East Coast Hard Clam Selective Breeding Collaborative-NYSG

B. Allam, E. Pales Espinosa, X. Guo, K. Reece, A. Clemetson, H. Yang, K. Bunting-Howarth, R. Shuford
East Coast Hard Clam Selective Breeding Collaborative:
Research Updates

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Virginia Institute of Marine Science

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UF | University of Florida

Gregg Rivara
Cornell University Cooparative Extension

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Antoinette Clementson

Ximing Guo

Sea Grant
New York

Sea Grant Aquaculture Research Symposia, 11/3/2021

HardClamHub.org
hardclamhub@gmail.com
Partners

- **Advisory panel:** Pete Rowe (NJSG), Dina Proestou (USDA), Brent Vadopalas (WASG), Karen Rivara (ECSGA), Joseph Vinarski (FMF), Wade Carden (NYSDEC)

- **Research team:** Bassem Allam, Emmanuelle Pales Espinosa, Sarah Farhat, Arnaud Tanguy, Kimberly Reece, Jan McDowell, Huiping Yang, Leslie Sturmer, Gregg Rivara, Joshua Reitsma, Michael Deluca and Ximing Guo

- **Extension team:** Antoinette Clemetson, Katherine Bunting-Howarth, Pete Rowe, Lisa Calvo, Leslie Sturmer, Bruce Barber, Karen Hudson, Joshua Reitsma

- **Industry members:** Industry partners in each of the 5 states (private growers, town hatcheries)
The hard clam (northern quahog), *Mercenaria mercenaria*

Aquaculture production in VA. Hudson 2019
Some of the hampers to clam aquaculture growth

- Market constraints
- Predation
- Disease outbreaks
- Extreme environmental factors
- Neoplasia
- QPX disease
- Low salinity
- Extreme temperature
Overall objective:

Establish selective breeding programs to produce better adapted strains to the various growing landscapes
How we got here?

www.whoi.edu
Clams are not all equal towards QPX

Experiment 1 (deployed in NY)

Experiment 2 (deployed in MA)

Dahl et al. 2010

Farhat et al. 2020

Seed type

Seed type
Clams are not all equal towards QPX

Experiment 2 (deployed in MA)

Seed type

Farhat et al. 2020
Develop heat-resistant strains for southern growers

- Previous effort:
  - Hybridization (with *M. campechiensis*)
  - Evaluation of heat shock protein as biomarker
  - Transcriptome analysis for marker identification

*FIGURE 1. From left to right: samples after 8-months of growout of Mercenaria mercenaria (*Mm*), hybrid (*♀ Mm x ♀ Mc*), hybrid (*♀ Mc x ♂ Mm*), and *M. campechiensis* (*Mc*).*

Strumer et al. 2010
Our approach: Use of genetic features associated with resistance to improve breeding

Single nucleotide polymorphism (SNP)
Single nucleotide polymorphism (SNP)

Our approach: identification of genetic features associated with resistance
Specific objectives of this NOAA collaborative

- Sequence, assemble and annotate the hard clam genome and develop a cost-effective genotyping platform (SNP array) for *M. mercenaria*

- Use this tool to enable genome-assisted selection for QPX resistance and heat tolerance

- Build a regional hard clam breeding program linking scientists, extension and the industry
Chromosome-level assembly produced

Karyotype from Wang and Guo, 2007
Empirically shown to bind QPX

Broad diversity of complement 1q proteins (over 400 c1q domain-containing genes)
# Tumor necrosis factor (TNF) domain-containing genes

<table>
<thead>
<tr>
<th>Orthogroup</th>
<th>Aplysiida</th>
<th>Mytiloida</th>
<th>Pectinida</th>
<th>Ostreida</th>
<th>Arcoida</th>
<th>Cardiida</th>
<th>Myida</th>
<th>Venerida</th>
<th>TNF Mollusca</th>
<th>TNF Bivalvia</th>
<th>TNF Heteroconchia</th>
<th>TNF Specific to Mercenaria</th>
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</thead>
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<tr>
<td>Aplysiida</td>
<td>Aplysia californica</td>
<td>Mytilus coruscus</td>
<td>Mytilus galloprovincialis</td>
<td>Limnoperna fortunei</td>
<td>Modiolus phillipinarum</td>
<td>Bathymodiolus platifrons</td>
<td>Pecten maximus</td>
<td>Mytilus yessensis</td>
<td>Sacostrea glomerata</td>
<td>Ostrea edulis</td>
<td>Crassostrea gigas</td>
<td>Crassostrea virginea</td>
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Phylogenetic relationships of bivalves Gypsy retrotransposons
Genome paper recently submitted

BMC Genomics

Comparative analysis of the Mercenaria mercenaria genome provides insights into the diversity of transposable elements and immune molecules in bivalve mollusks

--Manuscript Draft--

Manuscript Number: GICS-D-21-00500

Sarah Farhat\textsuperscript{a}, Eric Bonivard\textsuperscript{b}, Emmanuelle Pales Espinosa\textsuperscript{a}, Arnaud Tanguy\textsuperscript{b}, Isabelle Boutet\textsuperscript{b}, Nadège Guiglielmoni\textsuperscript{c}, Jean-François Flot\textsuperscript{c,d} and Bassem Allam\textsuperscript{a*}

\textsuperscript{a} Stony Brook University School of Marine and Atmospheric Sciences

\textsuperscript{b} Sorbonne Université

\textsuperscript{c,d} ULB Université Libre de Bruxelles
Genome re-sequencing: sampling

- 96 individual libraries
  - 8 populations
  - 12 ind./pop.
  - Middle Bay, ME
  - Harbor Cove, MA
  - FMF, NY (aq)
  - Raritan Bay, NY
  - Mobjack Bay, VA
  - Bogue Sound, NC
  - Cedar Key, FL (aq)

- 7 Pooled libraries
  - 29-50 ind./pool
  - ME
  - MA
  - FMF, NY (aq)
  - RB, NY
  - VA
  - NC/SC
  - FL

M. campechiensis
Genome re-sequencing: workflow

- 96 individual libraries
  - 8 populations, 12 ind./pop.
  - ~5,300 Gbase

- 7 Pooled libraries
  - 29-50 ind./pool
  - ~1,000 Gbase

- Read alignment (BWA)
- Data manipulation (SAMtools)
- Variant calling (GATK – HaplotypeCaller)
- SNPs annotation (SnpEff)
- SNP filtering (Plink)
Remain to be done

- **Select** most informative SNP to use on the SNP Array
- **Train** the SNP array using clams with various levels of QPX and heat resistance (training populations = 2 x 1,000 clams)
- **Select** and **Genotype** the breeding populations (2 x 300 clams)
A set of VIP SNPs have been generated using independent tools (RADSeq)
Thank you for your attention!

Extension activities are next

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Developing a framework to transfer hard clam selective breeding research to industry

SEA GRANT HARD CLAM SELECTIVE BREEDING HUB
Antoinette Clemetson | Lisa Calvo | Josh Reitsma | Peter Rowe | Rebecca Shuford | Leslie Sturmer
www.HardClamHub.org
Email: HardClamHub@gmail.com

Collaborators
Goals
Process
Progress
Next Steps
Sea Grant Hard Clam Selective Breeding Collaborative

This collaborative functions as a partnership involving Sea Grant College Programs: New York Sea Grant, New Jersey Sea Grant, Woods Hole Sea Grant, Virginia Sea Grant, and Florida Sea Grant, Stony Brook University’s Marine Animal Disease Laboratory and other research institutions, Cooperative Extension, not-for-profits, an advisory panel, and private sector.
## Hub Collaborators

<table>
<thead>
<tr>
<th>Sea Grant Team</th>
<th>Research Team</th>
<th>Advisory Panel</th>
<th>Industry Partners</th>
<th>Affiliates</th>
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<tbody>
<tr>
<td><strong>Dr. Rebecca Shuford</strong>&lt;br&gt;NY Sea Grant</td>
<td>Dr. Bassem Allam&lt;br&gt;SBU Marine Animal Disease Laboratory</td>
<td>Dr. Peter Rowe, Chair&lt;br&gt;NJ Sea Grant Consortium</td>
<td>NY: Frank M. Flowers &amp; Sons Inc.</td>
<td>Dr. Bruce Barber&lt;br&gt;Gulf Shellfish Institute (Florida)</td>
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<tr>
<td><strong>Antoinette Clemetson</strong>&lt;br&gt;NY Sea Grant</td>
<td>Dr. Emmanuelle Pales Espinosa&lt;br&gt;SBU Marine Animal Disease Laboratory</td>
<td>Dr. Rebecca Shuford&lt;br&gt;NY Sea Grant</td>
<td>NJ: Parsons Mariculture</td>
<td>Dr. Arnaud Tanguy&lt;br&gt;Station Biologique de Roscoff (France)</td>
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<td>Dr. Katherine Bunting-Howarth&lt;br&gt;NY Sea Grant</td>
<td>Gregg Rivara&lt;br&gt;CCE of Suffolk County</td>
<td>Wade Carden&lt;br&gt;NYS Department of Environmental Conservation</td>
<td>VA: Cherrystone Aqua Farm</td>
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<td><strong>Dr. Peter Rowe</strong>&lt;br&gt;NJ Sea Grant Consortium</td>
<td>Dr. Ximing Guo&lt;br&gt;Haskin Shellfish Research Laboratory</td>
<td>Dr. Dina Proestou&lt;br&gt;USDA Agriculture Research Service</td>
<td>MA: Aquaculture Research Corporation (ARC)</td>
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<tr>
<td><strong>Lisa Calvo</strong>&lt;br&gt;NJ Sea Grant Consortium</td>
<td>Lisa Calvo, NJ Sea Grant Consortium</td>
<td>Dr. Brent Vadopalas&lt;br&gt;WA Sea Grant</td>
<td>East Coast Shellfish Association</td>
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<tr>
<td><strong>Leslie Sturmer</strong>&lt;br&gt;FL Sea Grant</td>
<td>Michael Deluca, Rutgers University NJ Aquaculture Innovation Center</td>
<td>Joseph Vinarski&lt;br&gt;Frank M Flowers &amp; Sons Inc.</td>
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<tr>
<td><strong>Joshua Reitsma</strong>&lt;br&gt;Woods Hole Sea Grant and Cape Cod Cooperative Extension</td>
<td>Dr. Kimberly Reece&lt;br&gt;Virginia Institute of Marine Science</td>
<td>Karen Rivara, President ECSA&lt;br&gt;Aeros Cultured Oyster Company</td>
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<td><strong>Paul Focazio</strong>&lt;br&gt;NY Sea Grant (Comm Unit)</td>
<td>Jan McDowell&lt;br&gt;Virginia Institute of Marine Science</td>
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<tr>
<td>Christopher Gonzales&lt;br&gt;NY Sea Grant (Comm Unit)</td>
<td>Karen Hudson&lt;br&gt;VIMS Marine Science Advisory Program</td>
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<tr>
<td>Leslie Sturmer&lt;br&gt;FL Sea Grant</td>
<td>Dr. Huiping Yang&lt;br&gt;University of Florida</td>
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N= 25
PROJECT GOAL

SELECTIVE BREEDING PROGRAM

BEYOND AWARD

RESEARCH

MAINTAIN BROODSTOCK LINEAGE

APPLY RESEARCH

Strains resistant to stressors

Research hatchery network

Mechanism to transfer strains to industry
SELECTIVE BREEDING PROGRAM FRAMEWORK
aka “Process”

Advisory Panel

Environmental Stressors (heat/QPX)

Markers to identify clams possessing traits (strains)

SGE/CCE field validation

Maintain broodstocks/node i.e. research hatchery (NY/NJ/FL)

Resilient seed distribution/Commercial hatchery

Monitor/report impacts in PIER (State SGE)

Transformation of the hard clam industry

SELECTIVE BREEDING PROGRAM FRAMEWORK
aka “Process”

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Transformation of the hard clam industry
• Research
  o Dr. Bassem Allam’s Update

• Advisory Panel Meeting
  ✓ Winter 2020, Fall 2021

• Project Team Workshop
  (annual)
  ✓ Winter 2020, Spring 2021
    o Plan of Work
    ✓ What is the Hub?
    o How will industry access this program?
    o Measure success/Impacts & Accomplishments
    o Industry Needs Assessment Survey

➢ Identify specific tasks extension and communications workplan development
What is the Hub: public interface
www.HardClamHub.org
Email: HardClamHub@gmail.com

- Website is a tool to communicate with stakeholders
  - Report on progress
  - Archive factsheets, media articles
  - Convey instructions about accessing breeding program
- Electronic mailbox
  - Stakeholders communicate with Hub
  - Request information, speakers
- Graphic creates visual identity
  - Visual cue (icon) to build brand trust
  ✓ Unites collaborators while maintain their autonomy
What are challenges to establish this hard clam selective breeding program

**EDUCATE**

“In order to elevate industry, the Hub must educate, build trust, and develop a plan to engage these stakeholders in the breeding program”

- Industry is unaware of the hard clam breeding hub
- Stakeholders don’t understand why use selective breeding
- Reluctance arising from GMO confusion
- How to present project diverse expertise, stakeholder, and research objectives
- Technology seems unapproachable (to nontechnicians)

**TRUST**

- Adoption of selectively bred clams
- Will growers be open to these selectively bred clams
- Growers reluctance to share broodstock lines
- Who are breeders
- Growers may prefer using local broodstock
- What if these strains don’t perform as well as expected

**PLAN**

- How will industry access breeding program
- Development of broodstock and transfer seeds locally
- How/who will maintain broodstock lineage after project
- Will broodstock and/or progenies require special handling
### How will we know this effort is successful?

