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2016 AQ Summit: Shellfish Sub-sector Update by Carter Newell

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BIVALVE CULTIVATION IN MAINE*

Jan, 2016 2nd Maine Aquaculture R +D Forum

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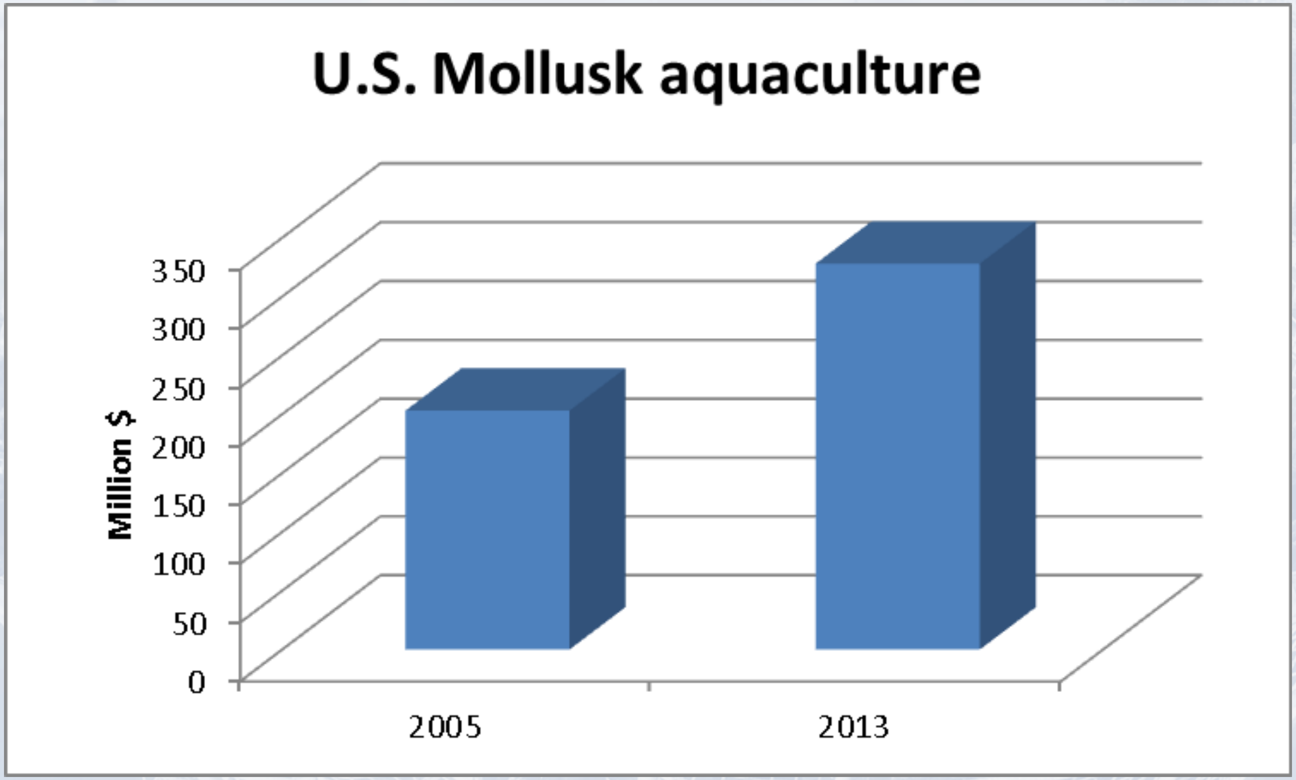
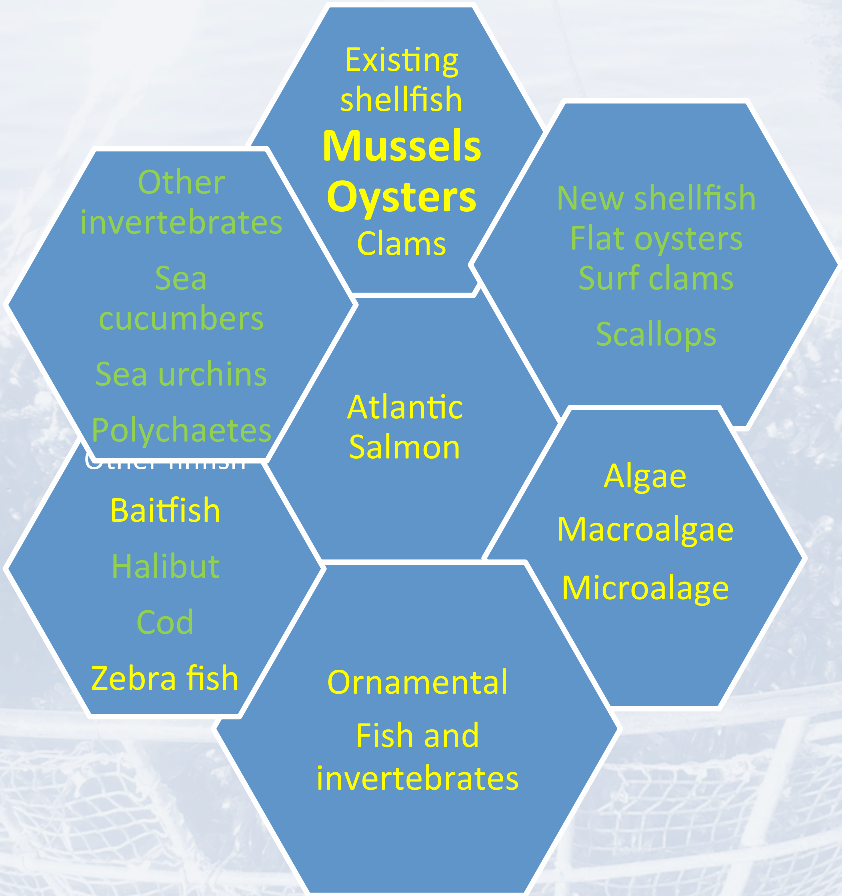
RIGHT SPECIES/RIGHT ENVIRONMENT/RIGHT CULTURE TECHNOLOGY/ RIGHT MARKET PRICE = SUCCESS

U.S. mollusk aquaculture has grown 35% in the last 8 years to over $300 million



Maine Aquaculture



Over 600 jobs

Estimated $100 million industry

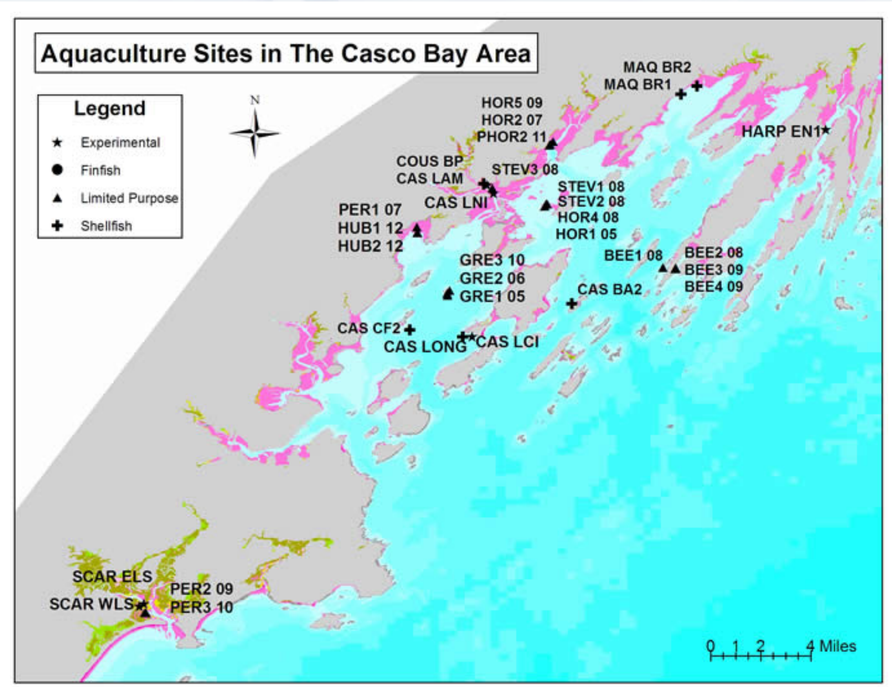
Fastest growing sector worldwide in food production

