# Competing Risks and Nest Success of American Oystercatchers and Wilson's Plovers on the Georgia Coast

American Oystercatcher Working Group Meeting 2014

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# Background: American Oystercatchers

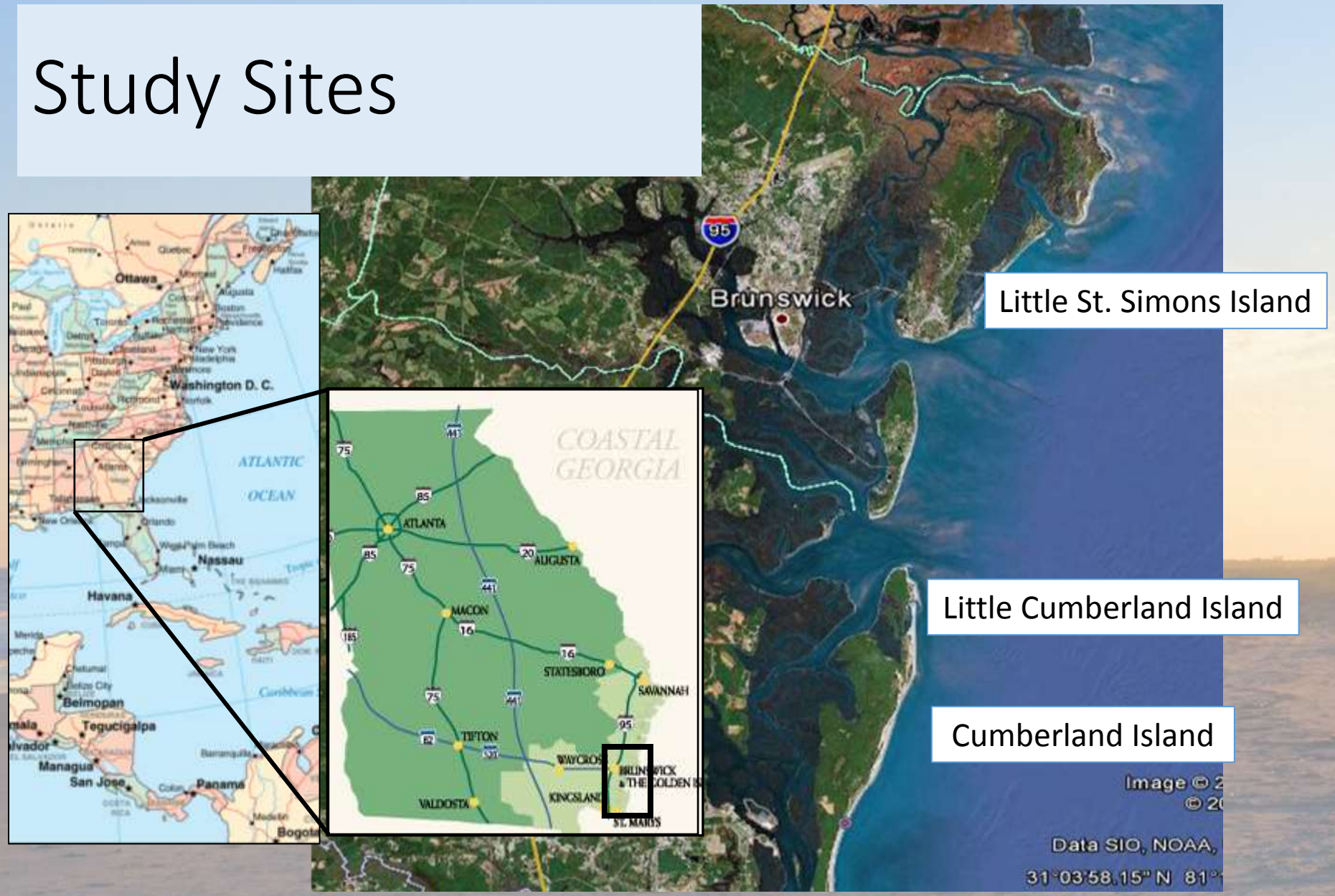

Photo: Brad Winn

121 nesting pairs in GA (2014)
Rare (SWAP, 2005)

# Background: Wilson's Plovers

300 nesting pairs in GA (2010)
Threatened (SWAP 2005)

