RESTORATIVE AQUACULTURE AS PART OF AN INTEGRATED SOLUTION TO THE ACCELERATING NITROGEN CRISIS DAMAGING COASTAL MARINE ECOSYSTEMS

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Memory of MON CHER AMI/ My Dear Friend

Estuaries and coastal areas of the world are the prime habitats for 80% of humanity and wastewater discharges are **increasing**

Nearshore marine ecosystems are deteriorating from **nitrogen pollution** that leads to a cascade of adverse impacts to ecosystems – a major constraint to current & future aquaculture & fisheries !

Nutrient reduction and water quality restoration goals are almost everywhere being addressed by the expansion of capital- energy-water intensive sewer systems and/or direct ocean discharge

Billions of Dollars/Euros are being invested in Sewers…However…

- Sewers Don't Remove All Nitrogen
- Sewers are NOT 100% efficient in denitrification to N_2
- Sewers release significant amounts of N_2O
  *a greenhouse gas 298x more powerful than CO_2
- Sewers release significant amounts of CH_4
  * a greenhouse gas 84x more powerful than CO_2
- Sewer costs result in large tax increases & real estate crises

Falmouth, Massachusetts, USA has 14 seriously nutrient impaired estuaries due to excess N loadings

State has mandated a target nitrogen reduction goal (TMDL) for each estuary

A Question ?

Are their more cost-effective, energy efficient and resource conserving alternatives that engage the community, restore ecosystems, require less capital and operating money (or even generate money?!) and have less climate impacts?

Conduct Comparative Analyses of All Alternatives!

LET's PUT ALL REMOVAL OPTIONS ON THE TABLE !

ALTERNATIVE ECOLOGICAL NITROGEN REMOVAL METHODS

Upstream
Removal of N by
Urine Diversion (UD)

Downstream
Removal of N by
Restorative Aquaculture

CONVENTIONAL NITROGEN REMOVAL METHODS

Sewers

Alternative Septic Systems (I/A's)

Ecosystem Engineering
(hydrodyamics, tidal flushing, permeable reactive barriers, etc.)

Ocean Disposal
(pipes)

State TMDL for N

Massachusetts Estuaries Project
University of Massachusetts Dartmouth

Watershed Estuary Loadings
(understand sources, totals)

Integrated Ecological Restoration Plan

Upstream N Removal
Urine Diversion (UD)

Downstream N Removal
Restorative Aquaculture

Ecological Alternatives

Upstream,
Homeowner Engaged
N Removal
= Urine Diversion (UD)

Downstream,
Public-Private Partnership
Community Engaged
N Removal
=Restorative Aquaculture

Sewers

Alternative Septic Systems

Ecosystem Engineering
(hydrodyamics, tidal flushing, etc.)

