Steps for growing oysters (or other bivalves)

- Course Sequence
- Growout
  - 25mm through to market
- Nursery
  - 2mm through to 25 mm
- Hatchery
  - Egg/sperm through to 2mm

Growing strategy

[Diagram showing growth strategy over the months with different phases labeled.]
Let’s start with the species

- **American oyster**
  - From hatchery or spat collected in wild
  - Will cover in more detail later
  - Start with as big seed as you can afford!
  - As you gain confidence, you can decrease the size of the seed you handle
  - Size to move into growout system
  - Depends on technology
  - Can be anywhere between ¾” to 2”
  - Don’t invest more than you can afford to lose in the first year!
Optimal conditions for grow-out:

What technology options do I have?

- Land-based
- Intertidal
- Floating
- Subtidal
- Suspended
- On-Bottom

On Bottom (Intertidal)
Sowing oyster seed

- Most growers free-plant at 1½” to 2” (about 1 year old)
- Use alternative technology for smaller seed
- Plant at density of 300-600 bushels of seed per acre (Moore 1897)
- 100-200 oysters/m²
- Split plots up into small units
- Separate oysters by size
- Spread evenly

Also can place on bottom in bags

- Often used for short-term holding of market-sized oysters

Bottom bag culture with a twist

- Roger Williams
# Bottom Culture considerations

<table>
<thead>
<tr>
<th>Selected Advantages</th>
<th>Selected Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less labor to maintain and stage seed for stocking grow-out areas</td>
<td>Higher percentage of mortality from predators and pests</td>
</tr>
<tr>
<td>Lower capital and maintenance expenses as no nursery or grow-out structures are required</td>
<td>Higher potential for ablation</td>
</tr>
<tr>
<td>Less labor in moving shellstock to grow-out areas because structures are not involved</td>
<td>Spar usually survive only on one side of the mother shell</td>
</tr>
<tr>
<td>Generally, fewer permits are required for bottom rather than off-bottom culture</td>
<td>Public resistance to many predator control methods</td>
</tr>
<tr>
<td>Usually less negative visual impact at nursery and grow-out sites</td>
<td></td>
</tr>
</tbody>
</table>

## Off Bottom

Oysters in trays directly on bottom
Wire Mesh Oyster Tray configurations

**OYSTER TRAYS**

Trays can be used with or without grow-out bags and generally require some type of crane or hoist to lift them out of the water.

- 1000
- 2000
- 3000
- 1500

Numbers are total oyster capacity.

---

**Large bottom trays**

- Image of workers handling oyster trays.

---

**Aquatray**

- Image of oyster trays and workers.

---
A local Aquatray system

The oyster bag (ADPI or OBC Bag)

Oyster Bag: mesh details
Oyster Bag: end closure details

Oyster Bag details

<table>
<thead>
<tr>
<th>Bag size (mm)</th>
<th>Types</th>
<th>2cm</th>
<th>3cm</th>
<th>4cm</th>
<th>6cm</th>
<th>9cm</th>
<th>14cm</th>
<th>18cm</th>
<th>23cm</th>
</tr>
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<tbody>
<tr>
<td>10x40</td>
<td>R</td>
<td></td>
<td></td>
<td>*</td>
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</tr>
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<td>10x40</td>
<td>XL</td>
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<td>10x75</td>
<td>B</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10x75</td>
<td>NRB</td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>10x55</td>
<td>NS</td>
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<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>10x55</td>
<td>NRE</td>
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</tr>
</tbody>
</table>

Oyster bag closure details and characteristics

<table>
<thead>
<tr>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH or NR = Reinforced and Not Reinforced open on both sides</td>
</tr>
<tr>
<td>RH or NRB-NM = Reinforced Sealed, and Not Reinforced Sealed Not Molded</td>
</tr>
<tr>
<td>RH or NRB-M = Reinforced Sealed, and Not Reinforced Sealed Molded</td>
</tr>
</tbody>
</table>

Standard with stock.

