IMTA Components: Deposit Feeders

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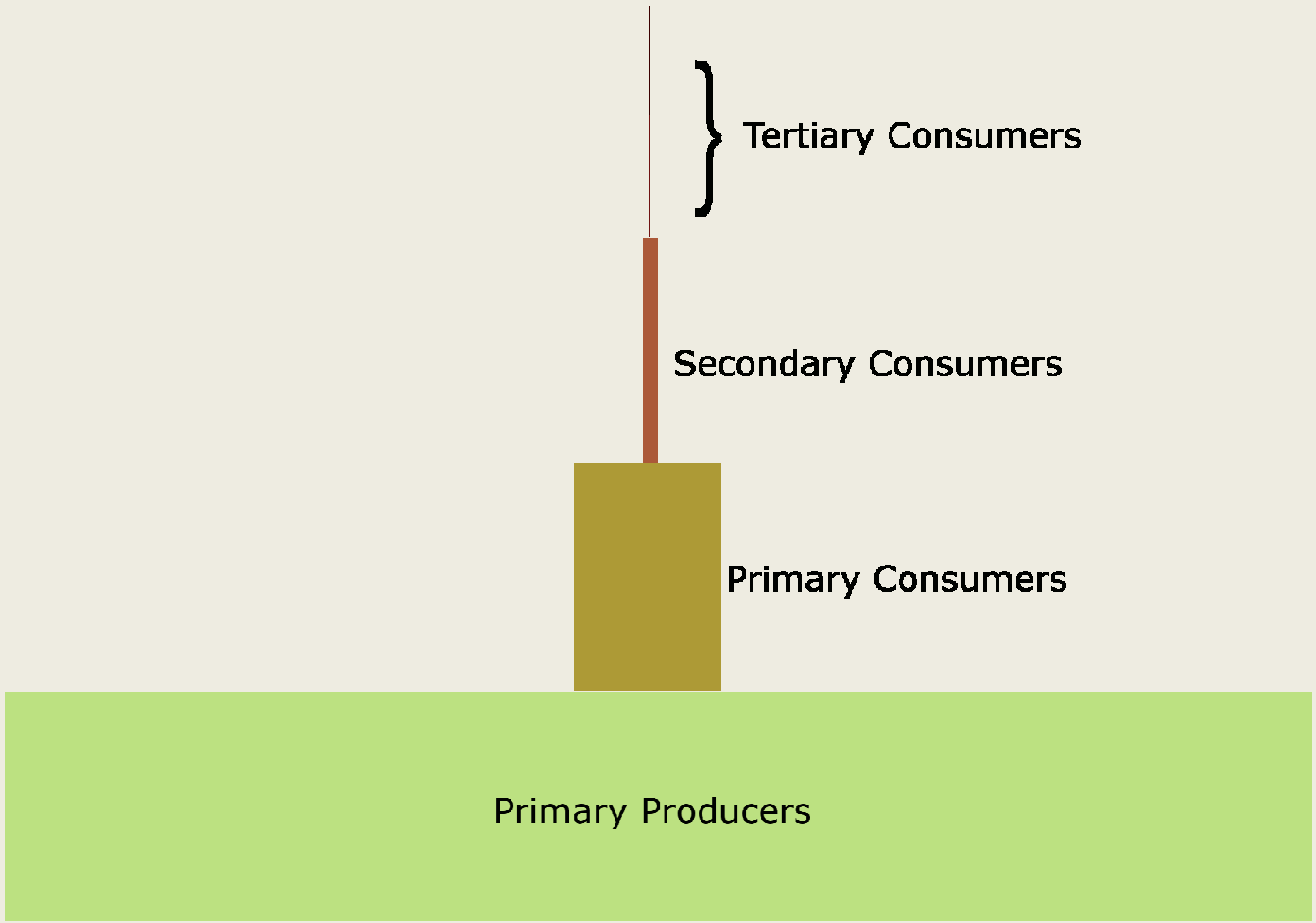
Presentation Outline

