Effects of Local Shoreline and Subestuary Watershed Condition on Waterbird Community Integrity in the Chesapeake Bay

Diann J. Prosser, USGS Patuxent Wildlife Research Center

Wetlands Working Group Meeting, May 18, 2017

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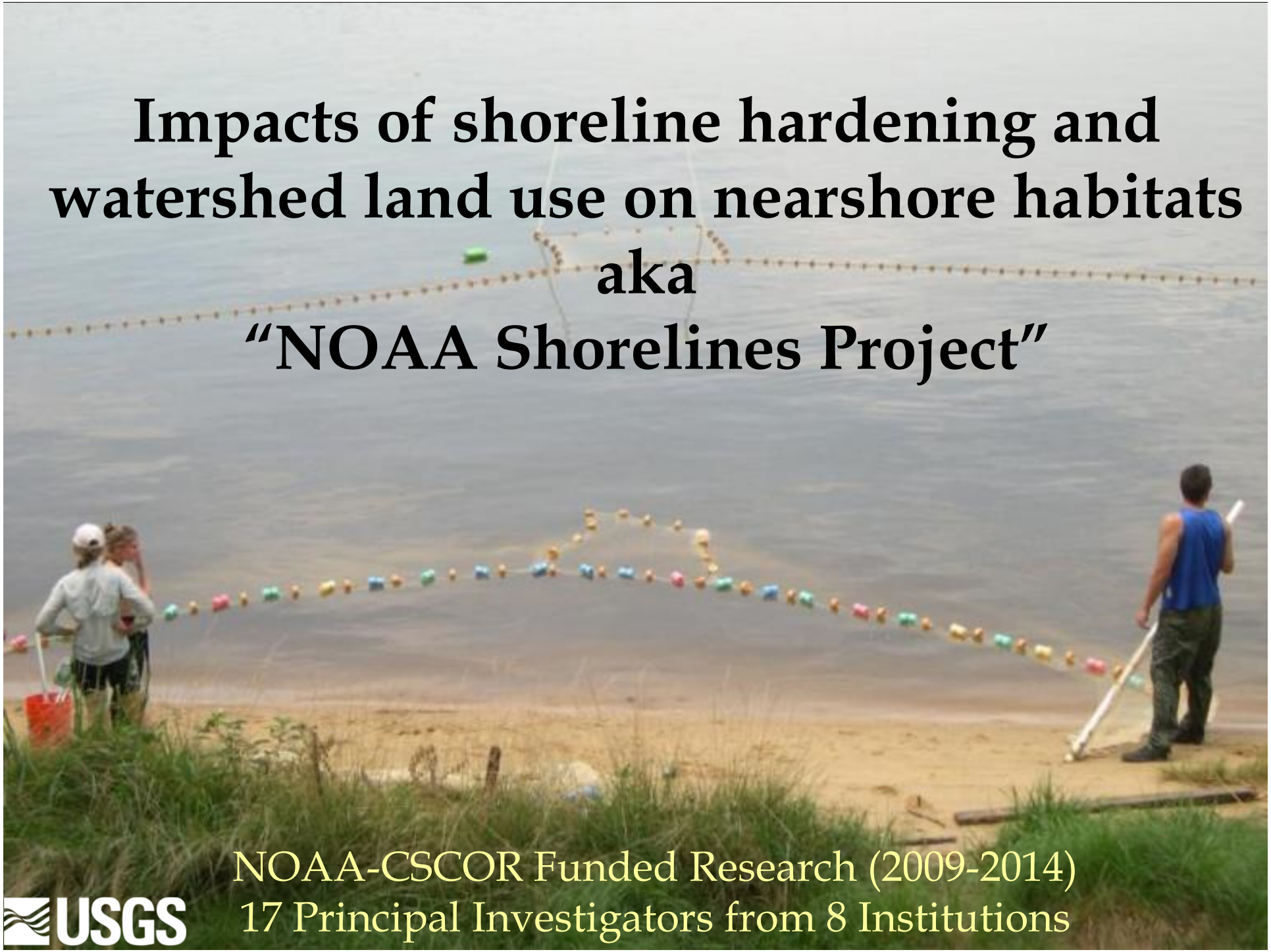
Impacts of shoreline hardening and watershed land use on nearshore habitats aka "NOAA Shorelines Project"



NOAA-CSCOR Funded Research (2009-2014)
17 Principal Investigators from 8 Institutions

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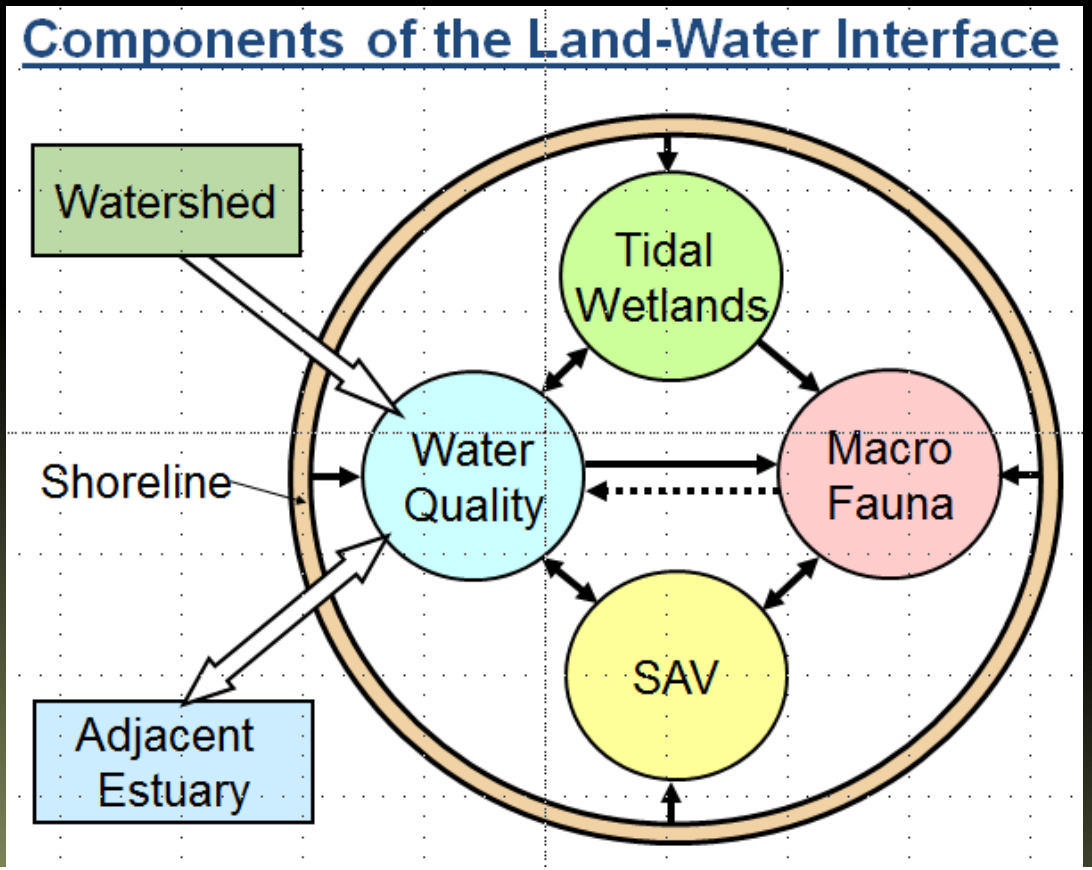
Goals

- Improve scientific knowledge about effects of stressors in near-shore environments (<2m deep)
- Transition new knowledge to improve management of near-shore environments



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Compare shoreline types

Natural Marsh

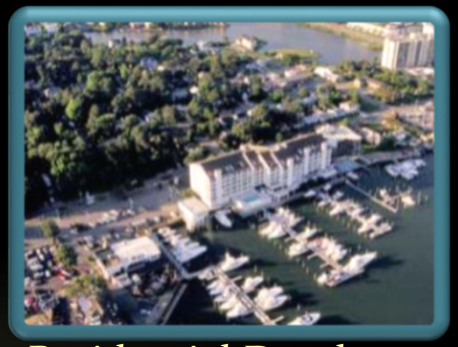
Phragmites Marsh

Rip-Rap

Bulkhead

Beach

Forested



Residential Development

Agricultural

…in bays and sub-estuaries with watersheds that have differing land use

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Objectives – Waterbird Component

- Improve our understanding of the effects of shoreline hardening and land use on waterbird communities using the Chesapeake and Coastal Bays

- Work in conjunction with the other macro-fauna groups (fish and invertebrates),

Credit: Johann Schumacher

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How to Assess Waterbird Community Usage?

Community Metrics: Species Richness, Diversity
Species level abundance/density; Guilds

1. Index of Waterbird Community Integrity (developed by DeLuca et al. 2008)

2. Subestuary Scale (plus 2 others)

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Index of Waterbird Community Integrity (IWCI)

(After DeLuca et al. 2008. Biol. Conserv.)

$$IWCI = (\sum S_{IWCI} / S_N) + (2) A_I$$

ALSO:
Species Richness
Species Density
Guild Analysis

Where: S_{IWCI} = Individual Species Index

S_N = Total no. of species

A_I = Abundance score for each species (i)

Weighted for sensitive versus tolerant species

Indices
Foraging Breadth
Nesting Sensitivity
Migratory Status
Breeding Range
State Listing
Native Status

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Index of Waterbird Community Integrity

S_{IWCI} (range 21 to 5)

Disturbance Sensitive Species

Royal Tern
(Thalasseus maximus)
S_{iwci} = 21

Hooded Merganser
(Lophodytes cucullatus)
S_{iwci} = 20

Semipalmated Sandpiper
(Calidrus pusilla)
S_{iwci} = 18.5

Laughing Gull
(Leucophaeus atricilla)
S_{iwci} = 17.5

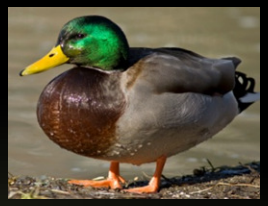
Bald Eagle
(Haliaeetus leucocephalus)
S_{iwci} = 16.5

Disturbance Tolerant Species

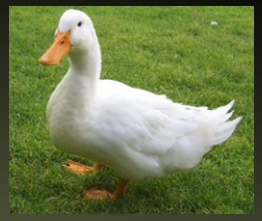
Ring-billed Gull
(Larus delawarensis)
S_{iwci} = 9.5

Double-crested Cormorant
(Phalacrocorax auritus)
S_{iwci} = 9.5

Canada Goose (resident)
(Branta canadensis)
S_{iwci} = 8.5



Mallard
(Anas platyrhynchos)
S_{iwci} = 7



Domestic duck
S_{iwci} = 5

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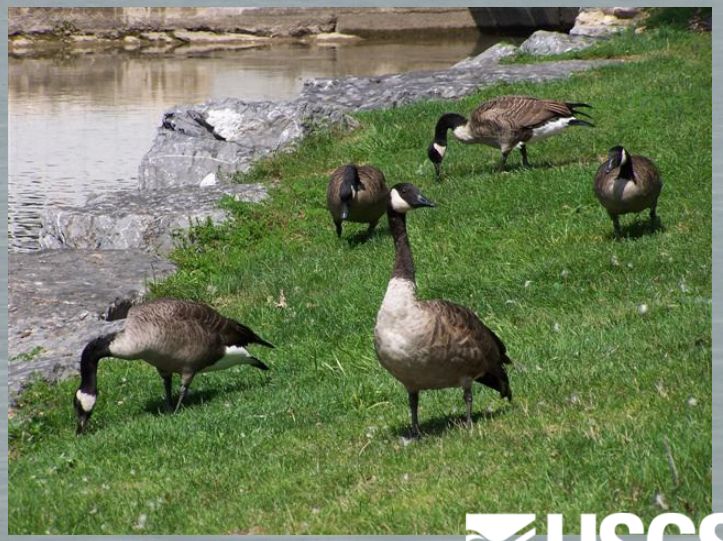
Resident versus Migratory Canada Geese

MIGO = Siwci 12 (disturbance sensitive)
CAGO = Siwci 8.5 (disturbance tolerant)

- September 15 – MD DNR threshold for migrant CAGO
- Compare summer surveys (should be resident) to Fall
- Confirm using survey notes (on lawns)



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Adaptations to Deluca et al 2008

1. Updated IWCI species database

   a) Standardize IWCI index scores definitions
      - Foraging Niche
      - Nesting Site Selectivity
      - Migratory Distance
      - Breeding Range
      - Conservation Status

   b) Score all species for Chesapeake Bay (n=120 spp)

2. Deluca used 100m transects; we used area counts and densities because it was hard to find contiguous shoreline types at that scale

