Management-driven research to identify optimal piping plover foraging habitats

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ACE Basin National Estuarine Research Reserve

https://www.fws.gov/refuge/Wassaw/wildlife_and_habitat/piping_plover.html
https://www.kiawahisland.org/the-red-knots-are-here/

Management-driven research to identify optimal piping plover foraging habitats

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SCDNR: Environmental Research: Joseph Cowan, Sharleen Johnson, Norm Shea, Denise Sanger
Population Genetics: Cameron Doll, Matt Walker, Katherine Silliman, Tanya Darden

Outreach: Abi Locatis Prochaska

Wildlife: Janet Thibault

Citizen scientist: Mark Andrews, Seabrook Island

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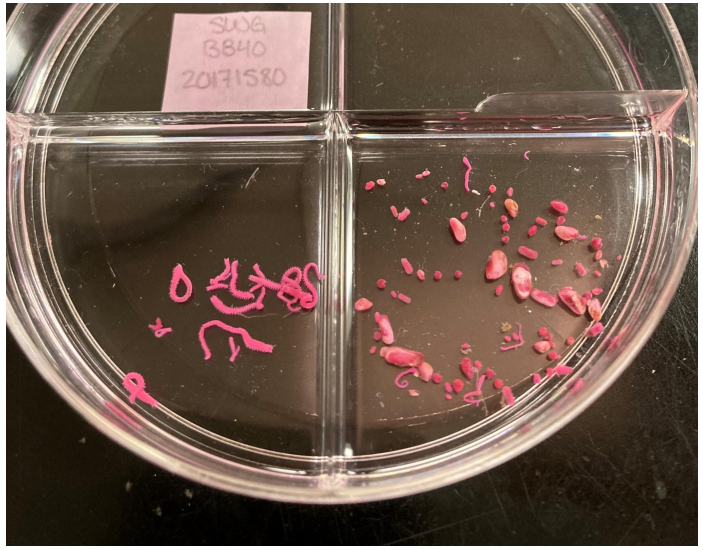
Like many shorebirds, piping plovers rely on SC beaches in winter and during migration


Kawah River

Goals:

1. To improve our understanding of winter SC piping plover diet and foraging site selection
2. To inform beach management and the coastal permitting process by developing a tool to quantify foraging habitat value for piping plovers



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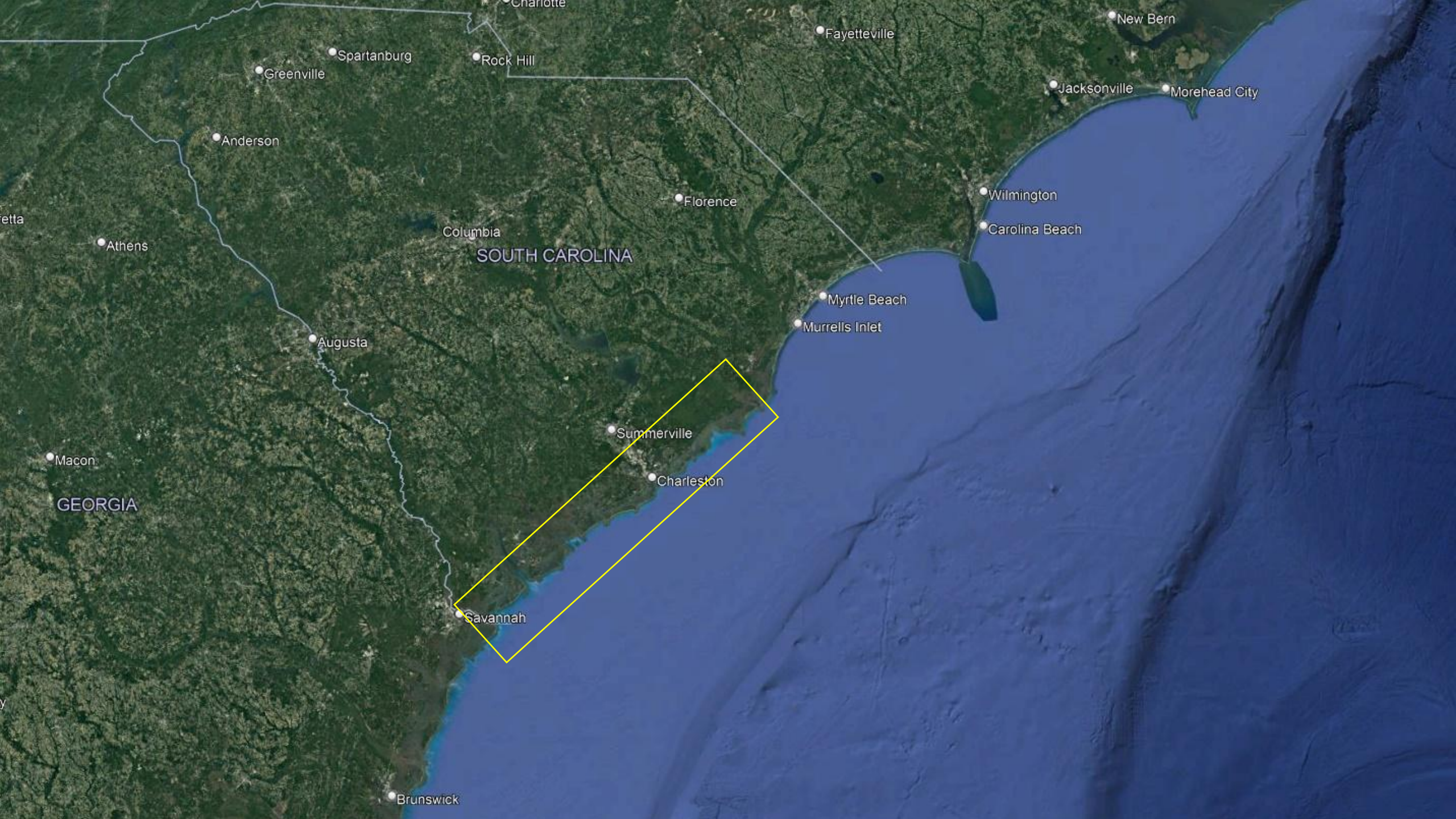

