OYSTER FARMING FUNDAMENTALS

• OFF/CLASS OF 2020

• MISSISSIPPI DEPARTMENT OF MARINE RESOURCES,

• AUBURN UNIVERSITY, ALABAMA COOPERATIVE EXTENSION
CLASS TOPICS

Class One
- Introductions
- What is off-bottom oyster farming and why do it?
- Oyster Biology and Life Cycle
- Understanding Triploidy
- Site selection
- Gear options
- Introduction to Business Planning

Class Two – Starting an Oyster Farm
- Gear Assembly and Installation
- Permitting
- Storm Preparation
- Mitigating Hazards
- Inventory Management
- Harvest Requirements
- Protecting Public Health
- Business Planning – Part Two
CLASS TOPICS

Class Three – Operating an Oyster Farm
- Grading & Splitting
- Controlling Bio-Fouling
- Nursery Options

Class Four – Making the Most of an Oyster Farm
- Best Management Practices
- Marketing and Branding
- Basics of Distribution
- Risk Management
- Business Planning – Conclusion
CLASS TOPICS

• Hands on learning

With designated gear, raise ~10,000 oyster seed
AUBURN UNIVERSITY SHELLFISH LAB TEAM

• BECKY WASDEN, OYSTER AQUACULTURE EDUCATION SPECIALIST
  • VOCATIONAL TRAINING FOR HIGH SCHOOL STUDENTS, TRAINING FOR SEAFOOD PROFESSIONALS

• RUSTY GRICE, OYSTER AQUACULTURE BUSINESS SPECIALIST
  • BUSINESS PLANNING, PERMIT ASSISTANCE

• ADRIANE MICHAELIS, POST-DOCTORAL RESEARCH SCIENTIST
  • STUDY OF PERCEPTIONS IN SEAFOOD RESTAURANT INDUSTRY ABOUT AQUACULTURE
  • CULTURAL ‘SERVICES’ PROVIDED BY SHELLFISH AQUACULTURE

• BILL WALTON, ASSOCIATE PROFESSOR & EXTENSION SPECIALIST
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Pictures will be on Facebook, Twitter and Instagram  
https://www.facebook.com/AUShellfishLab

AU Shellfish Lab Website  
https://sfaas.auburn.edu/shellfish-lab/
E-newsletter
2016 Aquaculture Production Highlights

Marine & Freshwater National Totals

**VALUE**

- **$1.5 billion**
- **$192 million**
- **$138 million**
- **$68 million**

**MARINE**

- **$418.3 million**
- **86 million pounds**

**FRESHWATER**

- **$719.8 million**
- **547 million pounds**

**21%** of U.S. seafood production & fishery products by value

Marine Species Totals

- **Oysters**
  - **$192 million**
  - **37 million pounds**

- **Clams**
  - **$138 million**
  - **10 million pounds**

- **Salmon**
  - **$68 million**
  - **36 million pounds**

- **Mussels**
  - **$10 million**
  - **0.9 million pounds**

- **Shrimp**
  - **$10 million**
  - **4 million pounds**

Regional Marine Totals

- **PACIFIC**
  - **41%** by value

- **GULF OF MEXICO**
  - **21%** by value

- **ATLANTIC**
  - **38%** by value

**PRODUCTION**

- **633 million pounds**
- **16th** in global aquaculture production

**MARINE**

- **86 million pounds**

**FRESHWATER**

- **547 million pounds**
SHELLFISH CULTURE IN USA

• OYSTERS, CLAMS, MUSSELS – A SUCCESS STORY FOR US AQUACULTURE

• BUT IN 2008, VERY LIMITED OYSTER CULTURE IN SOUTHERN US
TWO MEANS OF TRADITIONAL OYSTER PRODUCTION IN THE GULF

‘WILD’ PUBLIC OYSTER REEFS

PRIVATE ‘OYSTER BEDS’
CULTCHING'/SHELL PLANTING IS DONE TO IMPROVE THE HABITAT FOR OYSTER SETTLEMENT TO IMPROVE SET ON PRIVATE BEDS, OYSTER SEED MAY BE MOVED TO DIFFERENT AREAS

BOTH RELY UPON NATURAL SET

• ‘CULTCHING’/SHELL PLANTING IS DONE TO IMPROVE THE HABITAT FOR OYSTER SETTLEMENT TO IMPROVE SET

• ON PRIVATE BEDS, OYSTER SEED MAY BE MOVED TO DIFFERENT AREAS
PRIMARILY COMMODITY MARKET

- FOCUSED ON THE COMMODITY, SHUCKED PRODUCT MARKET
- GULF PRICES VARY WIDELY WITH SUPPLY
- IN THE SHELL, BOUGHT BY WEIGHT OR VOLUME, NOT BY THE PIECE

Credit: Scott Mowbray
### WHY OFF-BOTTOM OYSTER FARMING?