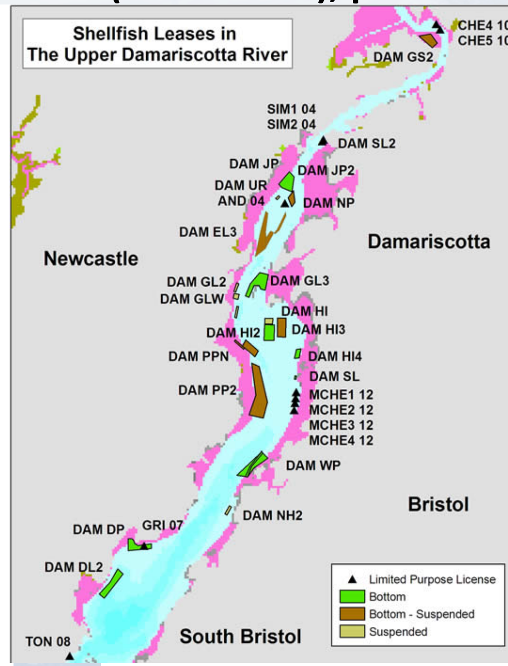
EXISTING SHELLFISH FARMS

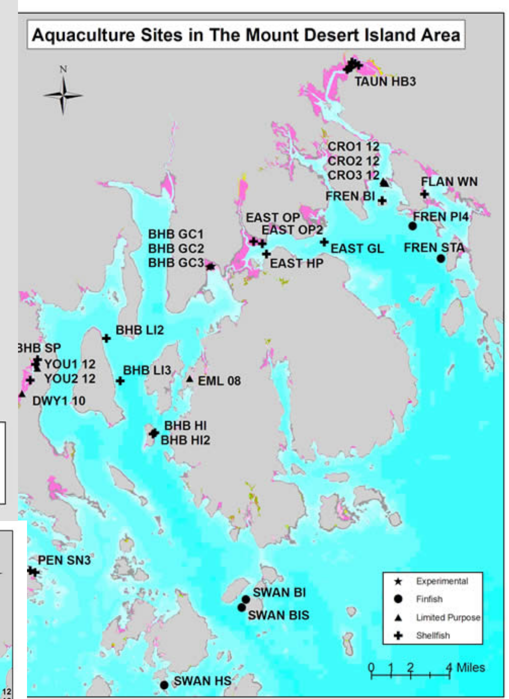
Maine.gov/dmr/aquaculture

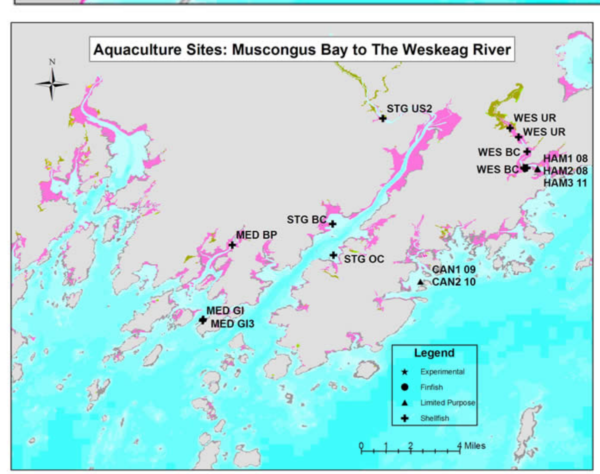
Oysters – warmer water (over 20 C) for good growth rates, protected

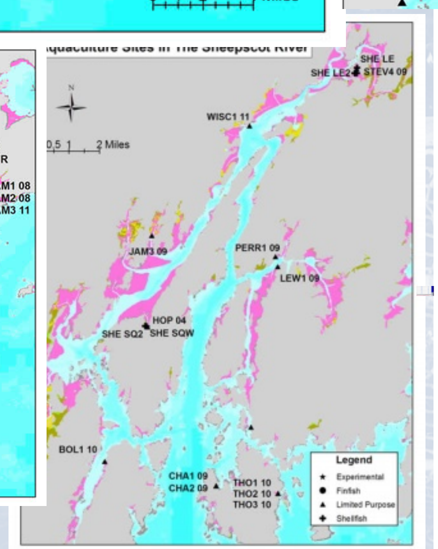
Mussels – colder water (below 20 C), protected

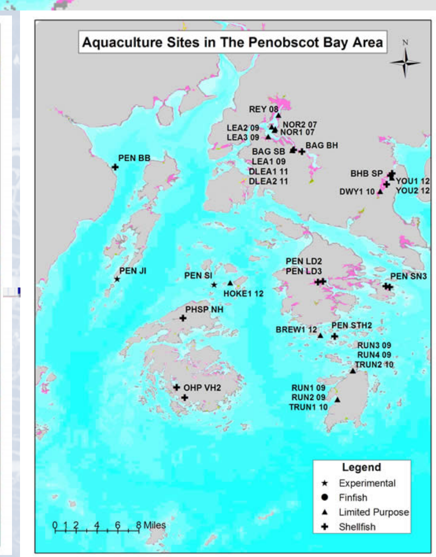






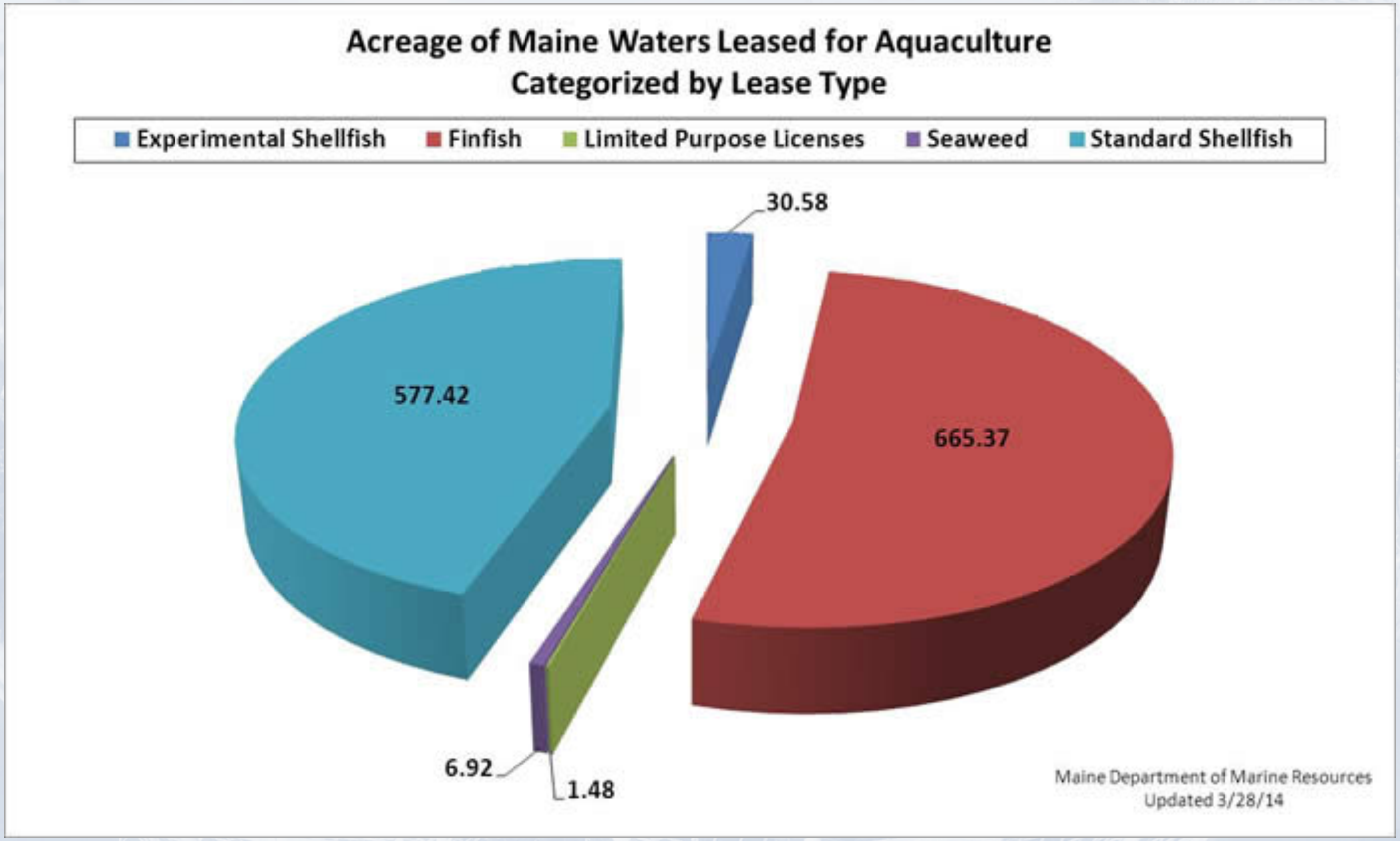






25 finfish
56 shellfish
19 experimental
150 LPA

ACREAGE BY TYPE OF SEAFARM
Shellfish and seaweed sectors growing



Oysters $5 to $10 million and growing
Mussels $1 to $2 million and growing

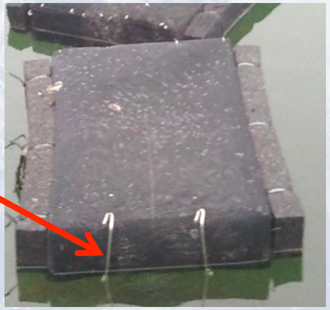
Oyster farming processes

site selection, hatchery, upwellers, nursery, grow-out, processing, harvesting, sales.