- Some definitions
- Ecological perspectives
- Examination of aquaculture biosolids
- Sea cucumbers as a case study
- Other opportunities for biosolid utilization

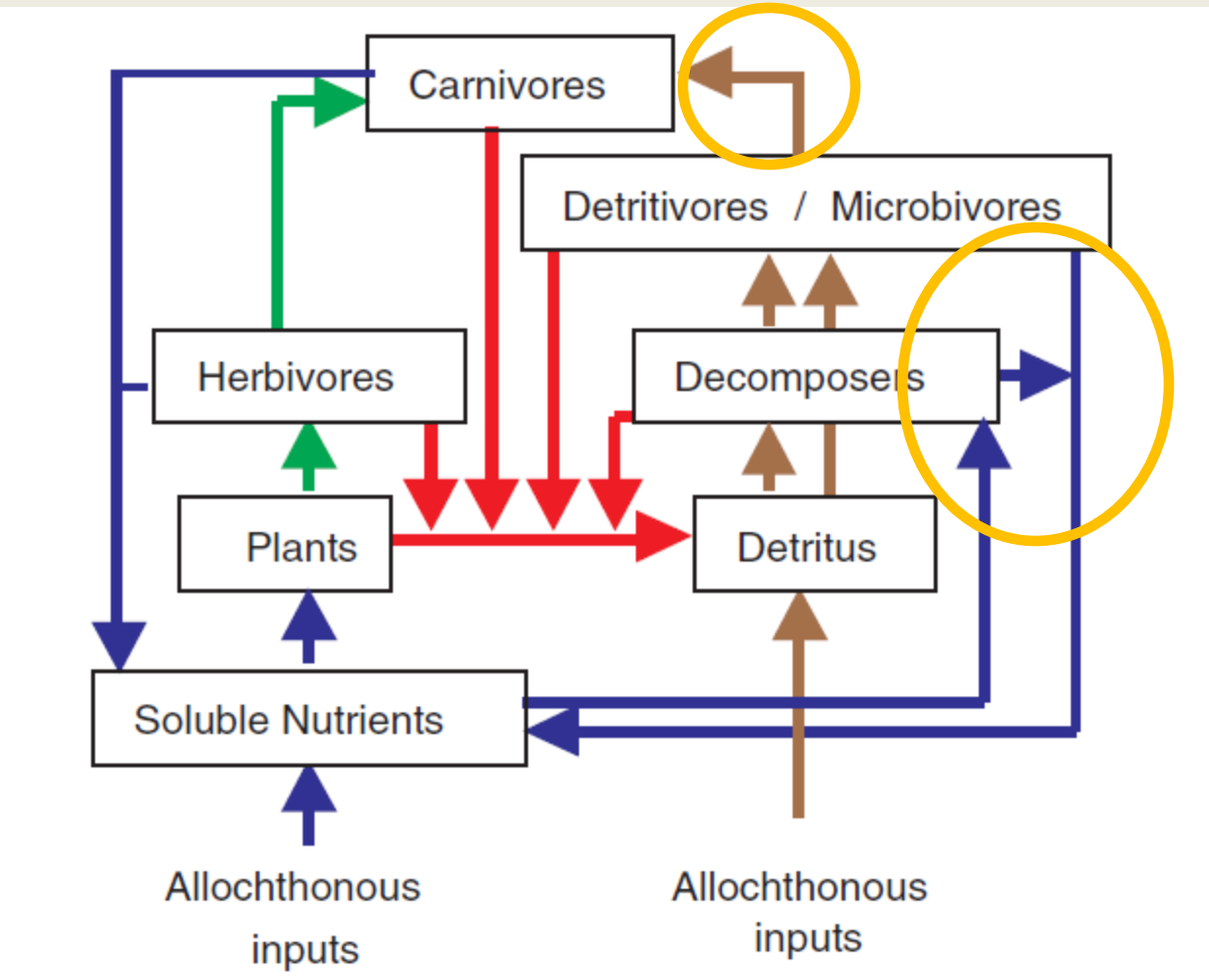
Some Definitions

- Deposit feeders
  - Organisms that feed on settleable detritus
- Detritus
  - Any form of non-living organic matter
- Aquaculture terminology
  - Extensive vs. intensive aquaculture
  - Open vs. closed or semi-closed aquaculture