#### Defining Impacts & Accomplishments

<table>
<thead>
<tr>
<th>TIMEFRAME</th>
<th>METRIC</th>
<th>INDICATOR</th>
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<tbody>
<tr>
<td><strong>IMMEDIATE/SHORT TERM</strong></td>
<td>• Broodstock strains</td>
<td>• Clams expressing traits (THTI=T and S stressor success)</td>
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<tr>
<td>(3-year project implementation)</td>
<td>• Tools created</td>
<td>• Robust SNP Array</td>
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<td></td>
<td>○ Genome</td>
<td>• Improved survivorship</td>
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<td></td>
<td>○ SNP chip</td>
<td>• Industry buy-in/support for the program</td>
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<td>○ GEN1 lineage</td>
<td>• Industry sharing animals for genotyping</td>
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<td></td>
<td>• Research Hatchery Plans</td>
<td>• Publications</td>
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<td>• Website</td>
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<td><strong>MEDIUM TERM</strong></td>
<td>Research Hatchery network</td>
<td>• Lineage available for evaluation in field (via sentinel farms)</td>
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<td>(5 years post-project after broodstock</td>
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<td>○ Performance of strains against other stocks used by industry</td>
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<td>technology is transferred to industry)</td>
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<td>• Hard Clam Hub viewed as trusted, credible source for science-based</td>
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<td></td>
<td></td>
<td>○ Build capacity to provide timely response to new challenges</td>
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<td></td>
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<td>• Adoption of strains by 30% of industry</td>
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<td></td>
<td></td>
<td>○ # commercial hatcheries distributing seeds</td>
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<td></td>
<td></td>
<td>○ # seeds produced</td>
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<td></td>
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<td>○ Percent (or #) growers using progenies</td>
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<td>• Reduction in loss from disease/heat improves production</td>
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<td><strong>LONG TERM</strong></td>
<td>Transform hard clam industry</td>
<td>• Increase in production and sales by growers (30%?)</td>
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<td>(Several years after project maturation</td>
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<td>• Increase in survivorship and/or growth rates</td>
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<td>with economic return and market changes)</td>
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<td>• Increase in # growers/farms to reverse plateau experienced in in NE</td>
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Anticipated Accomplishments & Impacts

**SHORT**
- Research tools created
  - Genome (pub)
  - SNP array chip
    - GEN1 lineage
    - Broodstock strains
- Mechanism to transfer research to industry (how will industry access breeding program)
  - Research hatchery plans
- Build industry trust (start)

**MEDIUM**
- Research hatchery network
  - Maintain broodstock lineage
  - Transfer research (strains) to industry
- Sentinel farm plots
  - Field monitoring to assess strain performance against other stocks used by industry
- Capability to provide timely response to address new challenges
- Build industry trust (ongoing)

**LONG**
- Hard clam industry is transformed
  - Reduction in mortality attributed to disease and heat
    - Measurable increase in survivorship and/or growth rates
  - Increase in # farms using these strains
    - Positive change on plateau observed in NE hard clam production
    - Economic return and market changes

3 years
5 years
>5 years/decade
Obtain industry buy-in for breeding program
Define traits producers hope to select
Stakeholder engagement, ensure products meet industry needs
What will industry gain from this effort
Identify outreach and communications needs
Prioritize desirable traits in clams to advance industry
Clarify structure of breeding operations

Commercial and municipal growers
State resource managers
Hatcheries, wholesalers, consumers, researchers.
Growers
Breeders (if any)
Seed suppliers

Identify most important traits to target for breeding
How would you support this breeding program
Managers: What’s the greatest challenge facing the industry and how are you trying to solve it
Researchers: What are research needs and tools in 5-10 year timeframe
Consumers: Will you purchase these products, why/why not

After results are available to report (~3 years)
Latter half of project implementation; need to continue post-project
Now/ASAP
Late fall when hatchery operations slow down

GSS, state agencies
NJ Aquaculture agencies
NJ Shellfish Growers Association
East Coast Shellfish Growers Association
MA Aquaculture Association
Cedar Key Aquaculture Association
LI Oyster Growers Association
LI shellfish managers groups (town municipalities)
Survey grower organizations and not individual growers
How will industry access this program

Next Steps

- **Field Validation (SGE/County); Fall ‘22**
- **Hatchery Plan Development; Sum ‘22**
  - Webinar series; leverage collaborator expertise (Winter 2021)
  - State SGE/research hatchery managers draft plan acknowledging
    ✓ Autonomy/institutional policy
    ✓ Capability/capacity (commercial hatchery/growers)
    ✓ Temporal constraints
    ✓ Handling/biosecurity
- **Industry Needs Assessment Fall ’22 (tentative)**
  - Commercial hatchery/breeders
    ✓ Perspectives/input research hatchery plans
    ✓ Future research needs/stressors

Photo Credit: Leslie Sturmer, FLSG
Thanks to NOAA National Sea Grant for funding this project, and our collaborators, industry, Sea Grant/County extension colleagues, researchers, not-for-profit organizations, and managers.
Join at slido.com
#905542
How has this presentation helped to improve your understanding about the Hard Clam Selective Breeding Collaborative?
Suggest barriers, challenges, or concerns that could prevent the industry from accessing the selective breeding program.
How can the Hard Clam Selective Breeding Collaborative address these issues that you identified, previously?
What measures, actions, or policies could be considered to support the Hard Clam Selective Breeding Collaborative after conclusion of this award?
https://app.sli.do/event/g4vqa3ai
Atlantic and Gulf Shellfish Seed Biosecurity Collaborative-NJSG

P. Rowe, R. Carnegie, B. Walton, D. Bushek
Atlantic and Gulf Shellfish Seed Biosecurity Collaborative

Peter Rowe (NJSG), David Bushek, Lisa Calvo & Lucas Marxen (Rutgers), Ryan Carnegie & Karen Hudson (VIMS), Robert Rheault (ECSGA), Lori Gustafson (USDA APHIS)
William Walton (Auburn /VIMS), Leslie Sturmer (UF-IFAS), Jerome La Peyre (LSU), Jennifer Pollack (TAMU-CC)

Sea Grant Aquaculture Research Symposia -- November 2, 2021
Atlantic-Gulf Shellfish Seed Biosecurity Collaborative
Motivation: A problem long recognized

- Inefficiencies and ineffectiveness of regional shellfish health management have been known for decades
- “Batch certifications” problematic as a foundation for management
- Rapid growth of shellfish aquaculture has made this an acute concern for industry, and created acute biosecurity implications and risks

2002 workshop prompted by emergence of QPX as a major concern at the time
Problems with status quo

- **Growth outpacing biosecurity policy development**
  - Irrelevant regulatory system: pathogens don’t recognize jurisdictional boundaries

- **Piecemeal surveillance of disease risk**
  - Independent, limited in scope
  - Not coordinated or accessible

- **Direct Costs**
  - Batch certifications can be cost prohibitive, and overwhelm agencies and laboratories
  - Zero tolerance policies unnecessarily limit commerce, restoration and enhancement

- **Indirect Costs**
  - Processing time limits timely responses to opportunities when little or no risk exists
  - Seed grows rapidly while awaiting results
Path Forward

- Enhance industry and resource sustainability
  - Develop more effective health management
  - Lower costs (time and money)
  - Improve biosecurity

- Promote an increased focus on surveillance of wild populations and farms
  - Better understanding of pathogen distributions
  - Improve alertness to emerging threats

- Streamline management and incentivize use of the most biosecure products from/for hatchery, nursery, farm and restoration
  - Increased but less obstructive engagement of producers with shellfish health managers
  - Creates a deeper, more systematic and sustained perspective on shellfish health in culture facilities

- Expand program regionally
Project journey began with a VIMS symposium

- Seed funds brought together:
  - Industry stakeholders
  - Pathologists
  - State regulators
  - Federal agencies (NOAA, USDA APHIS)

- Goal: Revitalize 2002 effort stimulated by QPX

- Needs identified:
  - minimum acceptable certification standards
  - recommendations for clear and effective science-based regulatory strategies
  - tools (e.g., database) and implementation framework
Outcome: Four committees, three major grants

- **Shellfish Health Advisory Committee (voluntary)**
  - 13 members representing industry, regulation, extension, academia
  - Provide support for decision making of seed transfers

- **Molluscan Pathology Working Group (voluntary)**
  - Standardization of diagnostics
  - Information-sharing, annual updates on changes in status and trends

- **Hatchery Certification Working Group**
  - NOAA SG Aquaculture Impediments Grant: “Establishing Shellfish Hatchery Biosecurity Certification Standards to Facilitate Interstate Transport of Shellfish Seed”

- **Database/Zoning Working Group**
  - NOAA SK Aquaculture Project: “Assembling the Best Available Science to Inform Interstate Transport of Shellfish Seed”

- **Gulf Regional Expansion**
  - NOAA Advanced Aquaculture Collaboratives: “Atlantic and Gulf Shellfish Seed Biosecurity Collaborative”
# Shellfish Health Advisory Committee

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<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
<th>State</th>
<th>Area</th>
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<tbody>
<tr>
<td>Debbie Bouchard</td>
<td>University Maine</td>
<td>ME</td>
<td>Pathology</td>
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<tr>
<td>Dave Bushek</td>
<td>Rutgers University</td>
<td>NJ</td>
<td>Pathology</td>
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<tr>
<td>Ryan Carnegie</td>
<td>Virginia Institute Marine Science</td>
<td>VA</td>
<td>Pathology</td>
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<td>Tal Ben-Horin</td>
<td>North Carolina State</td>
<td>NC</td>
<td>Extension</td>
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<tr>
<td>Lisa Calvo</td>
<td>Rutgers University</td>
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<td>Virginia Institute Marine Science</td>
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<tr>
<td>Bob Rheault</td>
<td>East Coast Shellfish Growers</td>
<td>RI</td>
<td>Industry</td>
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<tr>
<td>Mike Congrove</td>
<td>Oyster Seed Holdings</td>
<td>VA</td>
<td>Industry</td>
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<tr>
<td>Julie Davis</td>
<td>Lady’s Island Oysters</td>
<td>SC</td>
<td>Industry</td>
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<tr>
<td>Carolina Borque</td>
<td>Louisiana Department Fish and Wildlife</td>
<td>LA</td>
<td>Regulatory</td>
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<tr>
<td>Marcy Nelson</td>
<td>Maine Department Marine Resources</td>
<td>ME</td>
<td>Regulatory</td>
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<tr>
<td>Rebecca Thur</td>
<td>MD Department Natural Resources</td>
<td>MD</td>
<td>Regulatory</td>
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<tr>
<td>Lori Gustafson</td>
<td>USDA APHIS VS</td>
<td>Federal</td>
<td>Regulatory</td>
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Goal

- Establish a regional seed biosecurity certification protocol for hatchery products (e.g., gametes, larvae, early set)

Status - complete

- Created BMP guide, application, and audit process
- Piloted in winter 2020-21 with four hatcheries – all passed and used compliance documents this past season
- Contacting hatcheries to participate this winter
NOAA SK Project
Assembling the Best Available Science to Inform Interstate Transport of Shellfish Seed

**Goal**

- Develop an online portal for molluscan shellfish health
  - document known pathogen distributions
  - illustrate risk to inform shellfish seed importations

**Status** - ongoing

- Portal created with tools developed to compare source and destination pathogen profiles to assist risk assessment
- Data input ongoing
- Site to go public in January
Database showing sample locations, hatcheries, SSO distribution

Side panel allows user to select what they want to see. User can zoom in and get summary data in various formats.
Re-Branding the Program

Regional Shellfish Seed Biosecurity Program (RSSBP)

Logo created for identity

• Easily recognized
• Conveys security
• Implies shellfish
• Green industry
• Blue economy
NOAA Advanced Aquaculture Collaborative Programs: Atlantic and Gulf Shellfish Seed Biosecurity Collaborative

**Goal**

Expand Shellfish Seed Biosecurity Initiative to Gulf States

**Objectives**

1) Collaboratively assess performance to date and applicability to the Gulf.

2) Expand database into Gulf.

3) Establish surveillance program.

4) Develop a future funding model.

**Progress**

- Rebranded the program and combined efforts into a single web portal
- Expanding database into gulf via existing data, collating data on cultured shellfish, and collecting new surveillance data
- NOAA SG Special Projects Grant: *Extension to Extension: Supporting the Rollout of a Regional Shellfish Health Initiative*. PIs Hudson and Calvo
- Initiating Gulf regulatory contacts
- Continuing all efforts to obtain surveillance data, certify hatchery compliance, and solicit regulatory input and participation
Gulf Hatcheries and Nurseries

FISH & WATER

Shellfish Seed Suppliers for Gulf of Mexico 2021

This list of shellfish seed suppliers was compiled by the Alabama Extension and is based on readily available information. It is not intended to promote or endorse any of the companies. However, if you are interested in acquiring shellfish seed and have any questions regarding the companies, you should contact the company directly for more information.

Alabama

Auburn University Shellfish Lab (H., N.)

Contact: Lois Akin

105 Walton Street, Auburn, AL, 36849

www.auburn.edu/shellfish

Types of seed or larvae sold: Oyster

Naval GP Oyster Company (H.)

Contact: Sandy Smolik

1520 Beach Blvd., Gulfport, MS, 39501

www.navalgp.com

Types of seed or larvae sold: Oyster

Florida

Apalachicola Oyster Company (H.)

Contact: Bill Knight

P.O. Box 878, Apalachicola, FL, 32320

www.apalachicola.org

Types of seed or larvae sold: Oyster

Bay Shellfish Company (H.)

Contact: Tom McDaniel

P.O. Box 210, Pensacola, FL, 32502

www.bayshellfish.com

Types of seed or larvae sold: Oyster, Hard Clam, Sun Ray Venus, Bay Scallop

Great Florida Shellfish Company (H.)

Contact: Tom McDaniel

P.O. Box 210, Pensacola, FL, 32502

www.bayshellfish.com

Types of seed or larvae sold: Oyster, Hard Clam, Sun Ray Venus

![Image](88x16 to 369x371)

2021 Florida Shellfish Seed Suppliers

These hatchery and nursery operations are supplying molluscan shellfish to Florida growers this year. Contact suppliers for information on species, seed size, price, color variation and availability.

Apalachicola Oyster Company (H.)

456 Hwy. 90

Apopka, FL, 32320

Contact: Tim Jackson

(850) 274-1368

hatchery@apalachicolaoyester.com

Species: OY

Bay Shellfish Co. (H., N.)

P.O. Box 269

Terra Ceia, FL, 34250

Contact: Curt Hemmle

(727) 309-1269

coupl@apostle.com

Website: bayshellfish.com

Species: HC, OY, SRV, BA

Clamartico (H., N.)

P.O. Box 644

Cedar Key, FL, 32625

Contact: Chris Topping or Antonio Hidalgo

(352) 213-5999 or (949) 2233

coupl@apostle.com

Website: clamartico.com

Species: HC

Ewan Leighton - H.

P.O. Box 821

Sanibel, FL, 33957

Contact: Ewan Leighton

(239) 388-8201

ewen1971@gmail.com

Species: HC

Ewan Leighton - H.

2700 S. Ocean Drive

Melbourne Beach, FL, 32951

Contact: Ewan Leighton

(239) 388-8201

ewen1971@gmail.com

Species: HC

Ewan Leighton - H.

2700 S. Ocean Drive

Melbourne Beach, FL, 32951

Contact: Ewan Leighton

(239) 388-8201

ewen1971@gmail.com

Species: HC

Great Florida Shellfish Company (H.)

Contact: Tim McDaniel

P.O. Box 210, Pensacola, FL, 32502

www.bayshellfish.com

Types of seed or larvae sold: Oyster, Hard Clam, Sun Ray Venus

Premium Seafood - H.

7539 A1A South

Crestview, FL, 32530

Contact: Mike Sullivan

(850) 847-2302

preniumseedandvice@gmail.com

Species: HC

Seawolves Clam Co. (H.)

5600 US-1

Fort Pierce, FL, 34946

Contact: Dwayne Hines

(941) 726-8348

dwayne@seawolves.com

Species: HC, OY

Southern Cross Oysters - H.

P.O. Box 1493

Bradenton, FL, 34206

Contact: Granite Dugger

413-424-2948

gwolookies@gmail.com

Species: HC, OY

Shelling Shellfish, LLC (H., N.)

P.O. Box 1949

Bradenton, FL, 34206

Contact: Mike Sullivan

(850) 847-2302

preniumseedandvice@gmail.com

Species: HC

Sunray Shellfish - H.

11 W. Garden St.

Pensacola, FL, 32502

Contact: Dwayne Hines

(941) 726-8348

dwayne@seawolves.com

Species: HC

![Image](405x22 to 686x370)

January 2021

This list is provided as a service of the UniFAS Shellfish Aquaculture Extension Program. We do not sponsor or endorse any of these suppliers or any others. To obtain a list of East Coast shellfish seed suppliers, contact Doug Zemek with Rutgers Cooperative Extension, (732) 248-1522, doug.zemek@rogers.org, or go to www.rnceo.org. Shellfish seed obtained from unauthorized suppliers must meet management practices. For more information, contact the F. Department of Agriculture and Consumer Services. Division of Aquacultures at (850) 417-7600, or visit their website, click on Best Management Practices, Chapter 6-6.
What do we know about shellfish disease in the Gulf of Mexico?

