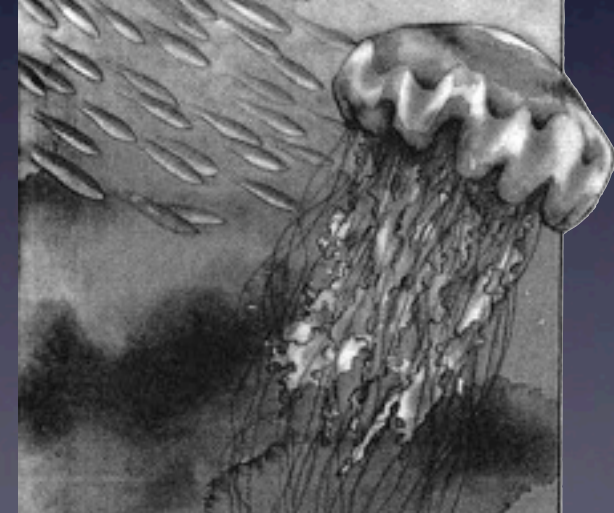


The Forsaken Fjord v1.1

Casey Rice

Watershed Program
Mukilteo Research Station
NOAA/NWFSC



Acknowledgements

Committee

Jim Karr
Correigh Greene
Si Simenstad
Eric Beamer
Rick Keil
Michael Brett

Data

WDFW
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Images

“The Internets”
Asahel Curtis
Bon Harriott
Eric Beamer
J. Davies & K. Lagueux
Todd Bennett
Hiroo Imaki
Dan Hershman
Others...

Collaborators & Funding

SRSC
USGS
UW
USACOE
SPU
NWFSC/FE

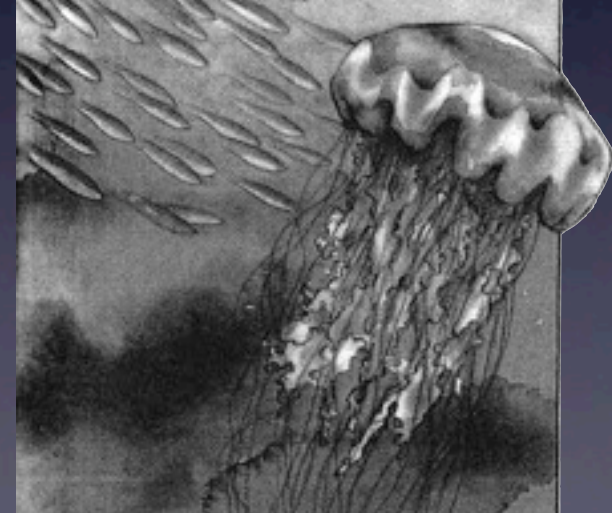
Super Friends

Katheryn Hayes
Frank Sommers
Kathryn Sobocinski
Jeff Duda

The Forsaken Fjord

Casey Rice

Watershed Program
Mukilteo Research Station
NWFSC



The Fertile Fjord

Plankton in Puget Sound



Richard M. Strickland

“...a fragmented, uneven jumble of mostly small pieces, remote in the public mind, and so far unable to sufficiently prevent or explain biological decline.”

Me (2007)

“...a fragmented, uneven jumble of mostly small pieces, remote in the public mind, and so far unable to sufficiently prevent or explain biological decline.”

Me (2007)

“The Puget Sound region enjoys a rich history of high quality science, including several recent efforts to comprehensively review the state of ecosystem science...”

Puget Sound Partnership Science Panel (2008)

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?

Puget Sound Partnership Action Agenda (2008)

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**

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

Causes

Causes

- Governance, complexity, resources, but...

Causes

- Governance, complexity, resources, but...
- Focus
 - often not biological
 - abundance trends without context
 - vs.
 - explicit human influence gradient (“It wasn’t designed that way.”)

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- Scope
 - stressors
 - spatial, temporal, biological
 - disciplines
- Data handling
 - availability
 - synthesis
 - communication

Biological Assessment

Biological Assessment

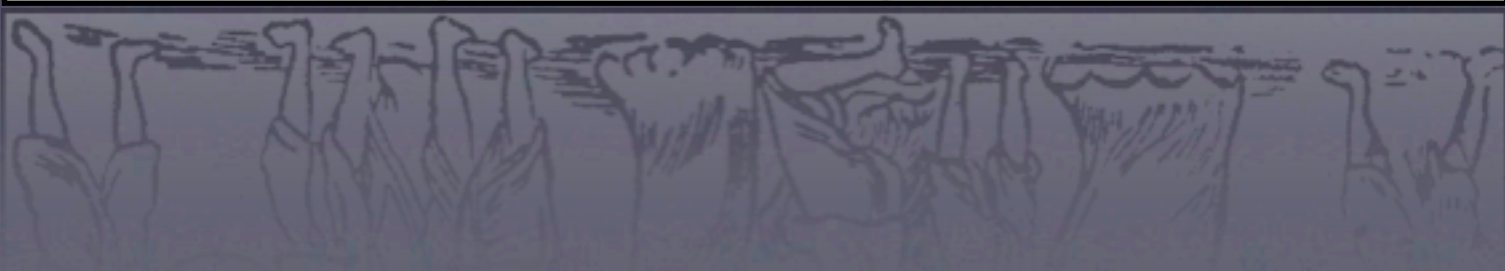
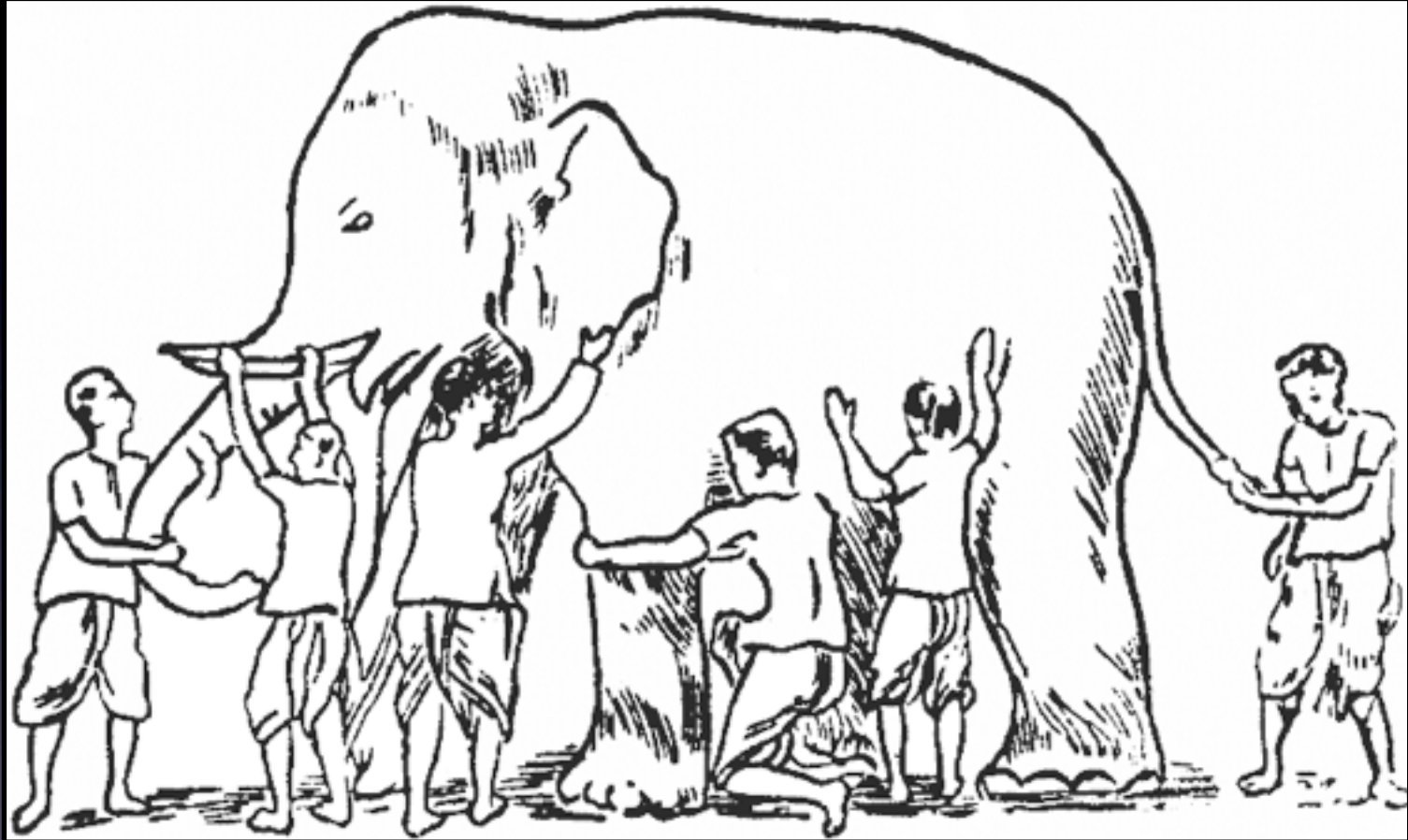
- Goals:
 - Determine biological condition
 - Diagnose cause if degradation detected
 - Prioritize problems
 - Formulate solutions
 - Evaluate effectiveness of management actions

Assessment Must Do's:

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- Measure biology directly
 - Beware of physical or chemical surrogates
 - Full range of natural conditions and human influences

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Assessment Must Do's:

- Measure biology directly
 - Beware of physical or chemical surrogates
 - Full range of natural conditions and human influences
- Define reference condition (what does “healthy” look like?)
- Determine comparable units
- Look for responsive attributes (to human activities)

Basic Conceptual Framework



**Natural Ecosystem
Parts & Processes**

Parts

land forms

water masses

genes

species

communities



**Natural Ecosystem
Parts & Processes**

Parts

land forms
water masses
genes
species
communities

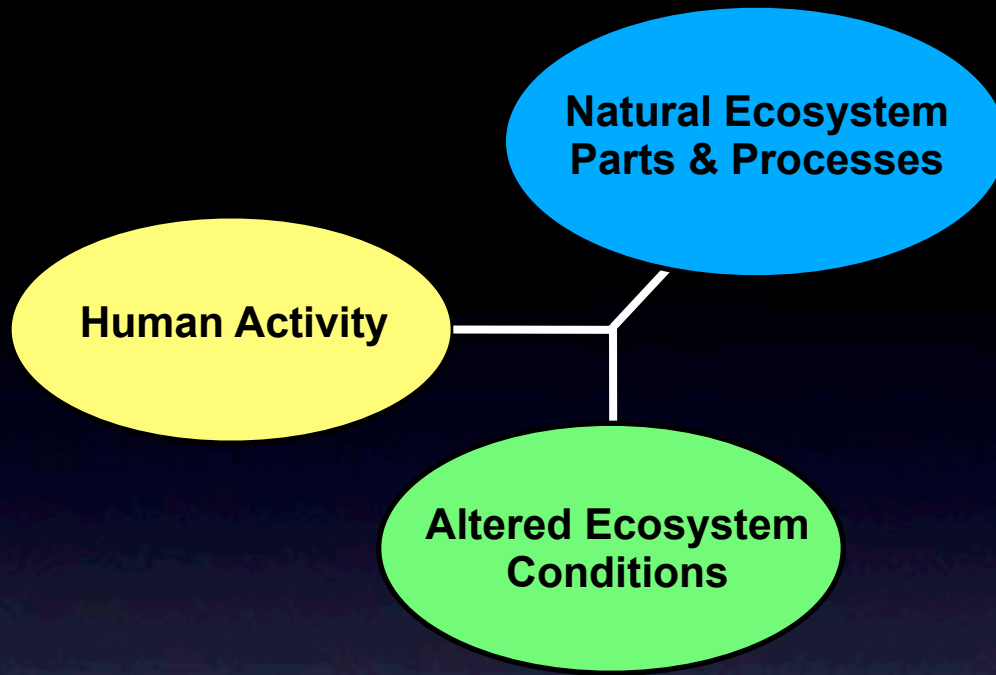
**Natural Ecosystem
Parts & Processes**

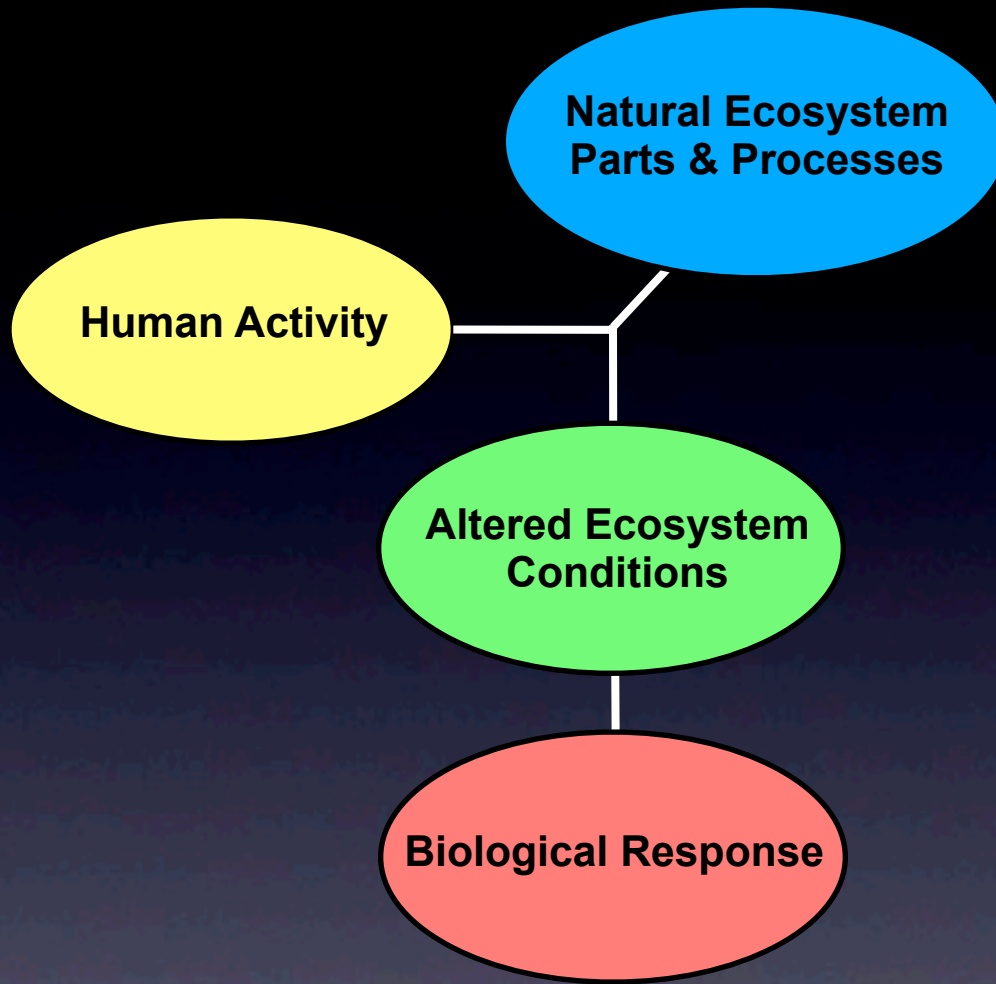
Processes

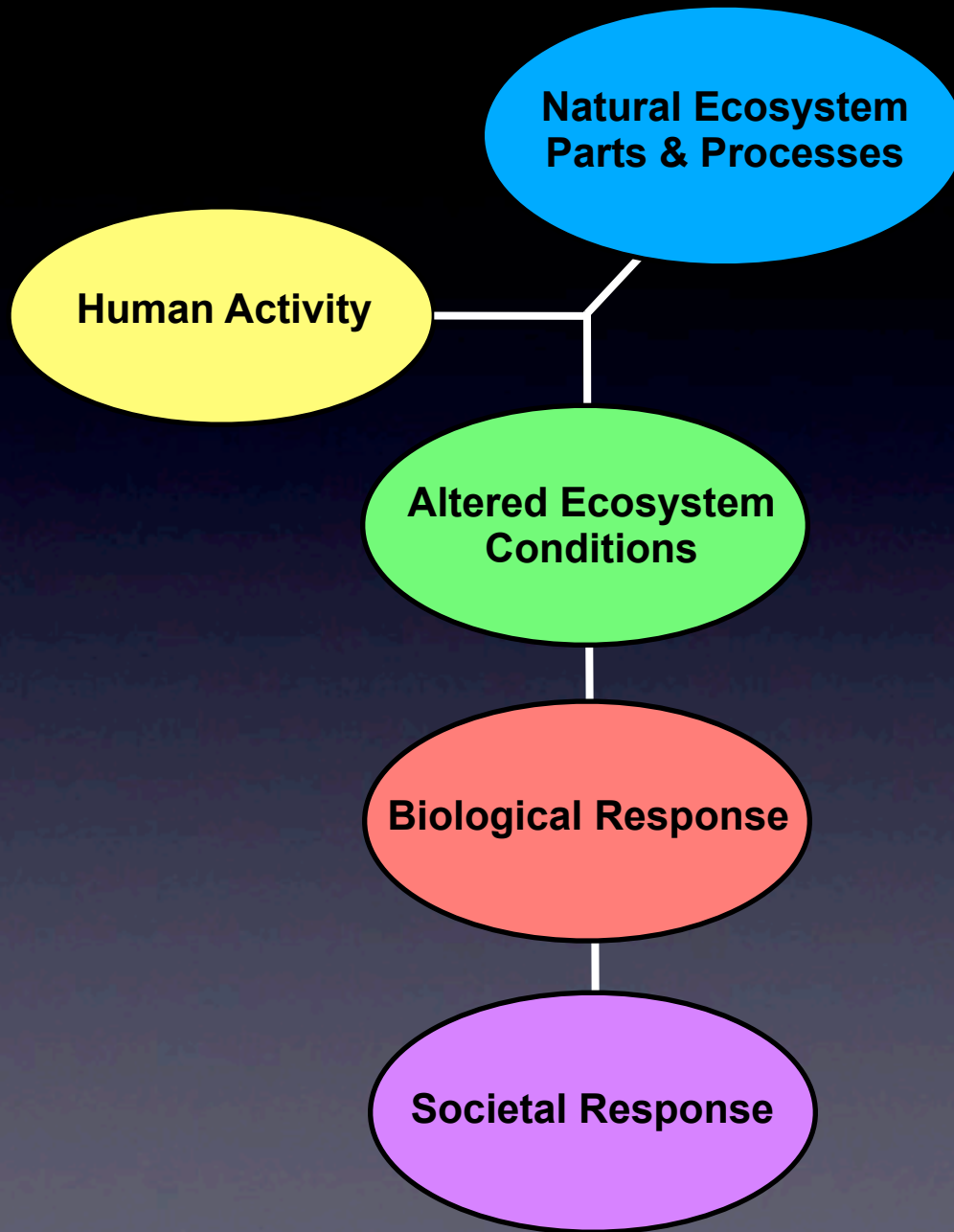
hydrology
sediment dynamics
species interactions
production
energy flow
nutrient dynamics