# Study Sites


Ottawa
Washington D. C.
ATLANTIC
OCEAN
Nassau
Havana
Belmopan
Tegucigalpa
Managua
San Jose
Panama
COASTAL
GEORGIA
ATLANTA
AUGUSTA
MACON
STATESBORO
SAVANNAH
TIFTON
VALDOSTA
KINGSLAND
ST. MARYS
95
Brunswick
Little St. Simons Island
Little Cumberland Island
Cumberland Island
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Data SIO, NOAA,
31°03'58.15" N 81°

# Objectives

- Quantify nest site characteristics
- Estimate nest success and fledging success
- Determine nest site characteristics that predict productivity
- Identify common features between both species
- Develop predictive models to guide management

# Methods

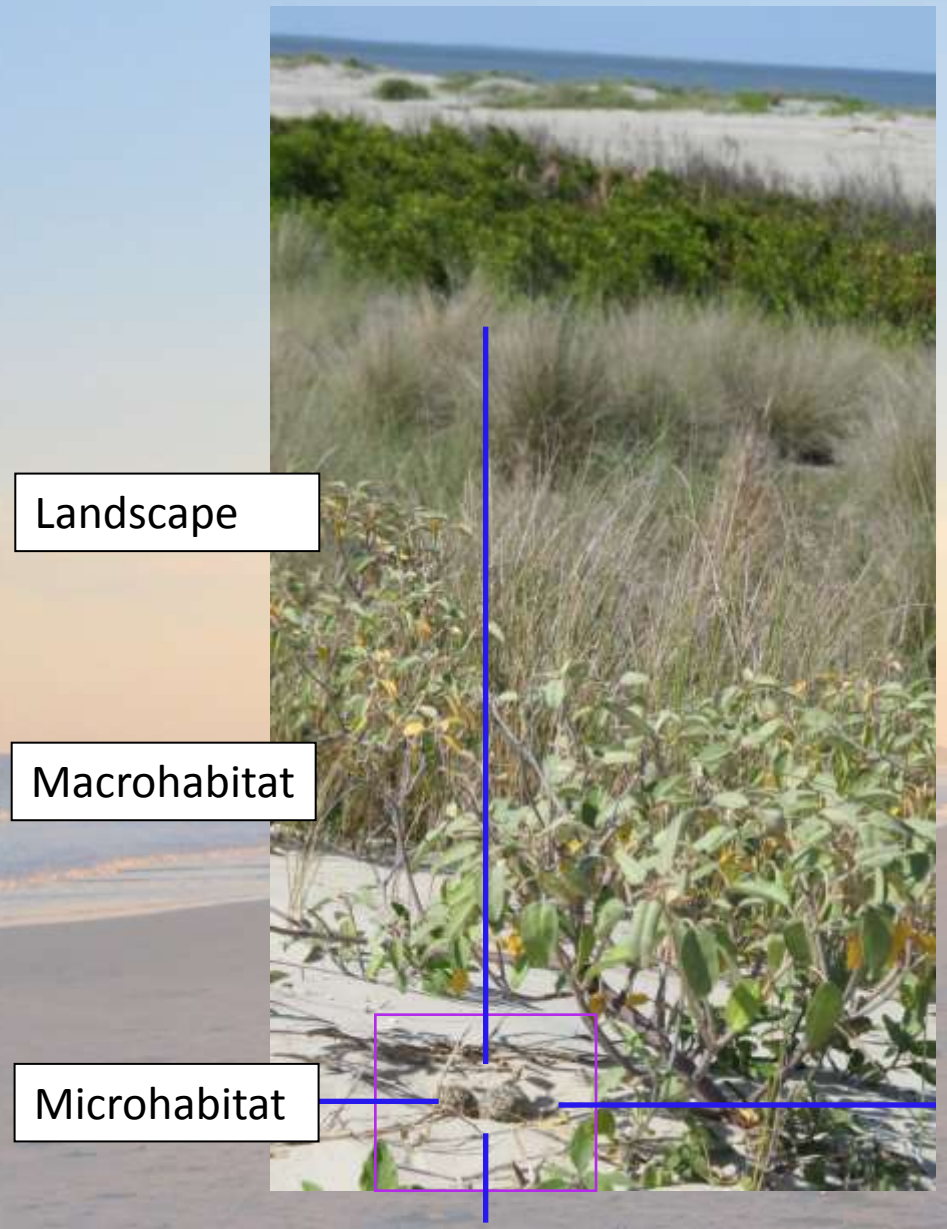
- Locate and monitor nests during 2012 and 2013 breeding season
  - Visual survey, tracking, parental behavior
  - Assess cause of failure by track identification