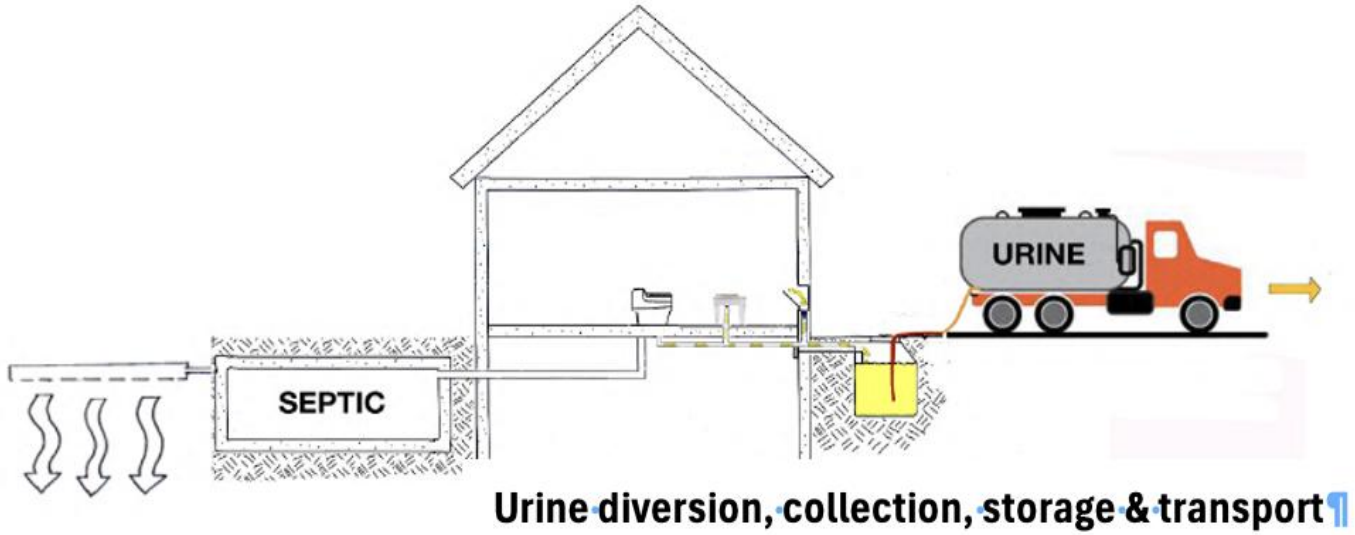
Permeable
Reactive Barriers

Ocean Outfalls

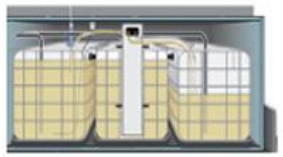
Urine Diversion

Urine Diversion (UD) is the practice of capturing urine at the source with water saving or waterless UD fixtures and urinals, collecting it and recycling the resource-rich nutrients in urine as agricultural fertilizers

~ 80% of the N in wastewater is from urine but urine is only 1% of its volume



Urine diversion, collection, storage & transport



urine depot
+ pasteurizer

transport

apply as fertilizer

Urine Diversion (UD)


nature

Feature

HOW RECYCLING URINE COULD HELP SAVE THE WORLD

Separating pee from the rest of sewage could mitigate some difficult environmental problems and provide a sustainable source of fertilizer. But there are big obstacles to radically re-engineering one of the most basic aspects of life. By Chelsea Wald

UD is an innovative, low-cost method of capturing and recycling N

at its source

...well developed worldwide... especially in France...

AND VERMONT!

but remains relatively unknown/underappreciated

Analysis of Pharmaceuticals in Food Crops Grown in Urine- and Struvite-Fertilized by Liquid Chromatography- Tandem Mass Spectrometry

Rachel A. Mullen, Abraham Noe-Hays, Kim Nace, Rebecca Lahr, Heather Goetsch, Nancy Love, Krista Wigginton, and Diana S. Aga

UNIVERSITY OF MICHIGAN

NSF

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Upstream Removal by Urine Diversion

A study of residential urine diversion for 40 households by The Green Center and MASSTC showed that 4.4 kg N/year/household can easily be captured and kept out of residential wastewater

MASSTC
The Massachusetts Alternative
Septic System Test Center

Ecological Alternatives

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Restorative Aquaculture and NbS

The Nature Conservancy®

Saving the Last Great Places

European Commission

RESTORATIVE AQUACULTURE FOR PEOPLE, PROFIT AND PLANET

Barry Antonio Costa-Pierce

Narratives continue to provide the public and decision-makers with a bleak image of aquaculture sites as industrial waste areas, destroying and depleting the natural environment and its biodiversity, and creating a desert from an ocean oasis. However, examples demonstrate how restorative aquaculture could lead sector-wide approaches to decisions on financial allocations for nutrient removal using combined best practices that merge aquaculture into plans to ameliorate damaging coastal pollution while increasing aquaculture growth for both business development and accelerated seafood production.

IUCN

Aquaculture and Nature-based Solutions

Identifying synergies between sustainable development of coastal communities, aquaculture, and marine and coastal conservation

