Presented at Puget Sound Shorelines and the Impacts of Armoring Workshop,
May 12-14 2009.
This presentation not peer reviewed.

(some) Biological Effects of Shoreline Modification in Puget Sound

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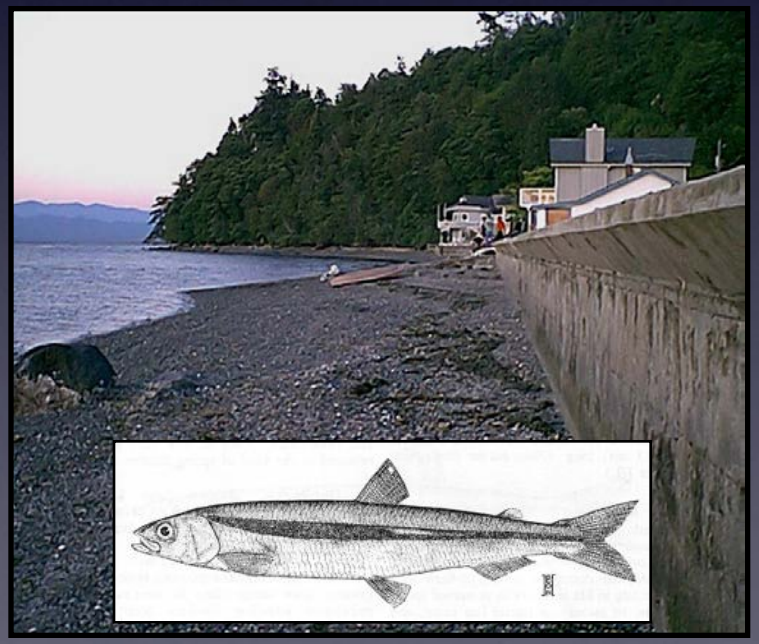
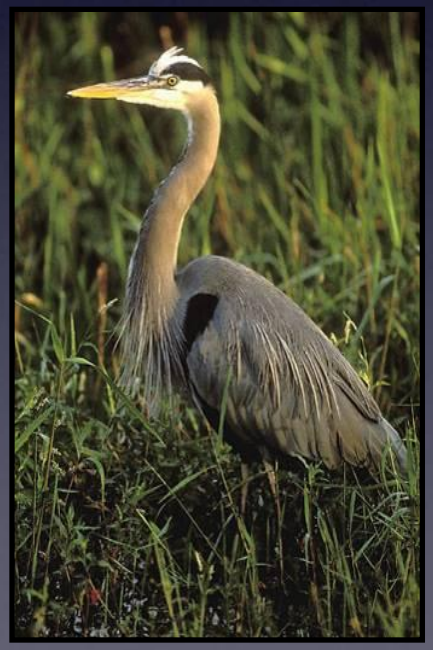
NOAA/NWFSC, Watershed Program, Mukilteo





A Puget Sound Science Problem

Assessment that does not make the **biological** effects of **human** activity the primary emphasis in the study of regional **ecosystems**

Biology, human influence, and whole systems—
explicit requirements of major environmental laws

Structure = Function?

You can’t have fish without water

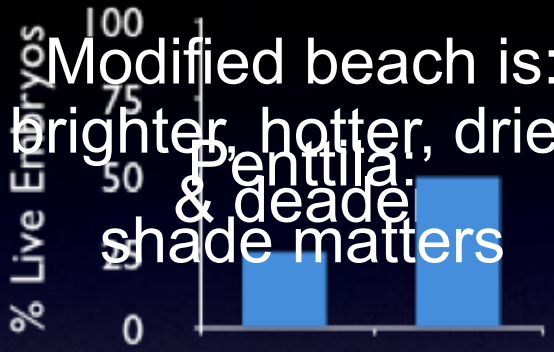
but…

You can have water without fish

Problems with the Biology

- often not done
- abundance trends without context
  vs.
- explicit human influence

Shoreline Modification 1): Microclimate and Smelt Embryos

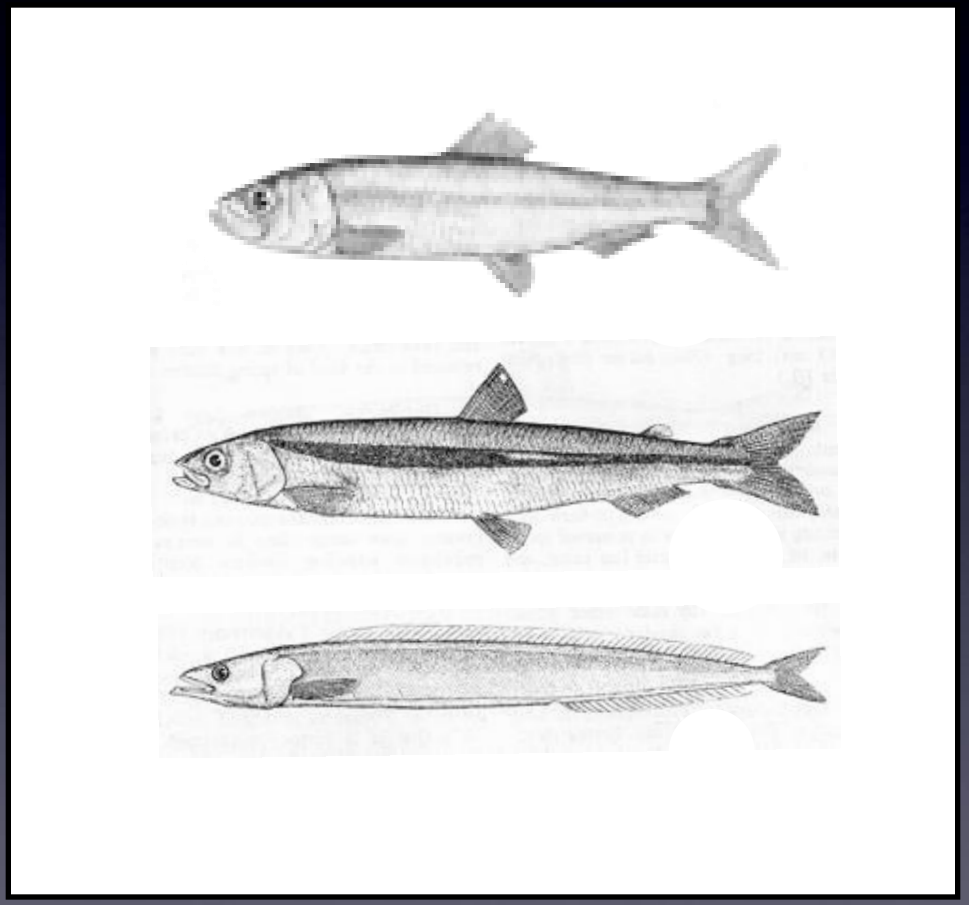


Modified beach is: brighter, hotter, drier, & deader

Penttila: shade matters

Rice (2006) Estuaries and Coasts 29(1):63-71

So What?



Shoreline Modification 2): Benthic Inverts, Insects, Wood, and Wrack in the supratidal

Kathryn Sobocinski Thesis 2003; ms in review….

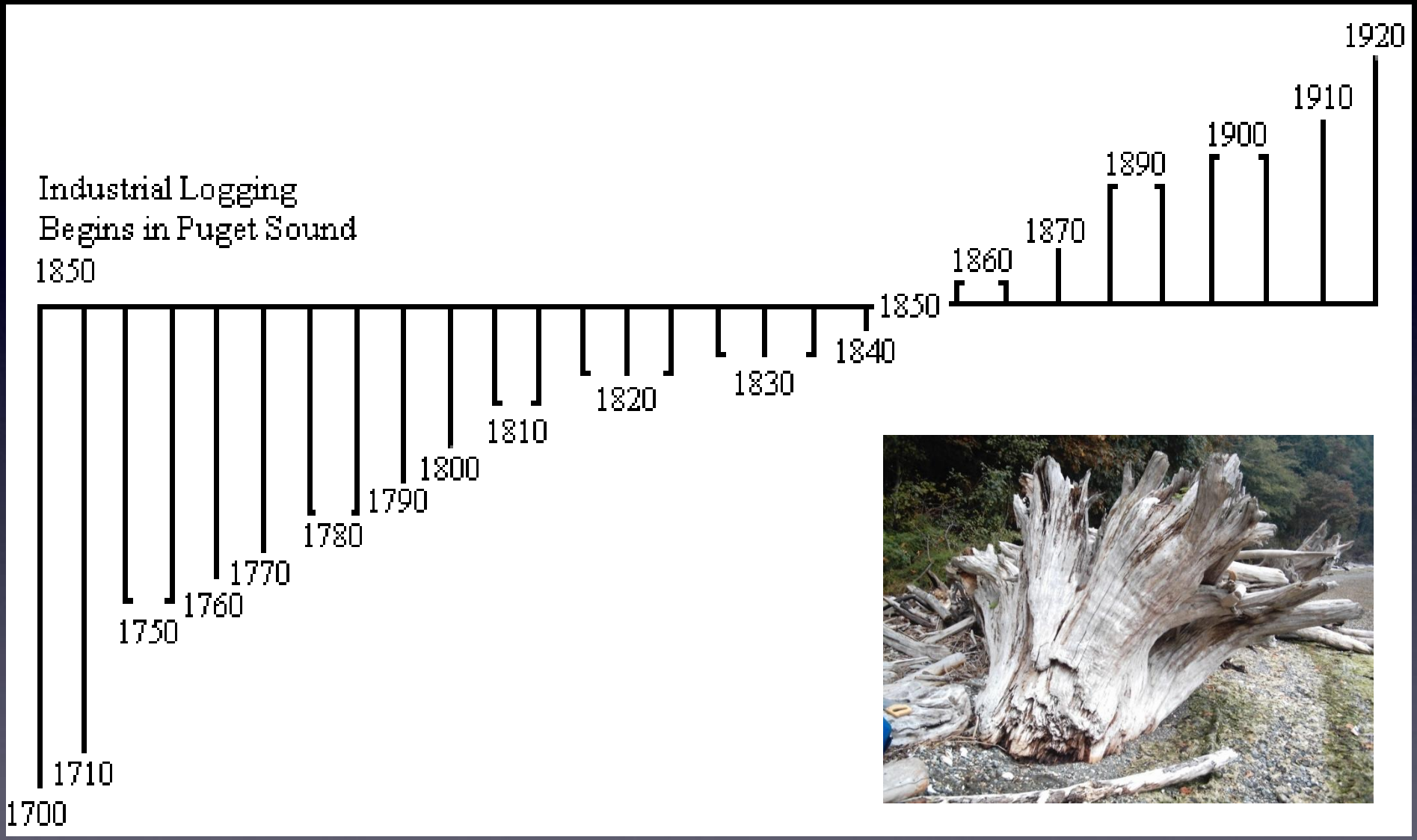
- 2 Sampling schemes
- Invert diversity and abundance lower
- Wrack and wood greater
- But…. Only clear at paired sites
  (armoring elevation, spatial variation??)