<table>
<thead>
<tr>
<th>Intended for the premium, high value niche markets</th>
<th>Primarily live, raw half-shell market that emphasizes quality</th>
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<tbody>
<tr>
<td>Off-bottom farming has very high survival, allowing culture of bred lines and/or triploid oysters – which do not suffer from poor summer condition</td>
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<tr>
<td>Branded oysters reduce variation in quality</td>
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<tr>
<td>Not competition with shucked product or even less expensive sacks of oysters</td>
<td>Rather, adds high value niche product that could help overall perceptions</td>
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<td>Stability of income with possible limited season harvest</td>
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WHY FARM INSTEAD OF BOTTOM PLANT?

• CAN PROMOTE FASTER GROWTH

• INCREASES SURVIVAL

• ALLOWS CONTROL OF FOULING

• IMPROVES SHELL SHAPE AND APPEARANCE

• INCREASES PRODUCT CONSISTENCY

• BUT …

• BOTTOM PLANTING CAN ALLOW MUCH HIGHER PRODUCTION

• PRODUCTION COST PER OYSTER IS MUCH LOWER
OFF-BOTTOM OYSTER FARMING IS NOT ...

- A PUBLIC COMMERCIAL FISHERY
- TRADITIONAL ON-BOTTOM OYSTER LEASING
- OYSTER RESTORATION
OYSTER ‘GARDENING’

• TYPICALLY NON-COMMERCIAL AND OFTEN NO HARVEST

• OFTEN MOTIVATED BY ENVIRONMENTAL BENEFITS
PIER FARMING

• COMMERCIAL AND NON-COMMERCIAL

• TYPICALLY SMALLER SCALE (UNDER 50,000)

• PERMITS MAY DIFFER FROM TYPICAL OFF-BOTTOM OYSTER FARMING

• PHOTOS FROM AL.COM
HOW DOES THIS DIFFER?

- Usually relies on hatchery-reared native seed
- Gear is used to protect oysters from predators, burial and other losses
  - Requires $ investment
  - Requires time
  - Bottom cage, suspended, floating
- Can be established in areas where oysters on the bottom don’t survive (high salinity, soupy bottom)
WHY WEREN’T WE DOING MORE OFF-BOTTOM OYSTER FARMING?

• WHY FARM SOMETHING THAT NATURE PROVIDES IN ABUNDANCE?

• PROBLEMS OF FOULING AND OVERSET

• CONCERNS ABOUT POTENTIAL PRICE FOR REGIONAL FARMED OYSTERS

• RISK OF HURRICANES

• RISK OF THEFT, VANDALISM
WE CAN NOW PROVIDE CONSISTENTLY HIGH QUALITY THAT NATURE DOES NOT

- SOUTH HISTORICALLY HAS HAD A LOT OF RELATIVELY INEXPENSIVE OYSTERS
- QUANTITY AND QUALITY VARY
- TARGET HIGH-END MARKET WITH BEAUTIFUL, BRANDED OYSTERS
SOLVING PROBLEM OF FOULING & OVERSEASON COST EFFECTIVELY

• IN ALABAMA, COLLABORATIVELY TESTED 4 TYPES OF GEAR, OF WHICH 3 CONTROL FOULING THROUGH AIR DRYING
  • AUSTRALIAN LONG-LINES
  • FLOATING CAGES
  • FLOATING BAGS
  • BOTTOM CAGES
• NEEDED TO PRODUCE OYSTERS THAT AT MOST NEEDED A RINSE
AIR DRYING TAKES OYSTERS FULLY OUT OF WATER: CONTROL FREQUENCY AND DURATION OF LOW TIDE

FERNANDO DECILLIS
MARKETS AND PRICE

In 2009, advised that top price would be 15-35 cents per oyster

Currently, wholesale prices of 35 to 70 cents per oyster

Focused on high end markets in US Southeast

Opportunity/challenges in outside markets?
NEW WAVE OF OYSTER BARS

• WITHIN THE SOUTH, NEW EMPHASIS ON OYSTER VARIETIES

• OUTSIDE REGION, INTEREST IN WHAT IS BEING PRODUCED

• CERTAINLY SEASONAL OPPORTUNITIES
WHY WEREN’T WE DOING MORE OFF-BOTTOM OYSTER FARMING?