UPWELLERS

- A variety of different kinds used
- Most have square silos and use “ice eater” electric pumps
- Early grading by hand, then use quick tube sorter with ½ inch and ¾ inch drum
- Utilize warmest site possible for growth from 2 mm to 20 mm (> 20 C)
- Hydraulic design has not yet been optimized
- Put in warmest water available

Floating bag nursery (double longline)



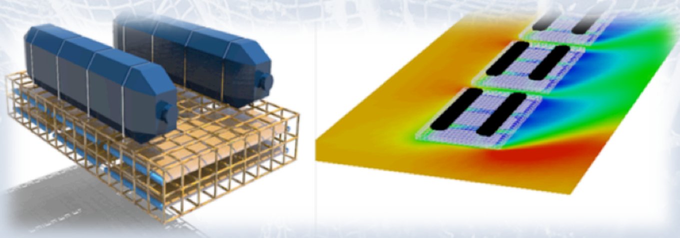
- Bags cut and formed into boxes 4 inches thick using hog rings
- Bags attached to longlines using longline clips on each end of bag
- Open end of bag held closed using SS clips made using a simple jig. The clips also act as handles to lift bags which weigh 35 lbs when ½ full.
- 200 bags in a longline – holds 800,000 small or 200,000 large seed
- Bags flipped weekly to eliminate surface fouling
- Water temperature 2 degrees C warmer at the surface = rapid growth
- Seed from upwellers go into 3/16 bags 4,000/bag
- Seed from 3/16 bags graded ½ and larger go into 3/8 bags 1,000/bag
- Fast growers make it to 45-50 mm June 1 - December bottom planted
- Bottom planted seed go through 7/8 and 1 ¼ inch drum (over 1 ¼ planted)
- Seed under 45 mm overwintered and put out next spring for August planting
- Nursery of 1500 bags grows 1.5 million July-Dec new crops, use same bags for .5-1 million overwintered seed April - July

Bottom planting

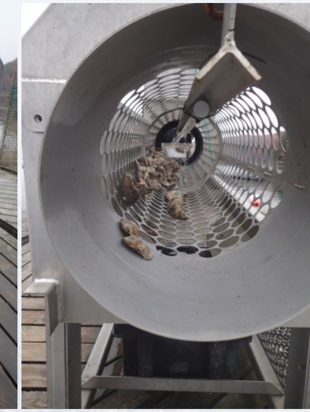
- Oysters are planted using a GPS and plotter in 1-4 acre plots
- Oysters hit prop wash and distribute very evenly
- Bottom density depends on water velocity: for 30 cm per second currents, 20/square foot is used to get even growth
- 50 mm seed grows to 85 mm in 1 year
- Bottom oysters develop nice cup, no labor, clean shells, average 60% survival

Surface culture : OysterGro Cages

Costs about $120/each
Holds 6 bags/up to 900 market sized
Has to be flipped weekly
Sunk to bottom in winter



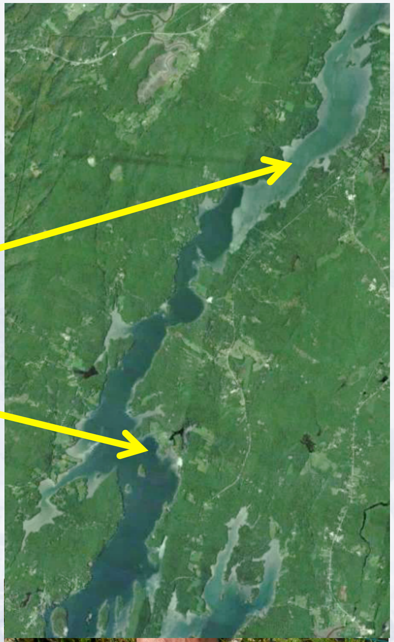
Harvesting and grading

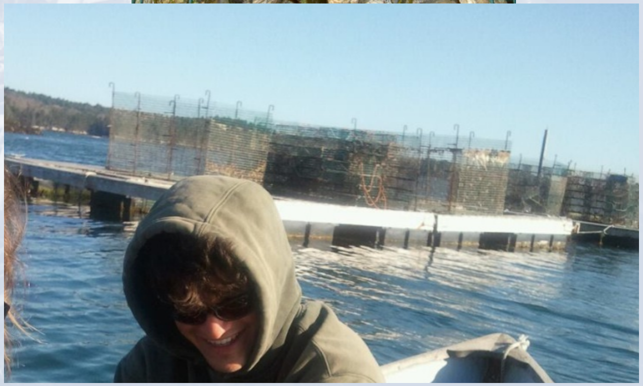


- Harvest about 10,000 in 3 hours 3 person crew
- Grade out cocktail, select and jumbo in 1 hour
- Drum size 1 7/8”, 2 ½”
- Count into 200, 120 or 60 count bags
- Steam down to wet storage area for reimmersion, and quality improvement

Wet Storage and Sales

- Wet storage site 6 miles away in colder, clean water with higher salinity
- Wet storage is a *Vibrio* control strategy
- Oysters purge out an grit and repair any shell damage during harvesting
- Special baskets hold oysters allowing for circulation and fattening
- Each car with 4 inserts holds 36 baskets or 4,000-7,000 oysters per insert
- Two cars hold 32,000 oysters
- Inserts removed periodically and air dried to elminate fouling
- Baskets also serve as overwintering trays using inserts
- Sales is facilitated by having oysters already sorted, graded and counted : they are washed, bagged and put into a refrigerated truck immediately
- Site is protected, ice free, and available year-round





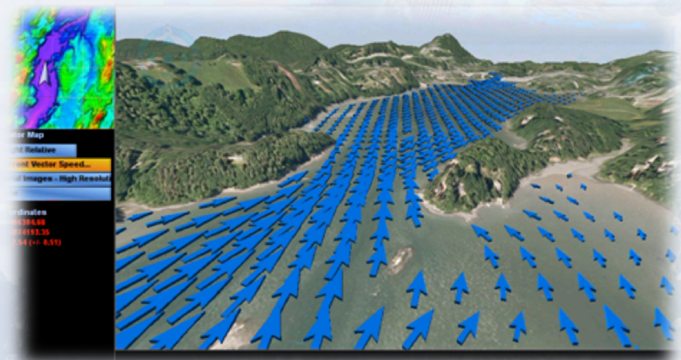
Pemaquid Oyster Festival

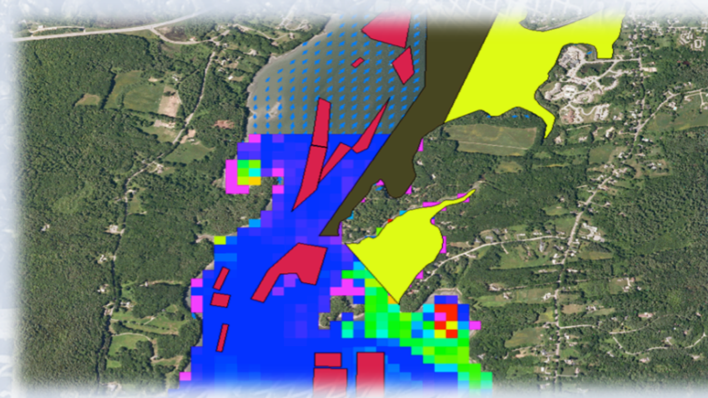
- Shuck 15,000 oysters
- Raise $15,000 for Ed Myers marine conservation fund
- Boat tours of oyster farms
- Shucking contest
- Live music all day
- Tent of education/information including land trusts, conservation groups, regulators, research, touch tank, children's activities