Surveillance strategy:
1. Summarize existing data
2. Conduct targeted sampling
   a. Regional differences
   b. Areas of likely transfer

https://data.oystersentinel.cs.uno.edu/dermo
https://products.coastalscience.noaa.gov/collections/ltmonitoring/nsandt/data2.aspx
What do we actually know about disease levels in hatcheries?
235 total “business as usual” submissions
- 177 from Atlantic Coast
- 146 oysters (Crassostrea virginica)

RFTM analyses for dermo in oysters
19 Gulf and Atlantic larval samples evaluated from 2017-2019
- all negative by PCR

Oyster larvae enrobed in agar for histology
Small Seed, to 3.5 mm

- 41 samples
  - no detection of dermo or MSX

Histology of oyster seed
Nursery Seed, ~4-20 mm

- 56 samples, 22 positive for dermo
- Max prevalence: 13.3%
- No infection reached moderate intensity (1 light-moderate)
- Most intensities rare
- No MSX
Large Seed and Submarkets, (to ~60 mm)

- 14 samples
- Maximum dermo prevalence 3.6%
- Only rare infections
- Even near-market-sized cultured oysters can have surprisingly low levels of infection
Independent data sets demonstrate pathogen absence in larvae and small seed.

Seed Certification History
Haskin Shellfish Research Laboratory

<table>
<thead>
<tr>
<th>Period of record 2004-2019</th>
<th>Size range of detection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C. virginica</strong></td>
<td></td>
</tr>
<tr>
<td>Positive for MSX</td>
<td>5</td>
</tr>
<tr>
<td>Positive for Dermo</td>
<td>7</td>
</tr>
<tr>
<td><strong>M. mercenaria</strong></td>
<td></td>
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<tr>
<td>Positive for Dermo</td>
<td>4</td>
</tr>
<tr>
<td>Positive for QPX</td>
<td>1</td>
</tr>
<tr>
<td>Positive for neoplasia</td>
<td>1</td>
</tr>
</tbody>
</table>
What do we actually know?

- Youngest stages are most biosecure
- Field
- Hatchery
- Nursery
- Field/Growout
- Infection Level / Disease Transmission Risk

- BROODSTOCK
- GERMLASM
- LARVAE/POST SET
- NURSERY SEED
- SUBMARKETS/MARKETS

2/24/20
Collective results provide empirical support for the presumed high biosecurity of larvae and small (<4 mm) seed from hatcheries.

Low infection of smaller nursery seed suggests that the Hatchery Certification paradigm could justifiably be extended, as a next step, to nurseries.

Efforts could be better focused on environmental surveillance to assess risk and changes in pathogen distributions.
Summary

The RSSBP is a voluntary program collaboratively developed by shellfish growers, scientists, extension specialists and State resource managers to foster a common goal of minimizing risks associated with interstate transfers of bivalve shellfish.

Core Elements

• Regional Shellfish Health Advisory Council
• Regional network of shellfish pathologists
• Interactive Shellfish Disease Database Mapping Tool
• Best Management Practices for minimizing shellfish disease risks
• Hatchery Certification Program
Next Steps – Questions – Discussion

- Continue Hatchery Compliance Program, adding Gulf hatcheries
- Conduct surveillance to fill in gaps, particularly across GoM
- Conduct an extension training workshop to facilitate outreach
- Pursue state by state outreach to regulators
Nurturing the Successful Growth and Maturation of a Domestic Seaweed Aquaculture Industry: Identifying and Removing Barriers and Promoting Opportunities-CTSG

A. Concepcion, J. Robidoux, M. Good, S. Otts, S. De Guise
National Seaweed Hub

Anoushka Concepcion
Connecticut Sea Grant
University of Connecticut
anoushka.concepcion@uconn.edu
Driver:
Need for a collective generation and sharing of science-based information:

National Seaweed Hub

www.SeaweedHub.org
Background

- 12+ Sea Grant states
  - Actively cultivating or investigating cultivation
- 2018 “State of the States of Seaweed”
  - Similar challenges
  - Common goals
Opportunity

• NOAA collaborative grant opportunity
• Establish a National Seaweed Hub
• Better understanding
  • Current status of the seaweed industry
  • Needs identified by various sectors
• Active participation
  • Collaborate
  • Strategize
  • Path forward
Steering Committee

• Guidance
• Meet goals/objectives of the project

• Caird Rexroad, USDA
• LaDon Swann, MS-AL Sea Grant and Sea Grant Aquaculture Liaison
• Steven Bloodgood, FDA
• Kevin Madley, NOAA NMFS
• David Hansen, OR Sea Grant
• Michael O’Neil, UConn Extension
• Katherine Bunting-Howarth, NY Sea Grant
• Quentin Fong, AK Sea Grant
• David Hansen, OR Sea Grant
Hub Objectives

NEEDS ASSESSMENT
SEAWEED SYMPOSIUM
STAKEHOLDER WORK GROUPS
PRODUCTS
OUTCOME
Needs Assessment

- 259 responses, 14+ states
- Stakeholder groups
  - Permitted/prospective farmers, regulators, culinary, nursery operators, processors, researchers, other (i.e. extension, non-profits)
- Challenges identified – established Work Groups
  - Market Opportunities
  - Post-harvest and Processing Infrastructure
  - Regulations
  - Production Systems
- Dawn Kotowicz (RISG)
Seaweed Symposium

• Day 1: Introductory presentations and break-out discussions
  • Global overview
  • State of the States
  • Needs Assessment
• Day 2: Break-out discussions, Farmers’ Forum, Seaweed Showcase
• Day 3: Wrap-up
Work Groups Sessions

- Participants pre-assigned

Day 1
- Big ideas
- Identify pressing needs, challenges, opportunities

Day 2
- Refine by achievable goals or objectives
- Identify outcomes or products for Work Group

Day 3
- Present Work Group Strategies
Evaluation

• 33% responded
  • 91% strongly agreed/agreed – good use of my time
    • 0% disagreed
  • 71% - increased knowledge of seaweed industry (a great deal/a lot)
  • 85% - can apply knowledge to their work (a great deal/a lot)
• 97% - want a follow-up meeting
  • Willing to pay a nominal registration fee
Virtual Work Groups

• Diverse, meet regularly
  • Rules of Engagement

• Strategy or work plan
  • Polling, MIRO

• Applied project funds

• Summaries and products available on web
Refining Work Group Recommendations

• Production Systems
  • 30+ challenges/opportunities

• Regulations
  • 60+ challenges/opportunities

• Post-harvest and Processing Infrastructure
  • 30+ challenges/opportunities

• Market Opportunities
  • 60+ challenges/opportunities
Production Systems Work Group

- Meg Chadsey* (WASG) and Joshua Reitsma (WHOI SG)
- Focus: Improve seed-stock supply
  - Obj 1: Develop a national nursery list
    - Resource for growers (also regulators, end-users, etc)
    - Refining nursery survey questions
    - Use applied project funds to hire UConn students
    - Plan for long-term maintenance
  - Obj 2: Increase nursery capacity
Regulations Work Group

• Stephanie Otts and Catherine Janasie* (NSGLC)
• Develop resources providing an overview of:
  • Food safety of seaweed-related food and food products (i.e. Preventive Controls)
  • Permitting concerns of seaweed farms
Post-harvest and Processing Work Group

- Antoinette Clemetson (NYSG) and Melissa Good* (AKSG)
- Feasibility study for a model regional processing facility
- Identify and assess processing technology to assist with product innovation
Market Opportunities Work Group

• Gabriela Bradt* (NHSG) and Jaclyn Robidoux (MESG)
• 3 subgroups formed to address work group priorities:
  • **Consumer education** and outreach opportunities to build markets, which can be accomplished relatively short-term
  • **Product development** needs, including standards and grading, scale and supply, nutritional profiles and labeling
  • **Industry representation** to tap into long-term marketing efforts, including pros/cons of industry associations, science-industry institutes, etc.
Outcomes

• Compilation of practical resources
• Transparent, accessible information
• Fostering long-term relationships
• Path forward for commercial seaweed aquaculture
• More informed audiences
Economics of production systems and stabilization processes
Next Steps

• Seaweed Symposium 2.0 or biennial seaweed meeting
• Continuation of work group discussions
• More ways for specific stakeholder groups to connect (i.e. farmers with farmers, regulators with regulators)
Thank you!

Anoushka Concepcion
Gabriela Bradt
Meg Chadsey
Antoinette Clemetson
Melissa Good
David Hansen
Dawn Kotowicz
Stephanie Otts
Joshua Reitsma
Jaclyn Robidoux
Advancing Southern New England Shellfish Aquaculture Through an Engaged Public and Next Generation Decision Support Tools-CTSG

T. Getchis, A. Cygler, A. Franklin Archer, R. Porter, S. De Guise
Advancing Southern New England Shellfish Aquaculture Through an Engaged Public and Next Generation Support Tools

Abigail Archer¹*, Judy Benson², Azure Cygler³*, Dana Bauer⁶, Catherine Dwyer³, Giulio Farolfi⁶, Tessa L. Getchis²,⁴*, Brooke Hodge⁵*, Robert J. Johnston⁶*, Kristen Jabanoski⁷*, Sue Kennedy³, Stephanie Murphy¹, Tom Ndebele⁶, Diana Payne², Read Porter⁸, Catherine Schulter⁸*, Grace Simpkins¹, Julia Wyman⁸ (*denotes speaker)

¹Woods Hole Oceanographic Institution Sea Grant, ² Connecticut Sea Grant, ³ Rhode Island Sea Grant, ⁴ UConn Extension, ⁵ New England Aquarium, ⁶ Clark University, ⁷ NOAA NEFSC Milford Laboratory, ⁸ Rhode Island Sea Grant Legal Program

National Sea Grant Aquaculture Symposium, Nov 2, 2021
Project Overview

1. Shellfish aquaculture landscape in southern New England
   1.1. What brings us together?

2. Research to inform extension programming
   2.1. Public concerns and tradeoffs for coastal aquaculture
   2.2. Role the media plays in aquaculture messaging

3. Engaging stakeholders with essential information and tools
   3.1. Public & media fact sheets, displays & interpretative signage
   3.2. Private sector training
   3.3. Law, policy & permitting initiatives
   3.4. Map & data viewers
Southern New England’s shellfish aquaculture landscape

- Focus is bivalve shellfish aquaculture
- Hundreds of small businesses
- Farms located in near shore coastal areas
- Shellfish initiatives established to grow industry
- Expansion of submerged and floating gear
- Aquaculture has become increasingly visible
- Increased public attention, concern, scrutiny
Southern New England’s shellfish aquaculture landscape

- Previous efforts focused mainly on producing information and tools for prospective farmers
- Now engaging public to increase knowledge of shellfish aquaculture and shared role of siting farms in coastal waters
- Opportunity to work together regionally to:
  - Listen to public & media perspectives
  - Develop targeted information and tools
  - Engage audiences across the region
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Tradeoffs in Shellfish Aquaculture

- All shellfish aquaculture involves tradeoffs, e.g., economics, aesthetics, use of water resources, environmental impacts, etc.
- The public’s initial impressions of shellfish aquaculture sometimes depend on misperceptions or lack of information.
- Existing research provides minimal information on what type of shellfish aquaculture development would maximize support.
- How does this support depend on the information provided on aquaculture characteristics and impacts?
- How and why does it differ across different population groups, areas of New England, etc?
Discrete Choice Experiment to Quantify Preferences

- Develop and implement a stated preference discrete choice experiment (DCE) to quantify public preferences for different types of shellfish aquaculture
- Compare results across three New England states
- DCEs estimate preferences based on how different individuals would 'vote' for or against different types of hypothetical but realistic future scenarios.
- Statistical results demonstrate the public’s value and preferences for different types of shellfish aquaculture in different areas.
- Can predict public voting support for different types of future development scenarios.
DCE Survey Design and Analysis

- Survey was designed over a two-year process with input from the literature, aquaculture experts and 6 focus groups with members of the public.
- Key attributes for scenario design include changes in (1) floating gear, (2) bottom gear, (3) jobs and income, (4) localized water clarity, (5) region where new aquaculture occurs, and (6) household taxes / fees.
- Scenarios grounded in actual (current) conditions in each state.
- Additional questions will allow preferences and values to be modeled as a function of household attributes, coastal recreation activities, experience with aquaculture, etc.
- Statistical analysis will enable public support to be predicted across sampled states, for different types of potential future aquaculture development strategies.
- What types of characteristics and impacts are most important to public support and why?
Next Steps

- Survey design is complete and coded on Qualtrics platform.
- Will be implemented via random internet panel in target states (CT, MA, RI), with sample quotas to match Census population.
- Anticipate N= ~1250 per state (3,750 total), conditional on quotes from survey implementation firms (e.g., Dynata).
- Expect implementation during fall 2021; initial results by early 2022.
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Public perception challenges

- Between 70 and 85% of the seafood Americans consume is imported
  - 50% of those products (finfish, shellfish, seaweed) are farmed
- Few Americans have firsthand experience with aquaculture
- Low awareness of benefits, risks, effects and practices associated with aquaculture industry (Murray et al. 2017)
- 47% of Americans have a negative view of farm raised seafood due to concerns for product quality, food safety and the environment (Bacher 2015)
- 1 in 4 respondents were aware of positive environmental contributions of shellfish aquaculture operations in a recent survey (Atlantic Corporation 2019)
- More general reporters covering science and the environment
Importance of understanding public discourse and perceptions

- Understanding how to educate and inform the public
- Foster support for public policy
- Design strategic risk communication
- Market local aquaculture products
Content analysis study compared aquaculture coverage in 4 regional & 4 national newspapers

Overall media coverage of aquaculture increased during study period, especially discussion of benefits and sustainability

Most prevalent themes: economics and risk

Finfish aquaculture discussed in 62.3% of articles, shellfish 51.5% & seaweed 5.3%

More national coverage of risks, benefits and sustainability compared to regional

39% of Boston Globe articles mentioned benefits of aquaculture, ⅓ discussed sustainability
Objectives of Southern New England Content Analysis Study

● Analyze temporal and geographic trends and dominant themes in media coverage of shellfish aquaculture in southern New England,

● Determine whether and to what extent state shellfish initiative outreach efforts are informing or impacting media dialogue, and

● Explore which outreach activities (if any) are having a measurable effect on how aquaculture is covered by the media.
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3. Engaging stakeholders with essential information and tools
   3.1. Public & media fact sheets, displays & interpretative signage
Public/Media Outreach Information

Aquaculture Interpretive Signage
● Pivot due to COVID
● 2 signs using community model

Media education
● Media forum
● Adopted/shared common language on events like HABs

Public Education
● Fact Sheets
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   3.2. Private sector training
Training

- Class has been taught in person for 30+ years (MA)
- Updated/adapted curriculum to 10-wk class via Zoom
- 50+ students (2021)
- Weekly Interactive assessments & discussion time
- Presentations from farmers, town managers & regulators
Evaluation Survey Feedback

Successful Components of Class
- Weekly homework via Padlet
- Zoom class time of 75 minutes
- “Face-time” with regulators
- Level of technical content

Things to work on in 2022
- If covid-safe to do so - hybrid approach
- Change format of weekly discussion groups
- Limit class size to allow time for more interaction
Training

- Launch in December 2021
- Hosted through Teachables.com - FREE
- Modules will include emphasis on safety on the farm & skills to work with newer growing techniques & products such as kelp
- Will advertise through paid ads across the region
- Collaboration with Education Exchange, East Coast Shellfish Growers Association, Shedlight Productions
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   3.3. Law, policy & permitting initiatives
Assessment of Connecticut Aquaculture Laws

- 2 major parts divided into 11 questions
  - Comparing Connecticut aquaculture laws to other eastern states (MA, RI, ME, NJ, VA, MD)
  - Reviewing Connecticut laws for inconsistencies or outdated sections
Examples of Questions

● What mechanisms do states use to allocate shellfishing grounds for aquaculture?