# Methods

- Band and monitor chicks until fledging

# Methods

- Measure nest-site characteristics at nests and random sites




# Methods

Scale and Measurements:

1. Microhabitat (1 meter quadrat)
   - Percent cover of vegetation, open sand, wrack and shell, elevation
   - Presence of predator
2. Macrohabitat (25 meter line transects)
   - Characterization of vegetation
   - Presence of predators
3. Landscape Scale
   - Distances to marsh edge, mud flats, tideline

# So far…

| | Microhabitat | | Landscape | |
|---|---|---|---|---|
| | Location | Success | Location | Success |
| AMOY | wrack(+), open sand (-) | other scales? Covariates? | mixed landcover (+), elevation (+), topography (-) | mixed landcover (+) |
| WIPL | vegetation (+), wrack (+), open sand (-) | elevation (+), open(-) | | |

# Notes about competing risk models

- "correctly adjusts the probabilities of failure due to one cause conditional on failure due to another cause not occurring." (Etterson et al. 2007)
- Uses Markov chain likelihood estimator which allows for temporal heterogeneity
- Used in a variety of systems and widely with nesting birds
- Etterson developed Mcestimate ~2012, as working model for research

# Using Competing Risks Models

- Used MC Estimate to build and compare models with biologically relevant hypotheses:
  - Factors impacting overwash risk: Elevation, Date
  - Factors impacting predation: Cover of vegetation, Substrate, and Openness
    Nest location in vegetation
    Date
    Age
  - Year was used in all models
- Excluded correlated variables and nests with no known assigned fate
- Ran models for each site and species separately
- Compared models with AIC and examined parameter estimates for top models (no model averaging)

# LSSI Wilson's Plover

| | Model name | NLL | AICc | delta AICc | Weight | K |
|---|---|---|---|---|---|---|
| 1 | overwashed(year+elev+Date)predated(.) | 294.25 | 598.52 | 0 | 0.36 | 5 |
| 2 | overwashed(elev+Date+year)predated(year+in_veg) | 292.74 | 599.53 | 1.01 | 0.22 | 7 |
| 3 | overwashed(elev+Date+year)predated(year) | 294.18 | 600.39 | 1.87 | 0.14 | 6 |
| 4 | overwashed(elev+Date+year)predated(year+in_veg+sand_cov) | 292.37 | 600.81 | 2.29 | 0.12 | 8 |
| 5 | overwashed(year+elev)predated(.) | 297.07 | 602.16 | 3.64 | 0.06 | 4 |
| 6 | ove | | | | | 9 |
| 7 | ove | | | | | 10 |
| 8 | ove | | | | | 11 |
| 9 | ove | | | | | 11 |
| 10 | ove | | | | | 11 |
| 11 | overwashed(elev)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date+Age) | 297.32 | 614.74 | 16.22 | 0 | 10 |
| 12 | overwashed(year)predated(.) | 305.75 | 617.52 | 19 | 0 | 3 |
| 13 | overwashed(.)predated(.) | 308.41 | 620.82 | 22.3 | 0 | 2 |
| 14 | overwashed(.)predated(year+in_veg) | 306.91 | 621.84 | 23.32 | 0 | 4 |
| 15 | overwashed(.)predated(year) | 308.41 | 622.83 | 24.31 | 0 | 3 |
| 16 | overwashed(.)predated(year+in_veg+sand_cov) | 306.55 | 623.12 | 24.6 | 0 | 5 |
| 17 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov) | 306.55 | 625.13 | 26.61 | 0 | 6 |
| 18 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov+wrack_cov) | 305.83 | 625.71 | 27.19 | 0 | 7 |
| 19 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date) | 305.56 | 627.19 | 28.67 | 0 | 8 |
| 20 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date+Age) | 305.26 | 628.6 | 30.08 | 0 | 9 |

| Top Models | npar | AIC_c | delta | weight |
|---|---|---|---|---|
| Overwash(Year+Elevation+Date) Predation(.) | 5 | 598.52 | 0 | 0.36 |
| Overwash(Year+Elevation+Date) Predation(Year+Nest In Veg) | 7 | 599.53 | 1.01 | 0.22 |
| Overwash(Year+Elevation+Date) Predation(Year) | 6 | 600.39 | 1.87 | 0.14 |