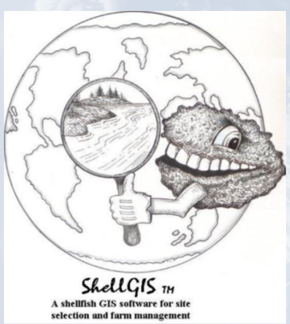
Research : Site selection and optimizing growth and yield

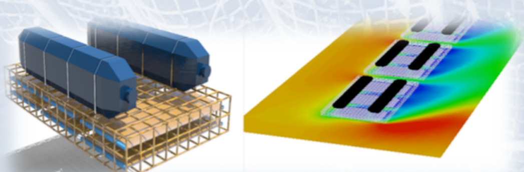
Development of aquaculture GIS system (SHELLGIS, www.shellgis.com)

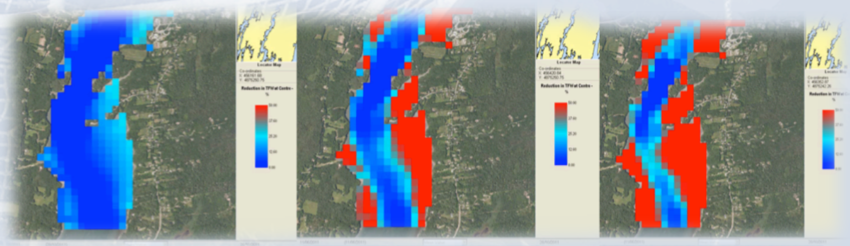
- Initial funding by Maine Aquaculture Innovation Center (MAIC) for proof of concept 2009
- Funding from Northeast Regional Aquaculture Center (NRAC) to develop system for American Oysters in upper Damariscotta River 2010-2015
- Partners: MAIC, Blue Hill Hydraulics, Pemaquid Oyster Company, Plymouth Marine Laboratory, Discovery Software, U. Conn. Sea Grant, Pacific Shellfish Institute





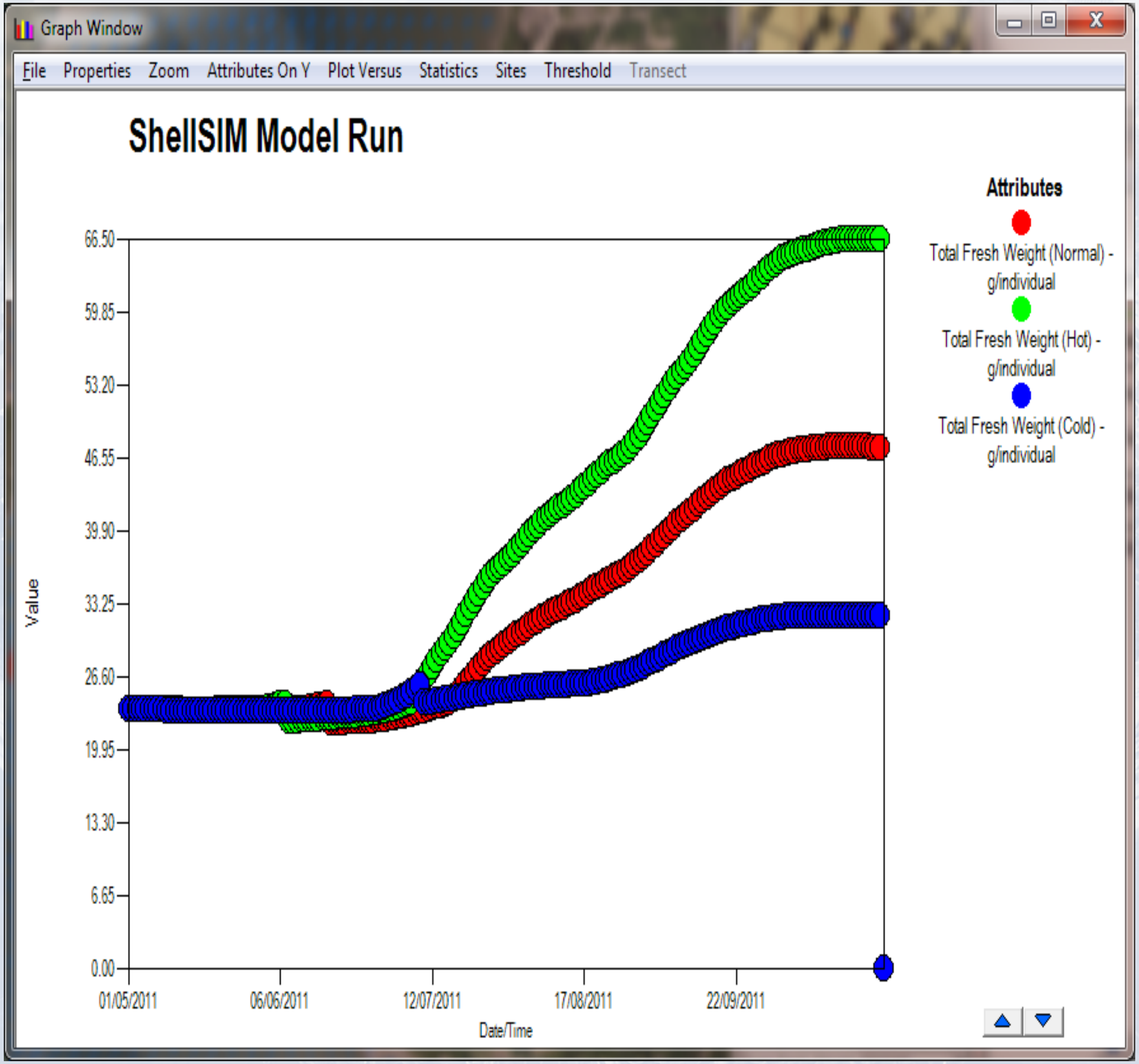






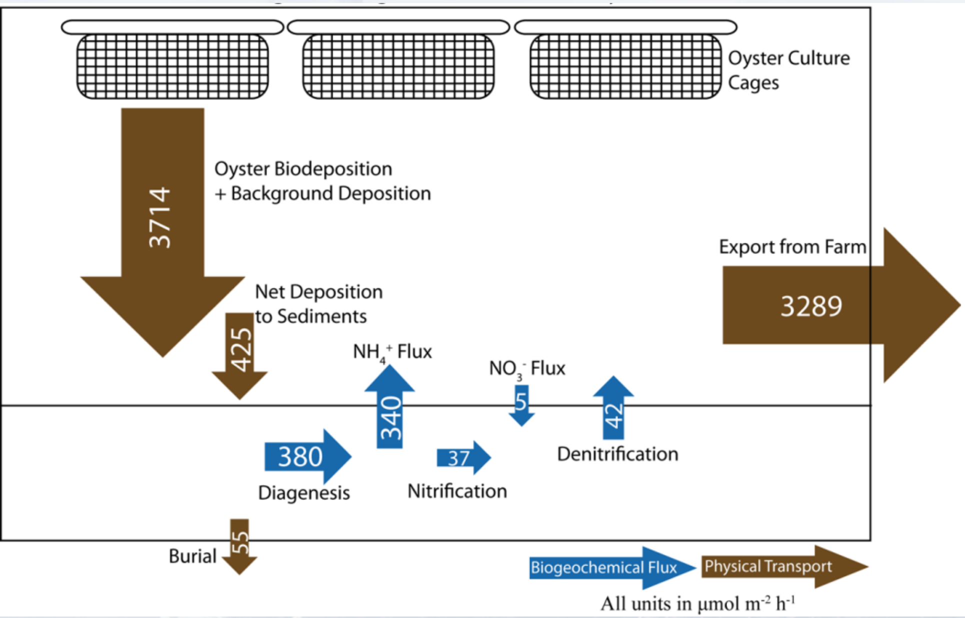
Research: SHELLGIS

Modelled effects of a changing climate: Simulated growth at 300 m^{-2} on a hot year (green) or cold year (blue) (+/- 3 C)



Research: Environmental effects Sediment Flux Modeling and Biodeposition (National Sea Grant 2011-2014).