Prosser et al. 2017 *In Press*. Waterbirds

Methods

- Area Counts– survey shoreline and open water from boat
- Each site visited 2 seasons per year (2010-2014) Late Summer (Aug-Sept) and late Fall (Oct –Dec)
- Each site visited 3 times per season
- Calculated Index of Waterbird Community Integrity, species richness, and density by subestuary and season

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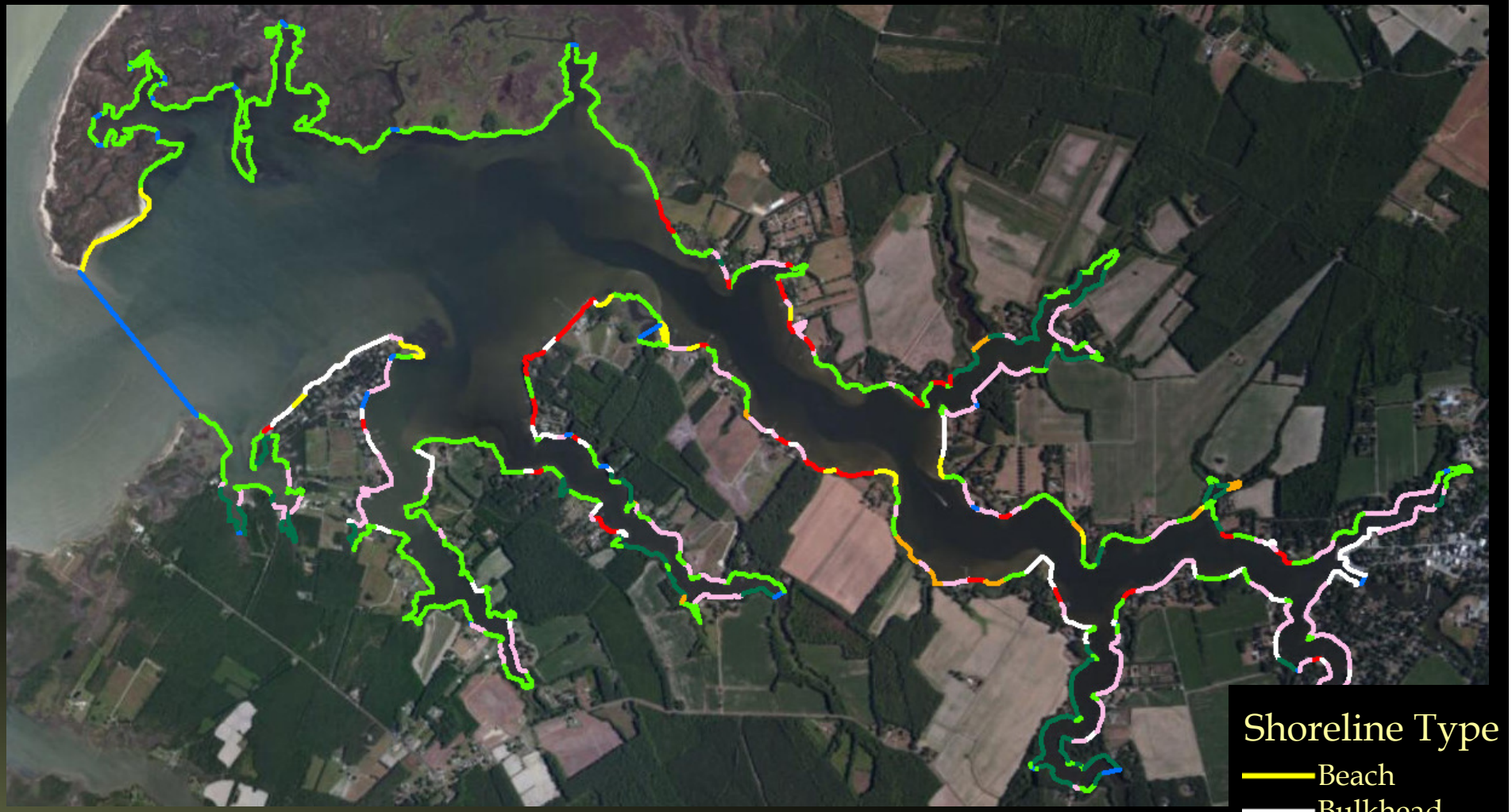
Shoreline Delineations (GIS and Groundtruth)



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Study Sites (n=21)

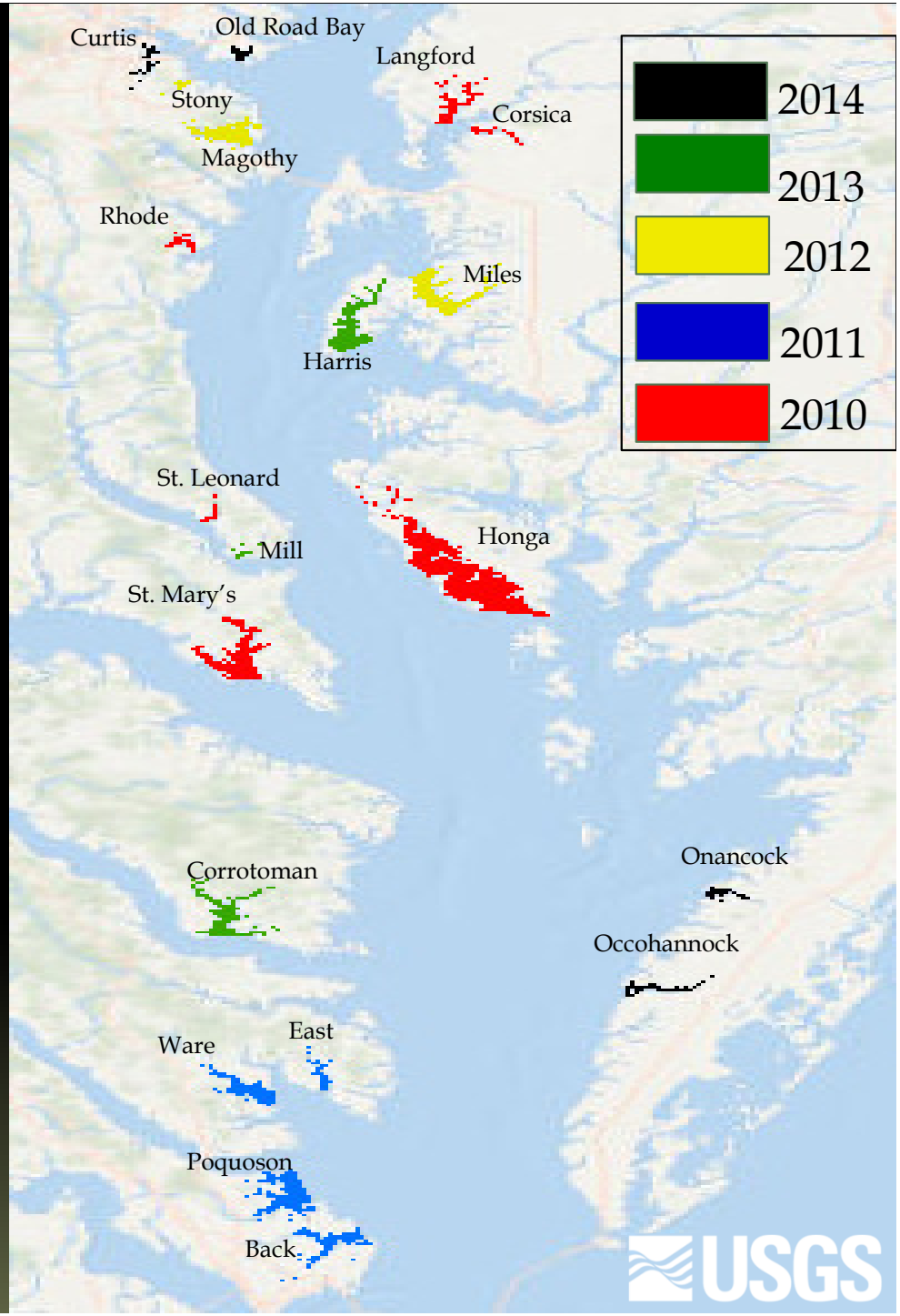
2014
Curtis Creek (Dev)
Old Road Bay (Dev)
Onancock River (Mix Ag)
Occohannock River (Mix Ag)

2013
Corrotoman River (For)
Harris Creek (Agr, MixDev)
Mill Creek (MixDev)

2012
Magothy River (MixDev, Dev)
Miles River (Agr, MixDev)
Stony Creek (Dev)

2011
Back River (Dev)
East River (For)
Poquoson River (Mix Dev) – Poq East and West
Ware River (For)

2010
Corsica River (Agr)
Honga River (Oth Mix)
Langford Creek (Agr)
Rhode River (For)
St. Mary River (Oth Mix,For)
St. Leonard Cr. (For)



A total of 64 species were observed

American Black Duck
American Coot
American Oystercatcher
Bald eagle
Black-crowned Night Heron
Belted kingfisher
Bonaparte's Gull
Brown Pelican
Bufflehead
Canada goose
Canvasback
Caspian Tern
Common Goldeneye
Common Loon
Common Merganser
Common tern
Double-crested Cormorant
Domestic duck/goose
Fish crow
Forster's tern
Gadwall
Great black-backed gull
Great blue heron
Great egret
Green heron
Greater Yellowlegs
Herring gull
Horned Grebe
Hooded Merganser
Killdeer
Laughing gull
Little Blue Heron
Lesser Scaup
Least tern
Long-tailed Duck
Mallard
Mute swan
Osprey
Pied-billed grebe
Ring-billed gull
Red-breasted Merganser
Redknot
Ring-necked Duck
Red-necked Grebe
Royal tern
Ruddy Duck
Sanderling
Sandwich Tern
Short-billed Dowitcher
Semipalmated Plover
Semipalmated Sandpiper
Snowy egret
Spotted sandpiper
Surf Scoter
Tri-colored Heron
Tundra swan
Western Sandpiper
Wood duck
Yellow-crowned Night Heron

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2014 Summer Surveys (Aug-Sept)

Sub-estuary	Mean No. Birds Observed	Mean Species Richness	Shoreline Length (km)	Density by Shoreline Length	IWCI
Curtis Creek	54.39	21	17.09	3.48	16.93
Old Road Bay	26.13	17	16.66	1.45	14.26
Occohannock River	22.07	17	37.517	0.58	16.53
Onancock River	15.69	19	50.147	0.29	17.78

Top three species (abundance):
Laughing Gull
Double-crested Cormorant
Canada Goose

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2014 Fall Surveys (October-December)

Sub-estuary	Mean No. Birds Observed	Mean Species Richness	Shoreline Length (km)	Density by Shoreline Length	IWCI
Curtis Creek	35.69	17	17.09	2.09	16.86
Old Road Bay	17.79	15	16.66	1.07	15.63
Occohannock River	46.05	17	37.517	1.23	17.27
Onancock River	44.04	15	50.147	0.88	17.22