Shoreline Modification 3): Wood and Amphipods

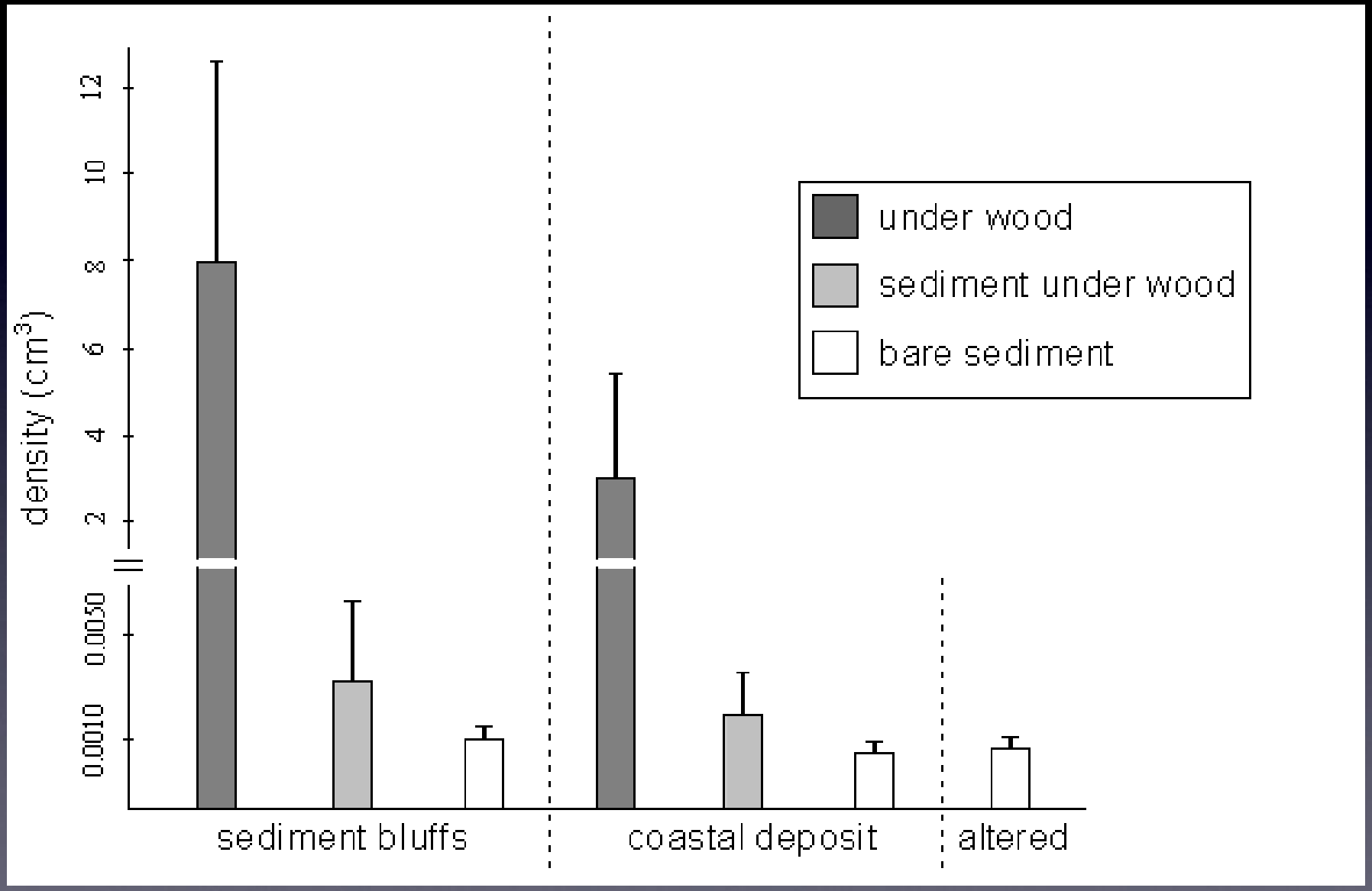
Dan Tonnes' Thesis 2008; 2 ms in prep….

- Not quantified but little or no wood on altered beaches
- Tagging: Larger, more complex wood more stable; more vegetation associated with it
- Carbon dating shows most remaining large wood from before industrial logging
- Amphipod density strongly related to wood

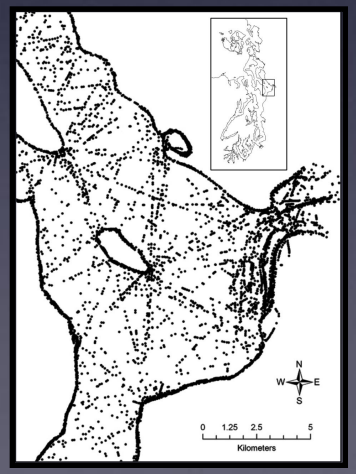
Carbon Dating Results (+/- 30 yrs)