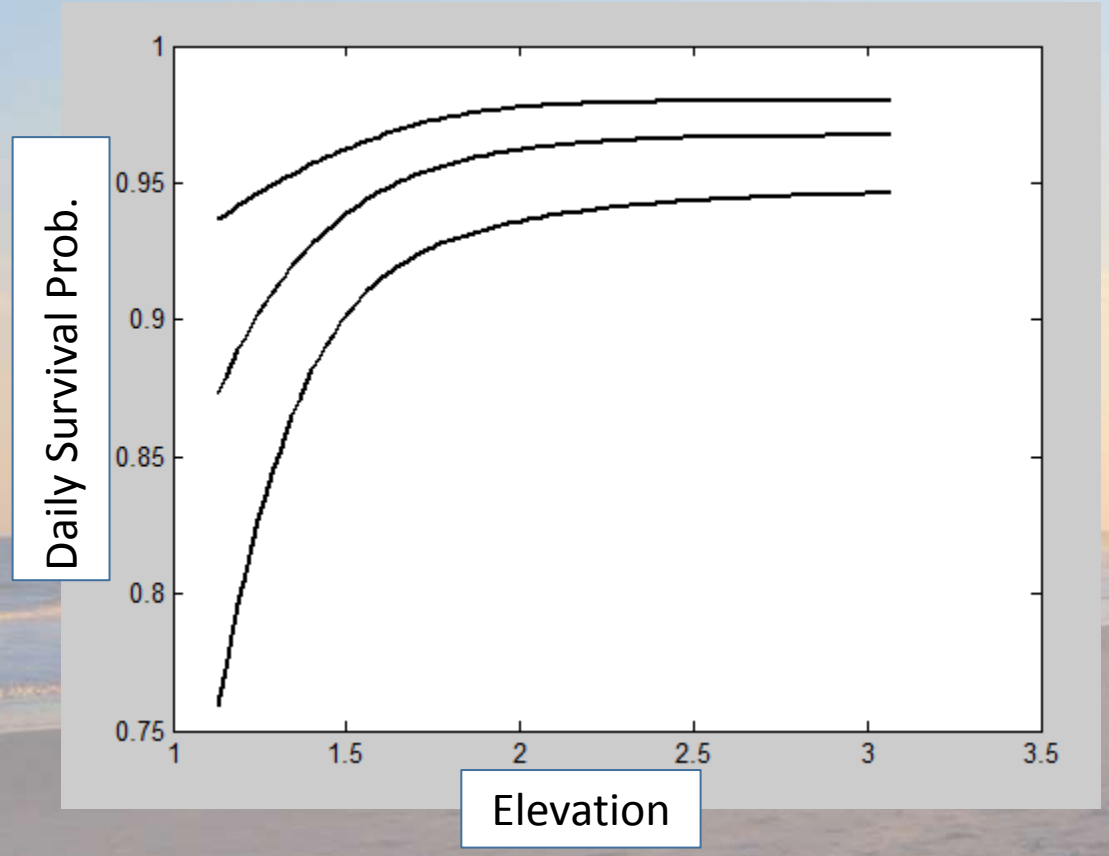
# Model: Overwash(Year+Elevation+Date) Predation(Year+Nest In Veg)