Conclusion: ***good flow means good growth as well as environmentally sustainable*** (benthic impacts)*

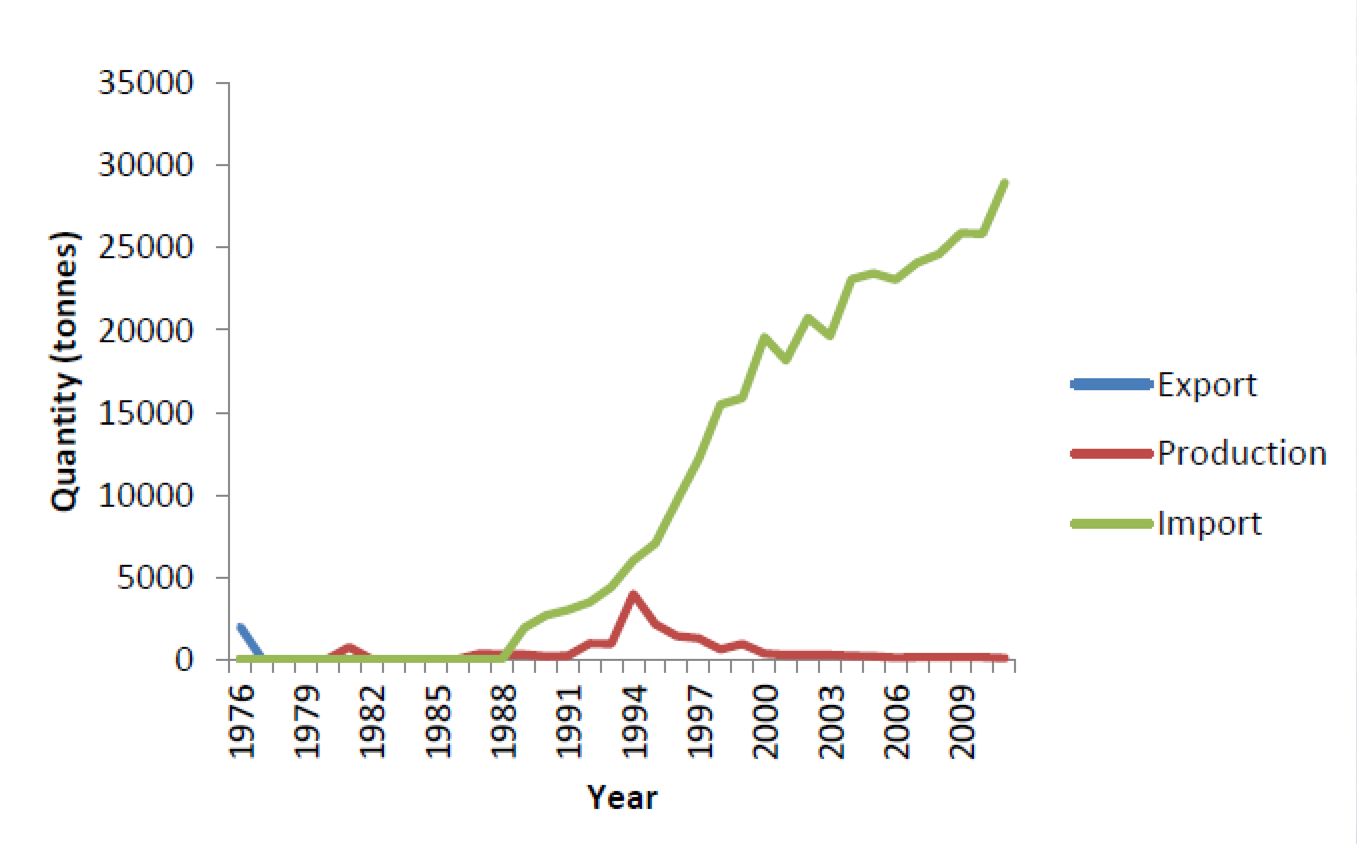


- Maryland farm biodeposition **settles to bottom and mostly moves off site due to resuspension from tidal currents and waves**
- Most of the **nitrogen is converted back to ammonium** for the phytoplankton to use within days

At this site in Maryland, **tidal resuspension** (light green) moved the material regularly, and periodically the sediments were **resuspended by waves** (dark green)

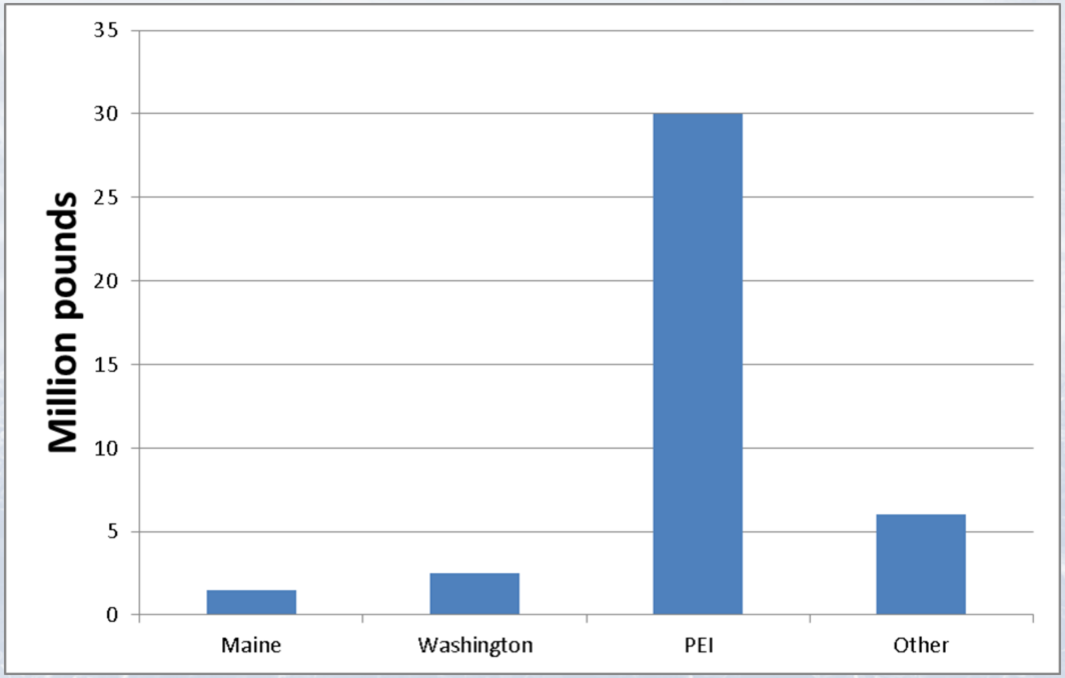
* Testa, J.M., Brady, D.C., Cornwell, J.C., Owens, M.S., Sanford, L.P., Newell, C.R., Suttles, S.E. and Newell, R.I.E., 2015. Modeling the impact of floating oyster (Crassostrea virginica) aquaculture on sediment–water nutrient and oxygen fluxesAquaculture Environment Interactions 7: 205-222.