Bag Closures
Oyster stocking density in bags

- Site specific - Rule of Thumb
- Generally put 4 – 6 liters (1 – 1.5 gallons) of biomass in a bag (test it out!!)

For example:

- Ninigret Pond
  - Growth rates seemed to be declining over time
  - Tested for
    - Food availability
    - Water flow
    - Stocking density
  - Results
    - Plenty of food in the water
    - Water flow was minimal
    - Stocking density critical

"Jiffy Pop" syndrome

June 26th
July 17th
August 11th
November 10th
Oyster stocking density in bags

- Site specific - Rule of Thumb
- Generally put 4 – 6 liters (1 – 1.5 gallons) of biomass in a bag (test it out!!)
  - If small oysters ½” (12.7mm) = 10,000 – 16,000 oysters/bag
  - If 1 inch (25mm) = 1,700 – 2,700/bag
  - If 2 inch (50mm) = 300 – 450/bag
  - If markets (75mm) = 100 – 250/bag

- Jiffy Pop (Be Aware!!!!!)
  - If start with 50,000 oysters
    - Need 3 - 4 bags at 10mm
    - Need 18 – 30 bags at 25mm
    - Need 110 – 165 bags at 50 mm
    - Need 200 – 500 bags at market size

Plan Ahead!!!

---

Rack & Bag

---

The “Rack”
Rack & Bag

A collapsible rack & bag system

Australian Long-line System – single backbone
Longline Oyster Bag System

Double backbone system

Seapa Bags
### BST Oyster Basket

![Image of BST Oyster Basket](image)

### Comparison of technology (SEMAC Study)

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Cost</th>
<th>Growth Performance</th>
<th>Durability</th>
<th>Ease of Use</th>
<th>Rating</th>
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</thead>
<tbody>
<tr>
<td>Seapa Basket</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4 Stars</td>
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<tr>
<td>Aqua Tray</td>
<td>1</td>
<td>.75</td>
<td>1</td>
<td>.75</td>
<td>3.5 Stars</td>
</tr>
<tr>
<td>Bag &amp; Rack</td>
<td>.5</td>
<td>.5</td>
<td>.5</td>
<td>.5</td>
<td>2.0 Stars</td>
</tr>
</tbody>
</table>

*Overall Performance Rating: Based on Total Unit Cost, Growth Performance, Durability, and Ease of Use*
Optimizing space use

Another idea for growing oysters

Flip bag oysters, is it worth the effort?
**Product Quality and distinction is Increasingly Important!**

**Oyster and Hard Clam Production**
- 8.27 million oysters sold ($5.6 million)
- 241 acres, 61 farms
- 81% increase in production in the past 10 years

**Product Quality**

**Shell shape**
- Cup ratio (length:depth)
- Fan ratio (length:width)

**Shell condition**
- Hardness
- Parasites (mud blisters, sponges)
Product Quality

**Meat condition – plumpness & shell fill**

- Cup ratio (length:depth)
- Fan ratio (length:width)

**Shell condition**
- Hardness
- Parasites (mud blisters, sponges)

**Meat condition**
- plumpness
- Shell fill

**CONSISTANCY**

Growing superior grade oysters

- Tumbling
- Shaking bags
- Cleaning
- Air dry
- Floating gear
Product Quality

- Growing superior grade oysters
  - Flip Bags – Tide tumbled

East Coast effort: NARF-Net

- Northeast Aquaculture Research Farm Network
  - Established up to 5 demonstration/evaluation projects on farms in each of 5 northeast states (ME, NH, MA, RI, CT, & NY)
  - Compare oyster morphometrics and CI between flip bags and traditional growing methods in place on each farm
  - Started in summer 2014 and continued through summer 2016
  - Each state will host a farm demonstration day this winter
  - (Funded by the NOAA National Sea Grant Extension Program)
Do flip bags produce a superior grade oyster?