Human Activity

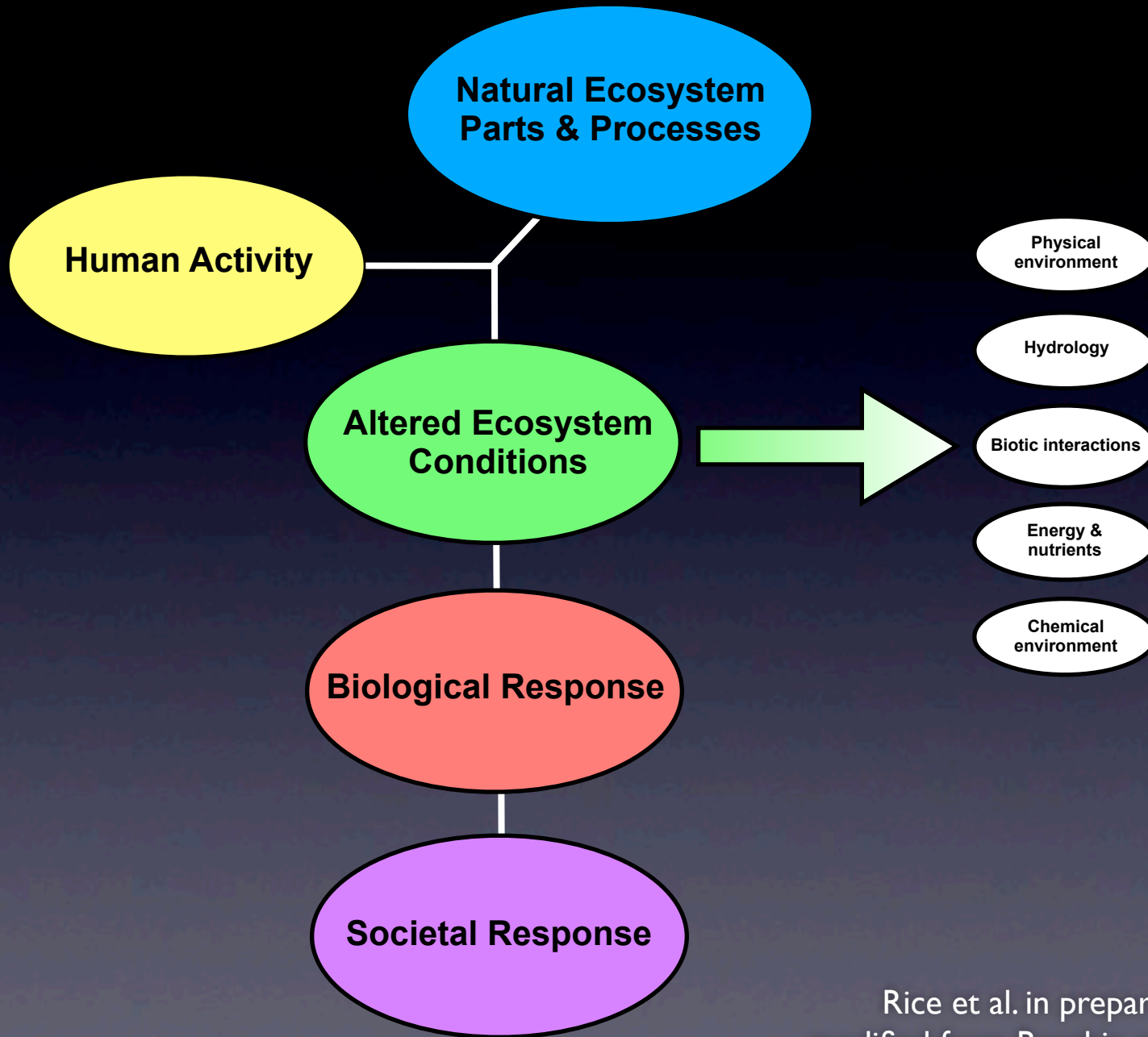
**Natural Ecosystem
Parts & Processes**



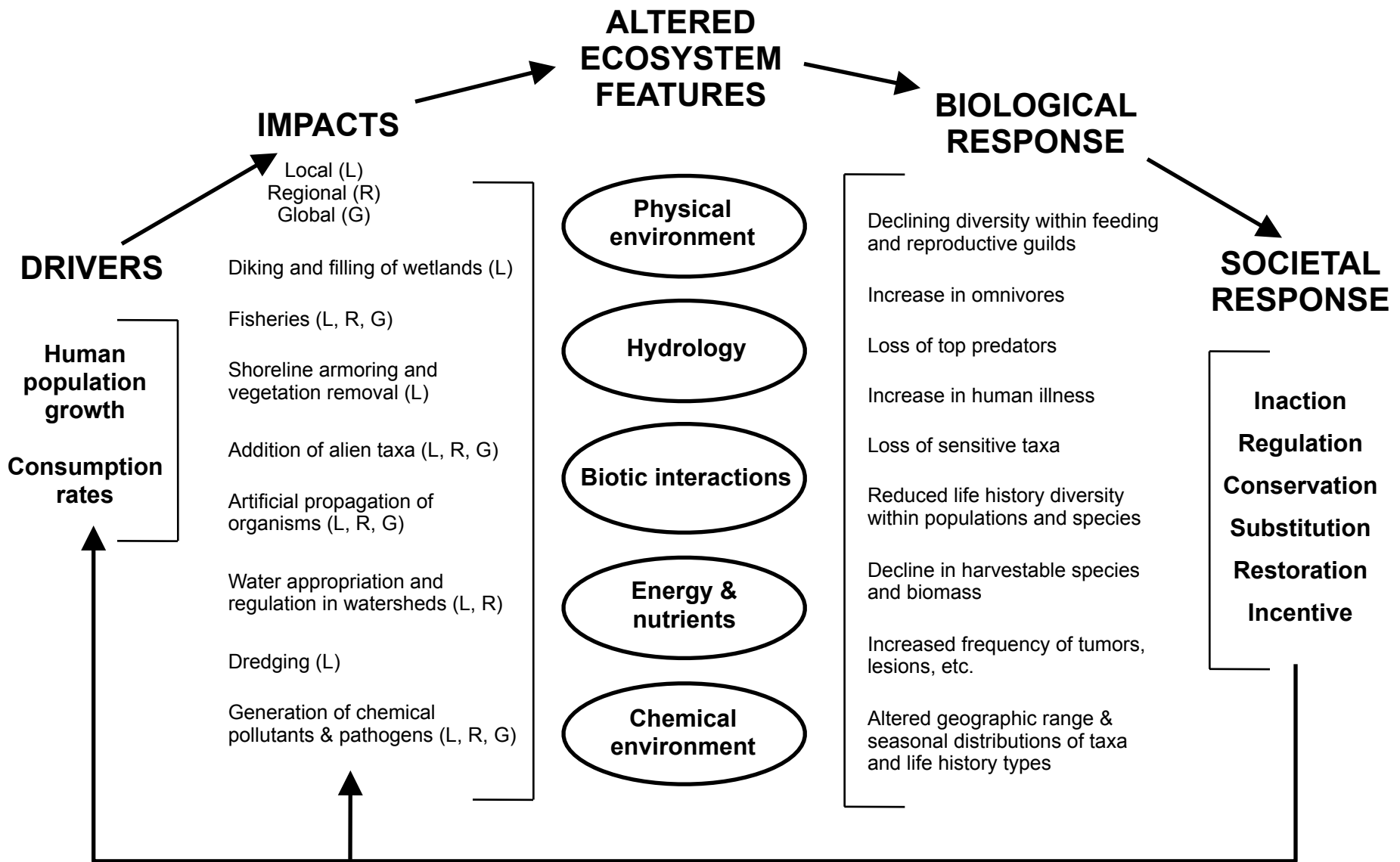




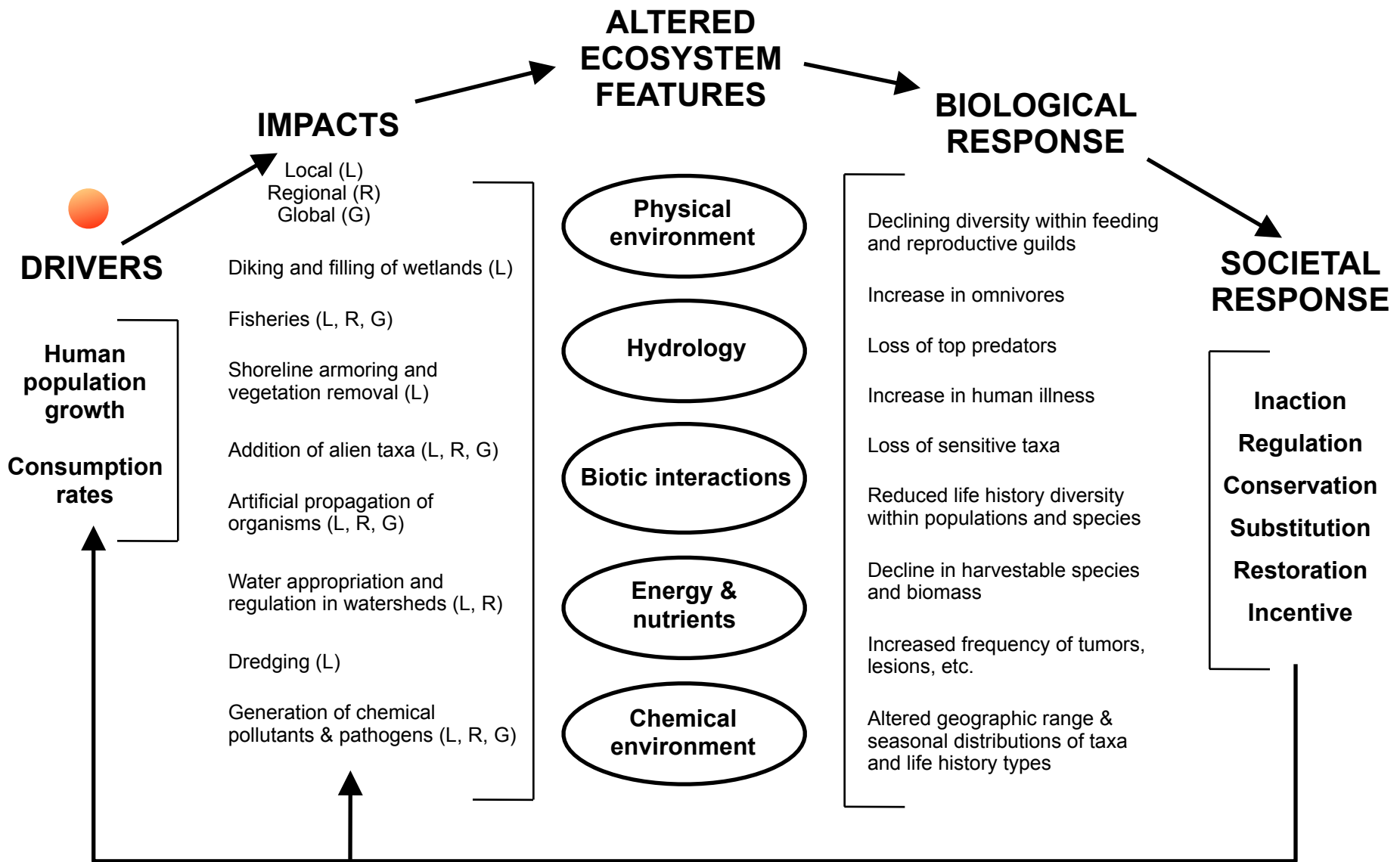
Rice et al. in preparation;
modified from Beechie et al. (2004)



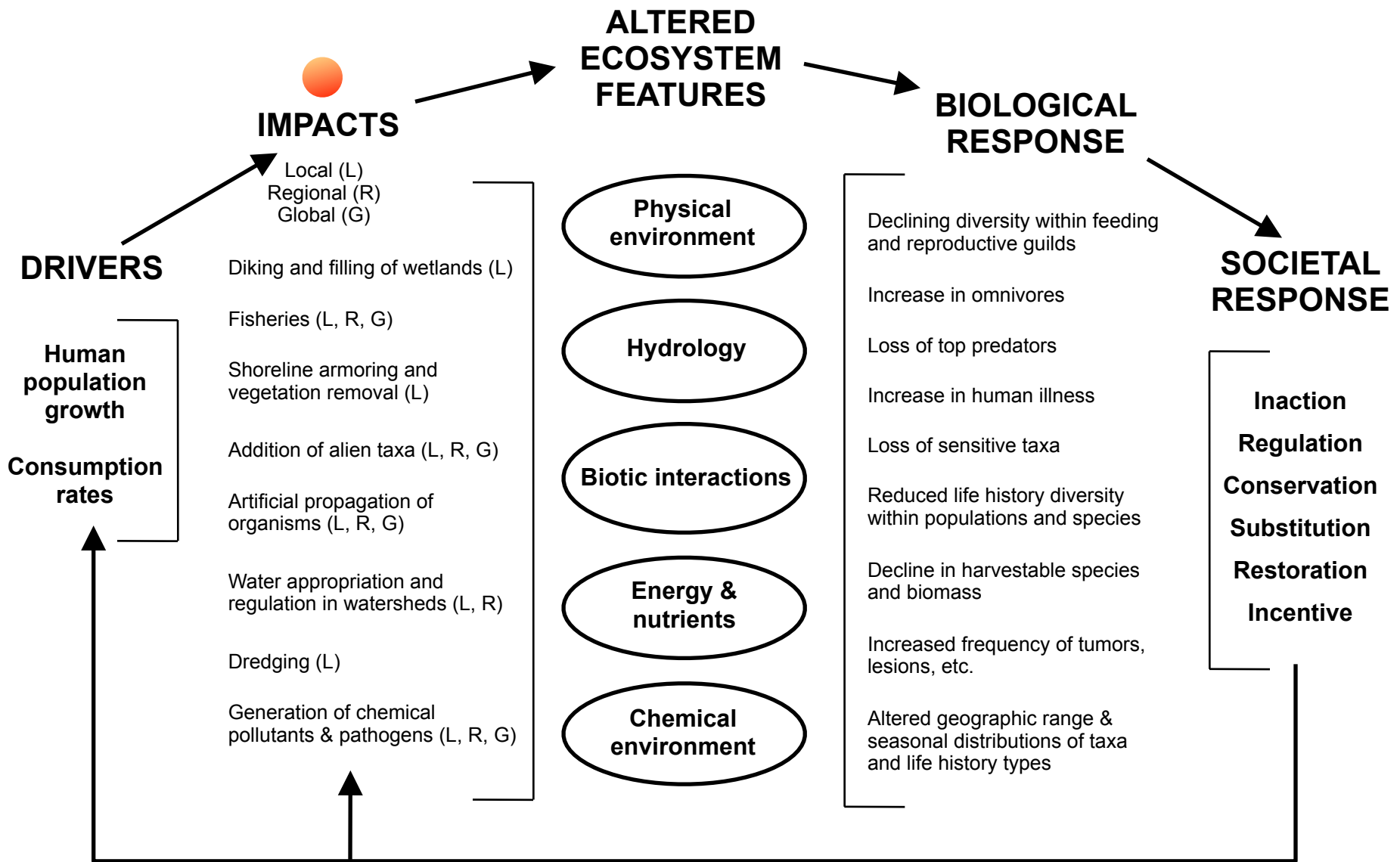
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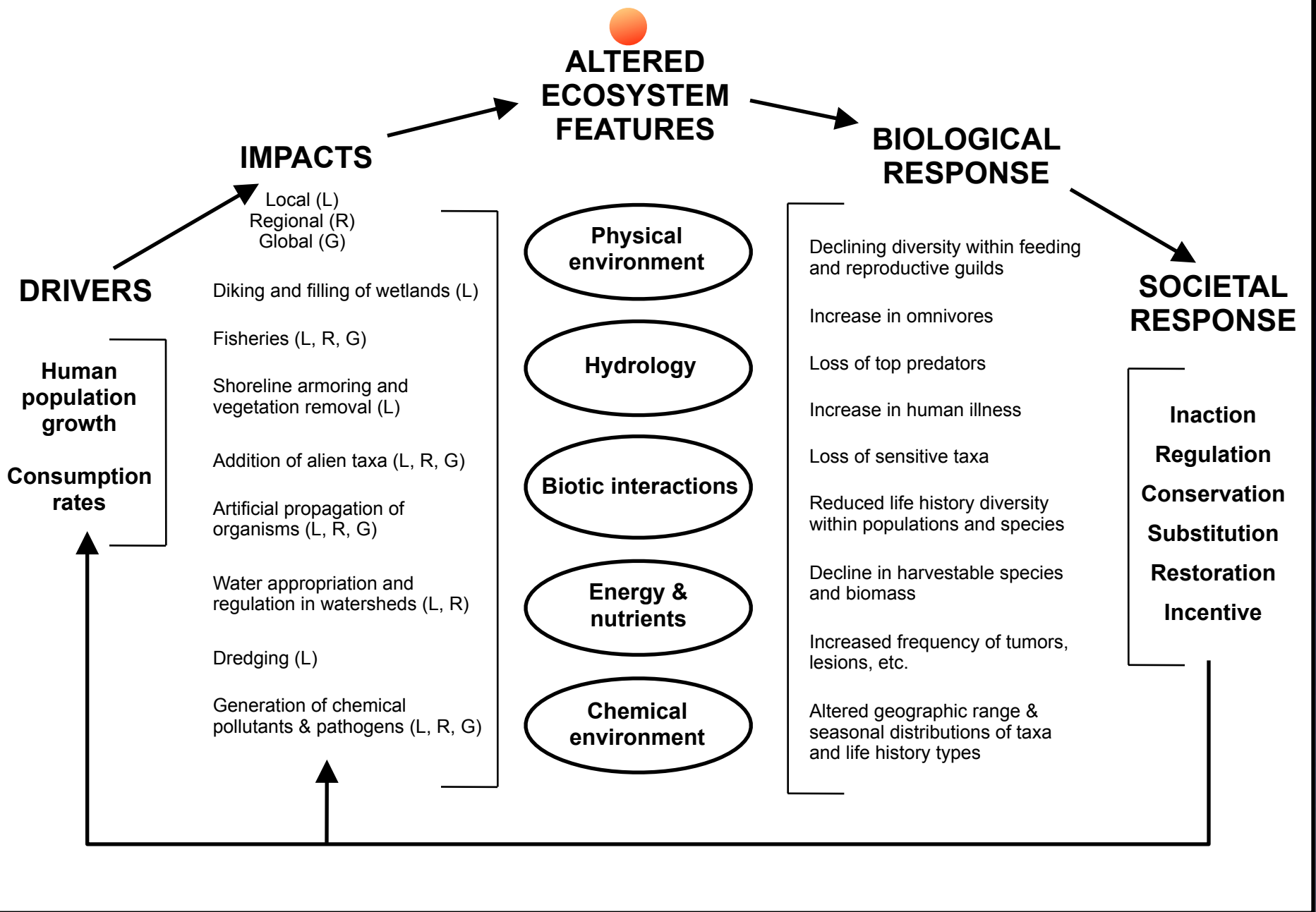
Rice et al. in preparation; adapted from: Karr (2006) & others