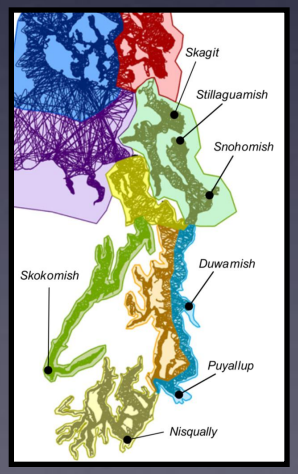


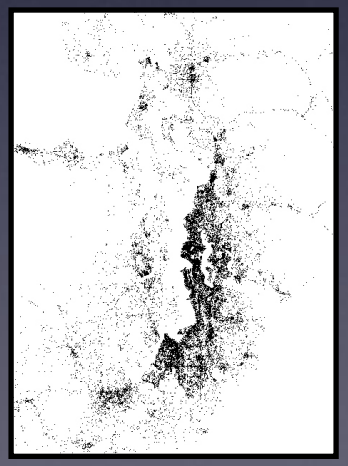
Talitrid Amphipod Density

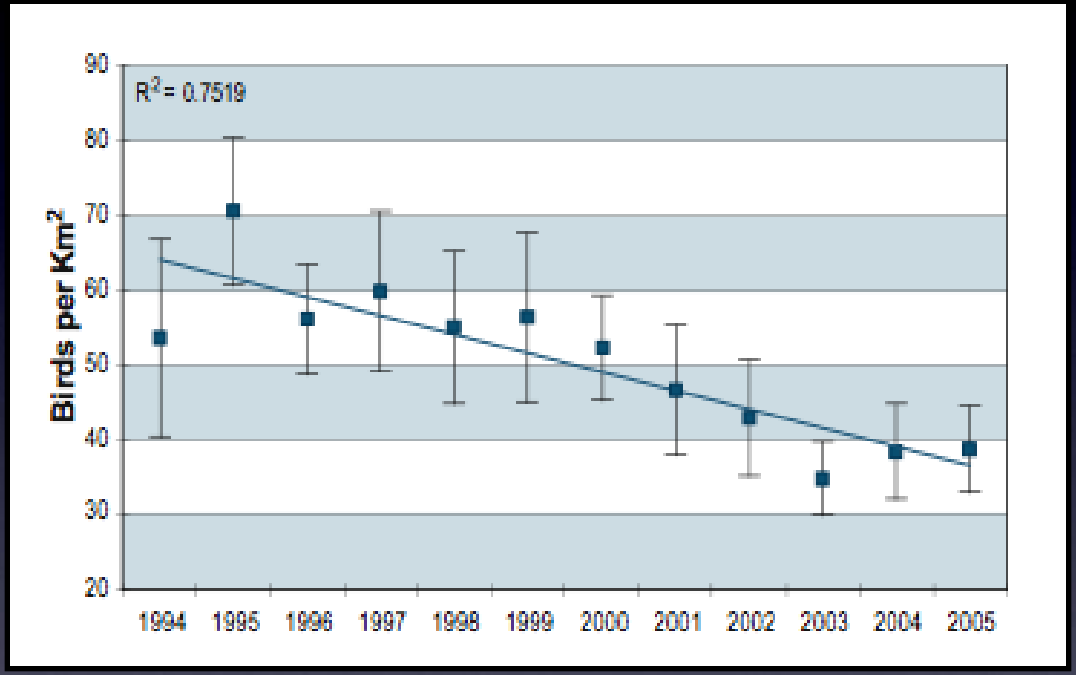


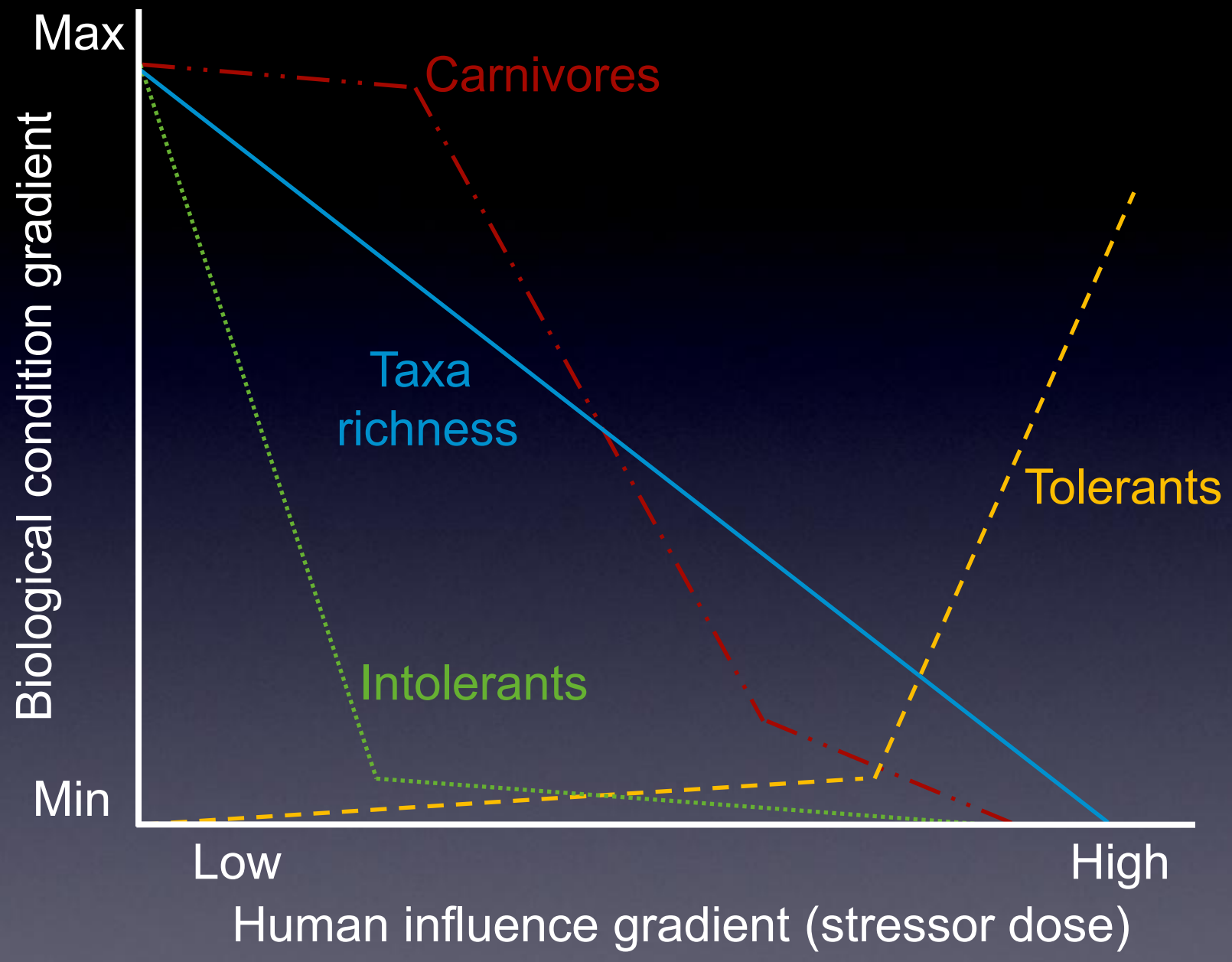
Integration and Reanalysis: Beyond Simple Abundance



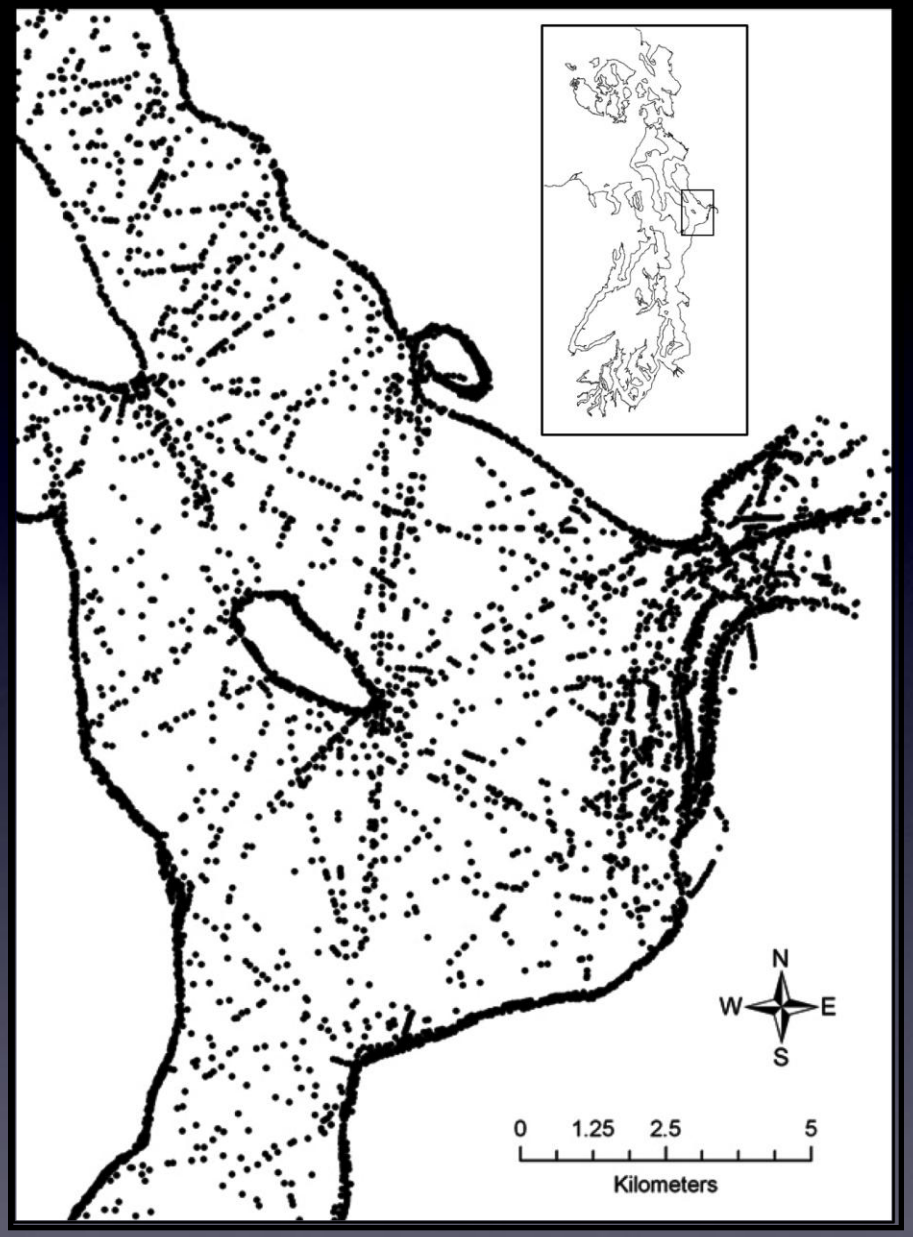





R^2 = 0.7519
Birds per Km^2
90
80
70
60
50
40
30
20
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005



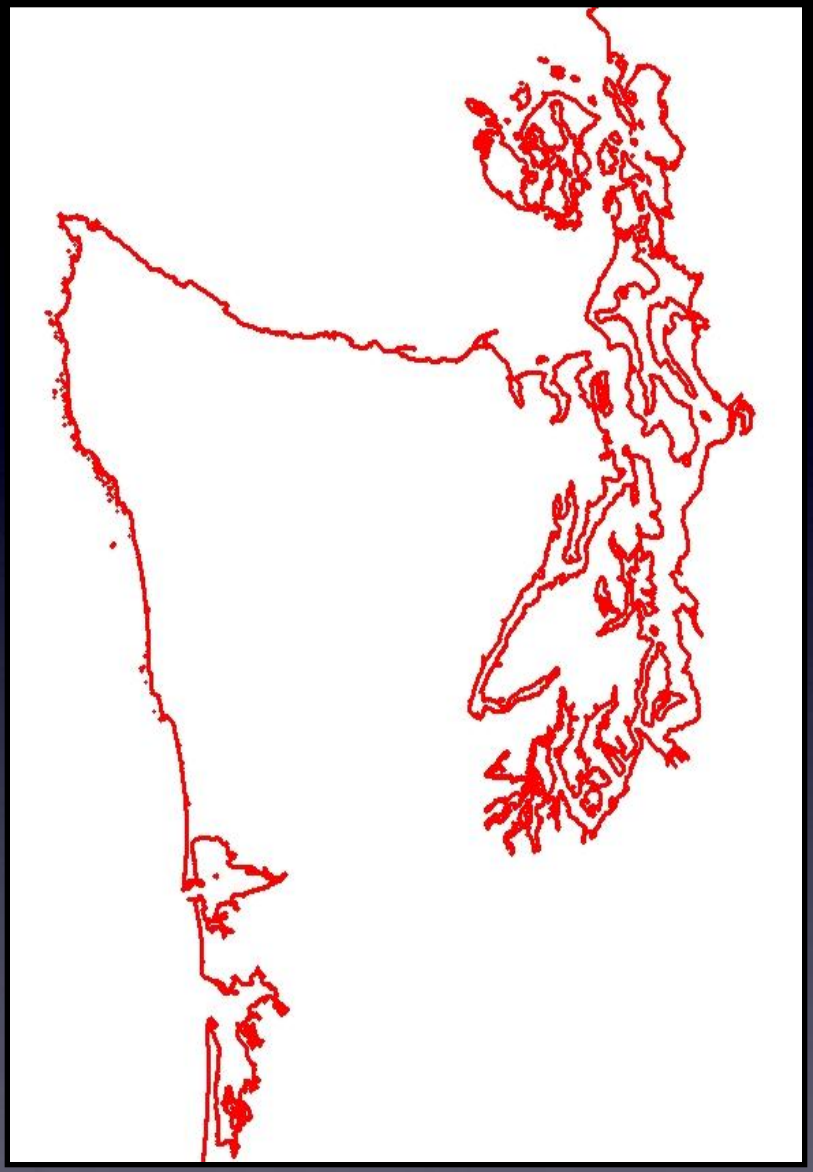
Adapted from: Karr (2006)



BIOLOGICAL DATA

Marine Birds and Waterfowl

Aerial survey data from WDFW
Over 400,000 points in greater Puget Sound, 1993 - 2004