MUSSELS: DEMAND
U.S. Farmed Mussel consumption is growing



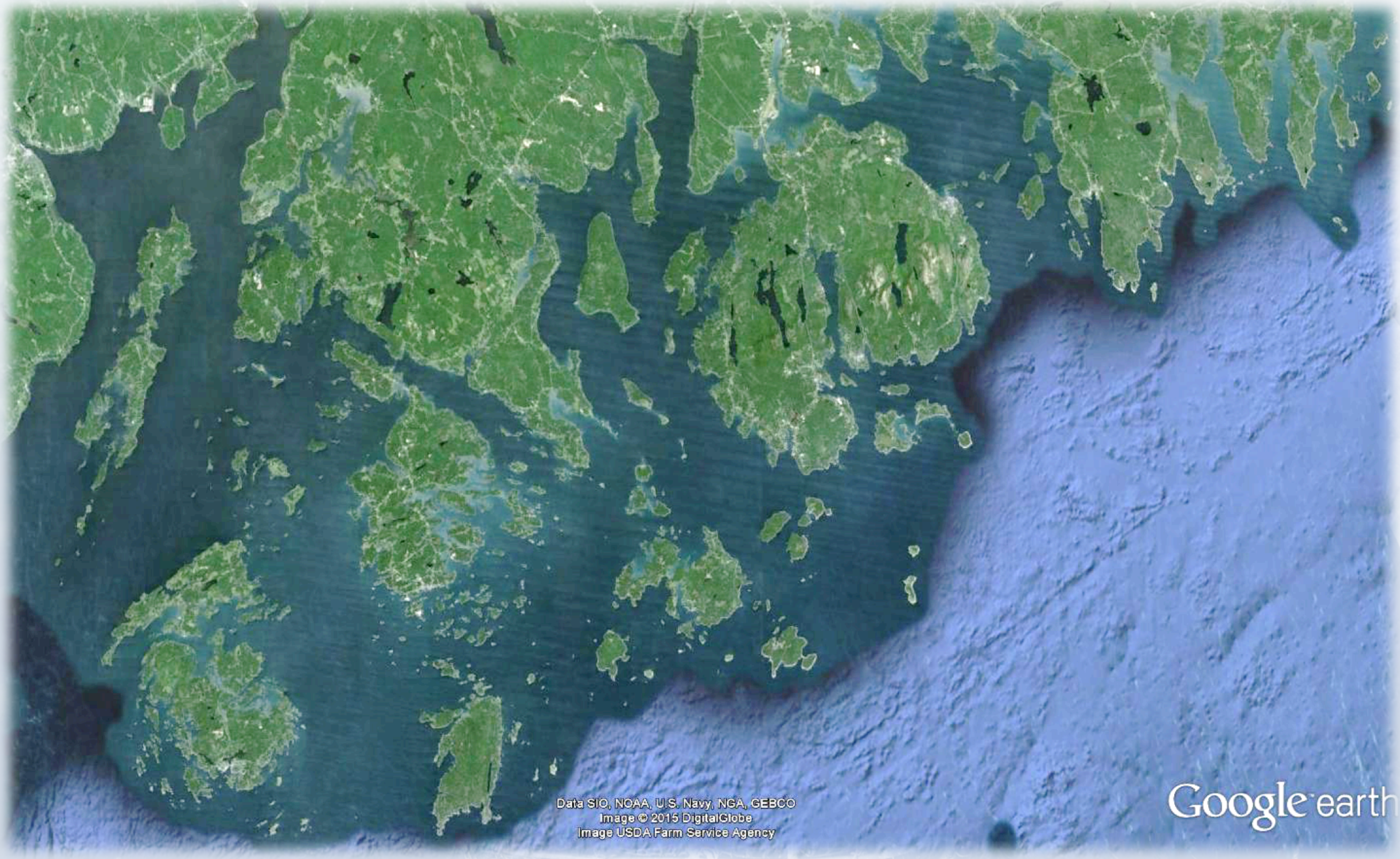
FAO 2014

Maine and U.S. mussel production lags way behind imports



World production of farmed mussels is over
3.5 BILLION pounds

Maine has vast amounts of semi-exposed bays suitable for mussel farming



Raft culture is the future (due to ducks)

Bottom culture

Raft culture

Longline culture

Emerging trends : sustainability, local food movement, polyculture

- Mussels have 1/10 carbon footprint rel. to chicken and 1/30 relative to beef
- Artificial reef, increases biodiversity, improves water quality
- Maine mussel and kelp polyculture

Buy Local
SPEND IT HERE • KEEP IT HERE

Mussel farming processes: site selection, seed collection, grow-out, harvesting, processing, sales

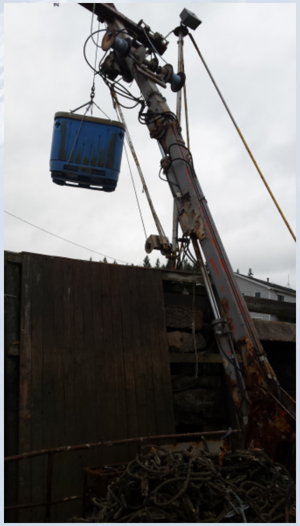










Mussel Bottom Culture

Grew 10's of millions of pounds from 1985-2007, ran out of wild seed, conflicts with wild fishery, clam diggers and worm diggers
Still a couple of farms left but much less production

Growth of mussels in bottom cultivation is function of water velocity, seeding density, phytoplankton and detritus concentration and quality, and water temperature (NSF SBIR)

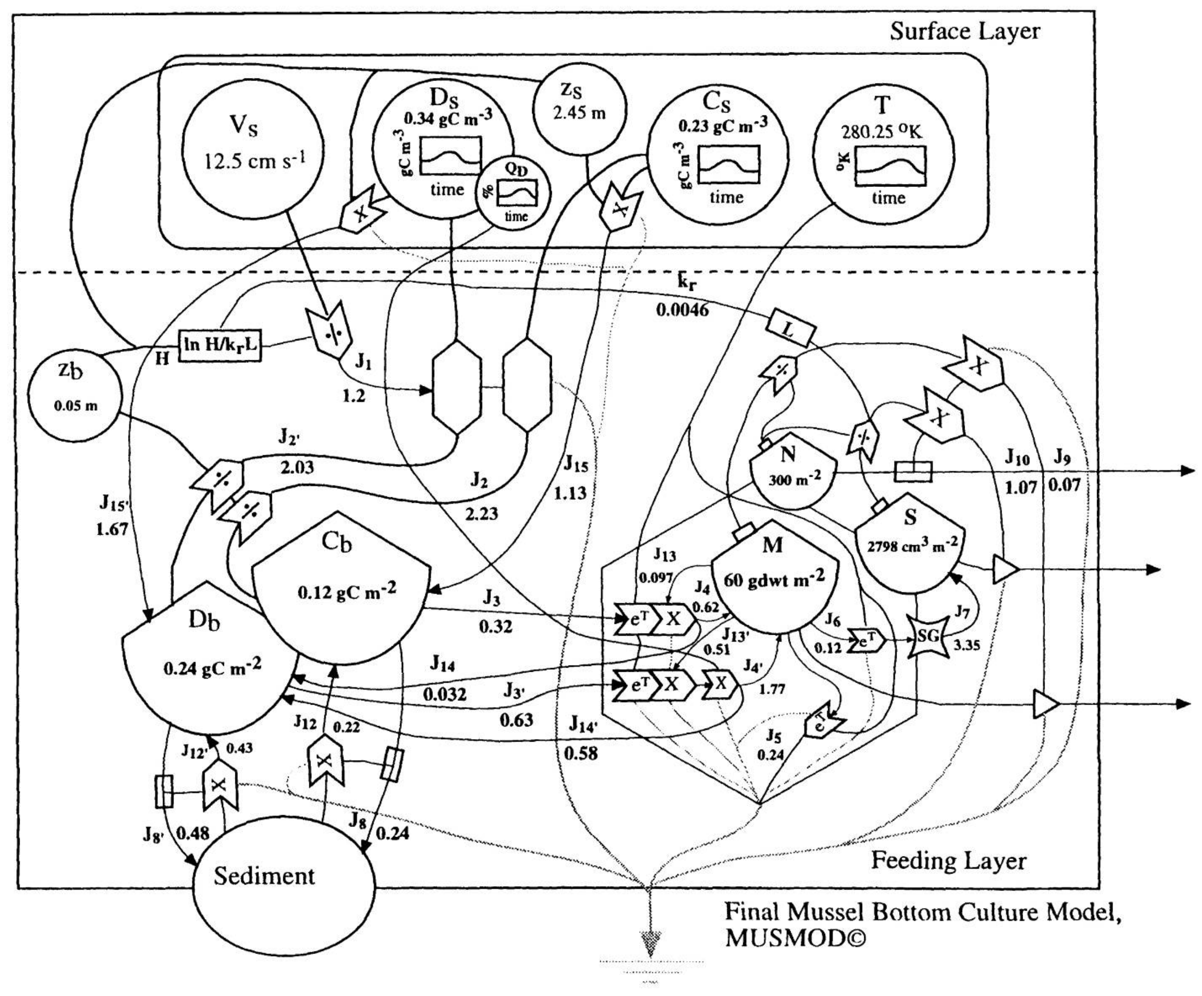
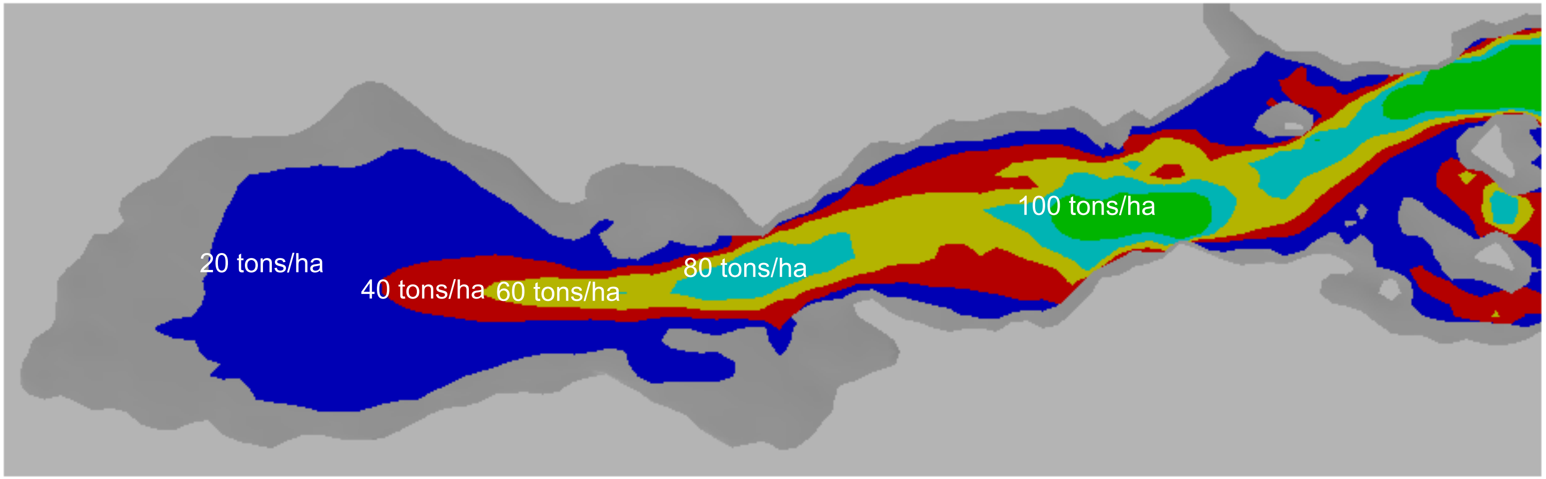


