


Filter Feeders in IMTA:

Aquaculture Engineering Considerations and Commercial Aquaculture Considerations

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Talk Outline

1. What characterizes the source particulate
2. Filter feeders: shellfish or fish…or both.
3. Are trophic level interactions of many species available from the open literature (e.g. filtration size and component uptake rates and selectivity)?
4. Choices: local ecology *and/or* marketability.
5. Successful IMTA systems are engineered: (not just assembled from available components)… (anymore).

Food Particle Studies

Most fish waste particle studies on salmonids have been done on recirculation systems where effects of bubblers and ozonation can affect particle size spectrum. Krumins et al. (2001)

However, Patterson and Watts (2002) determined that the particle size power distributions in recirculation systems were consistent with those of waters adjacent to Atlantic salmon (Salmo salar) farms Including a spectral spike at 4µm determined to be from artificial feed.

Krumins, V., J. M. Ebeling and F. Wheaton, 2001, Ozone's effects on power-law particle size distribution in recirculating aquaculture systems **Aquacultural Engineering** 25, Issue 1, August , PP 13-24

Patterson, R. N., and K. C. Watts 2003 Micro-particles in recirculating aquaculture systems: particle size analysis of culture water from a commercial Atlantic salmon site **Aquacultural Engineering** Volume 28, Issues 3-4, August, PP. 99-113

Food Particle Studies contd.

Finally, Chen, et al. (1993) had previously characterized suspended solids from several aquaculture systems with 95%≤ 20µm and a specific gravity of 1.19. These particles represented 40-70% of the total suspended solids by weight.

Also, Rensel, et al. (2005) have characterized Sablefish *(Anoplopoma fimbria)* waste as to sinking rate and published estimates for Cobia (*Rachycentryum canadum*) conservatively at 1cm s^{-1}.

So the particle size, specific gravity and settling rates for several Important species are at least measured (if not fully resolved) and there is some data to work with.

Chen, S, M. B. Timmons, D. J. Aneshansley and J. J. Bisogni Jr, 1993. Suspended solids characteristics from recirculating aquacultural systems and design implications **Aquaculture**, 112, Issues 2-3, 1 May PP. 143-155

Rensel 2005, unpublished *sablefish* data

Fish “Particle” Constituents

Cripps (1995) study of the particulate from salmonid hatcheries notes that while:

“The phosphorus content, in both the suspended solids and the volume of the particles, increased significantly with decreased particle size. Total phosphorus and total nitrogen concentrations were (sic) unaffected by variations in the particulate phosphorus concentration associated with different size particles.” This was observed over 7 size classes from ~5µm to 200µm.

Cripps, Simon J., June 1995, Serial particle size fractionation and characterisation of an aquacultural effluent. Aquaculture, 133, 3-4, Pages 323-339.

Possible Filter Feeders




- We typically assume filter feeders will be bivalves but adult gill Raker *Cyprinidae,* such as Silver Carp, *Hypophthalmichthys molitrix*, consume solely phytoplankton and/or particulate.
- Grey Mullet, *Mugil auratus* offer a frequently cultured, filter feeding fish for use in marine systems.
- Abuzinadah (1995) offers a good review of marine fish gill raker morphology and selectivity for particles.
- ✓ One can engineer a system with marine or freshwater fish filter feeders, bivalves or other mollusks.

Abuzinadah, OA. 1995, Gill Raker Morphology of Some Red Sea Fishes of Different Feeding JAKU Mar. Sci. 6. 93-122

Particle Selectivity

Particle selectivity in bivalves has been extensively studied.

Bayne et al. (1987) determined *Mytilus edulis* could efficiently select food particulate at low concentrations from high silt levels in the marine environment.

Rosa, et al.(2010) described how both the American Oyster (*Crasostrea gigas) and Mytilus edulis,* have the ability to discriminate between carbohydrate or proteinaceous particles and select or reject prior to their crossing the gill.

Bayne, B.L., A.J.S.Hawkins, and E. Navarro. 1987. Feeding and Digestion by the Mussel *Mytilus edulis* in mixtures of silt and algal cells at low concentrations. Journal of Experimental Marine Biology and Ecology. 111:1. PP1-22 .

Rosa, M., J. E. Ward, S. Schumway, E. Pales-Espinosa, B. Allam, G. H. Wickfors and B. A. Hollahan. 2010. Effects of particle surface properties on feeding selectivity by the Eastern Oyster (*Crasostrea gigas*) and the Blue Mussel (*Mytilus edulis*). Aquaculture 2010, San Diego, CA March 2010.

Particle Size Selection

Sea Scallop, Plactopectin magellanicus, an important East coast commercial scallop, was found to be insensitive to particle size but sensitive to particle food quality (high chlorophyll-a content) by MacDonald and Ward (1994)

The East coast Market Clam, *Mercenaria mercenaria,* an important as a fishery and an aquaculture species shows greater particle size selectivity at lower temperature (20C) (Larger particles) than at higher (30C) (smaller particles) , but no effect on clearance rates. But more study needed.

Tapes and *Mytilus edulis* were found to reject particles > 7.5µm to 22µm by Defossez and Hawkins (1997).

MacDonald, B. A. and J. E. Ward, 2004. Variation in Food Quality and particle Selectivity in the Sea Scallop *Plactopectin magellanicus. Mar. Ecol. Prog. Ser., 108:251-264*

Beals, C.D., 2004. *Clearance Rates and Particle Selectivity in the Hard Clam Mercenaria mercenaria* from warm water habitats. MS Thesis. University of Florida.