ENVIRONMENTAL DATA 1

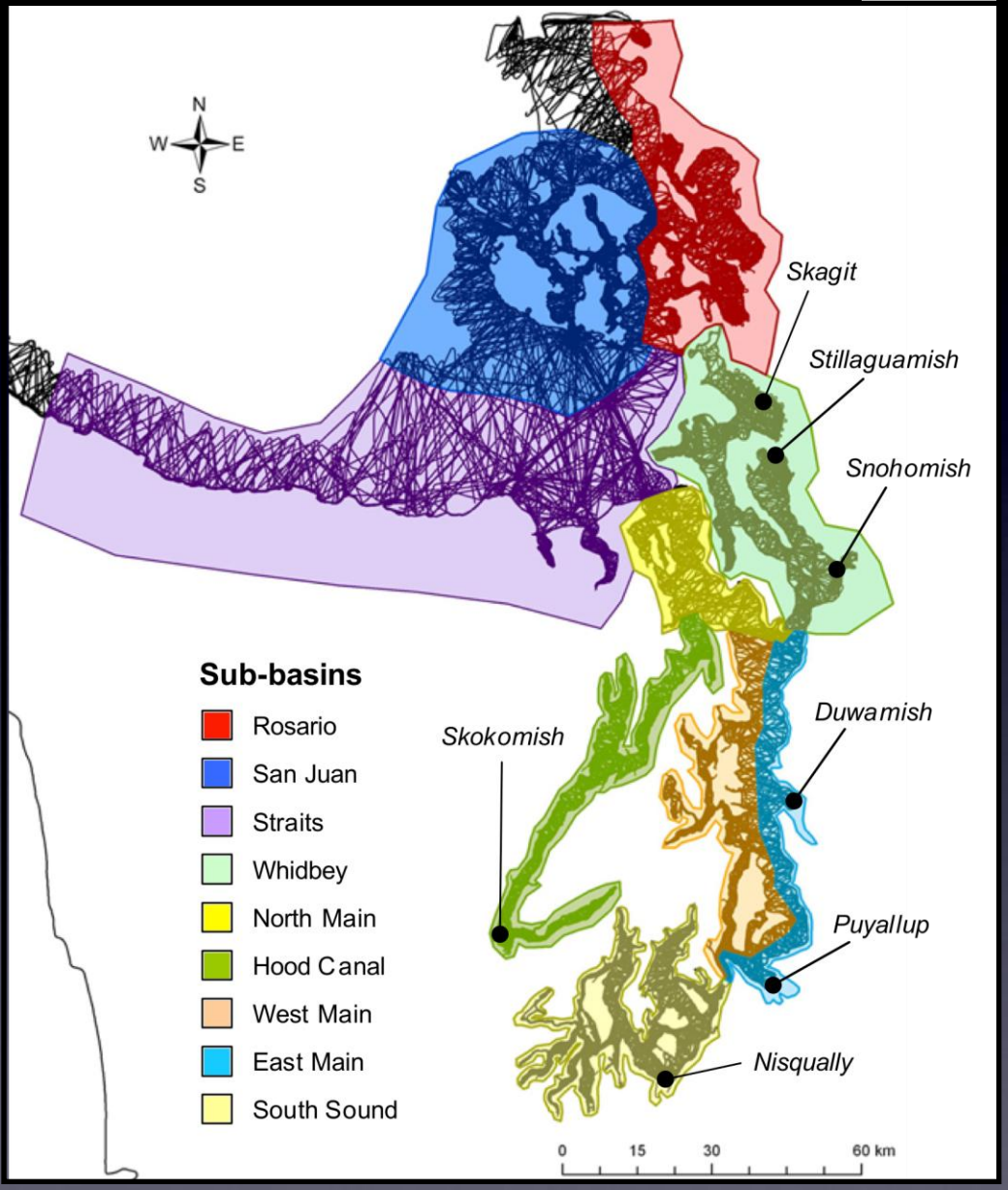
Washington ShoreZone Inventory (WDNR)

Approximately 4000 shoreline segments in greater Puget Sound, mid-1990's

ENVIRONMENTAL DATA 2

Puget Sound land cover (2002)