● How do Connecticut’s regulations governing the minimum commercial size of wild-harvested shellfish and aquaculture-reared shellfish compare to competitor states?
Fact Sheet

- “The Relationship Between Aquaculture and the Public Trust in Connecticut, Massachusetts, and Rhode Island” - written by Andrew Spaulding, Law Fellow
- To improve the public’s understanding of the public trust doctrine and the use of public waters for shellfish aquaculture in Connecticut, Massachusetts, and Rhode Island
Permitting Portals
Project Overview

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   3.3. Law, policy & permitting initiatives
   3.4. Map & data viewers
Rhode Island Shellfish Aquaculture Siting Tool (ShellfAST-RI)

- Beta version built and sent out for review by advisory board
- In the process of collecting feedback
- Plan to launch publicly in early 2022
Massachusetts Shellfish Aquaculture Siting Tool (ShellfAST-MA)

- Launched in 2018
- Update slated for late 2021/early 2022
Connecticut Aquaculture Mapping Atlas

- Fourth iteration
- Update slated for 2022
- Will expand upon number of datasets, tools and query options
Summary

- Expansion of shellfish aquaculture in Southern New England faces common challenges
- Developing targeted outreach information and tools that are informed by social science research
- Sea Grant Aquaculture Collaborative has allowed us to:
  - Better understand public and private sector concerns
  - Improve upon and develop new shared information and tools
  - Expand our reach beyond traditional audiences
Acknowledgments

We are grateful for funding through DOC/OAR/National Sea Grant Program: Advanced Aquaculture Collaborative Programs NA18OAR4170081, and matching funds through partner organizations.

Much of the work presented here includes collaboration with industry, researchers and state and federal regulatory agencies.
Establishing a Hawai'i-Pacific Aquaculture Consortium: A Revitalization and Expansion of the Aquaculture Development Program-HISG

D. Lerner, M. Haws, D. Okimoto, A. Seale, S. Ellis, K. Anderson Tagarino, M. Sudnovsky
ESTABLISHING A HAWAI‘I-PACIFIC AQUACULTURE CONSORTIUM: A REVITALIZATION AND EXPANSION OF AN AQUACULTURE DEVELOPMENT PROGRAM

Darren T. Lerner, Darren K. Okimoto, Kelly Anderson Tagarino, Max Sudnovsky, Andre P. Seale, Maria Haws, and Simon Ellis
w/Bradley “Kai” Fox, Cherie Kauahi, Katy Hintzen, and David Crisostomo

NOAA, Sea Grant Advanced Aquaculture Opportunities (Hubs) Symposium
November 1, 2021 (Virtual)
University of Hawai‘i Sea Grant College Program

- Founded in 1968 at UH Mānoa and designated a Sea Grant College Program in 1972
- Organized research unit in the School of Ocean and Earth Sciences and Technology
- State-wide and Pacific region presence
Mission

To provide integrated research, extension and education activities that promote sustainable coastal and marine resources and resilient communities across Hawaiʻi and the Pacific region.
Focus areas

Healthy Coastal Ecosystems

Resilient Communities and Economies

Sustainable Fisheries and Aquaculture

Environmental Literacy and Workforce Development
Seaweed Farming
1968-1986

Prawn Program
1973-1987

Cold Deep Ocean Water Aquaculture
1982-1983

Aquaculture Research
Marine Shrimp Program 1985-1990
Shrimp Virus Research 1984-2000
Feeds Technology Research 1985-2001
Aquaculture Research
Open Ocean Aquaculture
1995-2002

Hawaiian Fishpond Research
2007-present

Aquaculture Research
Aquaculture Research

- 95 newsletters
- Over 100 peer-reviewed publications
- 34 conference, symposium, or workshop papers
- 20 brochures
- 14 books authored/edited
- 12 book chapters authored
- 10 technical reports
- 19 dissertations/theses
Past extension faculty for Hawaiʻi

- Mary Brooks 1982-1986 Oʻahu
- Bob Howerton 1994-2015 Maui
- Clyde Tamaru 1995-2009 Oʻahu
- Jim Szyper 1999-2009 Hawaiʻi Island
- Maria Haws 1999-2008 Hawaiʻi Island
Aquaculture Extension

Freshwater & marine ornamentals
Commercialization of Hawai‘i bivalve industry
Industry diversification

Photo by M. Haws
Photo by C.S. Tamaru
Open ocean cage culture
Hawaiian fishponds
Aquaculture as education

Aquaculture Extension
Pacific Regional Aquaculture Extension Service

• Est 1987
• Support aquaculture development in the US-affiliated Pacific Islands and US territories
• Partners: UH, US Dept. of Interior, CTSA, Land Grant Programs in Palau, RMI, American Samoa, CNMI, FSM, and Guam.
Aquaculture Extension
US Pacific

Aquaponics & feeds production
Black Pearl culture
Marine ornamentals

Aquaculture Extension US Pacific
Economic Recession in 2008
Sea Grant Aquaculture NSI

National Sea Grant Initiatives

<table>
<thead>
<tr>
<th>Year</th>
<th>Funding (in millions)</th>
</tr>
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<tbody>
<tr>
<td>1999</td>
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<tr>
<td>2001</td>
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<td>2003</td>
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<td>2005</td>
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ADP crash
Post economic recession extension capacity
ROBERT DEAN HOWERTON

ROBERT DEAN HOWERTON June 16, 2016 Robert Dean "Bob" Howerton, PhD., age 59 passed away unexpectedly at his home in Makawao, Maui, Hawai‘i on June 16, 2016. A kind and gentle soul, he was well-known by the aquaculture community locally and abroad and his passing is a huge loss for Bob's family, colleagues and friends. Born November 14, 1957 in Las Vegas, NV, to the late James M. Howerton and Mona (Brennecke) Howerton, he was the husband of the late Cynthia Lynn "Cindi" (Taylor) Howerton. He leaves behind his two beloved daughters Lauren Howerton of Wailuku, Maui and Jaime Howerton of Portland, OR, He also leaves behind brothers Jim (Robin Kuo) of Des Peres, MO, David of Sydney, Australia, and nieces Izzy and Mia. He was an alumnus of Punahou School, the University of Hawai‘i at Manoa, and Auburn University, AL, and worked with the UH Sea Grant
Sea Grant Aquaculture NSI

National Sea Grant Initiatives

Congressional Directed Initiatives

ADP crash

NSI Funding [numbers in millions]
Establish an aquaculture program at UHM that leverages and integrates Land Grant and Sea Grant research, extension and education resources, including a state-of-the-art recirculating aquaculture demonstration center called the **Tuahine Aquaculture Research and Education Center (TAREC)**
Establishing A Hawaiʻi-Pacific Aquaculture Consortium: A Revitalization and Expansion of An Aquaculture Development Program

PI: Darren T. Lerner, Hawaiʻi Sea Grant
Co-PIs: Darren K. Okimoto, Kelly Anderson-Tagarino, and Max Sudnovsky, Hawaiʻi Sea Grant; Maria Haws, UH Hilo PACRC; Andre P. Seale, UH Mānoa CTAHR; and Simon Ellis, Marine and Environmental Research Institute of Pohnpei

Revitalize, solidify, and expand an aquaculture development program through the establishment of an aquaculture-focused, collaborative hub which fully integrates research, extension, and education services directed towards supporting the continued development and enhancement of indigenous practices and the aquaculture industry in Hawaiʻi and the Pacific.

2019 $1.2M
Objective 1. Formalize current and new collaborative alliances to create integrated and synergistic research, education, and outreach efforts that foster the development, expansion, and promotion of local, regional, and indigenous sustainable aquaculture.

Objective 2. Support and conduct collaborative, applied research that addresses production barriers and bottlenecks related to feed availability, hatchery seed stock, production, disease, engineering limitations, and/or traditional practices.

Objective 3. Support critical extension/technology transfer capacity in Hawai‘i and the Pacific region in support of past research and the development of next generation efforts.
**Objective 4.** Explore the development of a regional aquaculture education program that leverages curricula, training courses, and extension materials for aquaculture audiences and work towards improved delivery of instruction.

**Objective 5.** Develop adaptation strategies and practices that enhances the resilience of traditional aquaculture practices and the aquaculture industry to climate change.
Co-Investigators and Current Extension, Specialist, and Research Faculty

Dr. Bradley “Kai” Fox
Aquaculture Extension Specialist

Cherie Kauahi
Aquaculture Extension Specialist

Kelley Anderson Tagarino
American Samoa Extension Specialist

Max Sudnovsky
Republic of Marshall Islands Extension Specialist

Simon Ellis
Pohnpei Aquaculture and Marine Resource Management Specialist

David Crisostomo
Guam Aquaculture Extension Specialist

Dr. Maria Haws
Professor of Aquaculture

Dr. Andre Seale
Assoc Professor of Animal Sciences

Katy Hintzen
Coastal Resilience Specialist

Dr. Kanesa Seraphin
Prof & Asst. Director of Education

Dr. Rosie Alegado
Assoc. Prof of Oceanography, Director, Center for Integrated Knowledge Systems

Dr. Beth Lenz
Asst. Director for Diversity & Community Engagement
Katy Hintzen
Coastal Resilience Specialist
Future & History of Loko Iʻa Adaptation

Photo Credit: Kanda
Holistic approach that includes needs directly related to climate adaptation and the systemic social, political, and economic conditions that facilitate or hinder the perpetuation of loko iʻa
Nā ‘Ono o ka ‘Āina

Strengthening Indigenous Food Systems and Supporting Restaurant Workers During COVID-19
Begin

Gorilla Ogo Salad by Alicia Nunez

Samoa Crab Ramen by Dilyuns Michael

Papio Ceviche by Alicia Nunez

Barracuda McNuggets by Yamachika

Gorilla Ogo Sourdough Crackers by Roxanne
Indigenous Aquaculture Hub Gathering on Oʻahu
Connections to Indigenous Aquaculture Hub
Dr. Andre Seale
Assoc Professor of Animal Sciences
Research

An adaptable fish model that allows for interdisciplinarity: from aquaculture to biomedical research

- Integrating Osmosensitivity and Autocrine Signaling in a Model for Osmoregulation
- Identifying osmosensitive molecular targets using a unique vertebrate model
- The development of acclimation salinity-based rearing strategies to maximize growth in Mozambique tilapia, *Oreochromis mossambicus*
- The use of a euryhaline tilapia to assess the endocrine disrupting effects of anthropogenic chemicals on growth and osmoregulation
- Establishing an aquaculture program at the University of Hawai‘i that leverages and integrates Land Grant and Sea Grant research, extension and education resources
- Physiological effects of environmental stressors in a key finfish for aquaculture
Dr. Maria Haws
Professor of Aquaculture
Academic Contributions

- Aquaculture specialization part of Bachelor’ degree in agriculture
- This is the only 4-year degree program in aquaculture in Hawai‘i
- TCBES Masters degree students may choose aquaculture research topics
- Pursuing partnerships with community colleges
- Wildlife/Fisheries/Aquaculture degree program in planning stages
Aquaculture Student Workforce Training Program
PACRC’s Fish Research, Development, and Extension Program

- Two fish hatcheries at PACRC
  - Marine food fish
  - Marine ornamental fish
- Also supported by NSGO and NOAA SK grants
Development of native food-fish species

Nenue (*Kyphosus* spp.)

Moi (*Polydactyus sexifilis*)

Mullet (*Mugil cephalis*)

Nabeta (*Pavo iniiistus*)

Āholehole (*Kuhlia sandvicensis*)

Achilles Tang (*Acanthuras achilles*)
Developing captive breeding methods for coral reef fish is an opportunity to elucidate life history traits to aid in fisheries management and conservation.

Hawaiian Flame Wrasse (*Cirrhilabrus jordani*), one of 10 ornamental species used for R&D at the PACRC.
Shellfish research, training, and extension program

- Seed and technical training for fishponds and other producers
- Hawaiʻi’s hatcheries supply 50-80% of NW seed
- Polyploid oyster research
  - Climate adapted polyploids (w/molluscan Broodstock Program, OSU)
Development of native bivalve species for production and restorative aquaculture
Simon Ellis
Pohnpei Aquaculture and Marine Resource Management Specialist
Marine and Environmental Research Institute of Pohnpei, Micronesia (MERIP)
• Three tier, fully integrated development approach to sustainable development:
  — Product development
  — Community technology transfer/training
  — Marketing and market development
Products and Activities

- Farmed corals and giant clams for the marine ornamental trade
- Natural Sponges
- Capture-based farming of Rabbitifishes
- Giant clam Hippopus for food security
- Partnering with more than 60 farmers across Pohnpei and Kosrae
Aqua-Farming

- Simple Design
- Lagoon & Community-based
- Easy to establish & run
Kelley Anderson-Tagarino
American Samoa Extension Specialist
American Samoa’s only aquaculture program

- A Sea Grant – Land Grant partnership based at the American Samoa Community College providing extension services and aquaculture education for the Territory.
Enhancing resilience
David Crisostomo
Guam Aquaculture Extension Specialist
Building a Better Aquaculture Industry

**Major Focus Areas**
* Public awareness
* Public/private partnerships
* Applied research
* Community Training
PUBLIC AWARENESS

SOCIAL MEDIA :

- VIRTUAL “TALK AND TOUR” OF AQUACULTURE ACTIVITIES
  - *HAWAII AQUAPONI
- PAYLESS MARKET LOCAL FOOD PROGRAMMING “CHAGI”
- CONFERENCE ON ISLAND SUSTAINABILITY
- TILAPIA TASTING EVENT
Public/Private Partnership

Community Level
Backyard Recirculating Aquaculture Systems

- 3 local non-profits organizations
  - GUHAHAN SUSTAINABLE CULTURE
  - ISLAND GIRL POWER
  - HARVEST OF GRACE INTERNATIONAL, INC

- 2 Mayor’s Offices
  - PITI MAYOR
  - SINAJANA MAYOR

Stakeholder Group (advisory)

Guam Aquaculture Stakeholder Group
* New group working to register as non-profit.
APPLIED RESEARCH

Production and Economic Analysis of Commercial scale aquaponic system in Guam

- Construct small commercial scale aquaponics system
- Compare production and economics between “coupled” and “de-coupled” aquaponics system.
Community Training

* G3 Conservation Corp.
* Guahan Sustainable Culture
* Island Girl Power
* Harvest of Grace International, Inc
* Piti Mayors Office
* Sinajana Mayors Office
* GSC-AmeriCorps
Future Directions
Core Partners

• Agriculture, Community, and Natural Resources Division, American Samoa Community College
• Aquaculture and Livestock Support Services, Hawai‘i Dept of Agriculture
• College of the Marshall Islands-Cooperative Research and Extension
• College of Tropical Agriculture and Human Resources, UH Mānoa
• Guam Sea Grant
• HATCH Accelerator
• Hawai‘i Aquaculture and Aquaponics Association
• Hawai‘i Strategic Development Corporation
• Kua‘āina Ulu ‘Auamo
• Natural Energy Laboratory of Hawai‘i Authority
• Oceanic Scientific, LLC
• Pacific Aquaculture and Coastal Resources Center, UHH
• Pacific Islands Regional Office, National Oceanic and Atmospheric Administration
• The Marine and Environmental Research Institute of Pohnpei
• University of Hawai‘i System
• Waterkeepers Hawaiian Islands
• Washington Sea Grant
• Windward Community College, University of Hawai‘i
EDA Good Jobs Challenge NOFO

Figure 1 – Visualization of a Sectoral Partnership

Strategic Partners
EDA-eligible organizations involved in workforce development

Backbone Organization

Sea Grant

Kauai Sea Farms
Kauai Shrimp
Public/Private Aquariums
State Entities (i.e. DAR, Anuenue, etc.)