- Compare flip bag performance to conventional rack and bag and floating bag grow out methods
  - Adjacent systems
  - Same cohort
- **Treatments:** 5 replicates per treatment (Avg. starting size ± SE)
  - ADPI flip (62.3 mm ± 0.5)
  - Seapa flip (62.4 mm ± 0.5)
  - Rack & bag (62.6 mm ± 0.6)
  - Floating bag (avg. = 59.2 mm ± 0.5)
- **Stocking density**
  - Rack & bag (150 oysters per bag)
  - Floating (150 oysters per bag)
  - Seapa (75 oysters per basket)

**RWU – Experimental set-up**

- Measured for morphometrics (length, width and depth) at intervals thru summer and fall
  - Measured condition indices at end
  - CI = [dry soft tissue weight (g) X 1000] / [total weight (g) – shell weight (g)]

**RWU Rack & bag system**

- [Image of rack and bag system]
Based on growth data, flip bags are less productive than rack & bag and floating gear:

- ADPI flip bag (avg. finish size = 62.6 mm ± 0.7)
  - ADG = 0.003 mm/day
- Sepa flip basket (avg. = 66.1 mm ± 0.7)
  - ADG = 0.03 mm/day
- Rack & bag (avg. = 77.9 mm ± 0.9)
  - ADG = 0.12 mm/day
- Floating bag (avg. = 83.5 mm ± 1.6)
  - ADG = 0.19 mm/day

Too much tumbling to permit good shell growth? But does that tell all of the story?

Length doesn’t determine quality alone

![Oyster images]
• ADPI flip oysters have significantly deeper cups compared to rack & bag and floating bag oysters
• ADPI flip, Seapa flip and floating bag oysters have significantly deeper cups compared to rack & bag

• Seapa flip oysters have significantly larger fan ratio compared to rack and bag oysters \( (p=0.002, \alpha=0.05) \)

• Higher shell weight per length in flip bag oysters
  • 3.0" flip oysters (dry shell wt. = 41.35 g)
  • 3.0" rack & bag oysters (dry shell wt. = 34.95 g)
**Condition Index**

- Flip bag oysters have significantly higher meat condition ($p<0.0001$, $\alpha=0.05$)

**Meat weight by length**

- Higher meat weight per length in flip bag oysters
- 2.5" flip oysters (dry meat wt. = 2.01 g)
- 3.0" rack & bag oysters (dry meat wt. = 1.69 g)

**Shell Fill**

- Rack & Bag
- ADPI Flip
Blister Worms

- Rack & Bag
- 100% prevalence

- Grown adjacent to one another
- Both air dried at low tide
- Does physical disturbance drive the difference?

ADPi flip
- 30% prevalence

Does the flip bag increase oyster quality?

- An emphatic yes!
  - Heavier shell
  - More consistent grade
  - More meat per unit of size
  - Increased shell fill (observational)
  - Reduced presence of mud blisters

- However...
  - It slows down overall growth rate

- To compensate – marketing
  - Noticeably different product
    - shorter but more meat
    - heavier, cleaner shell
  - Command a premium price to counter loss of growth
    (i.e. pay for extra time to achieve market size)

Does the consumer care?

The Seattle Times
Oyster heaven: Hama Hama hits upon a tasty business model

Tumbled to Perfection – Washington Oyster Farmers Use Innovative Flip-Bag Technology

> ROGER WILLIAMS
**Does the consumer care?**

- Market them at a “Premium” price
  - West Coast kushi oysters (produced via flip bags)
    - City Fish Company (Pike’s Place, Seattle, WA)
      - 1 doz farmed Pacifics - $13.99
      - 1 doz kushi oysters - $19.99
    - Starvin’ Marvin’s Seafoods (Blaine, WA)
      - Pacifics (Fanny Bay – 10 pack) - $6.96
      - kushi oysters (10 pack) - $11.10
    - The Lobsterman (Vancouver, BC)
      - 1 doz Pacifics (Lighthouse Oyster) - $9.98
      - 1 doz kushi oysters - $17.95
  - Average retail - about 60% price increase over a regular farmed oyster