By UW for PRISM



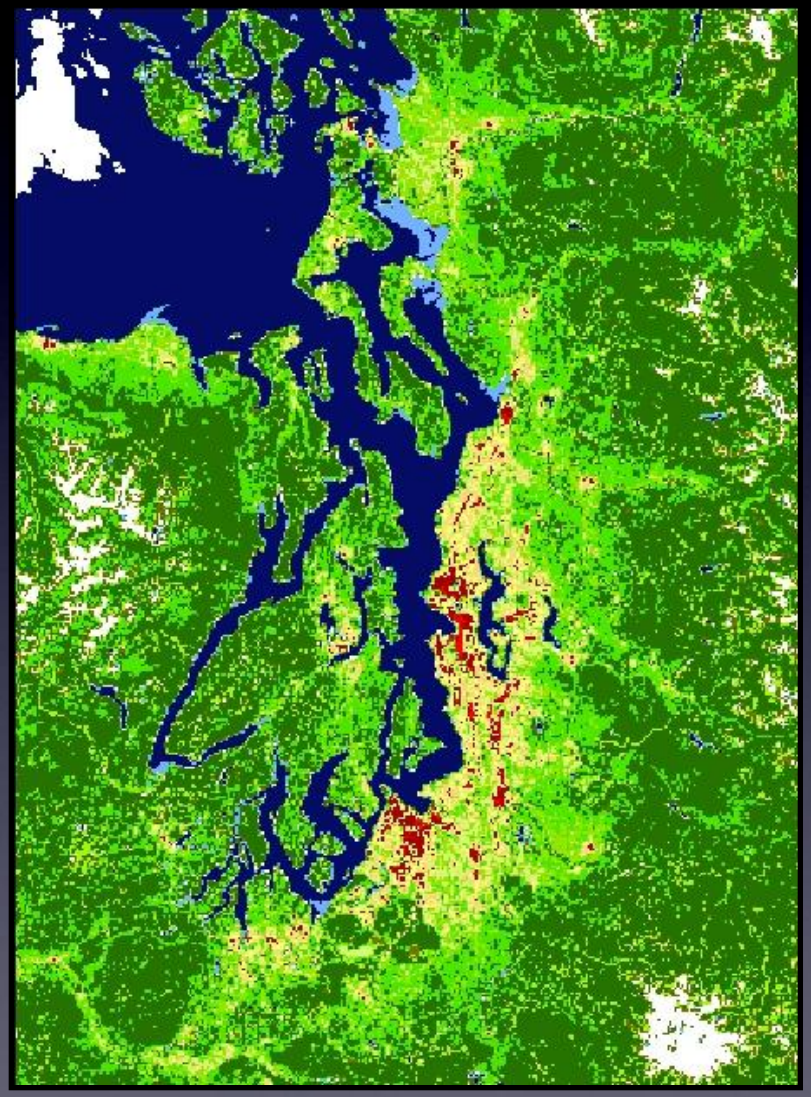
ENVIRONMENTAL DATA 3

Oceanographic Sub-basins

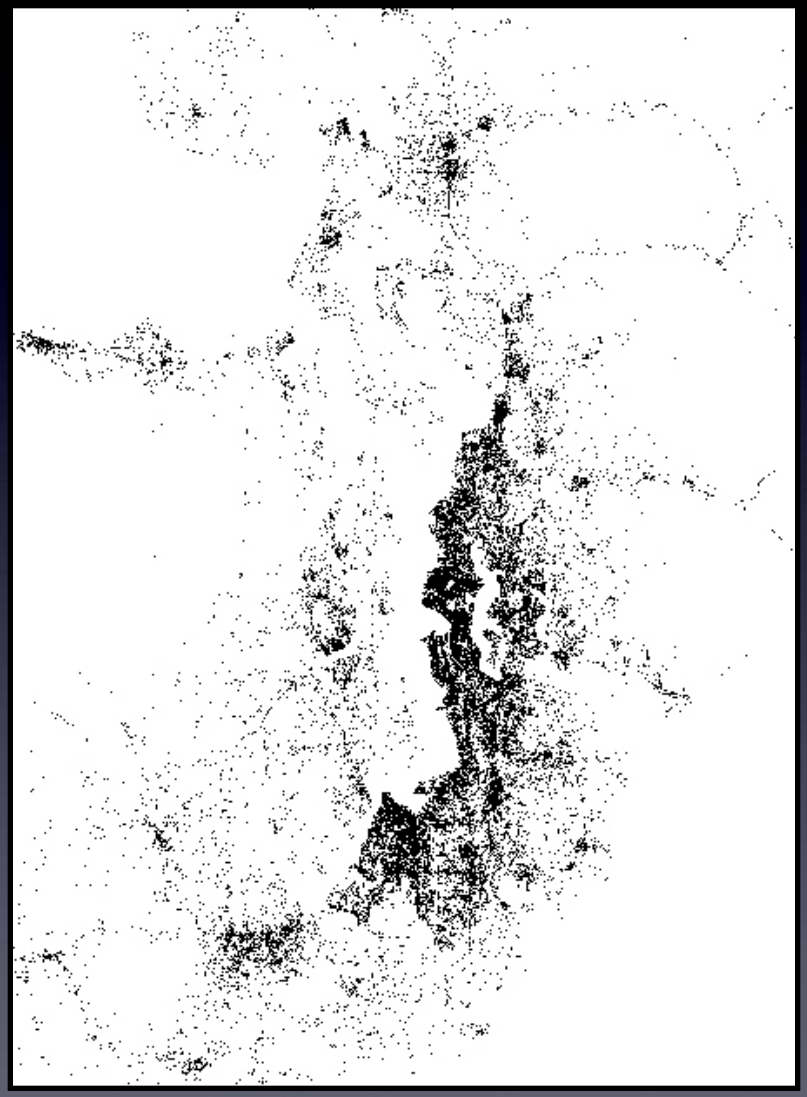
&

Estuaries

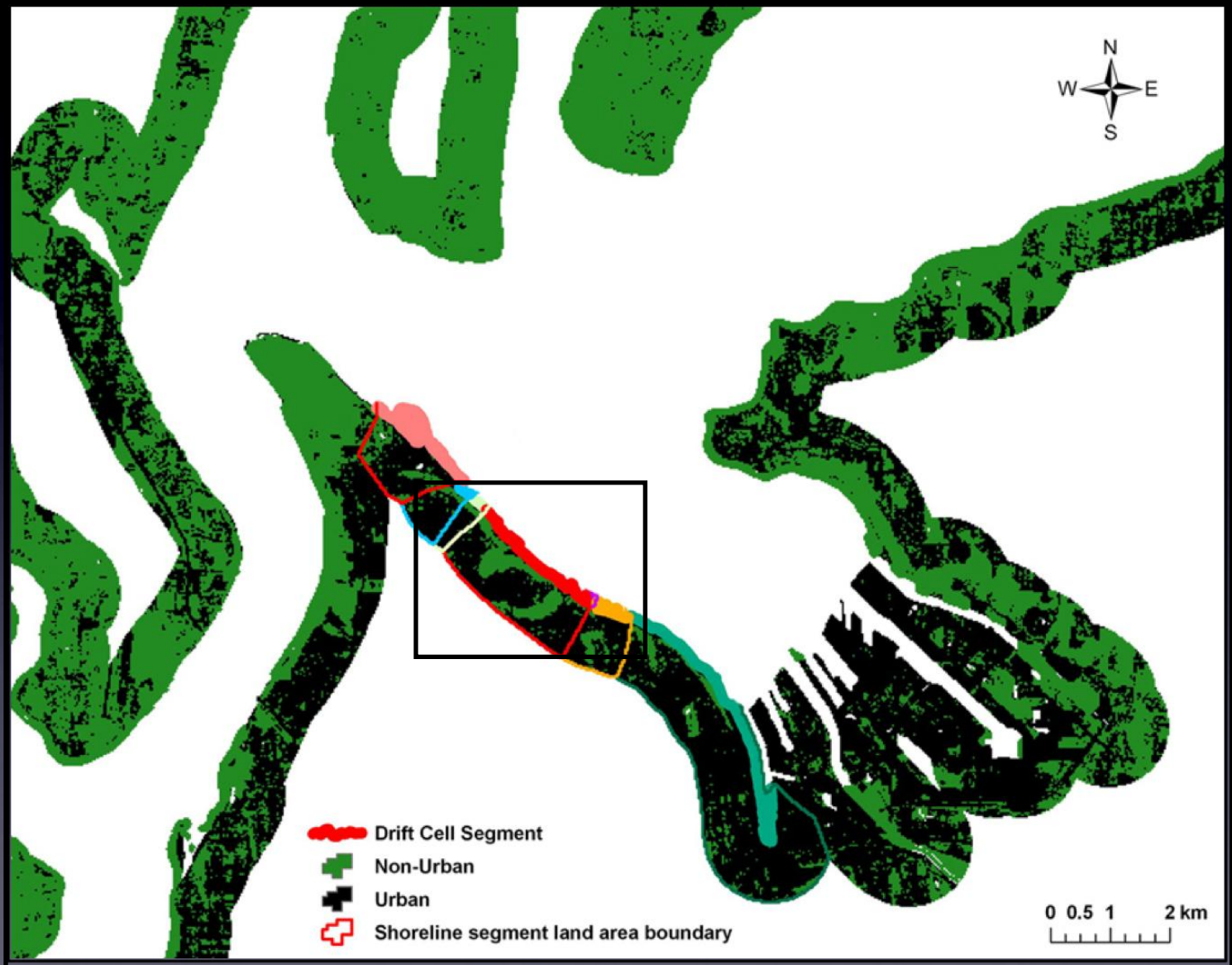
Characterizing Human Influence Gradients



Characterizing Human Influence Gradients

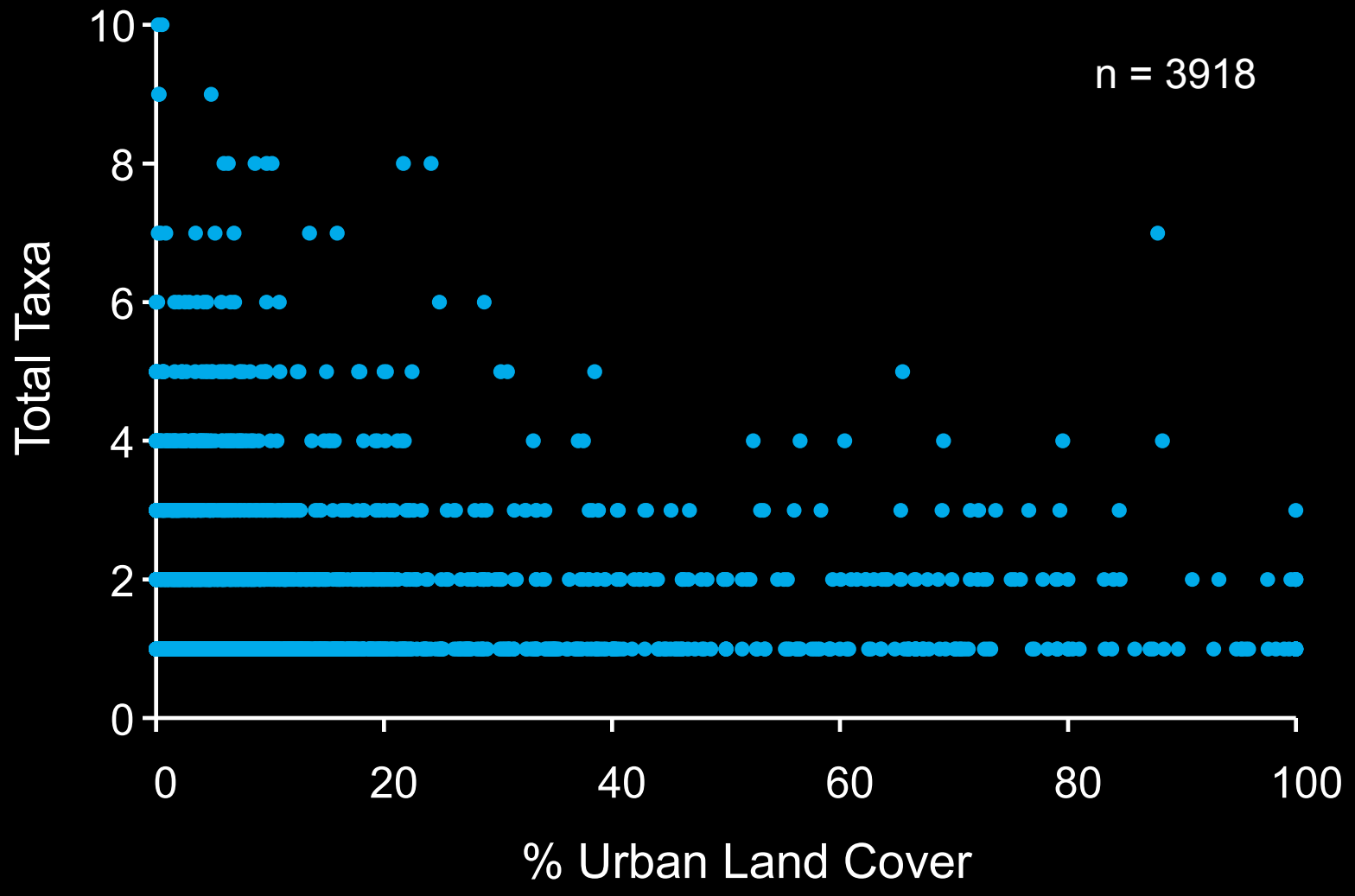


Shorelines as Sampling Units



Joining Bird and Shoreline Attributes

Bird Taxa Richness by Shoreline Segment
All of Greater Puget Sound (Summer, 1996)



Bird Conclusions

- Explicit consideration of biology, humans, and whole systems yields clear patterns, despite coarse lumping and disparate data sets
- Bird diversity declining over time across much of Puget Sound
- Assemblage composition changes as function of local and regional human influence
  - generalists win, specialists decline, and so on
- Basins, estuaries, and shoreline segments useful sampling units

Future Bird Directions

- Additional years of data
- More detailed land cover and shoreline feature analysis
- Incorporate forthcoming shoreline typology and change analyses
- Development of robust bird metrics for monitoring and assessment

Where are We?

- Some recent progress in Puget Sound documenting changes in taxonomic composition and abundance in inverts and fish (Jason et al.); wood, microclimate.

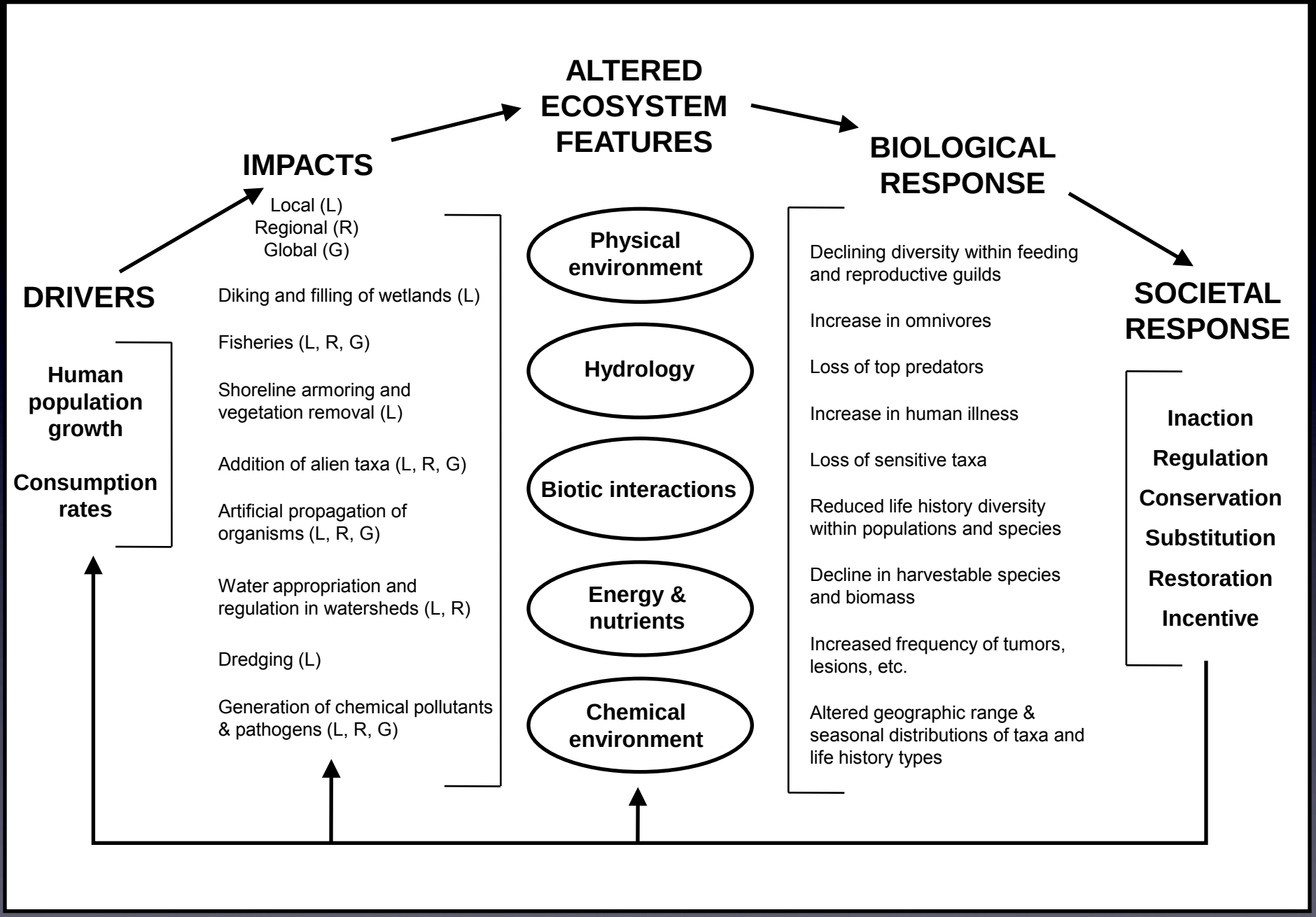
- Still a long way off from conclusively testing some of the major supposed effects (SAV, benthos, beach-spawning fishes, food web, etc.), and applying those relationships

