Conceptual model of benefits of tidal marshes to fishes

Denise De Carion, John Durand, Jim Hobbs, Teejay O'Rear, Carson Jeffres, Matthew Young, Brian Williamson, Tommy Agosta, Samuel Mosle, Matt Ferner, Bill Fleenor, Randy Dahlgren, Peter Moyle

Bay Delta Science Conference, October 30th, 2014

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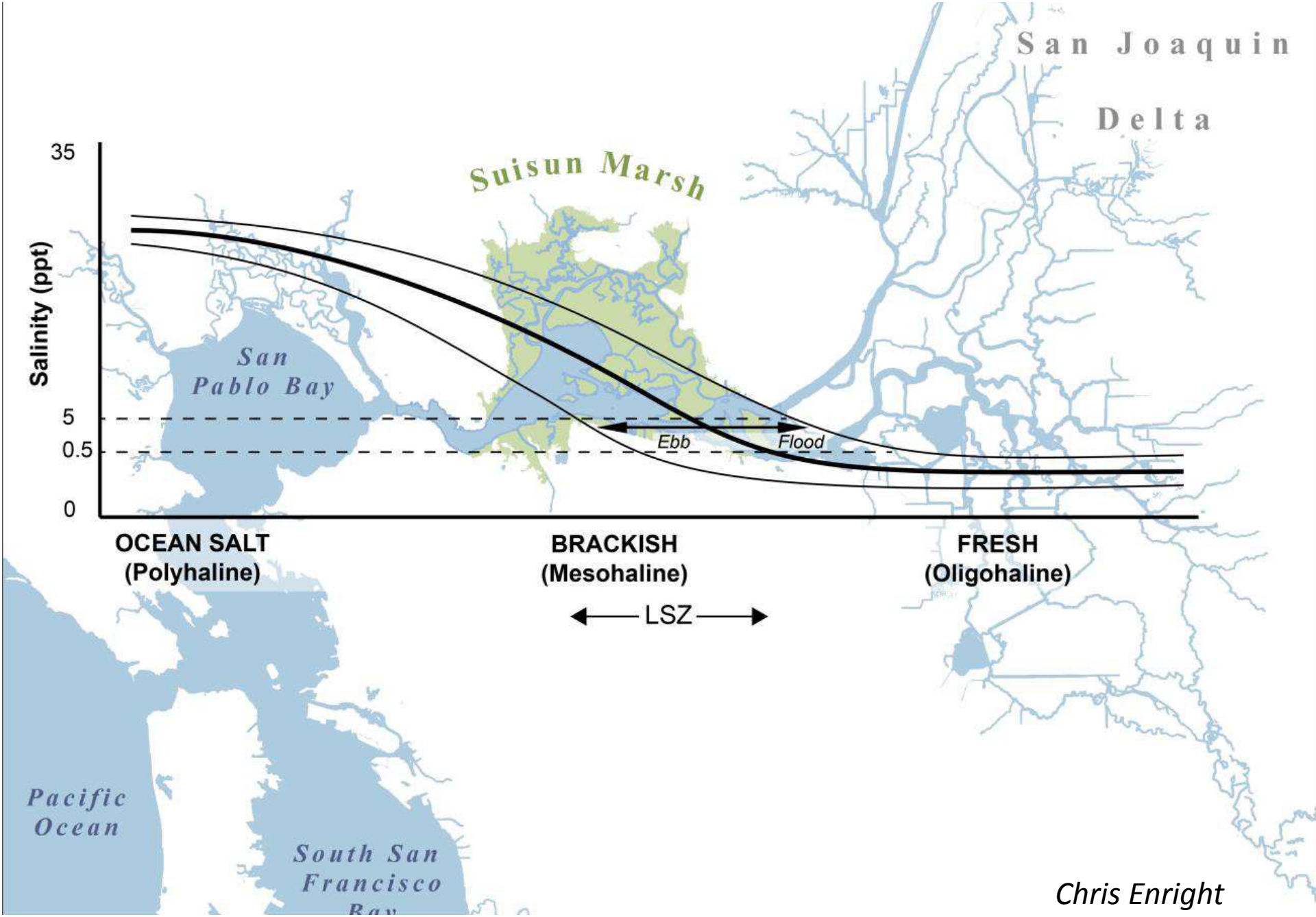
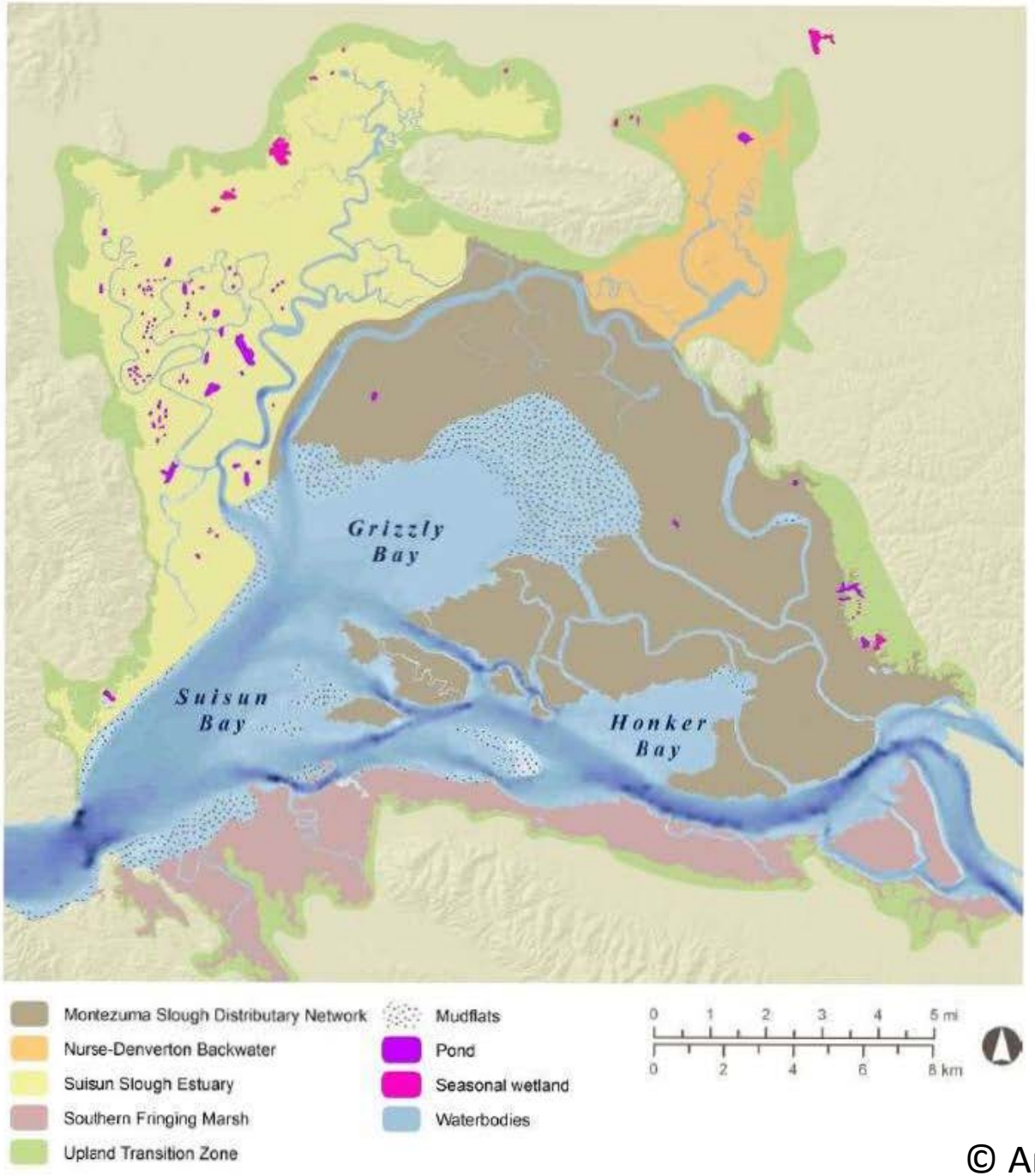


Chris Enright



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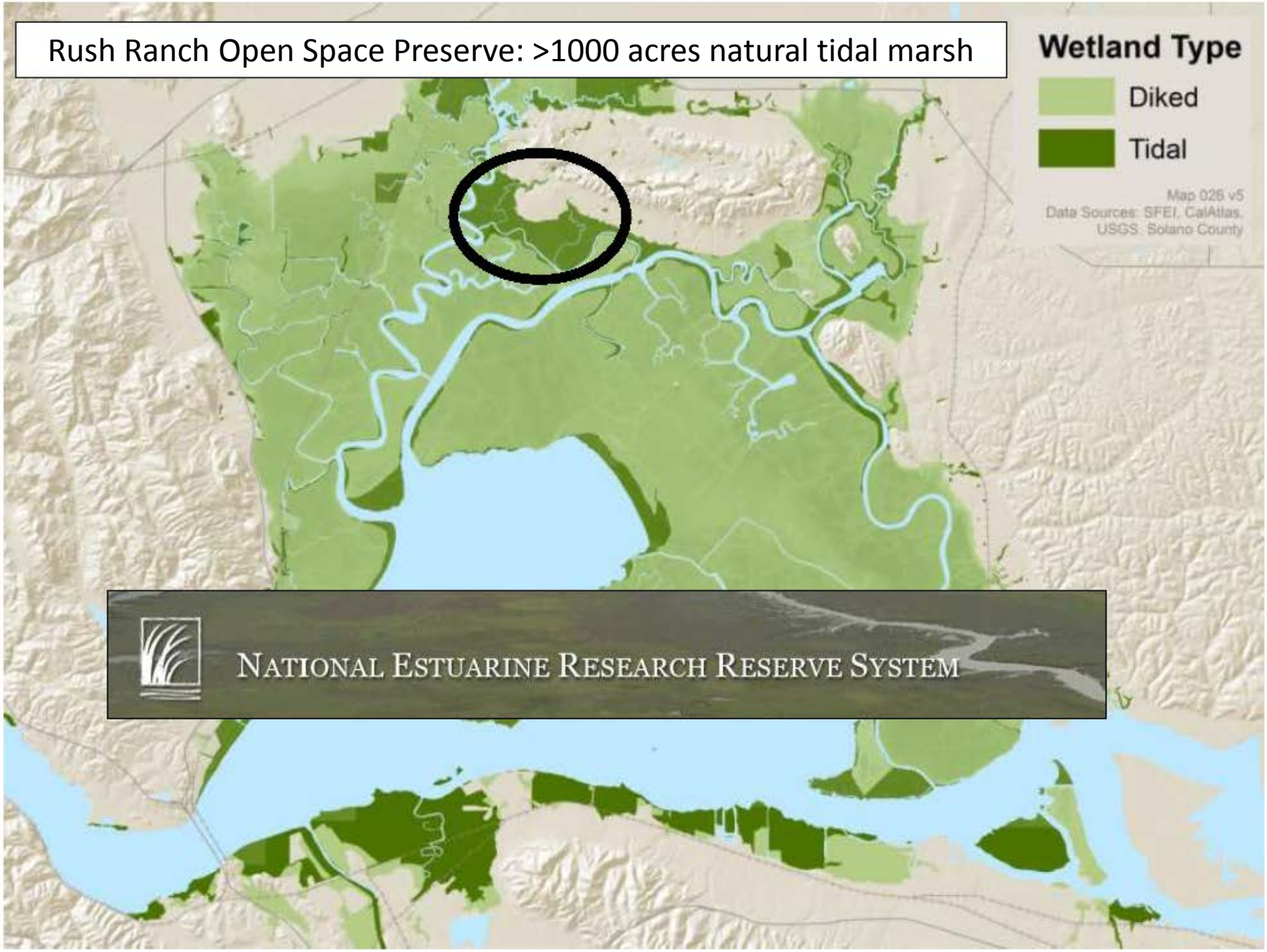
Landscape changes:
Tidal slough modification through diking

Rush Ranch Open Space Preserve: >1000 acres natural tidal marsh



Andy Bell
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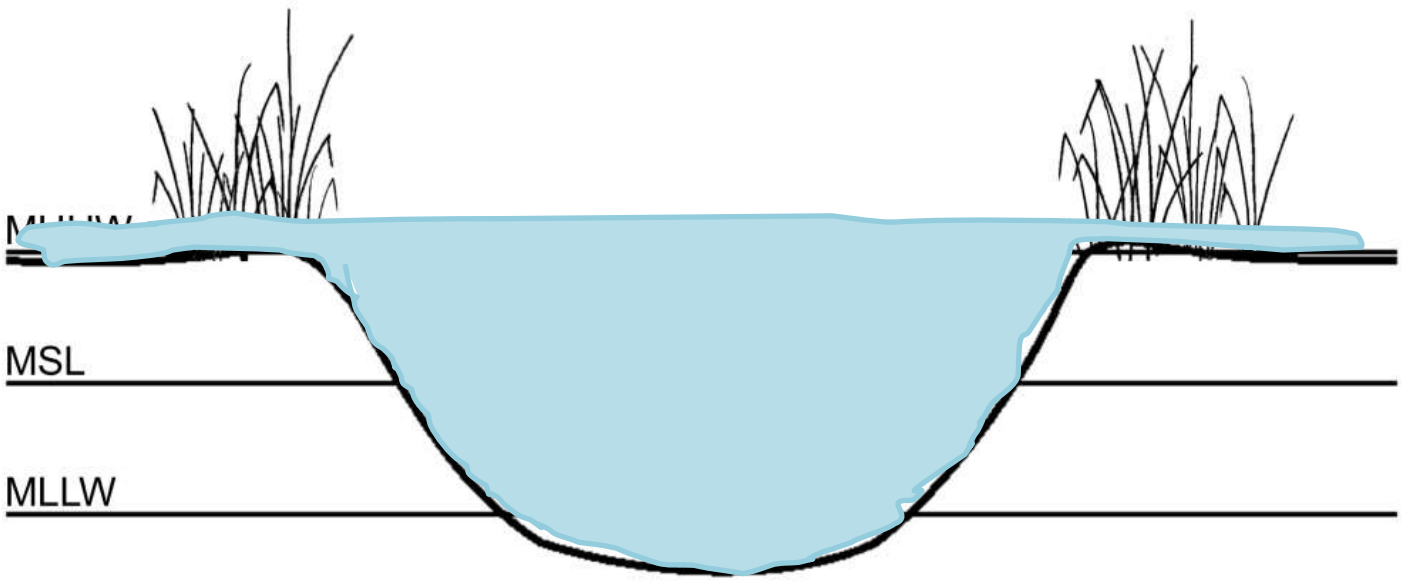
Tidal marsh is dynamic, variable over many time scales

- **Tidal scale**
- **Diel scale**
- **Spring-neap scale**
  - Spring tide (strong tides)
  - Neap tide (weak tides)
- **Lunar scale**
- **Seasonal scale**
  - Summer/winter king tides (strongest tides)
  - Spring/autumnal equinox tides (weakest tides)