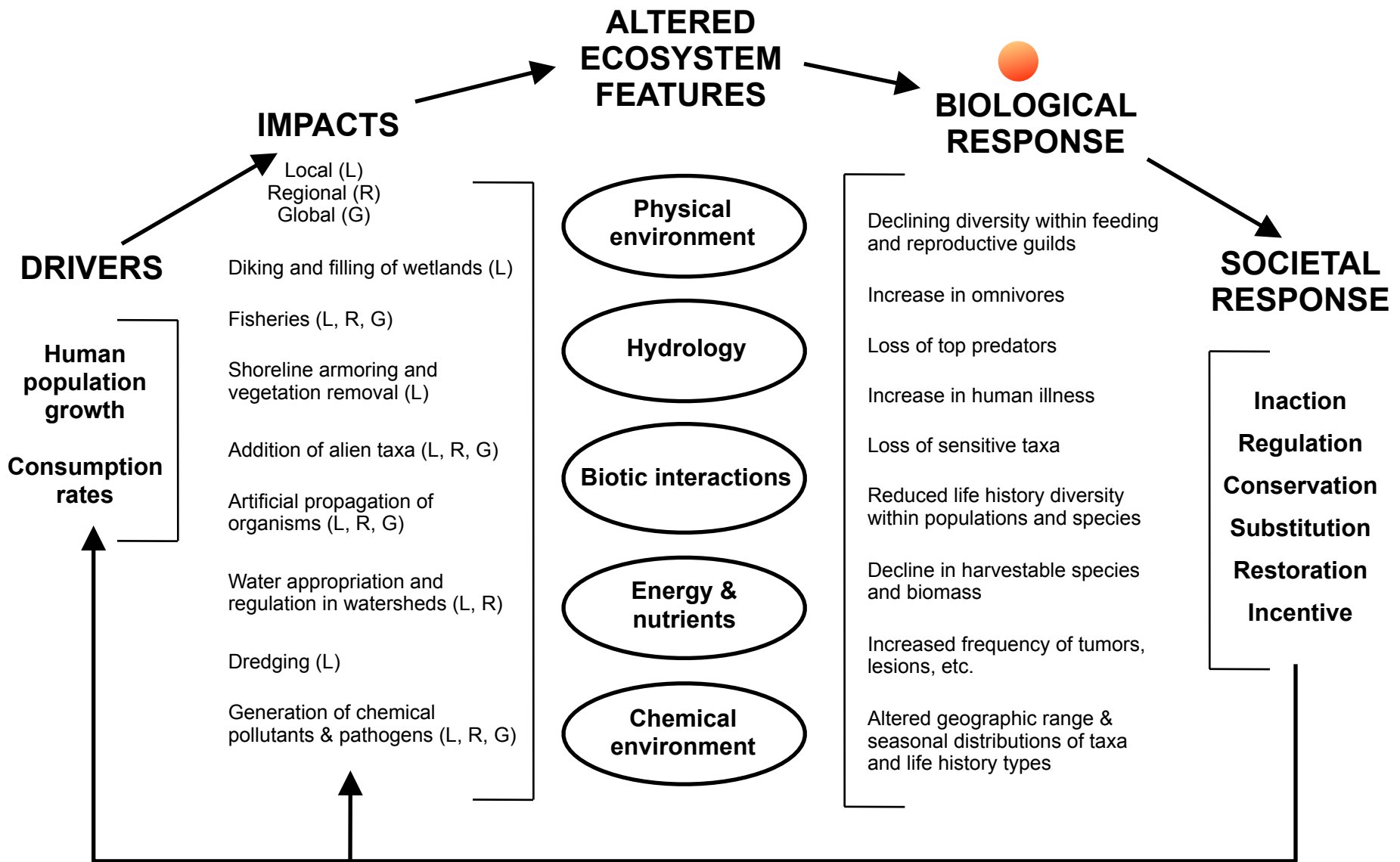
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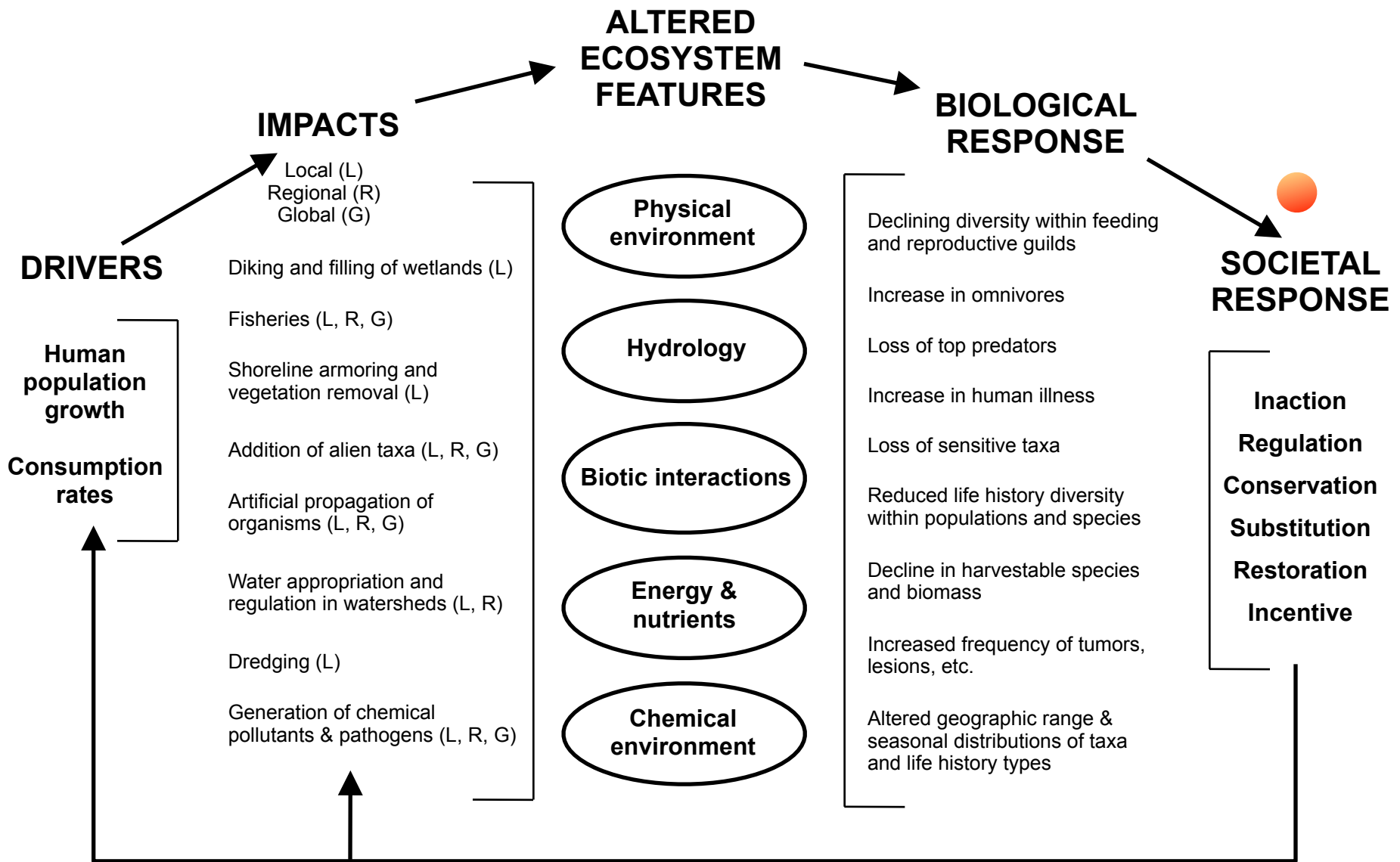
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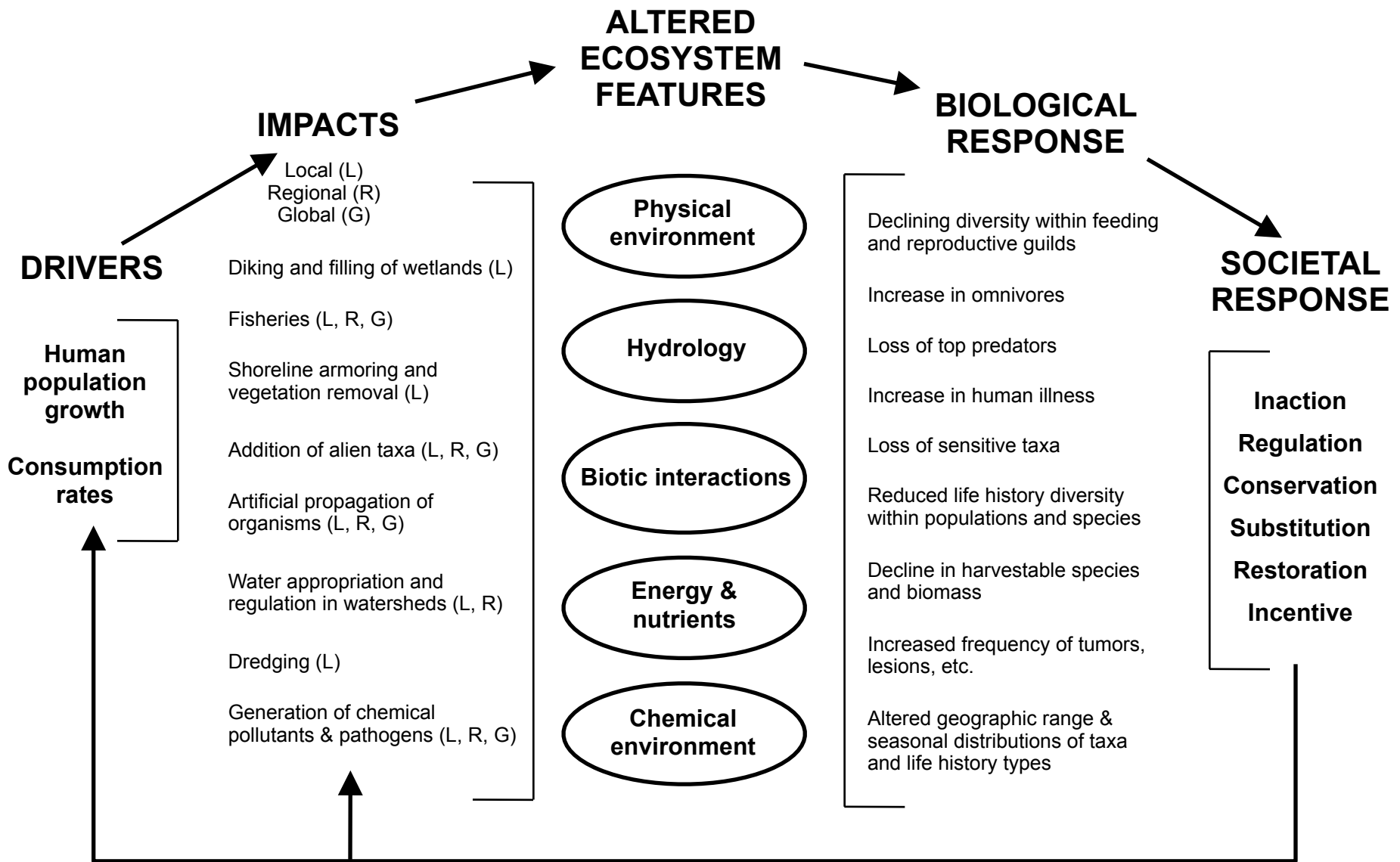
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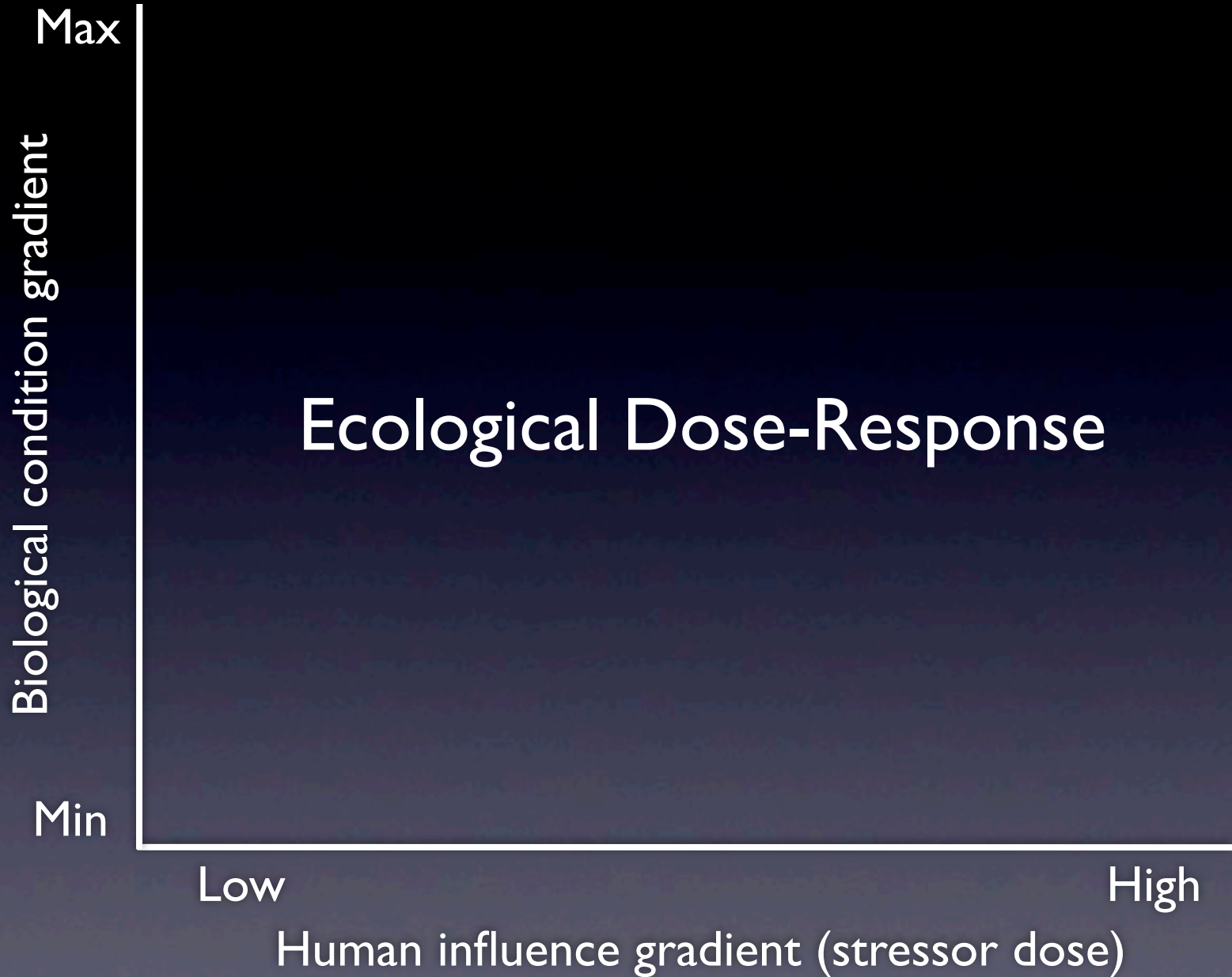


Which King County
stream is
“healthiest”
(best biological condition)?

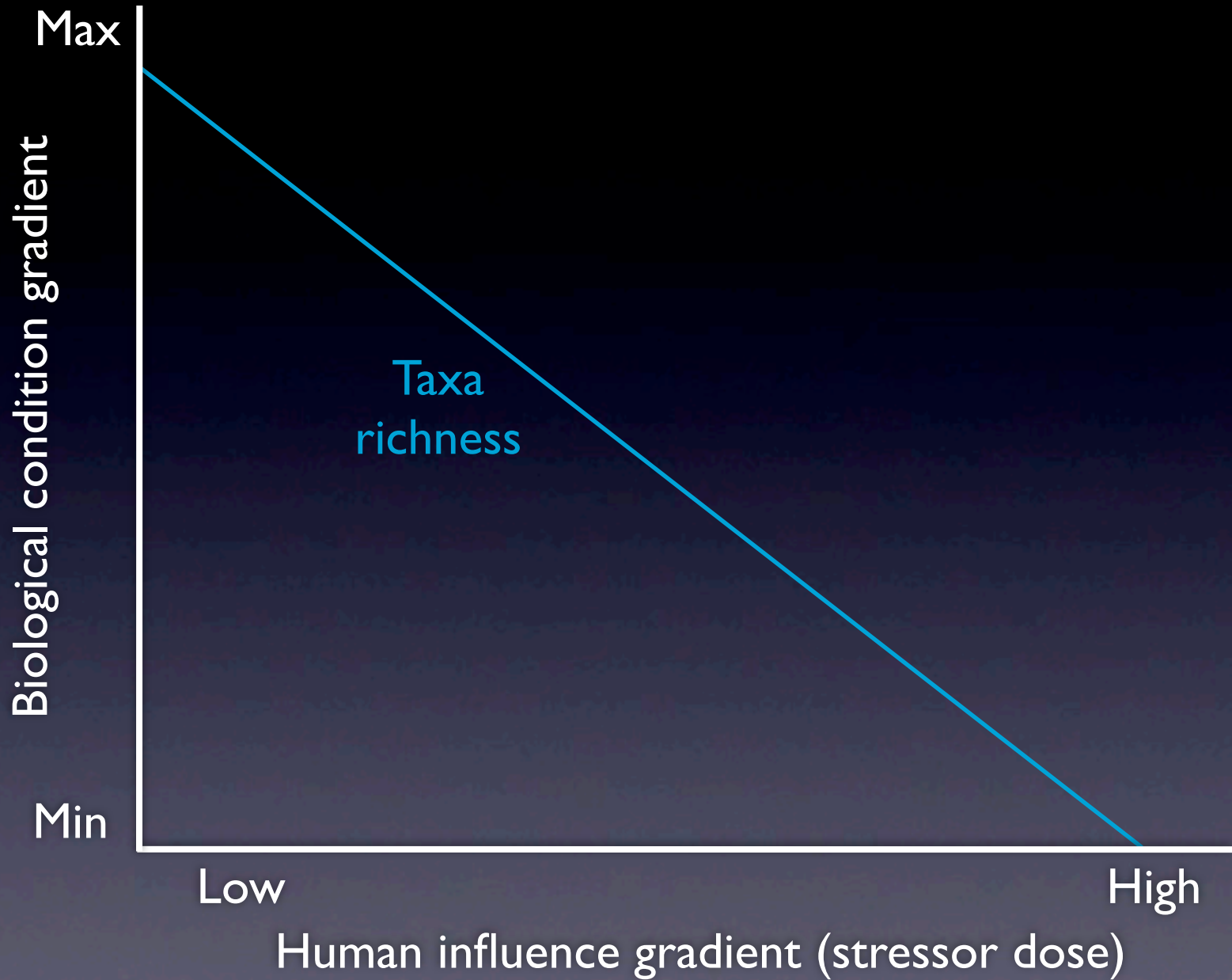
Why?

Source: Jim Karr, UW

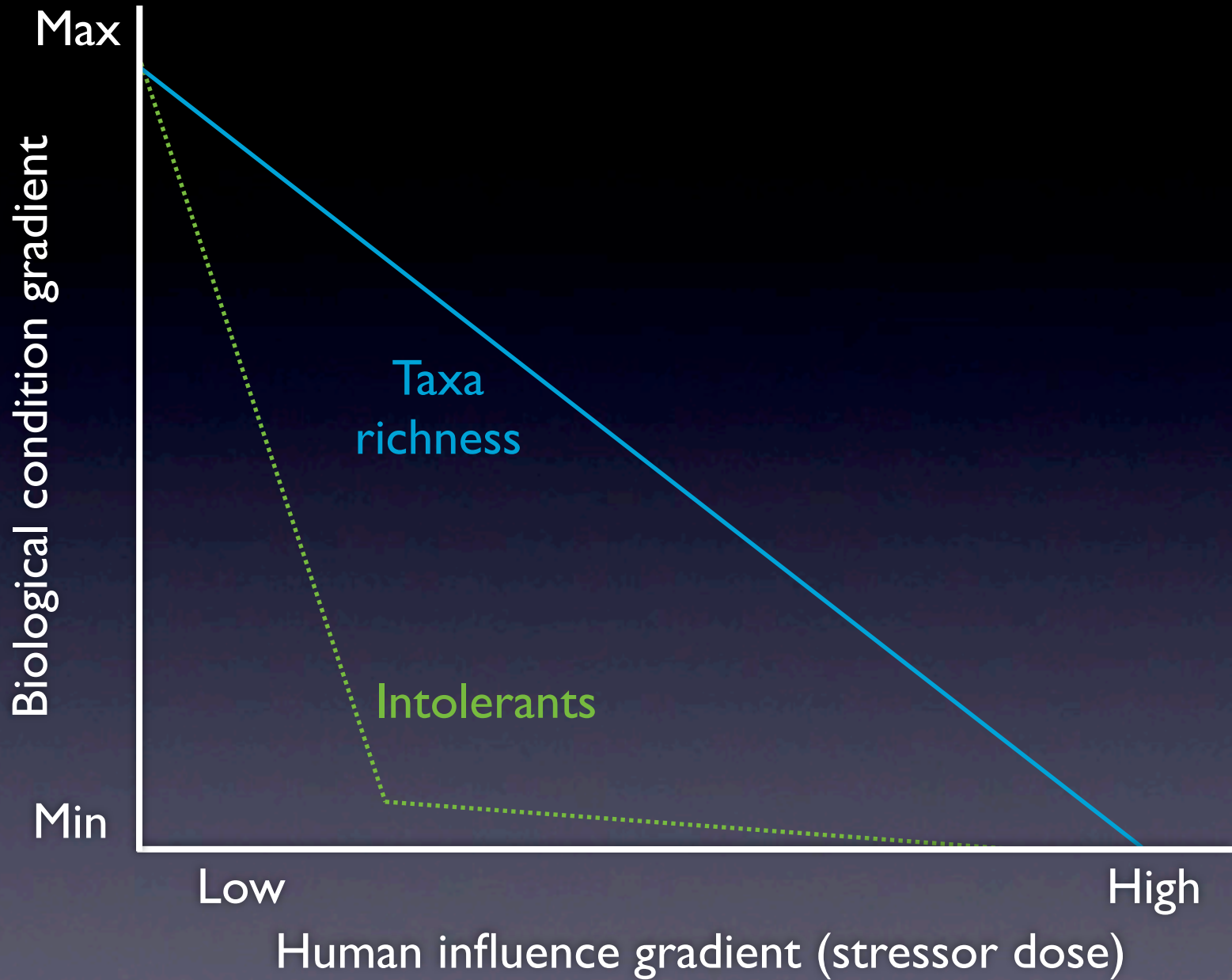
You can't have fish without water,
but you can have water without fish.