Industry Partners
Partnership of employers from the same industry

Oceanic Institute
Department of Agriculture
UH System - CTE
Kulā‘ina Ulu ‘Auamo
Local High Schools
KUPU
Ocean Era
NELHA
NELHA Tenants
NSF Engineering Research Centers Opportunity (TBA)

Establish an Engineering Research Center on Sustainable Offshore Integrated Multi-tropic Aquaculture

$50 Million over 10 years
Mahalo! • Photo by Andre Seale
West Coast Region

- Similar habitats and species
- Existing market connectivity
- Overlapping social license concerns
- Political and institutional diversity
Sustainable Aquaculture
Ecosystem-based Management

- Landscape-scale
- Collaborative
- Interdisciplinary
- Adaptive management
Hub Objectives

1. Establish a collaborative structure
2. Test the approach through a pilot study
3. Report outcomes and identify future opportunities
Hub Participants & Structure

Theresa Talley
Amy Ehrhart
Angee Doerr
Nicole Naar
Joe Tyburczy
Gina Contolini
Dave Hansen
Sean Macduff
Melissa Good
Pilot Study: WCSAS

- WA Coast Shellfish Aquaculture Study
  1. EBM approach for stakeholder engagement
  2. Field protocols for assessing aquaculture

WCSAS Overview

• 3-year state-funded project

• Goals:
  • Sustain shellfish farming
  • Ecosystem-based management
WCSAS Overview

• 2 key challenges:
  • Shellfish farming and eelgrass interactions
  • Burrowing shrimp management
WCSAS Approach

Science advisors + Tribal partners + Shellfish growers

Resource managers

EBM Collaborative

West Coast AQ Hub

Working Group

Field Research

WSG
WCSAS Field Research

- Comparing habitat conditions
- Monitoring and assessment tools
- BMPs
(Revised) Working Group Process

Ongoing Activities
- Field research by science partners
- W/G communication between workshops
- Review of existing scientific knowledge

Workshop 1
South Bend, WA
Oct 28-29, 2019

Online Sessions
2, 3
Summer 2019-
Summer 2021

Workshop 4
Ilwaco, WA
Aug 31- Sept 1, 2021

Workshop 5
REMOTE
October 18-19

Ecosystem-Based Management Collaborative
Fall 2021 and Beyond

State of the Science & System
Outside Perspectives & Local Challenges
System-wide Understandings
Recommendations
Workshop 1

• 2 days, in-person

• State-of-the-science

• Priority information needs
Workshops 2 & 3

• EBM case studies
• Science/management
• Farming methods
• IPM
Workshop 4

• 2 days, hybrid
• Science synthesis
• Shrimp impacts
• Social-ecological system
Workshop 5

- Remote sessions
- Draft charter for EBM collaborative
- Recommendations
WCSAS Products

1. Science synthesis report
WCSAS Products

1. Science synthesis report
2. Online outreach materials
   • Aquaculture timeline  
   • Prioritized information needs  
WCSAS Products

1. Science synthesis report
2. Online outreach materials
   - Aquaculture timeline
   - Prioritized information needs
3. Recommendations
   - Draft EBM collaborative charter
Assessing Opportunities

Oregon Aquaculture Needs Assessment

Ongoing & Future Collaborations

West Coast AQ Hub

- industry integration
- marketing, consumer education
- workforce development
- emerging species

IFAS (Fisheries, Aquaculture, Seafood)

Special Project I: COVID Impacts

Special Project J: Young Fisherman Development Act

Regional Seaweed Symposium
THANK YOU!

Questions?

nanaar@uw.edu

Co-Principle Investigators

Russell Callender (WA Sea Grant)
Dave Hansen (OR Sea Grant)
Theresa Talley (CA Sea Grant)
Bobbi Hudson (PSI)
Daniel Cheney (PSI)
Brett Dumbauld (USDA-ARS)
Jennifer Ruesink (UW Biology)
Catalyzing a Cross-Pacific Regional Collaborative Hub to Advance Indigenous Aquaculture Practices and Enhance Marine Food Production for Cultural-Ecological Benefits-WASG

M. Poe, R. Alegado, J. Barber, C. Greiner, K. Hintzen, R. Callender, D. Lerner, G. Eckert
Catalyzing a Cross-Pacific Regional Collaborative Hub to Advance Indigenous Aquaculture Practices and Enhance Marine Food Production for Cultural-Ecological Benefits

November 2, 2021
Sea Grant Aquaculture Research Research Symposia

Presenters: Melissa Poe, Rosie Alegado, Brenda Asuncion, Lindsey Pierce, Joe Williams, Courtney Greiner, Jodie Toft, and Ginny Eckert
The Indigenous Aquaculture Collaborative

https://indigenousaquaculture.org/
We think of **Indigenous Aquaculture** as:

Cultivated biocultural ecosystems based on Indigenous knowledge and observations of land and water, developed over generations in reciprocal relationships with places. These cultural-ecosystems strengthen community access to customary foods and increase local seafood production.
Herring spawn on kelp ponds

Lummi Nation sxwole (reef net) fishing, source: NW Treaty Tribes

Intertidal management features in a Heiltsuk location, Mathews & Turner 2017

Clam garden, credit: Lepofsky

Shell Midden
Estuarine Root Garden
Intertidal Stone Fish Trap
Ka moʻolelo o Lehoʻula: the 1st fishpond

• **Kūʻula**: “supernatural” understanding of fish
  - Head fisherman during a time of famine
  - Built the 1st fishpond at the confluence of the stream and ocean
  - Enabled cultivation of fish all year round

• Fishponds: an innovation of necessity
Historical Perspective – Ahupuaʻa
Capstones of the ahupuaʻa: Loʻi kalo
Capstones of the ahupuaʻa: Loko iʻa
BIOCULTURAL RESTORATION

“The science* and practice of restoring not only ecosystems, but human and cultural relationships to place, so that cultures are strengthened and revitalized along with the lands to which they are inextricably linked.”

~ Center for Native Peoples and the Environment

(*from plural knowledge systems)
Key Features:

- Revitalization and restoration of ancestral mariculture and coastal stewardship
- Food systems and food sovereignty
- Cultural and spiritual connections to the land and ocean
- Intergenerational knowledge and ethics
- Self-determination in resource management
- Just pathways for climate adaptation
- Rooted in Indigenous knowledge, values, and practices
Loko I’a fish survey during 2020 Gathering in Oahu, credit: Lindsey Pierce

https://indigenousaquaculture.org/
The Indigenous Aquaculture Collaborative is currently made up of about 75 members (elders, knowledge holders, restoration practitioners, researchers, students, and outreach and communications folks)

Representatives from WA, BC, AK, Hawaii elsewhere in the Pacific basin

We are active in:
- sharing experiences
- learning from one another
- supporting community efforts
- engaging students
- participating in hands-on restoration
Central Council of the Tlingit and Haida Indian Tribes of Alaska, and the Alaska Delegation
Types of clams that SE AK tribes send into SEATOR

www.seator.org
Swinomish Clam Garden Project
Swinomish Clam Garden Project

Socio-ecological site selection process:
- Technical Advisory Board
- Spatial exclusion map
- Intertidal surveys
- Community intercept surveys
- Fish Commission and Tribal Senate approval
Swinomish Clam Garden Project

Addresses socio-cultural and ecological concerns

Ancient technology resilient to environmental change

Monitoring response to climate change impacts

Knowledge transferable to other communities
We design, test and spearhead in-water actions to restore Puget Sound’s marine habitats, species, and waters – for people and place.
Developing aquaculture techniques for basket cockles, *Clinocardium nuttallii*

1. Develop capacity within the Chew Center to accommodate additional production
2. Produce cockle seed for research and experimental outplants
3. Assess impacts of ocean acidification and elevated temperature
Developing aquaculture techniques for basket cockles, *Clinocardium nuttallii*

1. Develop capacity within the Chew Center to accommodate additional production
2. Produce cockle seed for research and experimental outplants
3. Assess impacts of ocean acidification and elevated temperature

**Measure of success**
A new take on restoration aquaculture?
Cockle reconveyance to meet multiple objectives
Next stop, Kelp
For more info, please see https://indigenousaquaculture.org or email Dr. Melissa Poe mpoe@uw.edu
Establishing the Sea Grant Striped Bass Aquaculture Hub (StriperHub): Commercialization, Economics, and Marketing-NCSG

B. Reading, R. Borski, D. Berlinsky, M. Ciaramella, M. Parker, F. Lopez, B. Nash, D. Cerino, E. Herbst, B. Snyder, S. White
“Farm Raised Domestic Striped Bass”

Benjamin J. Reading bjreadin@ncsu.edu

R. Borski, B. Nash, F. Lopez, E. Herbst, D. Cerino, D. Berlinsky, M. Ciaramella, M. Parker, B. Snyder, and S. White
Hybrid striped bass

**Daily Growth Rates & Harvest Sizes**

**Hybrid striped bass**: Rapid growth rate up until about 2 lbs/fish, then slows. Target harvest size = 1.5 to 2.0 lbs/fish

**Striped bass**: Slower growth rate up to 2 lbs/fish then accelerates. Target harvest size = 3.0 to 5.0 lbs/fish

Data from historical NC State PAFL production (over many years)
Hybrid striped bass: Superior FCR when small; FCR increases as fish reach (or exceed) typical market size. Harvest size = 1.5 to 2.0 lbs/fish (680 to 900 g)

Striped bass: Slightly higher FCR when small; FCR remains consistent throughout production. Harvest size = 3.0 to 5.0 lbs/fish (1360 to 2268 g)
The aim of the proposed work is to establish a Sea Grant hub for striped bass aquaculture (StriperHub) that will overcome barriers to industry development and expansion through demonstration and promotion of commercial-level culture, economics, and marketing of striped bass in the U.S. StriperHub is guided by a diverse community of interdisciplinary stakeholders coordinated by North Carolina Sea Grant.

Objective 1. Establish a Sea Grant Aquaculture Hub: A nexis to commercialize striped bass as a major aquaculture industry (The Sea Grant StriperHub);

Objective 2. Demonstrate seed stock production, distribution, growout, and production economics of domestic striped bass aquaculture;

Objective 3. Develop marketing strategies, market economics, permitting clarity, and business models for domestic striped bass aquaculture; and

Objective 4. Establish communication, outreach, extension, and training to support domestic striped bass aquaculture development.
Vote for the Best Logo
(Circle Choice)
8th Annual NC Catch Summit
Monday, March 2, 2020
Transfer Co. Food Hall - Raleigh, NC

200+ Person Event!
35th Annual NC Seafood Festival
Morehead City, NC

Ken Riley  Linnea Andersen  Frank Lopez
Russell Borski
Eric Herbst  Caroline Dominguez
Barry Nash
Benjamin Reading

100+ Person Event!
2021
Accomplishments and Future Directives: To Dos...

- Monthly Planning Meetings (Eric Herbst)
- Annual Workshops (2020 in person, 2021 virtual, 2022?)

North Carolina Aquaculture Development Conference

- StriperHub Seminar
  Aquaculture America 2023
- Striped Bass Culture Manual
  Planning session 2022
- Commercial Ventures
  In person, starting soon…
"The aim of the proposed work is to establish a Sea Grant hub for striped bass aquaculture (StriperHub) that will overcome barriers to industry development and expansion through demonstration and promotion of commercial-level culture, economics, and marketing of striped bass in the U.S. StriperHub is guided by a diverse community of interdisciplinary stakeholders coordinated by North Carolina Sea Grant."

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Objective 4. Establish communication, outreach, extension, and training to support domestic striped bass aquaculture development.
National Breeding Program for the US Hybrid Striped Bass Industry

Benjamin J. Reading
Fish reproduction and aquaculture
North Carolina State University
Department of Applied Ecology
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Michael S. Hopper
Superintendent
North Carolina State University
Pamlico Aquaculture Field Laboratory
mshopper@ncsu.edu

S. Adam Fuller
Geneticist
USDA-ARS
Harry K. Dupree SNARC
adam.fuller@ars.usda.gov

Striped Bass
7th Generation Domestic

White Bass
12th Generation Domestic

Hybrid Striped Bass
Come visit us in Aurora, NC April-May to see us spawning striped bass!
National Striped Bass Breeding Program
Pamlico Aquaculture Field Laboratory

160 females crossed with 3 year-old males

4 Year-old
Males to farmers for sunshine hybrid cross*

Year Class
(# Fish)
160*
320
450
750

Cull

Females
(thousands of fingerlings)
375
375
225
225
160
160

Males

140 striped bass families created in 2019
100 striped bass families created in 2020
108 striped bass families created in 2021

NRSP-8

USDA Agricultural Research Service
“Aquaculture breeders can tap a rich trove of genetic material; most fish and shellfish have seen little systematic genetic improvement for farming, compared with the selective breeding that chickens, cattle, and other domesticated animals have undergone.”
Domestic striped bass growth performance for different age classes and generations during the springs and early summers (March-June) of each year (2005-2020): Year 1 (45-60 weeks of age), Year 2 (80-104 weeks of age), Year 3 (136-154 weeks of age), and Year 4 (197-209 weeks of age). The filial generation of captive breeding is indicated for the periods of 2004-2007 (F3), 2008-2011 (F4), 2012-2015 (F5), and 2016-2019 (F6). The gray shading indicates the target striped bass market size at between 1.36 and 2.27 kg (3.0 and 5.0 lbs.).
National Striped Bass Breeding Program
Growth Gains Through Domestication

Size of Domestic Striped Bass at Age 1 Year
(February-April; 10-12 months old)

![Bar chart showing growth gains through domestication](chart.png)

Age 1 data for F7 fish were available in February 2021

F7 fish were 415 g (almost 25% larger than the F6 fish of previous years!)
Striped bass and white bass genomes are part of the Dovetail Genomics Tree of Life

Jason Abernathy

Linnea Andersen

Striped bass & white bass genomes
About 685 Mb
24 linkage group resolution
Volitional tank spawning of domestic striped bass (Morone saxatilis) using human chorionic gonadotropin (hCG) and gonadotropin releasing hormone analogue (GnRHa)- induced ‘pace-setting’ females


1 North Carolina State University, Department of Applied Ecology, Raleigh, NC, USA
2 North Carolina State University, Ponds Aquaculture Field Laboratory, Aurora, NC, USA
3 University of New Hampshire, Department of Natural Resources and the Environment, Durham, NH, USA
4 University of New Hampshire, Department of Agriculture, Nutrition and Food Systems, Durham, NH, USA

Methods of domestic striped bass (Morone saxatilis) spawning that do not require the use of any hormone induction


1 North Carolina State University, Department of Applied Ecology, 100 Eugene Brooks Avenue, Raleigh, North Carolina 27695, USA
2 North Carolina State University, Ponds Aquaculture Field Laboratory, 2062 Hickory Point Road, Aurora, North Carolina 27506, USA
3 University of Maryland, Center for Aquatic and Estuarine Sciences, 8705 Greenmount Avenue, College Park, MD 20742, USA
4 University of New Hampshire, Department of Natural Resources and the Environment, Durham, NH, USA
5 University of New Hampshire, M.S. Agriculture, Nutrition and Food Systems, Durham, NH, USA
MAGIC AT 64.4 DEGREES

Science, Serendipity, and Farmed Striped Bass

By Dave Shaw

Dr. Rhodes and his team have been working on developing a method to grow striped bass in 64.4-degree water. They have been using a system called the Striped Bass Aquaculture Unit (SBAU) to test their methods. The SBAU is a large, enclosed, water-containing structure that allows for controlled environmental conditions. The researchers have been able to grow striped bass in 64.4-degree water by using a combination of different techniques, including the use of a cooling system and the addition of specific nutrients to the water. The goal is to be able to grow striped bass in areas where the water temperature is cooler than 68 degrees, which is the current limit for striped bass growth. The researchers believe that this technology could have significant implications for the fishing industry, as it could allow for the production of striped bass in areas where they could not be grown before. This would help to increase the supply of striped bass, which are a popular sport and food fish.
Group spawning

Harvest large quantities (20 to 30 L) of eggs at a time

Limited handling of broodstock and hormone use

Consistent production with good fertility (30-50% of eggs producing larvae or fry)

Commercially scalable and less labor intensive compared to strip spawning

20 million eggs at capacity

5.0 million fry at capacity
Advancing Fish Larviculture: Innovations in Production, Feeds and Feeding Systems

1) Technical improvements in swim bladder inflation and deformities
2) Developing microdiets to replace *Artemia*
3) Evaluating feeding behavior/ feed acceptance among commercial microdiets
4) Evaluating larval rearing success using commercial probiotics/prebiotics
5) Examining GI physiological changes
6) Evaluating microbiome / bacterial colonization
7) Developing automated *Artemia* and microdiet feeding systems

**FUTURE:** Commercial Scaling...

*Mike Frinsko – NC Extension*
Ben Reading – NC State
Steve Hall – NC State
Kim Livingston – ELANCO/CVM
Michael Joseph – NC State
Lou D’Abramo – UAB

Scoliosis deformities
Demonstrate production of market-sized Striped Bass (3-5 lb fish) in different aquaculture systems

- Freshwater Recirculating Aquaculture Systems – RAS (< 5.0 ppt)
- Flow-through Aquaculture System (fresh water)
- Seawater RAS simulated cage-culture (David Berlinsky, UNH)
- Pond – RAS/Flow-through combined (fresh water)
Growth curve for domestic striped bass in RAS at NCSU fed daily and on alternate days

Fish fed 5 days per week grew to a larger size overall and FCR was marginally better by 2.7% (FCR 1.485 versus 1.525), however the FCR changes as the fish age...