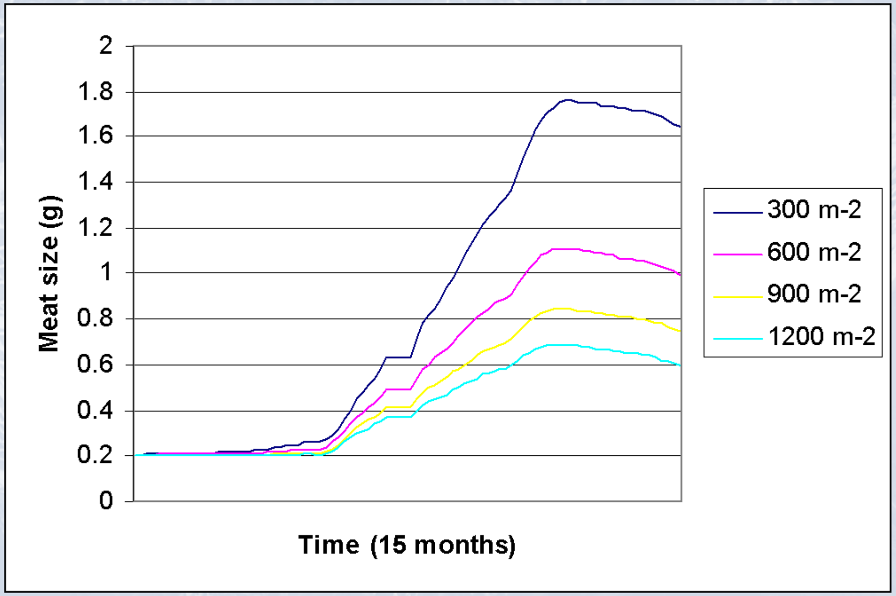
Figure 2. Final model MUSMOD©.(3) Food is supplied to the mussels from the surface layer and both food components (phytoplankton cells (C) and detritus (D)) are mixed to the bottom, resuspended or ingested by the mussels (M). For a given density N (300 m^2), current speed (V) and food supply, mussels will grow as a percentage of the food available at the edge of the lease site.

Optimizing bottom culture : Carlingford Lough Example



Recommended Seeding Densities

Mussel Bottom Culture: Carlingford Lough MUSMOD simulation



Raft Culture : developed in mid-1990s, MAIC mussel working group, sustainable

Seed Collection

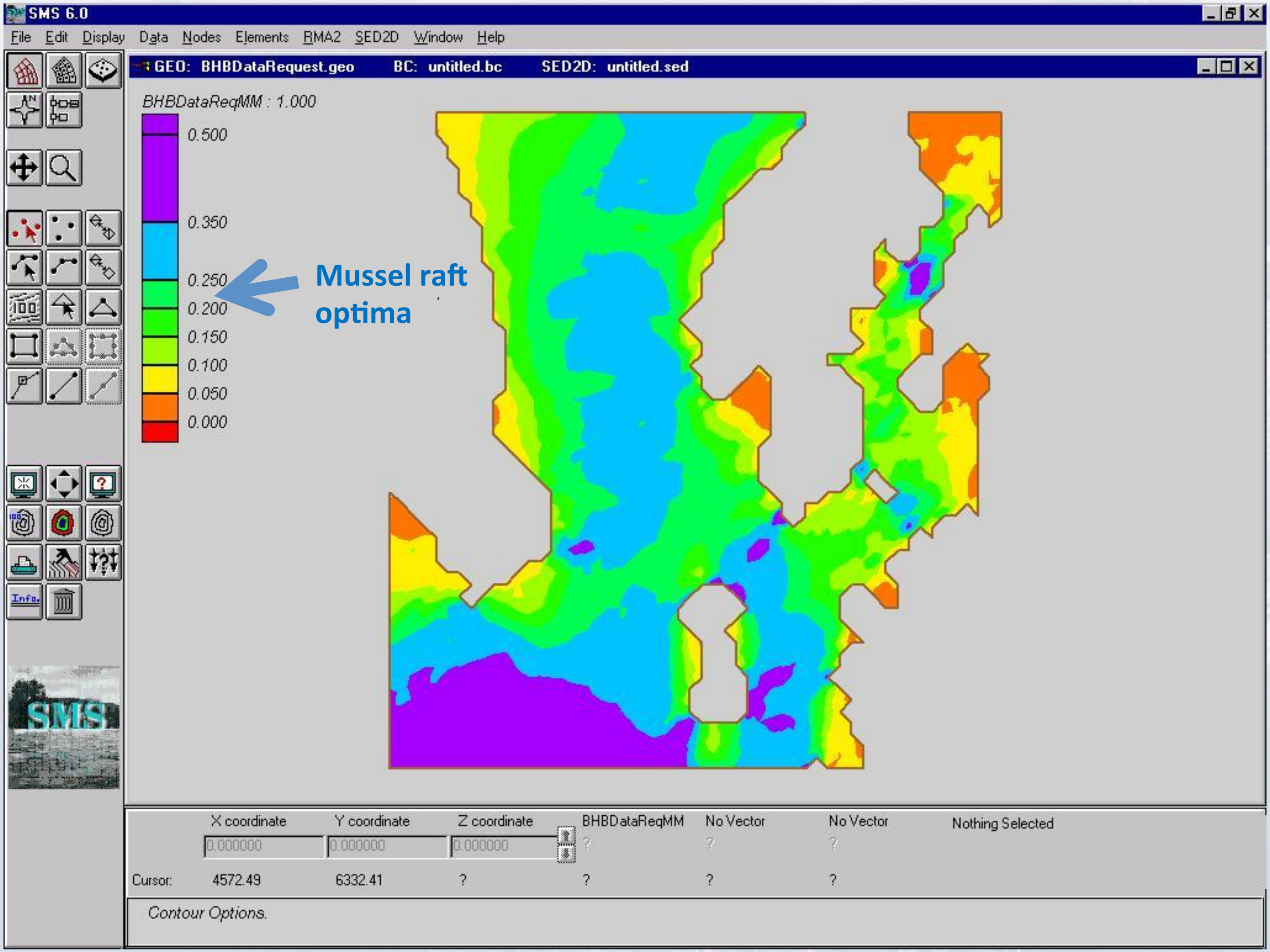
- Right density on rope – 2-5,000 per foot of collector
- Right timing of rope deployment: late June
- Right temperature and food for growth to seed size: ½ inch to 1 inch long.
- MAIC study: not all sites are good for seed collection. Starfish also a big factor. Coiled ropes collect more seed.
- Can collect it from predator nets and harvest lines.
- Seed attached to lines using biodegradable cotton