Charlotte
Fayetteville
New Bern
Spartanburg
Rock Hill
Greenville
Jacksonville
Morehead City
Anderson
Florence
Wilmington
Columbia
Carolina Beach
Athens
SOUTH CAROLINA
Myrtle Beach
Murrells Inlet
Augusta
Summerville
Macon
Charleston
GEORGIA
Savannah
Brunswick

First step: Synthesize existing USFWS and SCDNR data

- Compile 7,000+ piping plover foraging locations in SC, 2008-2021
- Compile all DNR benthic data + sediment composition + location/elevation data from past projects (2010-2021)

Kiawah East End

Captain Sam's Inlet

Deveaux Bank

Edisto Beach

Hunting/Harbor Islands

Hilton Head Island

Foraging and roosting data examples

Existing benthic and environmental data

2016 State Wildlife Grant

Captain Sam's Inlet Relocation

Next step: Collect new data at variety of foraging hotspots

- Prey (benthic infauna)
- Sediment composition (% silt/clay)
- Elevation surveying (tidal exposure)
- UAV imagery/elevation maps
- Plover fecal samples (diet)


Kiawah Island
Captain Sam's Inlet
Seabrook Island

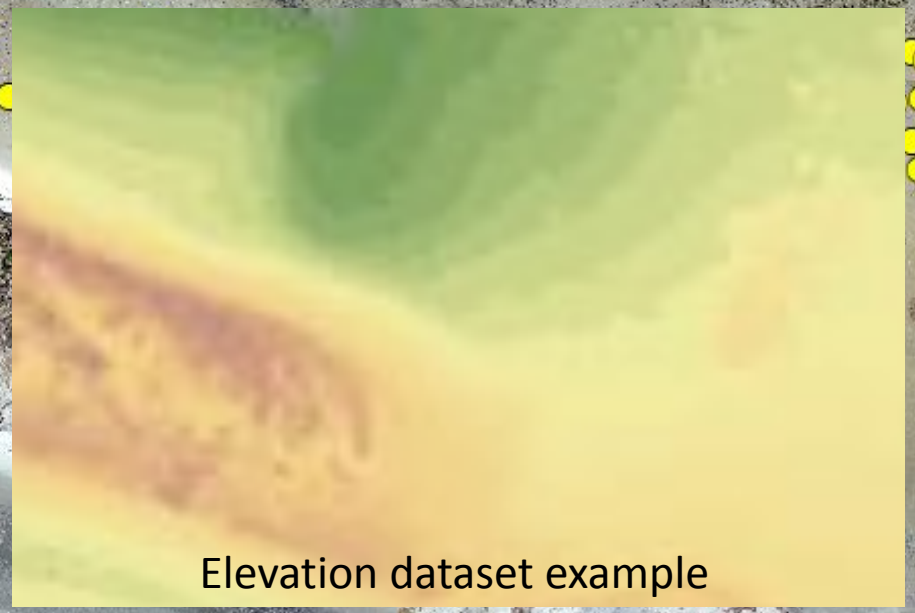
Captain Sam's Inlet

- Sheltered flats
- Isolated depression
- Exposed flats
- Red knot foraging area

High resolution imagery example

Deveaux Bank

- sheltered flats
- *Spartina* flats



Elevation dataset example

Hunting Island

- Sheltered flats (2)
- Runnels (3)

What are they eating?

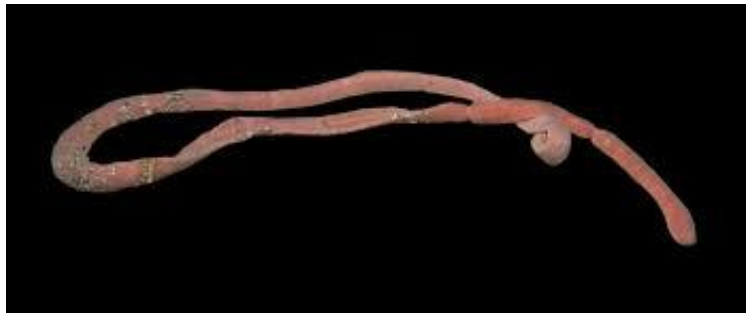
- Past studies, 2010-2020:
  - Examination of stomach contents of opportunistically-collected deceased birds (in collaboration with USFWS)
  - Examination of fecal samples for body parts (e.g., worm mouth parts), SCDNR
  - Comparative studies of available benthos between foraged and non-foraged area, SCDNR

What are they eating?

