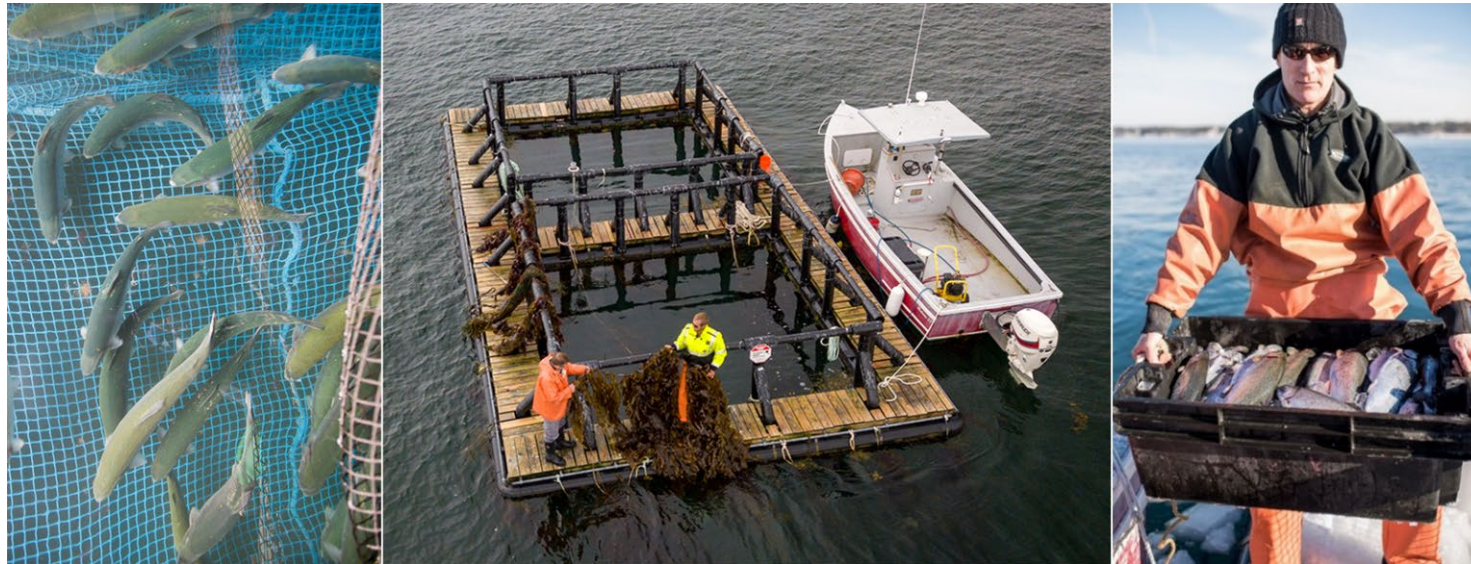
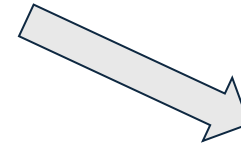
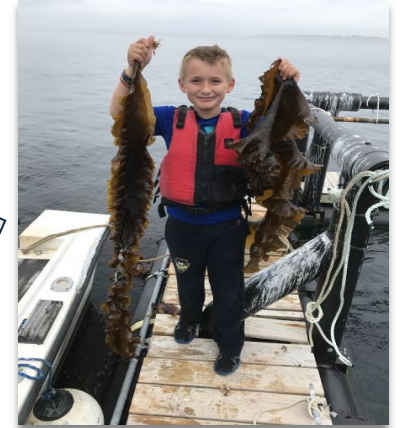
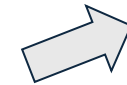


Integrated Multi-Trophic Aquaculture in the northern Gulf – culture operation



Species Selection: finfish, shellfish, macroalgae

- **Native**
- **Tolerant of prevailing environmental conditions**
- **Biologically suitable**
 - Available culture techniques
- **Value**
 - Commercial
 - Recreational
- **Market demand**
- **Suitable trophic structure for nutrient cycling**
 - Producer
 - Primary consumer (planktivore)
 - Secondary or tertiary consumer (carnivore)