Typical Trophic Model

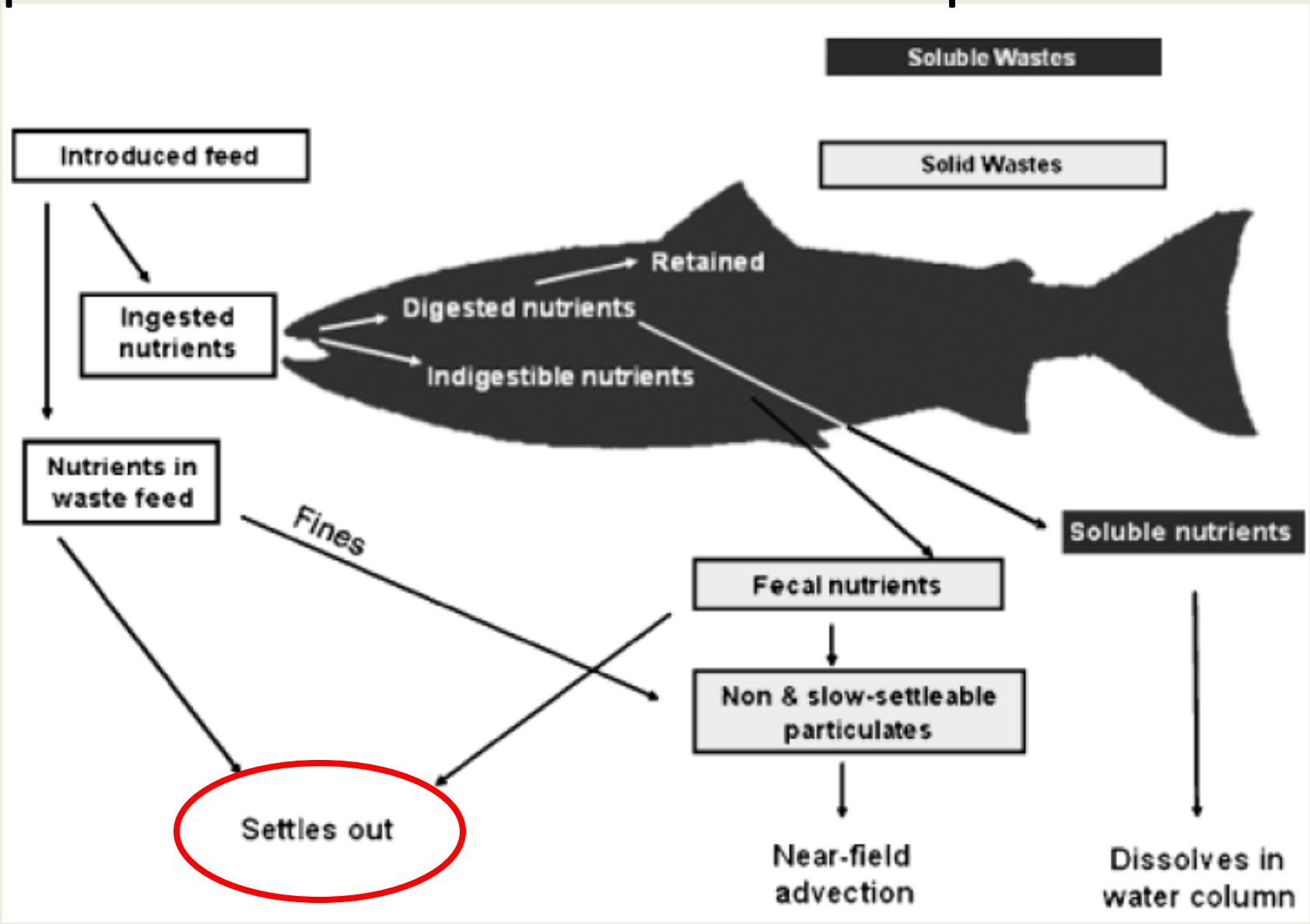


Modified Trophic Model



Moore, et al. 2004

Application to IMTA – Intensive aquaculture



Reid, et al. 2009.