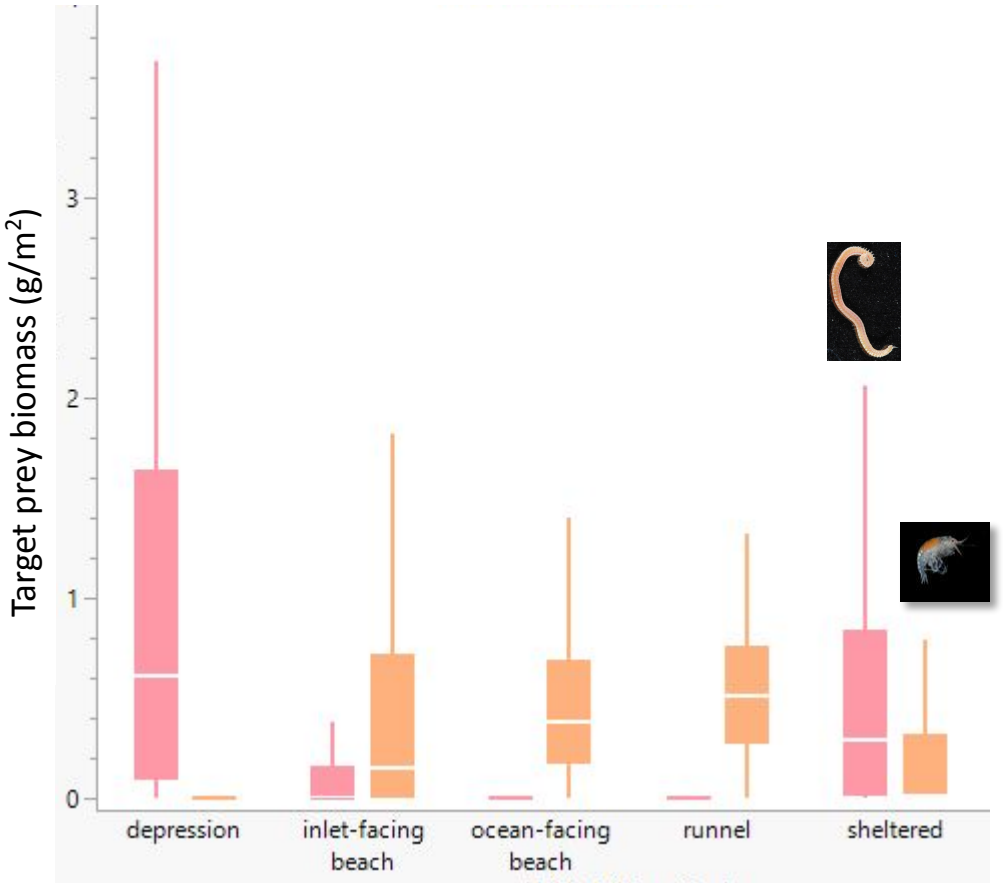
- Amphipods (3 dominant species)
- Polychaete worms (2 dominant species)
- Nemertean worms
- Insects (larvae or adults)

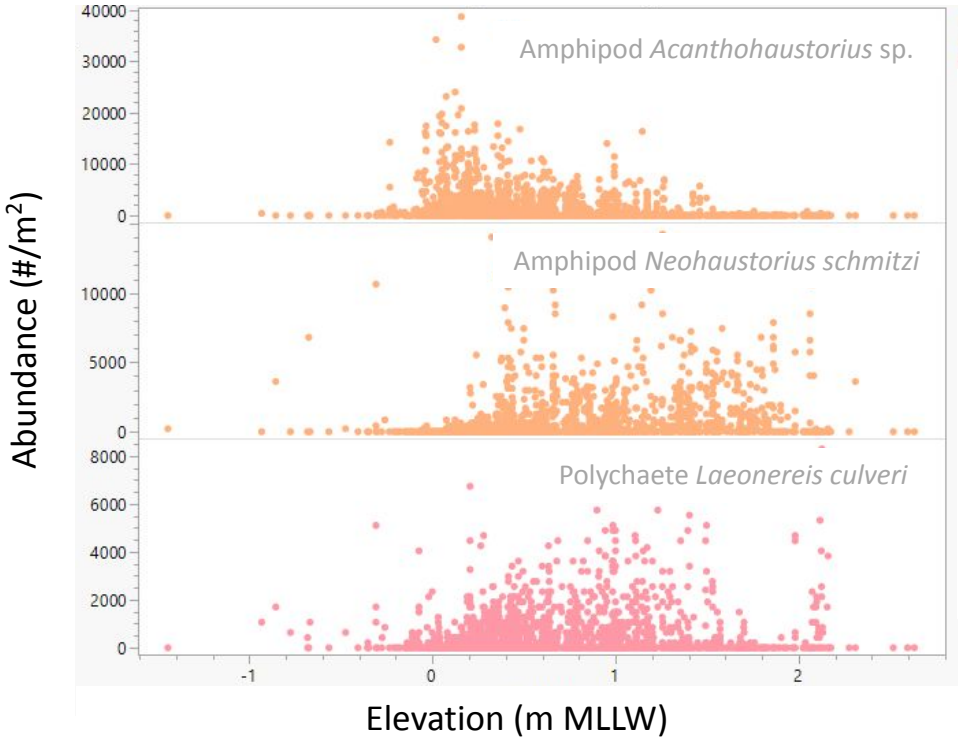
Average 0.34 mg

Average 0.79 mg



Where do these occur?





Low, rippled sand flats

High, runnels or smooth flats

Usually high, mudflats or depressions

Site selection factors

- ANOVA revealed foraging bird density correlated to:
  - Prey density (high worms or amphipods = more birds)
  - Elevation (higher = more birds)
  - Silt/clay (higher = more birds)

  - And… it ranked habitats by usage:
    - Depression > sheltered flats > runnel > inlet beach > ocean beach

  - But just knowing the habitats are different still leaves something to be desired
    - (in other words… WHY are they different… what is missing from the model?)

ANOVA: Adj $r^2 = 0.28$, $F_{(9,3130)} = 133$, $p < 0.0001$ model and variables. Tukey HSD to distinguish habitat types.