Floating and new submersible rafts: nets keep sea ducks away

Harvesting and processing at sea: declumping, debyssing, grading, purging, bagging, seed recovery

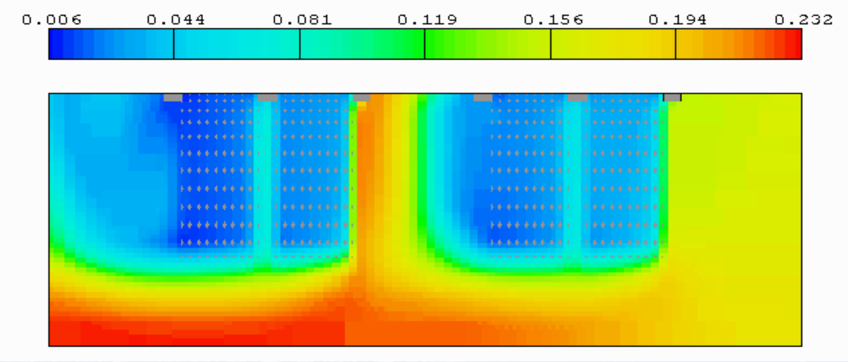



Site Hydrodynamics (mean velocity m s^{-1})
Currents can`t be too high or too low
Blue Hill Bay Example (Newell, Dudley, Panchang)



Raft hydrodynamics

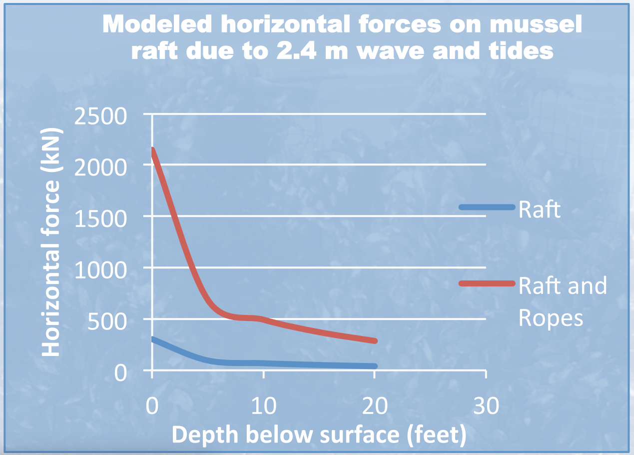
- Mussel rafts cause a 77% decrease in flow, creating favorable conditions for mussel pumping.
- Ambient current speeds over 14 cm s^{-1} are required to provide enough flow through the rafts to exceed the volume filtered by the mussels.
- Raft filtration rate and chl a consumption rate is a positive function of current speed and particle concentration.
- A maximum biomass of 1200 g m^{-1} was observed in Maine rafts, suggesting an optimal harvest density of 600 mussels m^{-1}.

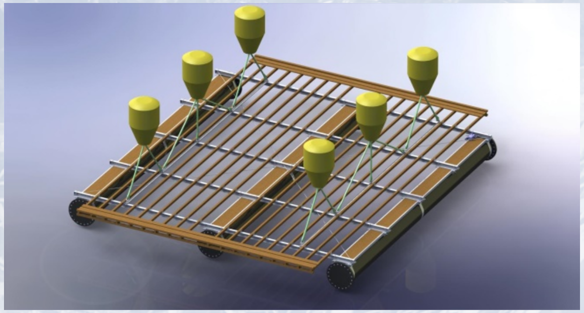


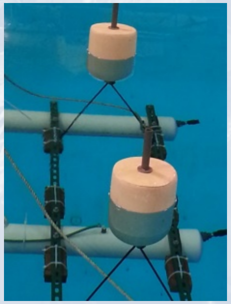
Development of deep ocean technology

LARGE FARMS WILL BE AWAY FROM SHORE

Prototype testing, design, scale model testing and beta testing for a novel Submersible Mussel Raft (patent pending). USDA SBIR 4 $450 k U Me AEWC, UNH Ocean Engineering Partners







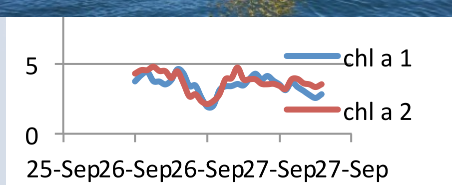
Research and Development Leading to Commercialization: USDA SBIR
Mussel MAP doubles demand and improves quality

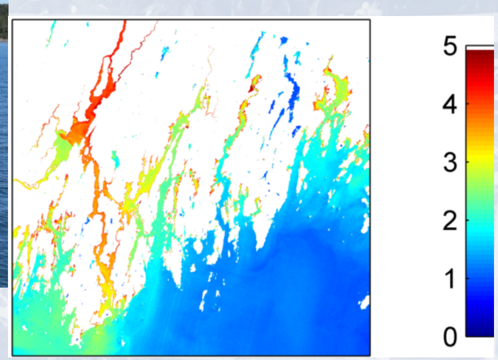
- USDA Phase II Mussel modified atmosphere package botulism challenge studies for FDA approval
- Great Eastern Mussel Farms 2004
- Partners: University of Georgia Department of Food Safety

- **Pending FDA approval** (papers in Journal Food Protection, 2012, and Food Microbiology (2014). New research direction: identification of lysosymes and antimicrobial factors in mussel haemolymph and pallial cavity fluid
- Project aided by MTI seed grant
- Opportunities for value added products

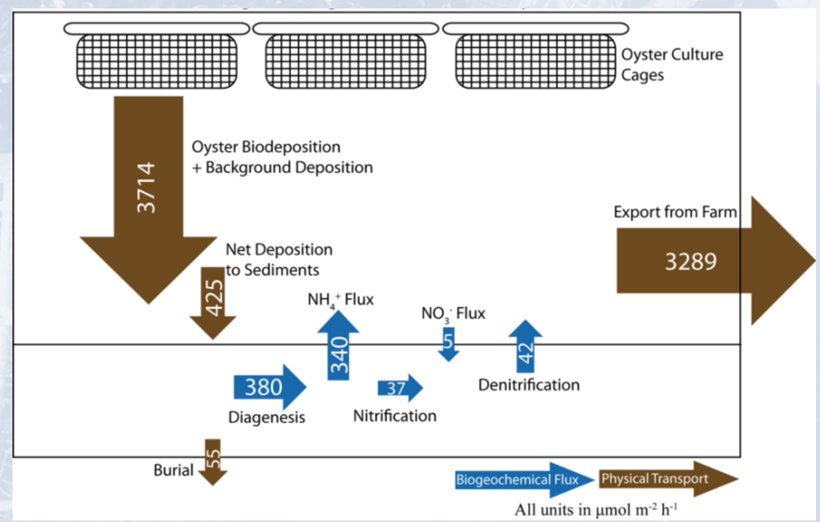
On-going marine research

- Determine **physiological requirements of species** – flow and food concentration including detritus
- Determine **hydrodynamics of ambient environment and effects of culture system**: bottom or suspension culture
- **Adjust density, biomass and distribution of molluscs to optimize growth**, ultimately limited by primary production.
- **Understand aquaculture/environment interactions** for sustainability especially **recycling of nutrients**
- **SHELLGIS system** (www.shellgis.com)
- Network of **inshore monitoring buoys** in Maine and **coastal productivity models**
- **Satellite remote sensing** for site selection and modeling growth





Mid-coast chlorophyll a from Landsat



Testa et al. , 2015

Diversification into sugar kelp for local farmer's market, food coops, restaurants and home consumption

Buy Local

SPEND IT HERE • KEEP IT HERE

Future Directions: Where do we go from here?

- ***Reduce risk and improve efficiency with improved technology and site selection*** (submersible rafts for semi-exposed sites, ShellGIS, brush declumpers, mooring systems, seed collection)
- **Technology transfer, extension, organic certification**
- **Business planning and marketing**
- "**Squirt gun" to create new farms**
- Marine scientists recognize coastal ocean as food growing areas

R &D Match.com

Do you have your perfect match out there somewhere?

Communication/translation/leadership

We need to better articulate what the *industry bottlenecks and research needs* are;

We need to match the *willingness and research capacity* of the scientific and economic development community with our needs

Chasing money and trying to justify it with industry needs is not a recipe for success

Industry growth and Development needs should drive the Research