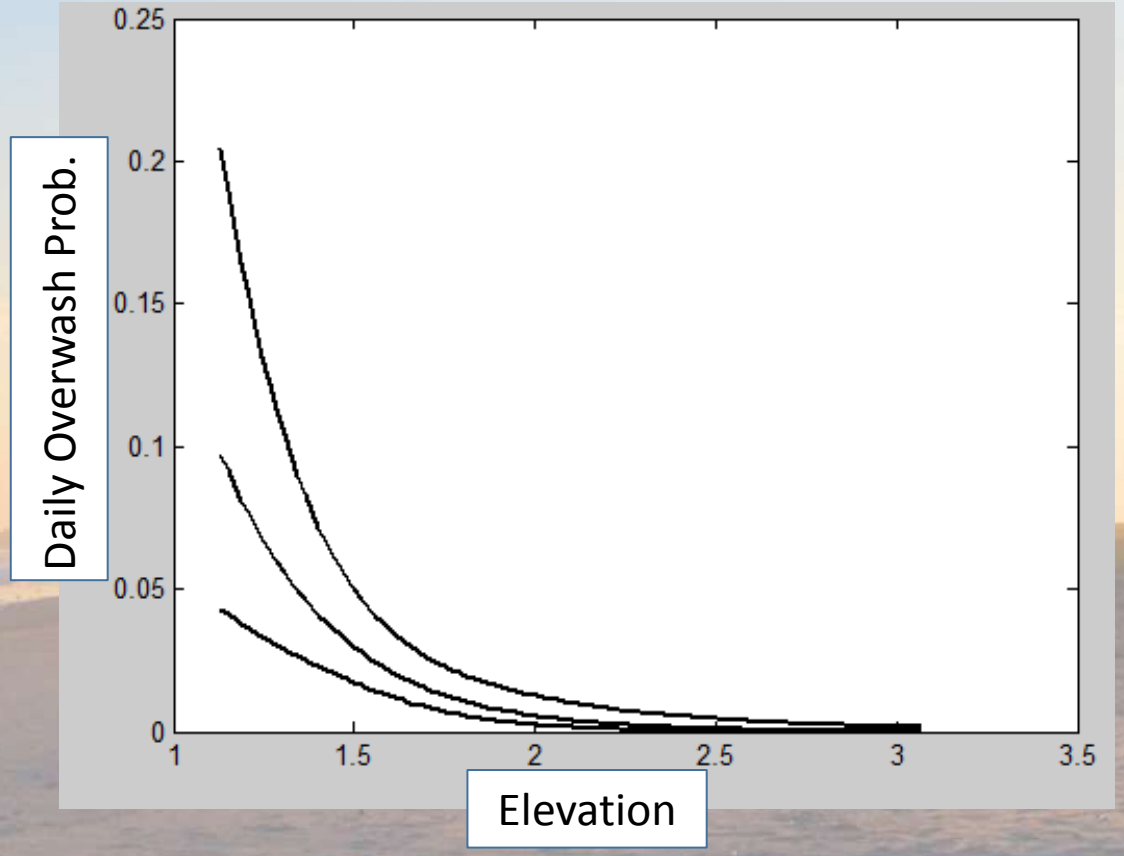
Parameter Estimates for Model for LSSI WIPL

| Fate | Parameter | Estimate | SE |
|---|---|---|---|
| Overwashed | Intercept | 5.1294 | 2.1632 |
| Overwashed | Elevation | -3.4183 | 0.7251 |
| Overwashed | Date | -0.0236 | 0.0108 |
| Overwashed | Year: 2013 | -1.0316 | 0.4448 |
| Predated | Intercept | -3.3912 | 0.2929 |
| Predated | Year: 2013 | 0.1133 | 0.2897 |
| Predated | Nest in Veg: Yes | -0.05021 | 0.2869 |

| | Daily Estimates | | Nest Period Estimate | |
|---|---|---|---|---|
| | Estimate | Standard Error | Estimate | Standard Error |
| Success | 0.9574 | 0.0095 | 0.3578 | 0.0877 |
| Overwashed | 0.0104 | 0.0036 | 0.1321 | 0.0510 |
| Predated | 0.0322 | 0.0091 | 0.5101 | 0.1000 |

# Plot of elevation parameter for LSSI WIPL




*Daily survival probabilities are fitted using 101 values of this quantitative variable between the maximum and minimum