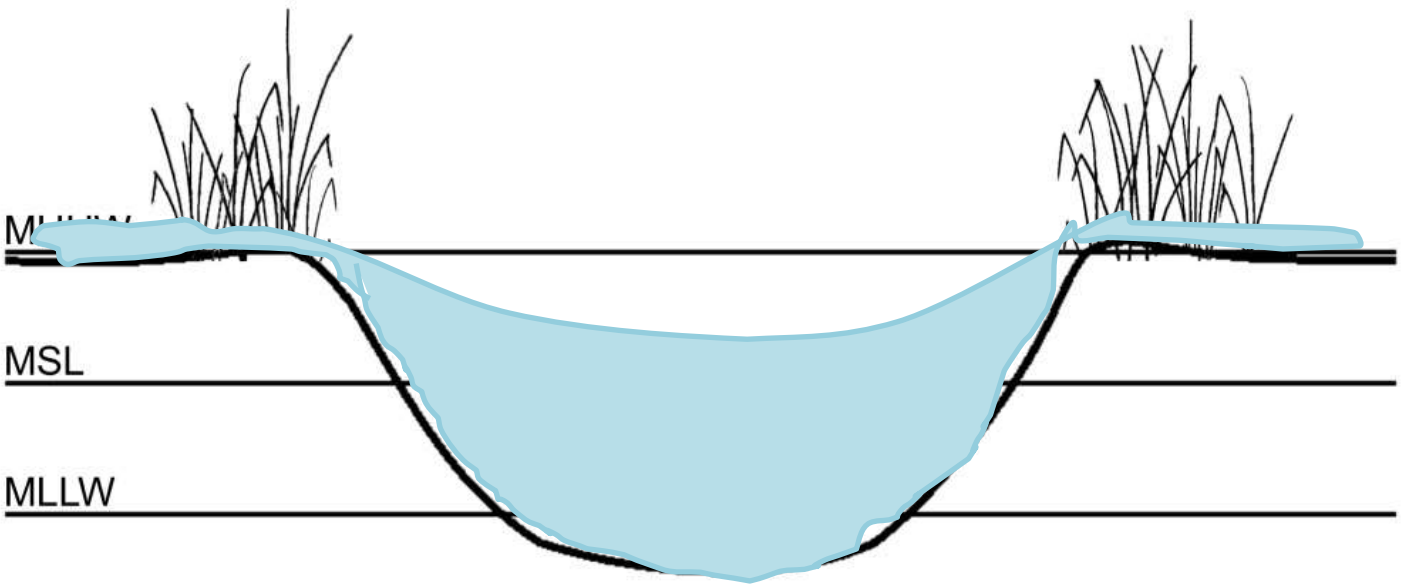
= **Influences habitat, food webs, behavioral adaptations**