Top three species (abundance):
Bufflehead
Canada Goose (Resident)
Herring Gull

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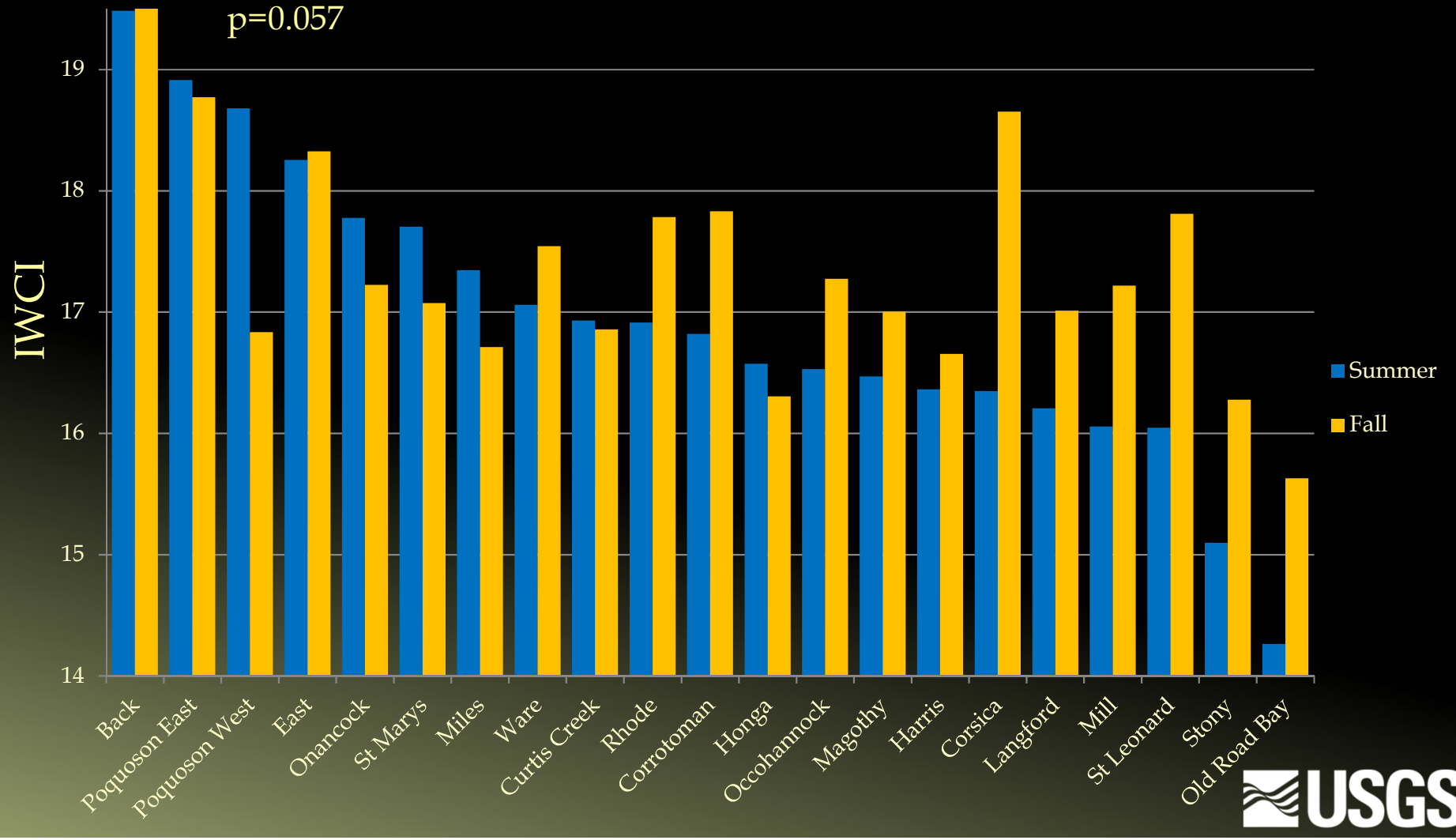
IWCI Scores by Season

Paired t-test
Summer x=16.94
Fall x=17.36
p=0.057

Summer 14.13 to 19.62
Fall 15.63 to 19.73



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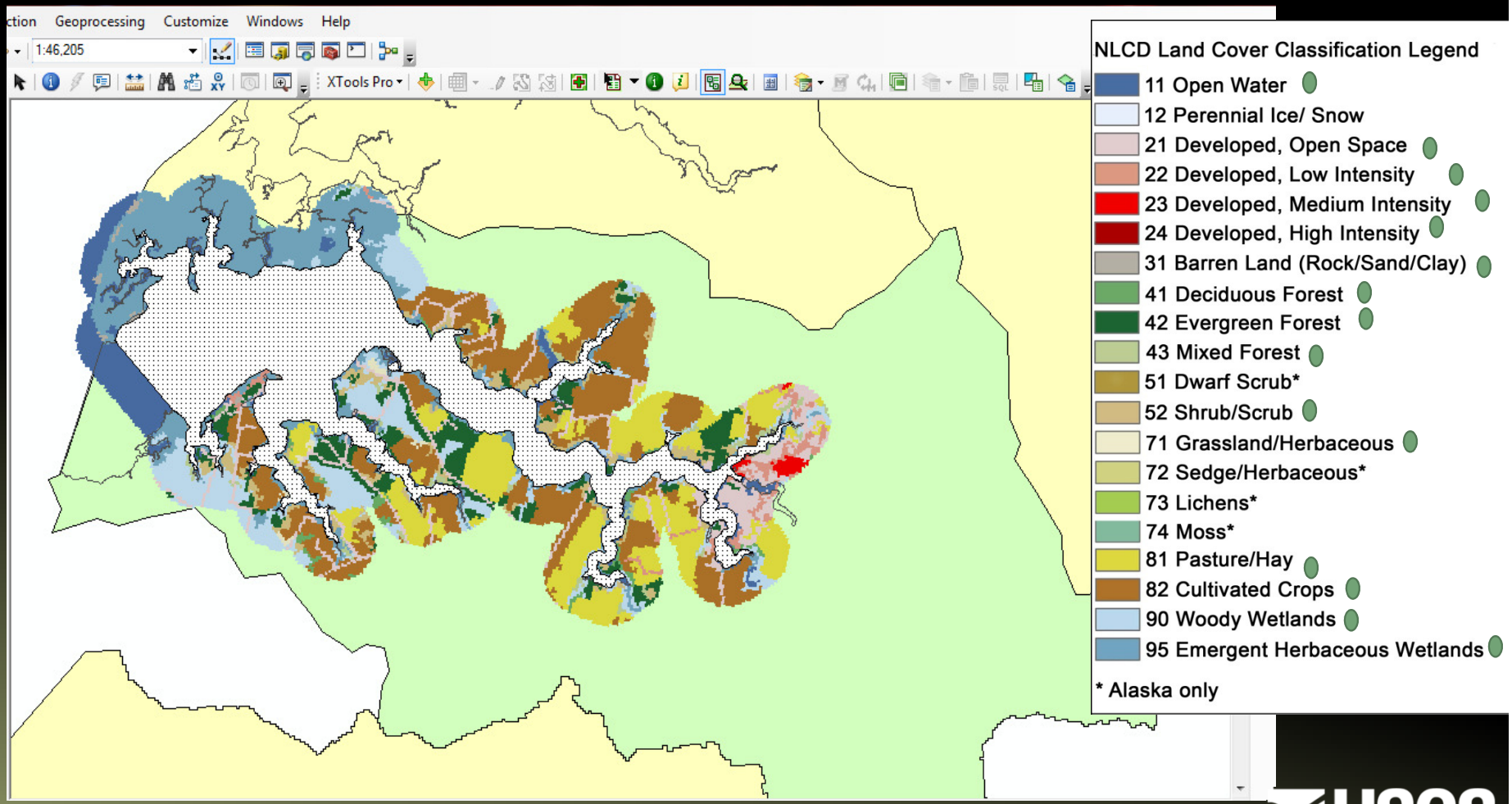
Three Scales of Shoreline/Landcover Categorization:

1. Shoreline (Bird Survey Area)
2. Landscape 500m around bird survey boundary
3. Landscape Watershed



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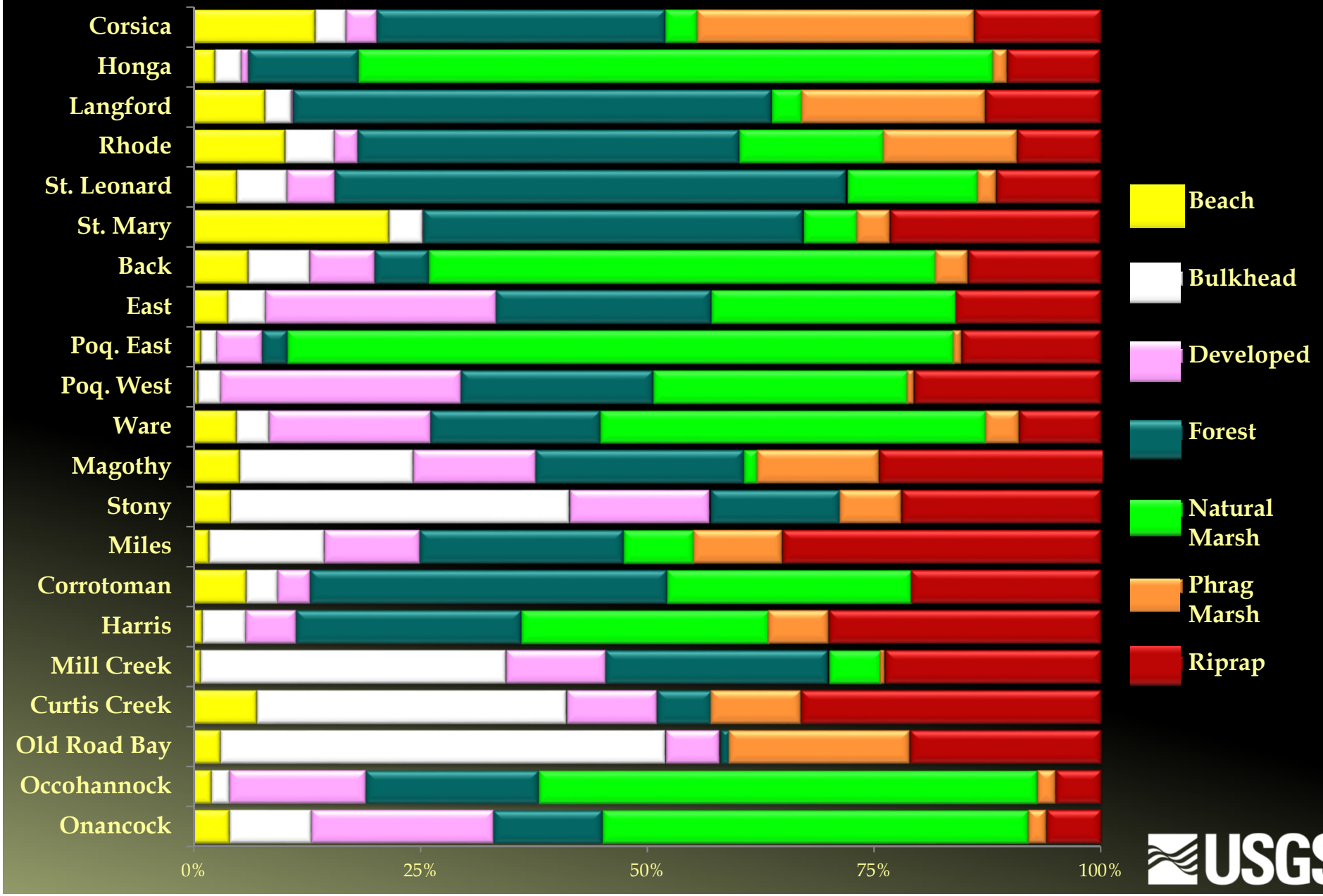
Shoreline Delineation – Shoreline Scale



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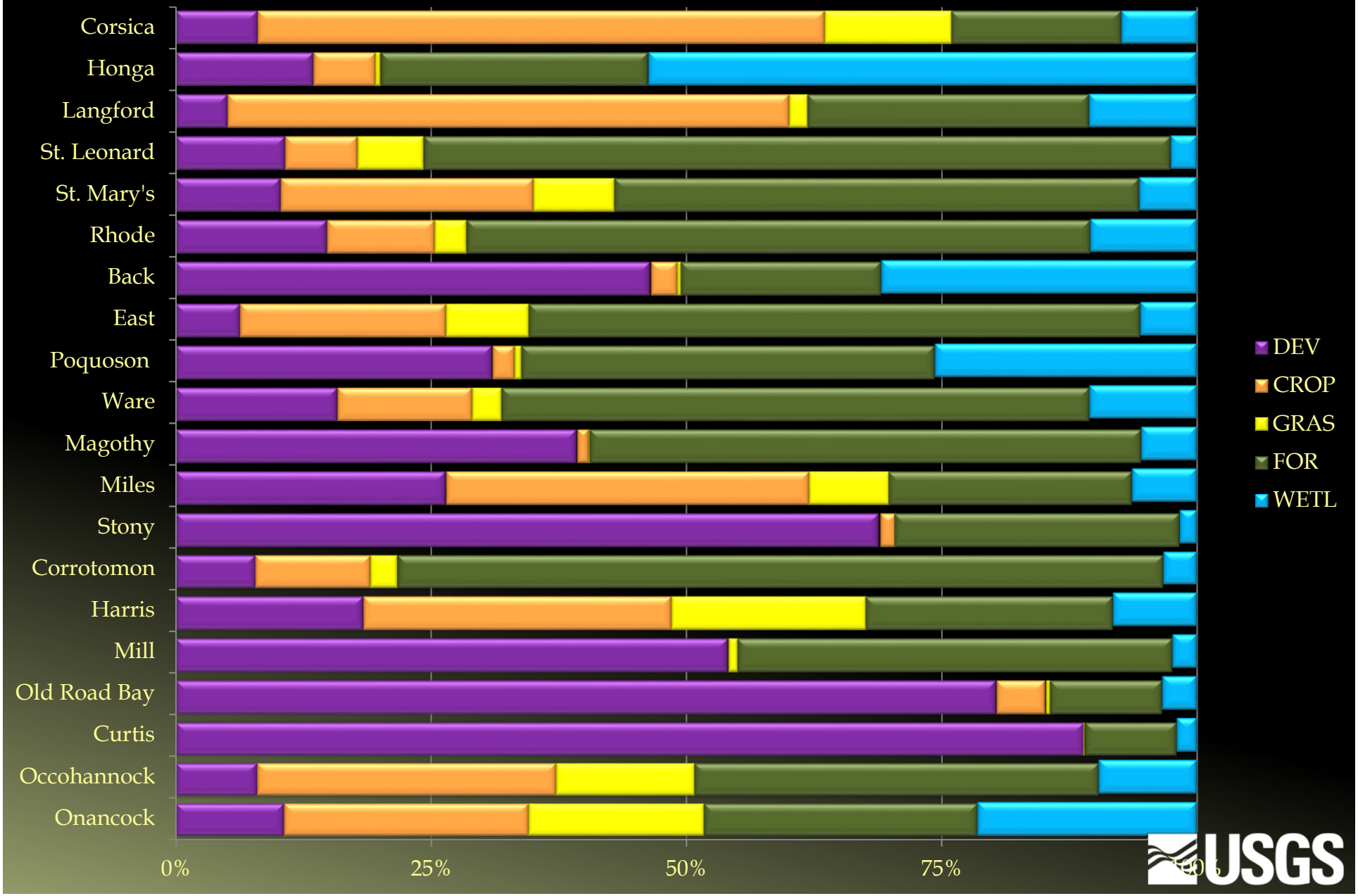
Landscape Analysis – 500m from shoreline



