The CASM for Evaluating Changes in Fish and Shellfish Communities from the Delta Management Study

Diversion Panel Presentation – Oct 27, 2015

Dynamic Solutions, LLC
CASM

- Bioenergetics-based growth in an aquatic food web

- Producers: \( dB/Bdt = \text{Photosynthesis} - \text{Photorespiration} - \text{Dark Respiration} - \text{Sinking} - \text{Mortality} - \text{Grazing} \)

- Consumers: \( dB/Bdt = \left[ \{ \text{Consumption} - (\text{Egest} + \text{Excrete} + \text{SDA}) \} - \text{Respiration} - \text{Mortality} - \text{Predation} \right] + \text{flux} \times h\text{mod} \)

- Consumption and respiration depend on size, temperature; Consumption on prey and predator biomasses

- Growth modified by salinity, proportion of vegetation
Biological Data for the CASM

- Biomass (g/m²) for initialization and calibration from LDWF seines and trawls, NMFS drop samplers
- Lengths, catch-per-unit effort from LDWF and NMFS data
- Bioenergetic parameters, L-W, diets from literature
- Benthic infauna data from NMFS (Minello and Rozas)
- Stage-specific mortality, growth, reproduction, migration for fluxes between life stages and in and out of estuaries to complete life cycle (Baker et al. 2014; EPRI 2005; Pattillo et al. 1997)
- Habitat preferences/tolerances for temperature, salinity, vegetation for life stages, benthic infauna from LDWF and NMFS data, 2017 Master Plan HSI models, literature
Mean Monthly Model Species Composition in LDWF Seines from 1995-2010

- CSA 1 (94% of total catch)
  - Atl. Croaker
  - Bay Anchovy
  - B. Shrimp
  - Caridean Shrimp
  - G. Menhaden
  - B. Crab
  - White Shrimp

- CSA 2 (94% of total catch)
  - St Mullet
  - Spot
  - SpST
  - Killi
  - Silversides
  - G. Menhaden
  - B. Crab
  - White Shrimp

- CSA 3 (92% of total catch)
  - SM
  - Spot
  - Silversides
  - SP
  - Killifish
  - G. Menhaden
  - Caridean Shrimp
  - B. Shrimp
  - B. Crab
  - White Shrimp

Proportion of Catch

Months
Brown Shrimp Early YOY Biomass Estimates from Data for Barataria Basin

** Biomass from LDWF Seines & NMFS Drops
Red Drum Early YOY Biomass Estimates from Data for Barataria Basin

** Mean over years

** Biomass from LDWF Seines & NMFS Drops
<table>
<thead>
<tr>
<th>Water column POC</th>
<th>Zooplankton</th>
<th>Benthic Infauna</th>
<th>Mollusks (bivalves, snails added)</th>
<th>Caridean shrimp</th>
<th>Small crabs</th>
<th>Oyster spat</th>
<th>Seed/sack oysters</th>
<th>Small jv blue crab</th>
<th>Lg jv/sub blue crab</th>
<th>Lg jv/sub brown shrimp</th>
<th>Small jv brown shrimp</th>
<th>Lg jv white shrimp</th>
<th>Small jv red drum</th>
<th>Sm jv Atlantic croaker</th>
<th>Sm jv/Adult red drum</th>
<th>Atlantic croaker</th>
<th>Juv/Adult spotted seatrout</th>
<th>Adult gc-menhaden</th>
<th>Sm jv gc-menhaden</th>
<th>Lg jv gc-menhaden</th>
<th>Sm jv green crab</th>
<th>Lg jv green crab</th>
<th>Juv gc-menhaden</th>
<th>Adult gc-menhaden</th>
<th>Lg jv gc-menhaden</th>
<th>Sm jv Menhaden</th>
<th>Lg jv Menhaden</th>
<th>Yellowtail (≤ 240 mm)</th>
<th>Sm jv/gc-menhaden</th>
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**Early YOY Brown Shrimp (≤ 65 mm TL)**

**YOY Brown Shrimp (> 65 mm TL)**

**Early YOY Red Drum (≤ 60 mm TL)**

**YOY Red Drum (61-350 mm TL)**

**Age-1+ Red Drum (> 350 mm TL)**
<table>
<thead>
<tr>
<th></th>
<th>Early YOY Blue Crab</th>
<th>Early YOY Brown Shrimp</th>
<th>Early YOY Red Drum</th>
<th>Early YOY Spotted Seatrout</th>
<th>YOY Menhaden</th>
<th>YOY Black Drum</th>
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Species-Specific Habitat Modifier Functions from Data