Intensive Aquaculture Feeds/Feeding

- Concentrated nutrients in extruded dry diets
- High level of digestibility
- Efficient feeding practices leading to reduced waste feed

Per 100 grams of feed (dry) for Atlantic salmon:

Diet Component	Diet Dry Mass g	Digestibility %	Feces Dry Mass g (%)
Protein	42.6	90	4.3 (26.4)
Lipid	36.1	95	1.8 (11.0)
Carbohydrate	10.9	60	4.4 (27.0)
Phosphorus	1.3	50	0.7 (4.3)
Other minerals	7.4	50	3.7 (22.7)
Fiber	1.6	10	1.4 (8.5)
Total	100		16.3 (100)

Based on Reid, et al. 2009.

Per 100 grams of feed (dry) for Atlantic salmon:

Diet Component	Waste Feed (3%) Dry Mass g	Feces Dry Mass g	Biosolid Dry Mass g (%)
Protein	1.3	4.3	5.6 (29.0)
Lipid	1.1	1.8	2.9 (15.0)
Carbohydrate	0.3	4.4	4.7 (24.4)
Phosphorus	0.04	0.7	0.74 (3.8)
Other minerals	0.2	3.7	3.9 (20.2)
Fiber	0.05	1.4	1.45 (7.5)
Total	3.0	16.3	19.3 (100)

Based on Reid, et al. 2009.

Fate of Waste Feed/Feces

- Disintegration, dispersal, composition influenced by:
  - Diet characteristics (size, density, binders)
  - Fish species (size and species)
  - Site characteristics (tidal current, turbulence, structures, depth, salinity, etc.)
  - Microbial colonization (digestibility)
- Importance:
  - Determines proportions of suspended vs. settleable
  - Area of influence (benthic surface area, water column)
  - Nutritional quality

Review of Biosolid Sources

- From fed fish:
  - Waste feed
  - Feces
- From fouling organisms (plants and animals)

IMTA: Co-cultured extractive species

- Seaweeds
- Bivalves
  - Feces
  - Pseudo-feces

Species Selection for Biosolid Utilization: Criteria for IMTA Use

- Efficiently performs at desired trophic level
- Capable of being produced from hatcheries
- Can be readily integrated into the farm system
- High value harvest product
- Low ecological risk

Sea Cucumbers

- 23 commonly fished sea cucumber species (Raison 2008)
- Commonly aquacultured:
  - North China- *Apostichopus japonicas* (Prickly red teatfish)
  - Ecuador- *Isostichopus fuscus (Galapagos sea cucumber)*
  - South Pacific- *Holothuria scabra* (Sandfish)
- Temperate species that have been cultured:
  - North Atlantic- *Cucumaria frondosa* (Orange footed cucumber)
  - North Pacific- *Parastichopus californicus* (Giant red sea cucumber) Mainly wild harvested on the West Coast

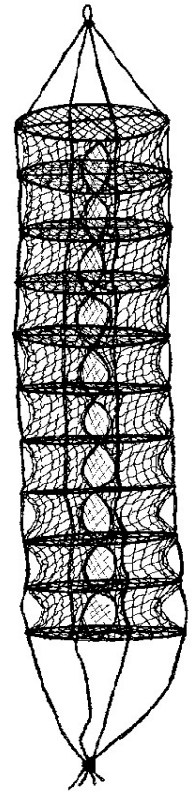
Aquaculture Methods

- Hatchery spawning and rearing similar to other invertebrates with planktonic larvae
- Monoculture is done in ponds and pens
- Sea ranching and stock enhancement is common
- Integration in IMTA has involved trays and benthic enclosures associated with shellfish and finfish operations