Looking Ahead

- Develop designs for more field studies to develop empirical "dose-response" relationships (disturbance explicit in the designs, landscape scale, across taxa); prioritize conservation & restoration, evaluate regulatory & alternative design effectiveness
- How to stratify?
- What are the best potential sources of response variables?
- How to fund it?
- Basic ecology of the system (pelagic zone)

Thanks…

Jim Karr, Kris Kleohn, Dan Penttila, Dan Tonnes,
Kathryn Sobocinski
WDFW, UW, WDNR



Adapted from: Karr (2006) & others

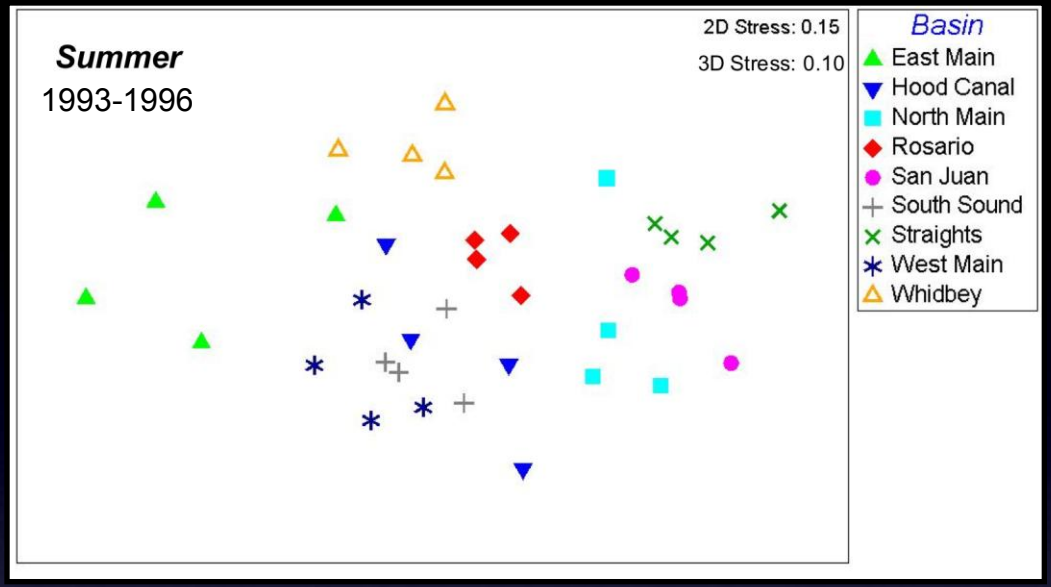
QUESTION 1: What is a healthy Puget Sound (and how do we know if we are moving toward one)?

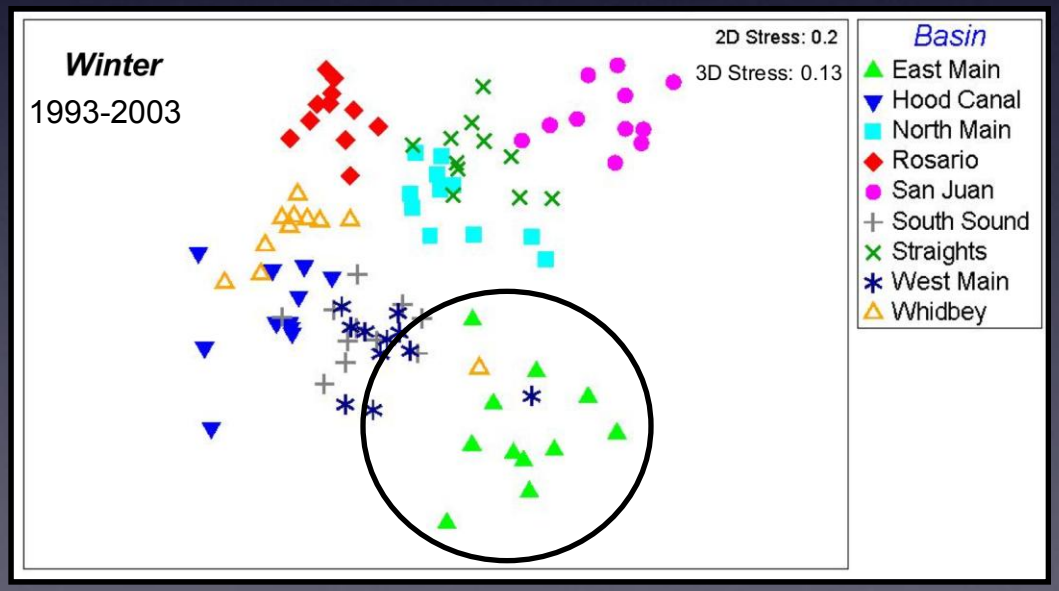
QUESTION 2: What is the status of Puget Sound and what are the biggest threats to it?

QUESTION 3: What actions should be taken that will move us from where we are today to a healthy Puget Sound by 2020?

QUESTION 4: Where do we start?

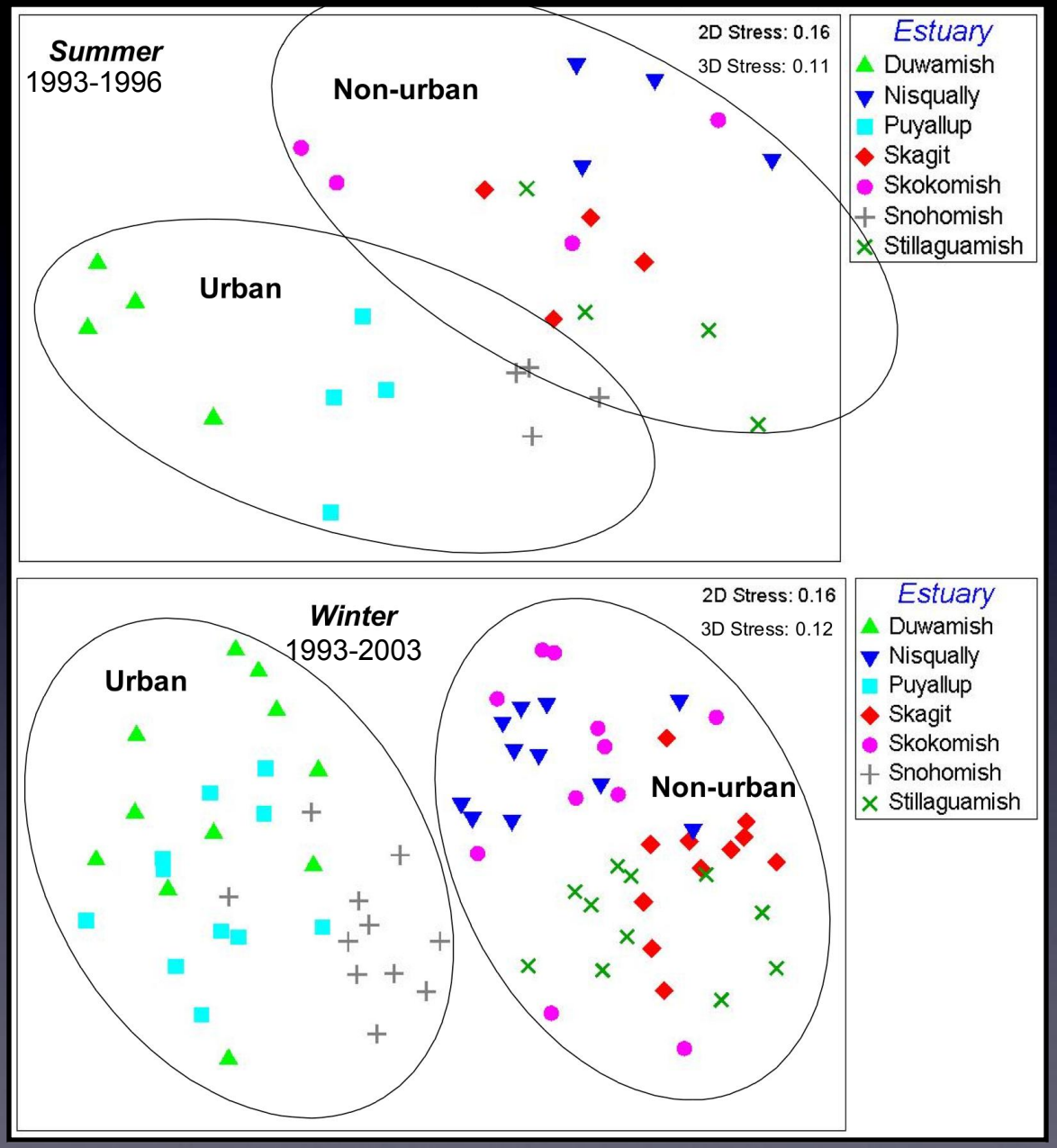
PSP Action Agenda (2008)





