

Modeling Foraging Preferences to Evaluate Beach Restoration Success: a Case Study with Piping Plovers (*Charadrius melodus*)

Brooke Maslo, Ph.D.

**Center for Urban Restoration Ecology
Rutgers, The State University
of New Jersey**

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Habitat Restoration, Habitat Quality, & Ecological Traps



Habitat Restoration Goal:

increase survival & reproductive success of target species

Questions:

How do we measure success?

Have we really created a high quality habitat?

What habitat conditions are contributing to species' survival or reproductive success?

Using Animal Behavior to Measure Restoration Success

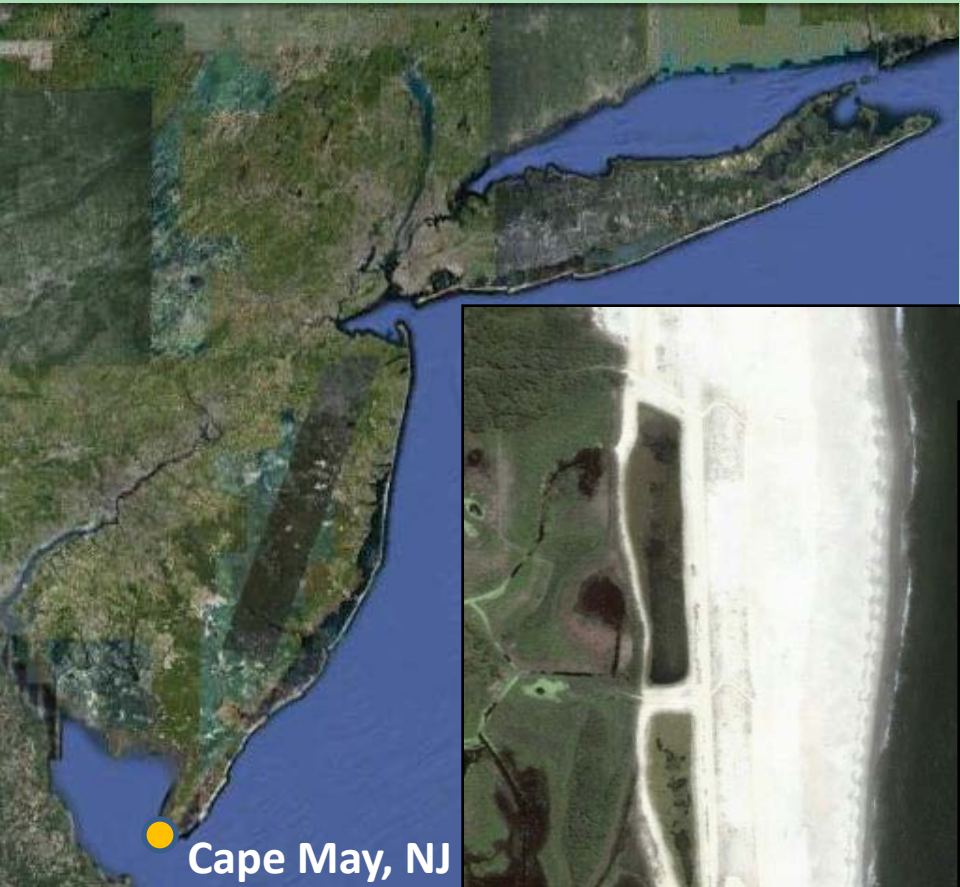


- o behavior is closely linked to fitness & reproductive success
- o behavioral observations are more effort-intensive
- o more conclusive & can lead to more effective design & management strategies

Study Objectives

1. compare the foraging activity budgets of piping plovers at both restored and natural foraging habitats
2. create foraging behavior models to identify the major factors that regulate foraging rates of piping plovers
3. use the evidence gathered in the field to examine the efficacy of artificial tidal ponds as a viable restoration alternative

