Carrying capacity estimation in common water bodies

Case studies in the Philippines

USSEC Southeast Asia Regional Symposium on Aquaculture Carrying Capacity Modeling for Common Water bodies

10-13 June 2013 Bangkok, Thailand
Scope of the presentation

• Aquaculture impact on the environment
  – nutrients, dissolved and particulate

• Small-scale aquaculture development
  – Bolinao, Philippines
  – Dagpan, Philippines
  – Taal lake Philippines

• Cumulative aquaculture impact

• Modelling carrying capacity
  – box models
Aquaculture nutrient balance

Simplified fish farm

Feed (C, N & P) → Fish (C, N & P)

Dissolved C → Particulate C
Dissolved N → Particulate N
Dissolved P → Particulate P

Water flow
Less than 30% of the nutrient inputs are retained by the fish. The remainder go into the environment where they are assimilated or concentrated.
Nutrient budget and fate - Phosphorous

- Fish food: 94-97%
- Harvest: 17-19%
- Juveniles: 3-6%
- Loss of fish: 1-4%
- External food
- Sedimentation: 50-57%
- Solute release: 25-30%
- Benthic flux: 2-4%
- Sediment accumulation: 47-54%
Impact on the sediments

Nutrient levels in the sediment

- **Sustainable levels**
  - slight build up of organic layer on the seabed
  - Organic layer not increasing over time

- **Unsustainable level**
  - Build up of thick organic layer
  - Change in benthic diversity
  - Smothering of seagrass
  - Smothering of corals
Phosphorus plume from fish cages
Impact on water column

Nutrient concentration in the water

• **Sustainable levels**
  – Stable dissolved nutrient levels not breaching water quality standards
  – increased algae production and zooplankton production
  – increased wild fishery production

• **Unsustainable levels**
  – leads to high algae production
  – algal bloom – algae die off – low/no oxygen – fish kill
Small scale aquaculture development

• Often located in shared water bodies
  – Shared by municipalities, tambaks, etc
  – Lack of integrated water management plan

• Often located in sheltered areas with reduced water exchange
  – Lakes
  – Closed bays
  – Lagoons

• Often not closely regulated or monitored
  – Leading to boom – bust – boom cycle
Norad funded EMMA project 3 case study areas
Bolinao and Anda
Bolinao Bay 2006

Fish cages  460
Fish pens   266
Oyster farms 254
23,000 tonne/yr
8.1 t/ha fish
0.6 t/ha mollusc
220 tonnes feed/day
Reoccurring fish Kills in Bolinao

- Boom 1995<sup>a</sup>, 1996<sup>d</sup>, 1997<sup>a</sup>, 1998<sup>a</sup>, 1999<sup>a</sup>, 2000<sup>b</sup>, 2001<sup>b</sup>, 2002<sup>e</sup>, 2003<sup>c</sup>, 2004<sup>c</sup>, 2005<sup>c</sup>, 2006<sup>c,f</sup>
- Bust 1995<sup>a</sup>, 1996<sup>d</sup>, 1997<sup>a</sup>, 1998<sup>a</sup>, 1999<sup>a</sup>, 2000<sup>b</sup>, 2001<sup>b</sup>, 2002<sup>e</sup>, 2003<sup>c</sup>, 2004<sup>c</sup>, 2005<sup>c</sup>, 2006<sup>c,f</sup>

Fish kill 1996<sup>d</sup>, 1998<sup>a</sup>, 2003<sup>c</sup>, 2004<sup>c</sup>, 2006<sup>c,f</sup>

Boom bust boom bust bust bust boom?

a Verceles et al., 2000, b FRMP, 2001; c Sagip, 2005; d LGCAMC, e PDI, 2002; f OPAG
Dagupan estuary system
Dagupan

Fish pens  553
Fish cages  124
Oyster farms  94
Fish traps  528
590 t/yr fish cage
4,860 t/yr fish pen
500 t/yr mollusc
Taal lake

- Cage sites
- Municipalities
Taal Lake

- 9,600 cages
- 112,800 t/yr
- 4.8 t/ha
- 530 t/feed/day
- 20 year residence time
Fish Kill occurrences Taal Lake

Number of fish kill occurrences

Years

Environmental impact

- Limited local Impact
- Cumulative impact
Estimating maximum aquaculture carrying capacity for Bolinao Bay

The process of determining carrying capacity for fish aquaculture based on determining the critical phytoplankton concentration

- Natural nutrient input
- Aquaculture nutrient input
- Water body characteristics, water volume and water exchange
- Natural equilibrium
- Phytoplankton growth
- Phytoplankton concentration
- Carrying capacity
Estimation of all nutrient sources
(cages + pens + river + domestic + agricultural) – (mollusc + flushing)
Carrying capacity affected by precipitation
Carrying capacity affected by tides

Tidal Height (m)

Sufficient exchange

January 2005
Predicting times of greatest risk