Juvenile fish require more frequent feedings, however less frequent feedings may improve feed conversion efficiency (FCR) in larger fish and reduce labor costs on farms.

Striped bass were fed 3 or 5 days per week and weighed every 2 months for 1 year.

Salger et al. unpublished
Grow Out in RAS at Grinnells (< 5 ppt salinity) 2019–2021

- **FCR = 2.35**
  - 3.72 g / fish
- **FCR = 3.44**
  - 0.47 lbs/gal
  - Market size
  - 72 fish
  - 530 gallon tanks x 6
- **FCR = 1.93**
  - 0.74 lbs/gal
  - Split fish, Alternate Day Feeding
  - 200 fish
  - 530 gallon tanks x 3

- **Time (Age of Fish)**
  - 6
  - 180
  - Nov '19
  - 22
  - 660
  - Sept '21
  - 28
  - 840
  - Months Days

- Borski
Grow Out in Flow-Through at PAFL (< 5 ppt salinity) 2018–2021 (Multiple Replicate Growout Tanks)

Average Weight (lbs)

FCR 1.63

FCR 1.85

FCR 2.36

0.2 lbs/gal

500 fish

10,153 gallons

Time (Age of Fish)

1 30 May

6 180 Nov

12 365 May

18 540 Nov

24 730 May

30 900 Nov

36 1095 May

Months

Days

Striper Hub
AQUACULTURE FIRM TO GROW STRIPED BASS IN OFFSHORE CAGES

MARCH 22, 2018

Taking the Plunge into a New Way of Farming: A Fish Farm Grows Off the East End of Long Island

Considerations

1. What are the populations (strains) of striped bass migrating in the northeast area?

2. What are growth rates of striped bass in offshore net pens in the northeast?

Donna Lanzetta

Berlinsky

Kenter

University of New Hampshire
Simulated Net Pen Growout at UNH (marine salinity ambient temperature and photoperiod) 2020–2021

Native migratory strains

2-year growth trials
- Nursery phase (~1yr)
- Net pen phase (~1yr)

Final weight ~1200 g (2.5 lbs)

Nursery 20-21 °C
Net Pen 5-22 °C
StriperHub Striped Bass Foodfish Distributions by Funding Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Striped Bass Distributions</th>
<th>Fry/Larvae #</th>
<th>Fingerlings #</th>
<th>Foodfish lbs.</th>
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<tr>
<td>2019</td>
<td>university</td>
<td>3,000,000</td>
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<td>TOTAL</td>
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<td>10,750,000</td>
<td>573,800</td>
<td>48,335</td>
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</table>

**Project Proposal**

“millions” | 100,000 | 140,000

*25,000 lbs produced in ponds by commercial cooperators*
Cut isthmus and bleed out in ice slurry
### Locations (78 total) of cultured striped bass marketed and distributed in NC

<table>
<thead>
<tr>
<th>Apex</th>
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<th>Raleigh (continued)</th>
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<tr>
<td>The Provincial</td>
<td>JuJu</td>
<td>Whole Foods Markets (2 locations)</td>
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<td>Littler</td>
<td>18 Seaboard</td>
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<td>Weaver Street Market</td>
<td>Lucky's Deli</td>
<td>42nd Street Oyster Bar</td>
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<tr>
<td>Glasshalfail</td>
<td>Luna Rotisserie</td>
<td>Beasley's Chicken + Honey</td>
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<td>Oakleaf</td>
<td>Piedmont</td>
<td>Bella Monica</td>
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<td>Cary</td>
<td>Pizzeria Toro</td>
<td>Bida Manda</td>
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<td>Brewery Bhavana</td>
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<td>Maximillians</td>
<td>Refectory</td>
<td>Death &amp; Taxes*</td>
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<td>Rose's Meat Market</td>
<td>Garland</td>
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<td>Verandah at Mayton Inn</td>
<td>Saltbox</td>
<td>Hummingbird</td>
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<td>Chapel Hill</td>
<td>Saltbox Rockwood</td>
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<td>Chapel Hill Farmer's Market</td>
<td>St. James Seafood</td>
<td>Mandolin</td>
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<td>The Lakewood</td>
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<td>Al's Burger</td>
<td>The Pit</td>
<td>Poole's*</td>
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<td>Lantern</td>
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<tr>
<td>Buldega</td>
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<td>The Pit</td>
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<td>Durham Co-Op</td>
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<td>Vinnie's Steakhouse</td>
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<td>Copa</td>
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<td>Dashi</td>
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<td>Left Bank Butchery</td>
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<td>Morrisville</td>
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<td>Oxford</td>
<td>Farm to Home Market</td>
<td>State Farmers Market</td>
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<td></td>
<td></td>
<td>Transfer Co. Food Hall</td>
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<td></td>
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<td>Weaver Street Market</td>
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<td></td>
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<td>Coastal Provisions</td>
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</table>
Production Economics

We are developing enterprise budgets for farming striped bass.

**Pond Culture:** *Pond culture budget analysis is underway.* Designing a production plan for cash flow each year the farm is in operation based on a feeding program compiled for striped bass from the NC State PAFL. Split stocking strategy where half of the ponds are stocked in year 1 and then the other half stocked the following year. This would give an annual crop rotation for yearly cash flow.

Once the enterprise budget is complete, we will use data from growers for inputs and complete a Monte Carlo Analysis to determine the probability of a successful operation at different production scales and break-even pricing. We are looking to obtain information from growers.

**Recirculating Aquaculture Systems (RAS):**
The system at NC State University Grinnellls will be used as a baseline.
“The aim of the proposed work is to establish a Sea Grant hub for striped bass aquaculture (StriperHub) that will overcome barriers to industry development and expansion through demonstration and promotion of commercial-level culture, economics, and marketing of striped bass in the U.S. StriperHub is guided by a diverse community of interdisciplinary stakeholders coordinated by North Carolina Sea Grant.”

Objective 1. Establish a Sea Grant Aquaculture Hub: A nexis to commercialize striped bass as a major aquaculture industry (The Sea Grant StriperHub);

Objective 2. Demonstrate seed stock production, distribution, growout, and production economics of domestic striped bass aquaculture;

Objective 3. Develop marketing strategies, market economics, permitting clarity, and business models for domestic striped bass aquaculture; and

Objective 4. Establish communication, outreach, extension, and training to support domestic striped bass aquaculture development.
Eat North Carolina Striped Bass!

“Wolfpack” Striper: Farm Raised striped bass at the Raleigh Farmers Market. Fillet skin-on Price: $16.00/lb (2015), $18.00/lb (current). Whole: $8.00-$10.00/lb (current).
35TH ANNUAL NC SEAFOOD FESTIVAL

COOKING WITH THE CHEFS

Saturday, October 2, 2021
10:00 am - 5:30 pm
Sunday, October 3, 2021
11:00 am - 4:00 pm
In the Chefs Tent at Katherine Davis Park

35TH ANNUAL NC SEAFOOD FESTIVAL

COOKING WITH THE CHEFS

Saturday, October 2, 2021
10:00: Benight's Lone Cedar Cafe - Sauteed Shrimp and Stone Ground Grits
11:00: Chef Clarke Merrill - Smoked Wahoo Salad
12:00: Chef Ana Sheline - Wonder Sustainable North Carolina Mussels
1:00: Chef Caroline Dominguez* - Seared Garlic-Basil Butter Striped Bass
2:00: Chef Dawn Freeman - Blackboard's Blackened Snapper with Tropical Fruit Slaw
3:30: Chefs Marshall Beatty and Jimmy Neale - Outer Banks Scallops
4:30: Chef Jeremiah Tryon - Pan Seared Flounder Tacos

Sunday, October 3, 2021
11:00: PBS North Carolina presents The Key Ingredient with Shelly Castle - Oyster Stew with Toasted Sesame Seeds
12:00: Chef Chad Blackwood - Seafare Charcuterie with Spiced Trout
1:00: Chef Keith Rhodes - Crab Cakes
2:00: Chef Caroline Dominguez* - Seared Garlic-Basil Butter Striped Bass
3:00: Chef Dawn Freeman - Ole' Salt Shrimp, Crab, and Corn Chowder

**Special event: NC Sea Grant will host a taste test and survey following the cooking demonstration.

In the Chefs Tent at Katherine Davis Park

Chef Caroline Dominguez
Sensory Evaluation: Farm Raised Domestic Striped Bass (2021)

<table>
<thead>
<tr>
<th>NC Agrotourism Networking Association (baked)</th>
<th>NC Seafood Festival Day 1 (sauteed)</th>
<th>NC Seafood Festival Day 2 (sauteed)</th>
</tr>
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<tbody>
<tr>
<td>N = 39 Persons</td>
<td>N = 46 Persons</td>
<td>N = 33 Persons</td>
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<tr>
<td>Flavor: 5.64</td>
<td>Flavor: 6.17</td>
<td>Flavor: 6.15</td>
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<tr>
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<tr>
<td>Aroma: 5.64</td>
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<tr>
<td>Appearance: 5.54</td>
<td>Appearance: 6.59</td>
<td>Appearance: 6.55</td>
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Scale: 1 unacceptable, 2 very poor, 3 poor, 4 fair, 5 good, 6 very good, 7 excellent

Striped Bass Similarity (votes):

<table>
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<tr>
<th>Fish</th>
<th>Sea bass</th>
<th>Cod</th>
<th>Grouper</th>
<th>Snapper</th>
<th>Haddock</th>
<th>Flounder</th>
<th>Triggerfish</th>
<th>Tilefish</th>
<th>Hogfish</th>
<th>Largemouth Bass</th>
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<tbody>
<tr>
<td>Sea bass</td>
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<td>Largemouth Bass</td>
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</table>

= Total Votes
Striped bass recipes

Seafood Specialist
Barry Nash

Joyce Taylor

Vanda Lewis
Baked Striped Bass with Garlic-Basil Butter

1 1/2 pounds striped bass fillets, skinless, cut into serving-size pieces
2 tablespoons butter, melted
salt
black pepper, freshly ground

Garlic-Basil Butter
1/2 cup butter or margarine, softened
1 teaspoon garlic, pressed
1 teaspoon fresh basil, finely chopped
1 teaspoon fresh lemon juice
1/4 teaspoon salt

Prepare Garlic-Basil Butter and set aside. Preheat the oven to 350° F.

Place fish on a parchment-lined baking sheet. Brush with butter. Sprinkle lightly with salt and pepper.

Bake for 15-20 minutes, until fish flakes easily with a fork. Serve with Garlic-Basil Butter.

In a small bowl, combine butter, garlic, basil, lemon juice and salt. Spread over warm fish.

Recipe contributed by Joyce Taylor (6/10/2021).
Sautéed Striped Bass with Garlic-Basil Butter

1 ½ pounds striped bass fillets, skinless, cut into serving-size pieces
1 tablespoon butter, melted
1 tablespoon oil
salt
black pepper, freshly ground

Garlic-Basil Butter
½ cup butter or margarine, softened
1 teaspoon garlic, pressed
1 teaspoon fresh basil, finely chopped
1 teaspoon fresh lemon juice
¼ teaspoon salt

Prepare Garlic-Basil Butter and set aside.

Pat fish dry with paper towels. Season with salt and pepper.

In a large nonstick skillet, melt the butter with oil over medium-high heat.

Place the fish in the skillet and cook about 6 minutes. Gently turn the fish over and cook about 1-2 minutes longer or until done. Serve with Garlic-Basil Butter.

Recipe contributed by Joyce Taylor (6/10/2021).
Ginger-Crusted Bass Over Vinegar Rice

https://homegrown.extension.ncsu.edu/2020/12/ginger-crusted-bass-over-vinegar-rice/
**Farm Raised Domestic Striped Bass Recipe Development**

<table>
<thead>
<tr>
<th>Recipes Developed</th>
<th>Hot Eats</th>
<th>Cool Science</th>
<th>NC Sea Grant</th>
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<td>2020</td>
<td>1 (video)</td>
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<tr>
<td>2021</td>
<td>0</td>
<td>9</td>
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<td><strong>TOTAL</strong></td>
<td><strong>7</strong></td>
<td><strong>12</strong></td>
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</table>

Vivian Howard Deep Run, NC

Ashley Christensen Raleigh, NC

2019 James Beard “Outstanding Chef”
Commercial sales of striped bass PROHIBITED
New Jersey, New Hampshire

Possession or commercial retail of striped bass requires special permitting/procedures
Maine, Massachusetts, Rhode Island, Connecticut, New York, Delaware, Pennsylvania, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida

Aquaculture operational permitting
Inshore states

National Sea Grant Law Center helped finalize *Striped Bass Regulations of Atlantic States*

- Regulatory provisions for Atlantic striped bass in each state
- Identifying Atlantic striped bass culture or production regulations in each state *(excluding hybrid striped bass)*

**Virginia**

- A permit is required for a striped bass aquaculture facility, which will authorize the purchase, possession, sale, giving, receiving, and transportation of striped bass or hybrid striped bass.
- Striped bass or hybrid striped bass fingerlings, fry, or eggs, may be obtained only from state permitted fish dealers and must be certified by the seller as having a disease-free status.
- All striped bass or hybrid striped bass except fingerlings, fry, and eggs from an aquaculture facility must be packaged with a printed label with the name, address, and permit number of the facility.
- Labeled, aquacultured bass may be transported and sold at retail or at wholesale for commercial distribution *(receipts required).* Striped bass or hybrid striped bass which are the product of an approved and state permitted aquaculture facility in another state may be imported into Virginia for the consumer market. 4 Va. Admin. Code 20-252-170 through 4 Va. Admin. Code 20-252-230.