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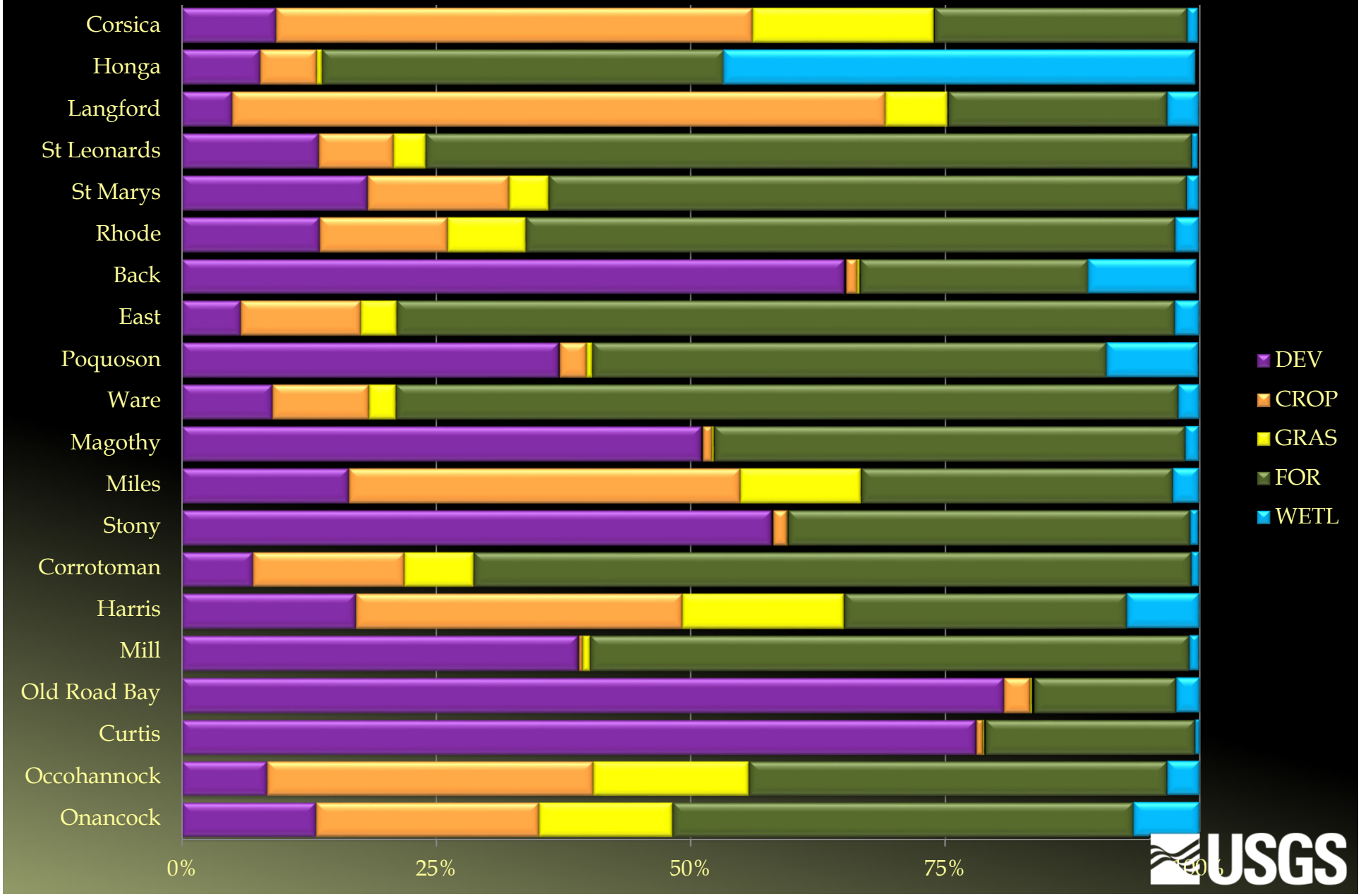
Landscape Analysis – Watershed



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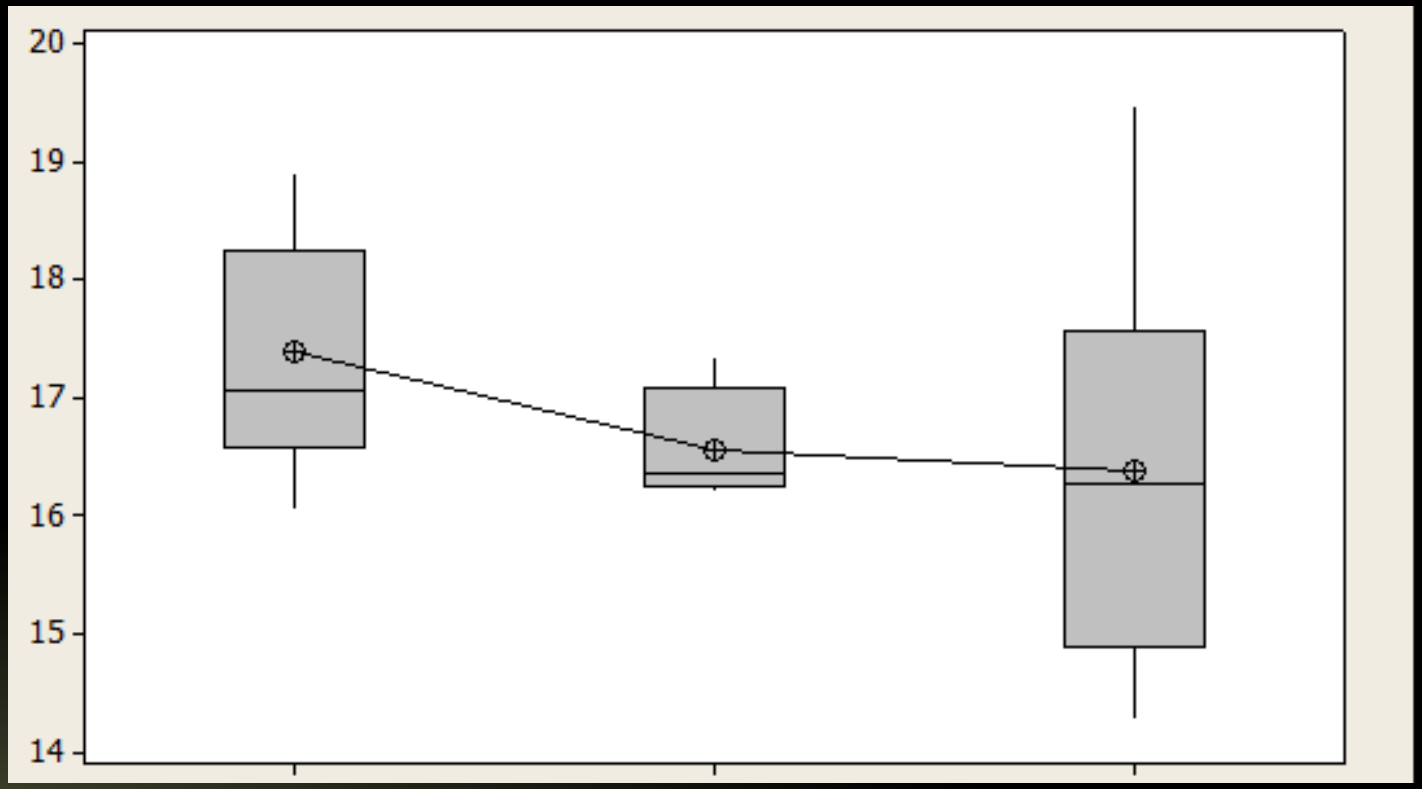
IWCI by Dominant Landscape (Summer)



p=0.23, ANOVA

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Univariate regression ($\alpha \leq 0.20$) to determine variables for Model Selection (Full Model)

Summer

Shoreline (7):

Bulkhead
Rip Rap
Developed (lawns)
Phragmites
Natural Marsh
Forest
Beach

500m (5)	Watershed (5):
DEV500m	DEV
CROP500m	CROP
GRASS500m	GRASS
FOR500m	FOR
WETL500m	WETL

Fall

Shoreline (7):

Bulkhead
Rip Rap
Developed (lawns)
Phragmites
Natural Marsh
Forest
Beach

500m (5)	Watershed (5):
DEV500m	DEV
CROP500m	CROP
GRASS500m	GRASS
FOR500m	FOR
WETL500m	WETL

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Backwards Model Selection

Regression: IWCI and shoreline/land use

Season	Model	AIC Score	Δ AIC$_c$	R^2
Late Summer	Null	72.10	--	--
	Full Model: Bulkhead + Phragmites Marsh + Natural Marsh + WETL500m + $(WETL500m)^2$	69.95	2.15	0.62
	Step 2: Bulkhead + Phragmites Marsh + Natural Marsh	66.70	3.25	0.50
	Step 3: Bulkhead + Phragmites Marsh	63.94	2.76	0.49
Late Fall	Null	60.97	--	--
	Full Model: Bulkhead + Riprap + Natural Marsh + DEV500m	64.11	3.14	0.38
	Step 2: Bulkhead + Riprap + DEV500m	60.36	3.75	0.38
	Step 3: Bulkhead + DEV500m	57.94	2.42	0.34
	Step 4: Bulkhead	56.90	1.04	0.28

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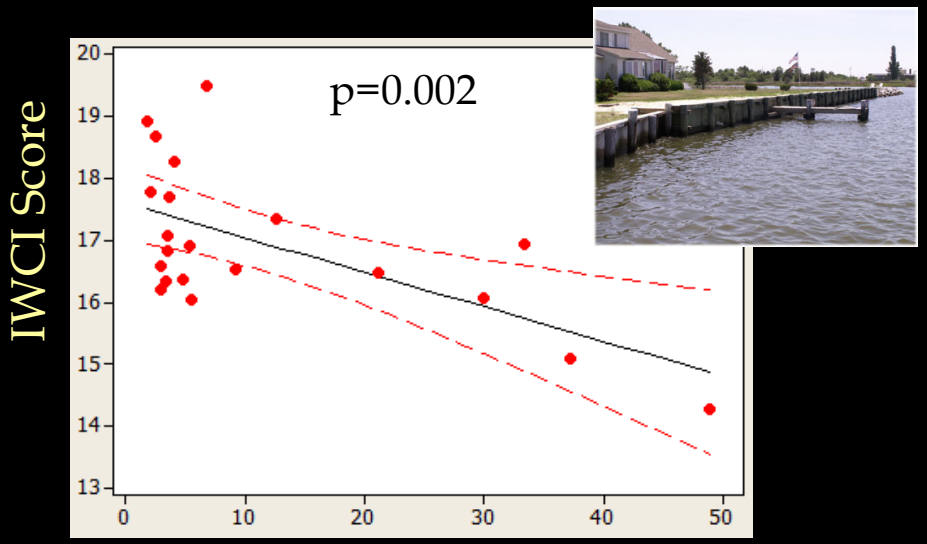
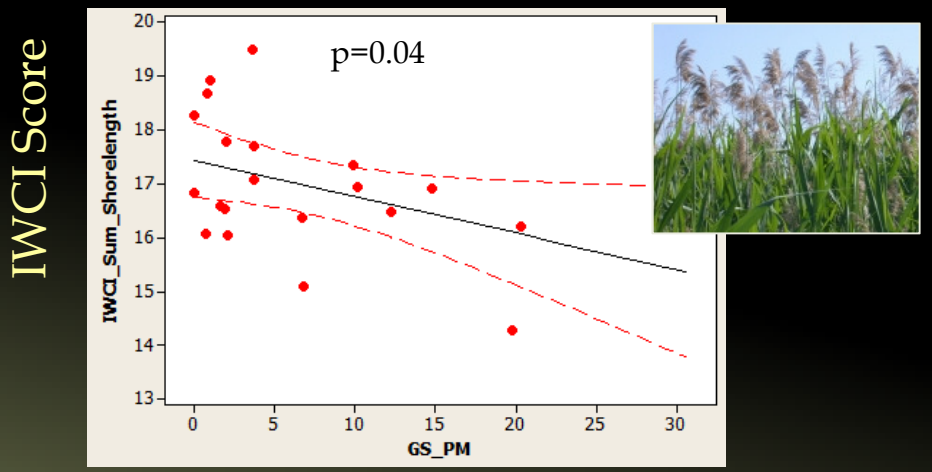
Birds are responding to effects at the shoreline scale!