# CUIS Wilson's Plover

| | Model name | NLL | AICc | delta AICc | Weight | K |
|---|---|---|---|---|---|---|
| 1 | overwashed(year+elev)predated(.) | 263.51 | 535.05 | 0 | 0.42 | 4 |
| 2 | overwashed(year+elev+Date)predated(.) | 262.77 | 535.58 | 0.52 | 0.32 | 5 |
| 3 | overwashed(elev+Date+year)predated(year) | 262.57 | 537.19 | 2.14 | 0.14 | 6 |
| 4 | overwashed(elev+Date+year)predated(year+in_veg) | 262.36 | 538.8 | 3.74 | 0.06 | 7 |
| 5 | ove | | | | | 8 |
| 6 | ove | | | | | 9 |
| 7 | ove | | | | | 10 |
| 8 | overwashed(elev+Date+year)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date) | 261.56 | 545.31 | 10.25 | 0 | 11 |
| 9 | overwashed(elev+Date+year)predated(year+sand_cov+shell_cov+wrack_cov+Date+Age) | 261.85 | 545.87 | 10.82 | 0 | 11 |
| 10 | overwashed(year+elev)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date+Age) | 262.21 | 546.6 | 11.54 | 0 | 11 |
| 11 | overwashed(elev)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date+Age) | 272.54 | 565.23 | 30.18 | 0 | 10 |
| 12 | overwashed(year)predated(.) | 281.08 | 568.17 | 33.11 | 0 | 3 |
| 13 | overwashed(.)predated(.) | 293.32 | 590.64 | 55.59 | 0 | 2 |
| 14 | overwashed(.)predated(year) | 293.2 | 592.41 | 57.36 | 0 | 3 |
| 15 | overwashed(.)predated(year+in_veg) | 292.99 | 594.01 | 58.96 | 0 | 4 |
| 16 | overwashed(.)predated(year+in_veg+sand_cov) | 292.9 | 595.84 | 60.78 | 0 | 5 |
| 17 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov) | 292.44 | 596.94 | 61.89 | 0 | 6 |
| 18 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov+wrack_cov) | 292.29 | 598.65 | 63.59 | 0 | 7 |
| 19 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date) | 292.2 | 600.49 | 65.44 | 0 | 8 |
| 20 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date+Age) | 292.08 | 602.28 | 67.23 | 0 | 9 |

| Top Models | npar | AIC_c | delta | weight |
|---|---|---|---|---|
| **Overwash(Year+Elevation) Predation(.)** | 4 | 535.05 | 0 | 0.42 |
| **Overwash(Year+Elevation+Date) Predation(.)** | 5 | 535.58 | 0.52 | 0.32 |

# Model: Overwash(Year+Elevation) Predation(.)

Parameter Estimates for Model for CUIS WIPL

| Fate | Parameter | Estimate | SE |
|---|---|---|---|
| Overwashed | Intercept | -0.2361 | 2.0973 |
| Overwashed | Elevation | -1.4976 | 1.0290 |
| Overwashed | Year: 2013 | -1.6709 | 0.5077 |
| Predated | Intercept | -3.3489 | 0.1411 |

| | Daily Estimates | | Nest Period Estimate | |
|---|---|---|---|---|
| | Estimate | Standard Error | Estimate | Standard Error |
| Success | 0.9375 | 0.0133 | 0.1989 | 0.0707 |
| Overwashed | 0.0296 | 0.0131 | 0.3794 | 0.1236 |
| Predated | 0.0329 | 0.0045 | 0.4217 | 0.0687 |

# LSSI American Oystercatcher

| | Model name | NLL | AICc | delta AICc | Weight | K |
|---|---|---|---|---|---|---|
| 1 | overwashed(elev+Date+year)predated(year+sand_cov+shell_cov+wrack_cov+Date+Age) | 56.68 | 135.85 | 0 | 0.35 | 11 |
| 2 | overwashed(year+elev)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date+Age) | 56.74 | 135.97 | 0.12 | 0.33 | 11 |
| 3 | overwashed(elev)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date+Age) | 59.46 | 139.33 | 3.48 | 0.06 | 10 |
| 4 | overwashed(year+elev)predated(.) | 65.85 | 139.78 | 3.93 | 0.05 | 4 |
| 5 | | | | | | 9 |
| 6 | | | | | | 6 |
| 7 | | | | | | 5 |
| 8 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date+Age) | 61.41 | 141.16 | 5.31 | 0.02 | 9 |
| 9 | overwashed(elev+Date+year)predated(year+in_veg) | 63.52 | 141.25 | 5.4 | 0.02 | 7 |
| 10 | overwashed(elev+Date+year)predated(year+in_veg+sand_cov+shell_cov+wrack_cov) | 60.93 | 142.27 | 6.42 | 0.01 | 10 |
| 11 | overwashed(elev+Date+year)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date) | 60.02 | 142.54 | 6.69 | 0.01 | 11 |
| 12 | overwashed(elev+Date+year)predated(year+in_veg+sand_cov) | 63.5 | 143.26 | 7.41 | 0.01 | 8 |
| 13 | overwashed(year)predated(.) | 68.77 | 143.59 | 7.74 | 0.01 | 3 |
| 14 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov) | 66.03 | 144.22 | 8.37 | 0.01 | 6 |
| 15 | overwashed(.)predated(year) | 69.16 | 144.36 | 8.51 | 0 | 3 |
| 16 | overwashed(.)predated(year+in_veg) | 68.54 | 145.16 | 9.31 | 0 | 4 |
| 17 | overwashed(.)predated(.) | 70.57 | 145.17 | 9.32 | 0 | 2 |
| 18 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov+wrack_cov) | 65.95 | 146.11 | 10.26 | 0 | 7 |
| 19 | overwashed(.)predated(year+in_veg+sand_cov+shell_cov+wrack_cov+Date) | 65.07 | 146.4 | 10.55 | 0 | 8 |
| 20 | overwashed(.)predated(year+in_veg+sand_cov) | 68.52 | 147.15 | 11.3 | 0 | 5 |