Sub-basin Birds MDS Relative Frequency

1 symbol = 1 year



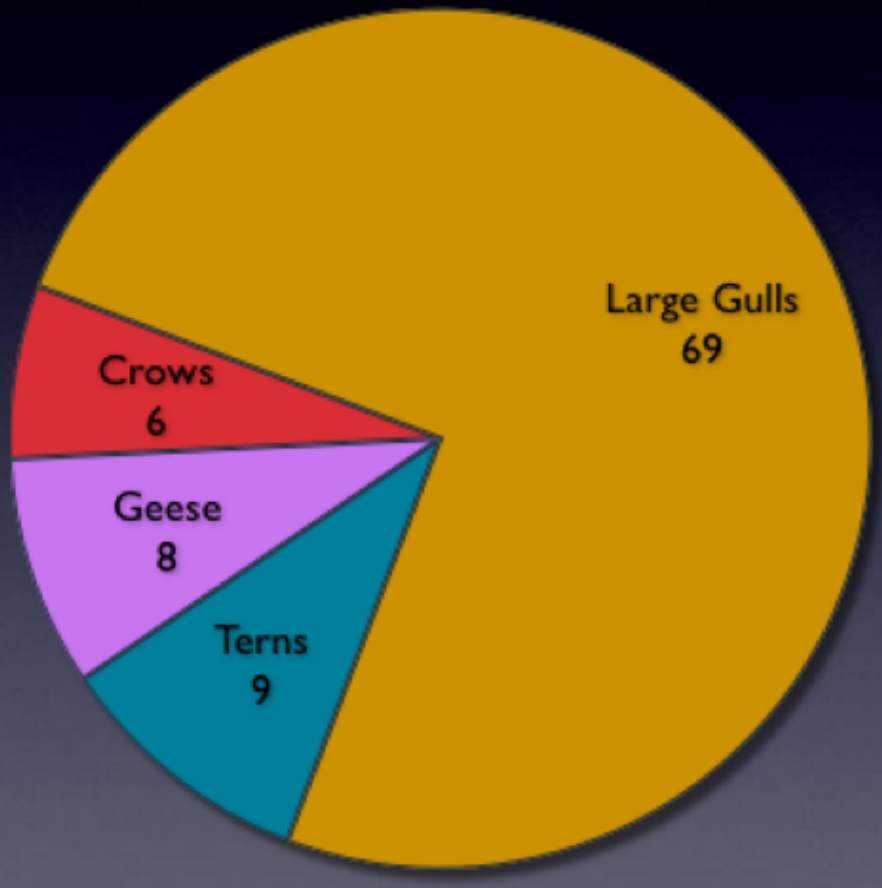
Estuary Birds MDS Relative Frequency

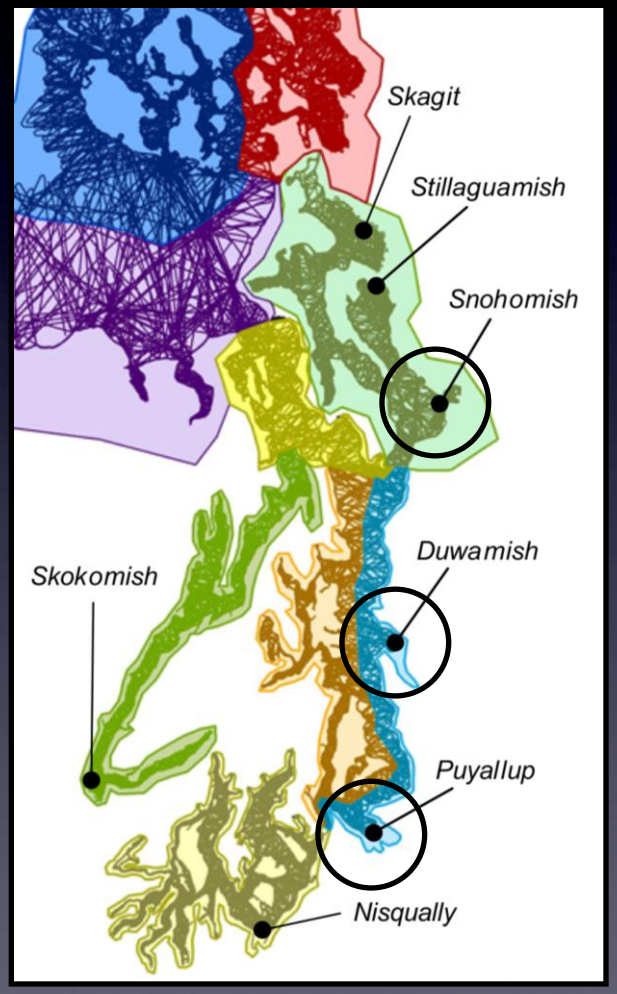
1 symbol = 1 year

Summer Taxonomic Similarity

(Top 90% contribution, SIMPER)

Urban

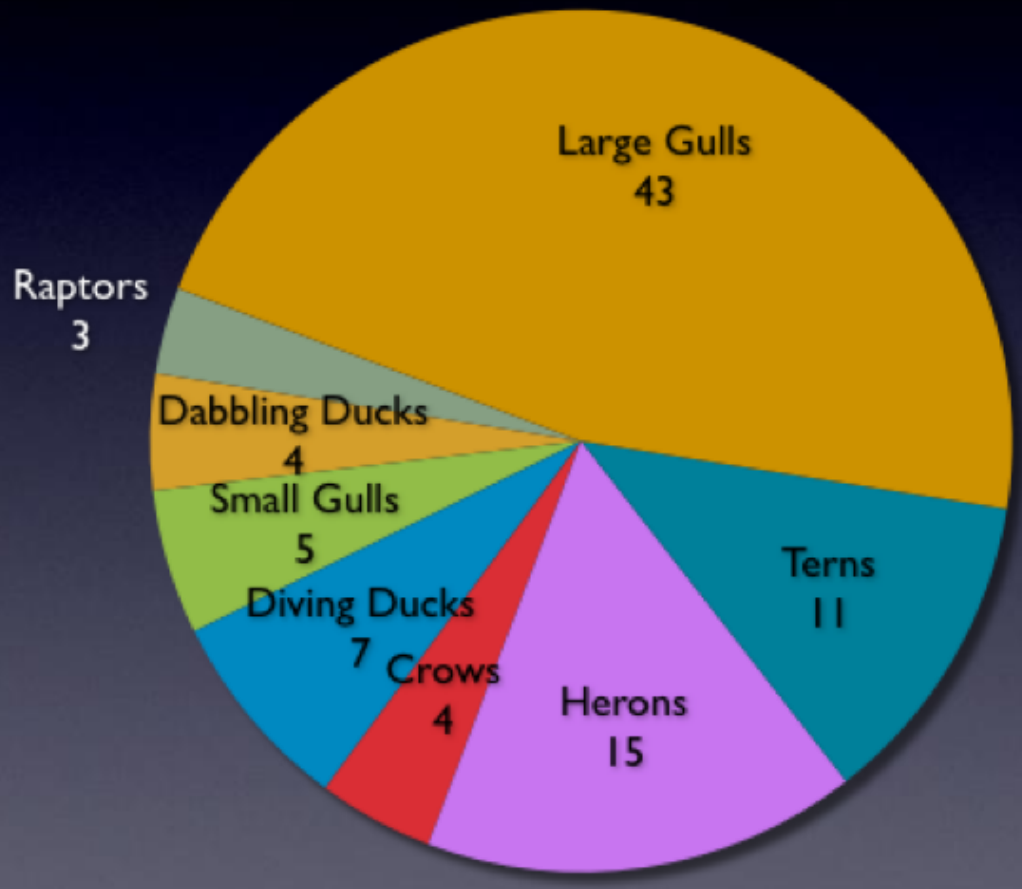


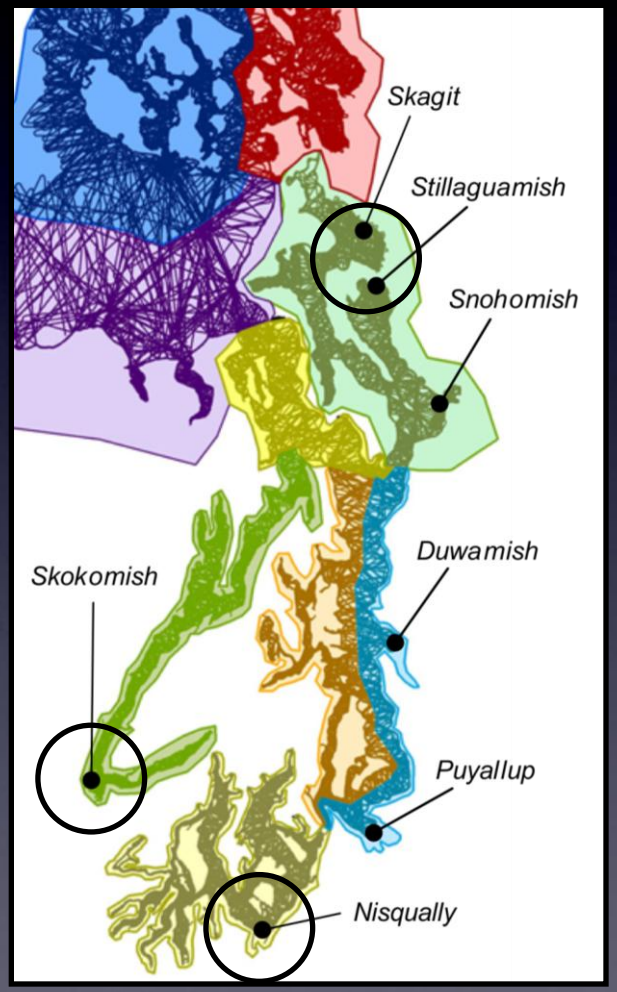


Summer Taxonomic Similarity

(Top 90% contribution, SIMPER)