Defossez, J.-M. and A. J. S. Hawkins.1997. Selective feeding in shellfish: size-dependent rejection of large particles within pseudofaeces from *Mytilus edulis* , *Ruditapes philippinarum* and *Tapes decussatus* Marine Biology, 129: 1 PP 139-147,

Filter Feeder Trophic Interactions

Sorokin (1977) observed facultative ability in *Mytilus edulis* to directly uptake dissolved organic compounds directly from seawater with C14 labeled component uptake studies. Mytilus thus can gain sufficient nutrition for survival and growth, compensating for lack of uptake of particulate seawater components, previously thought required for survival and growth.

Sorokin (1995), using the same C14 label technique, also noted that the diet of Manila clams (*Tapes phillipinarum* and *decussatus*) in the Adriatic was typically ~30% bacteria and a like amount of organic detrius, *not all phytoplankton*.

Sorokin, Y. I. 1977, On the mechanism of dissolved organic matter uptake in invertebrates (in Russian). Journal of General Biology (Moscow) 38: 185-197

Sorokin, Y. I. and O. Giovanardi 1995. Trophic Characteristics of the Manila Clam (*Tapes phillipinarum*) Adams and Reeve. ICES J. Mar. Sci. 52: 853-862

Ecosystem based IMTA Model

Swedish Shrimp Farm Discharge IMTA Biofilter

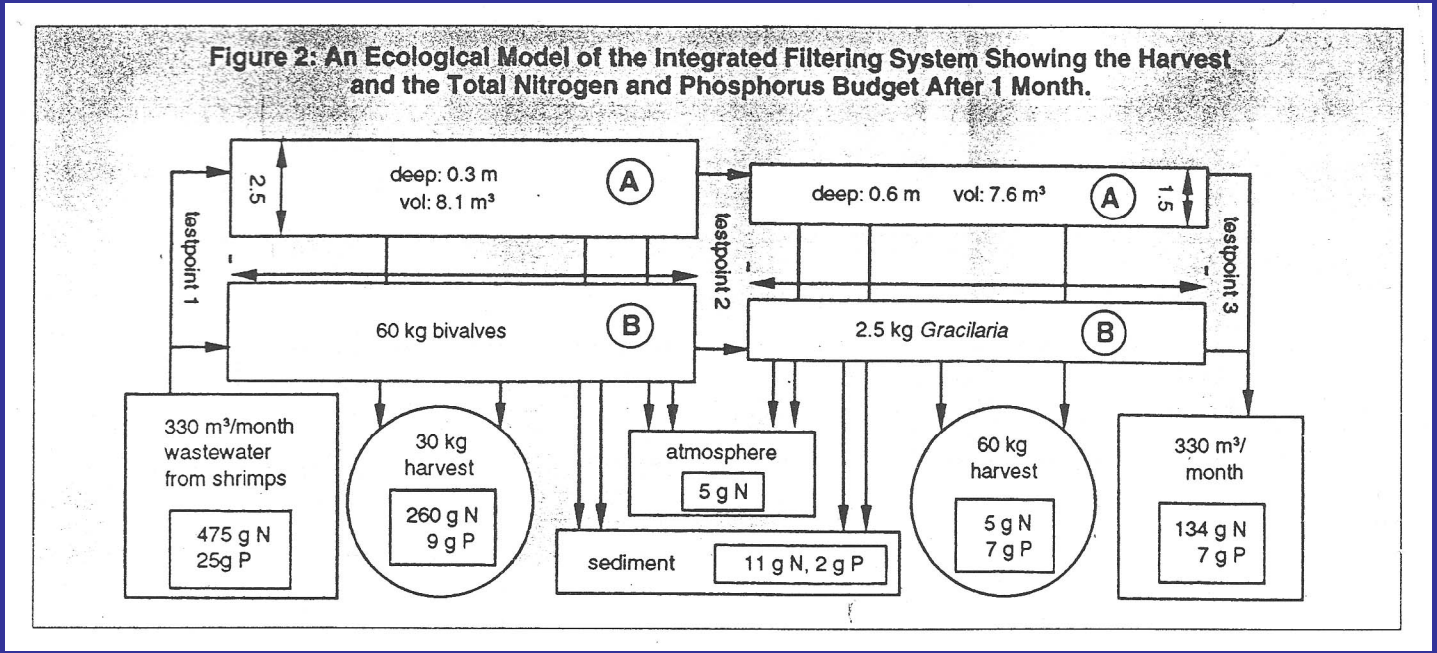
Camaros Shrimp Farm, Kota Bharu, Malaysia

(Mans Enander and Mans Hasselstrom ,Thesis work, 1990, U. Stockholm, Sweden) INFOFISH INTERNATIONAL 4-94, pp 56-61.

Hairy Cockle, *Scapharca inaequivalvis*

Macro Algae, *Gracilaria. sp*.

Layout of Integrated Filter System



Trials were in duplicate. Recovery average for 2 systems was:

72% N and 61% P, mostly as harvested product for resale.

Estimated Total Farm Output*

Farm drainage channel total length 2000m

Using oysters instead of Cockles as export crop:

Oysters = 11mt /month @ $3.46/kg (1994)

= $38,000/month*

Algae = 333kg (dry wt) / month**

* In excess of shrimp production

**may also be used as feed pellet binder for shrimp farm.

Aquaculture Engineering

Initial conditions for engineering a filter feeder component in an IMTA system to be considered:

a. What size particle range is the feed stock.
b. What chemical component range (carbohydrate or protein, N and PO4),
c. With what uptake characteristics do we need to accommodate.

Take Away

- Wide range of “filter feeders” to select from, both fish and shellfish.
- Particle size from source can be important for some bivalves at low temperatures due to size selectivity for larger particles
- Marketability will be a factor but should not an be overriding consideration…
- Engineered systems will succeed where ad hoc approaches fail