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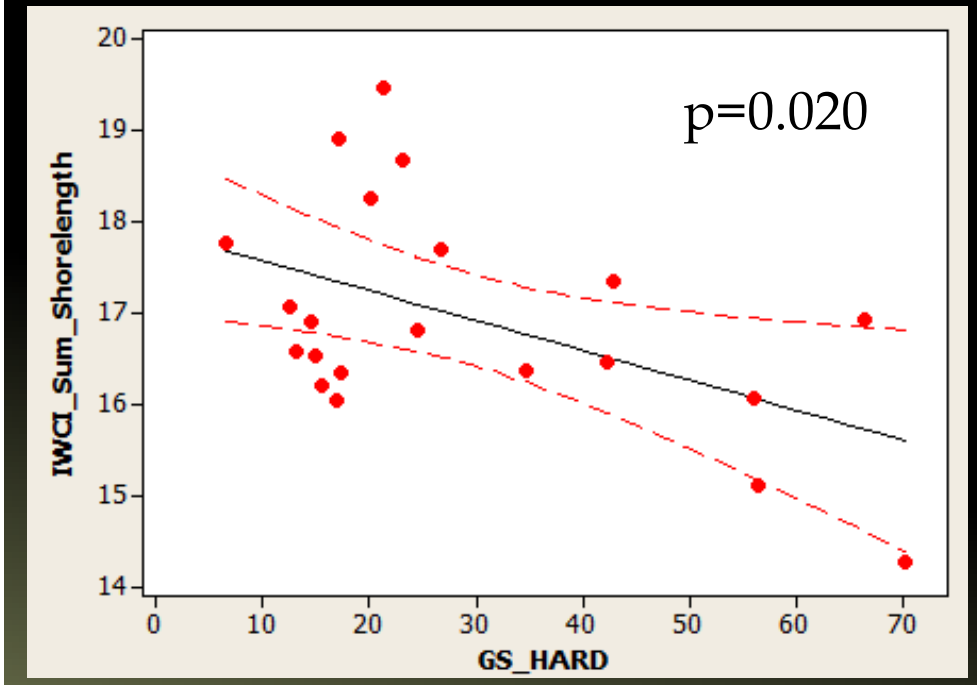
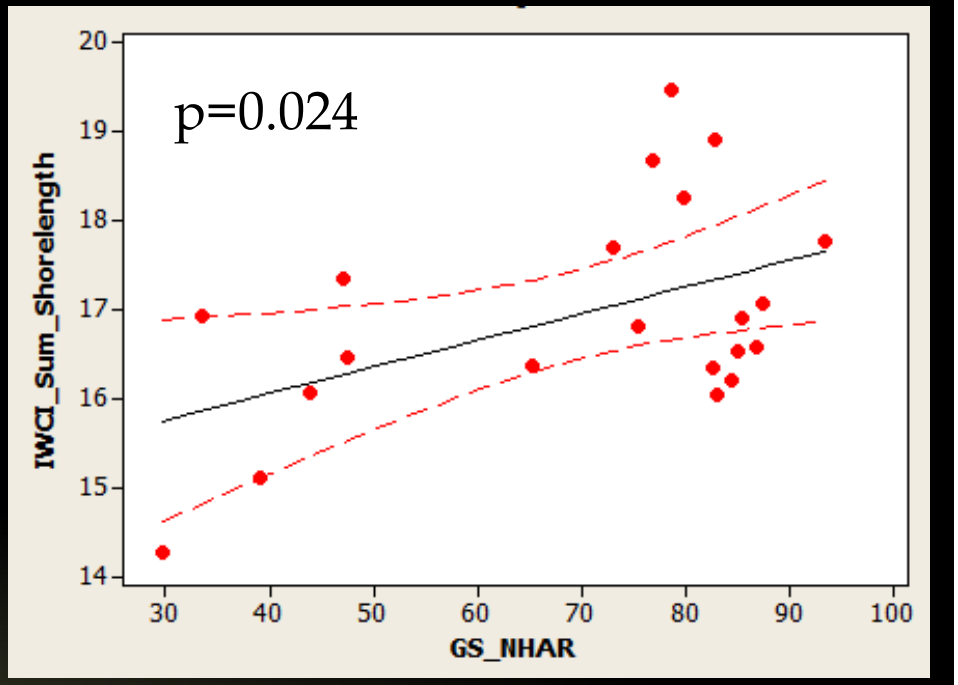
Hardened vs. Non-hardened Shoreline

(hardened= bulkhead and rip-rap)

Hardened



Non-hardened



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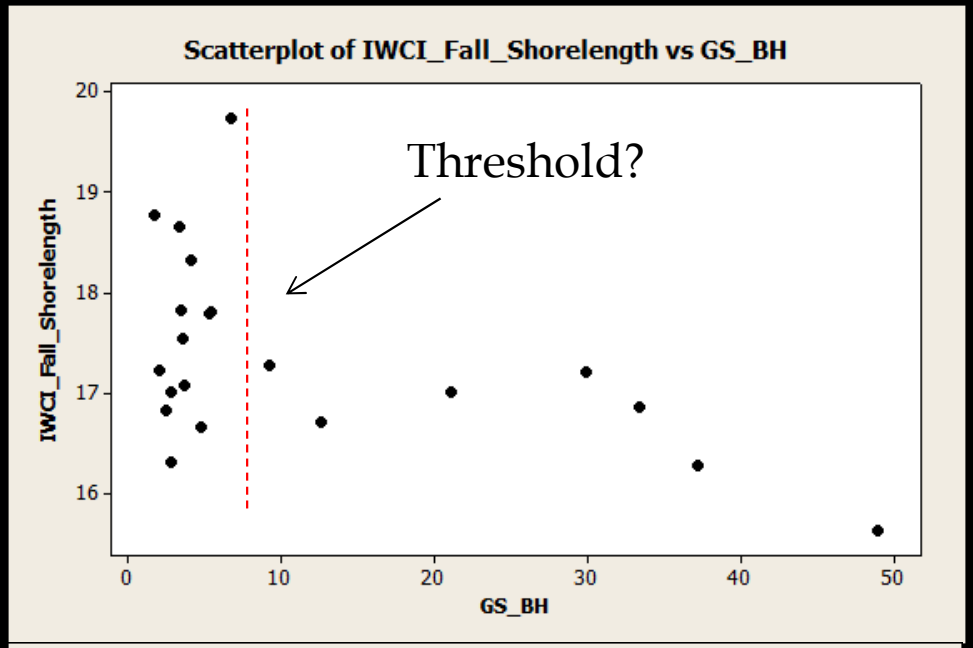
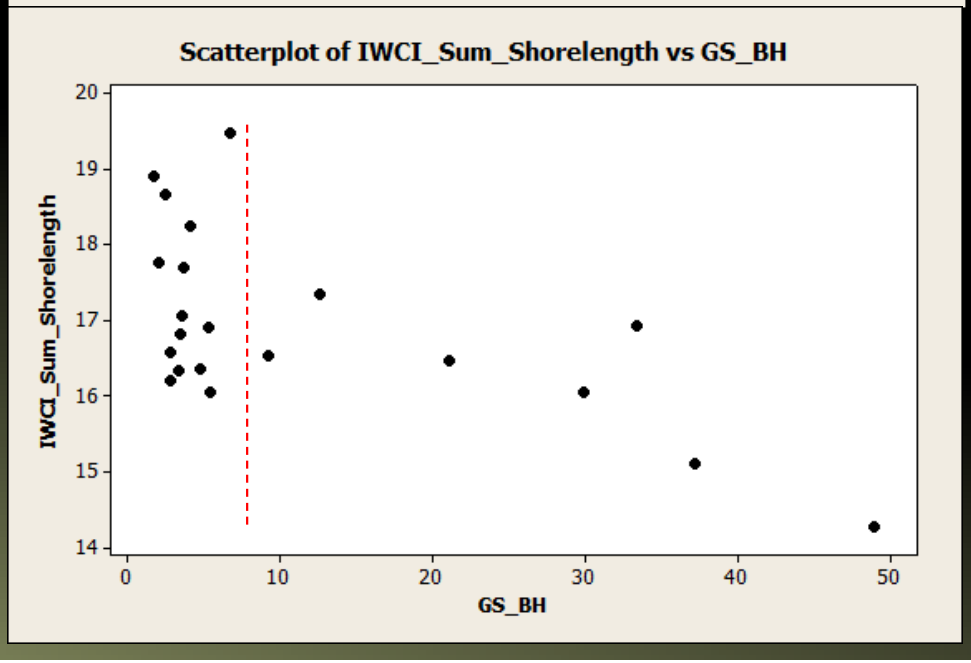
Threshold Limit of Bulkhead Development on IWCI





Cumulative Probability of a Threshold

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Looking Beyond the IWCI

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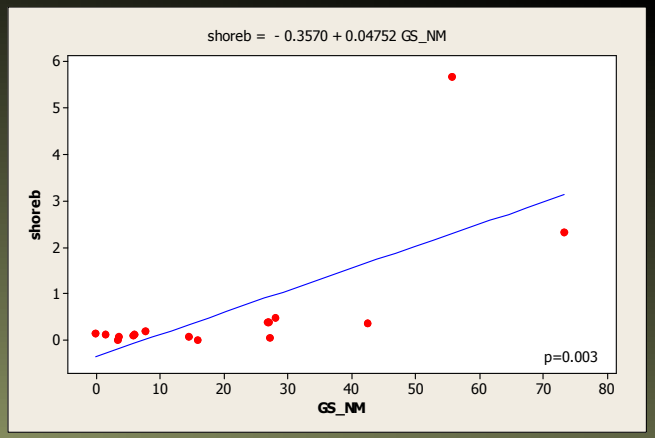
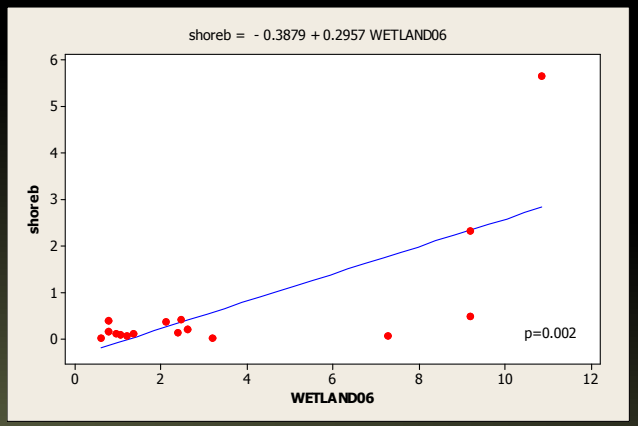
Shorebirds

Shorebirds x Wetland
Positive relationship at Subestuary and Watershed Scales

Shorebirds x Natural Marsh



Shorebirds x Wetland (NLCD06)



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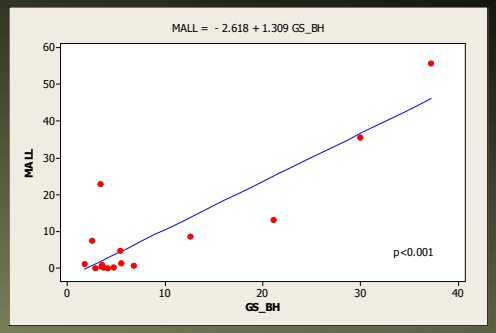
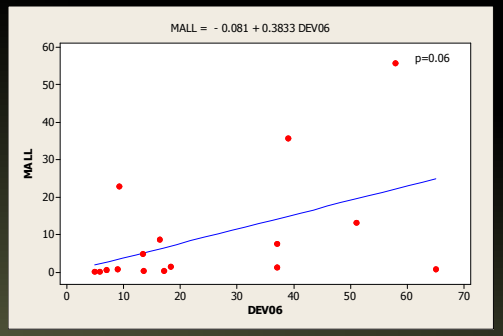
Mallards

