Assessing the effects of freshwater inflows and other key drivers on the population dynamics of blue crab and white shrimp using a multivariate time-series modeling framework

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Project Goals

- Compose a review of literature examining blue crab and white shrimp populations
- Assess the drivers of blue crab and white shrimp population dynamics using multivariate autoregressive (MAR) models
  - Texas Parks and Wildlife Department Coastal Fisheries monitoring data
### Project Timeline

#### Literature review

<table>
<thead>
<tr>
<th>Tentative timeline</th>
<th>Accomplishments</th>
</tr>
</thead>
</table>
| 2014 Apr-Jul       | ✓ Compose annotated bibliography  
|                    | ✓ Outline structure for review |
| 2014 Aug-Dec       | ✓ Complete annotated bibliography  
|                    | ✓ Begin literature review report |
| 2015 Jan-Mar       | ✓ Continue composition of literature review report |
| 2015 Apr-Aug       | ✓ Complete final literature review  
|                    | ✓ Present results at final workshop  
|                    | 🔴 Submit final report  
|                    | 🔴 Submit manuscript for publication |

#### Data analysis

<table>
<thead>
<tr>
<th>Tentative timeline</th>
<th>Accomplishments</th>
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<tbody>
<tr>
<td>2014 Apr-Jul</td>
<td>✓ Acquire and prepare datasets for model application</td>
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</table>
| 2014 Aug-Dec       | ✓ Meet with data managers and analysts  
|                    | ✓ Continue to prepare datasets for model application  
|                    | ✓ Construct and assess preliminary models |
| 2015 Jan-Mar       | ✓ Select and apply final models to data  
|                    | ✓ Compose data analysis report |
| 2015 Apr-Aug       | ✓ Prepare final report  
|                    | ✓ Present results at final workshop  
|                    | 🔴 Submit final report  
|                    | 🔴 Submit data and annotated R code |
### Literature Review

#### Number of references included by topic and region

<table>
<thead>
<tr>
<th>Topic</th>
<th>Mission-Aransas Estuary</th>
<th>Guadalupe Estuary</th>
<th>Texas</th>
<th>Gulf of Mexico</th>
<th>Atlantic Ocean</th>
<th>Lab</th>
<th>General</th>
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<td>Blue Crab</td>
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<td>9</td>
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<td>8</td>
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<td>3</td>
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</table>

#### MAR Model

**Lag 1**

- Blue Crab
- Red Shrimp
- Temperature

![Graph showing trends over years](image_url)
MAR Model

\[ X_{t+1} = A + BX_t + CU_t + E_t \]

- **Next abundance value**
- **Influence of each species**
- **Influence of other factors**
- **Error**

Species Environmental

<table>
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<th>p</th>
<th>1</th>
<th>…</th>
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</table>
Interaction webs from MAR analysis

Conceptual

1. Conceptual diagram showing interactions between different species and Total Phosphorus.

MAR

2. MAR analysis diagram showing interactions between different species and Total Phosphorus.

Hampton et al. 2006

TPWD Survey Data

Otter trawl Data (1982 – 2013)

Bag seine Data (1976 – 2013)

Gill net Data (1975 – 2013)
### Additional Data

<table>
<thead>
<tr>
<th>Data type</th>
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<tbody>
<tr>
<td>Species abundance time-series</td>
<td>TPWD Coastal Fisheries monitoring program</td>
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<tr>
<td>Water quality parameters</td>
<td>Mission-Aransas NERR System-Wide Monitoring Program</td>
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<td>Texas Coastal Ocean Observation Network</td>
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<td>Meteorological data</td>
<td>Mission-Aransas NERR System-Wide Monitoring Program</td>
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<td>Texas Coastal Ocean Observation Network</td>
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<td>NOAA National Climatic Data Center</td>
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<tr>
<td>Rain gauge data</td>
<td>U.S. Geological Survey</td>
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<tr>
<td>River flow gauge data</td>
<td>U.S. Geological Survey</td>
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<td>Climate oscillation indices</td>
<td>NOAA Climate Prediction Center</td>
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<td>Along-shore current patterns</td>
<td>Texas Automated Buoy System</td>
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<td>Commercial landing data</td>
<td>Marine Aquatic Products Reports (TPWD)</td>
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### Models