Spring tides have the highest high tides

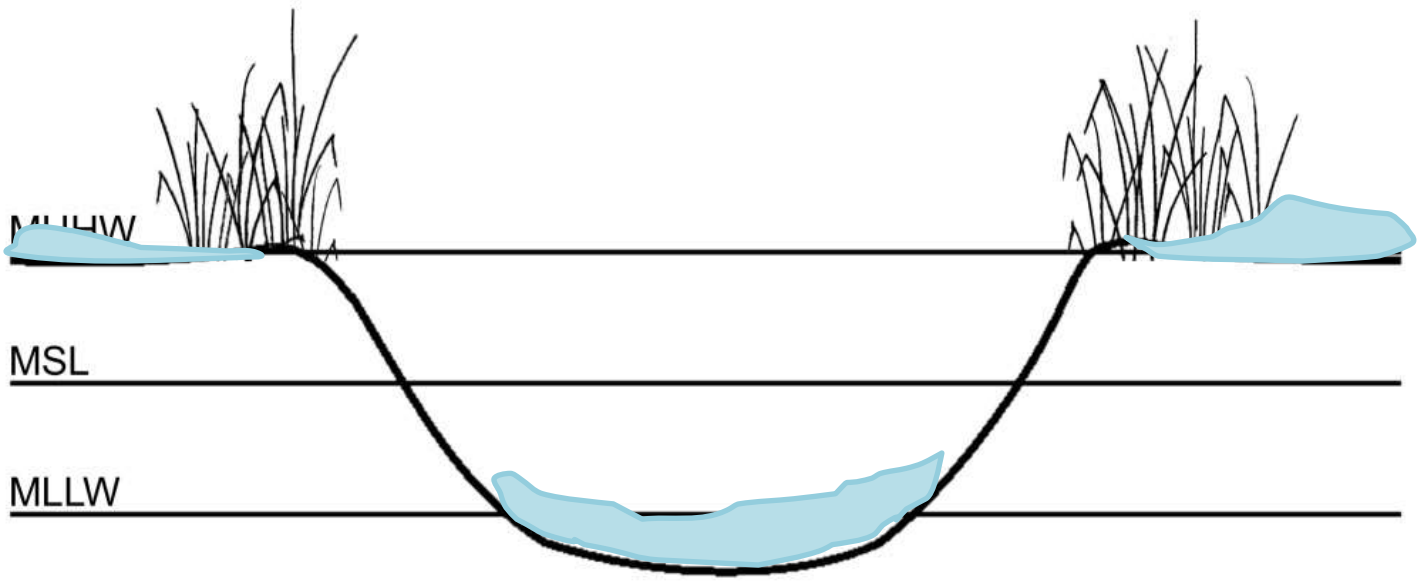


=Facilitates exchange with marsh platform

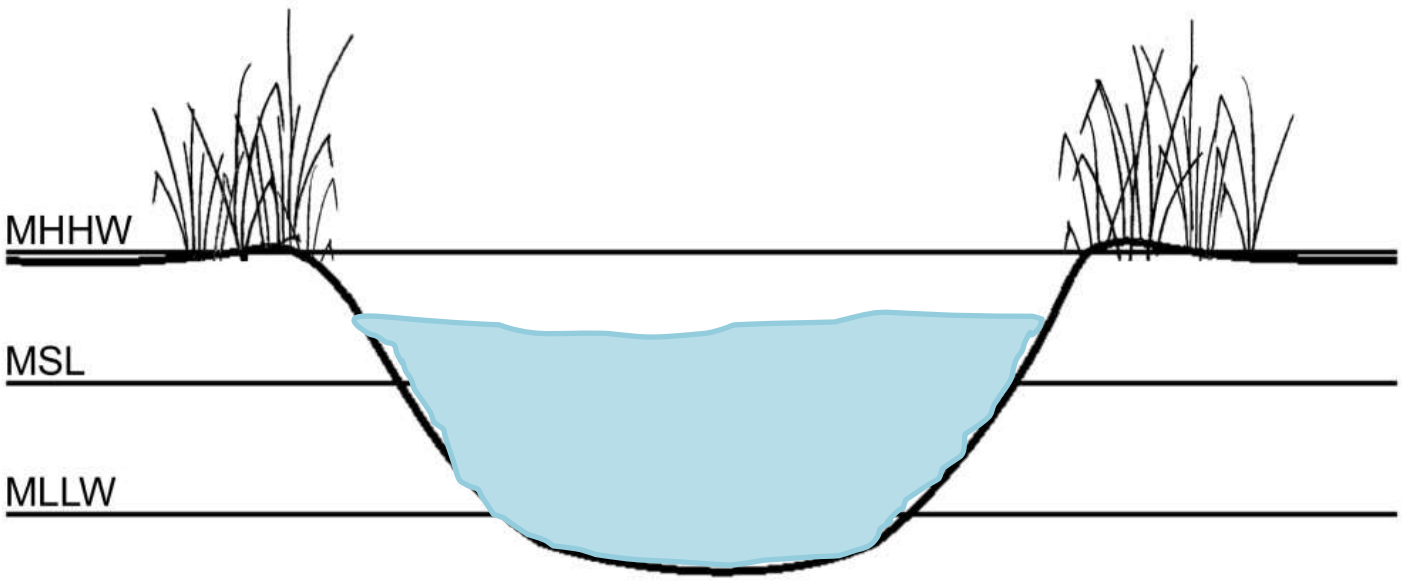
Spring tides have the highest high tide



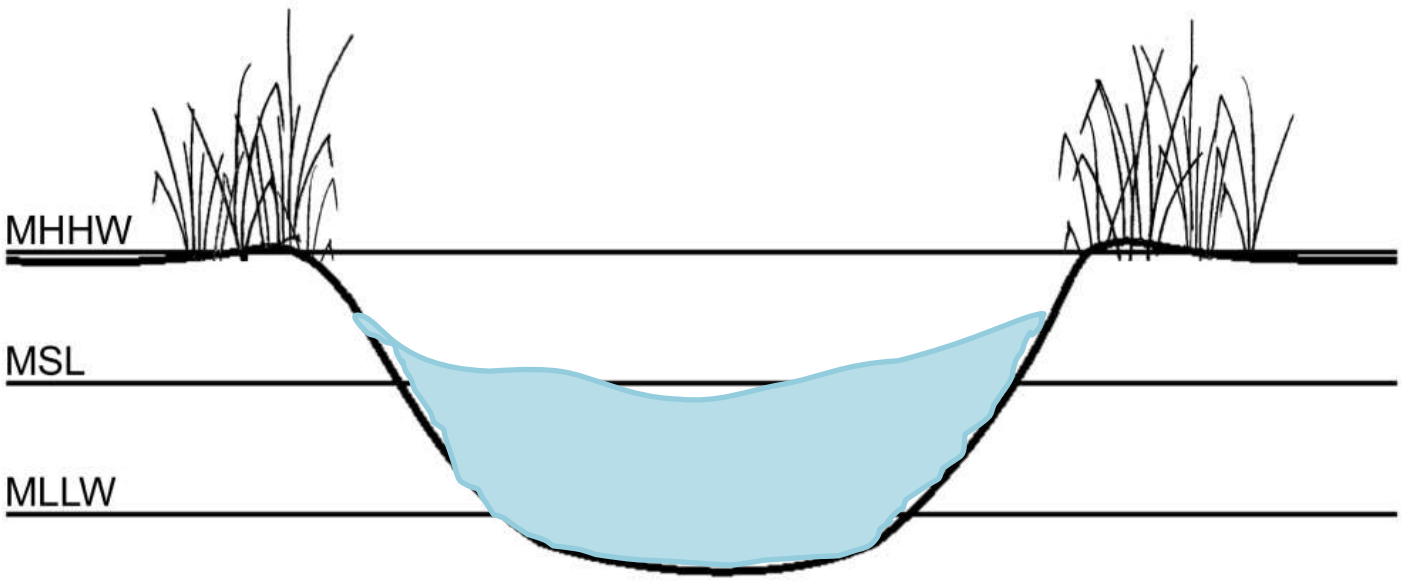
Spring tides have the lowest low tide



Neap tides have muted tides

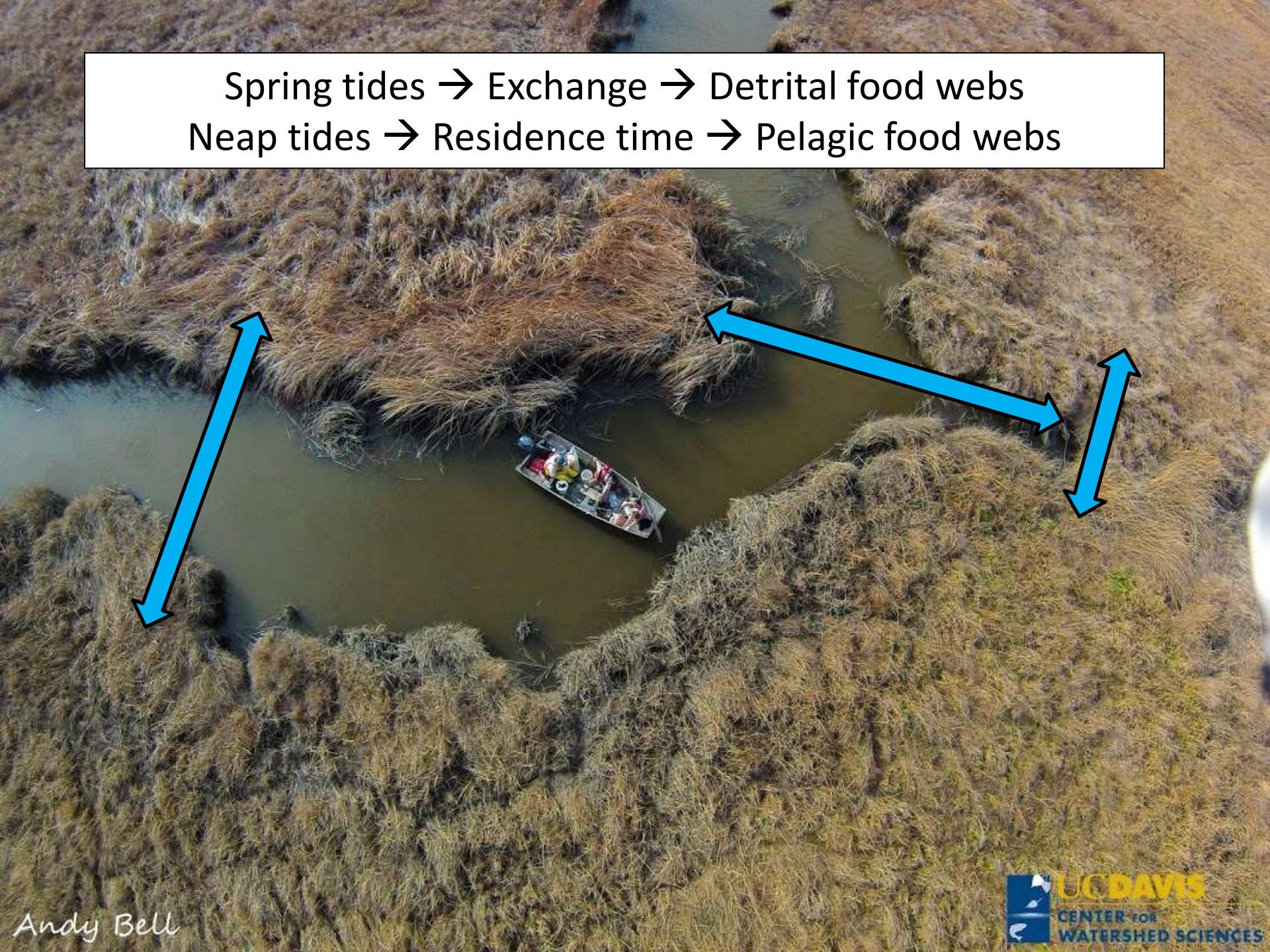


Neap tides have muted tides

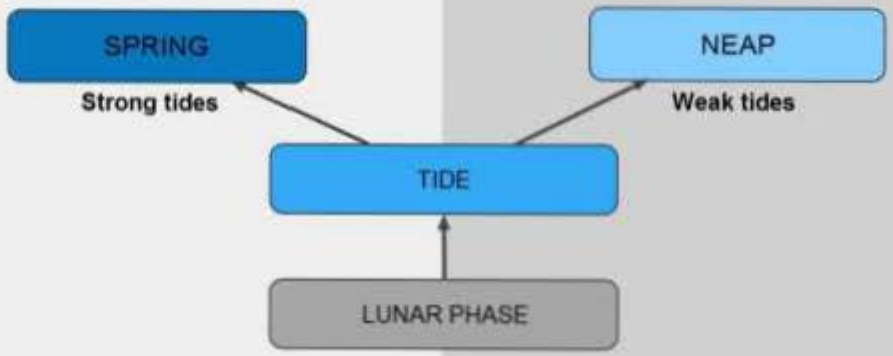


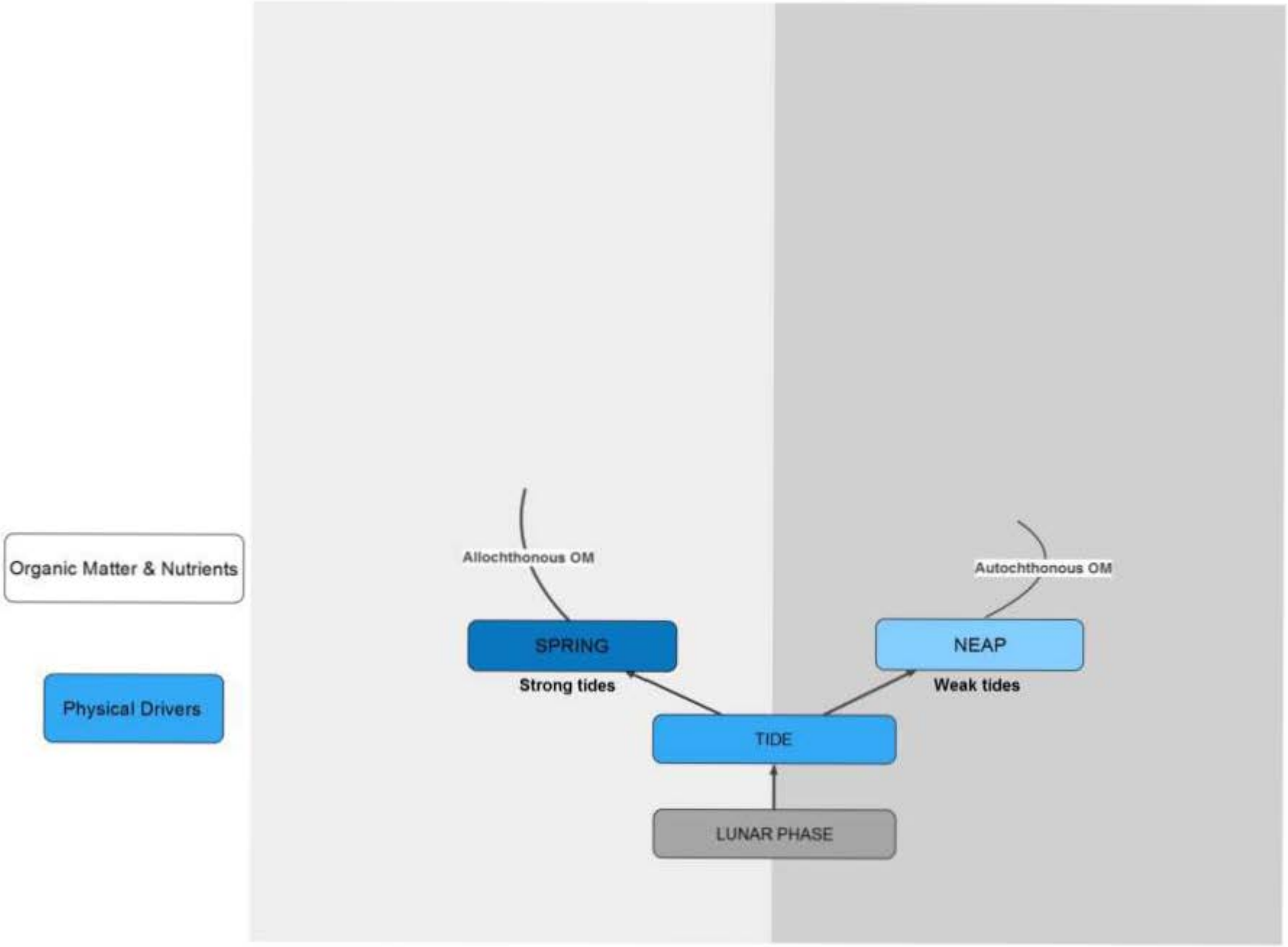
=Facilitates high residence time of water

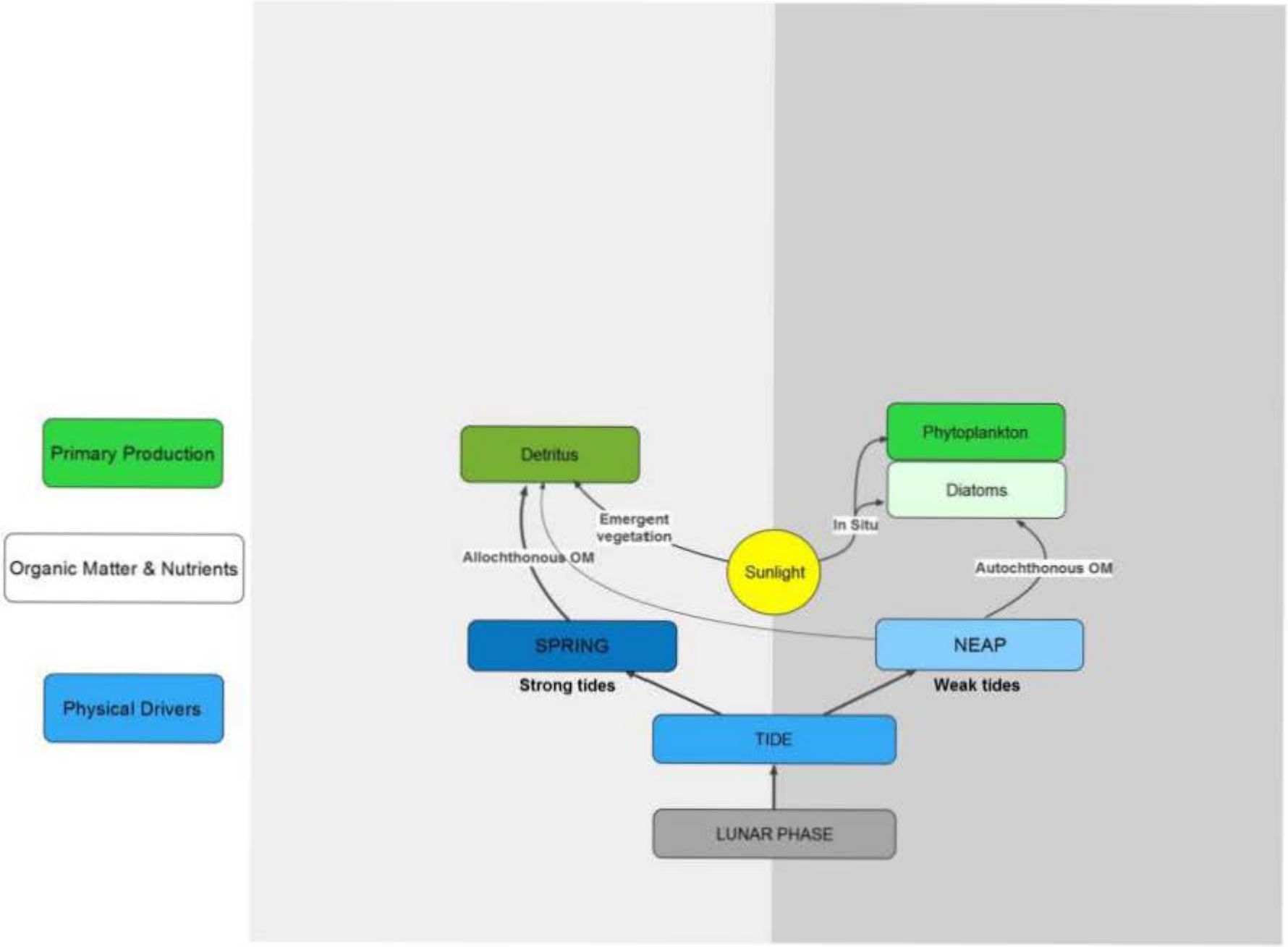
Spring tides → Exchange → Detrital food webs
Neap tides → Residence time → Pelagic food webs

