Adaptation of the CASM to Evaluate Food Web Dynamics and Species Responses in Louisiana’s Estuaries

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LA Coastal Protection and Restoration Authority (CPRA) and USACE, New Orleans District

*** NMFS, LDWF, CPRA, USFWS, USACE
CASM

- Bioenergetics-based growth in an aquatic food web model

- Producers: \( \frac{dB_p}{B_p dt} = \) Photosynthesis – Photorespiration – Dark Respiration – Sinking – Natural Mortality – Grazing

- Consumers: \( \frac{dB_c}{B_c dt} = \) \{Consumption - (Egest+Excrete+SDA) – Respiration – Natural Mortality – Predation\}*hmod

- Consumption dependent upon prey and predator biomasses

\[ f(T): f(I): f(N): hmod: \]

- Temperature
- Light Intensity
- Nutrient Conc.
- Salinity, Turbidity, DO
CASM Approach for Barataria

• 33 species/functional groups in the food web
• 18 CASM food webs set up on the hydro model grid
• Daily time step simulated over single years
• CASM inputs are averaged daily values from field data and cell outputs from the hydro model
• Environmental inputs modify producer and consumer processes in food webs
$dB/Bdt = \{C - (Eg + U + SDA) - R - M - P\} \times hmod$
## Data Used for Model Development

<table>
<thead>
<tr>
<th>Monitoring Programs</th>
<th>Dates of Record</th>
<th>Sampling Frequency</th>
<th>Variables Measured or Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Solar Radiation Database New Orleans Airport</td>
<td>1960 - 2010</td>
<td>Hourly</td>
<td>Surface light intensity (PAR)</td>
</tr>
<tr>
<td>USACE Water Quality Sampling</td>
<td>1997 - 2008</td>
<td>Monthly</td>
<td>NO₃, PO₄, TIS, POC, SiO₃, salinity, Chl concentration</td>
</tr>
<tr>
<td>Coast-wide Reference Monitoring System (CWPPRA)</td>
<td>2006 - present</td>
<td>Continuous</td>
<td>Temperature, salinity,</td>
</tr>
<tr>
<td>USGS Sampling</td>
<td>1998 - present</td>
<td>Continuous</td>
<td>Temperature, salinity</td>
</tr>
<tr>
<td>LDWF Fisheries-Independent monitoring</td>
<td>1967 - present</td>
<td>Monthly</td>
<td>Abundance, biomass, size of fish, invertebrates, oysters,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>habitat modifiers</td>
</tr>
<tr>
<td>Barataria Basin nekton sampling (Reed et al. 2007, NOAA)</td>
<td>2002, 2005, 2006</td>
<td>Spring and Fall</td>
<td>Nekton density, biomass, size in marsh, ponds</td>
</tr>
</tbody>
</table>
Environmental Data: Salinity, Temperature, Elevation

- CASM Stations
- CRMS Stations
- USGS Stations
Environmental Data: USACE Water Quality
Mean monthly species biomass (g/m²) calculated from LDWF seines and trawls and NOAA 1-m² drop samplers

Weight sample mean biomass by marsh and open water habitat in basin (Reed et al. 2007)

January biomasses initialize the CASM

Monthly (seasonal) biomasses used to calibrate the CASM
Biological Data: Species Biomasses
Field Data

Reed et al. 2007

LDWF 6’ and 16’ Trawl Stations
Baseline CASM Results for Existing Conditions

• 18 CASM Stations using environmental field data from 1999-2010 throughout basin

• Food web dynamics driven by temperature, light, nutrients, salinity

• Demonstrate seasonal biomass trends and distribution of species due to environmental gradients and shifting food web in estuary
Example Environmental Input Data for 18 CASM Stations (2004)

- Water Temperature (°C)
- Surface Light (E/m²/d)
- T/S (mg/L)
- Depth (m)
- POC (mg/L)
- Salinity
- NO₃ (mg/L)
- PO₄ (mg/L)
- SiO₂ (mg/L)

Day of Year
Blue Crab YOY Biomass in June

mg C/m²

- Colours indicate biomass levels:
  - Red: 360.0 mg C/m²
  - Orange: 320.0 mg C/m²
  - Brown: 280.0 mg C/m²
  - Yellow: 240.0 mg C/m²
  - Green: 200.0 mg C/m²
  - Light green: 160.0 mg C/m²
  - Dark green: 120.0 mg C/m²
  - Light blue: 80.0 mg C/m²
  - Dark blue: 40.0 mg C/m²
  - Blue: 0.0 mg C/m²

- Numbers 1 to 18 correspond to specific areas on the map.
a. $y = 0.0335x + 0.2347$
\[ R^2 = 0.8991 \]

b. $y = -12.547x + 2.8857$
\[ R^2 = 0.0289 \]

C. $y = -19.008x + 0.9293$
\[ R^2 = 0.8249 \]
CASM Approach for Delta Management

• 55 species/functional groups in the food web

• A lot of CASM food webs set up on model domain

• Daily time step simulated over *multiple years with regenerating populations*

• CASM inputs are averaged daily values from field data and outputs from the hydro model, *veg model*

• Environmental inputs modify producer and consumer processes in food webs
CASM Approach for Delta Management

• Differences in species/life stage biomasses by habitat from LDWF and NMFS sampling
  – Habitat: marsh (EAV); open water; SAV; oyster reef

• Differences in base prey due to habitat and water quality
  – Prey: phytoplankton, periphyton, zooplankton, benthic infauna, bivalves

• CASM set up and initialization based on available data for model domain and post-auditing of Barataria model
Life stages will be size rather than age structured

More diverse prey base that is driven by habitat

Add to food web:
- Killifish
- Atlantic croaker
- Sand searot
- Silversides
- Small crabs
- Caridean shrimp
- Florida Pompano
- Snappers
- Coastal sharks
- Shads
- Alligator gar
- Pinfish
- Silver perch
- Bay squid
- Sea catfish
- Spot
- Southern flounder
Then there’s California...
Selected EFDC Cells in LSZ of Delta Project Domain
CASM LTL Food Web

- Pelagic Fish
- Clams
- Mysids
- Acartiella
- Limnoithona
- Eurytemora
- Pseudodiaptomus
- Microzooplankton
- Bacterioplankton
- Small Phyto.
- Diatoms
- POC
- DOC
- Nutrients
CASM for Gulf Restoration

- CASM (other models) set up for specific coastal regions to evaluate lethal and sub-lethal effects from DWHOS on key species in food web

- Food web dynamics driven by temperature, light, nutrients, salinity, habitat structure, species effects from toxins measured in the field and laboratory

- Environmental inputs from data and/or linked with hydrodynamic and water quality models

- Evaluate bottom-up effects and species interactions at daily and seasonal, annual and multiyear time scales
  - Short-term, pulsed, decaying or varying effects