Lower Cape May Meadows Habitat Piping Plover Habitat Restoration Project



Natural vs. Artificial Foraging Habitats



Natural vs. Artificial Foraging Habitats

Average Productivity = 0.45



Avalon

Average Productivity = 1.02



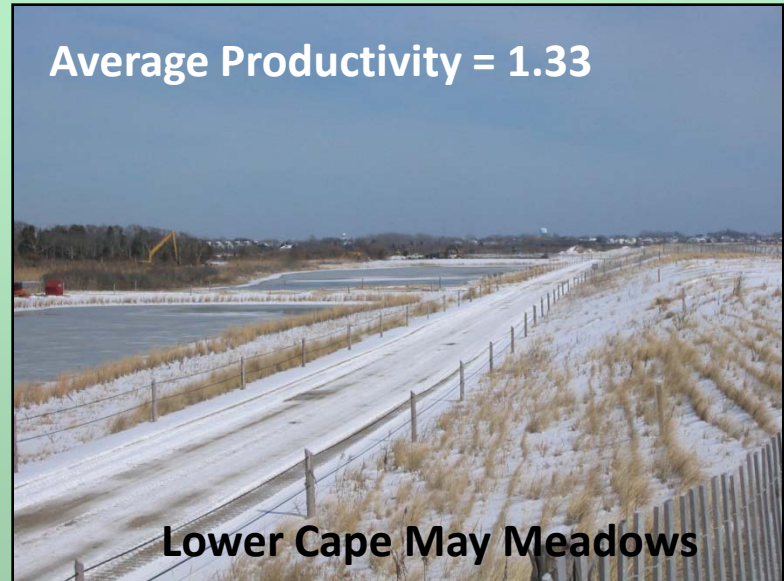
Barnegat Light

Average Productivity = 0.33

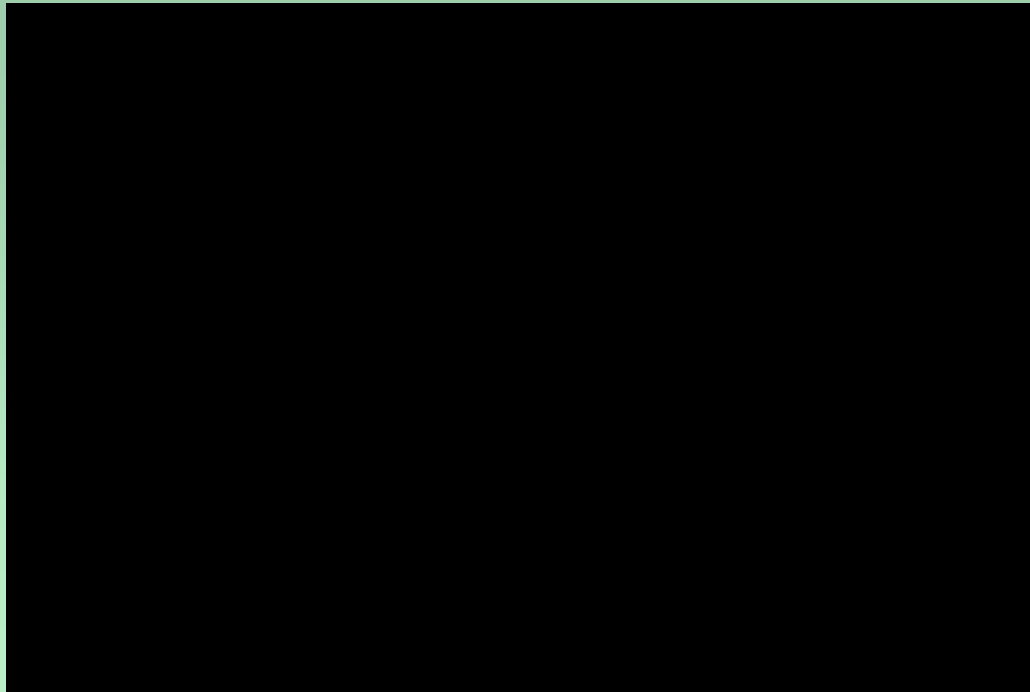


North Brigantine Natural Area

Average Productivity = 1.33



Lower Cape May Meadows



Foraging Time Budget

time spent:

1. foraging
2. being vigilant
3. running/walking away
4. flying away
5. crouching
6. other

Foraging Rate (pecks/min)