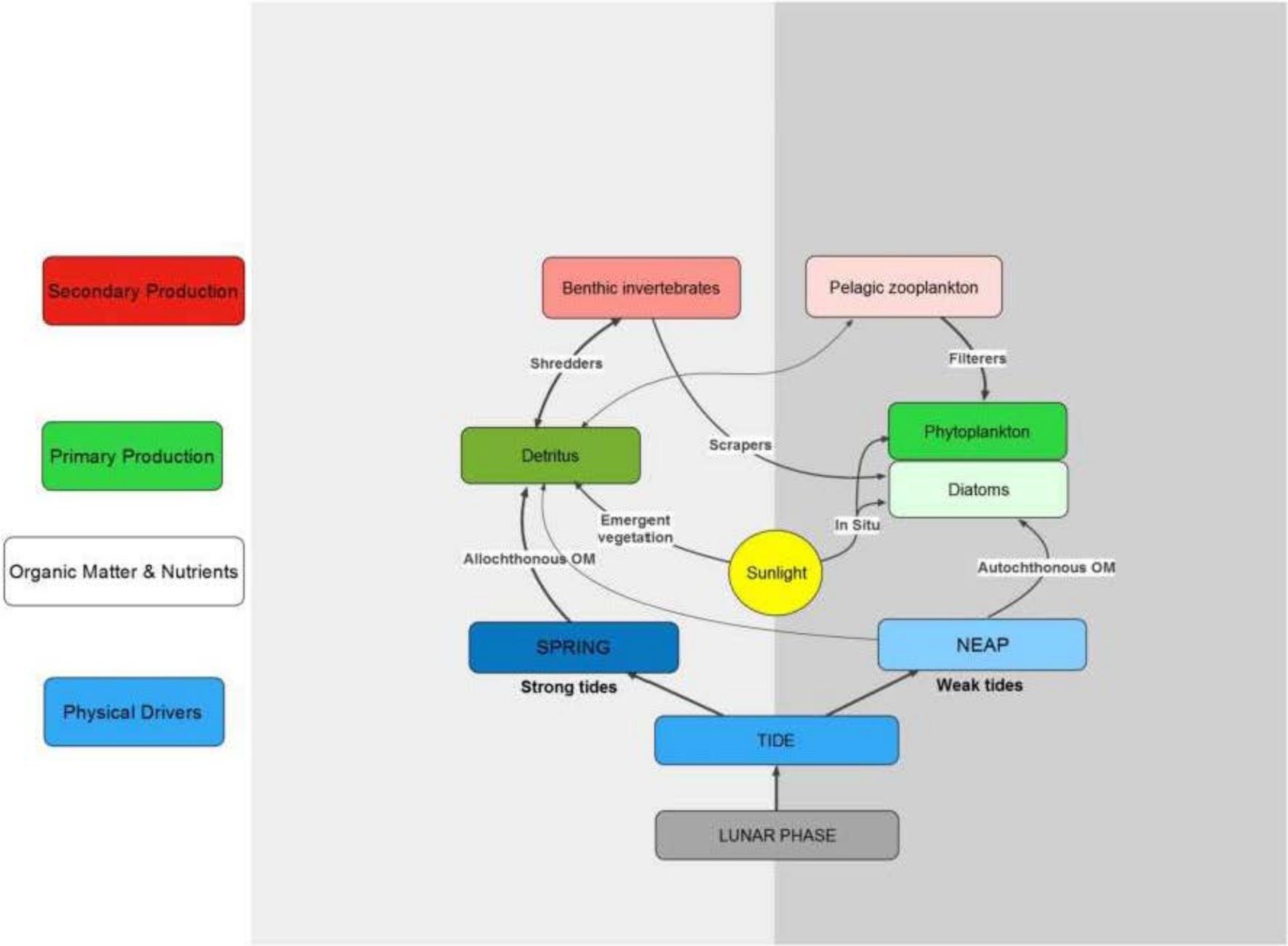


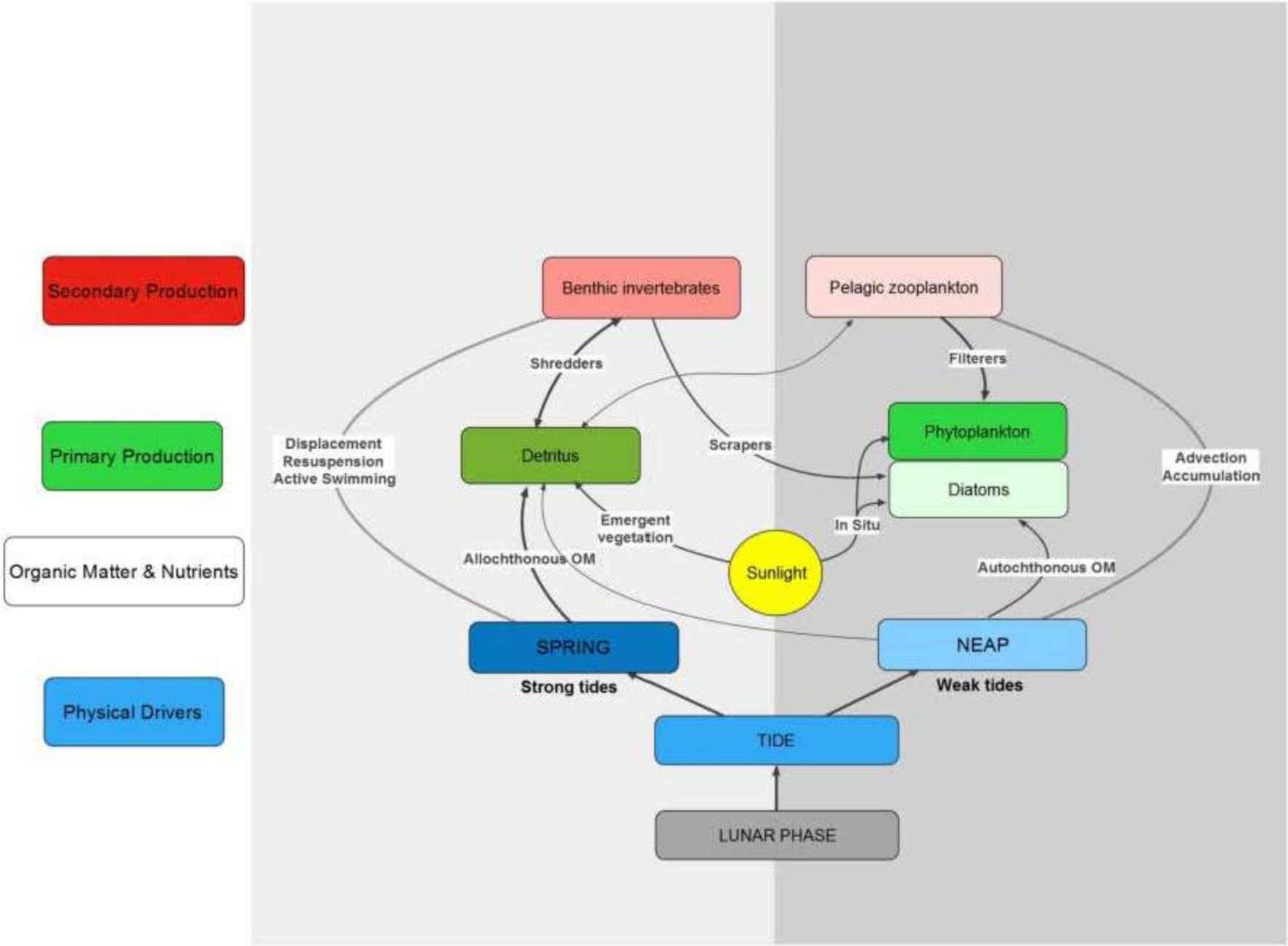
Physical Drivers



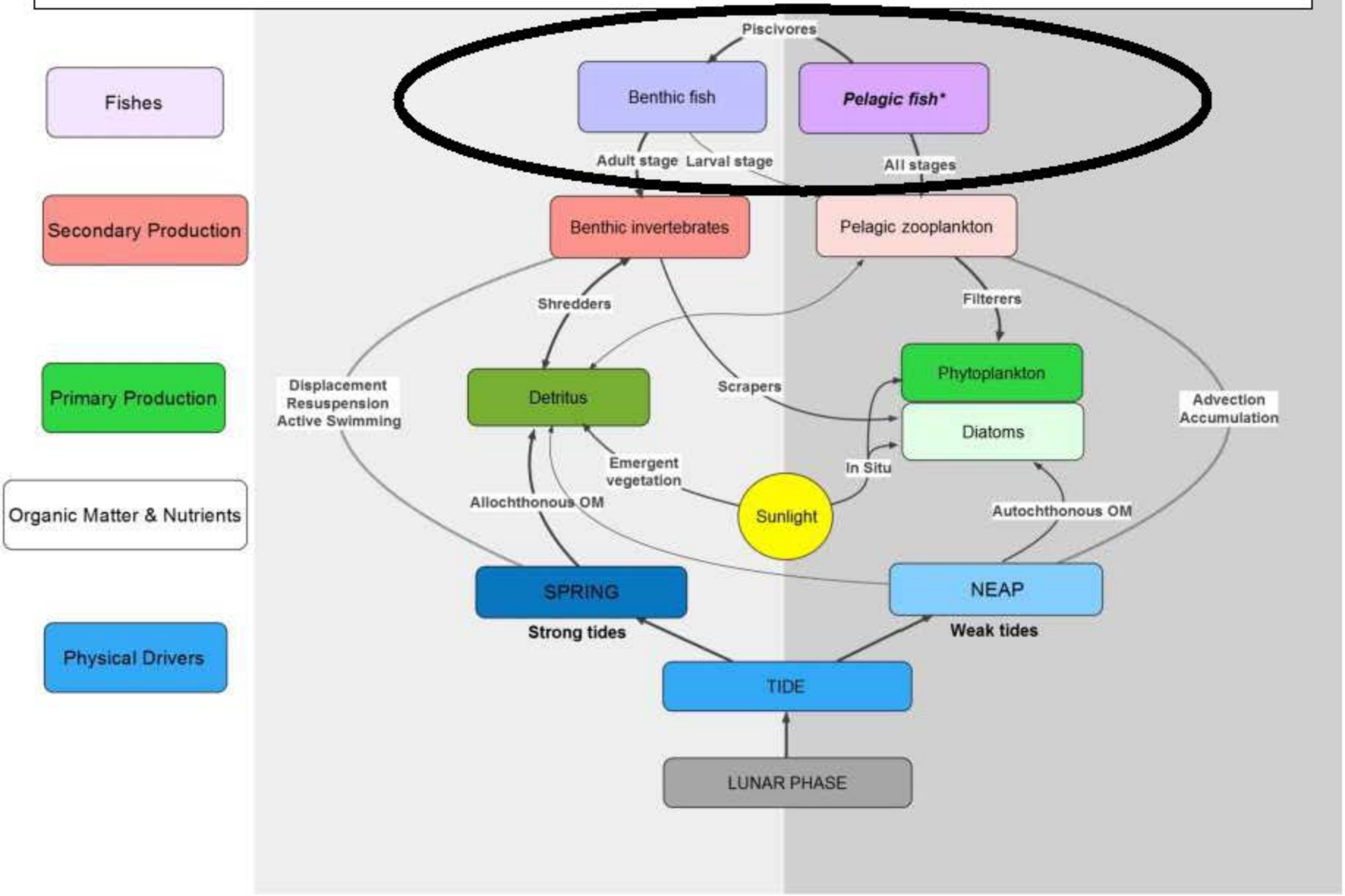

Organic Matter & Nutrients
Physical Drivers
Allochthonous OM
Autochthonous OM
SPRING
Strong tides
NEAP
Weak tides
TIDE
LUNAR PHASE


Primary Production
Organic Matter & Nutrients
Physical Drivers
Detritus
Phytoplankton
Diatoms
Emergent vegetation
In Situ
Allochthonous OM
Sunlight
Autochthonous OM
SPRING
Strong tides
NEAP
Weak tides
TIDE
LUNAR PHASE


Secondary Production
Primary Production
Organic Matter & Nutrients
Physical Drivers
Benthic invertebrates
Pelagic zooplankton
Shredders
Filterers
Scrapers
Detritus
Phytoplankton
Diatoms
Emergent vegetation
In Situ
Allochthonous OM
Sunlight
Autochthonous OM
SPRING
Strong tides
NEAP
Weak tides
TIDE
LUNAR PHASE


Secondary Production
Primary Production
Organic Matter & Nutrients
Physical Drivers
Benthic invertebrates
Pelagic zooplankton
Shredders
Filterers
Displacement
Resuspension
Active Swimming
Detritus
Scrapers
Phytoplankton
Diatoms
Advection
Accumulation
Emergent
vegetation
In Situ
Allochthonous OM
Sunlight
Autochthonous OM
SPRING
Strong tides
NEAP
Weak tides
TIDE
LUNAR PHASE

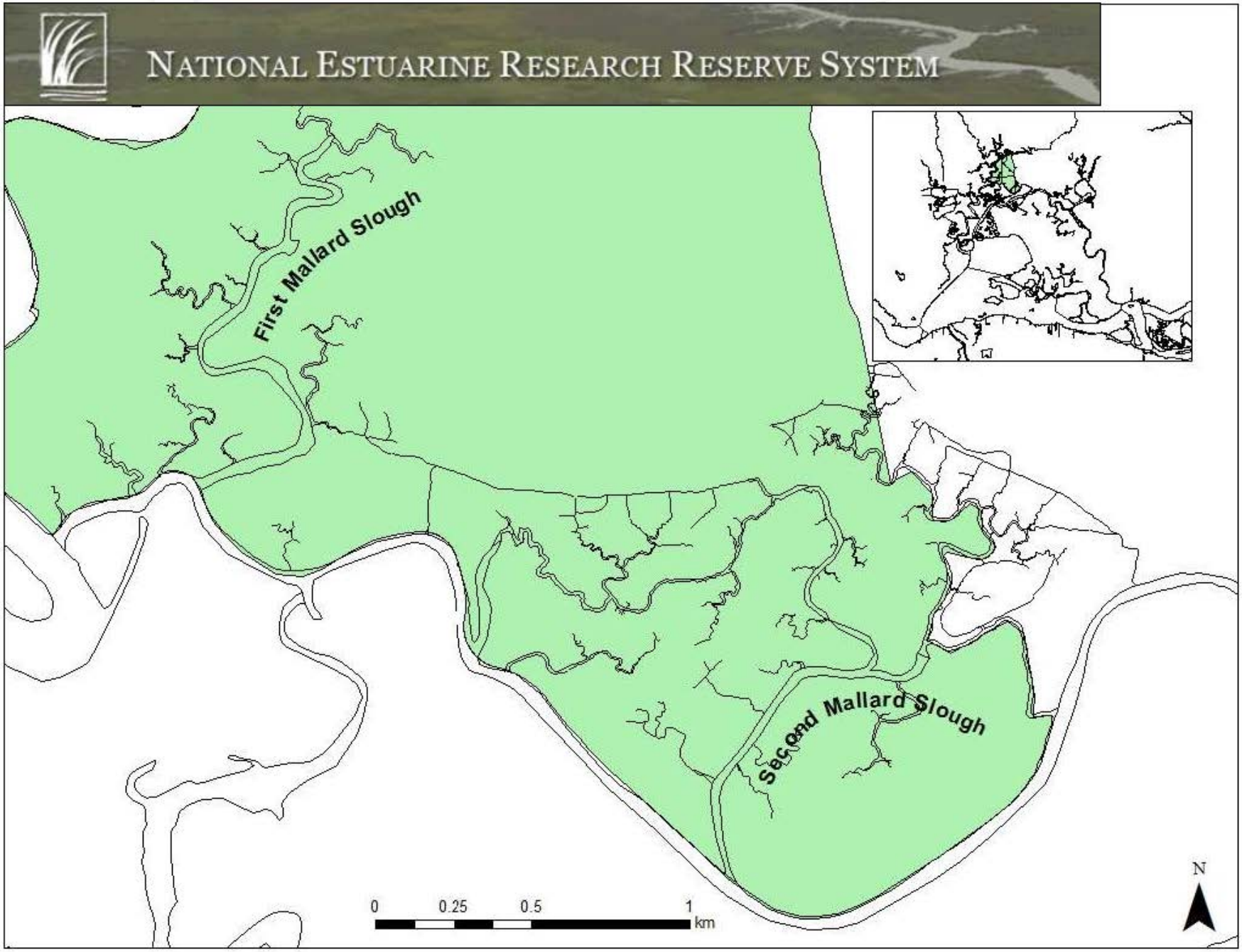
***Trophic relay hypothesis (Kneib)** = Pelagic fish main conduit for carbon transfer to other estuarine habitats*

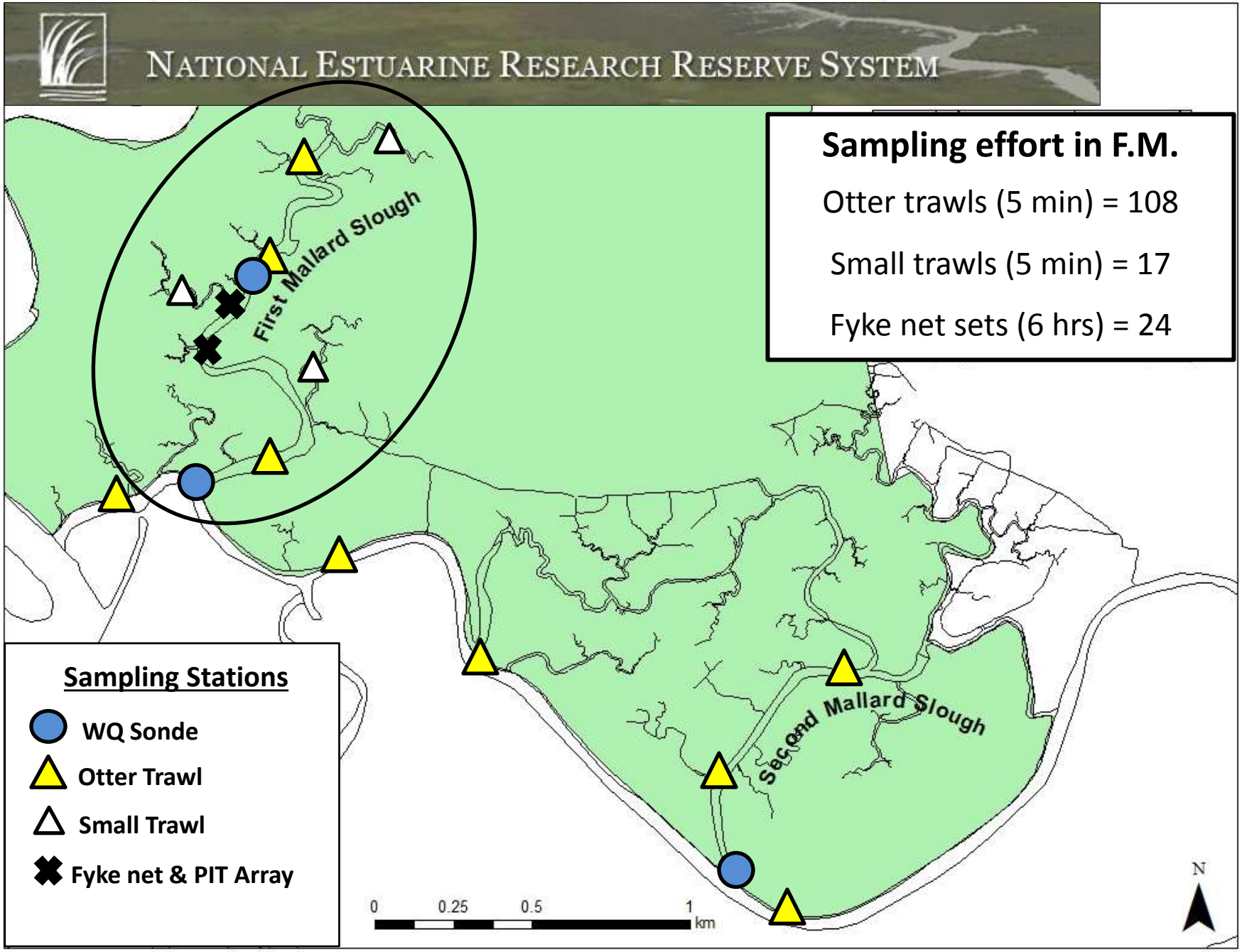


Question: How do fish use intertidal channels that flood & drain with the tide?