Mallards x Development
Positive relationship at Subestuary and Watershed Scales

Mallards x Bulkhead



Mallards x DEV (NLCD06)



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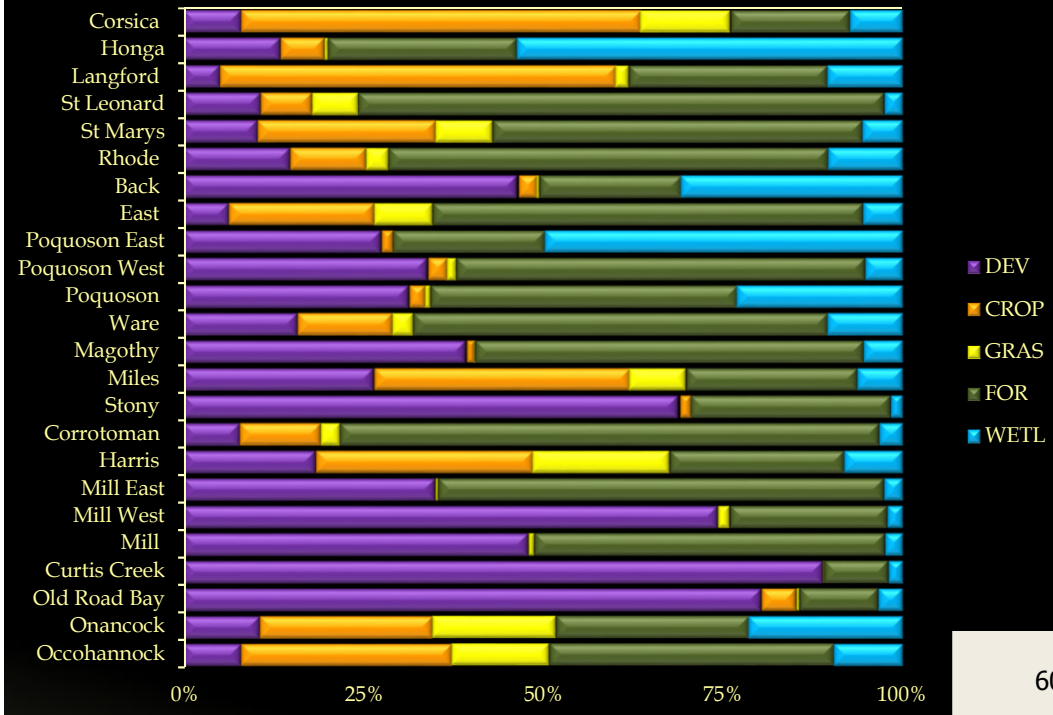
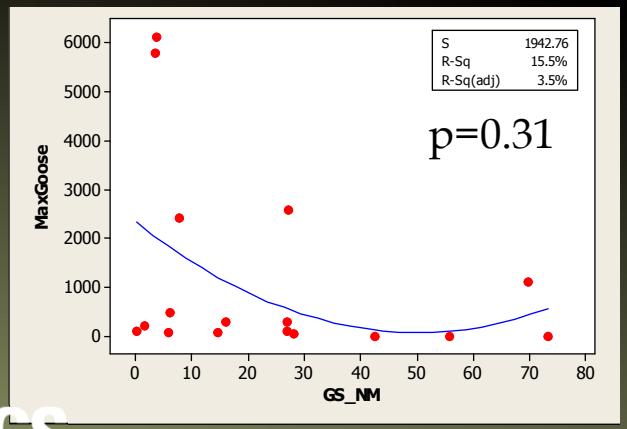
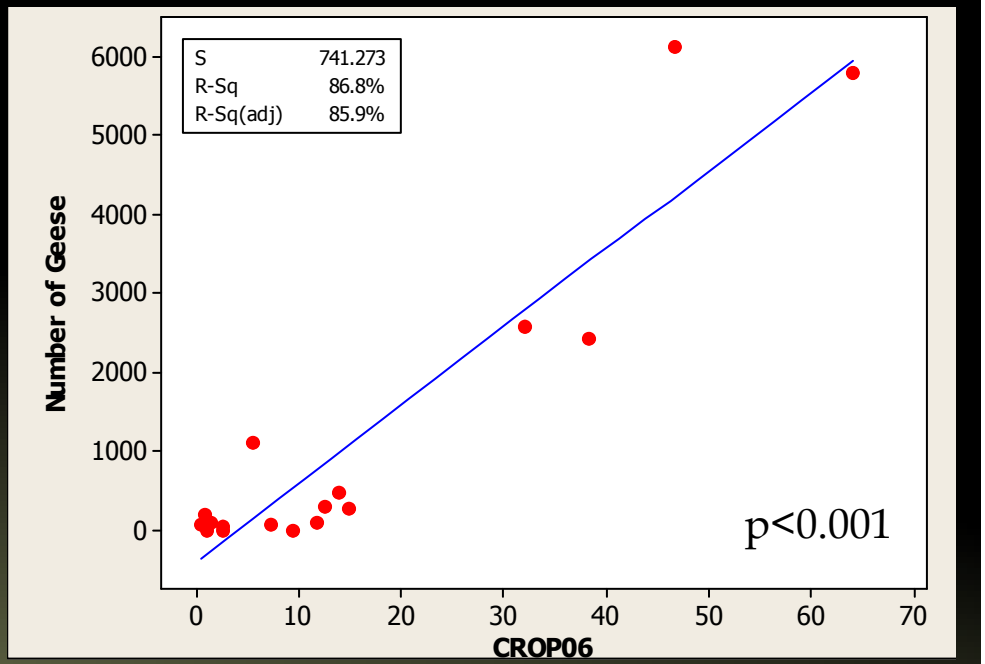
Canada Goose density driven by Landscape level Cropland



Geese x Local Natural Marsh



Geese x Landscape CROP



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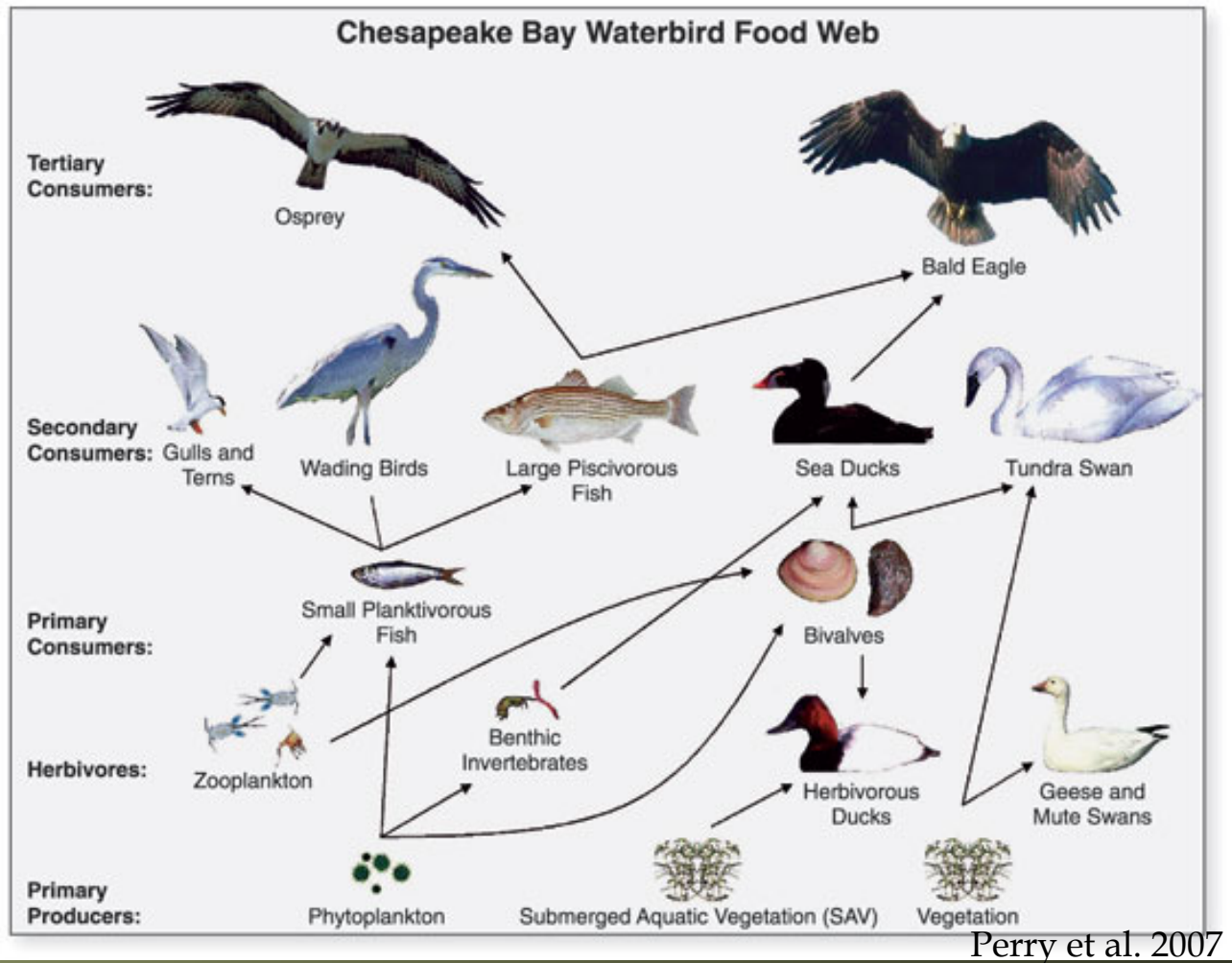
Looking across macro-fauna groups



Perry et al. 2007

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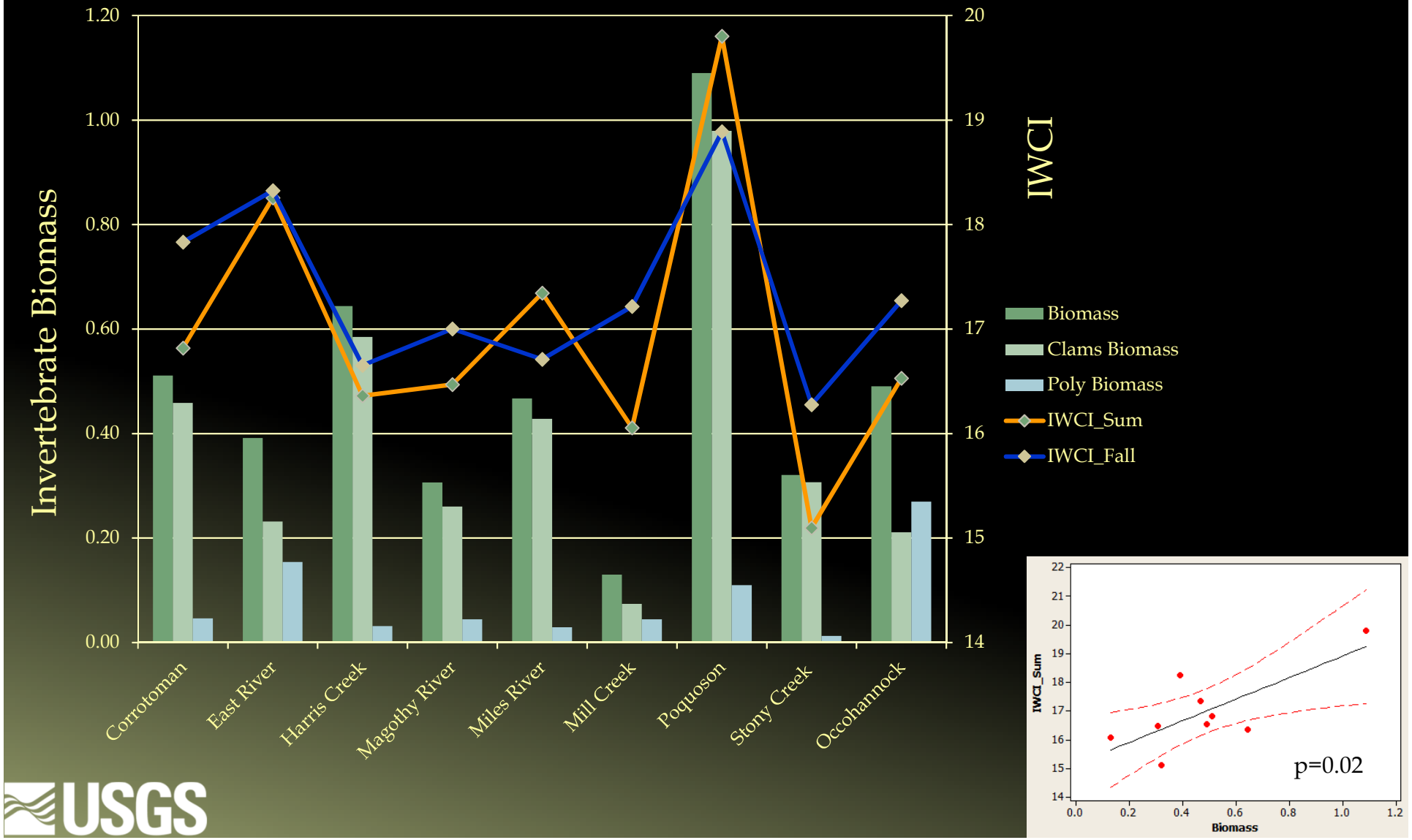
IWCI and Invertebrate Biomass (n=9 subestuaries)