| Top Models | npar | AIC_c | delta | weight |
|---|---|---|---|---|
| **Overwash(Year+Elevation+Date) Predation(Year+Openness+ Shell+Wrack+Date+Age)** | 11 | 135.85 | 0 | 0.35 |
| **Overwash(Year+Elevation) Predation(Year+Openness+ Shell+Wrack+Date+Age+NestInVeg)** | 11 | 135.97 | 0.12 | 0.33 |

# Model: Overwash(Year+Elevation) Predation(Year+NestInVeg+ Openness+ Shell Cover+Wrack Cover+Date+Age)

Parameter Estimates for Model for LSSI AMOY

| Fate | Parameter | Estimate | SE |
|---|---|---|---|
| Overwashed | Intercept | 2.4513 | 1.9164 |
| Overwashed | Elevation | -3.6445 | 1.0773 |
| Overwashed | Year: 2013 | -2.1154 | 0.9578 |
| Predated | Intercept | -9.3689 | 3.1847 |
| Predated | Year: 2013 | 3.0378 | 1.0519 |
| Predated | Nest in Veg: Yes | -1.0928 | 1.0542 |
| Predated | Openness | 5.07 e-04 | 0.0145 |
| Predated | Shell Cover | 0.2479 | 0.0833 |
| Predated | Wrack Cover | -0.0062 | 0.0206 |
| Predated | Date | 0.0076 | 0.0152 |
| Predated | Age | 0.1198 | 0.0432 |

| | Daily Estimates | | Nest Period Estimate | |
|---|---|---|---|---|
| | Estimate | Standard Error | Estimate | Standard Error |
| Success | 0.9839 | 0.206 | 0.5440 | 0.3763 |
| Overwashed | 0.0147 | 0.0205 | 0.4075 | 0.4040 |
| Predated | 0.0014 | 0.0015 | 0.0485 | 0.0552 |

# CUIS American Oystercatcher

| | Model name | NLL | AICc | delta AICc | Weight | K |
|---|---|---|---|---|---|---|
| 1 | fail(year+in_veg+sand_cov+wrack_cov+elev+Date+Age) | 6.48 | 31.22 | 0 | 0.85 | 8 |
| 2 | fail(year) | 16.07 | 36.31 | 5.1 | 0.07 | 2 |
| 3 | fail(year+in_veg) | 16.03 | 38.41 | 7.19 | 0.02 | 3 |
| 4 | fa | | | | | |
| 5 | fa | | | | | |
| 6 | fail(year+in_veg+sand_cov+wrack_cov) | 14.82 | 40.54 | 9.32 | 0.01 | 5 |
| 7 | fail(wrack_cov) | 18.47 | 41.1 | 9.88 | 0.01 | 2 |
| 8 | fail(Date) | 18.7 | 41.58 | 10.36 | 0 | 2 |
| 9 | fail(elev) | 18.7 | 41.58 | 10.36 | 0 | 2 |
| 10 | fail(sand_cov) | 18.82 | 41.8 | 10.59 | 0 | 2 |
| 11 | fail(Age) | 18.87 | 41.91 | 10.7 | 0 | 2 |
| 12 | fail(in_veg) | 18.88 | 41.92 | 10.71 | 0 | 2 |
| 13 | fail(year+in_veg+sand_cov+wrack_cov+elev) | 14.62 | 42.5 | 11.29 | 0 | 6 |
| 14 | fail(sand_cov+wrack_cov) | 18.46 | 43.27 | 12.05 | 0 | 3 |
| 15 | fail(year+in_veg+sand_cov+wrack_cov+elev+Date) | 14.59 | 44.9 | 13.68 | 0 | 7 |
| 16 | fail(sand_cov+wrack_cov+elev) | 18.44 | 45.48 | 14.26 | 0 | 4 |