Examples of striped bass with dealer (sales) tags for North Carolina. From Locals Seafood (Raleigh, NC; http://localsseafood.com/).
# Striped Bass Commercial Fishing: Availability in Seafood Markets and Gear Types

## Optimal Marketing Opportunity

**For Cultured Fish**

---

### Peak Availability

### Scarce

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</table>

- gn = gill net
- hl = hook and line
- ft = floating trap
- pn = pound net
- hs = haul seine
- mg = miscellaneous gear (including Fyke net, trot line, haul seine, and fish pot)
- * = or until quota is fulfilled.
"The aim of the proposed work is to establish a Sea Grant hub for striped bass aquaculture (StriperHub) that will overcome barriers to industry development and expansion through demonstration and promotion of commercial-level culture, economics, and marketing of striped bass in the U.S. StriperHub is guided by a diverse community of interdisciplinary stakeholders coordinated by North Carolina Sea Grant."

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A Fishy Business
NC State’s aquaculture program raises fish for local restaurants.

By Laura Buchanan

Not all fish come from the ocean. For Raleigh local chef and N.C. State University biology professor, Lin Peterson, the fish he uses are grown in tanks at NC State’s Fish Farm and Aquaculture Research Laboratory in Avon, NC. Aquaculture is a growing industry in North Carolina, one of the fastest growing regions of aquaculture in the state, and it helps take pressure off the wild stock in our oceans while providing more consistent and reliable fish. This is tough beneficial to people like Lin Peterson, the co-founder of Locals Food Co. and an alumni of N.C. State’s Agriculture, Wildlife and Conservation Biology program. Peterson says NC State’s fish are raised at market size and then sold directly to local restaurants, including Locals Oyster Bar. “They are fish that we actually have control over,” Peterson says.

The ideal site for the fish is achieved through selective breeding, Peterson explains. “Genetic modification of hybrid fish can lead to desirable traits like resistance to certain diseases or increased growth.”

Additionally, the fish are fed a nutritionally balanced diet. The diets are designed to promote healthy growth while minimizing environmental impact.

The fish are also quality controlled. “We have a quality assurance team that checks the fish for any abnormalities or disease,” Peterson says.

For Peterson, the ability to control the growth and quality of the fish is a significant advantage. “We are able to grow fish that are exactly what we want, and that makes a big difference in the final product,” Peterson says.

The fish are also sustainably raised. “We use sustainable practices to grow the fish and ensure that the fish are healthy and of high quality,” Peterson says.

Locals Oyster Bar is one of the restaurants that has adopted the program. “We believe in supporting local farmers and producers, and this is a great way to do that,” Peterson says.

Lin Peterson
Chef and Co-owner of Locals Oyster Bar

Bust the Oyster Myth

From a chef’s perspective on oysters, Lin Peterson suggests that the myths surrounding oysters are not true. Peterson believes that oysters are a healthy and delicious food source.

“Oysters are a great source of protein and minerals,” Peterson says. “They are also low in calories and fat.”

Peterson suggests that oysters can be enjoyed all year round and are a great source of nutrition. “Oysters are also great for the immune system,” Peterson says.

Locals Oyster Bar in Raleigh offers a variety of oysters throughout the year, including local and imported oysters.

Lin Peterson
Chef and Co-owner of Locals Oyster Bar

December 2019

Lin Peterson
Chef and Co-owner of Locals Oyster Bar

Ryan Speckman
Photographer
HOT EATS
COOL SCIENCE
(a delicious think tank)

Build the future of collaborative fundraising with your taste buds! Bring your banner, opinions, and appetite to our pilot event—Hot Eats, Cool Science. We’ll supply the gourmet meals, entertainment, and research behind the recipe in exchange for your feedback.

NOVEMBER 19TH | 6–9PM
DINAH E. GORE TEACHING & RESEARCH KITCHENS | 512 BRICKHAVEN DR

Kindly RSVP by September 30th
Contact: @@@msu.edu | 019-515-@@@@

Carolyn Dunn
Department Head
Agricultural & Human Sciences

Derek Aday
Department Head
Applied Ecology

Ben Chapman
Professor
Agricultural & Human Sciences
HOT EATS
COOL SCIENCE

is a collaborative dinner hosted by

Department of Agriculture & Human Sciences
https://cais.ncsu.edu/agricultural-and-human-sciences/

Department of Applied Ecology
https://cais.ncsu.edu/applied-ecology

Join our next evening of decadent striped bass dishes expertly paired with wines and science, at the Dinah E. Gore Teaching & Research Kitchen!

Contact: Michelle Jewell
majewell@ncsu.edu | 919-515-3766

NC STATE UNIVERSITY
Thai Bass Cakes

Ingredients
16 oz. striped bass fillet, bones & skin removed
1 Thai chili
1 shallot, peeled
4 inch piece of ginger, peeled
2 inch piece of galangal, peeled
5 kaffir lime leaves
2 lemongrass stalks, bottom 4 inches only
1 tsp. salt
2 tsp. fish sauce
1/2 cup Chinese long beans, sliced into paper-thin rounds
Non-stick cooking spray

Directions
2. Add fish to the food processor bowl and process to form a coarse paste.
3. Combine the spice paste, fish paste, fish sauce, and sliced Chinese long beans in a medium bowl. Stir until well combined, mixture will be slightly sticky.
4. Shape into 12 round, flat cakes.
5. Refrigerate until ready to cook.
6. Heat a large non-stick pan over medium heat. Spray with non-stick cooking spray. Sear cakes until golden brown, turn, and continue cooking until the internal temperature is 145-150°F.
Hot Eats | Cool Science 2020

NC State University College of Agriculture and Life Sciences

2 Events in 2019, 1 Event in 2020

Over 300 attendees tried Thai Striped Bass Fish Cakes with Kimchi and heard about striped bass aquaculture!
Shuck, Rattle, & Roll is an annual event showcasing seafood harvested and served by current and former Carteret CC Aquaculture students.
Striped Bass Dissection and Q&A in 2021!

https://www.youtube.com/watch?v=S85lwUOyzbE

This is a recording of striped bass dissection that was first streamed on February 16th, 2021. Hosted by Ph.D. candidate, Linnea Andersen, Prof. Ben Reading, and Michelle Jewell of NC State's Department of Applied Ecology. Follow the StriperHub & Striped Bass Genome Project with 780 others on Facebook: https://www.facebook.com/stripedbassgenome
Aquaculture is fast becoming a big agriculture product in North Carolina. We talk with Michael Frinkso of N.C. Cooperative Extension and Pete Anderson of the N.C. Department of Agriculture & Consumer Services about this growing sector.
“Fish Farms”, a WRAL Documentary, explores one of North Carolina's best-kept secrets: Aquaculture, or the farming of fish and seafood, is a thriving industry that brings over $60 million in revenue to the state each year. Broadcast July 2021.
Pure-strain striped bass: An opportunity waiting to be tapped

October 13, 2021
By Liza Mayer

“The market opportunity for striped bass exists, is strong and largely untapped — and it is for the taking.”
## StriperHub: Milestones / Timeline

![StriperHub Logo](image)

**Project Funding Began February 2020**  
**“Pandemic Closures”**

<table>
<thead>
<tr>
<th>Project Activities</th>
<th>A priori</th>
<th>Year 1:2019-2020</th>
<th>Year 2:2020-2021</th>
<th>Year 3: 2021-2022</th>
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<td>Sep-Nov Dec-Feb</td>
<td>Mar-May Jan-Aug</td>
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<td><strong>Objective 1</strong></td>
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<tr>
<td><strong>Final Reports</strong></td>
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*No Cost Extension:*  
- Symposium (WASA)  
- Culture Manual  
- Economics  
- Business Model  
- Finish Growout Trials

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*AMENDMENT*
- Continue chef survey distributions with striped bass foodfish (NC State University, NC Sea Grant, and University of New Hampshire)

- Distribute 25,000 lbs of striped bass foodfish to markets and distribute fry and fingerlings to producers for growout (NC State University)

- Complete striped bass growth trials (NC State University and University of New Hampshire)

- Carteret Community College continue to raise striped bass for *Shuck Rattle and Roll* (2022) and student training

- Continue analysis of striped bass production cycle and culture economics (University of Maryland and NC State University)

- White bass genome assembly annotation and release for public use (NC State University and USDA ARS)

- Monthly *StriperHub* planning meetings, online resources, and annual workshop to define and outline writing objectives for the revised striped bass culture manual (NC Sea Grant)

- Re-initiate outreach events, sensory panel analysis, and videography (All)
Feed the Future...
Maine Aquaculture Hub: Building capacity for industry-driven innovation, diversification, and workforce development-MESG

G. Zydelwski, H. Sadusky, D. Bouchard, S. Belle, H. Cowperthwaite, C. Davis
MAINE AQUACULTURE HUB

Building capacity for industry-driven innovation, diversification, and workforce development
AQUACULTURE IN MAINE

- Gulf of Maine is highly productive yet quickly changing
  - Coastal development pressures, climate change, decline in wild harvests
- Aquaculture is a growing industry in the state:
  - Salmon, oysters, mussels, seaweed, scallops
- Supports coastal communities, contributes to state’s economy, new area for job growth, maintains working waterfronts, produces healthy sustainable domestic seafood
- Valued at $88.4 million in 2019, $71.75 million in 2018
  - Economic impact study currently underway
FOUNDING THE HUB

• AQSW training program
  • Recipient of two NSI grants
  • Awarded 2019-2020 Sea Grant Extension Assembly Superior Outreach Programming Award
• Partners convened to identify barriers to the industry and activities to address them
• Starting point for the proposal for the Maine Aquaculture Hub
The Maine Aquaculture Hub is a network for strengthening aquaculture in Maine, connecting organizations and individuals across the state.

It was formed to help the aquaculture industry in Maine overcome barriers to growth.

The Maine Aquaculture Hub is supported by six organizations that make up the Steering Committee.
3 PRIMARY ACTIVITIES

- Expand AQuaculture in Shared Waters training program
- Responsive call for proposals to fund industry-led projects
- Develop 10-year Roadmap for aquaculture in Maine
• Since 2013, Aquaculture in Shared Waters has
provided training, technical support, and networking
opportunities to over 300 individuals.
  • >30 new aquaculture businesses established
  • >100 jobs established, expanded, or retained as program
    participants began working in the aquaculture field,
    added new species to their existing businesses, or
    expanded their harvest seasons (not including newest
    class)

• 2020 students: 33 Brunswick, 19 Belfast
• 2021 students (so far): 36 (virtual)
AQSW 2.0

• 2021 pilot
  • Followed format of original course
  • 29 students; held virtually March-May
• 2021-22 Winter Workshop offering
  • Four workshops in total
  • 3-night series taking place during one week
  • Targets existing sea farmers
  • Features numerous guest speakers
  • In person! With remote option
MAINE AQUACULTURE ECONOMIC ROADMAP

Goal: develop a shared vision for the future of aquaculture in the state; plan for the next 10 years; building off of 2010 Aquaculture Economic Development Plan

• Approach:
  • 10 Focus Group meetings with variety of stakeholders
  • Which goals from 2010 plan still relevant? New goals?
  • Specific action items needed to achieve goals, and identification of organizations that could work toward these
  • 1-on-1 calls to those who could not attend focus group

• In total, 140 individuals and 92 organizations provided input to the Roadmap

• Coming end of 2021!
2020: Building capacity for industry-driven innovation, diversification, and workforce development
   • 5 projects awarded funds, from Saco to Eastport
2021: Strengthening the sector through research, community engagement, and addressing farm challenges
   • Areas of Focus developed from needs/action items identified in the Roadmap
   • Steering Committee making recommendations to NSGO
   • Possible third call for proposals
"Mussel farming trials in Downeast Maine: testing new opportunities to expand Maine’s mussel aquaculture industry"
“Testing the efficiency of a net washing machine for intermediate culture of the Atlantic sea scallop”
“Ocean Smart Farm: Mechanizing Biofouling Control in Oyster Farming”
“Reducing the Cost of Biotoxin Testing in Scallop Aquaculture”
“Atlantic Sea Farms: Kelp Blancher” – retrofitting a vegetable blancher for seaweed
Social scientists at UMaine have been evaluating the Maine Aquaculture Hub throughout its life.

Now working to identify strategy, future directions:
- What is the Hub’s competitive advantage, its mission, its strengths;
- Where to best operate in the aquaculture landscape moving forward?
- What is the funding mechanism?
Potential Strategies

“Aquaculture Academy Collective”
Building on the longstanding AQSW program, this model builds content, courses, coaching, and standards as needed to strengthen the aquaculture sector across the state.

“Aquaculture Market & Brand Maker”
Brings together producers, tourism and hospitality sector, the greater food system and seafood industry to build a community that includes aquaculture and tells its story.
Thank you!

Questions?

heather.sadusky@maine.edu
Great Lakes Sea Grant Aquaculture Collaborative-MNSG

Aquaculture systems in the Midwest region

*Data from the 2018 Aquaculture census*
trout 26%
tilapia 23%
bass 13%
yellow perch 8%
salmon 5%
catfish, sunfish, bass, walleye, shrimp, misc.

Species raised in the Midwest region (308 farms)

*Data from the 2018 Aquaculture Census
## Aquaculture vs Recreational Fishery Value

<table>
<thead>
<tr>
<th>State</th>
<th>Total Aquaculture *</th>
<th>Food-fish Aquaculture *</th>
<th>Recreational Fishery **</th>
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<td>MI</td>
<td>$1.53 Million</td>
<td>$1.18 Million</td>
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<td>MN</td>
<td>$5.62 Million</td>
<td>$1.72 Million</td>
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<td>WI</td>
<td>$5.30 Million</td>
<td>$2.41 Million</td>
<td>$1.4 Billion</td>
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</table>

*2012 Aquaculture Census

**2011 National Survey of Fishing, Hunting, and Wildlife related Activities, USFWS
Goal: provide science-based information and activities that support an environmentally responsible, competitive, and sustainable aquaculture industry in the Great Lakes region.
GLAC phases

Phase 1:
State Sea Grant Program and Industry Focus

Phase 2:
Research/Academic Focus
GLAC Phase 1 - Sea Grant Program/Industry Focus

1. Establish GLAC within a formal structure
2. Develop and convene advisory groups
3. Develop process for annual event and webinar series idea
4. Develop GLAC website
5. Host webinar series (2-3 webinars per year) and annual aquaculture events (1 per year) to share and disseminate information
GLAC Organizational Structure

Regional aquaculture leadership

Regional advisory group

Representatives from each state advisory group

State advisory groups (AGs)

State leadership

Regional aquaculture leadership

State advisory groups (AGs)

State leadership

Minneapolis Sea Grant

IL-IN Sea Grant

MI Sea Grant

NY Sea Grant

OH Sea Grant

PA Sea Grant

WI Sea Grant

IL AG

IN AG

MI AG

NY AG

MN AG

OH AG

PA AG

WI AG
GLAC website:
https://greatlakesseagrant.com/aquaculture/
Webinars

AQUACULTURE CAN BE SUCCESSFUL, BUT...
OCTOBER 27, 2020
11:00 AM - NOON ET
Carole R. Engle, PhD | Engle-Stone Aquatic$ LLC

Fish to Fork: Cooking Great Lakes Fish
with Titus Seilheimer (Wisconsin Sea Grant) and Peter Fritsch (Rushing Waters Fisheries)
4/28/2021

Fish health on the farm
Sept. 22nd 2021
4pm ET/3pm CT
Lisa D. Tossey
Assistant Director for Communications and Outreach, Maryland Sea Grant
Events: Great Lakes Aquaculture Day 2020 and 2021
GLAC Research

1. What are consumers willing to pay for Great Lakes aquaculture products?

   Richard Melstrom (Loyola), Kerri Smetana (Loyola), Jillian Hyink (Loyola), Eric Abaidoo (MSU), Trey Malone (MSU)

https://conservationfilmfest.org/what-is-land-based-fish-farming/

Little to no GL data!
But other studies suggest consumers
1. will pay a premium for locally produced fish
2. are concerned with quality, freshness, food safety, animal welfare and will pay more for this
3. prefer fresh over frozen
GLAC Research

1. What are consumers willing to pay for Great Lakes aquaculture products?

   Richard Melstrom (Loyola), Kerri Smetana (Loyola), Jillian Hyink (Loyola), Eric Abaidoo (MSU), Trey Malone (MSU)

Qualitative and quantitative meta-analysis based on lit review of WTP studies:

- 136 studies
  - Database search for relevant studies
- 44 studies
  - Pass title and abstract check
- 32 studies
  - Final group of papers
1. What are consumers willing to pay for Great Lakes aquaculture products?