- Why Farm Something that Nature Provides in Abundance?
- Problems of Fouling and Overset
- Concerns about Potential Price for Regional Farmed Oysters
- Risk of Hurricanes – Developing strategies and insurance options
- Risk of Theft, Vandalism – To be determined
## Opportunities and Needs for Research and Outreach

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
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<tbody>
<tr>
<td>Improving</td>
<td>Improving production methods and product quality (reduce costs, increase profits)</td>
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<tr>
<td>Improving</td>
<td>Improving product safety</td>
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<tr>
<td>Understanding and predicting</td>
<td>Understanding and predicting water quality issues, harmful algal blooms, etc.</td>
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<tr>
<td>Understanding</td>
<td>Understanding ecological interactions and managing environmental impacts</td>
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<tr>
<td>Training</td>
<td>Training and technical advice</td>
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HANDS-ON TRAINING

• ~80 INDIVIDUALS TRAINED OVER FIVE YEARS
• PROVIDED CLASSES AND HANDS-ON INSTRUCTION
• EACH FARMER CHOSE A GEAR TYPE AND WAS GIVEN 10,000-20,000 OYSTER SEED TO RAISE
ALABAMA GROWTH

• IN 2008, NO FARMING

• IN 2016, SITUATION & OUTLOOK REPORT
  • 14 OYSTER AQUACULTURE
  • FARM GATE AT LEAST $1.9 MILLION
  • AT LEAST 2.6 MILLION OYSTERS HARVESTED
  • OYSTER MARKET PRICES RANGED FROM $0.30 TO $0.80 WITH AN AVERAGE PRICE OF $0.45
  • AT LEAST 20 FULL-TIME EMPLOYEES AND 10 PART-TIME EMPLOYEES
  • AT LEAST 28 ACRES PERMITTED FOR OYSTER AQUACULTURE WITH AT LEAST 18.1 ACRES USED IN PRODUCTION.
FIVE GROWING ‘AREAS’
WHERE HAS THIS GOTTEN US REGIONALLY?

- In Louisiana, now 4-6 oyster farms
- In Florida, at least 50 farms now raising oysters
- In Texas, considering legislation now to allow off-bottom oyster farming
- Working with colleagues in NC, SC and GA as well
- Mississippi had 14 trainees take seed in 2018
GOING FORWARD

- EXCITING GROWTH OF OFF-BOTTOM OYSTER FARMING IN THE REGION
  - TYPICALLY FAMILY FARMS
  - CREATING JOBS, ALLOWING PEOPLE TO MAKE A LIVING ON THE COAST
- POTENTIAL FOR SPAT ON SHELL IN THE REGION
- WE WILL CONTINUE TO PROVIDE:
  - SCIENCE-BASED ADVICE
  - DEMONSTRATION OF NEW TECHNIQUES
  - TRAINING FOR INDIVIDUALS
Oyster Biology and Life History
CRASSOSTREA

- EGGS SMALL
- MANY EGGS \((100 \times 10^6)\)
- NOT INCUBATED
- MALES AND FEMALES ARE BROADCAST SPAWNERS
OYSTER LIFE CYCLE

1. Fertilized egg
2. Egg + sperm
3. Free-swimming larvae
4. Adult males and females
5. Spat attached to shell
D-STAGE VELIGER

~ 90 um

- EARLY VELIGER STAGE
- REGION OF HINGE IS STRAIGHT
- Stage starts when the shell begins to calcify.
- Velum, well developed and distinct.
- Planktonic
- Begins feeding
- Stage lasts several days depending on temp.

http://www.youtube.com/watch?v=-pCi-I_Cc0u8
UMBONAL-STAGE VELIGER

Feeding
Locomotion
Respiration

velum

Umbo
EYED LARVAE

- Eye spots develop on both sides of the body.
- Umbo becomes more distinct.
- Takes 2-3 weeks to reach this stage.
- Marks beginning of transformation to pediveliger stage.

Foto: E. Turolla
PEDIVELIGER

• LATE VELIGER STAGE

• PROMINENT FOOT

• BEGINS TO LOOK FOR SUITABLE PLACE TO SET.

~ 275 um
SPAT

• GLUES ITSELF (**SETS**) PERMANENTLY TO SUBSTRATE.

• CLEAN (BUT WITH BIOFILM), HARD SUBSTRATE IS REQUIRED (**CULTCH**).