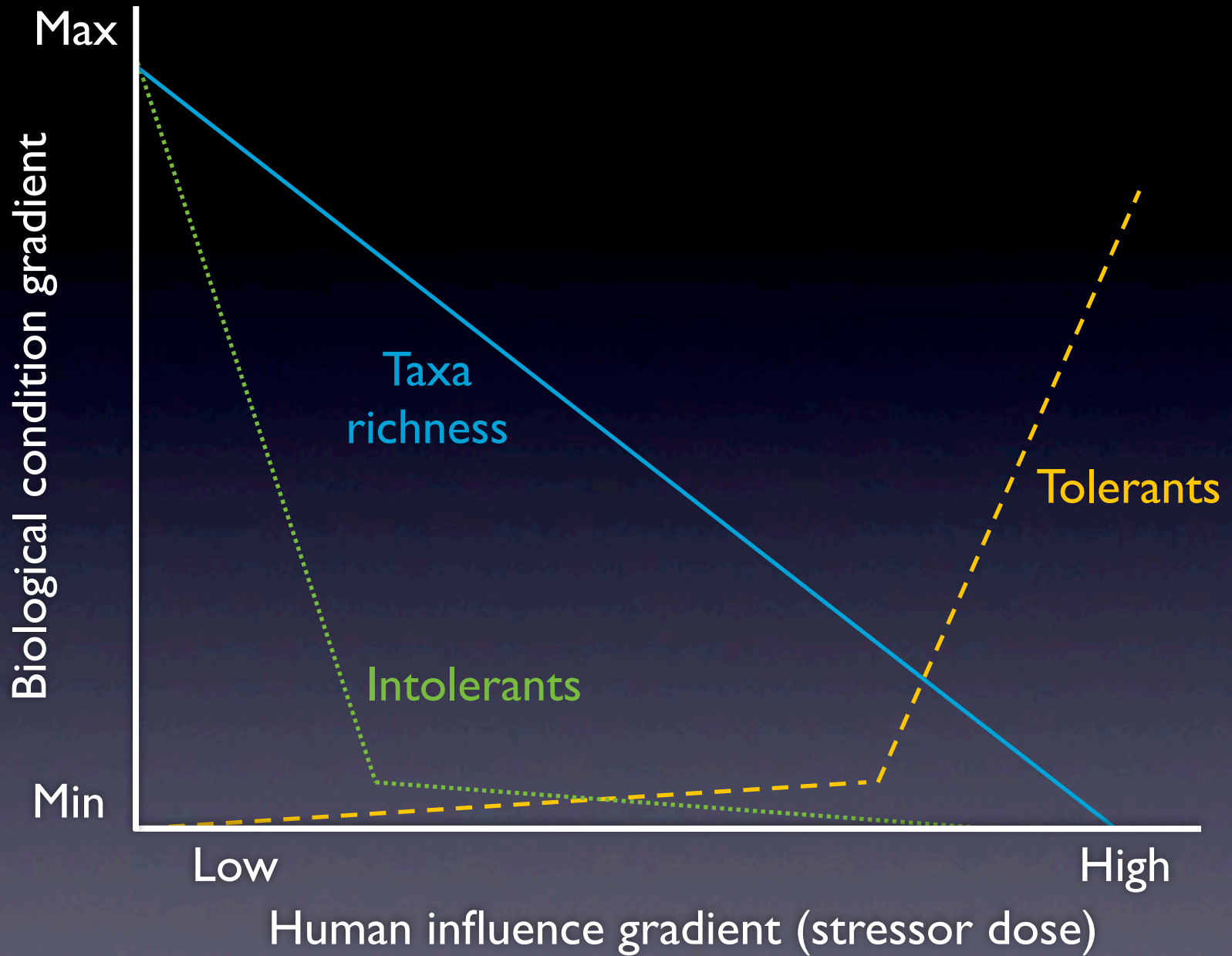
Adapted from: Karr (2006)



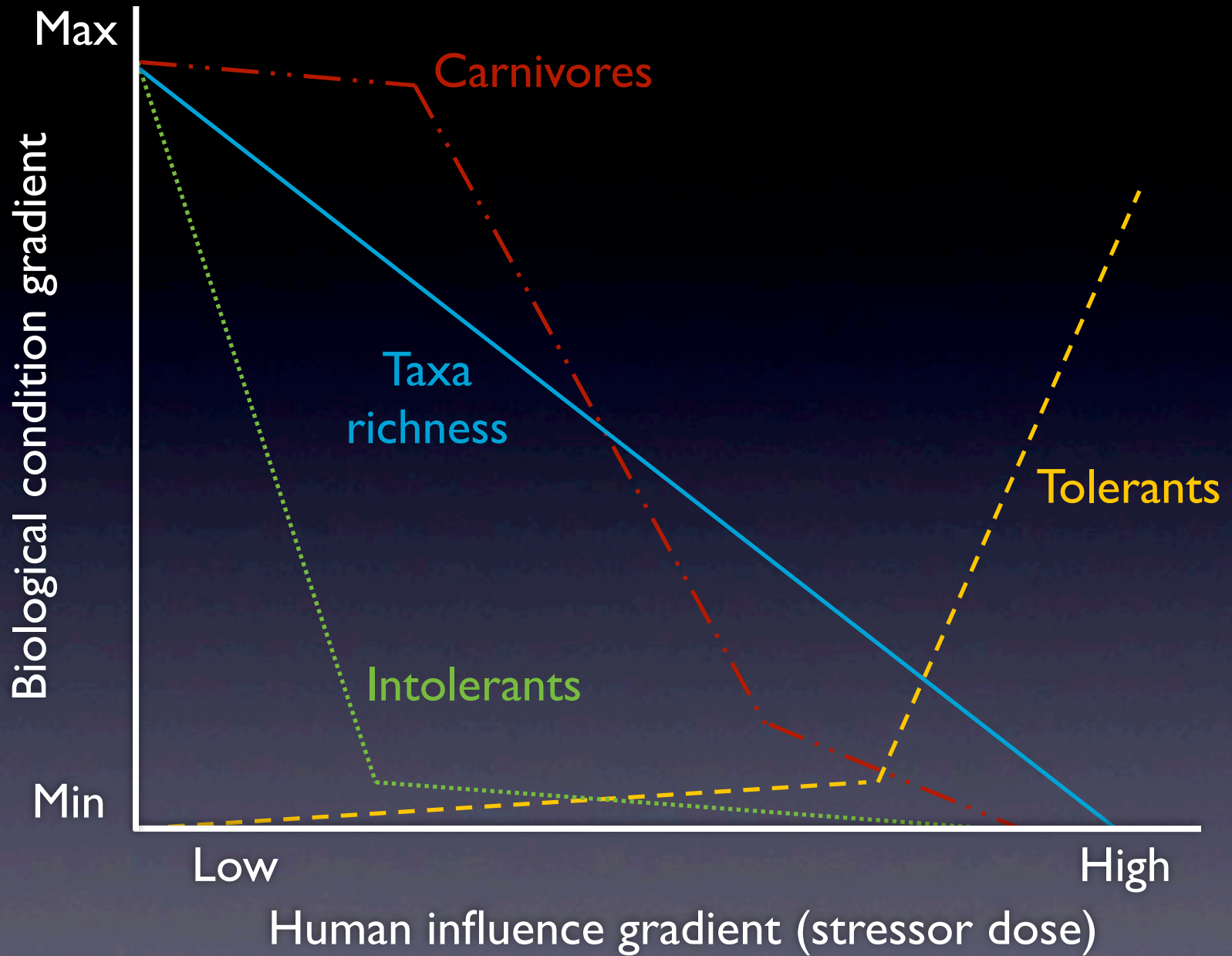
Adapted from: Karr (2006)



Adapted from: Karr (2006)



Adapted from: Karr (2006)



Adapted from: Karr (2006)



Puget Sound is...

Southern arm of the Salish Sea

Deep

Cold

Salty

Biologically rich

Altered by humans

Popular

Insufficiently understood,
monitored,
& managed

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Southern arm of the Salish Sea

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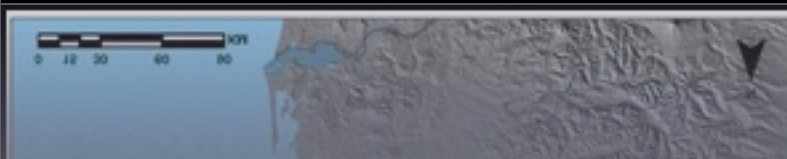
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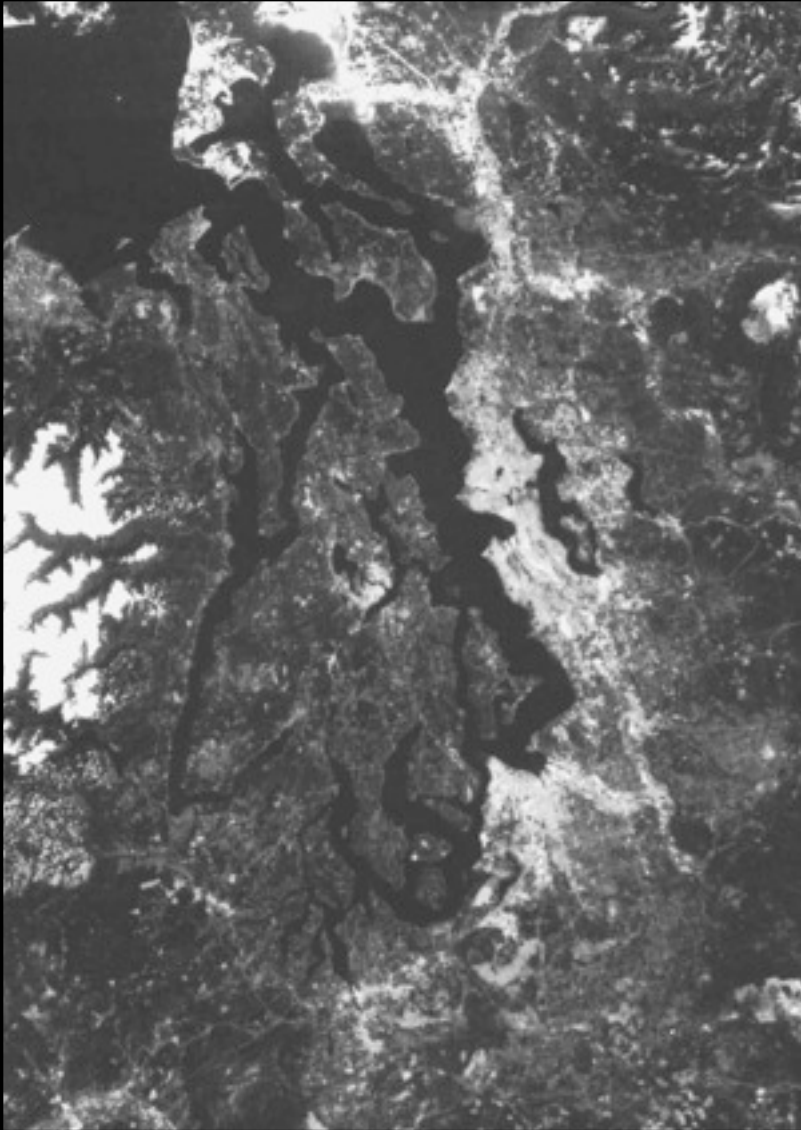
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The Early Years

- Drivers of early environmental change and information:
 - Natural resource extraction
 - Agriculture
 - Industrialization
 - Population growth



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The Early Years

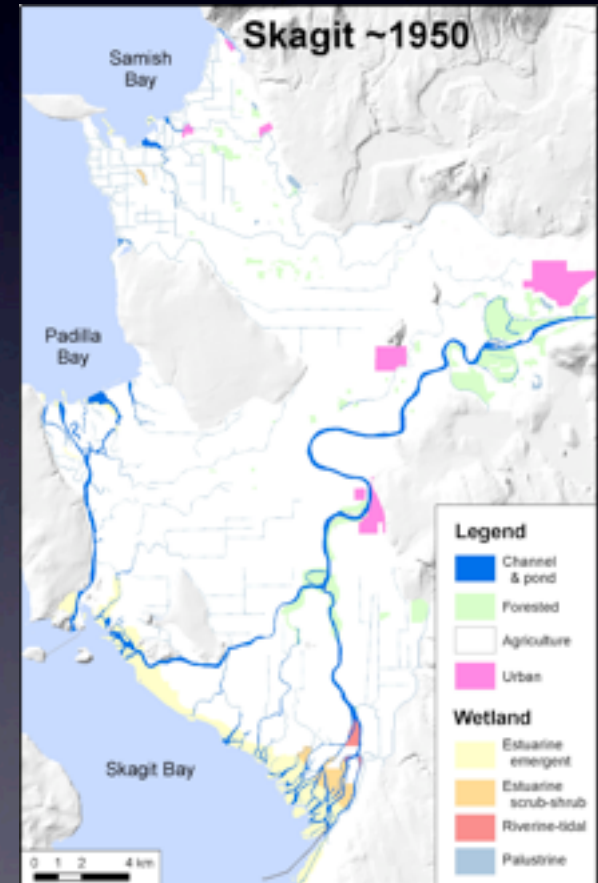
- Drivers of early environmental change and information:
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Brian Collins, UW

The Early Years

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Brian Collins, UW

The Early Years

- Drivers of early environmental change and information:
 - Natural resource extraction
 - Agriculture
 - Industrialization
 - Population growth
- Academics
 - Often “applied” and reductionist
 - Usually outside of Puget Sound (5% of COFS abstracts)

Modern Times

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- Environmental awareness of the 1960s and 70s.

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- Water quality and contaminant focus (poison matters, but...)

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Modern Times

- Environmental awareness of the 1960s and 70s.
- Water quality and contaminant focus (poison matters, but...)
- Still framed as a water quality issue
- Public works and accidents (short time scales, etc.)
- Still missing the comprehensive narrative

Major Efforts

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- Monitoring of exploited species

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- MESA – Marine EcoSystems Analysis (late 1970s)

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- PSNERP – Puget Sound Nearshore Ecosystem Restoration Project
- NST, CHIPS, PSP, IEA



ecosystem
model

Building the Narrative

- How does it work?
- What did we do to it?
- What should we do now?
- Did it work?

Building the Narrative

- New data

Building the Narrative

- New data
- New analyses

Building the Narrative

- New data
- New analyses
- New information

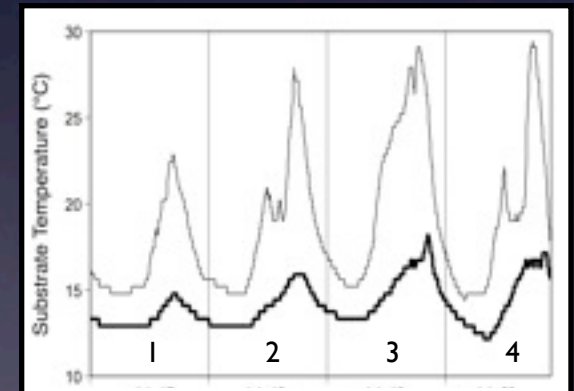
Examples

	Biology	Humans	Systems
1	surf smelt embryos	shoreline modification	pervasive disturbance; widespread species
2	juvenile Chinook small pelagic fishes jellies	hatcheries habitat loss & modification	broad seasonal & geographic coverage; multiple taxa
3	marine birds & waterfowl	urbanization	all of Greater Puget Sound; multiple taxa

Shoreline Modification

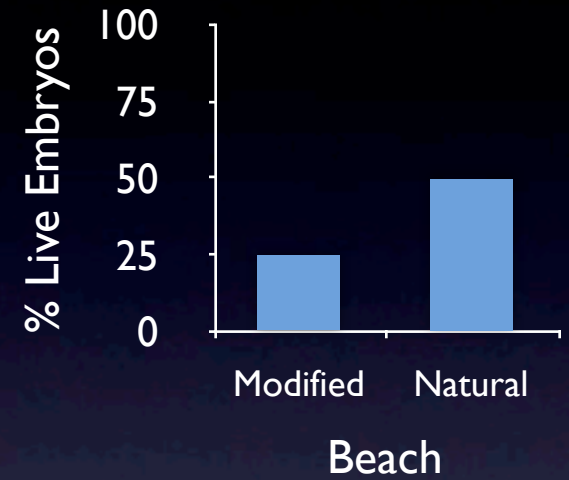


Modified beach is:
brighter, hotter, drier, &
deader



Day

Shoreline Modification



Juvenile Chinook Salmon in Puget Sound



ESA listed

Most estuarine
Pacific salmon

Basic estuarine
data gaps

Scientific Method

Observation



Hypothesis



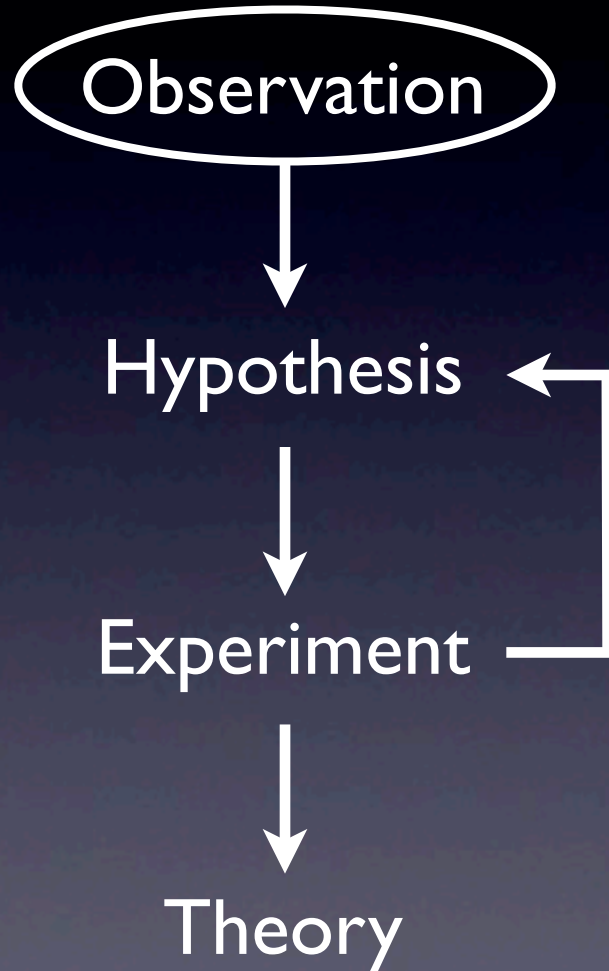
Experiment

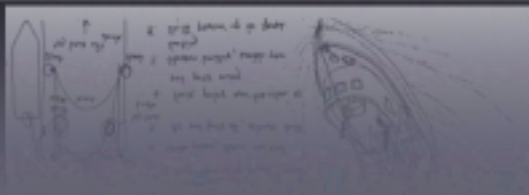
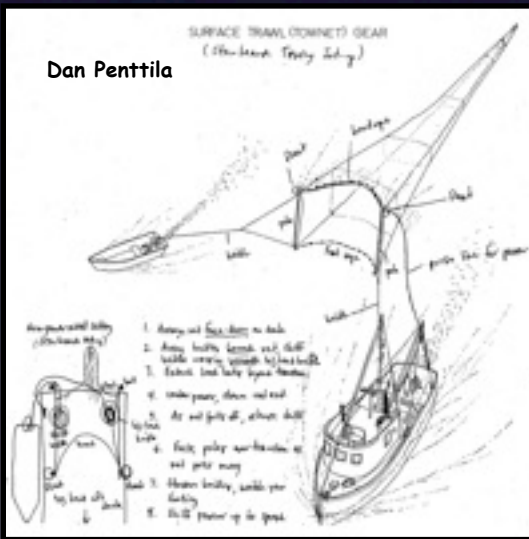
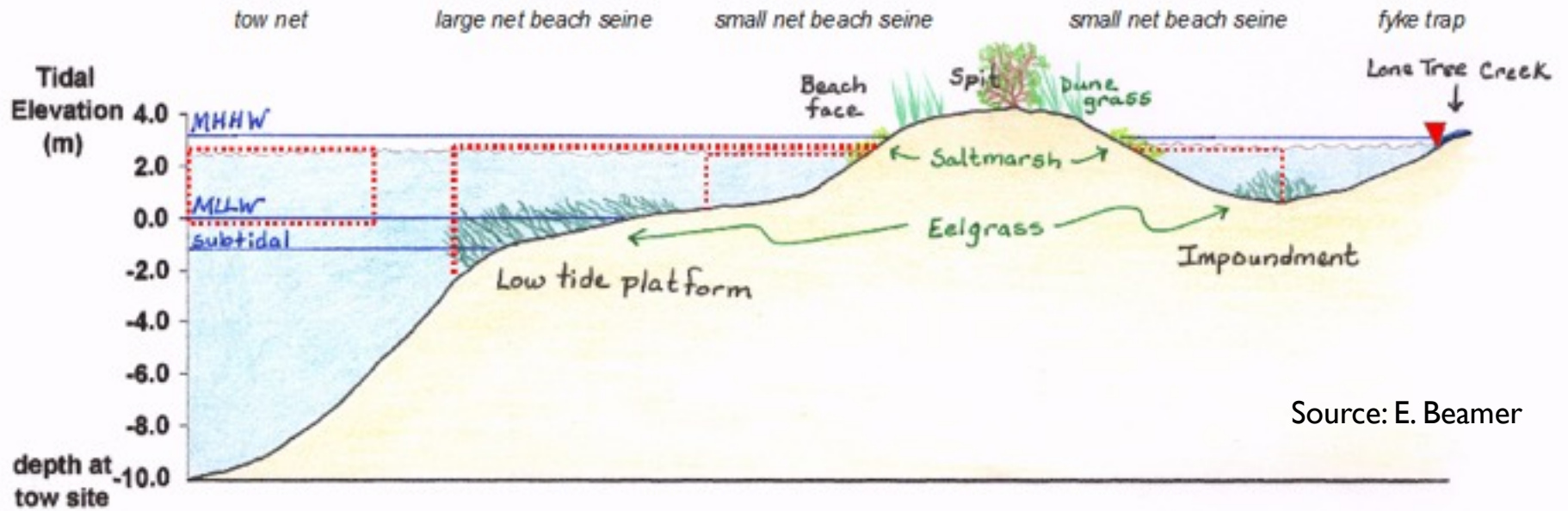