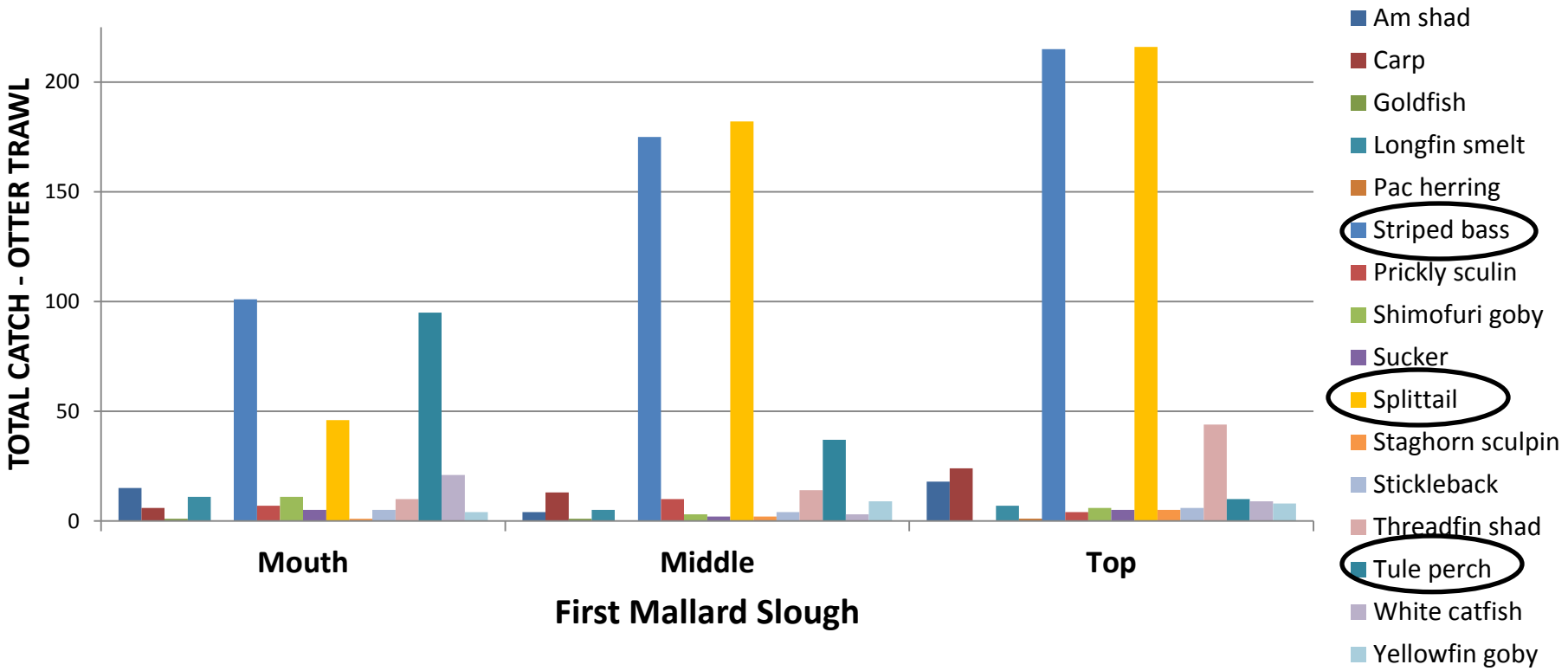
Approach:

- Choose representative pelagic and benthic fish species
  - Common enough to recapture
  - Different life history strategies
  - Rely on estuary in different capacities
- Track their movements into & out of intertidal channels


NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM
First Mallard Slough
Second Mallard Slough
0
0.25
0.5
1
km
N


NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM
Sampling effort in F.M.
Otter trawls (5 min) = 108
Small trawls (5 min) = 17
Fyke net sets (6 hrs) = 24
First Mallard Slough
Second Mallard Slough
Sampling Stations
WQ Sonde
Otter Trawl
Small Trawl
Fyke net & PIT Array
0
0.25
0.5
1
km
N

Most commonly found fishes = Splittail, striped bass, tule perch



Model organisms for movement study

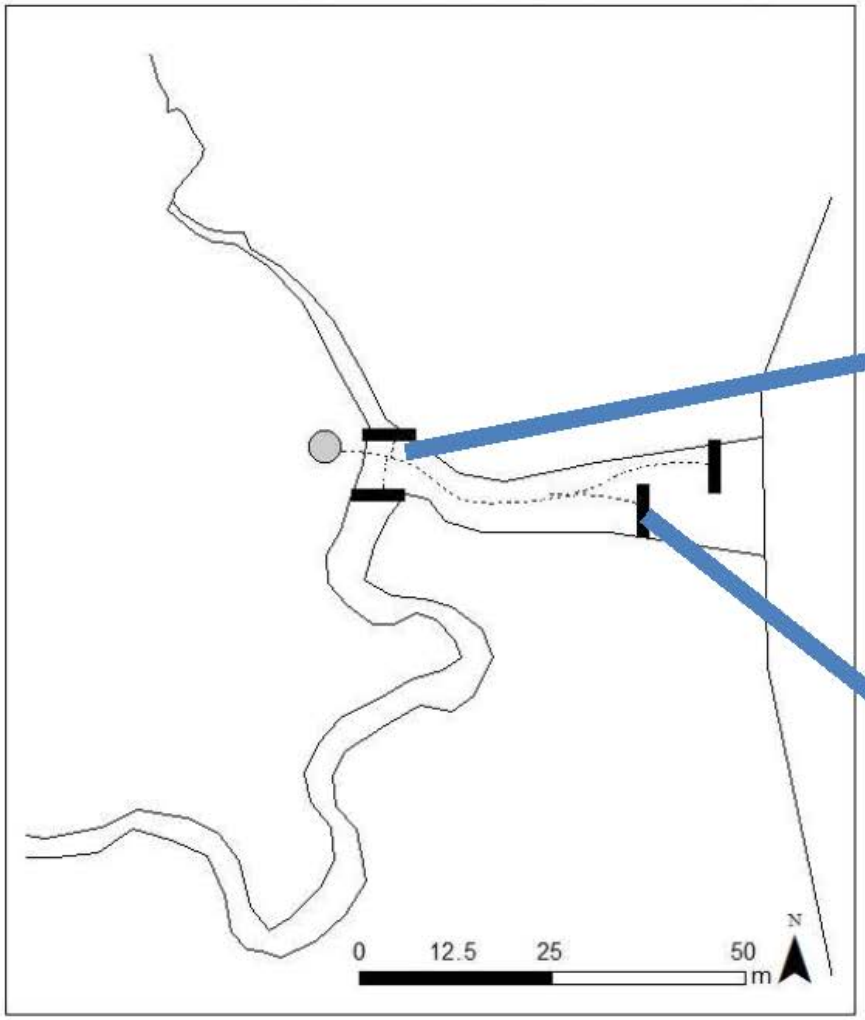
Sacramento splittail (native, benthic)

Tule perch (native, vegetation)

Striped bass (introduced, pelagic)

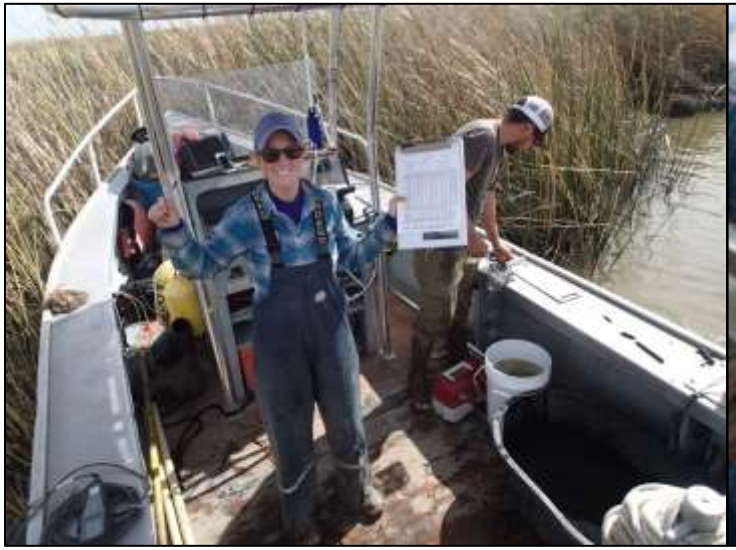
Photo credit: Matt Young & Amber Manfree

Passive Integrated Transponder Array

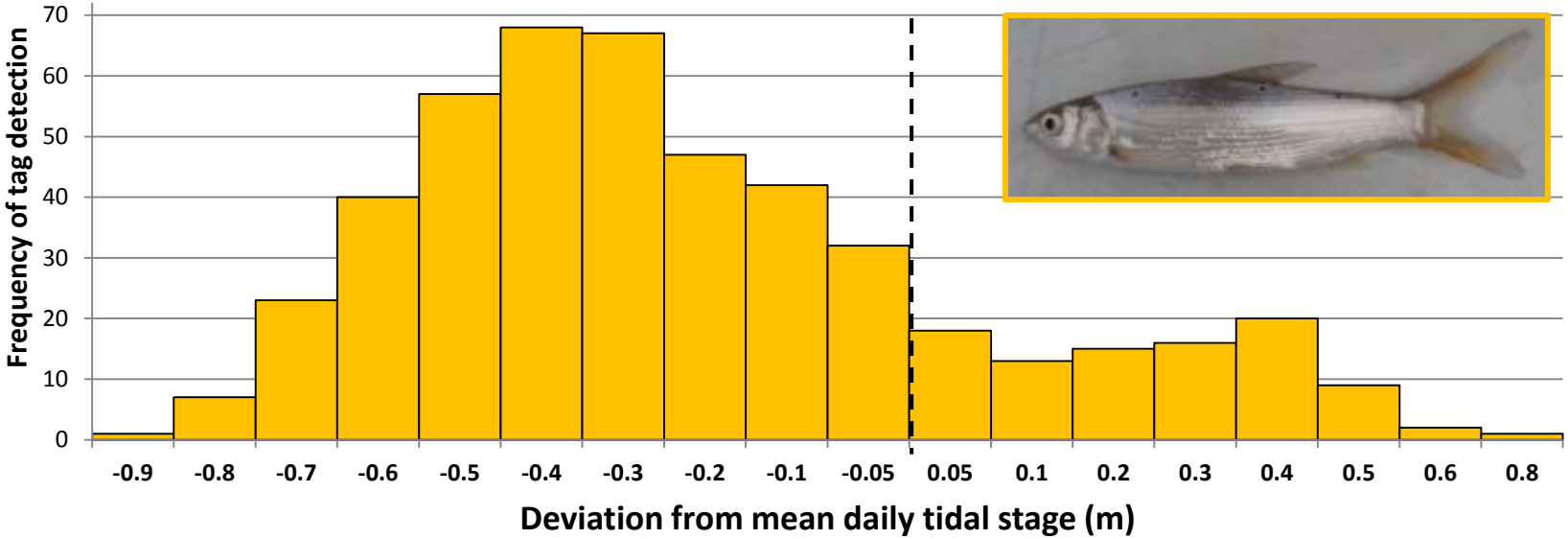


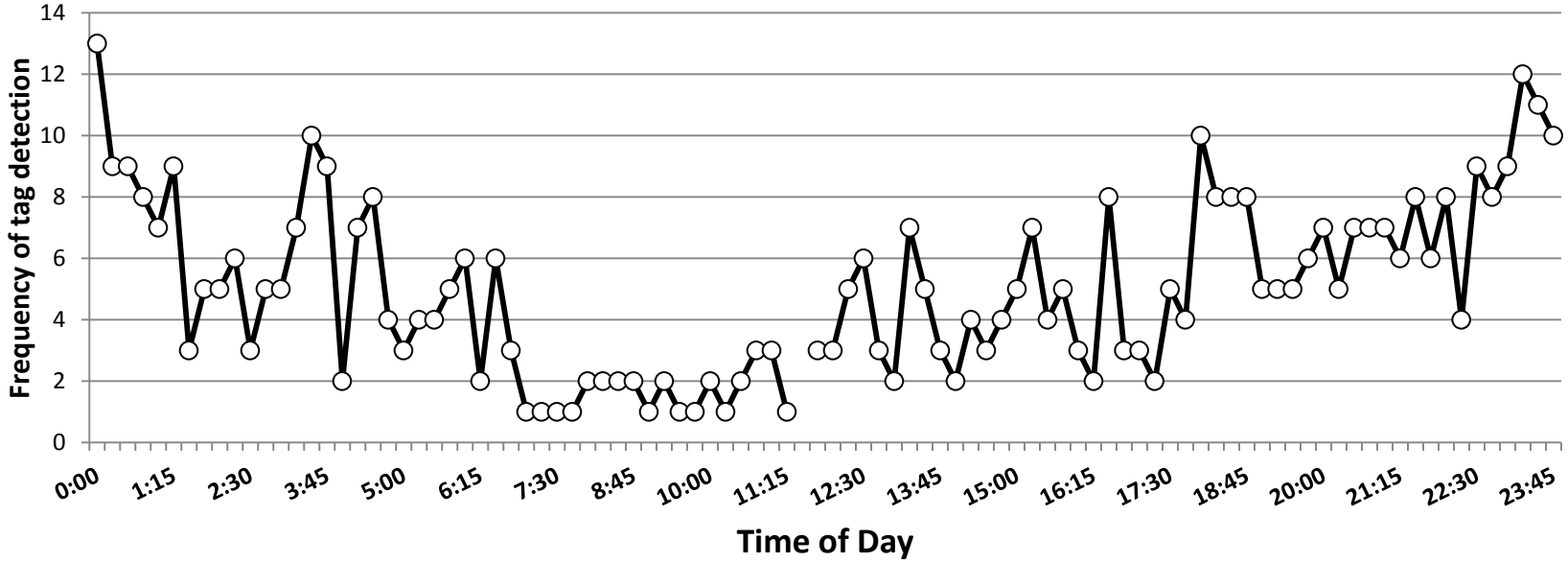
PIT Tagging Effort

SPECIES	#Fish tagged	#Fish detected in array	#Physical recaps	#Detection events (15 min intervals)
Splittail	573	28	5	**476**
Striped bass	135	10	2	**249**
Tule perch	95	7	1	**246**
Total	**804**	**45**	**8**	**971**