Accounting for biomass

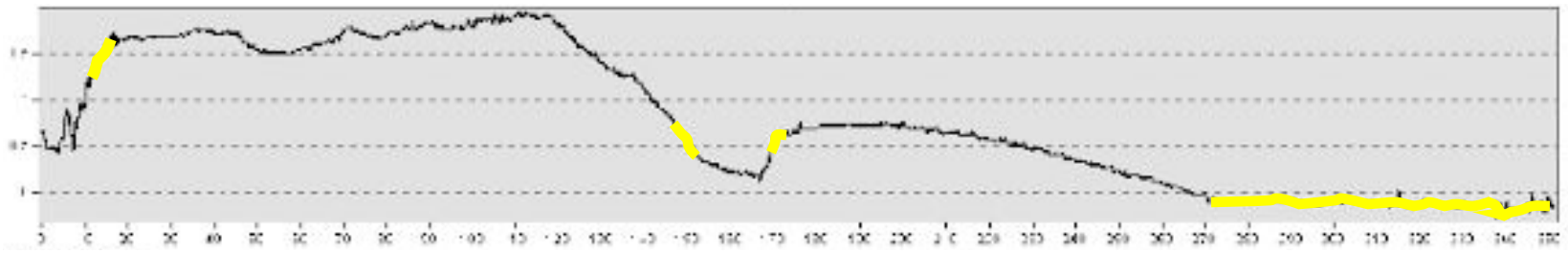
- We also know that prey varies in terms of its biomass (AFDW)… one worm can weigh more than three times an amphipod
- We assume it is energetically preferable to forage fewer large items than many small items

Taxonomic group	Avg. AFDW (mg)	Individuals contributing to analysis
Nemertea	**0.15**	
Nemertea (body fragments)	0.15	5
Haustoriidae	**0.23**	
Acanthohaustorius sp.	0.34	113
Neohaustorius schmitzi	0.24	36
Protohaustorius wigleyi	0.13	43
Polychaeta	**0.51**	
Laeonereis culveri	0.79	48
Alitta succinea	0.23	16

Accounting for exposure

- And some of these habitats are very high in the tidal frame, and others are exposed only for a brief period around low tide

Captain Sam's Inlet Elevation Transect

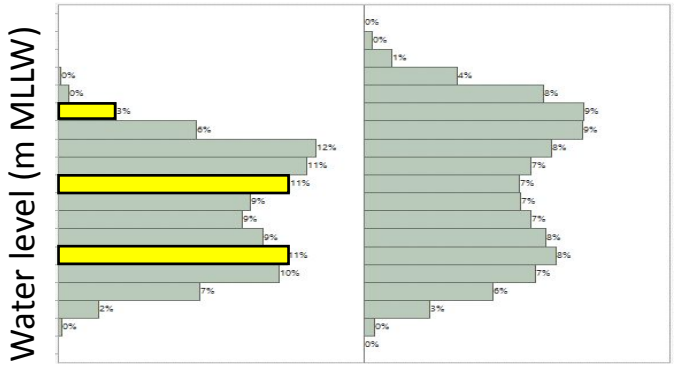


Isolated depression shoreline

Runnel

Sandy flat

Foraging habitats



Winter water level frequency

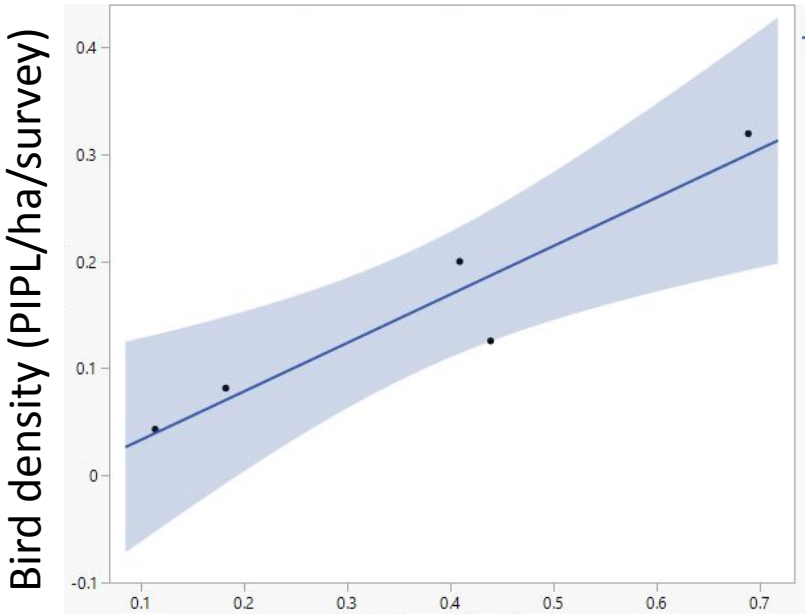
Foraging opportunity

- Biomass x time exposed
  - E.g., 100 g/m^2 amphipods x available 20% of time = 20
    30 g/m^2 amphipods x available 80% of time = 24

- Best single variable to explain bird density

- Then ranked habitats by foraging opportunity
  1. Depression (LS Mean 0.69)
  2. Runnel, sheltered flats (LS Mean 0.44, 0.41)
  3. inlet-facing beach flats, ocean-facing beach flats (LS Mean 0.18, 0.11)

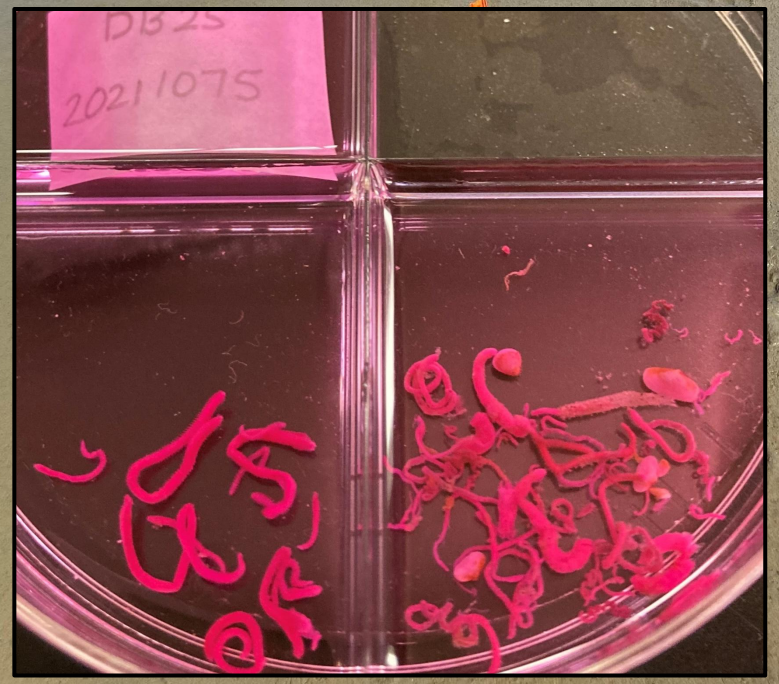
ANOVA $p < 0.0001$, Tukey HSD to distinguish habitat types