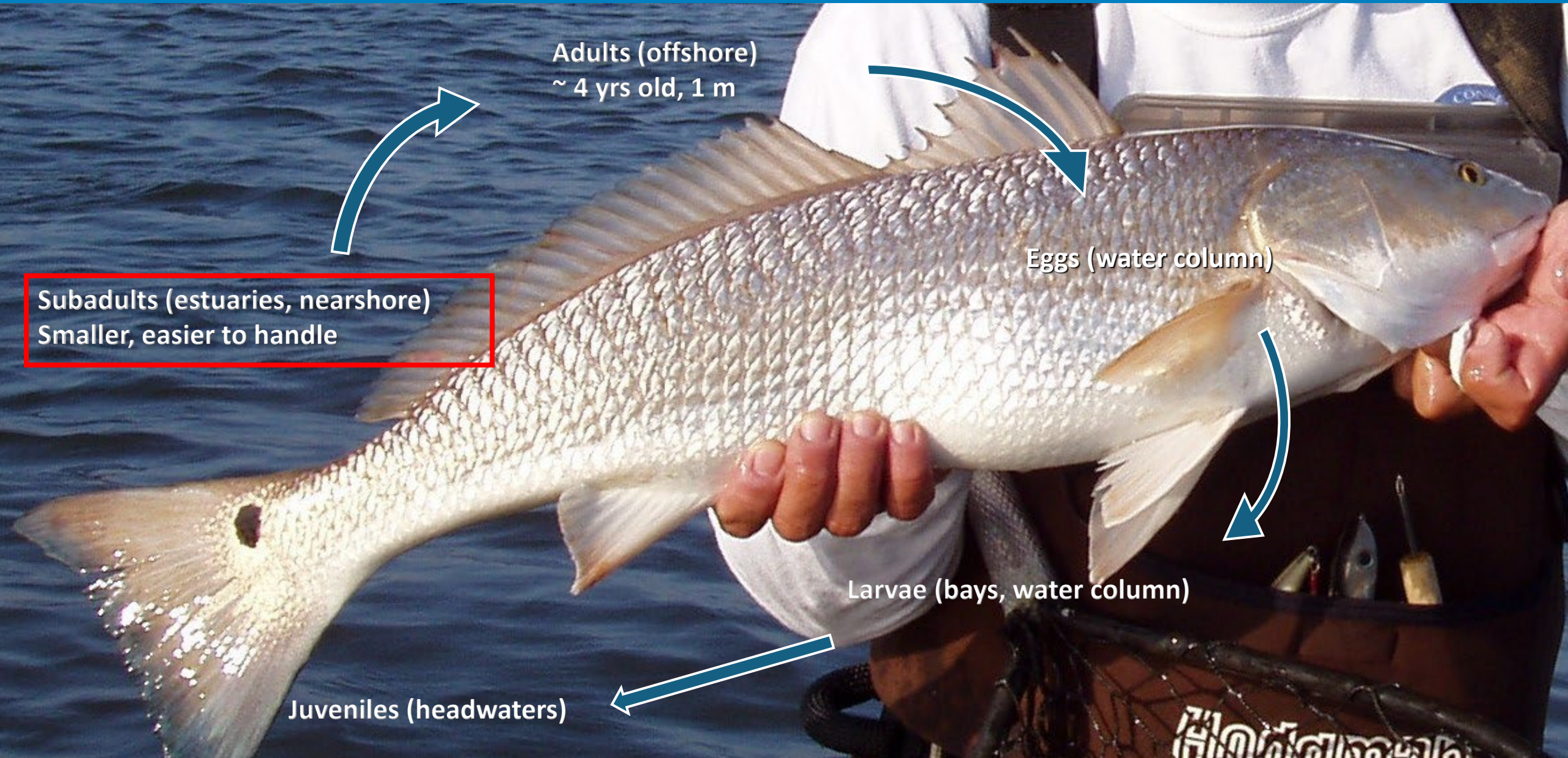
Finfish

Red Drum (*Sciaenops ocellatus*)