   Richard Melstrom (Loyola), Kerri Smetana (Loyola), Jillian Hyink (Loyola), Eric Abaidoo (MSU), Trey Malone (MSU)

Conduct discrete choice experiment measuring WTP for several product types:

   Whitefish vs trout vs salmon
   Fresh vs Frozen
   Farmed in state vs U.S. vs import
2. What policy challenges and opportunities exist?

Trey Malone (MSU), Aaron Staples (MSU), Richard Melstrom (Loyola), Stuart Carlton (Purdue)

Regulations at top of self-reported challenges

Content analysis of CFR partially validates this concern

- Cattle Ranching and Farming
- Hog and Pig Farming
- Poultry and Egg Production
- Sheep and Goat Farming
2. What **policy challenges and opportunities** exist?
   Richard Melstrom (Loyola), Stuart Carlton (Purdue),
   Trey Malone (MSU)

   Pricing is challenging

   Producers generally sell on farm and in restaurants
3. What are farmer attitudes towards business expansion?

Stuart Carlton, Haley Hartenstine (Purdue)
3. What are farmer attitudes towards business expansion?

Out of 30 interviews, 23 farmers were trying to expand production.

Producers are generally optimistic about business expansion.
GLAC Research


• Special issue in *Choices*:
  • Titus S. Seilheimer, Emma Wiermaa, and Lauren N. Jescovitch. Fisheries, Hatcheries, and Aquaculture—What’s the Difference?


• Four graduate researchers (Staples, Smetana, Abaidoo, Hartenstine)
• Three UG researchers (Jillian Hyink, Joanna Szremeta, Jessie Marshall)
Other outcomes from GLAC

Connect fish producers directly with consumers

freshfishfinder.org
Other outcomes from GLAC

• GLAD 2020: WAS publication

• GLAD 2020: 2 films were presented

• Survey advisory groups about potential regulatory barriers

• Compare USDA census data to direct producer contact across the region
Other outcomes from GLAC

• Hosted an aquaculture symposium at the Midwest Fish and Wildlife Conference
• Sponsoring a fish health workshop at the WIAA/MNAA joint conference

• North Central Regional Aquaculture Center (NCRAC)
• NOAA/NSG
Continue to develop from GLAC 1.0:

1. Advisory groups

2. Improve GLAC web presence

3. Maintain/expand GLAC community of practice
   - NCRAC
   - AFS Fish Culture section
   - Others
GLAC 2.0: new ideas

1. Focus on building networks:
   • Support producer focused sessions at state aquaculture conferences

2. Focus on workforce development
   • Potential to create an apprenticeship program

3. Develop synergy between wild-caught fisheries and aquaculture
   • Processing, distribution, etc.

4. Research: Consumer and network focus
From GLAC advisory group members:

• “Love this group!”

• “I truly appreciate the good work Sea Grant is doing! I see it of vital importance.”

• “I value what you are doing.”

GLAC events:

• “Thanks so much for bringing this symposium to us, the industry needs more of these.”

• “This was so incredibly well put together. I learned so much and I appreciated all the panels.”
Building capacity of land-based Atlantic salmon aquaculture in the US-MDSG

Recirculating Aquaculture Salmon Network (RAS-N)
Building Capacity of Atlantic Salmon Production in the U.S.

Yonathan Zohar and Catherine Frederick
University of Maryland and
Institute of Marine and Environmental Technology (IMET)
and many others...
Recirculating Aquaculture Salmon Network (RAS-N)

Background

- >90% of salmon consumed in the US (~500,000 tons) come from overseas, at a value of ~$3.2 B (20% of seafood trade deficit)
- >$ 3 billion investment in land-based Atlantic salmon production in the US
- Covid accelerated interest in local, safe, land-based production
- Maine, Florida, Virginia, Wisconsin, Indiana, Ohio, Texas, New-York, Washington, California, Maryland, Nevada
Projected Land Based Salmon Production

Global Proposed Volume, MT

USA Production Trend, MT
Overall Goal of RAS-N

- Establish a national, public-private holistic and collaborative hub of knowledge

- Build capacity for the land-based Atlantic salmon sector towards successful
  - Growth
  - Stability
  - Environmental compatibility
  - Economic feasibility
Recirculating Aquaculture Salmon Network (RAS-N)

Specific Objectives

1. Engage stakeholders, solicit input
2. Identify gaps and barriers, prioritize R&D and other areas to address them
3. Develop a White/Concept Paper
4. Economic analysis and feasibility
5. Education, Career & Workforce Development (ECWFD)
6. Extension and technology transfer
7. Demonstrate technology (R&D) and hands-on training projects
Building Capacity of Atlantic Salmon Production in the U.S.:
A national Public-Private-Federal Partnership
Building Capacity of Atlantic Salmon Production in the U.S.: A national Public-Private-Federal Partnership
Building Capacity of Atlantic Salmon Production in the U.S.:
A national Public-Private-Federal Partnership
Building Capacity of Atlantic Salmon Production in the U.S.:
A national Public-Private-Federal Partnership

We’ve Added Partners

Our Supporters
RAS-N to enable/’spawn’ future projects

Recirculating Aquaculture Salmon Network
Sustainable • Innovative
Sustainable Aquaculture Systems Supporting Atlantic Salmon (SAS²)

$10M, 5-year funding from USDA/NIFA for national program
RAS-N Mantra: Engage with Industry Stakeholders

Research and Industry Updates
Stakeholder Sessions, Panels and Surveys
Panels on Areas of Priority
Education Needs and Programming
Also: WAS and other meetings
- Develop and refine SOPs to optimize depuration
- Two peer-reviewed articles (2020-21) and trade press publications resulted from Sea Grant-funded work
- Freshwater Institute and IMET have also developed research (USDA-NIFA) to help the salmon RAS industry tackle this important challenge

Figure courtesy Davidson et al. (2020). Aquacult. Eng. 90, 102104
Atlantic Salmon Alternative RAS Feeds

Insect Digestibility:

- Protein 89% ± 3.84
- Lipids 92% ± 3.84

Superworms: Zophobas morio

FCR < 1
Converting RAS Organic Waste to Fuel Grade Methane (Biogas)

Kevin Sowers and Keiko Saito, IMET
Converting RAS Organic Waste to Fuel Grade Methane (Biogas)

Kevin Sowers and Keiko Saito, IMET
Stochastic Economic Simulation Model

Exploring the economics of RAS Atlantic salmon production from egg to market in the U.S.

- **Key Model Inputs**: Operating and capital costs for hypothetical 5,000MT facility (based on an industry survey)

- **Accounting for Uncertainty**: in key production parameters (e.g., feed; mortality) and market parameters (e.g., head-on gutted price)

- **Key Deliverable**: Obtain ten-year Net Present Value (NPV) for hypothetical 5,000MT facility

Scott Knoche and Kaitlynn Ritchie, MSU
Outreach, Education and Workforce Development Program Includes:

- K-12 education initiatives – incorporate aquaculture into the classroom
- Virtual tours and presentations showcasing facility, species, systems, and projects
- Interactive technical or educational demonstration tours for all audiences
- UWSP Aquaculture Minor and Aquaponics Certificate Program
- Intensive apprenticeships & internship training programs with nearly 100% job placement rating into the industry.

Emma Wiermaa, UW-SP NADF
1. Experiential Courses for All Learners

2. Industry Partnered Internship Program
   Interns work within a wide diversity of aquaculture organizations learning skills sets desired by the industry

3. UMaine Aquaculture Micro-Credentials
   - Prepare
   - Train
   - Apply
   - Earn

4. 4-H Aquaponics Program
   Virtual program that allows youth to design, build and maintain their own aquaponics system at home

Scarlett Tudor, UMaine
Maryland Sea Grant and University of Maryland Extension

➢ Uses aquaculture to provide K-12 learning opportunities meeting science education standards
➢ Student-Driven Science

Teacher Professional Development Workshops

Aquaculture in the classroom (Biology, Chemistry, Physics)

Adam Frederick, MDSG
Building Capacity of Land-based Atlantic Salmon (Salmo salar) Aquaculture in the United States

Prepared by:
The Recirculating Aquaculture Salmon Network (RAS-N)
A National Sea Grant-funded Private-Public Network

October 2021
Recirculating Aquaculture Salmon Network (RAS-N)
Delivering on objectives - Targeted Working Groups

Research and Development
- Brian Peterson (USDA-ARS)

Economics
- Scott Knoche (Morgan State)

ECWFD
- Adam Frederick (MDSG) and M.S. Tudor (UMaine)

Extension
- Bill Hubbard (UMD)

Communications
- Jennifer Smith (WISG)

Website Development
- PMT and WISG
Recirculating Aquaculture Salmon Network (RAS-N)
Delivering on objectives- Targeted Working Groups

34 Individuals from:
6 Industry Partners
2 USDA Agencies
NOAA
3 Sea Grant Programs
1 non-profit
5 Universities

Research and Development
Brian Peterson (USDA-ARS)

Economics

ECWFD

Website Development

Extensions
Bill Hubbard (UMD)

PMT and WISG

Jennifer Smith (WISG)
RAS-N Extension: Develop a White Paper (now Concept Paper)  
Involved Work Groups: R&D, ECWFD, Extension, and Economic  

- 28 Contributors  
- 15 Organizations/Companies  
- 20 Pages  
  - State of Supply and Production Practices  
  - Needs/Barriers  
    - Challenges  
    - Potential Solutions
**RAS-N Extension: Concept Paper Status**

- **Winter 2019**
  - Stakeholder Workshop to Outline Topics

- **Spring 2020**
  - Form Working Groups Around Topics

- **Summer 2020**
  - Generating Content for Concept Paper
  - Compiling Concept Paper and Meetings

- **Fall & Winter 2020**
  - Editing and 1st Round of Sharing w/ Chairs of Working Groups

- **Spring & Summer 2021**
  - Editing and 2nd Round of Sharing w/ Sea Grant Leadership

- **Summer & Fall 2021**
  - Editing and Final Round of Sharing w/ External Advisory Panel

- **In Progress**
RAS-N Extension: Survey of Salmon RAS Priorities

Involved Work Groups: Extension and Research

- Develop technologies and best practices for effective mitigation of off-flavor compounds
- Develop technology for early detection of detrimental compounds (geosmins, sulfides, sulfites, etc.) in RAS
- Identify variables and mechanisms that control the presence of off-flavor compounds
- Identify variable interactions that induce early sexual maturation to establish better management practices
- Design RAS specific feeds that optimize health and growth of Atlantic salmon and maintain water quality
- Identify and optimize RAS microbiomes to improve biofiltration, waste removal, and fish performance
- Research engineering solutions that reduce energy costs in RAS
- Develop and implement mono-sex cultures and sterility techniques to reduce or eliminate early maturation

Preliminary Results of 12 In-Network Respondents

Updated Results coming soon
RAS-N Extension: Website for Outreach and Information Sharing

Involved Work Groups: Web Development w/ PMT and Communications

John Stubblefield
Emma Wiermaa
Jennifer Smith
Tom Xiong (not pictured)
Lisa Tossey
RAS-N Extension: Website for Outreach and Information Sharing

Website: ras-n.org

Averaging 1,500-2,000 views a week
RAS-N Extension: Communicating Information with Targeted Audiences

Summary of RAS-N land-based salmon stakeholder priorities

Background and Rationale

The US faces a significant and growing seafood trade deficit ($16.8B in 2018; NOAA Current Fisheries Statistics, 2019) with nearly 90% of consumed seafood originating from abroad and over 50% of products coming from foreign aquaculture (NOAA Office of Aquaculture, 2020). Furthermore, many importing countries do not possess regulatory frameworks that meet US standards. Atlantic salmon consumption has risen in the US over the last decade at about 7-10% per year and currently is at a level of 493,000 tons annually. To meet consumer demands, Atlantic salmon imports to the US have grown in parallel to a record of 470,000 tons in 2018 valued at $3.4 billion (US-DOC, 2018). Domestic production of Atlantic salmon accounts for only ~4% of US consumption (NOAA-NMFS, 2017) and is confined to a relatively small industry off the coasts of Maine and Washington; however, Atlantic salmon production in ocean cages in Washington has been banned by state legislation after their current permits expire.

These staggering statistics mean that ~96% of consumed Atlantic salmon is imported, contributing over 20% to the $16.8 billion US trade deficit in edible seafood. Thus, there is an urgent need and opportunity to promote domestic aquaculture development and increase Atlantic salmon production in the US.

Benefits of the emerging land-based salmon industry to US seafood production, national food security and local economic development

The current strategy for supporting the future growth of US aquaculture production relies on the:

- Off-flavor and Mitigation updates
  - Exciton Technology for Removing Geosmin - Jack Holland, Exciton Clean

Building Maryland Capacity in Land-Based Aquaculture

- Land-based farming is considered a more sustainable way to produce Atlantic salmon and is identified by Monterey Bay Aquarium’s Seahorse Watch as a green choice (green). It creates opportunities to convert aquaculture waste into valuable products.

Program and Welcome

+ Plenary presentations

- October 8-9, 2020: Second Annual RAS-N Workshop (virtual meeting)
  - Institute of Marine and Environmental Technology (IMET), Baltimore, Maryland
  + Program and Welcome
  > Plenary presentations
  - Off-flavor and Mitigation updates
RAS-N Extension: Collaboration Efforts for Traditional Extension Products

The Conservation Fund
Freshwater Institute

The University of Maine

University of Maryland Extension

Off-Flavor: Ensuring Product Quality

Best Practices to maintain

What is off-flavor?

How does it occur?

How does it affect RAS raised fish?

Kata Sharrer (not pictured)

Laura Rickard
(including SAS2 efforts)

Allen Patillo
Recirculating Aquaculture Salmon Network (RAS-N)
A Final Deliverable: Road Map/Strategic Plan

An extensive analysis of the status of the industry, projected growth, biological and technological gaps, R&D priorities, mechanisms to promote public-private partnerships.

Help policymakers, federal and state agencies and industry identify and responsibly allocate resources to promote an economically feasible and environmentally sustainable land-based Atlantic salmon industry in the US.
RAS-N Hub Aquaculture Roadmap:
Addressing NSGO, NOAA and U.S. Goals & Policies

• NSGO
  • Stakeholder partners: academia, industry, government, consumers
  • Sea Grant partners (MD, ME, WI)
  • Integrate Sea Grant extension, communications and education networks

• NOAA- national marine and economic policy goals
  • Increasing sustainable marine aquaculture
  • Workforce development
  • Increasing diversity in marine science

• U.S. federal policy goals:
  • Sustainable seafood production
  • Reducing pressure on wild fisheries
  • Climate change mitigation and adaptation

• Congress’s goal: Increase U.S. aquaculture production

Fredrika Moser, MDSG, co-Lead PI
Our Network Welcomes Questions and Insights

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