**Other Considerations**

- Total farm production?
  - Number of pieces per unit area

- Site selection
  - Shallow water (<2’ MLW)
  - Minimal rocks (need to drive posts)

- Gear selection
  - Seapa/BST baskets are superior for handling and durability
  - Tension in line is critical

- Permitting
  - Highly visible at low tide
  - Navigational hazard if not properly marked
  - Currently permitted as floating gear in RI

**Acknowledgements:**

A group of RWU undergraduates were instrumental in assisting with this project:
- Heather Kinney
- Pandora Hudsworth
- Kuchien Lathem
- Das Arnold
- Tom Brooker
- April Thibodeau
- Sean Mazzino
- Brie Mellen
- Toby Adams-Cook

So if you run into any of them – hire them (but not Matt)!!!!!
Bottom cages

Bottom Cage

Bottom cages designs
**Bottom Cage configurations**

OYSTER CAGES

Cages require the use of a grow-out bag which is accessed from the side of the cage.

![Diagram of bottom cage configurations]

Bottom cages in the intertidal

![Image of bottom cages in the intertidal]

Sea scallop bottom grow-out cage.

![Diagram of sea scallop bottom grow-out cage]

See scallop grow-out cage travel.
Oyster cage hoist

Considerations: Off-bottom Culture

Selected Advantages
- Less impact on predictions and profits
- Significantly less chance for problems resulting from siting
- Use of total water column by three-dimensional culture techniques
- Spot survival on both sides of the mother shell
- Less expensive equipment required for harvest

Selected Disadvantages
- More public resistance to visual impact of culture structure
- Potential conflict with recreational boating
- Foulage organisms severely impact some containment systems
- Labor intensive in initial setup
- Capital cost and maintenance of nursery and grow-out structures

Some risks
Risks - Overwintering

Is your overwintering site secure?
You want to be certain that nobody besides you is going to make off with your crop.

- Is your overwintering location subject to disturbance, either accidental or deliberate?
- If you are using a bottom cage or other structure, is it in an actively fished location?
- Will you be in or near a navigational channel?

A “YES” answer to any of these questions might be cause to re-evaluate your overwintering site, and perhaps look for alternatives.

Is your overwintering site vulnerable to ice?

- Assess the potential for freezing on your site.
  Does it get lots of ice or just a little?
- How thick is the ice compared to the depth of your site—are your cages well below any ice that might form?
- Could large chunks of ice (which can devitalize a farm site) float over your site during the spring thaw?
- If you are in an area with limited water exchange, will dissolved oxygen levels be affected?

One solution: Overwintering oysters

Suspended oyster culture
Oysters in Lantern Net

Hanging trays

Surface Longline
Suspended from a raft

Figure 36  Oysters on strings suspended from rafts
The strings are about two metres long.

Stackable trays

Nestier Tray
Oyster bag
Oyster bag made of fairly rigid plastic netting (Nexor) attached to two polystyrene cylindrical buoys with elastic bands.

Floating bag construction

Floating bag floats

Floating bag arrays
Floating/Submersible Oyster Bag System

Business Plan

(100 Bag Grid)

Equipment Cost

US $1,200 per grid

Output Production @ 200 pcs. per bag

20,000 oysters per growout cycle

Market Value

$0.25 = $5,000

$0.35 = $7,000

$0.40 = $8,000

Equipment life span

8 – 12 years (amortized cost = $150 per year)

Low labor cost: nature does biofouling control, shell pruning, shell hardening; lower production time

One hectare or 50% surface coverage allowing for navigation and carrying capacity recognition