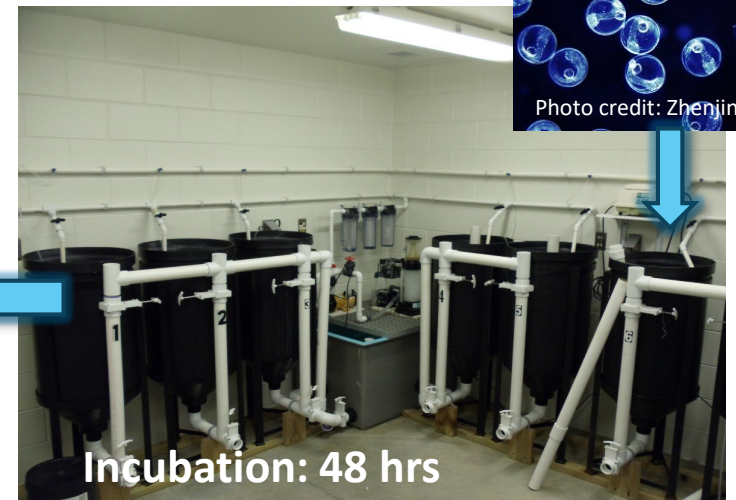
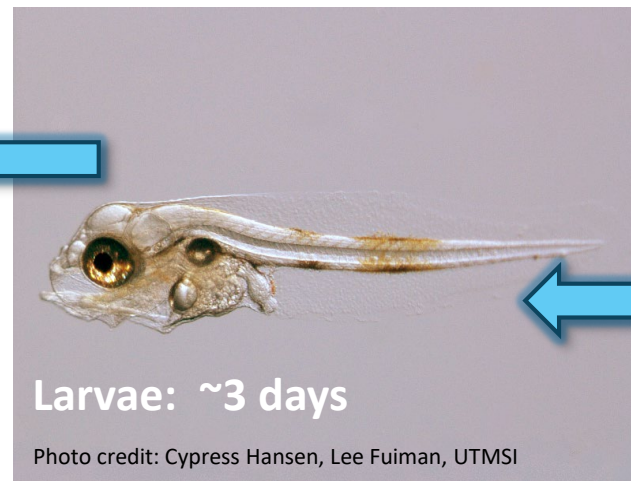
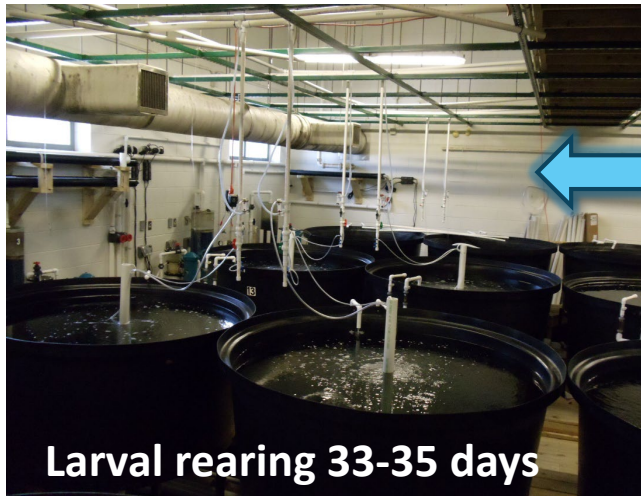
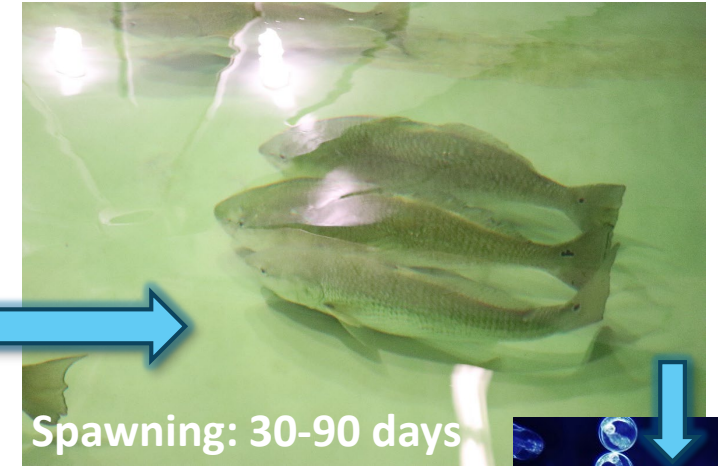
- Native resident sportfish species
- Optimal temp: 70-90° F
 - Tolerant of temps typical in Fall and Winter, even short-term cold
- Optimal salinity: 27-35 ppt
 - Tolerant of low salinity
- High demand market species
- Well-developed culture technology