Salinity (ppt)

% Vegetation

** Rozas and Minello 2002

Brown Shrimp

Red Drum

** Rozas and Minello 2002
Environmental Data for the CASM

• Existing conditions from 1995-2010 for model calibration and validation
  – Daily salinity (ppt), temperature (°C), and Chl a (µg/l) from 2012 Eco-Morphology model (Meselhe et al. 2013)
  – 2012 Vegetation:Water map (Couvillion et al. 2013)
  – Used for CASM calibration and validation

• MRDM Project Alternative Scenarios for 50 years
  – Daily salinity, temperature, Chl a from DELFT-3D with D-WAQ (Meselhe et al., in prep)
  – Vegetation:Water maps at 10 year intervals from Delft-3D with LA-VEG (Meselhe et al., Duke-Sylvester et al.)
  – Used as CASM inputs to evaluate key species responses
CASM Polygons with Example Salinity generated from Delft-3D

Delft data provided by Meselhe et al. (WIG)
Daily Environmental Inputs for Barataria Polygons
CASM Calibration and Validation

• Calibrate predicted biomasses to averaged observed biomass data from 1995-2010

• Adjust daily mortality rates, life stage fluxes, diet parameters, and temperature parameters

• Validate spatial distribution of species within basins related to conditions, habitat, food web

• Not shown but important to show model is a realistic and accurate representation of system
Evaluating Species Responses to MRDM Project Scenarios

• Delft-3D generated daily salinity, temperature, Chl a, Vegetation:Water inputs to 49 CASM polygons over 50 years

• Seven MRDM diversion scenarios including FWOP, single diversions, all four diversions at low and aggressive operations

• Report key species responses from TY0 for first 10 years, 20 years and at 50 years
  – Brown and white shrimp, blue crab, red drum, seatrout, menhaden, largemouth bass, oysters
  – System-wide, basins (CSA 1, 2, 3), and sub-basins (upper, mid, lower regions in basin)
Gulf Menhaden Biomass: Change from Initial Conditions

Future Without Project

All Four Diversions Aggressive Operation

% change

<table>
<thead>
<tr>
<th>Year 10</th>
<th>Year 20</th>
<th>Year 50</th>
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<tbody>
<tr>
<td>![Year 10 Image]</td>
<td>![Year 20 Image]</td>
<td>![Year 50 Image]</td>
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<td>![Future Without Project Image]</td>
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<td>![All Four Diversions Aggressive Operation Image]</td>
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</table>
Red Drum Biomass: Change from Initial Conditions

Year 10

Year 20

Year 50

Future Without Project

All Four Diversions Aggressive Operation

% change
-30
-20
-10
0
10
20

20
Brown Shrimp Biomass: Change from Initial Conditions

Future Without Project

All Four Diversions Aggressive Operation

Year 10

Year 20

Year 50
**Brown Shrimp:**

System-Wide Responses Relative to TY 0

<table>
<thead>
<tr>
<th>Years</th>
<th>MBARD PR1</th>
<th>FWOP PR2</th>
<th>MBSD PR3</th>
<th>LBSD PR4</th>
<th>LBARD PR5</th>
<th>ALL-L PR6</th>
<th>ALL-A PR7</th>
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<td>-4.46</td>
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**Minimum threshold response +/-10% = No response due to variation and uncertainty**

**Red more than 10% reduction; Green more than 10% increase from TY 0**

FWOP ~ LBS ~ LBAR ~ MBS ~ All-A over 50 years

MBAR ~ All-L reduced ~ 18% early but gone by TY 20 and 50
**Relative Response (%) in Brown Shrimp Biomass from TY 0**

*** Supporting results for evaluating CSA 3 for lower biomasses in PR1 & PR 6
*** Relative reductions largest in upper and mid basins of PR1 & PR6 (PR7) of CSA 3
BrShrimp_smYOY Biomass vs. driving variables in CSA 3 mid

Early YOY Brown Shrimp Biomass

Production Run
- PR 7
- PR 6
- FWOP
- PR 5
- PR 4
- PR 1
- PR 3
Evaluating Species Responses to MRDM Project Scenarios

• Key species responses from initial conditions often less than +/-10%

• Responses vary by species and are complex
  – Salinity, temperature, Chl a, Vegetation:Water, food web interactions differentially effect species and life stages within basins and by diversion scenarios

• Agency scientists working with modeling teams to interpret species responses and identify information gaps