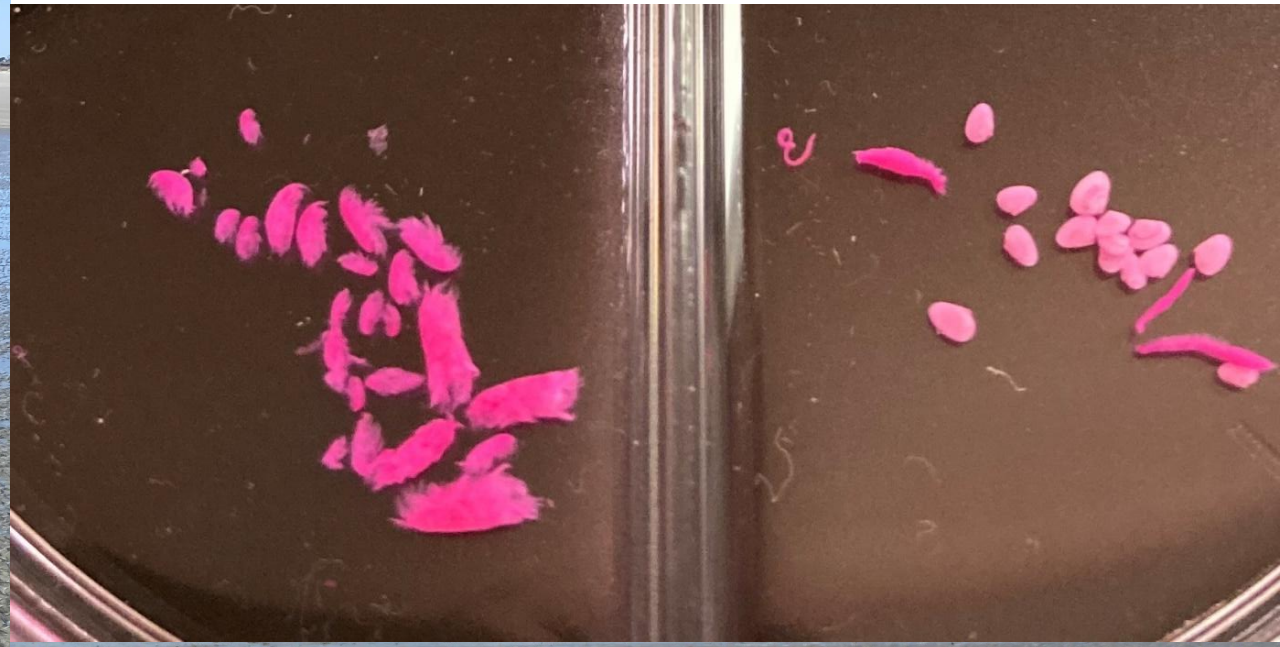
Captain Sam's Inlet

Harbor and Hunting Islands

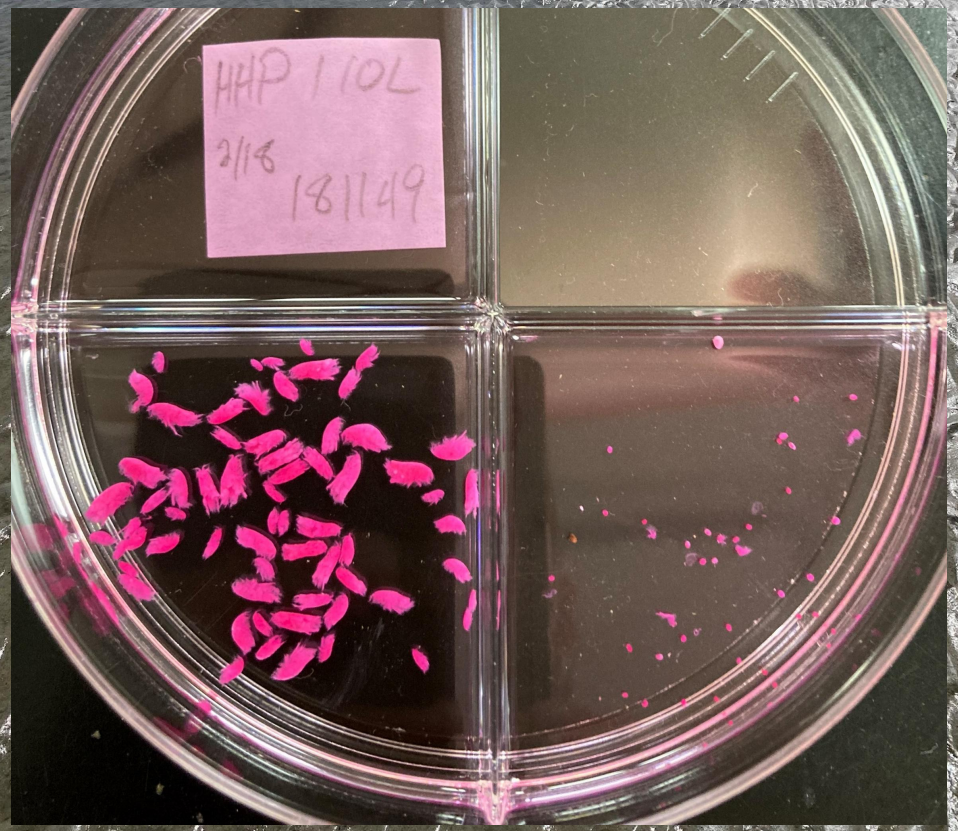
Sheltered flats

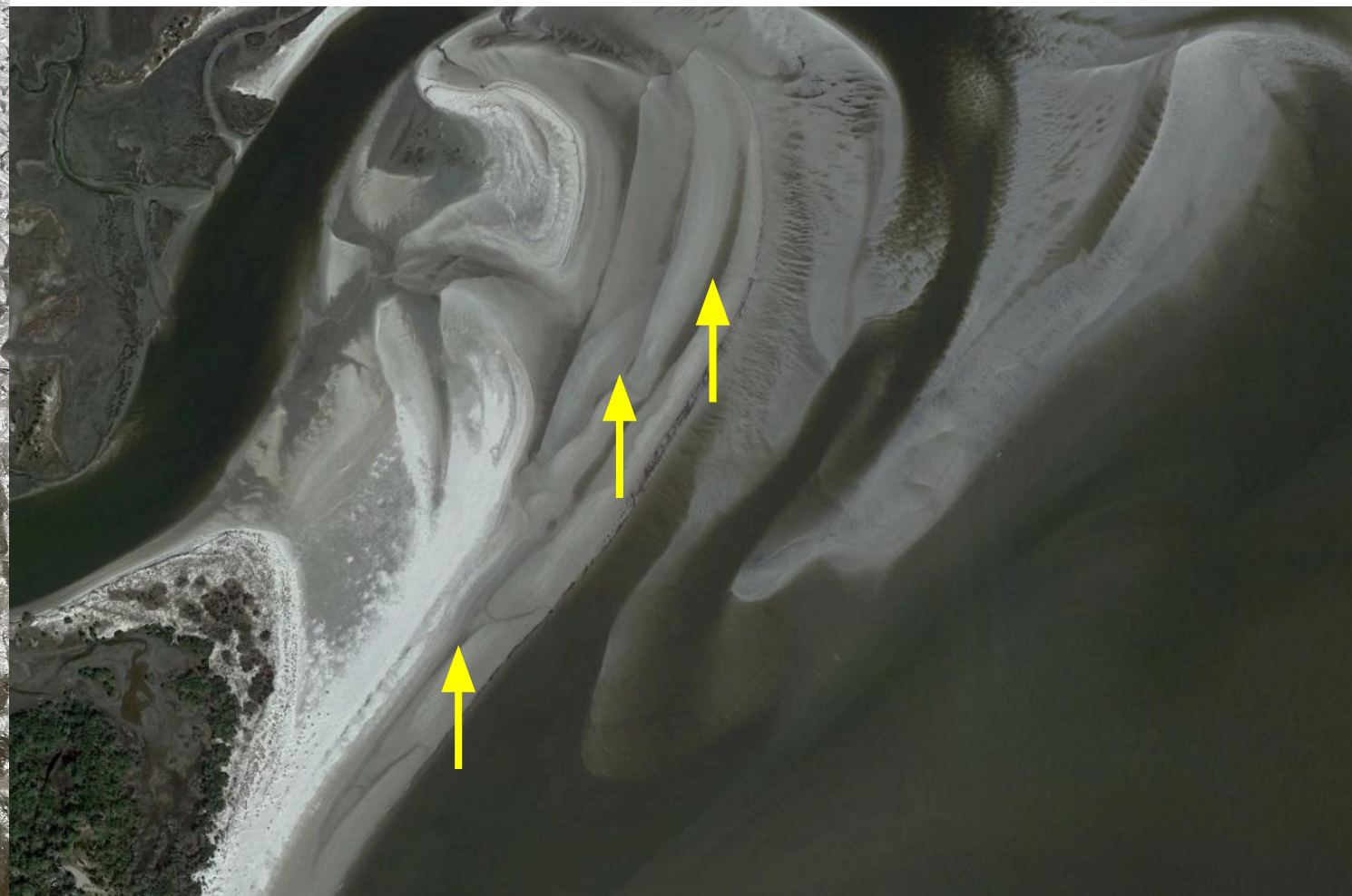


Beach flats



Runnels





Isolated depressions

Habitat assessment products

- Habitat key (coarse scale)
  - Large-scale, identifies major foraging habitat types, ranking, and description of what is unique about them
- Habitat indicator chart/guide (fine scale)
  - Smaller-scale, identifies site-level characteristics associated with foraging activity
  - Provides characteristics associated with more valuable or less valuable varieties
- Disturbance factor assessment
  - Assessment of characteristics that could detract from value

Beach flats

Waves			■	■								Calm
Sandy				■	■	■						Muddy
Amphipods			■	■	■							Worms
Low biomass								■				High biomass
Low bird activity							■					High bird activity
Low in tide frame			■									High in tide frame
Common			■									Rare

Isolated depressions

Waves											■	Calm
Sandy						■	■	■	■			Muddy
Amphipods										■	■	Worms
Low biomass											■	High biomass
Low bird activity											■	High bird activity
Low in tide frame											■	High in tide frame
Common											■	Rare