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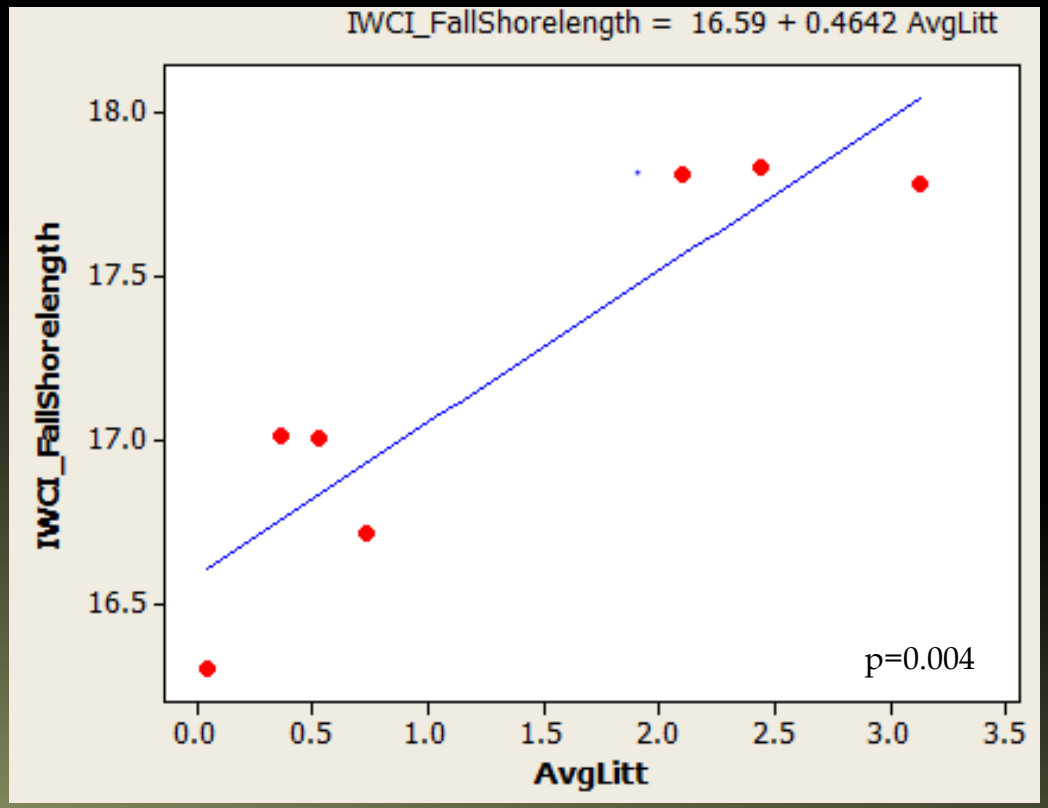
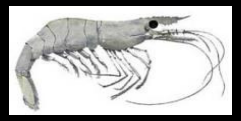
IWCI and Littoral Fish Biomass
(n=7 subestuaries)



Littoral-Benthic


Mummichog


Striped Killifish


Grass Shrimp


Naked Goby

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Summary

- IWCI is sensitive to measuring bird communities across subestuary conditions
- Seasonal differences
- IWCI decreases with:
  - Percent bulkhead and phragmites
- We observed relationships between IWCI and benthic invertebrates and littoral fish
- Looking at individual species or guilds is also informative

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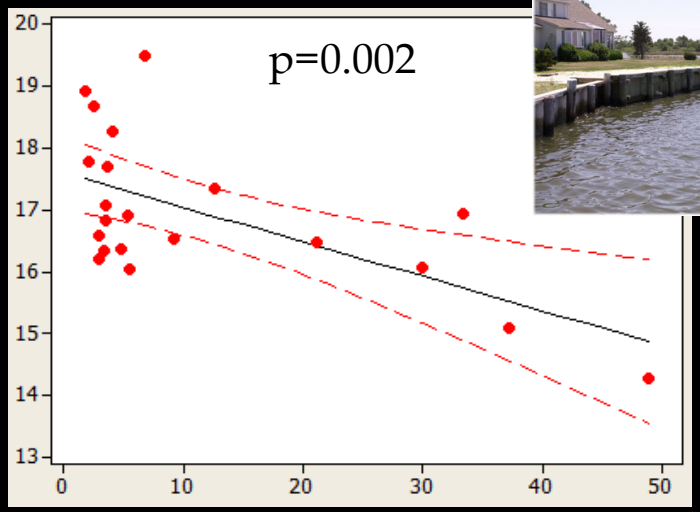
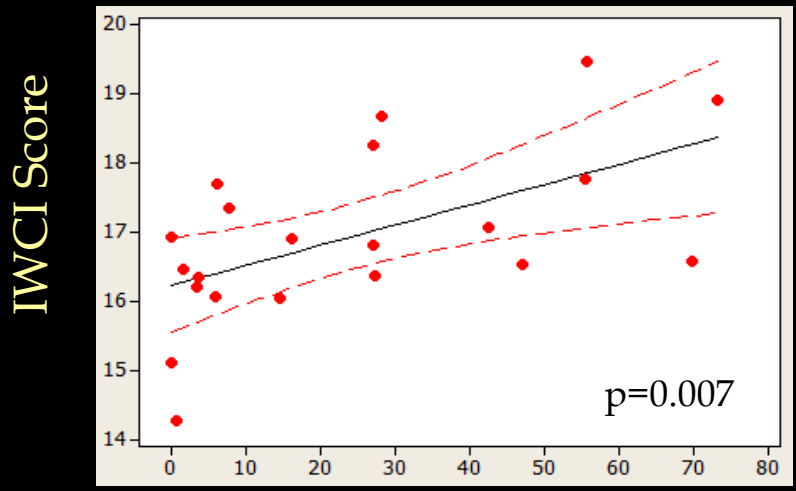
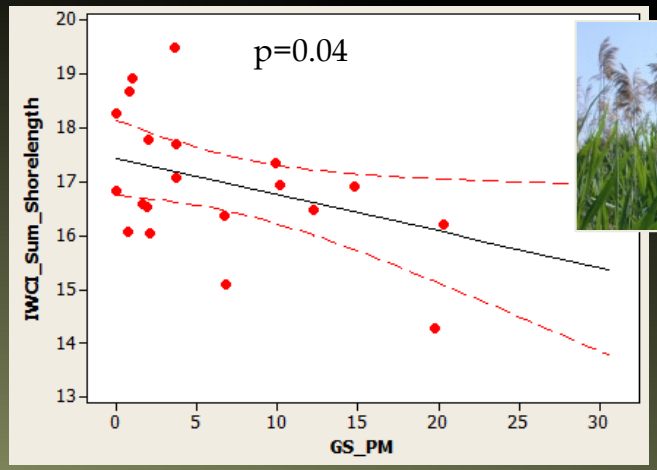
"Birds Boycott Bulkhead"



"Waterbirds are Wild for Wetlands"



"Birds say Phooey to Phragmites"



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Thanks to:

Mike Erwin, Dan Day, Paul Marbán, Brian Ho Sung Lee, Mary Maxey, Shane Heath, Bridget Collins, Lisa Vormwald

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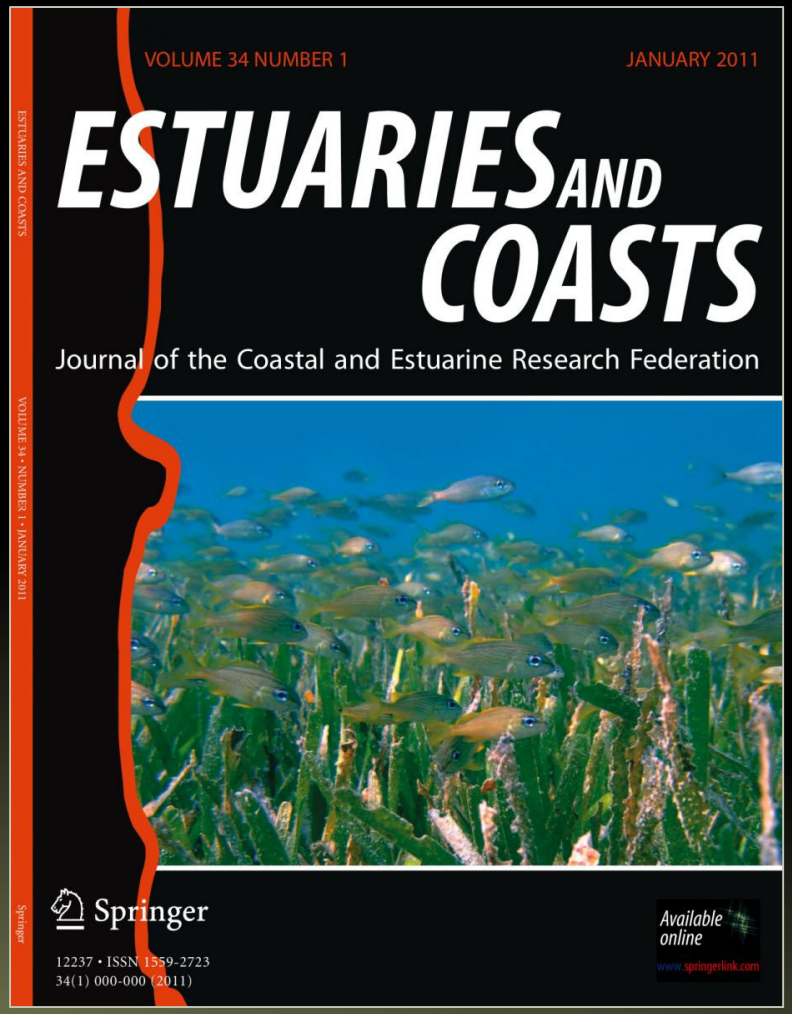
Special Issue, 2017



"Impacts of coastal land use and shoreline armoring on estuarine systems"

1 Overview paper
14 Research Papers


Thank You!
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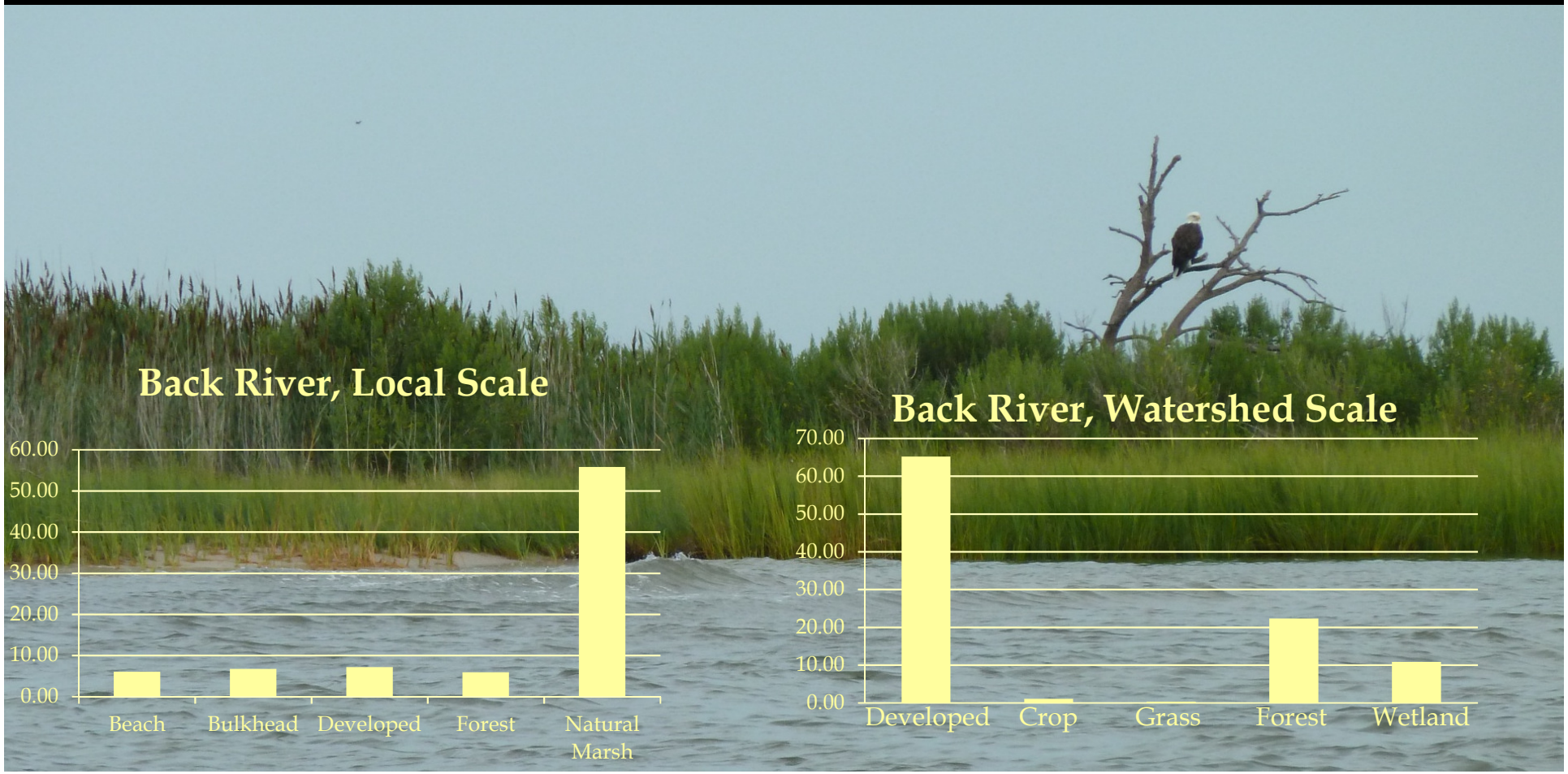
Back River – Highest IWCI