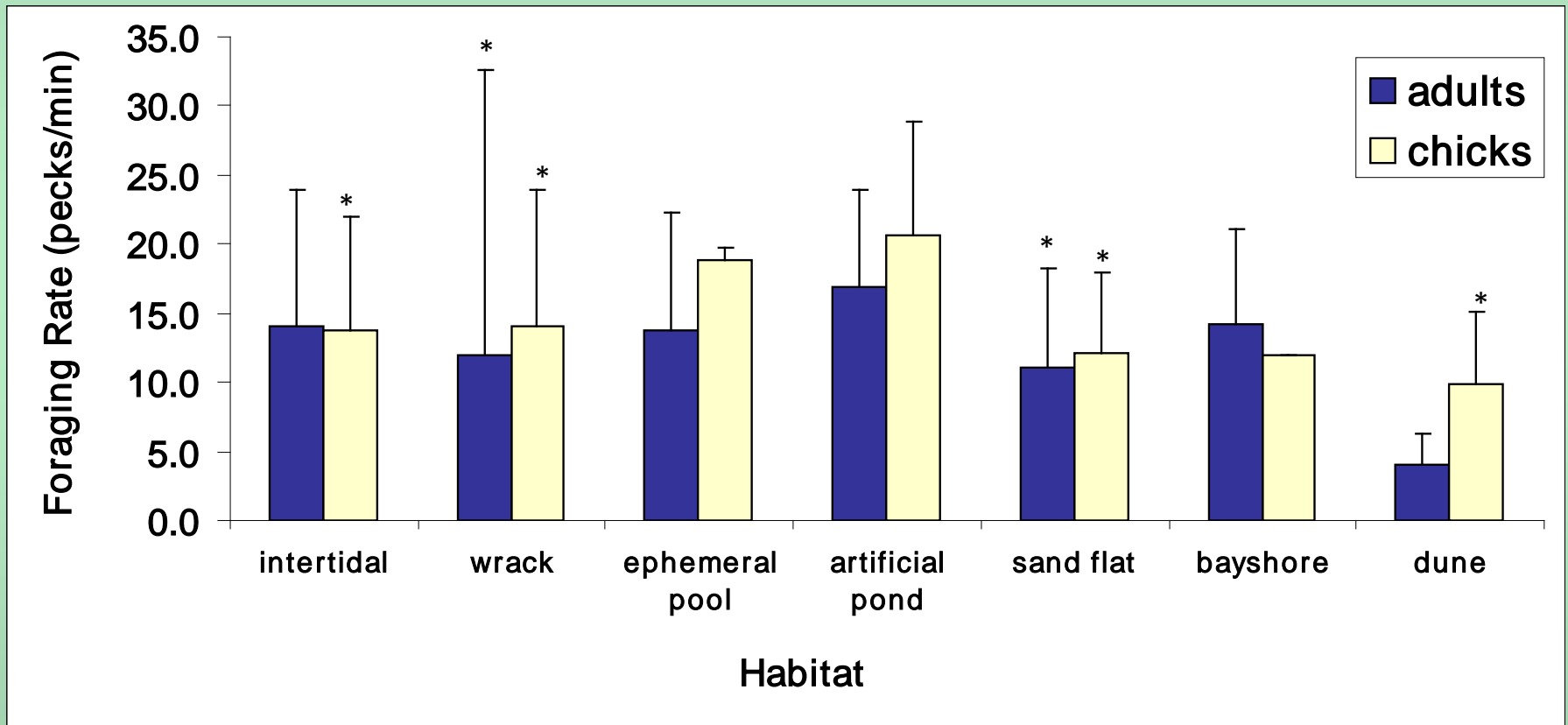
behavioral variables

- reproductive stage
- # of people, vehicles
- # and type of predators

environmental variables

- tidal stage
- wind speed
- air temperature

Plovers forage at significantly higher rates at artificial tidal ponds



1. *N = 471 observations of 151 adults, 108 observations of 83 chicks*
2. **significantly different from artificial ponds*