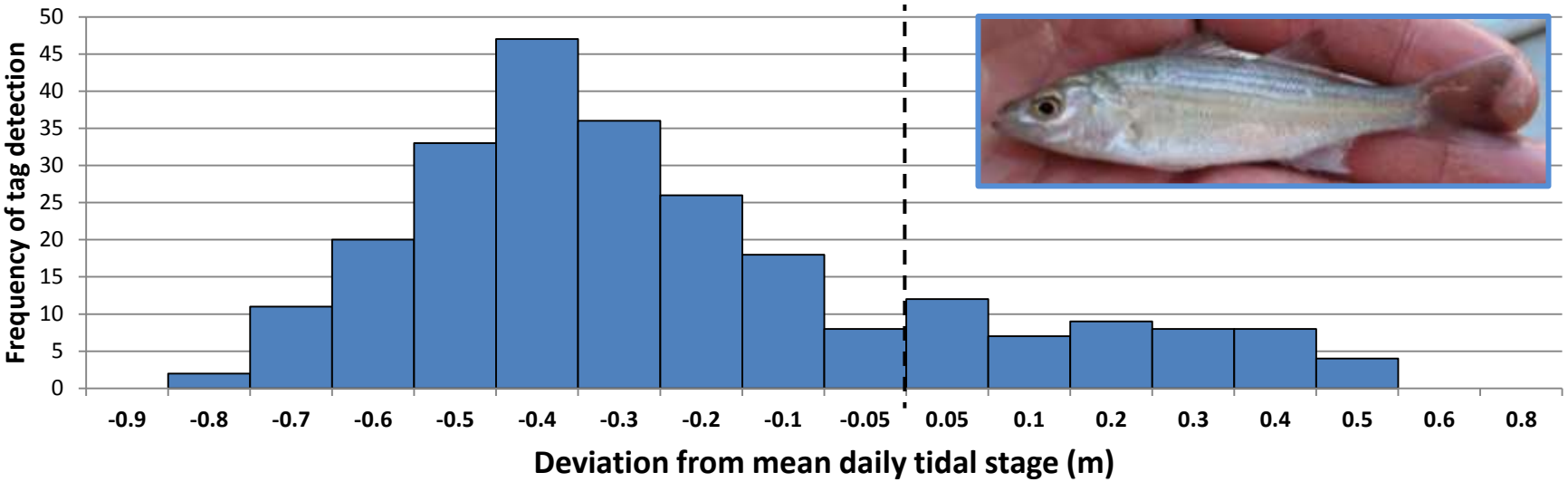


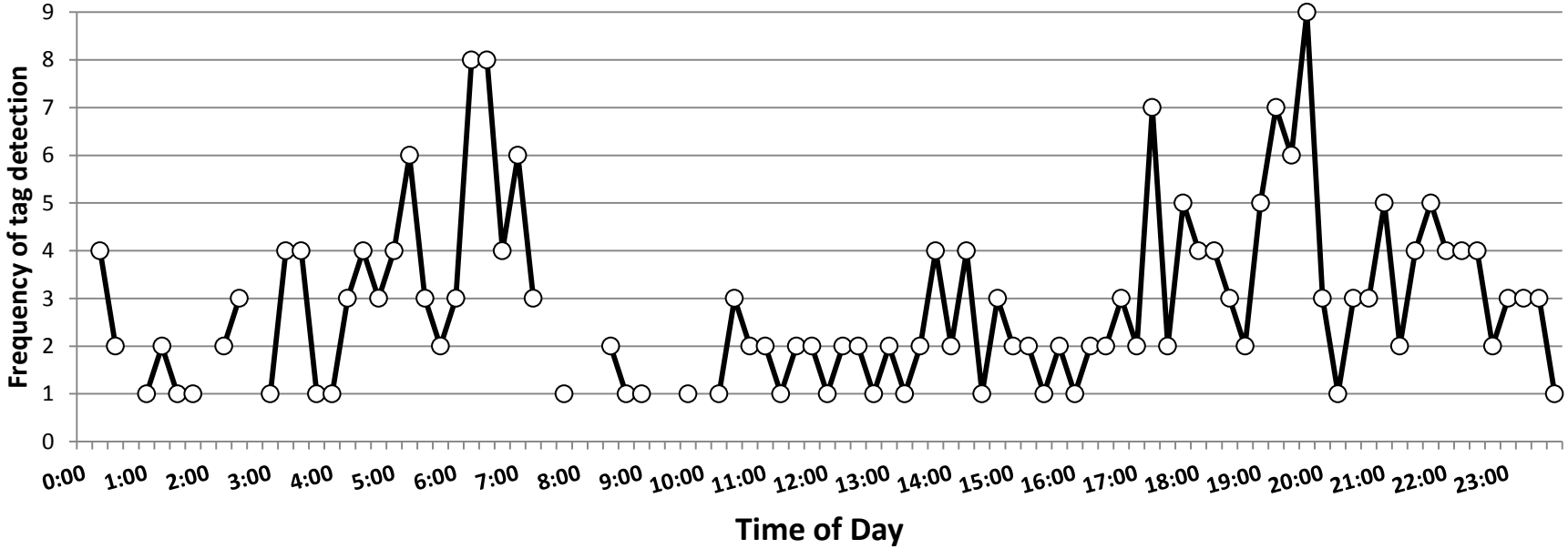
Splittail movements



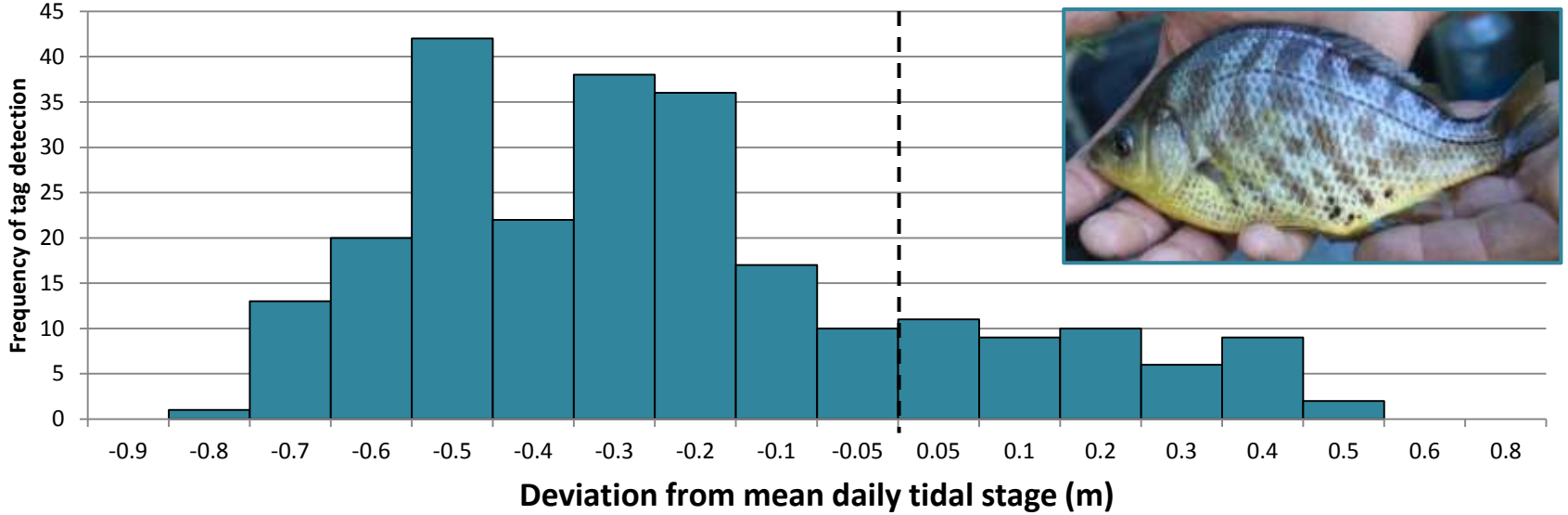


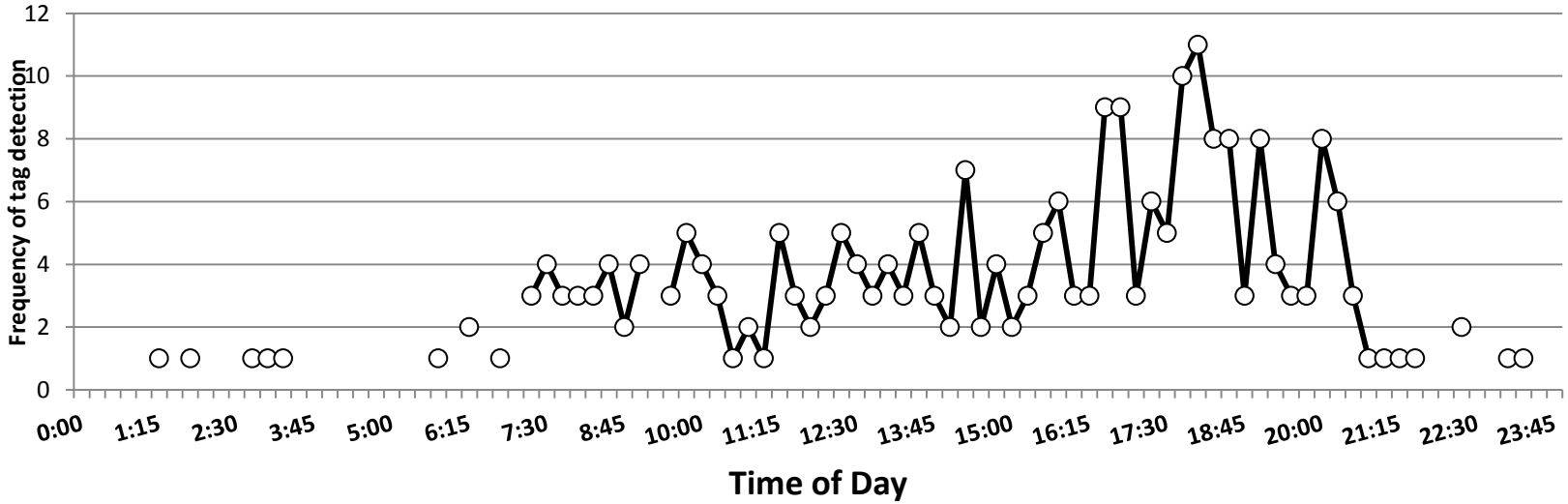
Striped bass movements





Tule perch movements

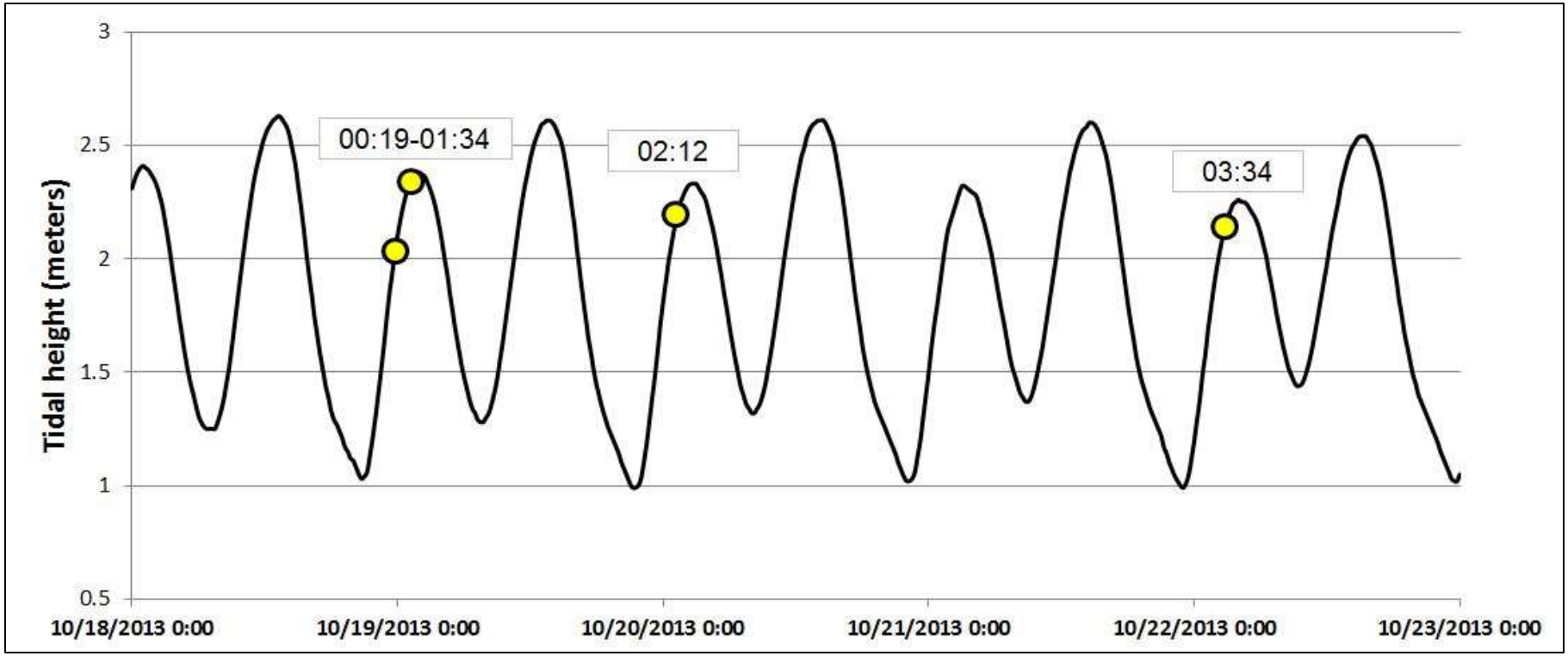




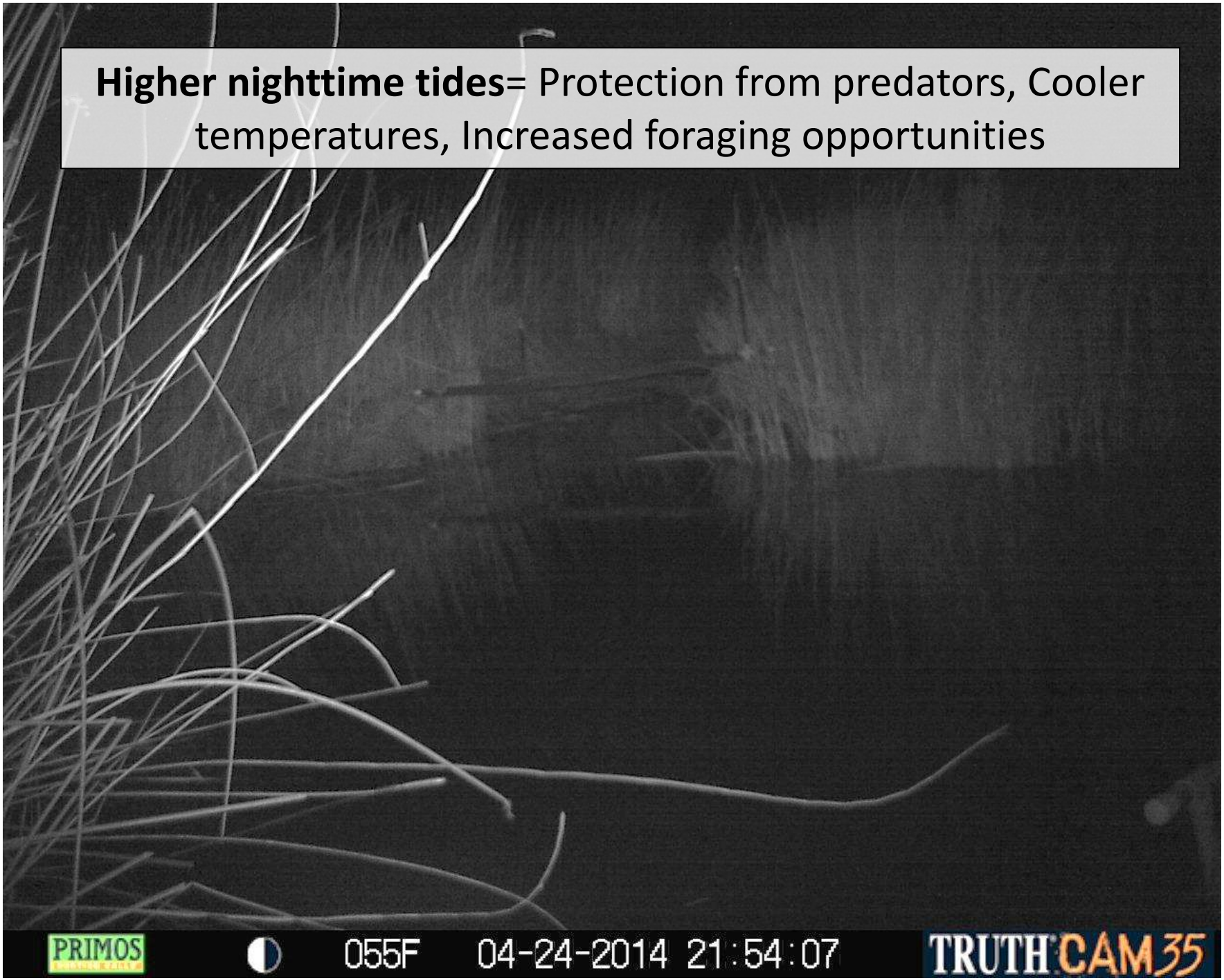
PRIMOS
079F
05-23-2014 11:18:38
TRUTH CAM35