45 grids

Total output per hectare

675,000 to 900,000 oysters

Gross income per hectare @ $0.25 =

$168,750 – $225,000

$195,000 average

Initial capital cost $54,000, amortized over 8 years; $6,750 per year x 2 year growout cycle $13,500

$182,500

Labor, fixed equipment usage, marketing, miscellaneous costs $70,000

Approximate Net Profit per Hectare

$112,500

($45,000/acre)
### Floating Bag system economics

<table>
<thead>
<tr>
<th>Desired Gross Income</th>
<th>$40,000.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of oysters sold ($/oyster)</td>
<td>$0.35</td>
</tr>
<tr>
<td>Survival rate for crop</td>
<td>60%</td>
</tr>
<tr>
<td>Final # oysters/flip bag</td>
<td></td>
</tr>
<tr>
<td>Total oysters needed to produce gross $</td>
<td>190,476</td>
</tr>
<tr>
<td>Oysters produced in year 1</td>
<td>20%</td>
</tr>
<tr>
<td>Oysters produced in year 2</td>
<td>80%</td>
</tr>
<tr>
<td>Final # oysters/flip bag</td>
<td>110</td>
</tr>
<tr>
<td>Lease size</td>
<td>3</td>
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### Oyster Grow-out Methods – cost comparison

<table>
<thead>
<tr>
<th>Deployment Method</th>
<th>Up-Front Capital Cost</th>
<th>Loading Capacity</th>
<th>Up-Front Capital Cost Per Unit</th>
<th>Life Span</th>
<th>Amortized Cost Per Unit</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALS</td>
<td>400/13.46</td>
<td>144,550</td>
<td>0.0397</td>
<td>8-10 years</td>
<td>0.0099</td>
<td>Least labor</td>
</tr>
<tr>
<td>Floating Bag</td>
<td>1,800/13.46</td>
<td>13,000</td>
<td>0.1333</td>
<td>8-10 years</td>
<td>0.0133</td>
<td>2nd least labor</td>
</tr>
<tr>
<td>Aquatech Trays (deployed in stacks of 7)</td>
<td>26.70</td>
<td>120</td>
<td>0.2253</td>
<td>10 years</td>
<td>0.0172</td>
<td>Sol. least labor</td>
</tr>
<tr>
<td>Dark Sea Trays</td>
<td>21.65</td>
<td>80</td>
<td>0.2711</td>
<td>10 years</td>
<td>0.0172</td>
<td>2nd least labor</td>
</tr>
<tr>
<td>Mexican Trays (deployed in stacks of 10)</td>
<td>22.49</td>
<td>80</td>
<td>0.2786</td>
<td>10 years</td>
<td>0.0172</td>
<td>3rd least labor</td>
</tr>
<tr>
<td>French Rack &amp; Bag</td>
<td>16.35</td>
<td>200</td>
<td>0.0843</td>
<td>6-8 years</td>
<td>0.0138</td>
<td>Most labor-intensive</td>
</tr>
</tbody>
</table>

**Notes:**
- Numbers for Aquatech Trays, Dark Sea Trays, and Mexican Trays are based on raft culture; cost per raft is $3,000 with 64 stacks per raft. These trays can also be deployed by long line which costs less ($1,800) but is more labor-intensive.
- French Rack & Bag System - Cost of one rack is $120 with a capacity of 8 bags.
Chessawanock Oyster Farm

A few other odd ways to grow oysters!

Rope oyster culture
Maintenance of oyster growout systems

Management ~ fouling ~

Fouling Control

- Will discuss later with other pests
Density management

- Need to hold similar sized oysters together
- Bigger ones will outcompete smaller ones for food
- Should sort them on a regular basis
- A couple of times per summer
- As you are thinning densities

Proper density

Sorting

- Need to hold similar sized oysters together
- Bigger ones will outcompete smaller ones for food
- Should sort them on a regular basis
- A couple of times per summer
- As you are thinning densities
Concentric tube tumbler/sorter

Roll Your Own
Oyster sorter/tumblers

Dale Leavitt
Roger Williams University

I wanted to build a sorter/tumbler!