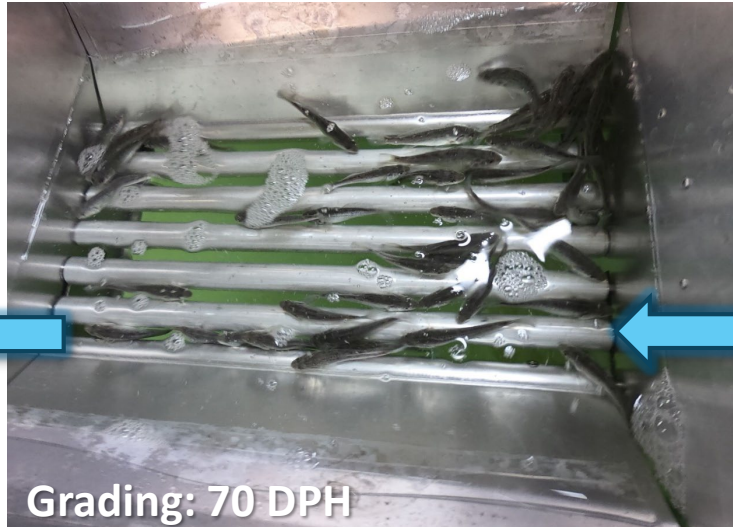
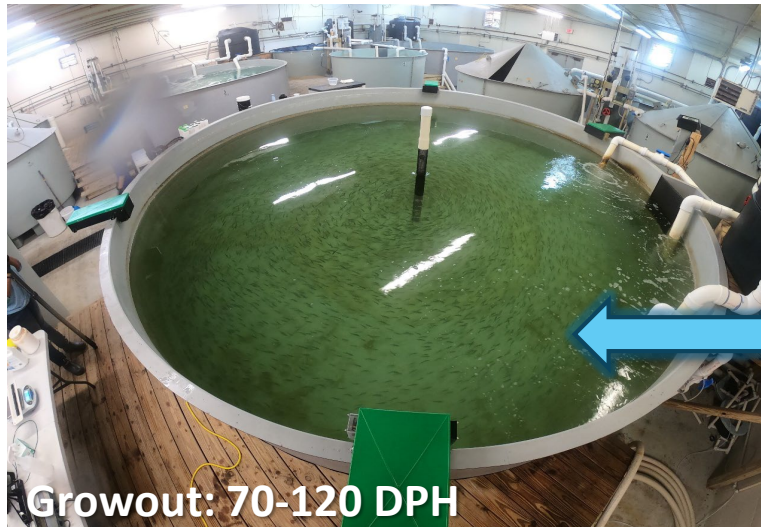
Red drum life cycle



Red drum culture



Red drum culture



Red drum production

- Stocking density for larviculture: 20-25 larvae/L
- Survival at 30-35 DPH: 45-60%
- Size at end of the LR: approx. 0.3 g, 3 cm TL
- Feeding at end of LR: 8% BW decreasing to 5% by 50 DPH and down to 3% by 70 DPH
- Aquafort stocking: 4000 juveniles at 40-60 g, 12-15 cm TL
- Aquafort feeding: 3-5% BW
- Target harvest size: 800-1000g, 38-45 cm TL, 7-8 mo. culture time