R. le Gouvello, C. Brugere and F. Simard

INTERNATIONAL UNION FOR CONSERVATION OF NATURE

PARTENARIAT FRANCE-UICN NATURE ET DEVELOPPEMENT

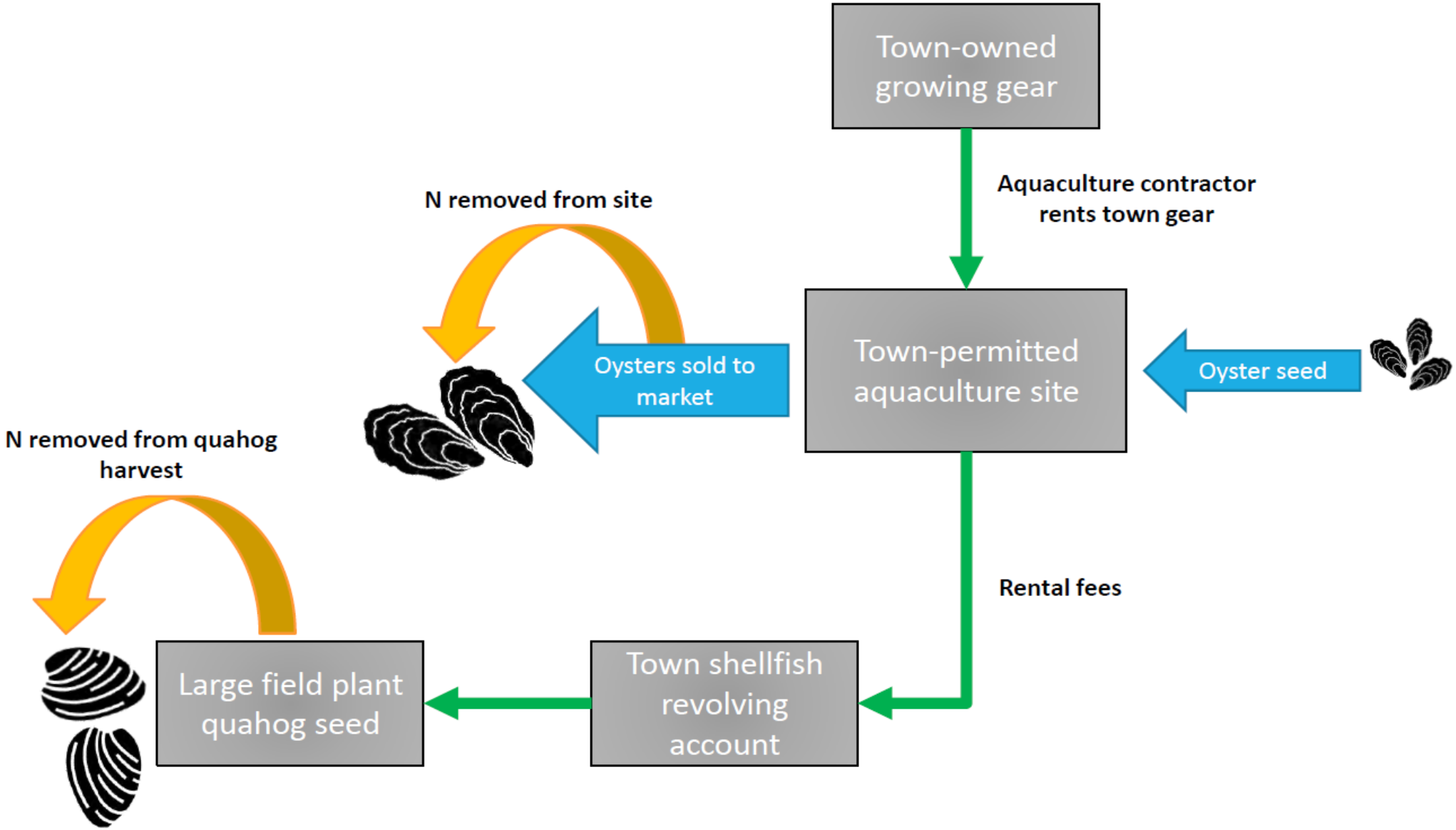
CEM

Restorative Aquaculture with Oyster Culture

Commercial oyster production in floating cages reduces nitrogen in coastal waters and recycles nutrients from coastal waters back to the land


Nitrogen pollution in coastal waters

Shellfish aquaculture will immediately improve water quality and will produce significant revenue



Martinsen, C. and T. Duncan. 2024. Aquacultural production and nitrogen removal in Falmouth, MA – Current progress & projections. -- https://waquoitbayreserve.org/wp-content/uploads/Aquaculture-Production-in-Falmouth_Duncan_Martinson_Falmouth.pdf

Municipal Restorative Shellfish Aquaculture in Falmouth, USA

Areas are zoned for both commercial and recreational aquaculture

Commercial = Public - Private Partnership

- Shellfish farmers get town supplied floating gear and seed
- Contracted by the town and pay a $20,000 access fee for 0.2 ha of estuarine area **= New Town Revenue/Food**
- Shellfish farmers are obligated to grow a preset minimum biomass on leases [2480 bags/0.5 ac (0.2 ha)]
- In 2023, shellfish farmers harvested 1.43 million oysters from 0.6 ha with an estimated value of US$ 650,000

= New Income/ Jobs/Food

Recreational

Resident recreational permit ($30/y, $6/y seniors) to harvest seasonally…can take one-quarter bushel of oysters/week (~100 oysters or 20-27 kg total) **= Revenue/Food**