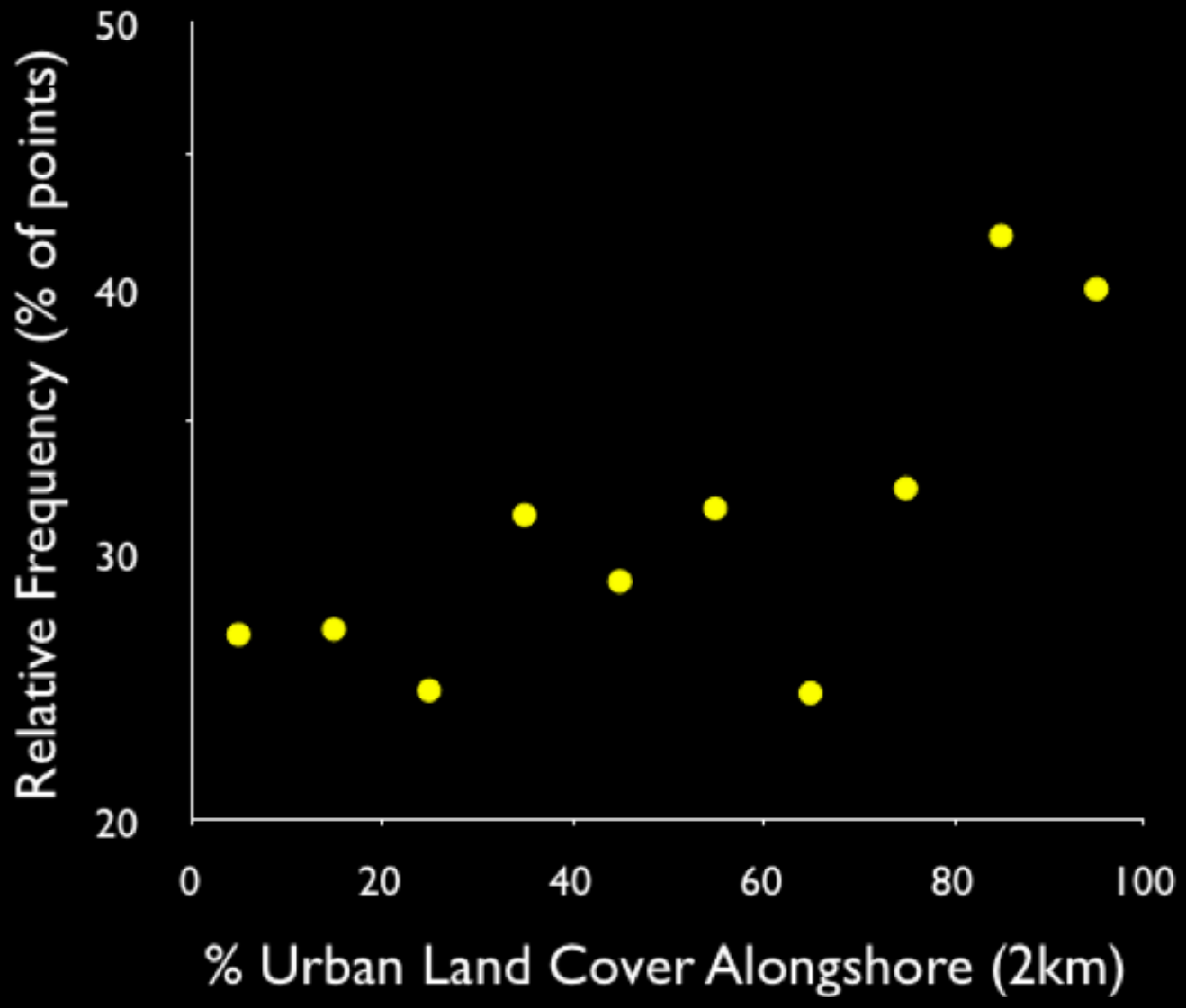
Nonurban





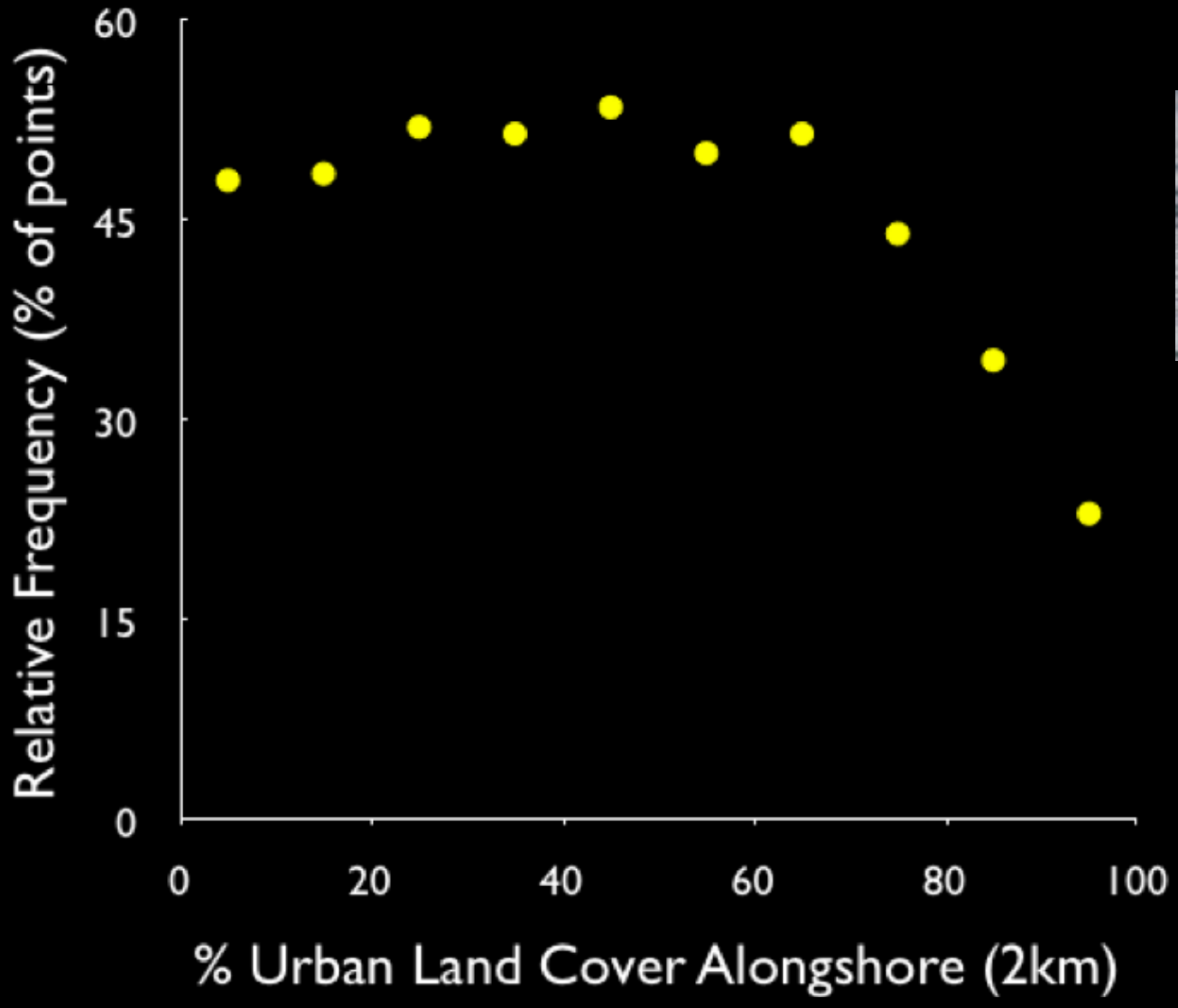
Large Gulls and Urbanization

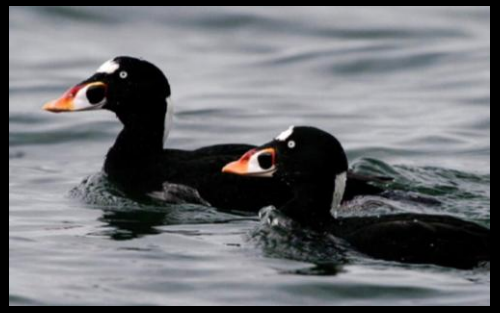
All of Greater Puget Sound (3918 beaches; Winter, 2002)

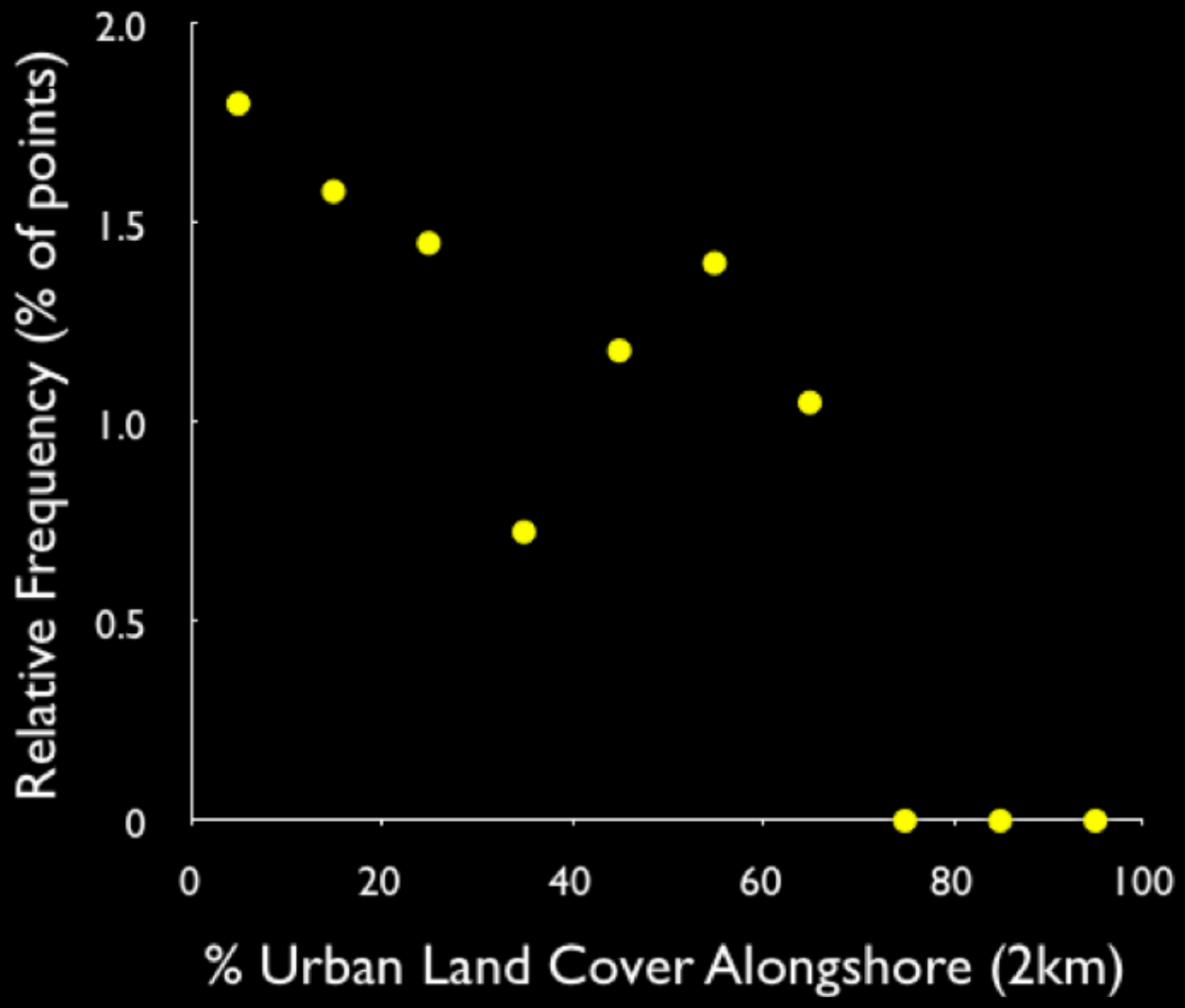


Diving Ducks and Urbanization

All of Greater Puget Sound (3918 beaches; Winter, 2002)





Herons and Urbanization

All of Greater Puget Sound (3918 beaches; Winter, 2002)