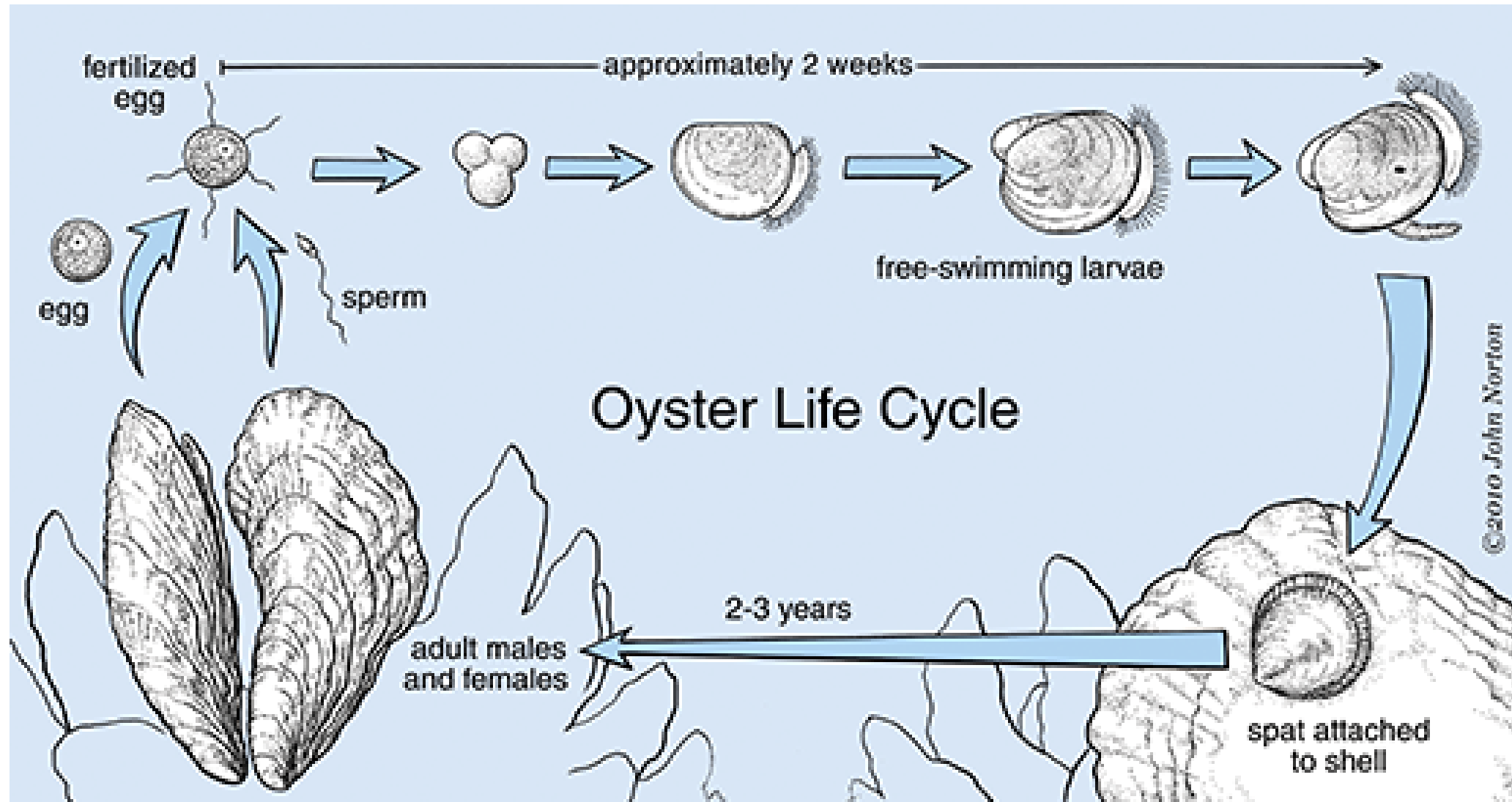
Shellfish

Eastern Oyster (*Crassostrea virginica*)