• CULTCH FREE FROM:
  • SILT
  • GREASE

• ALWAYS GLUES THE LEFT VALVE TO THE SUBSTRATE.
HATCHERIES MAXIMIZE STEPS OF OYSTER LIFE CYCLE

- SPAWNING
- FERTILIZATION
- LARVAL GROWTH AND SURVIVAL
- METAMORPHOSIS
- EARLY GROWTH OF OYSTERS AFTER METAMORPHOSIS (TYPICALLY CONSIDERED ‘NURSERY’)

Figure 8. Fertilized egg with first polar body.
BROODSTOCK CONDITIONING

CRASSOSTREA VIRGINICA

Females > 3 inches (76 mm)
Synchronized Spawning

**Spawning stimuli**

- increased temperature, chemical stimuli from algae stimulate males
- Released sperm stimulates both males and females to spawn (species specific), eggs stimulate only males to spawn (across species)

*(Rice et al. 2002)*
LARVAL FOOD

• AVAILABLE FOOD MUST BE THE RIGHT SIZE AND QUALITY.

• DIET CONSISTS OF:
  • BACTERIA
  • DIATOMS
  • FLAGELLATES
  • DETRITUS

• FOOD SIZE:
  • 10MM OR LESS.
Cultured Algae

Live

*Chaetocerus gracilis*

*Isochrysis galbana*

*Pavlova spp.*

*Nannochloropsis spp.*

Problems: labor, contamination

Commercial Concentrates

Example: Reed Mariculture Shellfish diet

Problems: cost, growth/survival may be somewhat lower than optimum growth on live foods
TWO HATCHERY ‘PRODUCTS’

SINGLES FOR ‘OFF-BOTTOM’ CULTURE

SPAT ON SHELL FOR ‘ON-BOTTOM’ CULTURE
ON-BOTTOM CULTURE

• THIS TO PRODUCE A LOT OF OYSTERS AT LOW COST

Diagram from Cosgrove et al. (2009). Full process detailed in Supan (1992), ‘Using remote setting to produce seed oysters in Louisiana and the Gulf coastal region’.
EYED LARVAE ARE SHIPPED TO SETTING STATIONS
SPAT ON SHELL ARE THEN PLANTED.
ON-BOTTOM CULTURE GOING FORWARD

- Several states are considering using spat on shell for stock enhancement (Louisiana, Mississippi, Alabama)

- Number of individuals trying spat on shell on private leases in several states
OFF-BOTTOM CULTURE

- NURSERY REQUIRED FOR MICRO CULTCH SET OYSTERS AND CULTCHLESS OYSTERS
- EXPENSIVE
- USED ONLY FOR PREMIUM OYSTERS
- MANY METHODS
Microcultch

- Micro cultch in downwellers (convert to upweller after metamorphosis: 24-48 hrs for settling and metamorphosis)

- Particle size: 250-300 μm crushed oyster shell
- 100 eyed larvae per cm²
DIPLOID VS. TRIPLOID OYSTERS

**Diploid**
- 2 sets of chromosomes
- Fecund
- Wild caught or hatchery produced

**Triploid**
- 3 sets of chromosomes
- Full to partial sterility (reduced gametogenesis)
- Chemically produced or produced through mating
CHEMICAL VS. MATED INDUCTION

MAIN PATHWAYS TO PRODUCE TRIPLOIDS:

- CHEMICAL INDUCTION:
  CYTOCHALASIN B (CB) OR 6-DIMETHYL-AMINOPURINE (6-DMAP)
- MATED INDUCTION:
  DIPLOID X TETRAPLOID

(From Callum, 2013)
THE
TRIPLOID
OYSTER


- BY 1999-2000 TRIPLOIDS WERE 1/3 OF PRODUCTION IN PACIFIC NORTHWEST AND BREEDING PROGRAMS STARTED IN EUROPE AND AUSTRALIA (NELL, 2002).
SITE SELECTION

• LOCATION, LOCATION, LOCATION

• SITE COMES FIRST! CHOOSE GEAR SECOND.

• FACTORS TO CONSIDER
  • BIOLOGICAL
  • PHYSICAL
  • ECONOMIC & REGULATORY
  • SOCIAL
BIOLOGICAL FACTORS

• You are raising a filter feeding bivalve that requires phytoplankton to grow

  • Your site will need good food quality

  • Not all ‘green’ is edible

• What is oyster growth and survival at site?
BIOLOGICAL FACTORS

- PREDATORS
  - CRABS, DRILLS, FISH, ETC.
- FOULING COMMUNITY
- DISEASE
  - DERMO OR PERKINSUS MARINUS
  - WWW.OYSTERSENTINEL.ORG
- FREQUENCY OF HARMFUL ALGAL BLOOMS
- **SALINITY**
  - **WHAT IS THE RANGE?**
  - **OYSTERS DO BEST ABOVE 10 PPT**
    - Don't survive below 5 PPT, especially at higher temperatures
  - **WHAT IS THE DURATION AND TIMING OF LOW SALINITY EVENTS?**
  - **HIGH SALINITY IS ACTUALLY FINE FOR OYSTERS BUT CAN PROMOTE DISEASE & FOULING**