- Couldn't afford a production model
- Couldn't find much in terms of specifications for their operation
- Did a quick Google survey of materials related to sorter/tumblers
- Summarized what I found out that I could apply to my own design

Dale Leavitt
Roger Williams University
Summary of tumbler designs

**~Construction Materials~**

- **QuickTube Sorter** ([http://chesbayoysterco.blogspot.com/2009/03/quicktube-sorter.html](http://chesbayoysterco.blogspot.com/2009/03/quicktube-sorter.html))
  - Aluminum frame with aluminum cylinder
- **David Steele** ([https://www.youtube.com/watch?v=7S31T7mR8F4](https://www.youtube.com/watch?v=7S31T7mR8F4))
  - PVC (Furniture grade) frame with PVC Cylinder
- **Chris Philips** ([https://www.youtube.com/watch?v=pyZVhIZuXDw](https://www.youtube.com/watch?v=pyZVhIZuXDw))
  - Aluminum frame with PVC cylinder
  - Wooden frame with wire mesh sorter
- **My design**
  - Steel frame with concentric wire cylinders

Summary of tumbler designs

**~Mesh Sizes~**

- **QuickTube Sorter**
  - Round holes
  - ¼ to ½” for small seed
  - 5/8 & 7/8” for seed tube
  - 1¼ & 1¾” for sub-market/market

- **David Steele homemade tumbler**
  - Round holes
  - 3/8 to 5/8” for very small seed
  - 5/8 to 7/8” for small seed
  - 3/4 to 7/8” for large seed
  - 1 ¼ to 1 ¾” for markets

- **Alaskan tumbler**
  - Square wire mesh
  - ½”
  - 1”
  - 1 ⅜”

  - 0.5, 1.0, & 2.0 cm seed tube

- **My final design**
  - Square wire mesh
  - ¾, 1, & 1 ½”

Summary of tumbler designs

**~Tube lengths per grade~**

- **QuickTube**
  - ~4’ long with 3 grades (8’ total)

- **Chris Philips**
  - ~3’ long with 3 grades (6’ total)

- **David Steele**
  - ~5’ long with 3 grades (10’ total)

- **Alaskan**
  - ~2’ long with 4 grades (6’ total)

- **My design**
  - ~4’ long with 4 grades (4’ total)
Summary of tumbler designs

~Rotation speed~
- QuickTube: 21 rpm
- David Steele: 23.4 rpm
- Chris Philips: 6.8 rpm
- Jack Blake: 18 rpm
- My design: 20 rpm

~Motor~
- Needed to have a relatively low speed motor with good torque
- Initially decided on a treadmill motor
  - Work at varying rpms
  - People are giving them away!
- Unfortunately the one I acquired didn’t work well
  - Kept tripping the breaker
- Ended up using a ½ hp - 1750 rpm - 110VAC motor
  - Have to gear it way down with pulleys to get to 20 rpm
  - 2-stage pulley: 1.5” to 12” linked with a 1.5” to 15”

~Pitch~
- Influences the rate that oysters move through the tube
- Made an estimate based on photos of tumbler/sorters that I could find pictures for
  - The overall pitch seemed to be approximately 1 foot in 8 feet
- I built mine with no pitch and then adjust it by elevated the hopper end
  - Have run it at 1:8 with good results
### My final design

<table>
<thead>
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<th>Spacing</th>
<th>Diameter</th>
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A Day in the Life of an Extension Agent  
~ A Tumbler Story ~

- A phone call
  - Experiencing 50-75% mortality
  - Near market size oysters
- Site visit
  - Buckets of dead shell
  - Opened up a few oysters

Harvest
Raking oysters

Harvest from bags/trays – easy!

Grading & Culling
Chessawanock Oyster Farm video
https://www.youtube.com/watch?v=ROoLZXg__5s

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