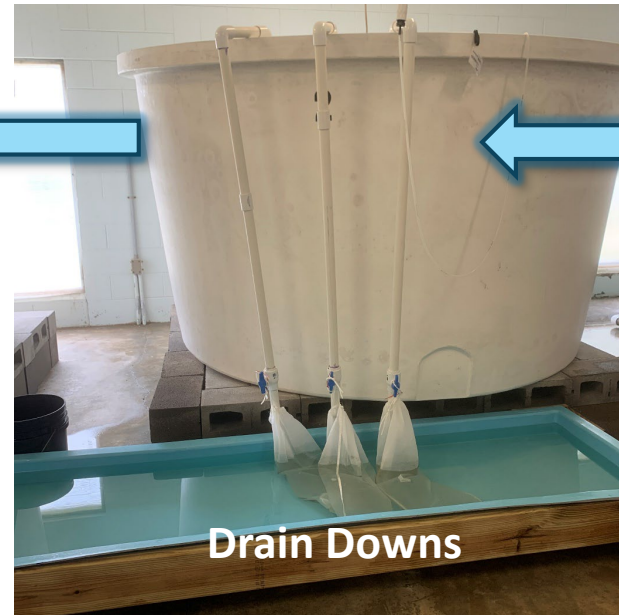
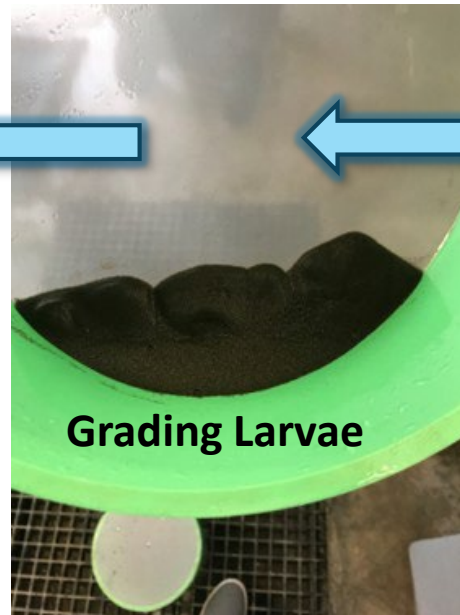
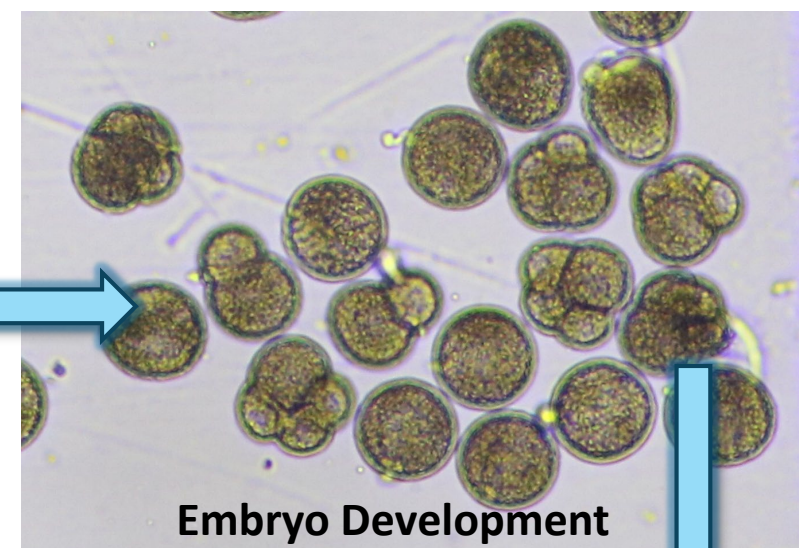
- Native commercially harvested shellfish
- Optimal temp: 68-86° F
 - tolerant
- Optimal salinity: 10-28 ppt
 - tolerant
- High demand market species
 - Commercial and restoration
- Site is unclassified
 - Project approved for restoration purposes