Runnels

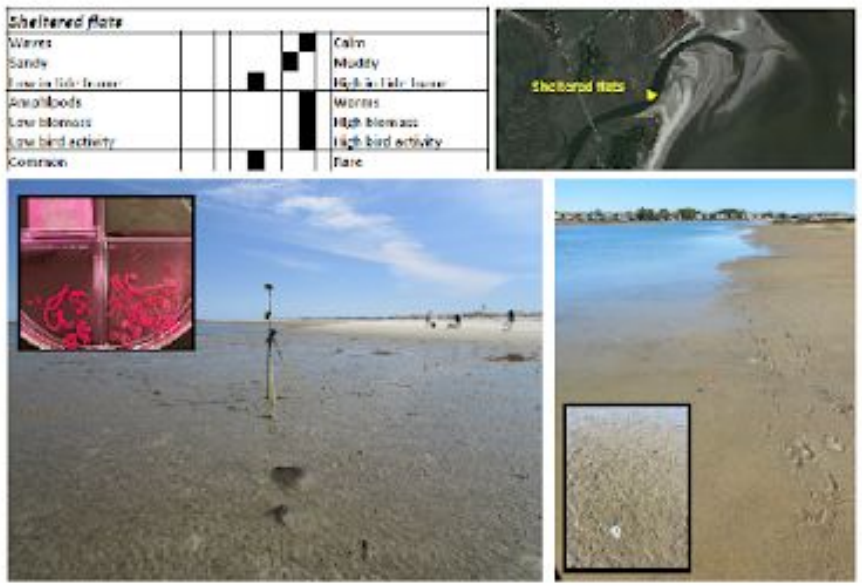
Waves					■	■						Calm
Sandy			■	■								Muddy
Amphipods		■										Worms
Low biomass									■			High biomass
Low bird activity							■	■				High bird activity
Low in tide frame									■			High in tide frame
Common						■	■					Rare

Sheltered mudflats

Waves										■		Calm
Sandy									■			Muddy
Amphipods										■		Worms
Low biomass										■		High biomass
Low bird activity										■		High bird activity
Low in tide frame							■					High in tide frame
Common							■					Rare

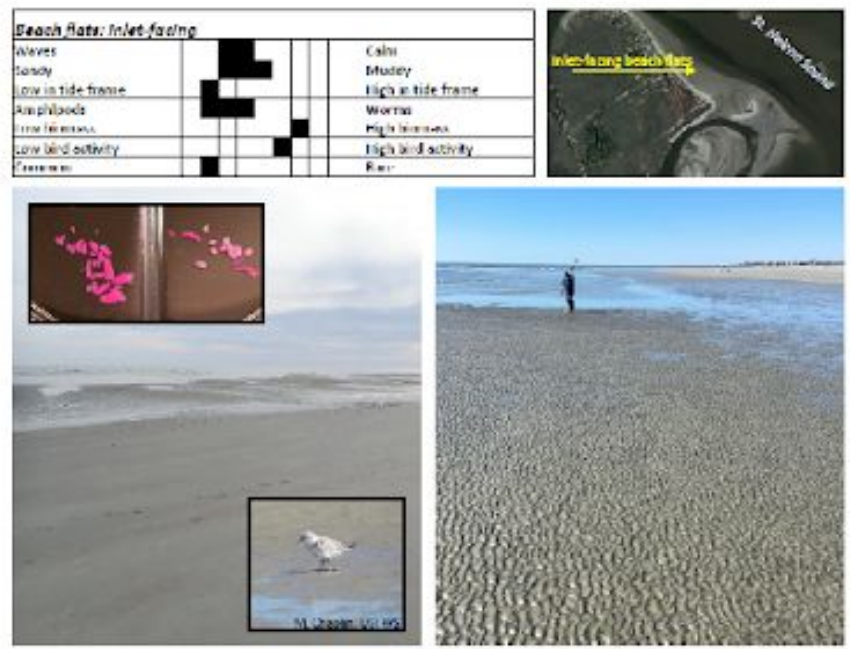
Sheltered flats

Sheltered flats or mudflats develop where wave energy is low, often on the protected side of sand shoals, inlets, or other features that block waves. This allows silts and clays to settle, and this substrate provides a stable, organic-rich, and high-moisture matrix for polychaete worms and other soft-bodied infauna to thrive (μ >1,000 m^{-2}). Silt/clay content is high compared to other habitats (4.3 ± 0.3 %). Elevation is generally moderate (1.1 ± 0.03 m MLLW), providing foraging accessibility over 50% of the tide cycle. These features are often situated near roosting habitats and other foraging habitats which both provide additional value. Signs of benthic infauna (castings, burrows, casings) are often visible, along with other foraging indicators (droppings, footprints). Vegetation, typically *Spartina alterniflora*, is usually absent or very sparse. Available biomass is high, resulting from a combination of dense polychaete community and large individual organism size *(e.g., Laeonereis culveri* μ 0.79 mg AFDW).



Inlet-facing beach flats

These beach flats develop where wave energy is moderate or low, typically on the north end of barrier islands, such as the 'heel' of Hilton Head Island. These flats can be expansive and are relatively common at the landscape scale, but are situated relatively low in the tide frame, exposed about 25% of the time (0.6 ± 0.01 m MLLW). The substrate is often fine sand and sometimes muddy sand. Silt/clay values are usually 1-3%, but are more variable than other habitats and can exceed 10% in small pockets. Tidal currents running across the flats can create a rippled texture, and these areas are associated with high densities of amphipods, especially *Acanthohaustorius* sp. (μ 0.34 mg AFDW), a desirable prey species. Rippled flats may also exhibit worm tubes projecting from the substrate, and some of the highest foraging bird densities have been documented at these areas (e.g., Harbor Island). Non-rippled flats can also provide quality foraging areas, but the prey density is usually lower and supports the haustorid species *Neohaustorius schmitzi* (μ 0.23 mg AFDW). The prey community in either type is dominated by amphipods, with densities exceeding 2,000 m^{-2}, but inlet-facing beach flats are also the most diverse foraging habitat, with polychaetes, pea crabs, and nemertean worms also present in pockets.