Theory



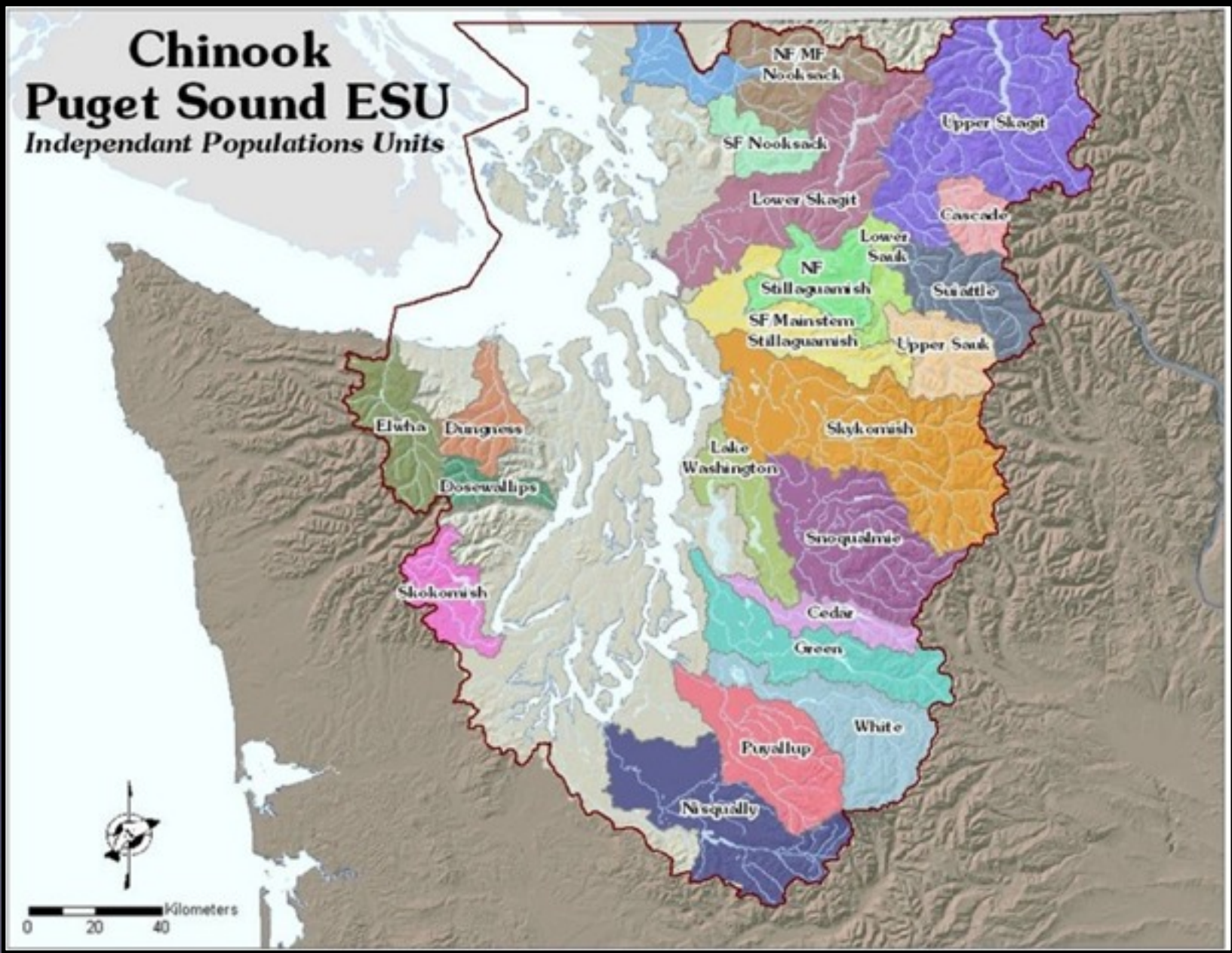
Scientific Method





Chinook Puget Sound ESU

Independent Populations Units



2003 Puget Sound townetting

52 sites

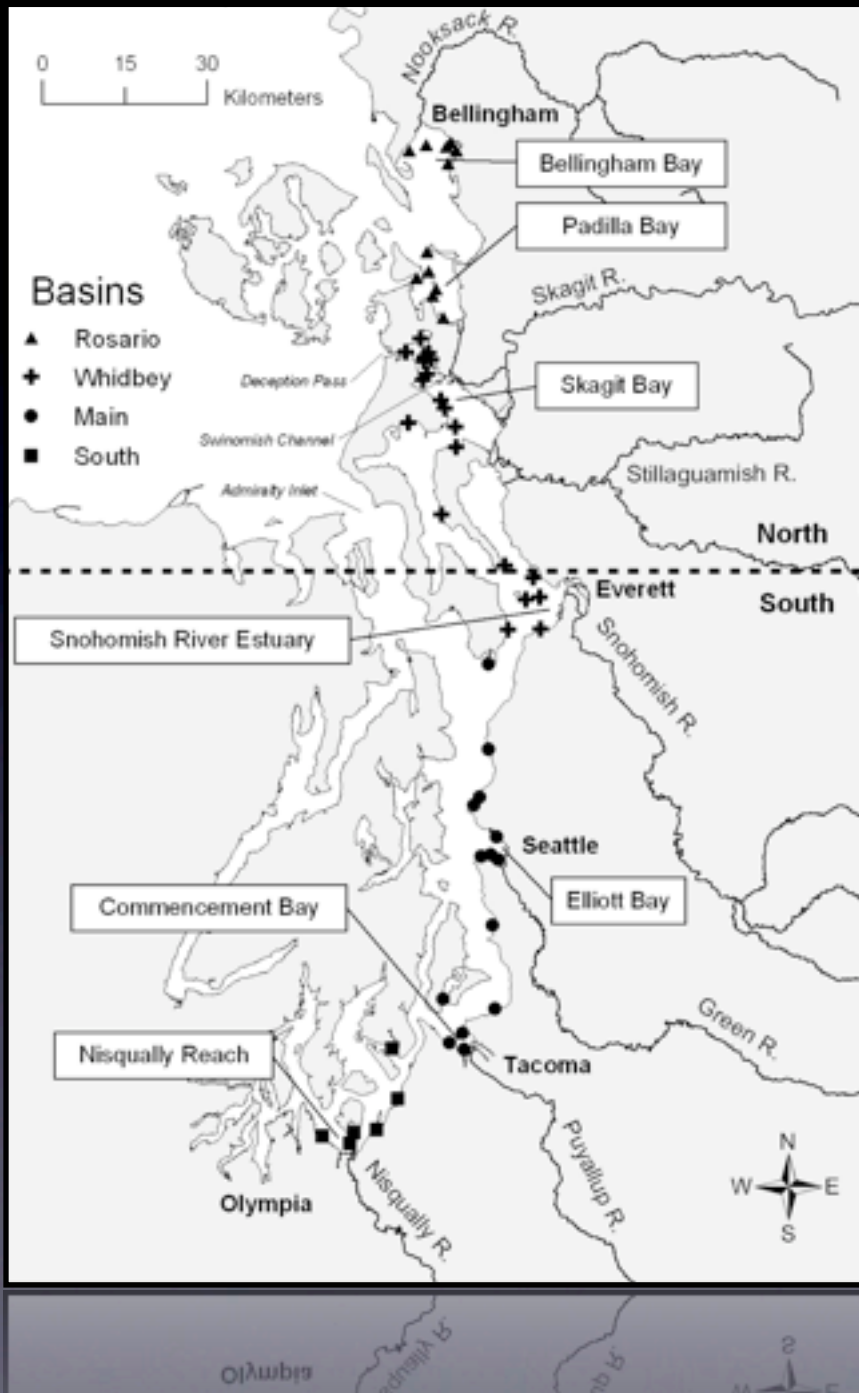
Monthly

April through October

~ 650 tows

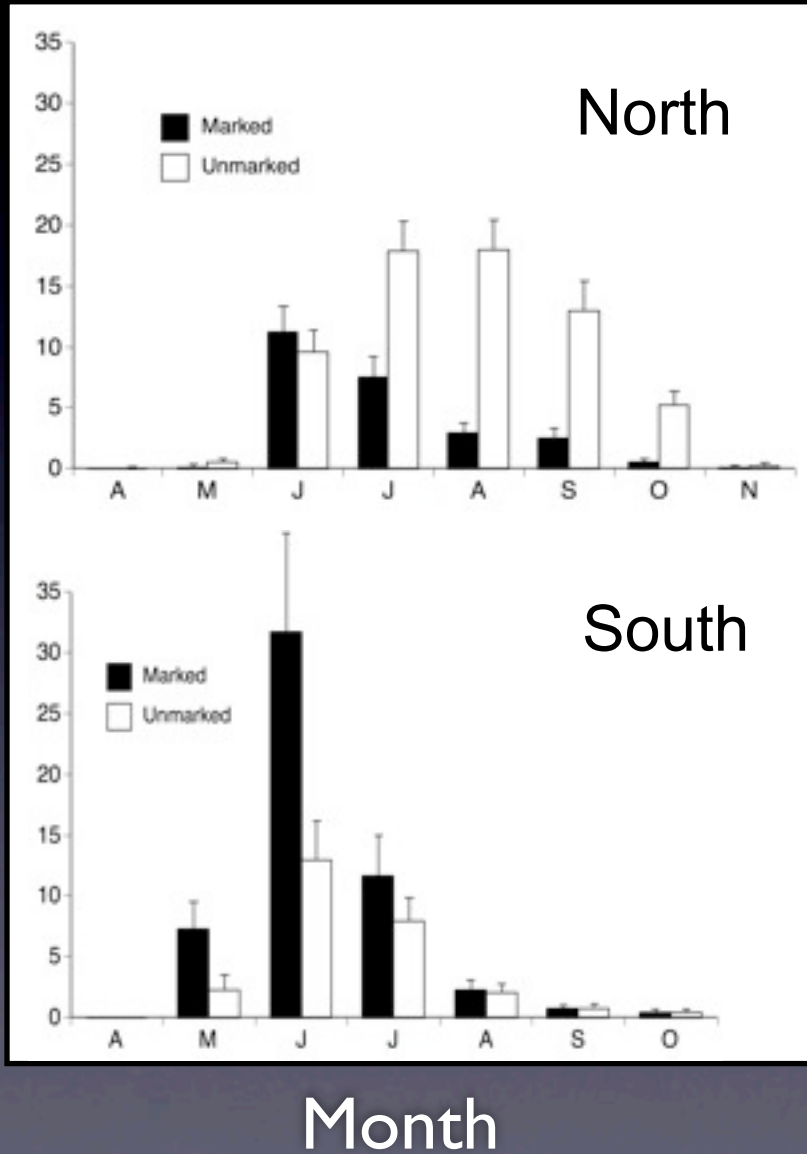
Complete catch &
biomass

Detailed sampling of
Chinook



Juvenile Chinook Seasonal Distribution, 2003

Mean fish per hectare (+ se)



Chinook Conclusions

Chinook Conclusions

- Juvenile Chinook present much of the year

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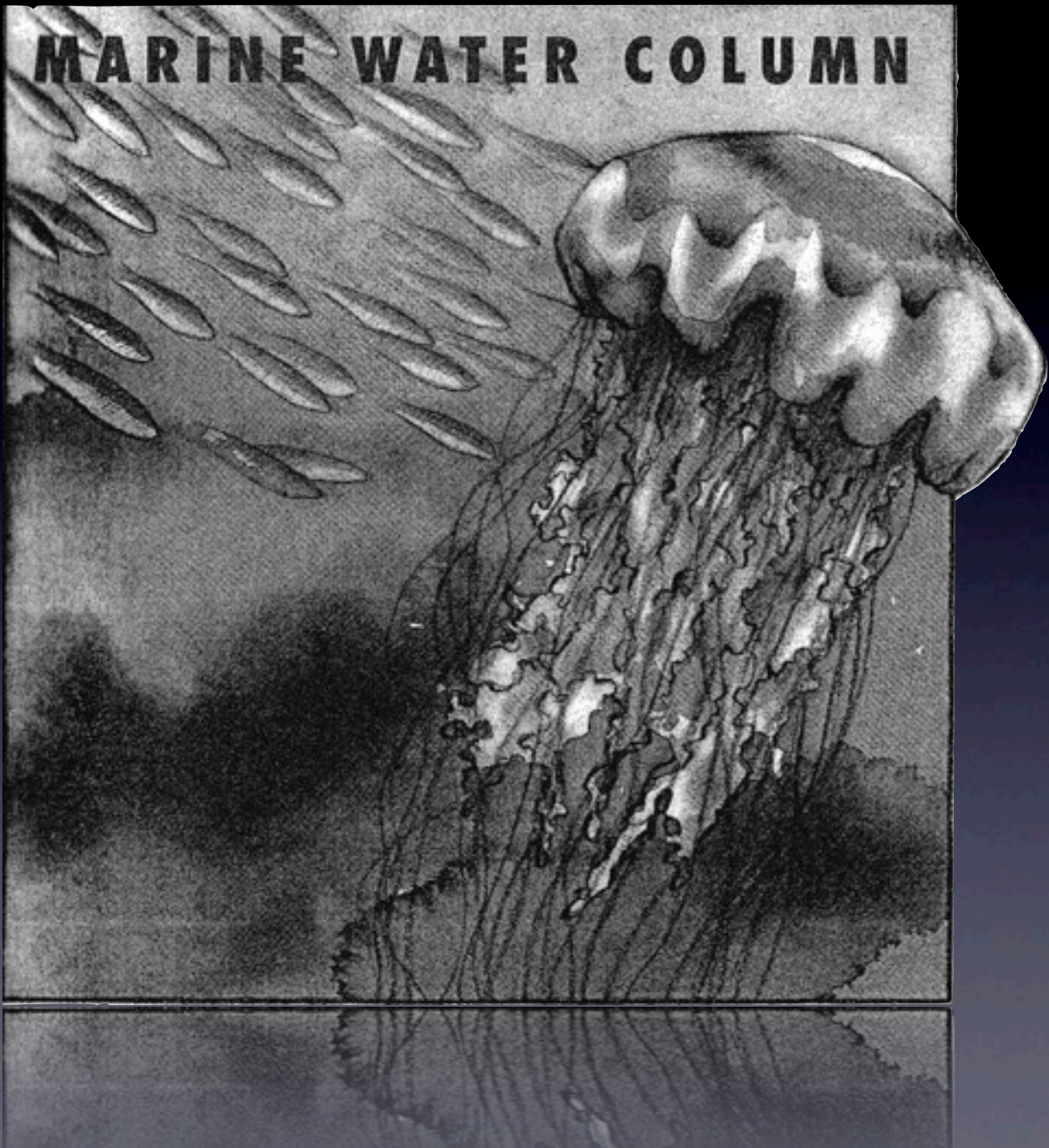
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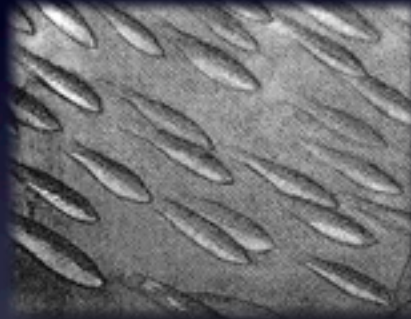
Chinook Conclusions

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- Hatchery fish larger
- Movement and mixing of source populations
- Broad spatial & temporal scale critical
- Initial data excellent basis for monitoring design

MARINE WATER COLUMN

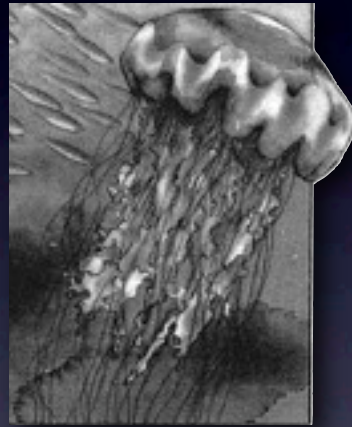


mammals
birds
fishes



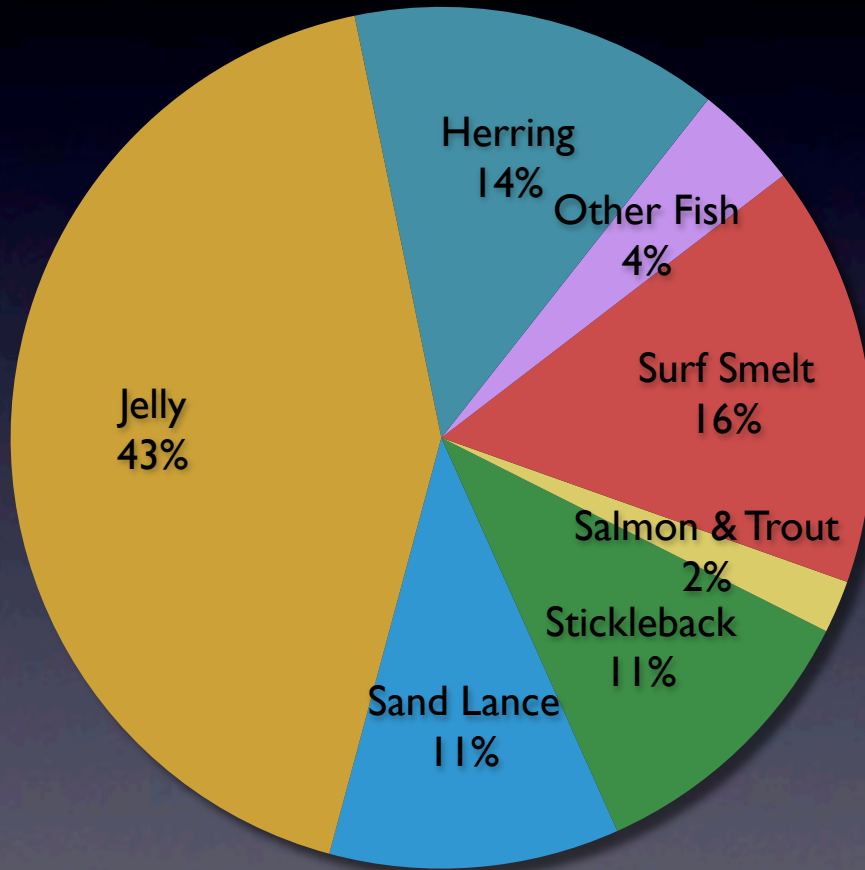
zooplankton
phytoplankton
bacteria

?