IWCI = 19.49, 19.73(summer, fall)



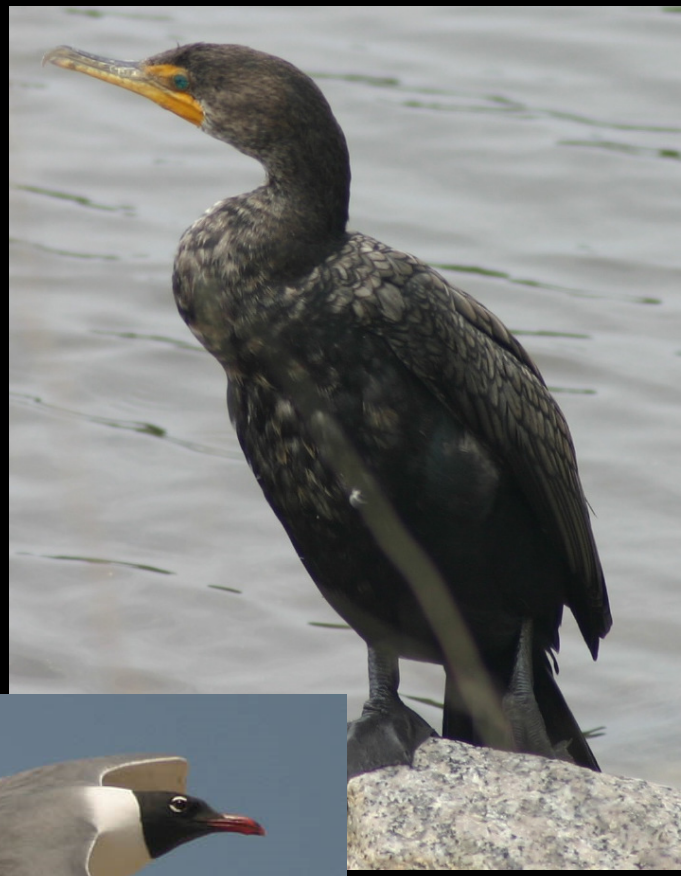
Back River

Extensive beach habitat

USGS

Back River

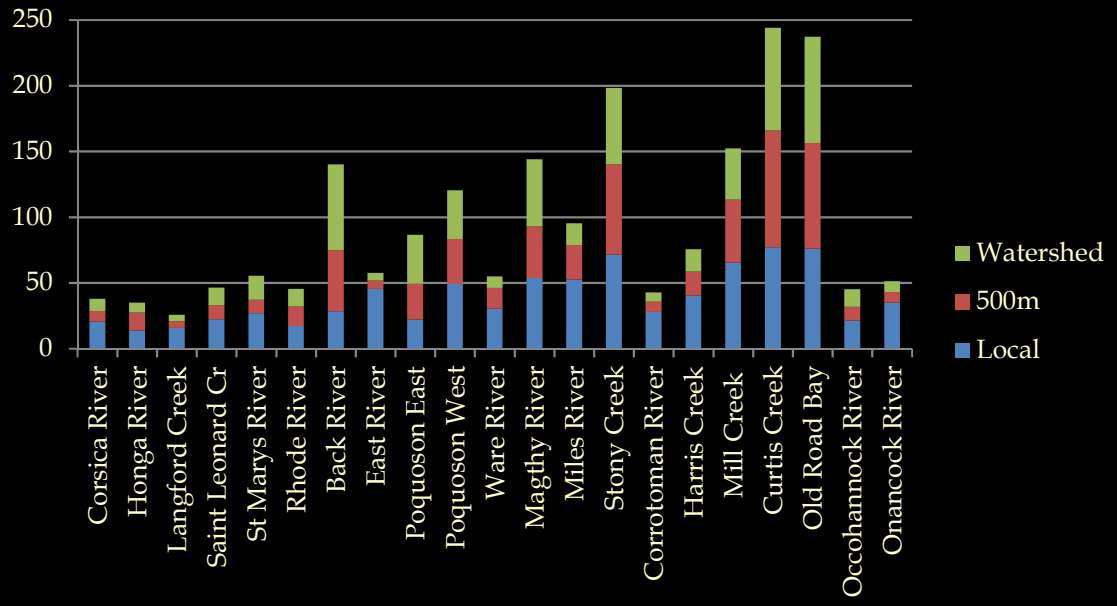
Top 5 Species	Mean Density (indiv/km)	S_{iwci}
Double-crested Cormorant	5.0	9.5
Laughing Gull	1.7	17.5
Royal Tern	1.7	21
Herring Gull	1.0	7
Forster's Tern	0.6	17.5



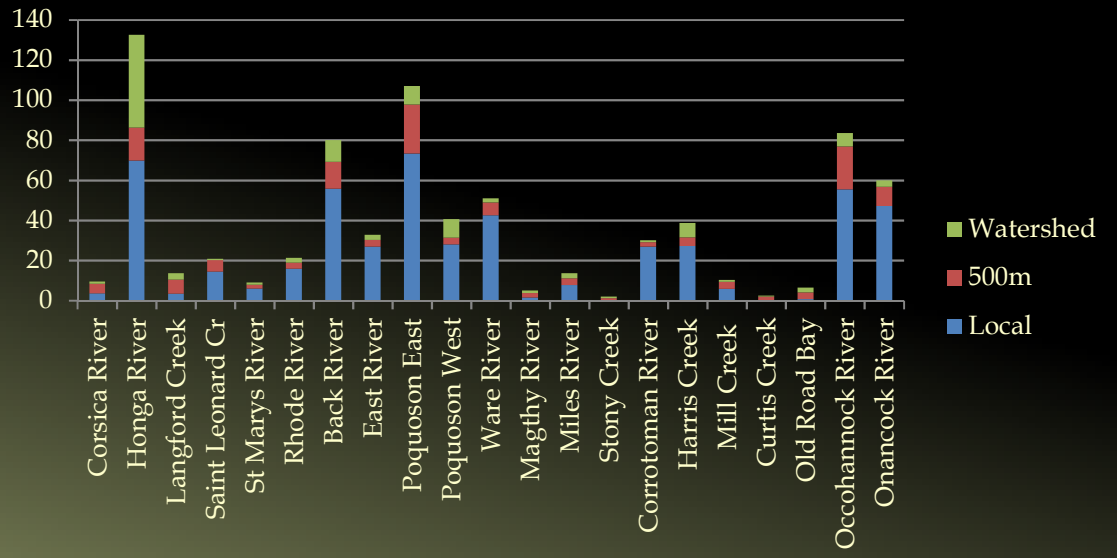
USGS

Land categories across Scales

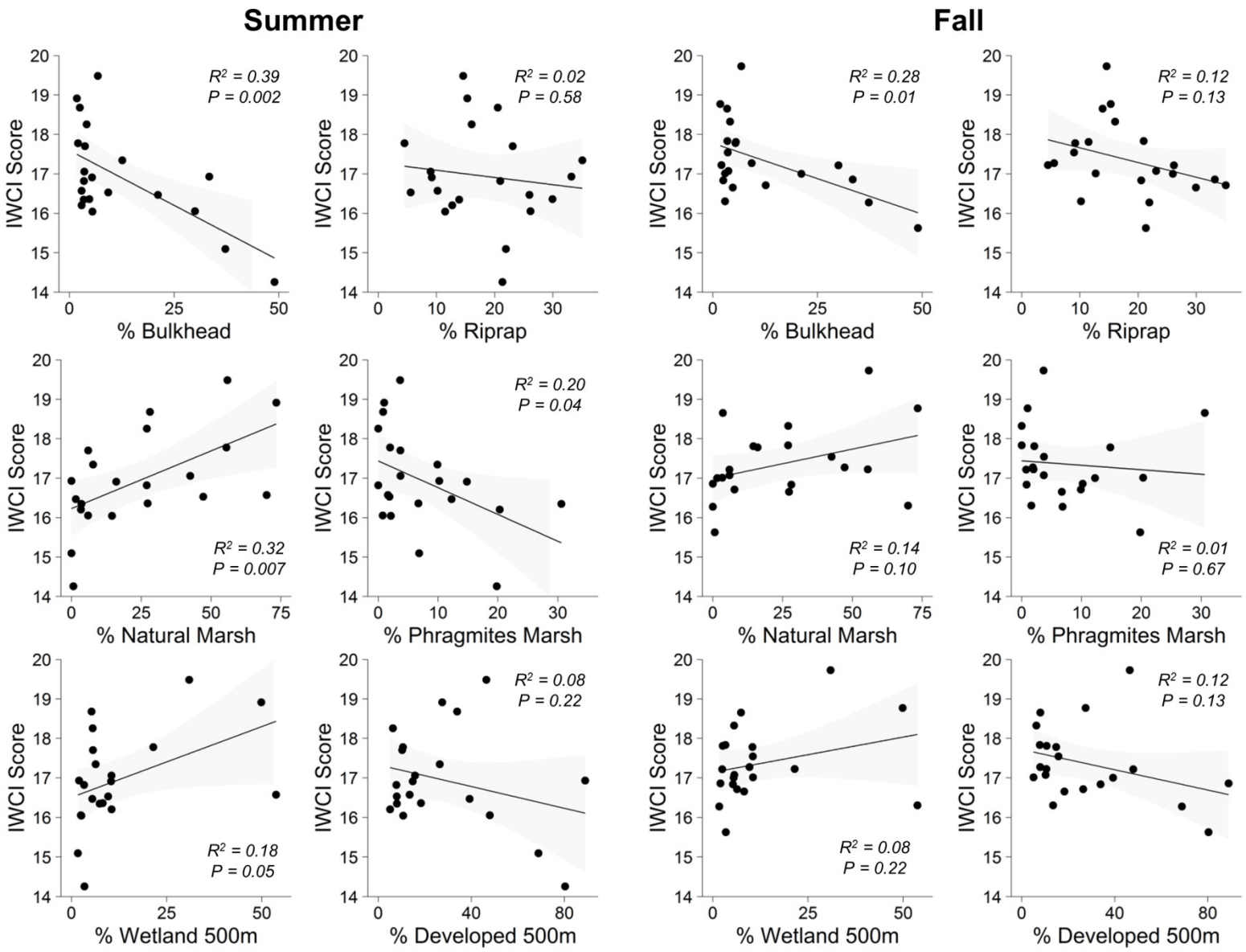
Developed



Wetland



USGS


Summer
Fall
IWCI Score
% Bulkhead
R² = 0.39
P = 0.002
% Riprap
R² = 0.02
P = 0.58
R² = 0.28
P = 0.01
R² = 0.12
P = 0.13
% Natural Marsh
R² = 0.32
P = 0.007
% Phragmites Marsh
R² = 0.20
P = 0.04
R² = 0.14
P = 0.10
R² = 0.01
P = 0.67
% Wetland 500m
R² = 0.18
P = 0.05
% Developed 500m
R² = 0.08
P = 0.22
R² = 0.08
P = 0.22
R² = 0.12
P = 0.13