IMTA applications: finfish marine net pen operation

- Species: *Parastichopus californicus*
- Application: Stocked in small mesh fish net pens
- Location: Southeast Alaska
- Findings: Significant clearing of fouling debris on nets; more growth than benthic controls; high level of assimilation compared to benthic sediment
- Conclusions: Recommended use for both net maintenance and additional crop
- Source: Ahlgren 1998

IMTA applications: Co-culture with bivalves



- Species: *Apostichopus japonicas*
- Application: Tank and field (lantern net) studies with scallops
- Location: Northern China
- Findings: Good growth on bivalve biodeposits in both tanks and lantern nets
- Conclusions: Recommended use for providing an additional crop
- Source: Zhou et al. 2006

IMTA applications: Co-culture with

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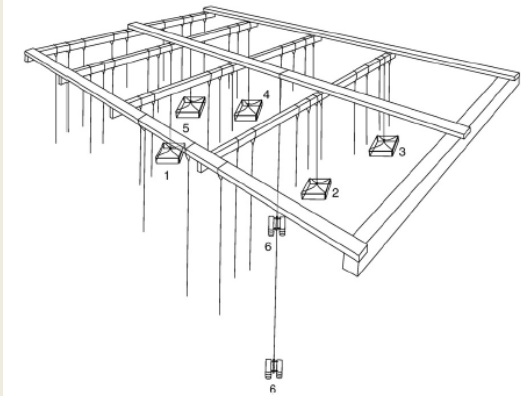
- enclosures) studies with mussels
- Location: New Zealand
- Findings: Growth is density dependent in benthic enclosures; successful feeding of mussel impacted sediments in lab studies
- Conclusions: “Ideal candidate for polyculture”
- Source: Slater and Carton 2007

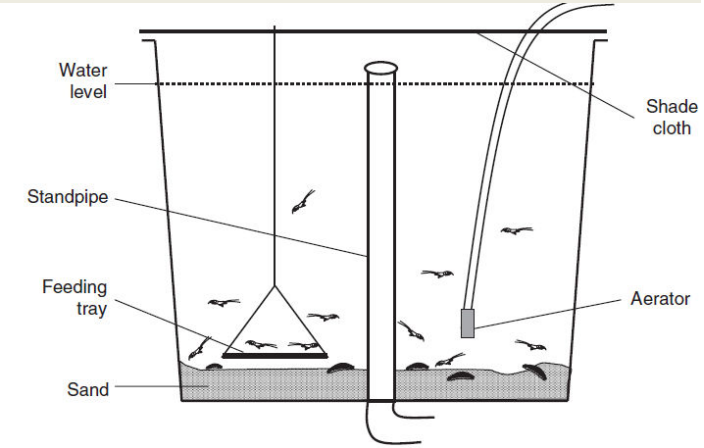
IMTA applications: Co-culture with bivalves

- Species: *Parastichopus californicus*
- Application: Suspended trays beneath suspended oyster culture operation
- Location: British Columbia, Canada
- Findings: Seasonal variations in growth; 40% assimilation efficiency; high survival in trays
- Conclusions: Commercial scale co-culture system to reduce organic deposition and provide additional crop
- Source: Palzat et al. 2008



IMTA applications: Co-culture with shrimp

- Species: *Holothuria scabra*
- Application: Tank co-culture with blue shrimp
- Location: New Caledonia (South Pacific)
- Findings: Comparable survival in co-culture; sea cucumbers feed successfully
- Conclusions: Synergistic effects not observed; more study needed
- Source: Purcell et al. 2006



Other Opportunities

- Other detritivores:
  - Finfish (e.g., mullets)
  - Invertebrates (Crustaceans, annelids)
- Contained aquaculture systems
  - Worm composting
  - Integration with terrestrial agriculture
  - Biofloc technologies

Questions