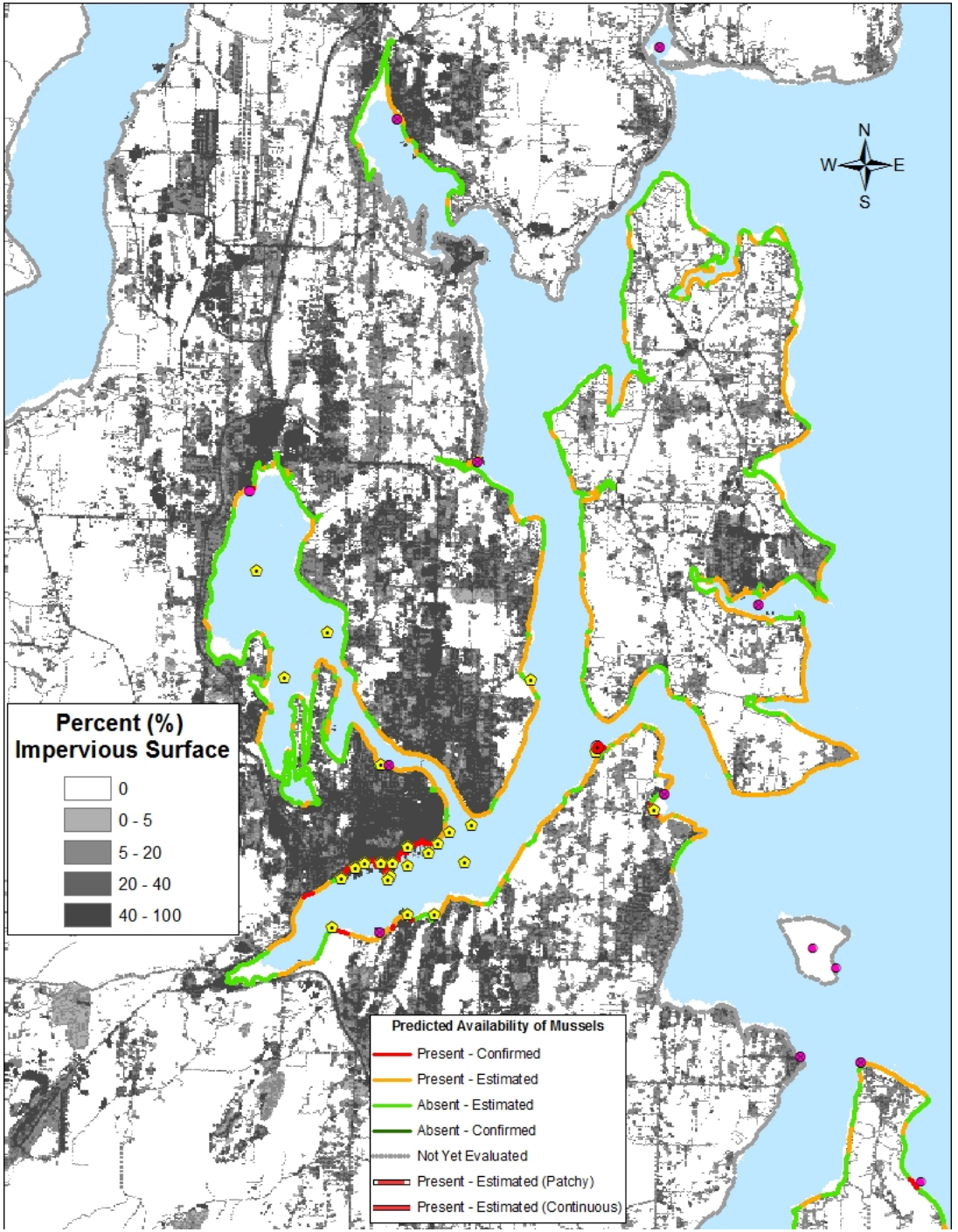
Whatcom
Skagit
San Juan Islands



Skagit
Island
Snohomish



Kitsap
Bainbridge



Vashon
Tacoma