<table>
<thead>
<tr>
<th>Time division:</th>
<th>Years</th>
<th>Seasons</th>
<th>Months</th>
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<td>0 1 2</td>
<td>0 1 2</td>
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<td>✅✅✅</td>
</tr>
</tbody>
</table>

- **All Bays**
- **Mission-Aransas Estuary**
- **Guadalupe Estuary**
Environmental Models
Blue Crab Models
(yearly increments)

Salinity

Water Temperature

River Discharge

Blue Crab (gilnet)
Blue Crab (trawl)
Blue Crab (seine)

Red Drum
Black Drum
Spotted Seatrout
Blue Crab Models
(yearly increments)

Salinity

Blue Crab (gillnet) → Blue Crab (troll) → Blue Crab (seine)

Water Temperature

Red Drum

Black Drum

River Discharge

Spotted Seatrout

Salinity

Blue Crab (gillnet) → Blue Crab (troll) → Blue Crab (seine)

Water Temperature

Red Drum

Black Drum

River Discharge

Spotted Seatrout
Blue Crab Models
(yearly increments)

Salinity

Water Temperature

River Discharge

Blue Crab (gillnet)

Blue Crab (trawl)

Blue Crab (seine)

Red Drum

Black Drum

Spotted Seatrout

Blue Crab Models
(yearly increments)
Blue Crab Models
(yearly increments)

Blue Crab (gillnet)  Blue Crab (trawl)  Blue Crab (seine)

Salinity  Water Temperature  River Discharge

Red Drum  Black Drum  Spotted Seatrout

White Shrimp Models

[Graph showing model results for different locations]

Copano Bay  Aransas Bay  San Antonio Bay  Estero Santo Bay
White Shrimp Models
(seasonal increments)
White Shrimp Models
(seasonal increments)

Lag 1

Salinity → Water Temperature → River Discharge

White Shrimp (trawl) → White Shrimp (seine)

Southern Flounder

White Shrimp Models
(seasonal increments)

Lag 2

Salinity → Water Temperature → River Discharge

White Shrimp (trawl) → White Shrimp (seine)

Southern Flounder
White Shrimp Models
(seasonal increments)

- Salinity
- Water Temperature
- River Discharge

- White Shrimp (trawl)
- White Shrimp (seine)
- Southern Flounder
White Shrimp Models
(seasonal increments)

White Shrimp (trawl)  White Shrimp (seine)

Salinity  Water Temperature  River Discharge

Southern Flounder
**White Shrimp Models**
(seasonal increments)

Summary

- **Higher water temperatures, higher salinities, and lower river discharge** are linked to **lower PDO and ENSO values and higher SOI values**
- **Blue crab abundance** is
  - *negatively* associated with *high water temperatures* and *predators*
  - *negatively* associated with *high salinity* at short time lags
  - *positively* associated with *high salinity* at longer time lags
    (possibly due to negative association of predators with high salinity)
  - *positively* associated with *river discharge* at longer time lags
- **Abundance of larger white shrimp** is
  - *negatively* associated with *predators* and *higher salinity*
  - *positively* associated with *higher water temperatures*
  - *positively* associated with *river discharge* at longer time lags
- **Abundance of smaller white shrimp** is
  - *positively* associated with *higher salinity*
  - *negatively* associated with *river discharge* at longer time lags
Model variations and future work

- Regions ✓
- Time lags ✓
- Time increments ✓
- Time span (additional datasets)
- Inter-bay effects
- Additional TX estuaries
- Wet vs. dry periods
- Extremes vs. averages
- Size and sex data