Comparison of Candidate Regression Models for Adults

Model	AIC _c	ΔAIC _c	ML	K	w
habitat + reproductive stage + tidal stage + people + vehicles	3328.45	0.00	1.00	6	0.42
habitat + reproductive stage + tidal stage + wind speed + people + vehicles	3330.30	1.85	0.40	7	0.17
habitat + reproductive stage + tidal stage + wind speed + people	3330.67	2.22	0.33	6	0.14
habitat + reproductive stage + tidal stage + people	3330.75	2.30	0.32	5	0.13
habitat + reproductive stage + tidal stage + wind speed + air temperature + people + gulls + crows + vehicles (global)	3332.44	3.98	0.14	10	0.06

Effect of Habitat Conditions on Foraging Adults

Parameter	Effect Size	95% Confidence Interval	
Intercept	11.8	10.1	13.5
Habitat			
intertidal	3.97	2.45	5.49
artificial pond	5.52	3.84	7.20
bay shore	2.32	0.03	4.61
sand flat	-2.29	-4.34	-0.26
People	-0.80	-1.06	-0.54
Vehicles	-1.87	-3.26	-0.48
Tidal Stage (low)	3.98	3.05	4.91

Constructed Tidal Ponds Have the Highest Predicted Foraging Rates for Adult Plovers



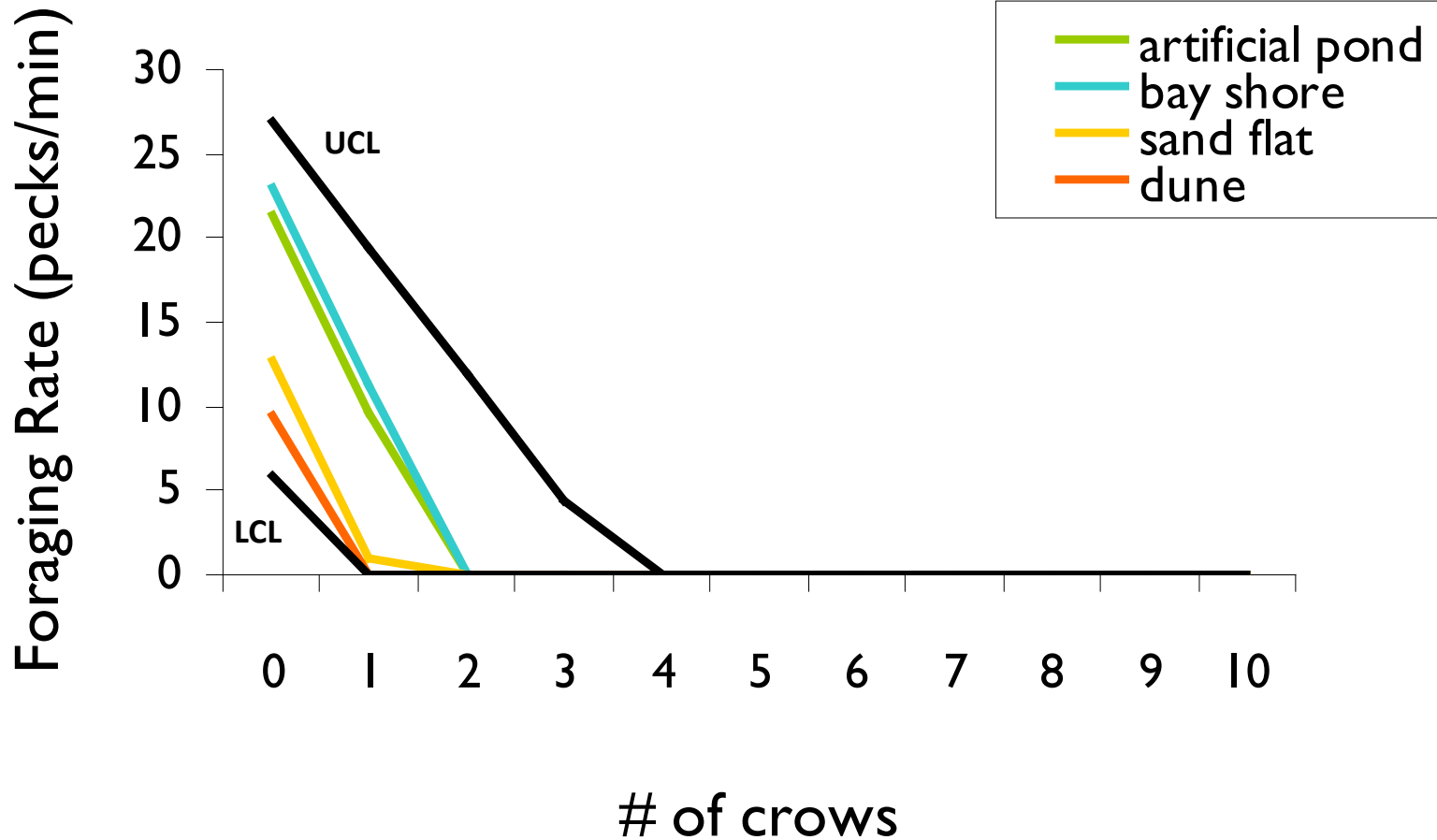
Comparison of Candidate Regression Models for Chicks