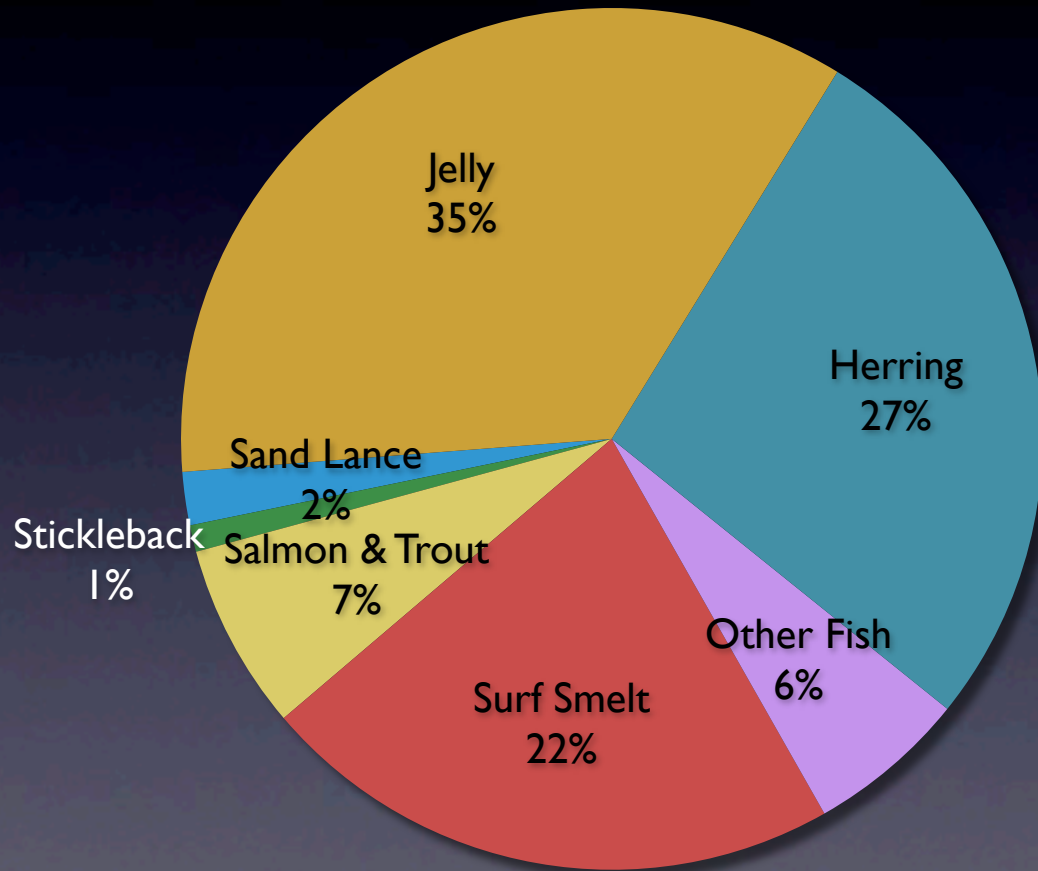


?

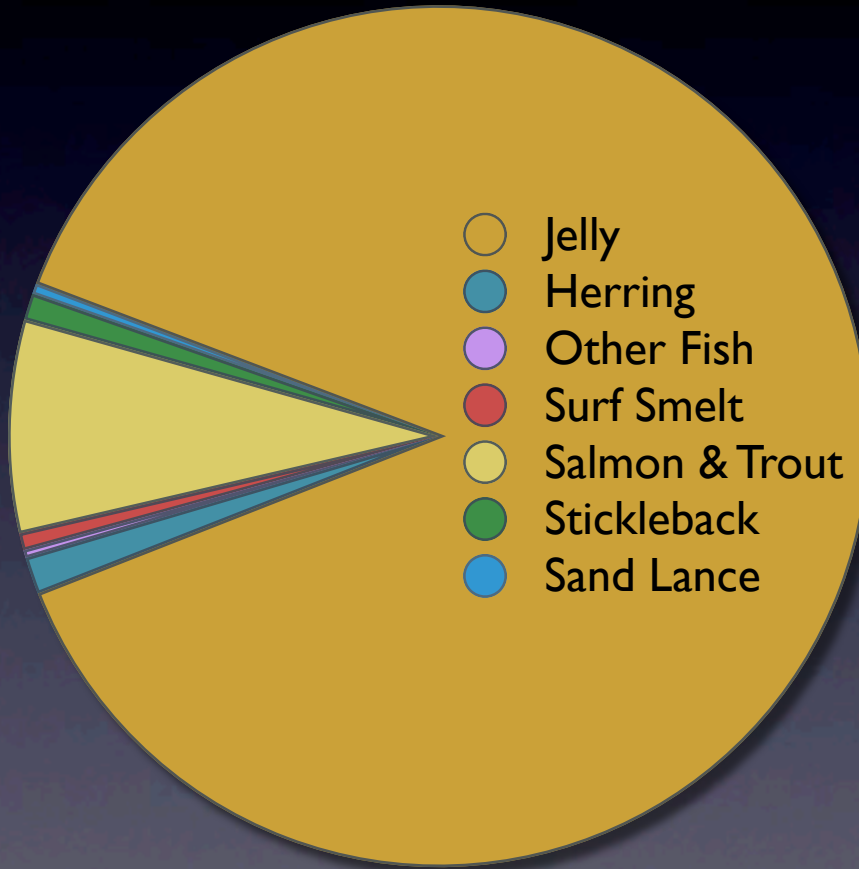
Biomass Composition (May – September, 2003)



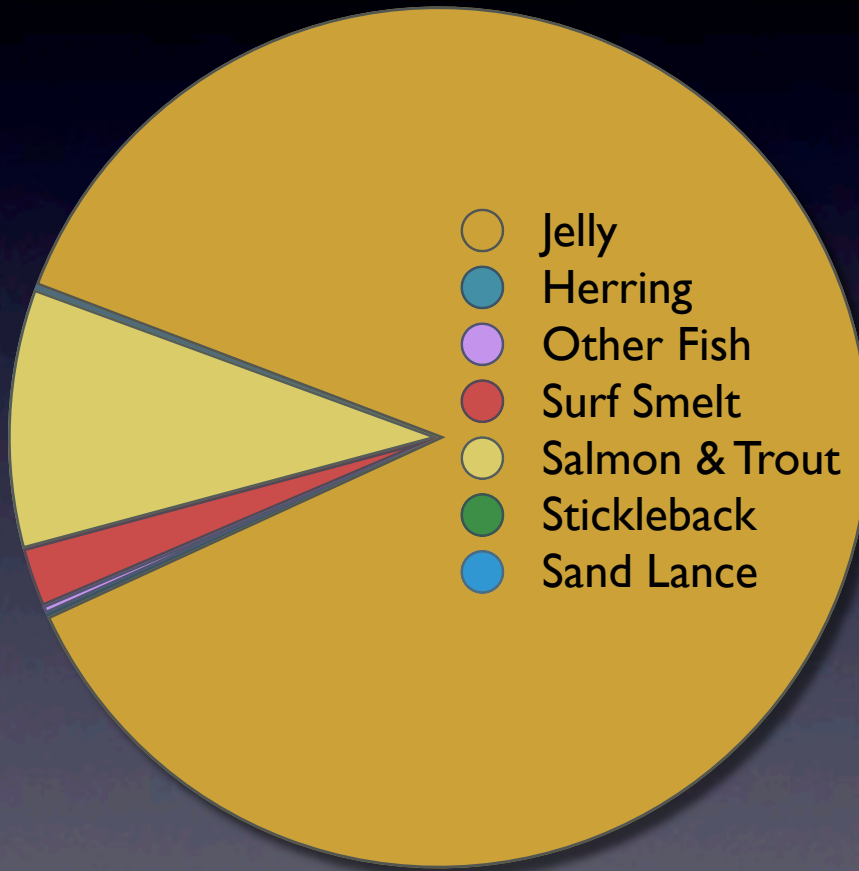
Biomass Composition (May – September, 2003)



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Biomass Composition (May – September, 2003)



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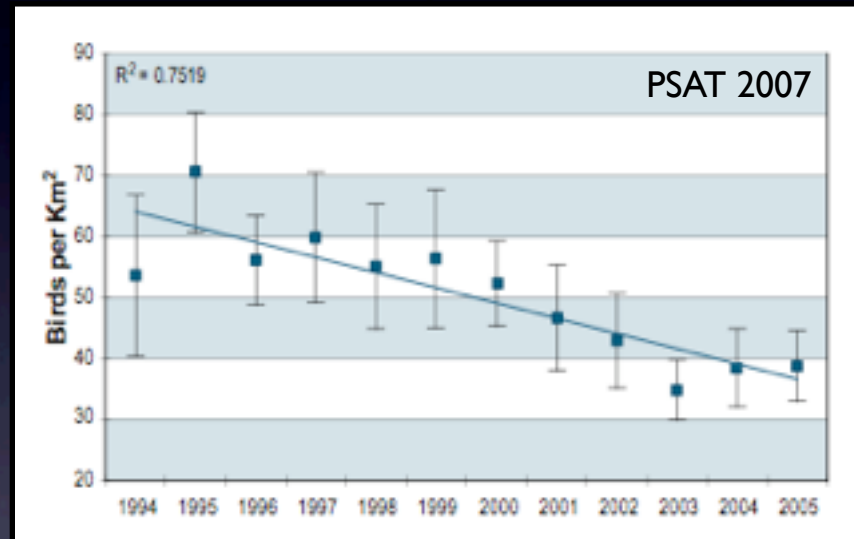
“By-catch” Conclusions

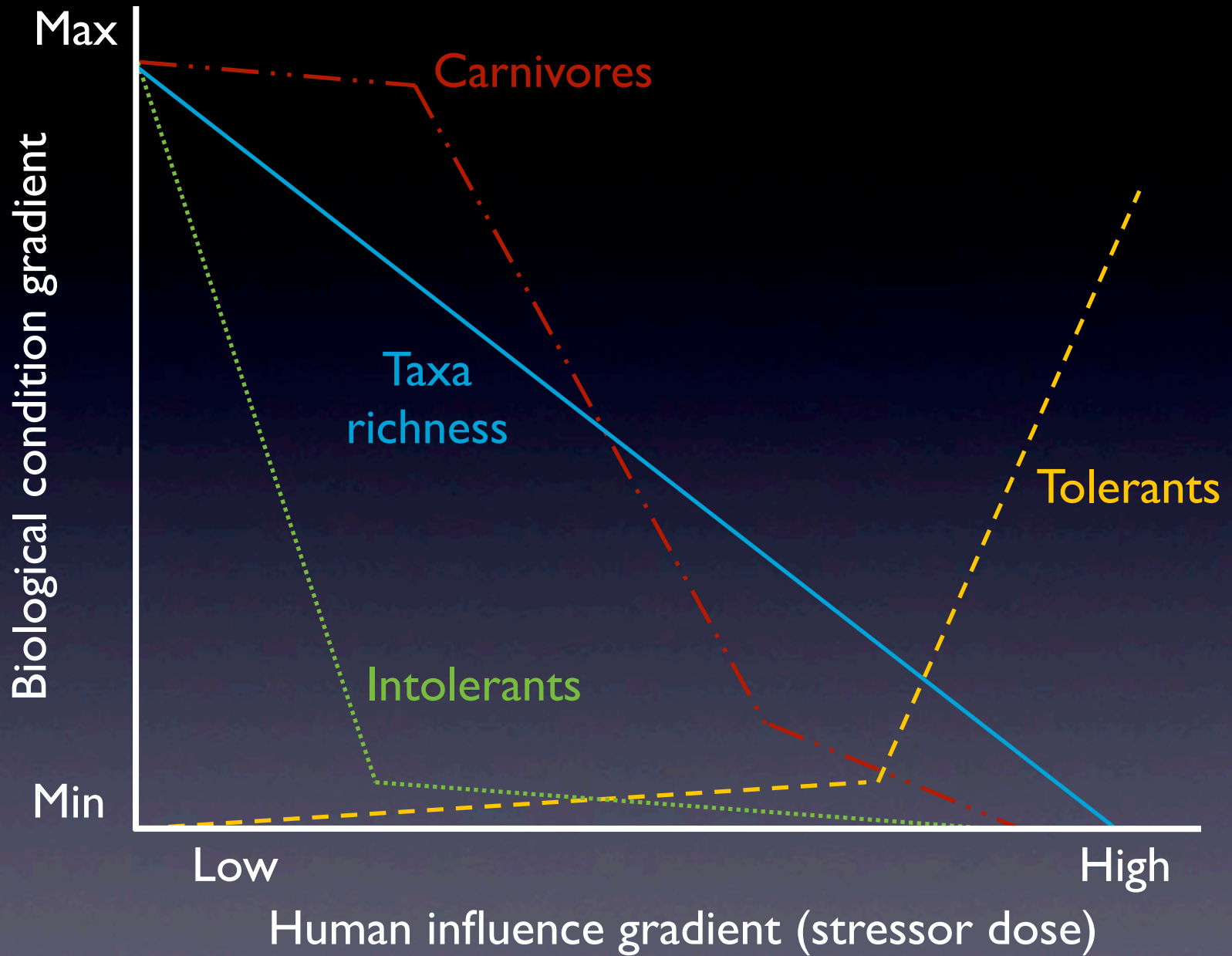
- Jellies major component of the biota
- Inverse relationships between jellies and fish abundance and diversity
- Geographic differences in taxonomic composition
- Latitude and water clarity most strongly related to taxonomy

Integration and Reanalysis: Beyond Simple Abundance

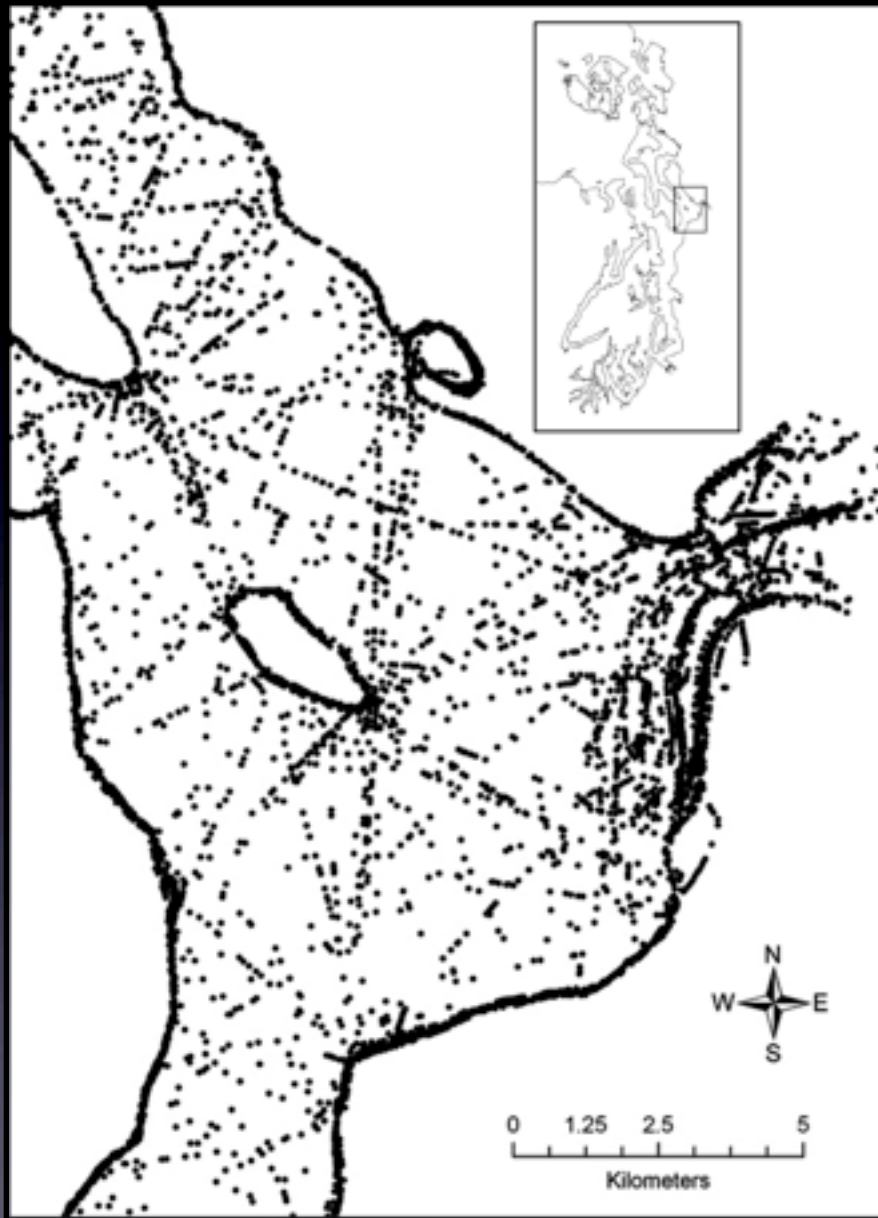


Integration and Reanalysis: Beyond Simple Abundance





Adapted from: Karr (2006)



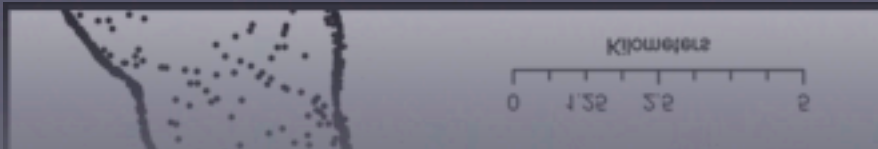
BIOLOGICAL DATA

Marine Birds and
Waterfowl

Aerial survey data from
WDFW

Over 400,000 points in
greater Puget Sound,

1993 - 2004





ENVIRONMENTAL DATA I

Washington ShoreZone
Inventory
(WDNR)

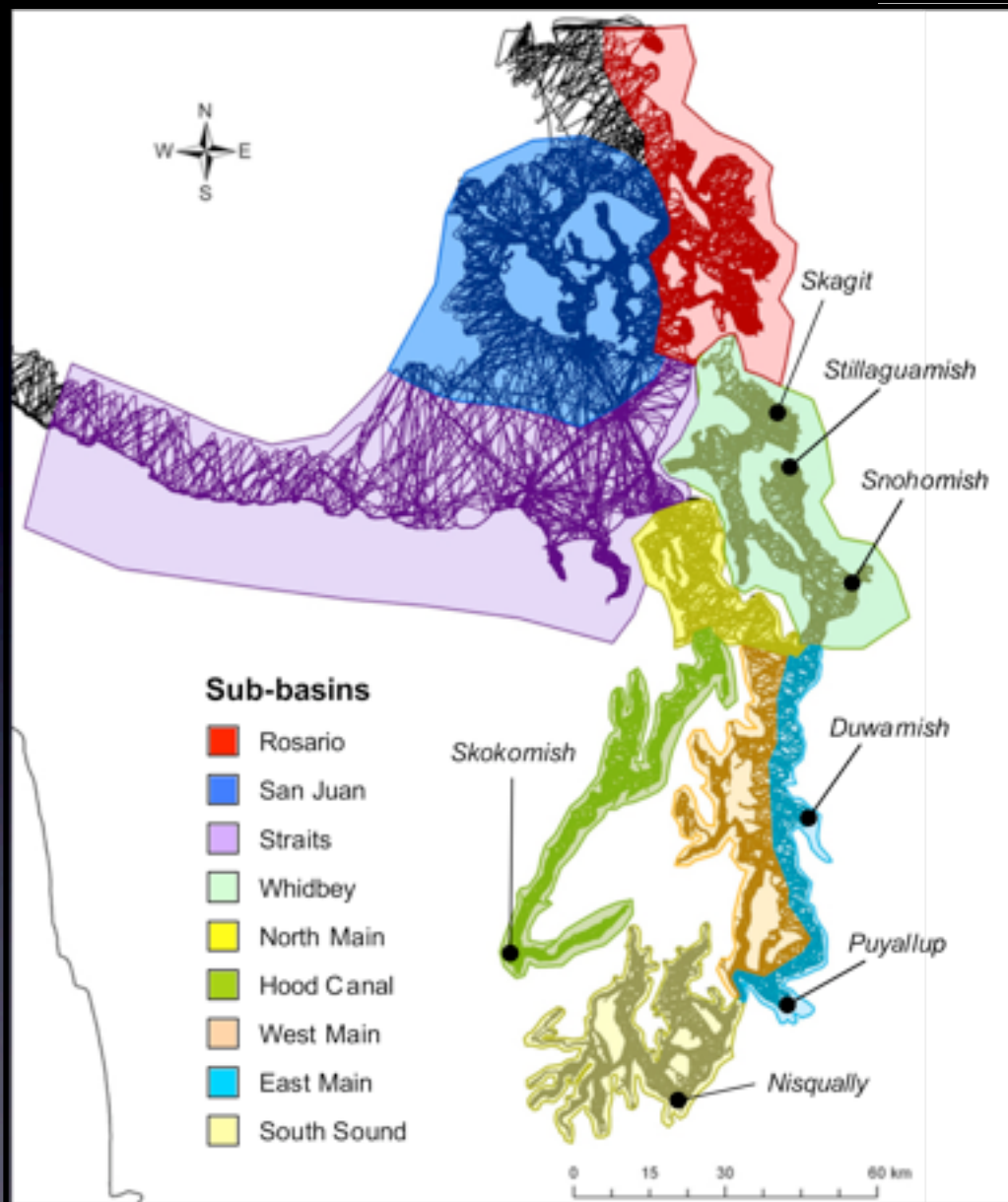
Approximately 4000 shoreline
segments in greater Puget
Sound, mid-1990's