Putting it all together

- Locations with a high diversity of habitats offer multiple options for prey and tidal availability

- Most of these habitats are found near inlets
  - Provides complexity
    - multiple options for foraging as well as roosting
- Physical/environmental characteristics are good predictors of prey availability and bird usage (scoring tool)
  - Assessing foraging value for coastal engineering permitting process
  - Informing habitat restoration projects

- Protecting imperiled shorebirds will also depend on mitigating other impacts

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Q&A

Q: How did you engage with local beach communities and resource managers to share your work and produce products they might use?

- **A**: We developed guides and keys to habitat types, and we also held two workshops that were more public-facing. The end user group was an agency group, and through these stakeholder workshops we engaged as many beach communities as we would. This was all happening during Covid, and the virtual setting allowed us to reach a much broader group than I think we would have been able to otherwise. We brought folks in from Hunting Island, Hilton Head Island, Myrtle Beach area, really the whole coast. We had a workshop at the beginning to get input from those folks on what types of information they need and what they find important, and we just last week gave a presentation back to roll out these results and get additional feedback. We had some interactive exercises looking at scoring different areas as far as disturbance factors and brought in a representative from DHEC OCRM to give an overview of some of the regulatory factors associated with beach management and how they plan to manage habitats for endangered species. The beach management guide will distill some of this information down to more of a public-facing level that they can use in developing those plans.

Q: How transferable to other shorebird species do you think the maps would be?

- **A:** We initially set out to work with Red Knot as well, but we don't have nearly as much data on those species. The protected status of Piping Plover is how we've been able to do so many projects over the years, which has given us this very large dataset. Many shorebirds use these same habitats, as they are areas that are desirable for a wide variety of species. The exact criteria we used were Plover-specific, but in a general sense many of these areas are shared with a wide variety of shorebird species.

Q: What is the most important thing managers and communities can do to protect these habitats?

- **A:** A lot of the geomorphological stuff is out of our hands, like when storms come through and change these habitats. As far as what we can do to protect these habitats, minimizing disturbance is a very direct thing that almost any of these communities can do something about. Managing access of dogs to certain areas is important, so if you have an off-leash dog area you want that to be away from an inlet. Many times people go down to inlets thinking that they're getting away from people to be less disruptive to them, but these are the same areas that are highly utilized by these species. Keeping vehicle and foot traffic to a minimum in those areas is also a good thing to do. If you do have to do some sort of beach engineering project, try to do it in a way that will minimize disturbance to these habitats by using nourishment materials that are similar in terms of grain size and other characteristics, and will provide habitats of similar elevations. We're also going to work to roll out some more formal outputs on what some of the best practices could be, which we'll provide to our state agency.

Q: How do you control your spatial analysis of older bird observations, given the shifting shoreline features? Plover observations made some years back may have been a different habitat type at the time compared to how it looks now.

- **A:** We have the Plover observation data over about the last decade, and also have benthic core data collected over about that same time period. When we looked at bird density for a given sample, we were able to retroactively calculate that using data from that same season. In terms of some of the other metrics, like the distance to inlet, that's a little bit more complicated by that point, but at that scale of analysis the shoreline changes are not quite as dramatic. For example, a sample on Deveaux Bank before it eroded is still near an inlet, as opposed to a current sample. Where possible, we're attempting to compare them to other data at that point in time, so it's not just using current data.

Q&A

Q: Based on this study, these cats-eye ponds seem to be preferential foraging areas. Do you think these birds actively seek out these areas, and do you think knowing this could influence beach restoration efforts?

- **A**: Yes and yes. Beach restoration is a little bit farther off, I don't think we're quite there in a regulatory sense and there are some complicating factors to that which are a little bit outside of my area of expertise. For example, in Charleston Harbor they were able to make some roosting habitat for birds, using material that was encountered during the ongoing Charleston Harbor deepening project. We just heard earlier this week that there was quite a bit of successful nesting on those roosting and nesting habitats. Conceptually, we have the information now about the foraging habitats to do something similar. All the information is there, I'm just not sure if we're quite there in the regulatory sense to do something like that.

Q: Is there any reason to think that different prey types would have differing levels of detectability in the fecal samples, i.e. are some species more completely digested than others?

- **A**: Possibly. We used the CO1 method, which targets a gene that is prevalent in almost every invertebrate species, so in that sense I don't think it would have bias. As far as digestibility, that was one of the pros of the genetics approach as opposed to the physical examination approach, but I suppose there still are some levels of biases. That's why we went with the additive approach, combining our four various approaches to get at this prey list.

Q: Do you have any numbers on the impact of loose bird-chasing dog impacts on the beach? I feel like a lot of owners don't realize the level of impact, and if they did this might change their behaviour.

- **A:** I don't personally have data on that. There have been some masters theses on that very topic here at the College of Charleston, I believe Schillerstrom was the name that was just recently concluded, as well as several others. I know Melissa Chaplin and Janet Thibault have both worked a little more in that subject area. I do think the issue is born mostly out of just not knowing, rather than any sort of mal intent. I do think stewardship and signage helps make folks aware of the impact, and most people once they understand would be sympathetic to the issue. Seabrook Island is a very nice case study for that. They were able to work with the local community - including Mark Andrews who I mentioned earlier in the talk as one of our citizen science helpers - to establish and move the dog zone away from these critical habitats to a more central part of the beach. In the end, everybody got what they wanted. The birds have a good protected foraging area, and the people who are walking their dogs have a more easily accessible designated dog zone.

Q: Do you think there is room for more links to citizen science for this kind of work?

- **A:** Yes, and that's one other thing that came out of our stakeholder outreach efforts. Each community along the coast is really different. They have different resources, the people that live there have different levels of knowledge and interest in conservation. You really have to approach it on a case by case basis to see where they're at, and then develop a plan from there. That's why we wanted to reach out to them through this project, to gauge their level of knowledge and interest and see what they needed. In a lot of cases they needed information on how to speak to people about these important issues.