Model	AIC _c	ΔAIC _c	ML	K	w
habitat + people + crows	1112.45	0.00	1.00	4	0.53
habitat + people + gulls + crows	1113.23	0.79	0.68	5	0.36
habitat + tidal stage + wind speed + air temperature + people + gulls + crows	1117.78	5.33	0.04	8	0.04
habitat + people	1117.81	5.36	0.04	3	0.04
habitat + people + gulls	1118.84	6.40	0.02	4	0.02

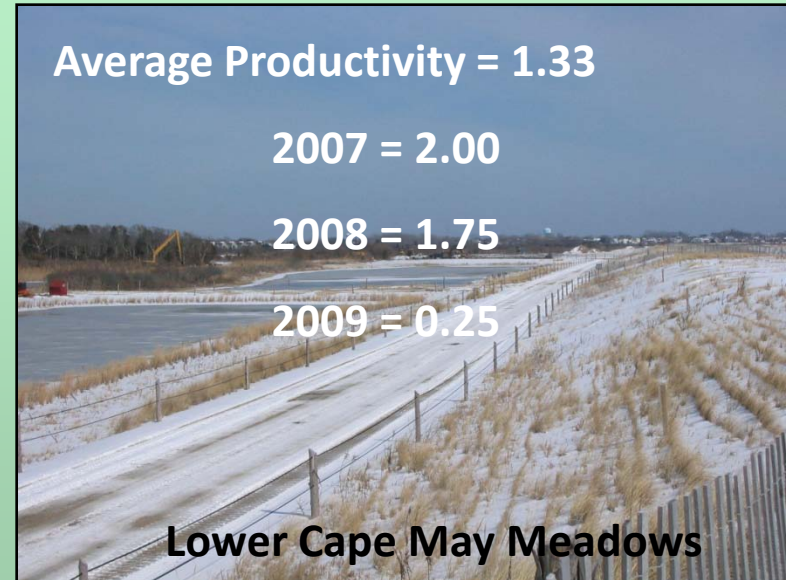
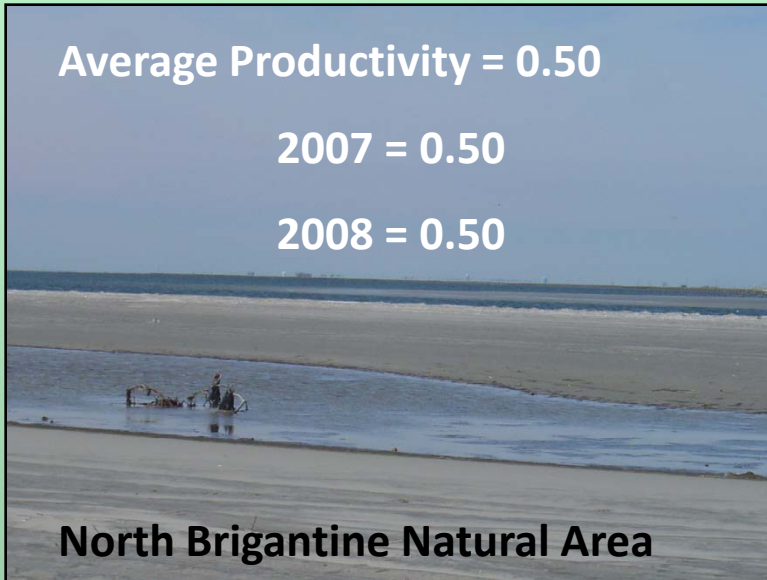
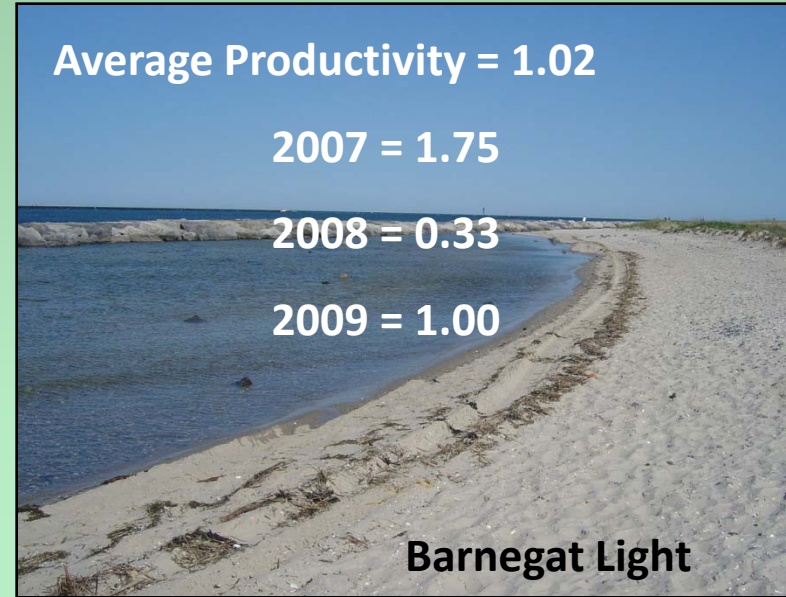
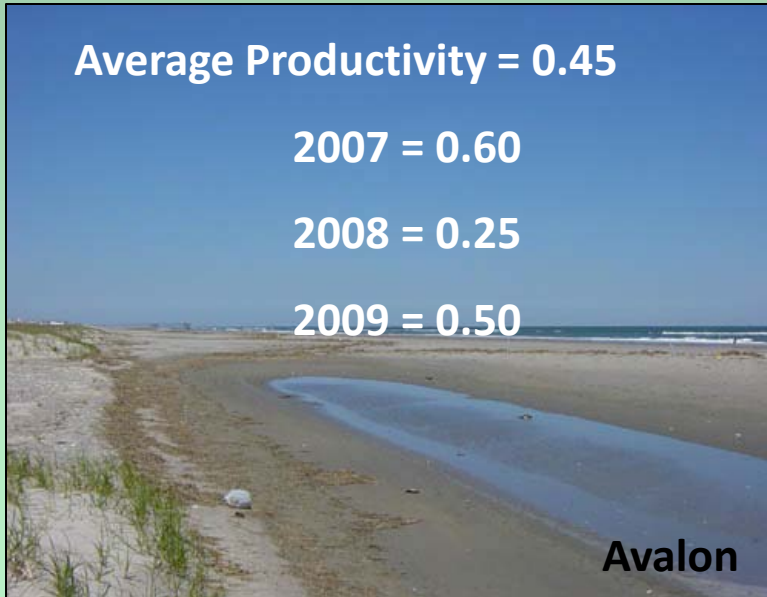
Effect of Habitat Conditions on Foraging Chicks

Parameter	Effect Size	95% Confidence Interval	
Intercept	15.70	14.4	17.0
Habitat			
artificial pond	5.37	3.89	6.84
bay shore	6.16	4.13	8.19
sand flat	-3.58	-5.37	-1.78
dune	-4.33	-6.09	-2.57
People	-1.64	-2.15	-1.13
Gulls	-0.08	-0.11	-0.05
Crows	-11.84	-16.0	-7.64

Plover Chicks Have Similar Predicted Foraging Rates at Bay Shores and Artificial Ponds



Habitat Quality Is Not Sustained at Restored Site



Site Changes in 2009



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