ENVIRONMENTAL DATA 2

Puget Sound land cover
(2002)

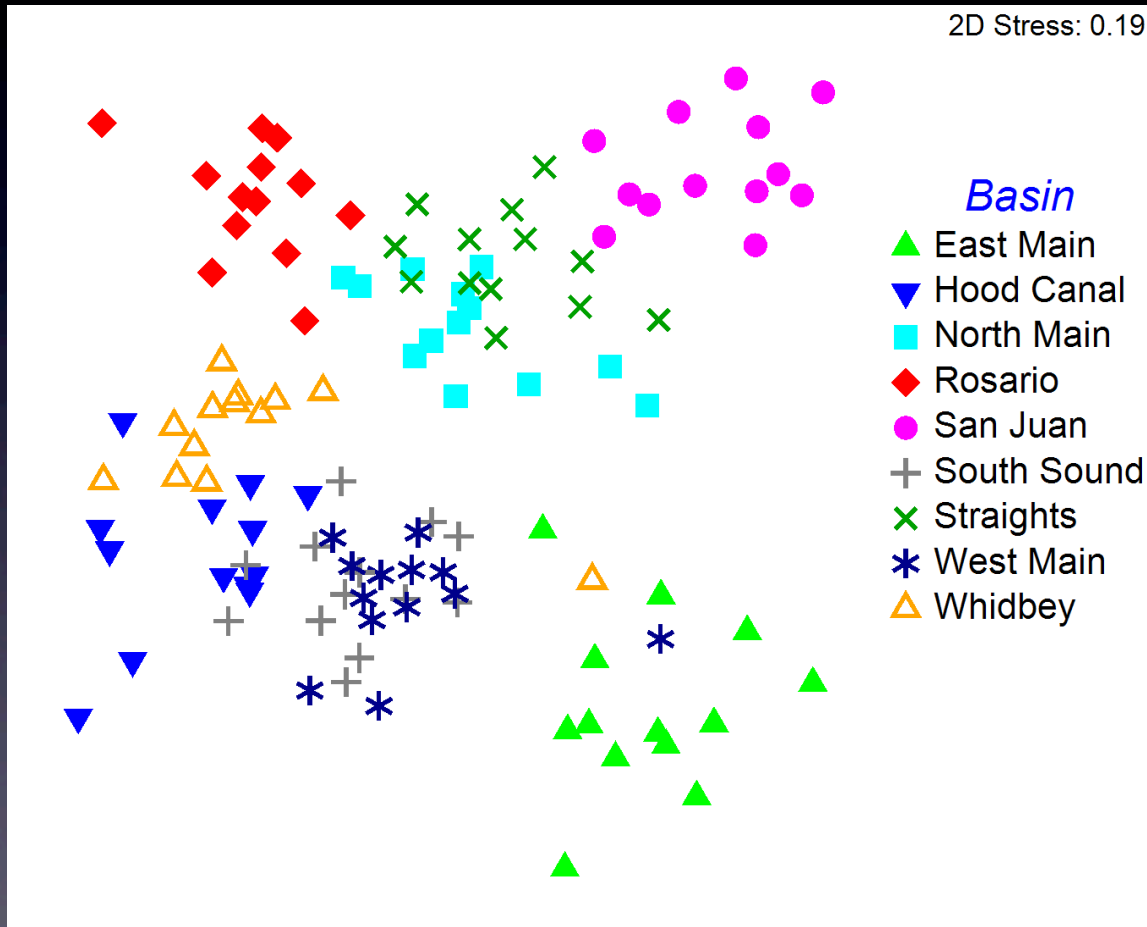
By UW for PRISM



ENVIRONMENTAL DATA 3

Oceanographic Sub-basins
&
Estuaries

Oceanographic Sub-basins



MDS
relative frequency

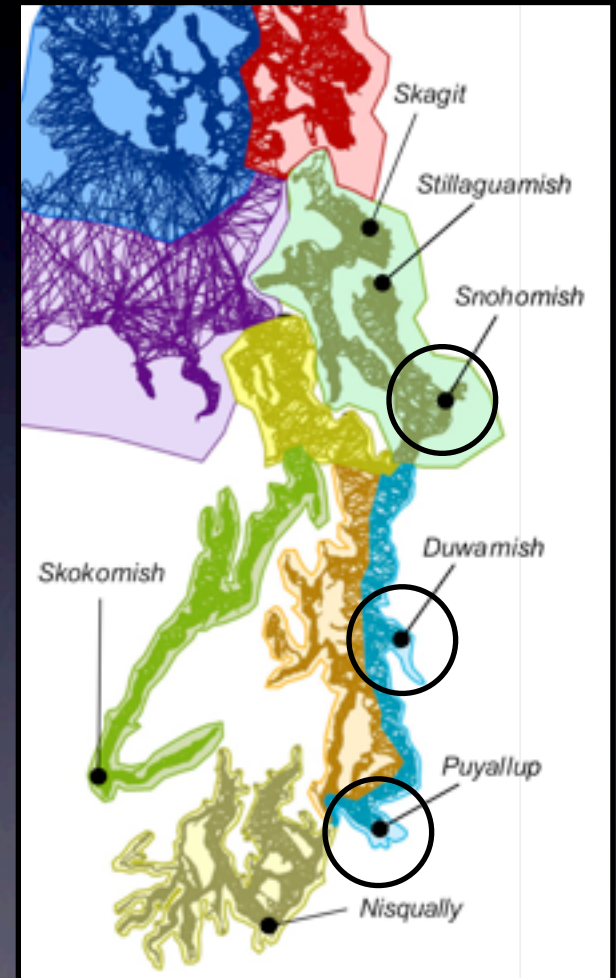
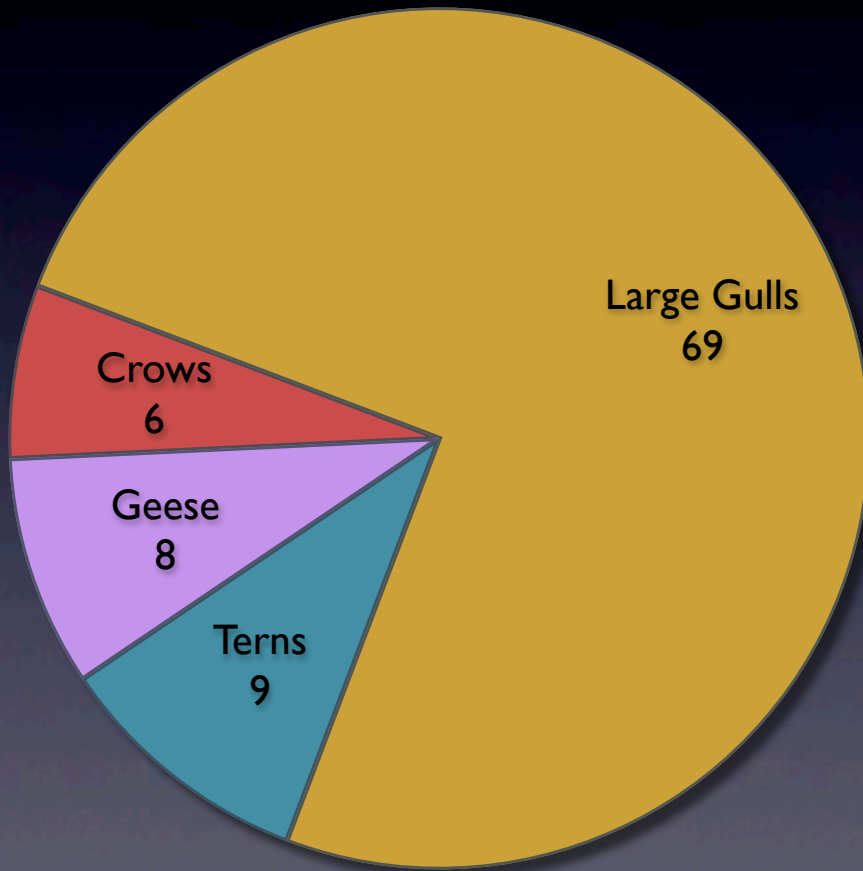
Winter
1994-2006

1 symbol = 1 year

Summer Taxonomic Similarity

(Top 90% contribution, SIMPER)

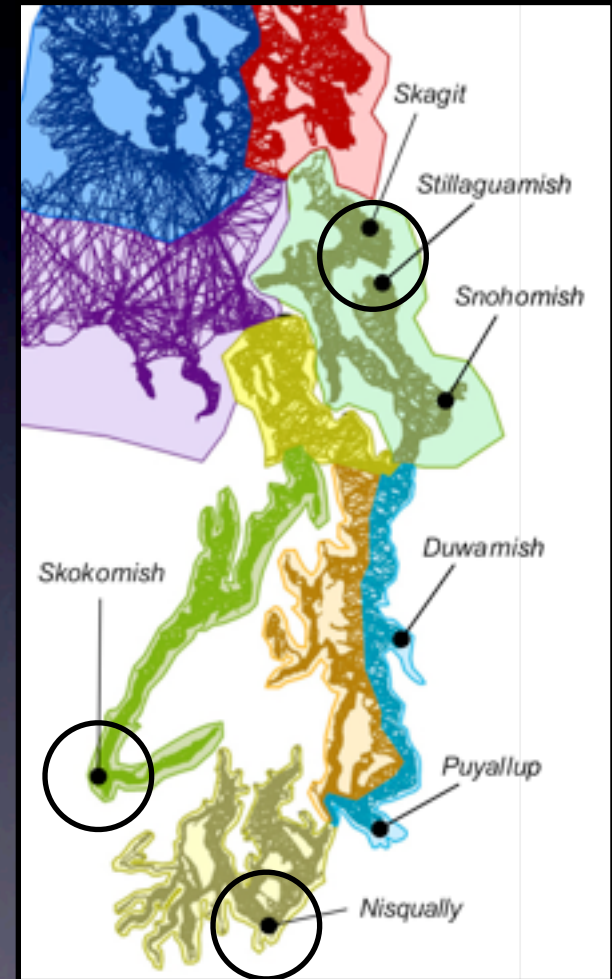
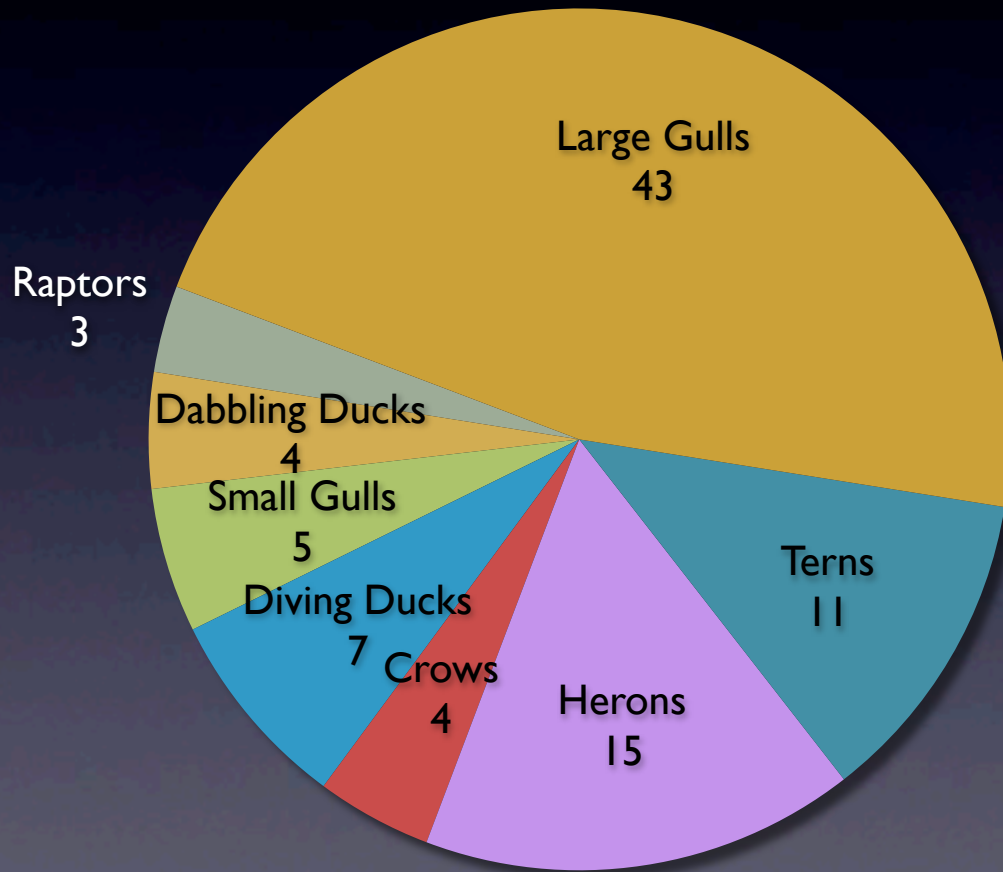
Urban



Summer Taxonomic Similarity

(Top 90% contribution, SIMPER)

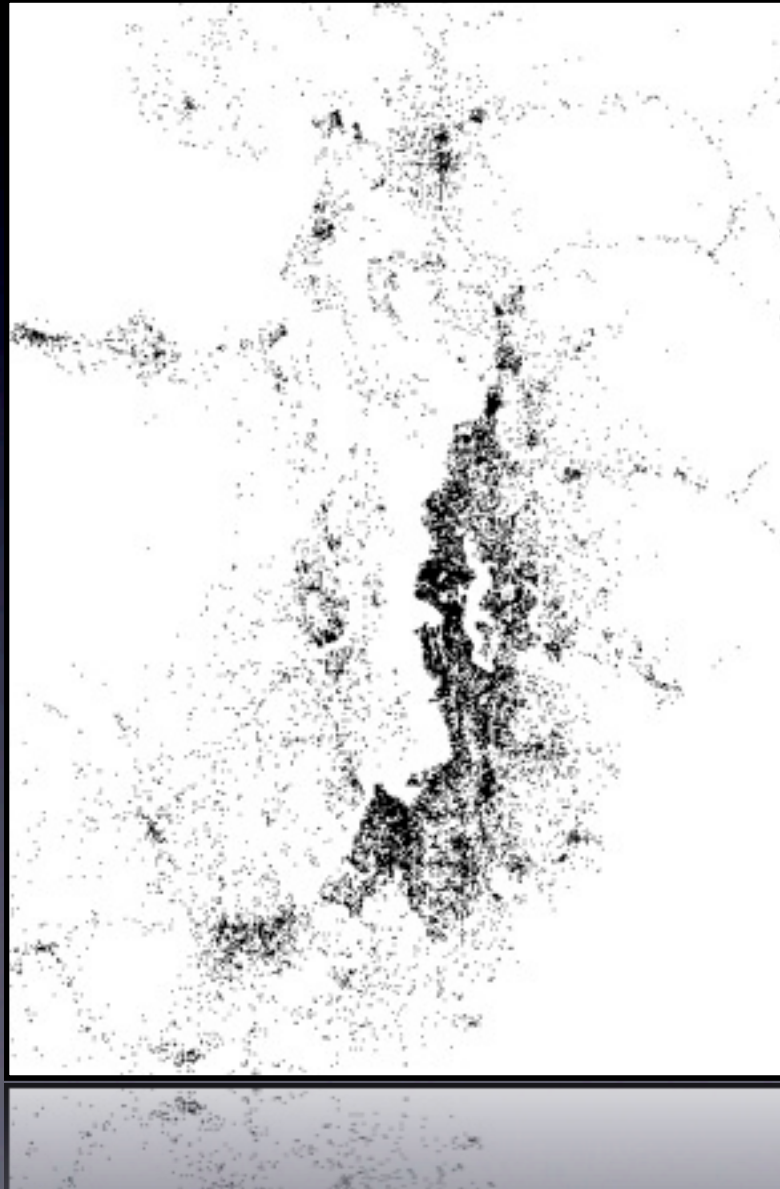
Nonurban



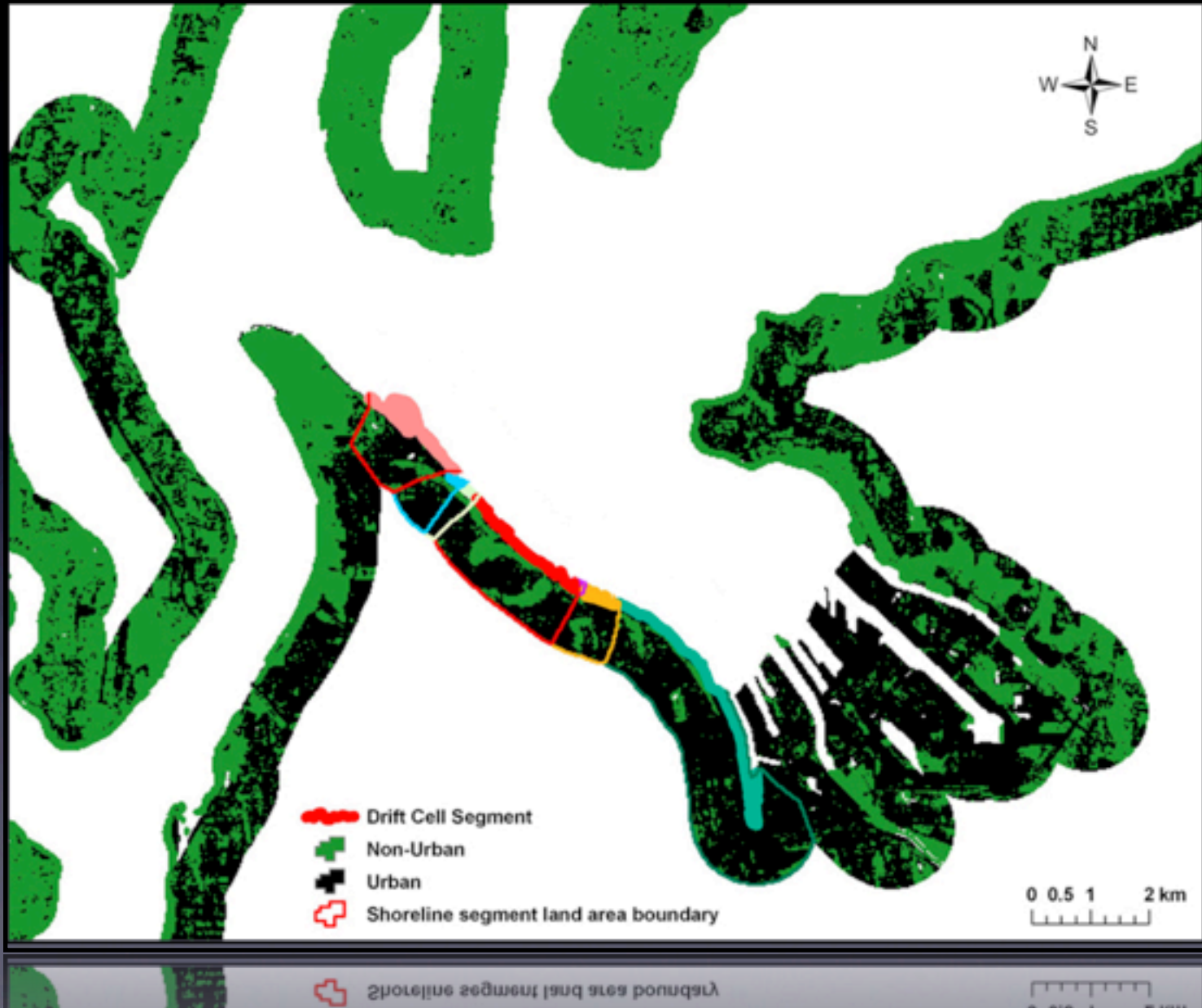
Characterizing Human Influence Gradients