- **TEMPERATURE**
  - **HIGH TEMPERATURES CAUSE STRESS, ESPECIALLY DURING AIR DRYING**
  - **LOW TEMPERATURES CAUSE STRESS ESPECIALLY WHEN OYSTERS ARE EXPOSED AT LOW TIDE**
PHYSICAL FACTORS

• DISSOLVED OXYGEN
• WATER DEPTH
• WATER CURRENT
  • THE MORE FLOW, THE BETTER GENERALLY
• WAVE EXPOSURE & STORM PROTECTION
• BOTTOM TYPE
• SIZE OF AREA
ECONOMIC AND REGULATORY FACTORS

- REQUIRED PERMITS
- RIPARIAN RIGHTS OR OTHER MEANS TO ALLOW USE OF WATERS & BOTTOM FOR OYSTER FARMING
- TERMS OF LEASE
- WATER QUALITY CLASSIFICATION
  - FREQUENCY AND DURATION OF CLOSURES?
ECONOMIC AND REGULATORY FACTORS

• LOGISTICS
  • WHAT ARE THE TIME/TEMPERATURE REQUIREMENTS AND CAN YOU MEET THEM AT YOUR SITE?
  • BOAT ONLY ACCESS?
  • DURATION OF TRIP TO FARM?

• SECURITY
  • SHARED AREA
  • CAMERAS

• MARKETABILITY OF SITE
SOCIAL FACTORS

- VIEWSHED CONCERNS
- CONFLICTS WITH OTHER STAKEHOLDERS
  - NAVIGATION
  - RECREATIONAL USE
  - FISHING
- MARINE DEBRIS
- BE A GOOD NEIGHBOR!
  - WE CAN ADAPT ECSGA BEST MANAGEMENT PRACTICES HERE IF THERE IS A DESIRE
CULTURE GEAR OPTIONS

- ON-BOTTOM CULTURE
  - NO GEAR
- OFF-BOTTOM CULTURE
  - BOTTOM CONTAINERS
  - SUSPENDED GEAR
  - FLOATING GEAR
- OTHER GEAR TO CONSIDER
  - BOAT/WORK BARGE
  - NURSERY EQUIPMENT
  - TRUCK/TRAILER
  - SORTER/GRADER
  - ETC.
GEAR OPTIONS: BOTTOM CAGES
GEAR OPTIONS: BOTTOM CAGES

**PROS**
- No visual impacts beyond buoys
- More secure from theft and boat strikes
- Familiar to watermen and regulators
- May not need certain permits

**CONS**
- No easy air-drying method to control fouling
  - Heavy equipment
- Fouling control by trash pump washing
- Losses to predators
- Reduced growth?
GEAR OPTIONS: SUSPENDED
GEAR OPTIONS: SUSPENDED

- WWW.EKONEOYSTER.COM
# Gear Options: Suspended

## Pros

- Easy handling and inventory control
- Tumbling (esp. in-line arrangement) can shape/clean oysters
- Fouling control accomplished by setting tidal height
- Automated grading and loading equipment available
- Tropical storm strategy

## Cons

- Limited to narrow tidal range (3’-5.5’ or so)
- Needs firm bottom
- Visually obvious
- Labor-intensive gear installation
GEAR OPTIONS: FLOATING
# Gear Options: Floating

## Pros

- Easy handling and inventory control
- Can adapt to variety of water depths
- Tumbling (esp. when flipped or in rough water) can shape/clean oysters
- Fouling control accomplished by flipping
- Gear can be moved around farm easily
- Tropical storm strategy

## Cons

- Cages get heavy to flip; may require additional labor
- Relatively space-inefficient due to flotation
- Need to be sure of anchors and reduce chafing
COMPARISON OF GROW-OUT GEAR (CODDINGTON, 2011)

Photos: Bill Walton, Courtney Coddington, & Julie Davis
EFFECT OF GEAR ON SURVIVAL
EFFECT OF GEAR ON CHANGE IN SHELL HEIGHT
EFFECT OF GEAR ON OCTOBER CONDITION INDEX
LACK OF EFFECT OF GEAR ON VIBRIO SPECIES ABUNDANCES
ADDITIONAL CONSIDERATIONS

- Cost of gear/production costs
- Ease of use
- Durability
- Ability to replace/restock gear
- Customer support
QUESTIONS