Approaching Coastal Aquaculture from an Ecosystem Perspective

M. Rawson\textsuperscript{1}, Chen\textsuperscript{2} C., Ji R.\textsuperscript{1}, Zhu\textsuperscript{3} M., Wang\textsuperscript{4} D., C. Yarish\textsuperscript{5}, J. Sullivan\textsuperscript{1}

\textsuperscript{1}Georgia Sea Grant College Program, School of Marine Program, The University of Georgia, Athens, GA 30602-3636 U.S.A.
\textsuperscript{2}University of Massachusetts, Dartmouth, MA 02744-1221
\textsuperscript{3}First Institute of Oceanography, State Oceanic Administration, Qingdao 266003, P.R. China
\textsuperscript{4}Hainan Marine Development, Planning, & Design Research Institute, Haikou, P.R. China
\textsuperscript{5}University of Connecticut, Stamford, CT 06901-2315
OBJECTIVES

- To encourage integrated aquaculture approaches in coastal management
- To illustrate the use of ecosystem modeling to aid coastal management of aquaculture
AQUACULTURE LOCATIONS

- Closed systems – no effluents
- Ponds - effluents
- Semi-enclosed water – Bays (Our focus)
- Offshore systems – 30-50 m
EUTROPHICATION

- Adding nutrients and organic matter
- Eutrophication negative and positive
- Sources –
  - Natural, i.e. Upwelling, Rainfall
  - Human, i.e. Sewage, Stormwater & Agricultural runoff, Fed aquaculture
Aquaculture Types

- Fed aquaculture - fish pens, shrimp ponds
- Extractive aquaculture - scallops and seaweeds
- Adds organic matter, increases bacteria and plankton, uses oxygen
- Decrease plankton numbers & nutrients, respire oxygen/carbon dioxide
Integrating Aquaculture Systems

- Integrating types of aquaculture - POLYCULTURE
- Bay-wide planning through ICM
- Using Ecosystem Models to SIMULATE effects of management decisions
Fed Aquaculture

- Shrimp Ponds
- Fate of Feed
- Nutrients - P, N
- Blooms/Oxygen
- Effluent

Holowitz & Holowitz, 2000
Boyd & Weddig, 1997
Fed Aquaculture

- Fish Pens
- Fate of feed
- Sedimentation
- Oxygen

Sullivan
Extractive Aquaculture

- Seaweeds
- Nutrients
- Clear water
- Respire
Extractive Aquaculture

- Cleaning Fishes
- Plankton feeders - i.e. Paddlefish
- Bottom feeders - i.e. Mullet, Tilapia

Advantage - Extract plankton & nutrients
Disadvantage - waste & respire
Extractive Aquaculture

- Bivalve Mollusca
- Plankton
- Nutrients
- Pollutants
- Respire
Location of Xincun Lagoon

Hai nan Island

Sanya

Xincun Lagoon

South China Sea
Xincun *Kappaphycus sp.* Culture Areas
Fish cage culture area declined because of severely eutrophication of water quality in 1997.
Existing Sources of Pollution

- **Fish cage culture**: 网箱养鱼
  - nearly 5000 tons of organic pollutant annually
  - 每年近5000吨有机污染物

- **Sewage discharging**: 污水排放
  - nearly 400 tons of COD annually
  - 每年近400吨COD

- **River**: 河流
Distribution of DO and Its Influencing factors

DO is low in fish cage culture area

Low DO is the main Eutrophication problem in Xincun Lagoon
Current Level of culture - Low Tide

Oxygen

Distance (Kilometer)

Xincun Town
Qu Gang River
Da Gang Stream
Monkey Island
Wang DR
50% increase in Finfish culture - Low Tide
Jiaozhou Bay
The SPOT Satellite Image
The Local scallop species
(*Chlamys farreri*)
• Shellfish aquaculture areas (gray-filled);
• Selected flux estimation regions (dashed boxes);
• Sections for the model-data comparison (solid lines)
Tidal Mixing
River Discharges
Winds
Heating/Cooling
Precipitation/Evaporation

Fluxes from inter-tidal zone
Nutrients
Phytoplankton
Zooplankton
Shellfish Aquaculture

Conceptual Model
Tidal-cycle averaged surface distributions of temperature, salinity, phytoplankton, and phosphate. (Tide, River Discharge, and A Southeasterly Wind)
Tidal-cycle averaged surface distributions of phytoplankton with the shellfish culture

Shellfish culture density:

- 12 inds./m$^3$
- 24 inds./m$^3$
Benthic Processes

Water Column

Sediment Anaerobic Layer

- DO
- CBOD
- NH₃
- ON
- OP
- OPO₄
- NO₃+NO₂

Phytoplankton Death

Vertical Diffusion

Oxidation

Denitrification