Ecosystem Services Provided by Shellfish Aquaculture

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What are Ecosystem Services?

The processes by which the environment produces resources that we often take for granted.

Example: Wetland marshes clean the water that passes through and provide food and habitat for juvenile fish and birds.

Grasses capture sediment which improves water quality and bacteria decompose organic waste.

The plants produce oxygen and stabilize sediment during storms and provide food.
What services are associated with shellfish aquaculture?

- Nutrient removal
  - At harvest
  - Through stimulated denitrification
- Turbidity reduction
  - Light penetration – deepens oxic zone and allows eelgrass to repopulate
- Improved habitat quality
Nutrient impacts

Nutrient pollution is the primary cause of eutrophication in our coastal waters.

Two thirds of our rivers and coastal waters are classified as “degraded” due to excessive nutrient inputs from fertilizer, sewage and fossil fuel combustion. (NOAA)
When excessive nitrogen leaches into coastal waters from fertilizer or sewage it can lead to blooms of algae and phytoplankton..

Which shades out eelgrass and....

When the algae dies bacterial decomposition leads to hypoxia, loss of habitat and diversity
Reactive Nitrogen

Nutrient impacts

- Nutrients are removed when shellfish are harvested
- Shellfish feeding enhances bacterial denitrification
- Shellfish enhance sedimentation rates and speed the sequestration of nutrients
- Shellfish repackage phytoplankton biomass and make it available to benthic deposit feeders
The harvest of 3,750 oysters compensates for the nitrogenous wastes from one person leaching into the watershed.
A market-size oyster contains about 0.5 grams N and 0.16 g P

The combined effect of US eastern oyster aquaculture harvest removes 357 metric tons of nitrogen and 110 metric tons of phosphorus from the marine environment.

That’s just the eastern oyster....
Shellfish Filtration
A single oyster filters 15-50 gallons a day

- Reduces turbidity
- Improves water quality and clarity
- Improves light penetration
  - Allows eelgrass to recolonize areas.
  - Increases depth of oxic layer
- Stimulates bacterial denitrification
Ecosystem Services from Shellfish Aquaculture

- Nutrients are removed when shellfish are harvested
- Shellfish enhance bacterial denitrification
- Oysters enhance sedimentation rates and speed the sequestration of nutrients
- Filter feeding improves water clarity and increases light penetration which helps eelgrass
- Aquaculture gear provides habitat and supports a diverse assemblage of juvenile fish, crabs, lobsters....
“dead bottom” - no prior use
Bottom Cages
Fouled growout bags
Study Area

A - MRBAG
B - NVSB
C - SAV

Pt. Judith Pond

Rhode Island, USA
Dominant Fish Species Throughout Sampling Periods

Fish # | Common Name
--- | ---
1 | American eel
2 | Seaboard Goby
3 | Grubby
4 | Toadfish
5 | Gunnel
6 | Winter Flounder
7 | Northern Pipefish
8 | Tautog
9 | Cunner
Aquaculture Structures Provide Habitat

- Kilpatrick (2002) found several times the abundance of fish and crustaceans in oyster gear vs. eelgrass beds
- Species diversity was similar to eelgrass and far superior to non-vegetated bottom
Are cages simply acting as “fish attracting devices” or do fish utilize them as habitat?

Shelter (demography)
Feeding & Breeding (productivity)
Tallman & Forrester 2007
Mark and recapture study comparing cages with constructed and natural reefs

- Density
- Size
- Growth
- Survival

Black sea bass
*Centropristis striata*

Cunner
*Tautogalabrus adspersus*

Scup
*Stenotomus chrysops*

Tautog
*Tautoga onitis*
Tallman’s Conclusions

- Cages are structurally similar to natural and constructed rocky reefs
- Develop similar species assemblages, similar growth and survival rates
- Preserve patterns of biodiversity
- Cages mimic essential fish habitat
Physical structure and firm substrate provided by mussel longlines, floating trays and oyster bottom culture also enhances juvenile fish populations.

Mussel longline ready for harvest.

Photo by T. Holm
What happens when gear is tended or at harvest?

• Impossible to harvest or tend gear all at once
• There is some mortality of associated organisms
• Farmers replant following harvest – replacing structure
• On balance predict a strong positive impact
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- Carbon deposited in shell is sequestered for decades
- Cultured shellfish release larvae into the environment
Cultured Eastern oysters release at least $1.7 \times 10^{15}$ larvae annually.
Benefits of Oyster Farming

- 357 metric tons of nitrogen removed
- 110 metric tons of phosphate removed
- Hundreds of tons of other nutrients removed by burial or denitrification
- 51,559 tons of carbon sequestered
- $1.7 \times 10^{15}$ larvae released each year
- 94 million cubic meters of water filtered daily
- Thousands of acres of barren bottom turned into productive fish habitat
And that is just the cultured Eastern oyster

Add in 500 Million cultured clams
Not a panacea

• Probably not going to solve the nutrient problems – but it will help
• Issues of scale – monoculture, habitat diversity
• Issues of temporal dislocation
• Really the only affordable mechanism to address non-point source nutrient issues
Shellfish farmers are passionate stewards of the environment and advocates for clean water.

And we are the virtual canaries in the coal mine when it comes to detecting (and fighting) declines in water quality.
Shellfish farmers lead the seafood industry in sustainability

- West Coast growers adopted Environmental Codes of Practice
- Cooperate with Monterey Bay Seafood Watch and Chef’s Collaborative
- ECSGA formulating BMPs
- WWF Dialogs to foster sustainability certification

BEST CHOICES

- Arctic Char (farmed)
- Barramundi (US farmed)
- Catfish (US farmed)
- Clams, Mussels, Oysters (farmed)
- Clams: Softshell/Steamers (wild)
- Cobia (US farmed)
- Crab: Dungeness, Stone
- Croaker: Atlantic
- Halibut: Pacific
- Lobster: Spiny (US)
- Pollock (Alaska wild)
- Salmon (Alaska wild)
- Scallops: Bay (farmed)
- Squid: Longfin (US)
- Striped Bass (farmed or wild)
- Swordfish (Canada and US, harpoon and handline)
- Tilapia (US farmed)
- Trout: Rainbow (farmed)
- Tuna: Albacore (troll/pole, US or British Columbia)
- Tuna: Skinski (troll/pole)
Performance standards based on best science.

International Steering Committee

Ensure sustainable practices and social standards

Lead to certification via Aquaculture Stewardship Council

Question of whether market cares enough to cover the cost of certification?

www.worldwildlife.org/bivalvedialogue
Virtues of Shellfish

- Delicious
- Nutritious (high in protein, minerals, omega 3 fatty acids – heart healthy)
- Feed low on the food chain
- Sustainably cultured
- Proven environmental benefits