Municipal Restorative Shellfish Aquaculture

Town/Ecosystem Benefits

- New town revenue from growers' access fees
- New town revenue for residential recreational permit fees from residents ($30 or $6/person/y)
- **Town receives N nutrient credit/oyster harvested of 0.28 g N/oyster****

In 2023, a total of 400 kg N/0.6 ha of oysters

= 667 kg N/ha/year removed

The shellfish zones are planned to increase ~10X in 2025

**Rick York, Josh Reistma, Diana Murphy, Abigail Archer
Cape Cod Cooperative Extension, Woods Hole Sea Grant, Town of Mashpee

Scenarios For Decisions

Participatory Action Research

Many Cape Cod Towns Joining In

Ecological Methods of Nitrogen Removal Avoids Massive Costs for Sewers

Restorative Shellfish Aquaculture

400 kg N removed by 1.43 million oysters would avoid ~$7 million for new sewer systems or IAs to remove the same amount of N

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Urine Diversion

For a watershed with 4,500 homes and a TMDL of 12,000 kg N/year, 2,700 urine-diverting homes would meet the TMDL

UD would avoid ~$270 million for new sewer systems or IAs to remove the same amount of N

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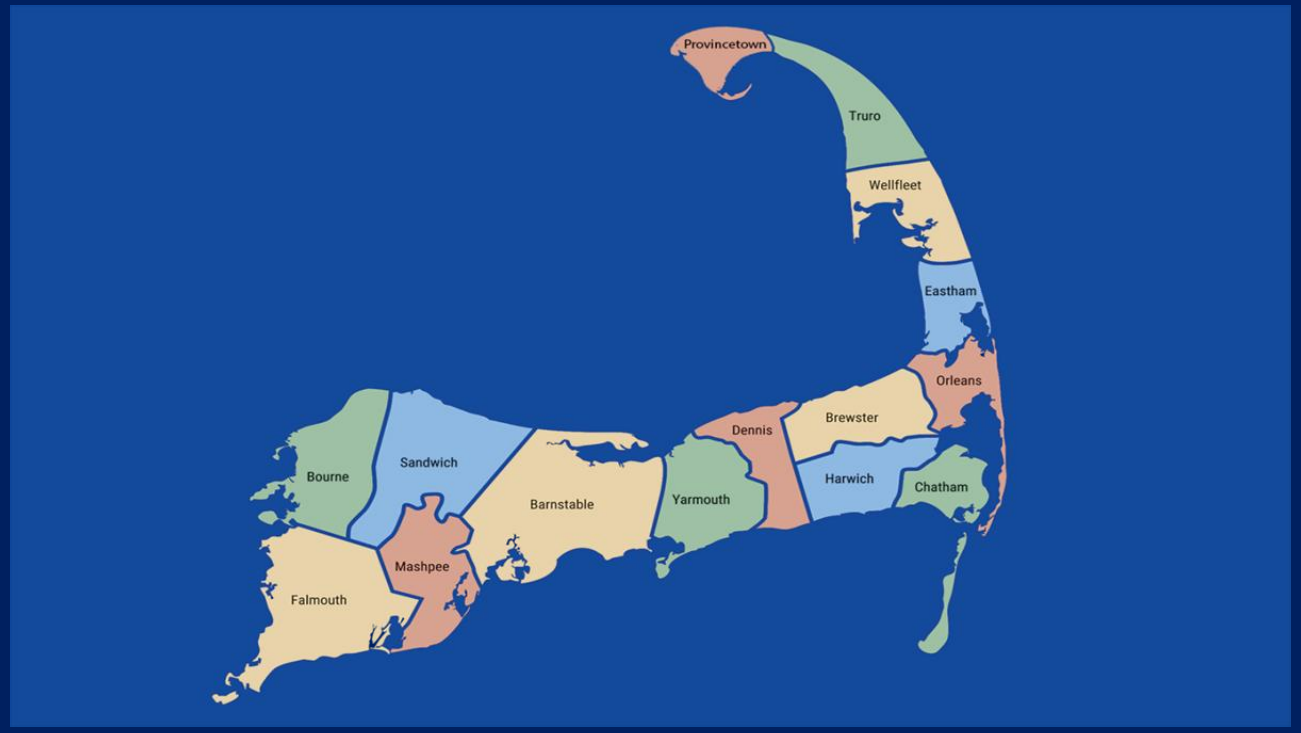
Provincetown
Truro
Wellfleet
Eastham
Orleans
Brewster
Dennis
Harwich
Chatham
Yarmouth
Barnstable
Sandwich
Bourne
Mashpee
Falmouth

THANK YOU! MUITO OBRIGADO(A) !

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