PRIMOS
089F
05-23-2014 17:26:12
TRUTH CAM35

Individual variation in movement patterns



Higher nighttime tides= Protection from predators, Cooler temperatures, Increased foraging opportunities

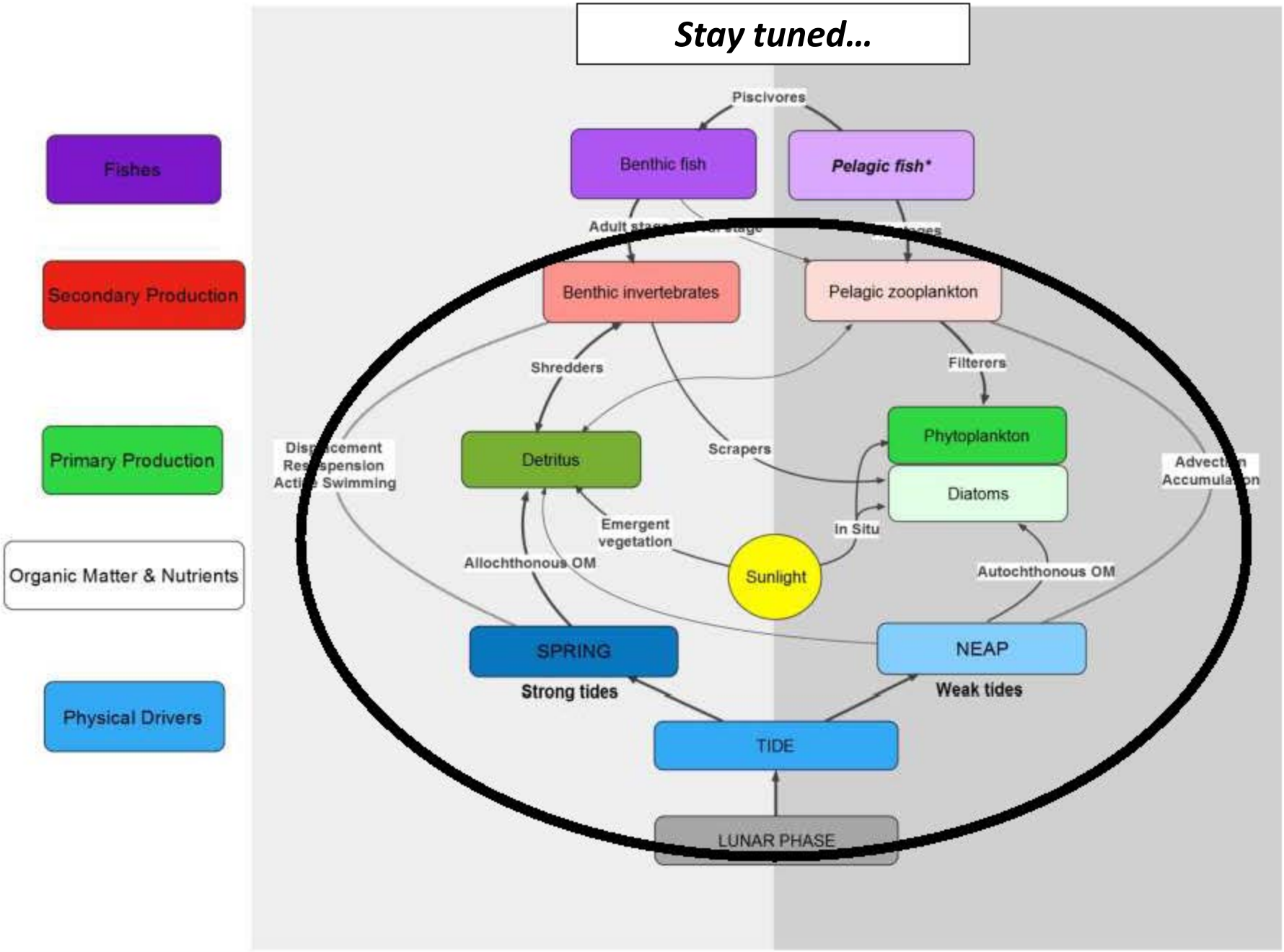


Lower daytime tides = Predation risk (wading birds), Risk of stranding, Higher metabolic costs

What we've learned so far about the fish…

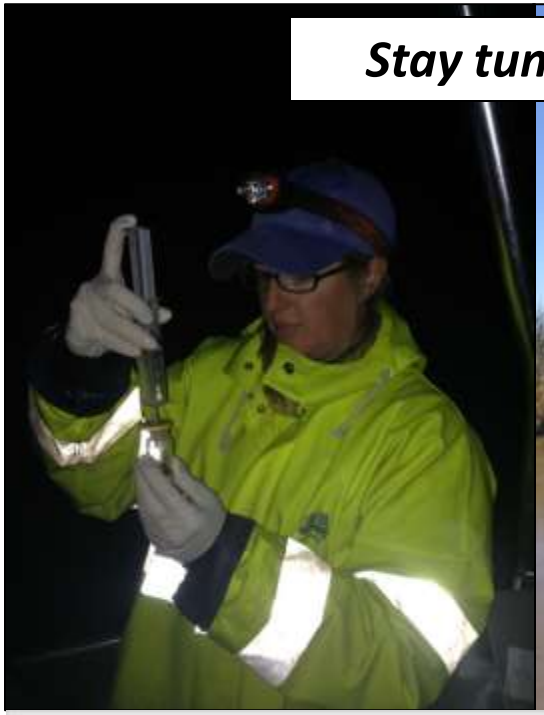
- Fish species display differences in movement patterns into and out of intertidal channels
- Fish tend to use intertidal channels at higher tidal stages
  - Suggests that access to adjacent, deep subtidal sloughs is important for thermal and predator refugia during low tides
- Time of day varies with species
  - Probably due to feeding behaviors and predator avoidance strategies
  - Suggests temporal niche partitioning
- In broader sense, fish are capitalizing on diverse opportunities offered by tidal marshes on daily and tidal time scales in an opportunistic way, i.e., when the conditions are good for them

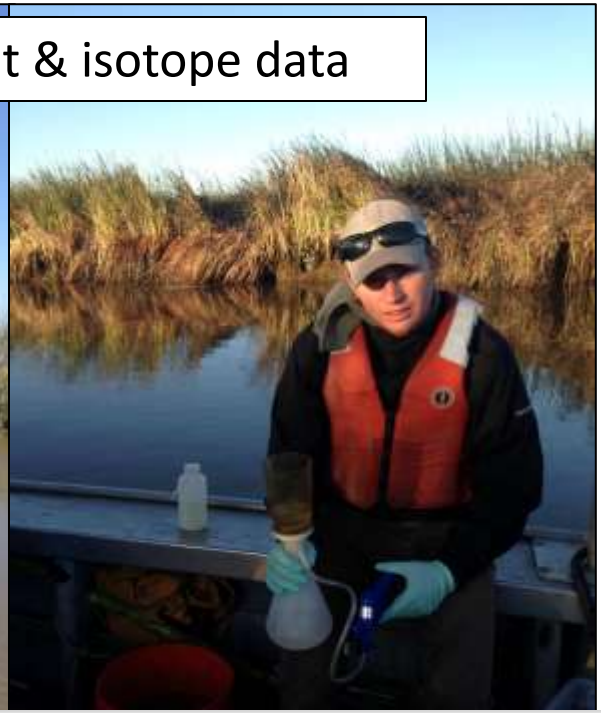
Stay tuned…

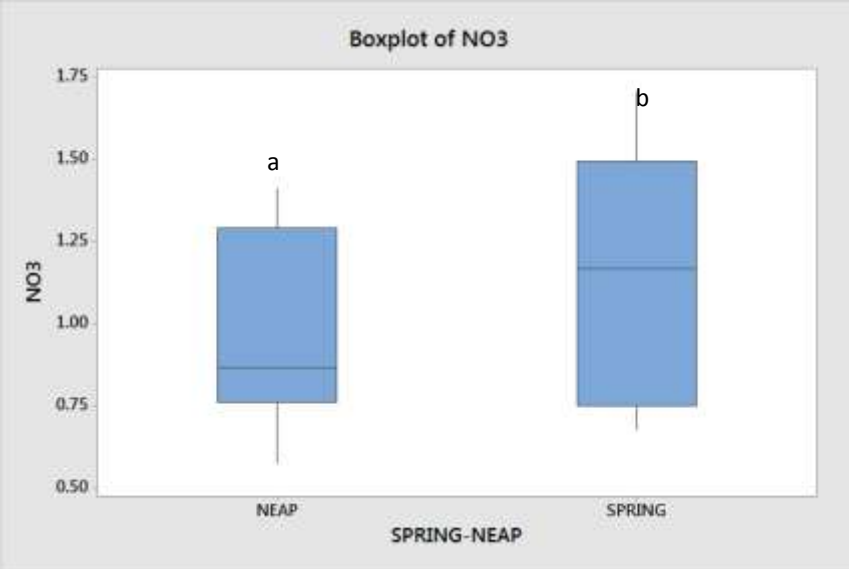

Fishes
Secondary Production
Primary Production
Organic Matter & Nutrients
Physical Drivers
Piscivores
Benthic fish
Pelagic fish*
Benthic invertebrates
Pelagic zooplankton
Shredders
Filterers
Scrapers
Detritus
Phytoplankton
Diatoms
Emergent vegetation
In Situ
Allochthonous OM
Sunlight
Autochthonous OM
SPRING
Strong tides
NEAP
Weak tides
TIDE
LUNAR PHASE

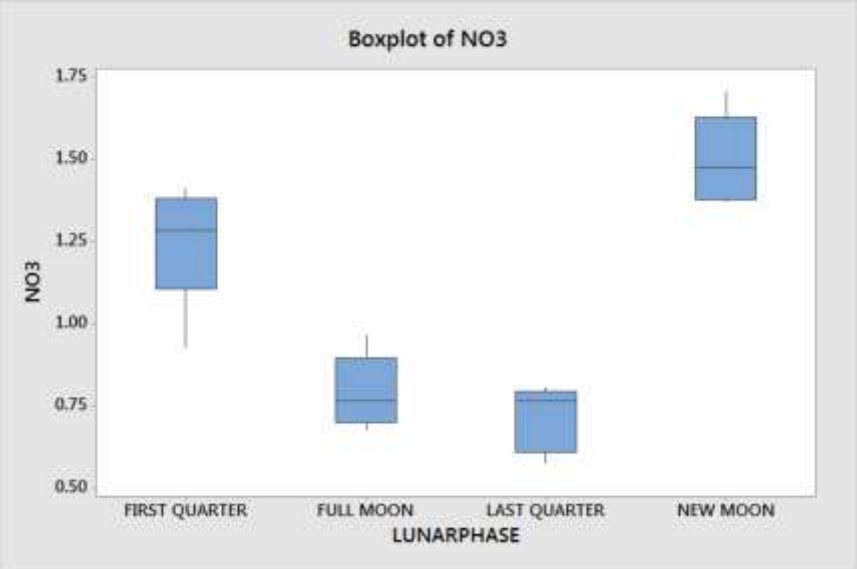
Stay tuned: Zooplankton & benthic macroinvertebrate data

Stay tuned: Water quality, nutrient & isotope data

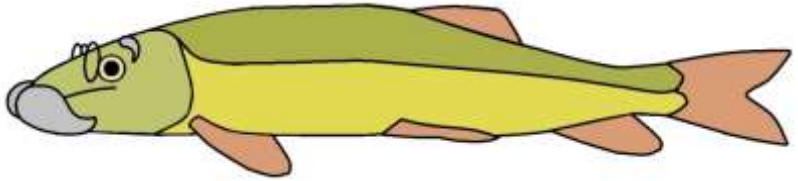








Thank you…



Arc Project: John Durand, Jim Hobbs, Teejay O'Rear, Matthew Young, Brian Williamson, Thomas Handley, K. Martin Perales, Jacob Montgomery, Kathleen Berridge, Felipe La Luz, Amber Manfree, Cathryn Lawrence, Bill Fleenor, Randy Dahlgren, Peter Moyle
Field Junkies: Tommy Agosta, Brian Williamson, Samuel Mosle, Thomas Handley, Patrick Fuller, Gina Benigno, Angelica Munguia, Jasmine Shen, Noble Webster, Elizabeth Reynolds
PIT Tag Array Support: Carson Jeffres, Chris Adams, Jon Cook, Al Colombano

Thank you for funding & support

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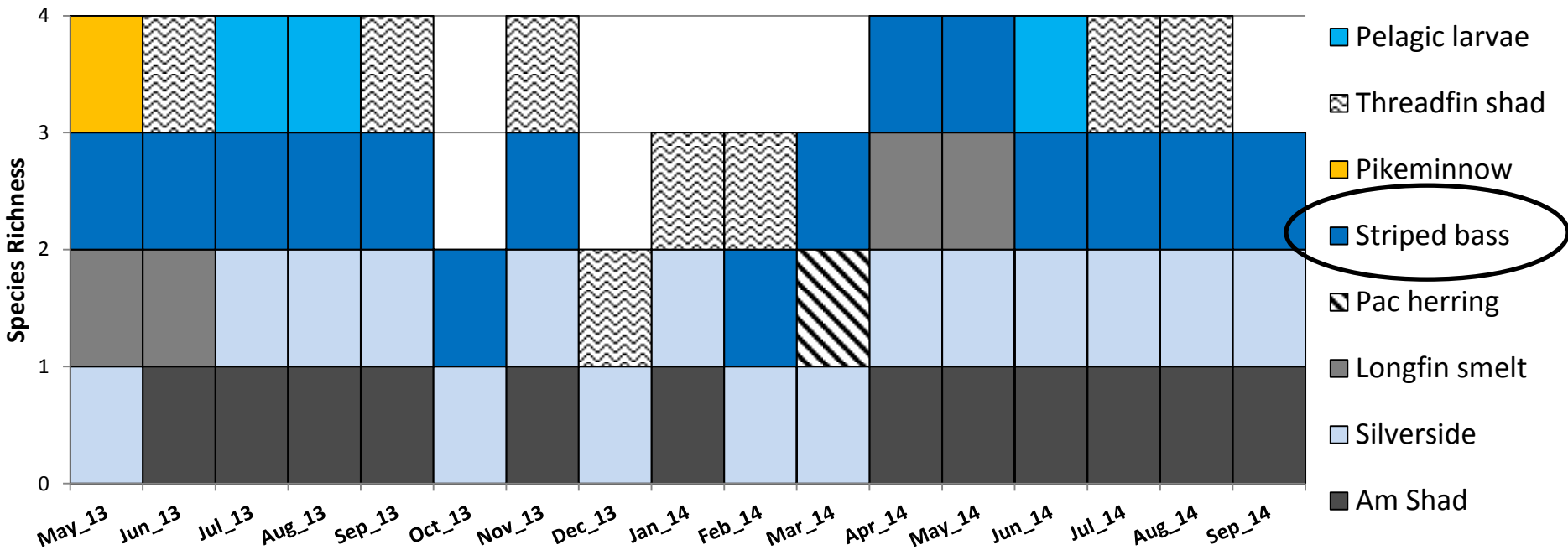
Storm surges also raise water levels and exchange across marsh platform