| Top Model | npar | AIC_c | delta | weight |
|---|---|---|---|---|
| **Failed (Year + Nest in Veg+ Openness+ Wrack Cover+ Elevation+ Date+ Age)** | 11 | 135.85 | 0 | 0.35 |

# Model: Fail(Year+Nest In Veg+Open+Wrack Cover+ Elevation+ Date+ Age)

Model name

fail(year+in_veg+sand_cov+wrack_cov+elev+Date+Age)

Multinomial logit scale estimates:

| | Fate | Parameter | Estimate | SE | min | max | fit |
|---|---|---|---|---|---|---|---|
| 1 | fail | Intercept | 18.9553 | 9.8363 | 1 | 1 | 1 |
| 2 | fail | year:2013 | -6.7983 | 2.7605 | 0 | 1 | 0 |
| 3 | fail | in_veg:Y | 16.1020 | 8.2218 | 0 | 1 | 0 |
| 4 | fail | sand_cov | 0.0597 | 0.0716 | 0 | 100 | 53.4737 |
| 5 | fail | wrack_cov | 0.2179 | 0.0950 | 0 | 40 | 16.5263 |
| 6 | fail | elev | -4.2147 | 2.5940 | 1.5590 | 3.4620 | 2.4675 |
| 7 | fail | Date | -0.1584 | 0.0655 | 97 | 174 | 140.8526 |
| 8 | fail | Age | 0.5848 | 0.2178 | 0 | 25 | 9.7684 |

Daily estimates:

z-value for confidence intervals: 1.96 decimal precision: 4

| | Parameter | MLE | SE | L_CL | U_CL |
|---|---|---|---|---|---|
| 1 | success | 0.7777 | 0.4901 | 0.0133 | 0.9989 |
| 2 | fail | 0.2223 | 0.4901 | 0.0011 | 0.9867 |

Overall estimates:

start: 1 days. end: 28 days. decimal precision: 4

| | Outcome | Estimate | SE |
|---|---|---|---|
| 1 | Fledge | 0.9983 | 0.0065 |
| 2 | fail | 0.0017 | 0.0065 |

## Model Failed to Converge:

Parameter estimates unrealistic;
N=20 with:

1 Nest overwashed
9 Nests predated
10 Nests failed due to unknown cause

Likely when many nests share the same fate, and there are many parameters in the model

# Summary

- Competing risk models can help us see the interaction between multiple threats

| | LSSI | | CUIS | |
|---|---|---|---|---|
| | **Predation** | **Overwash** | **Predation** | **Overwash** |
| **AMOY** | Year (2013 +)*<br>Nest in Veg (Y -)*<br>Shell Cover (+)<br>Age (+) | Year (2013 -)*<br>Elevation (-)* | Model failed to converge | |
| **WIPL** | Year (2013 +)*<br>Nest in Veg (Y -) | Year (2013 -)*<br>Elevation (-)* | No variables in top models | Year (2013 -)*<br>Elevation (-)* |

- Not very surprising but this does reflect the logistic exposure results (elevation)

# Other considerations:

- Density
- Predator type (avian vs mammalian, coyote vs raccoon)
- Scale (Macro, Landscape)
- Compare these results to used versus unused nest sites

# Next Steps

- Investigate macro & landscape characteristics
  - Community mapping?
  - Investigate how sea level rise, shoreline change and inlet dynamics might impact nesting habitat
- Create fledgling survival estimates and determine correlation to nest site
- Compare nest site features between species
- Agent-based model to look at effect of predation
- Create maps and recommendations to help guide managers to focus efforts on highly productive habitat

# Acknowledgements

Photo: Brad Winn

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# Questions?