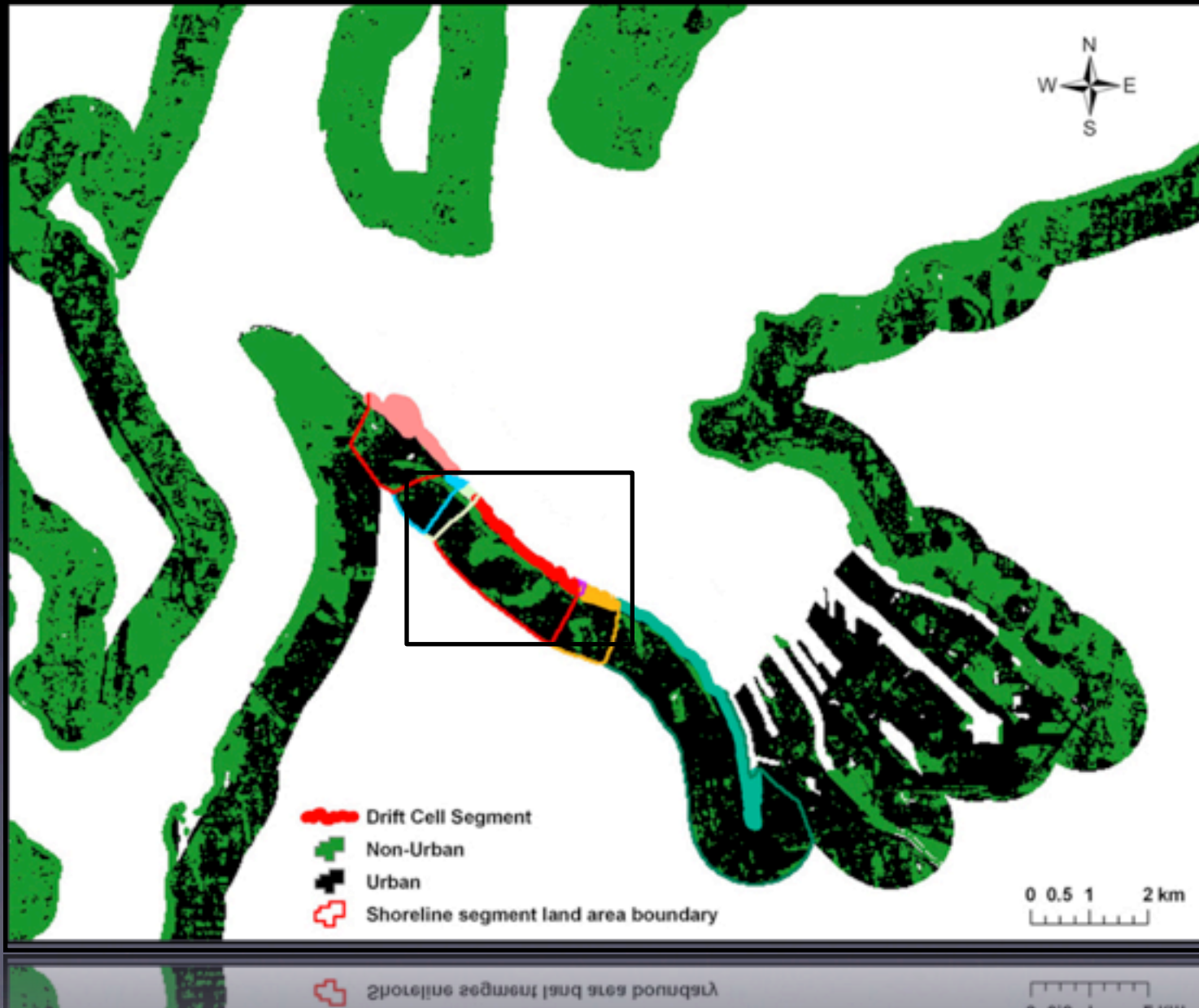
Characterizing Human Influence Gradients



Shorelines as Sampling Units



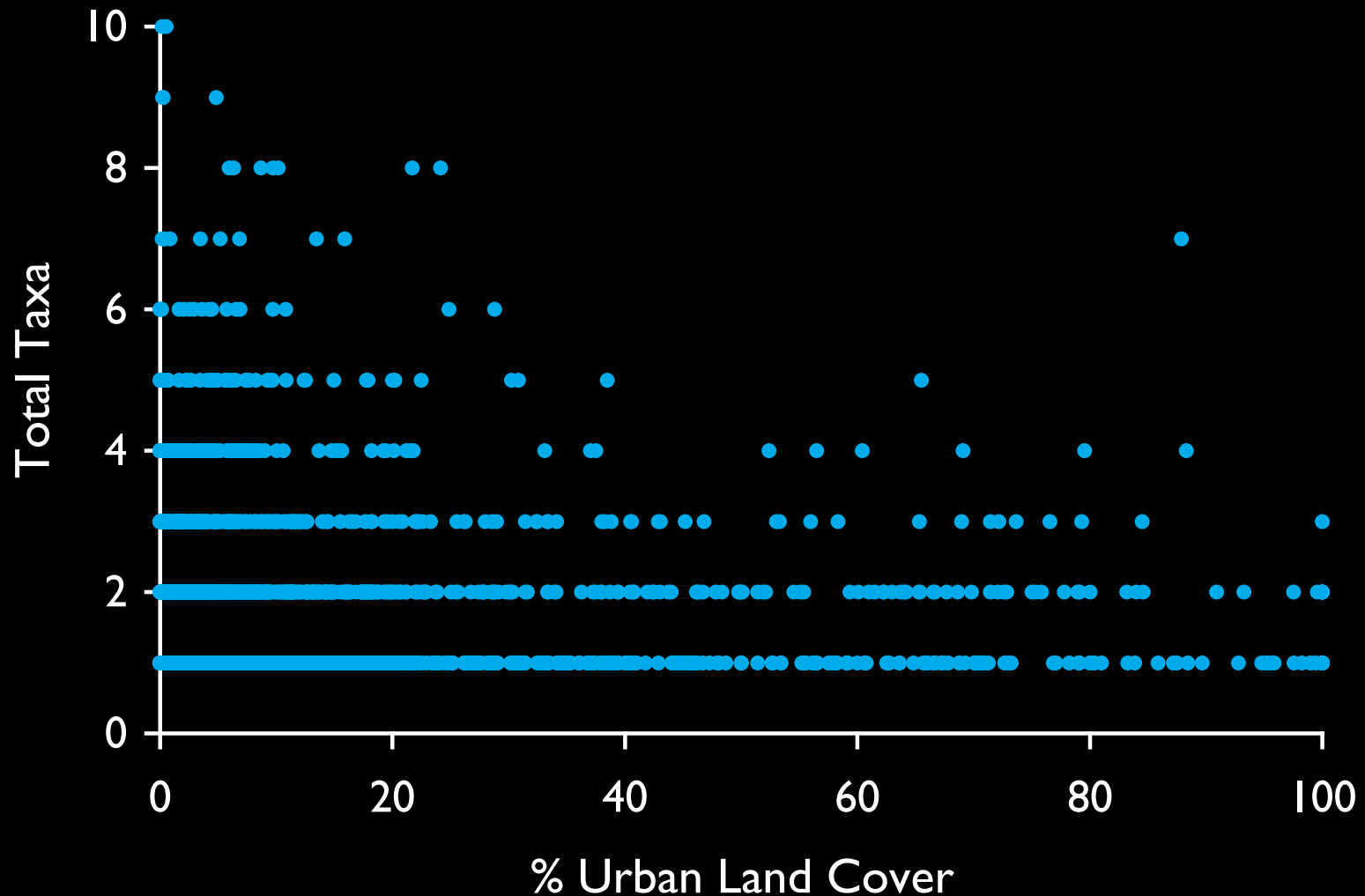
Shorelines as Sampling Units



Joining Bird and Shoreline Attributes

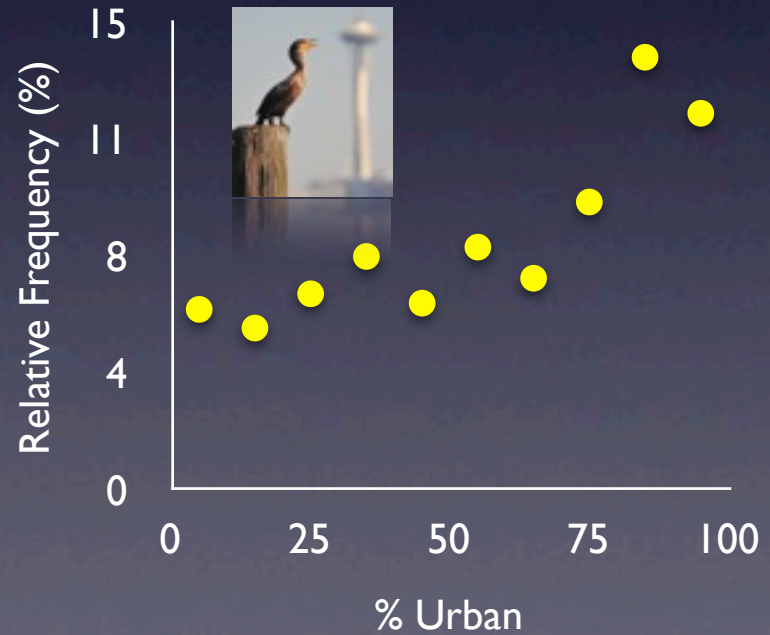
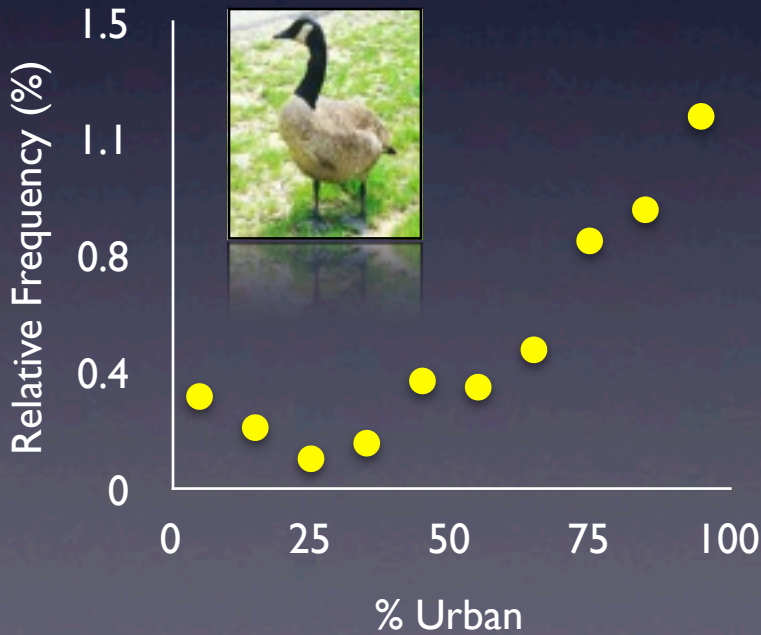
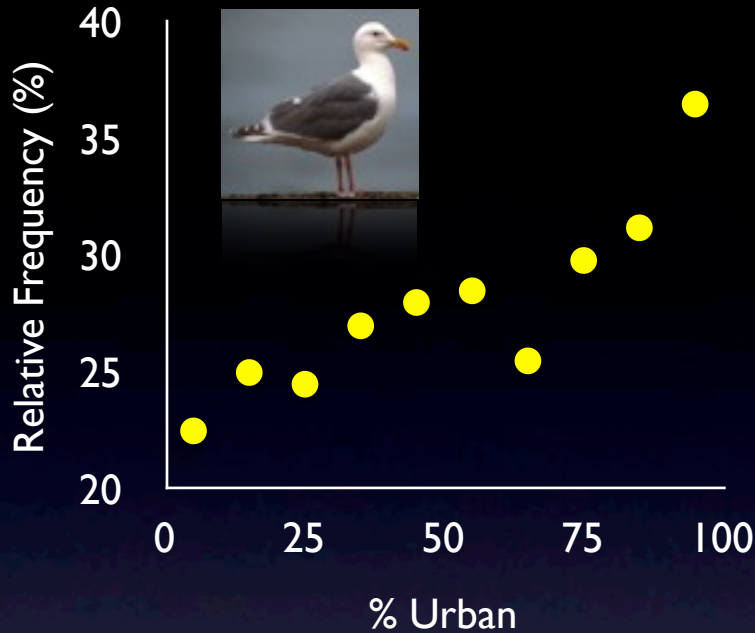


Bird Taxa Richness by Shoreline Segment All of Greater Puget Sound (Summer, 1996)



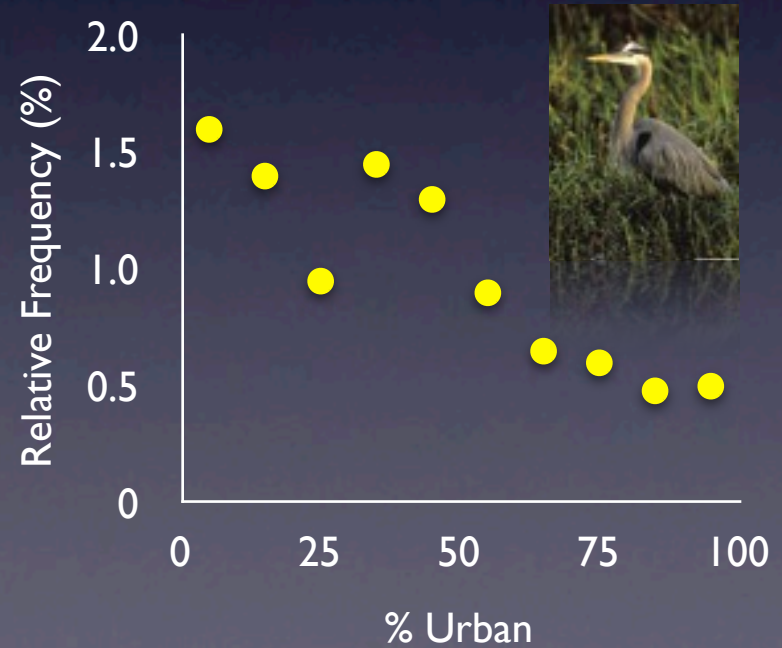
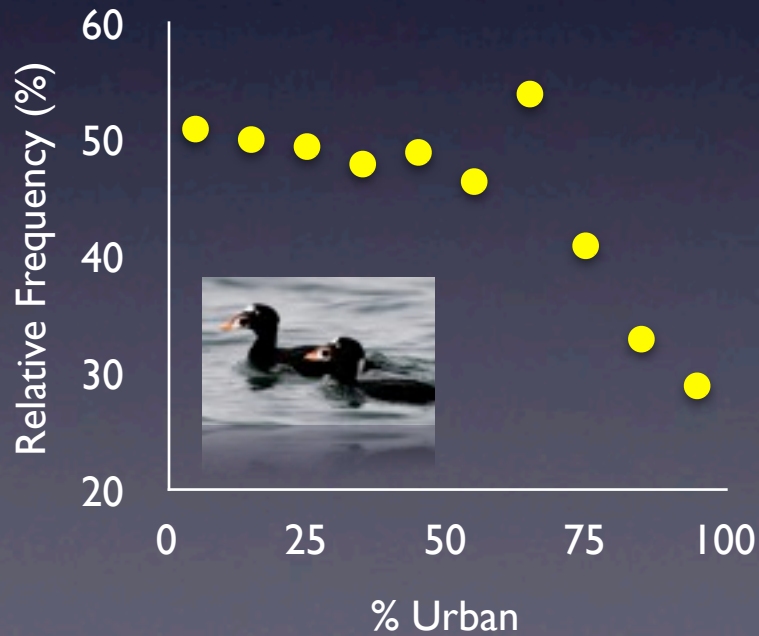
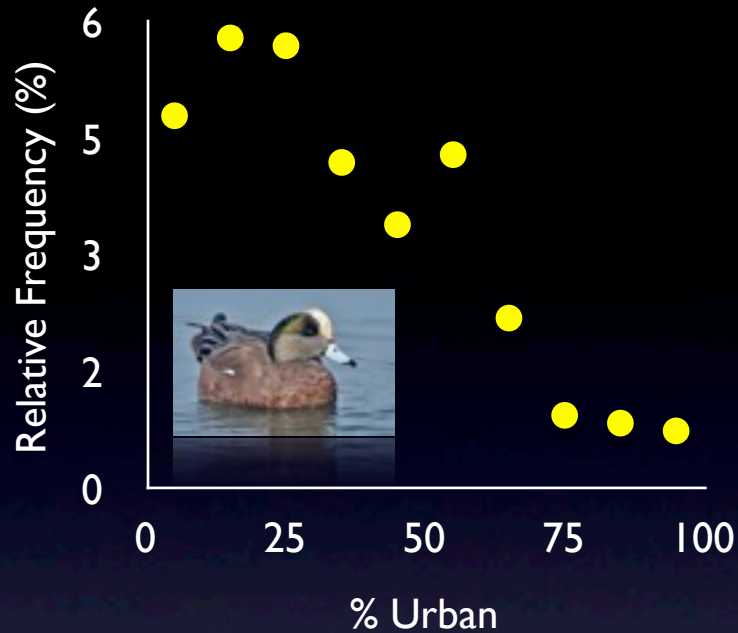
Taxa that go up with urbanization

All of Greater Puget Sound
(Winter, 1994-2006)



Taxa that go down with urbanization

All of Greater Puget Sound
(Winter, 1994-2006)



Bird Conclusions

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- Basins, estuaries, and shoreline segments useful sampling units

Future Bird Directions

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- Incorporate forthcoming shoreline typology and change analyses
- Development of robust bird metrics for monitoring and assessment

Building the Puget Sound Narrative

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History

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History

Conceptual Framework

Building the Puget Sound Narrative

History

Conceptual Framework

Data

Building the Puget Sound Narrative

History

Conceptual Framework

Data

Analysis

Building the Puget Sound Narrative

History

Conceptual Framework

Data

Analysis

Information

The Road Ahead

The Road Ahead

- Act

The Road Ahead

- Act
- Design and implement strategic science program

The Road Ahead

- Act
- Design and implement strategic science program
- Improve conceptual framework

SUB-BASIN	ZONE					
		DRIVERS	IMPACTS	5 FEATURES	BIOLOGY	MANAGEMENT
Whidbey	watershed					
	nearshore					
	pelagic					
	demersal					
Main						
Hood Canal						
South Sound						

PSP, DPSIR, & MIRADI

The Road Ahead

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- Evaluate the rationale, approach, and effectiveness of current, historical, and proposed efforts

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- Fill major gaps in Puget Sound ecology

Historical Ecology

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“This is a great falling off, and it is much the same way with all other fish on the sound.”

Fisherman's letter to S. F. Baird, 1886

Natural History

“An actual description of the properties of a real population is an ‘existence statement’ ... a fact that must be reconciled....”

L. B. Slobodkin (1994)

Thanks...

casimir.rice@noaa.gov