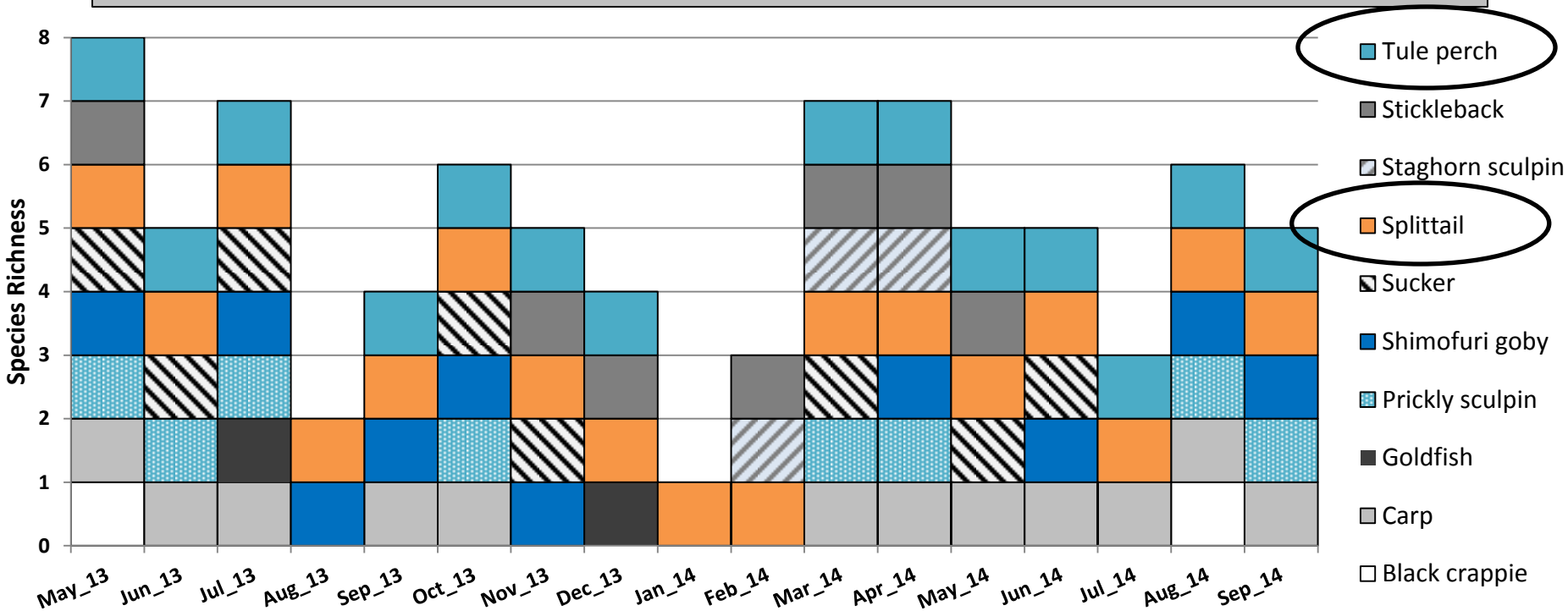
More PIT Tagging Information

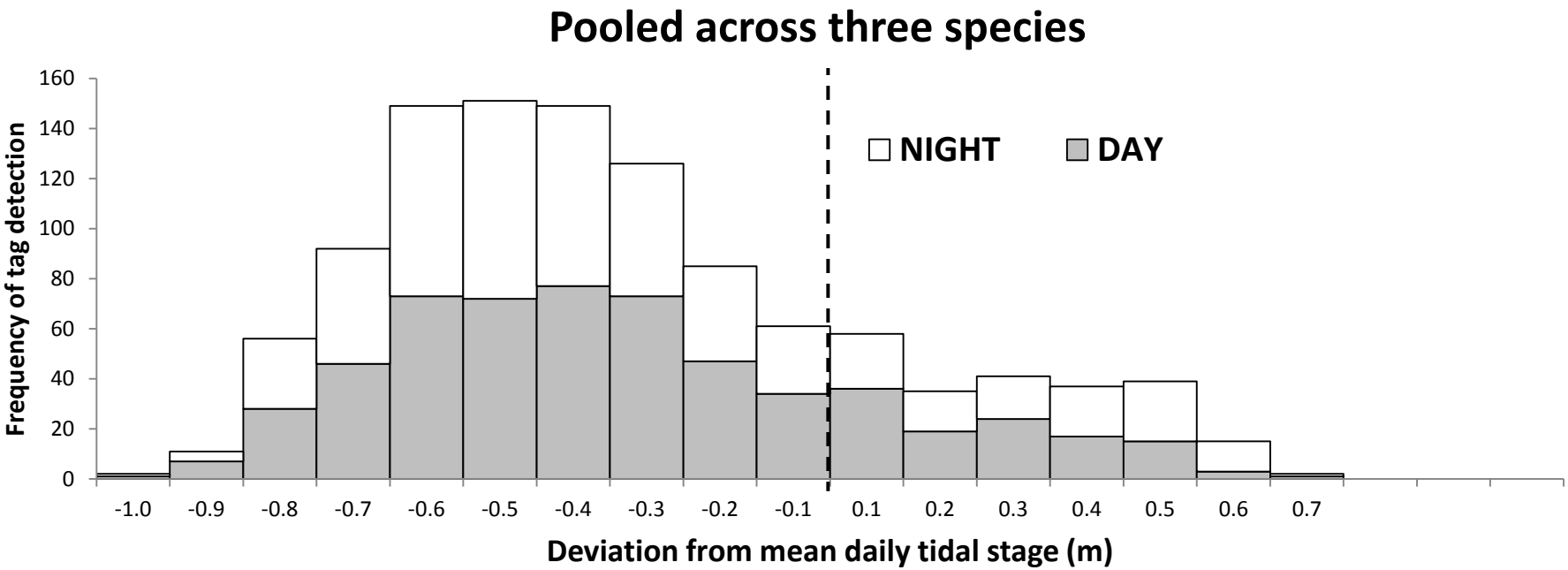
SPECIES	SL(mm) Range	Mean SL (mm)	#Fish tagged	#Fish detected in array	#Physical recaps	#Detection events (15 min intervals)
Splittail	70-335	160	573	28	5	**476**
Striped bass	80-720	162	135	10	2	**249**
Tule perch	100-210	130	95	7	1	**246**
Total	**70-720**	**~150**	**804**	**45**	**8**	**971**

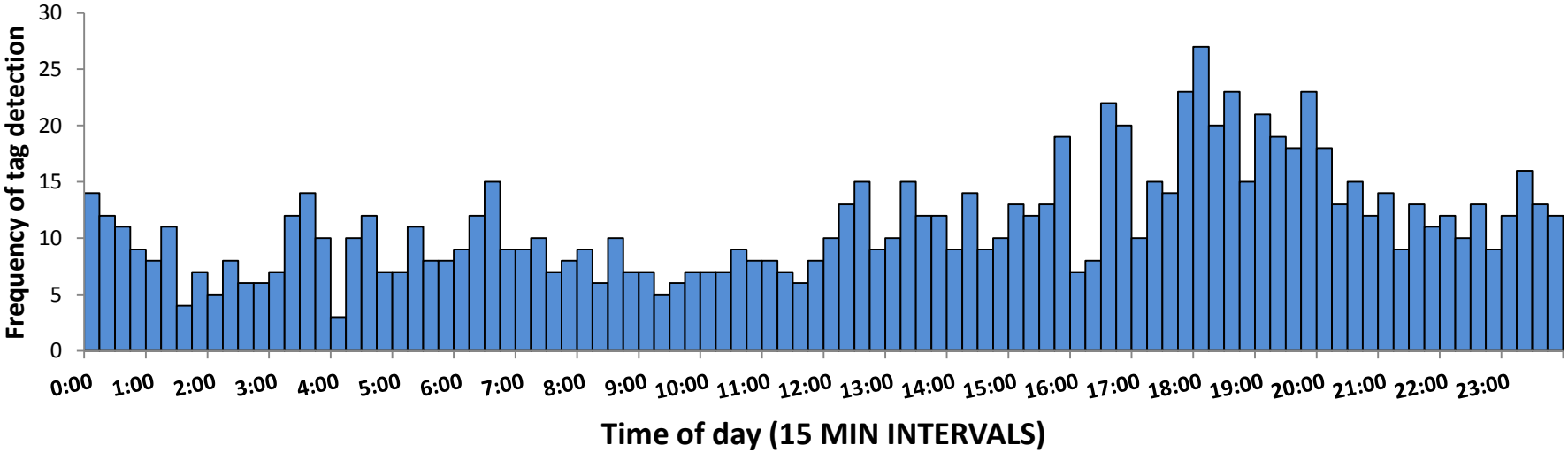
Pelagic Species Richness



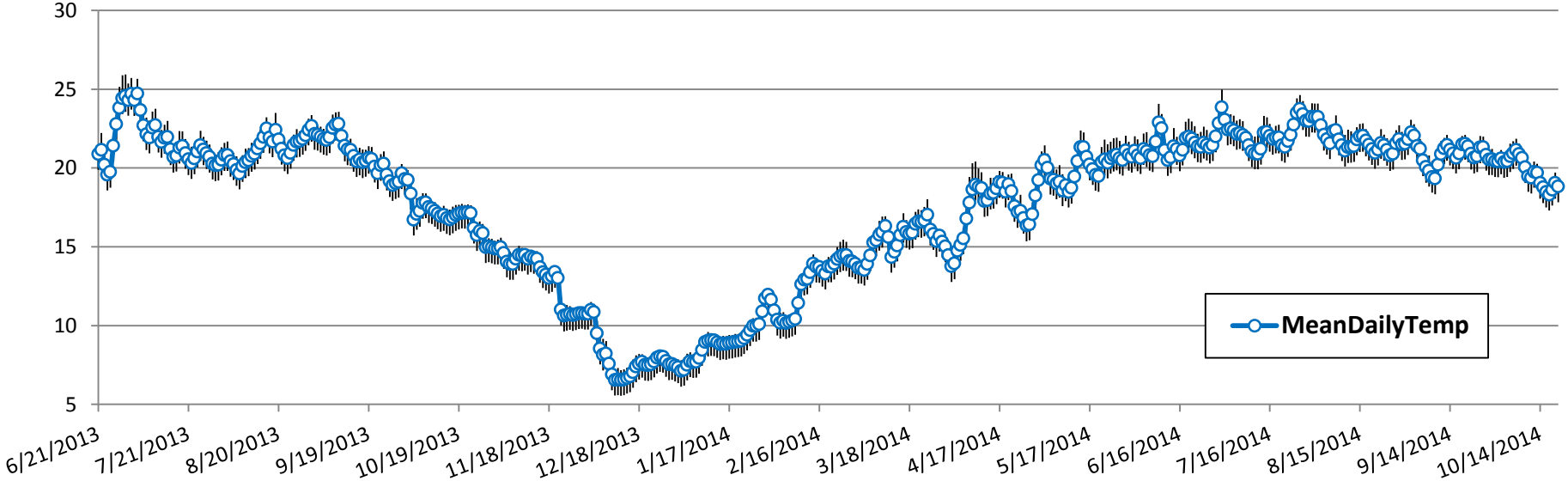
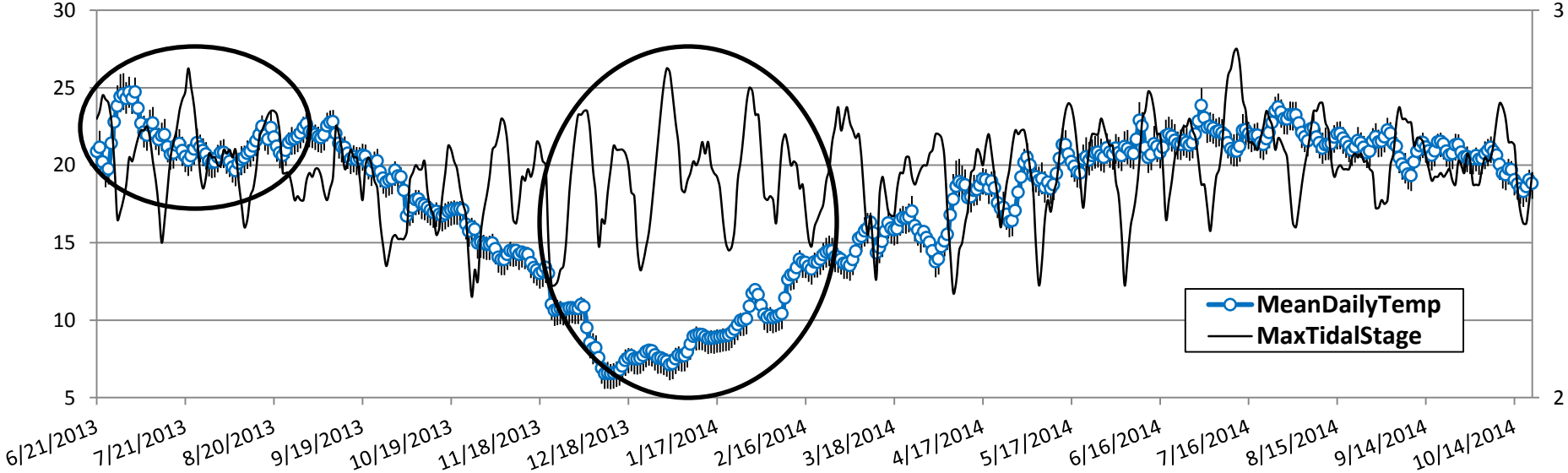
Benthic Species Richness




Pooled across three species
NIGHT
DAY
Frequency of tag detection
160
140
120
100
80
60
40
20
0
-1.0
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Deviation from mean daily tidal stage (m)


Frequency of tag detection
30
25
20
15
10
5
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
Time of day (15 MIN INTERVALS)

Temperature changes over seasonal time scales



Temperature changes over seasonal + tidal time scales