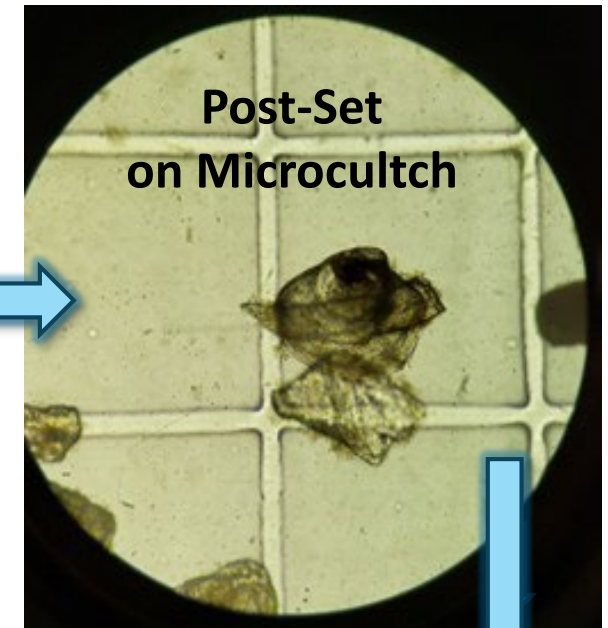
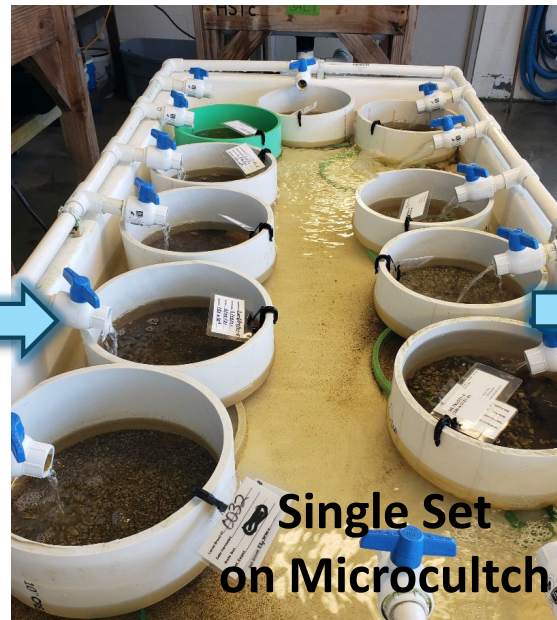
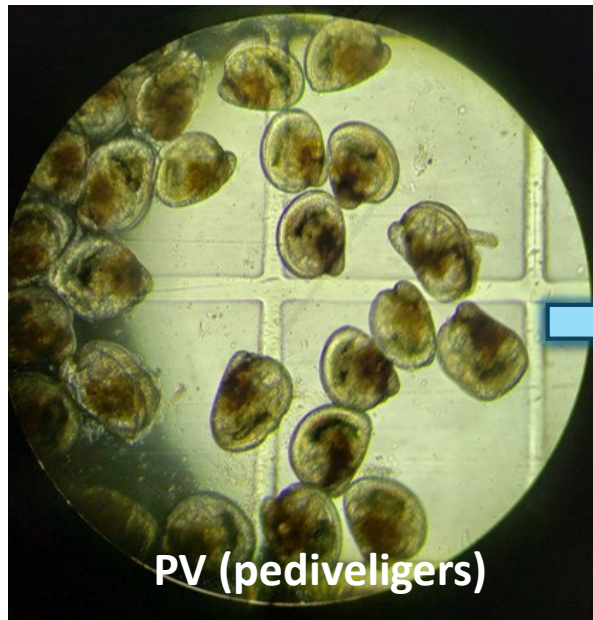
Oyster life cycle



Oyster Culture: Spawning and larvae culture



Oyster Culture: Setting and nursery growout



Oyster production

- 20 arrays x 4 Seapa baskets = **80 maximum total baskets**
- Initial deployment
 - **20 15L 6mm Seapa baskets** with up to 600 R9 seed at time of deployment
 - **12,000 R9 oysters** at initial deployment
- First split
 - **40 20L 12mm Seapa baskets** will be stocked up to 300 R14 seed
 - 9,000-12,000 oysters
- Final split
 - **80 20L 12mm Seapa baskets** will be stock at up to **150** oysters
 - ~9,000 oysters
- Final harvest
 - 4,000-11,000 oysters (minimum 50 per basket)
 - ~ 2 inches or greater in size
 - Depends on survival and growth



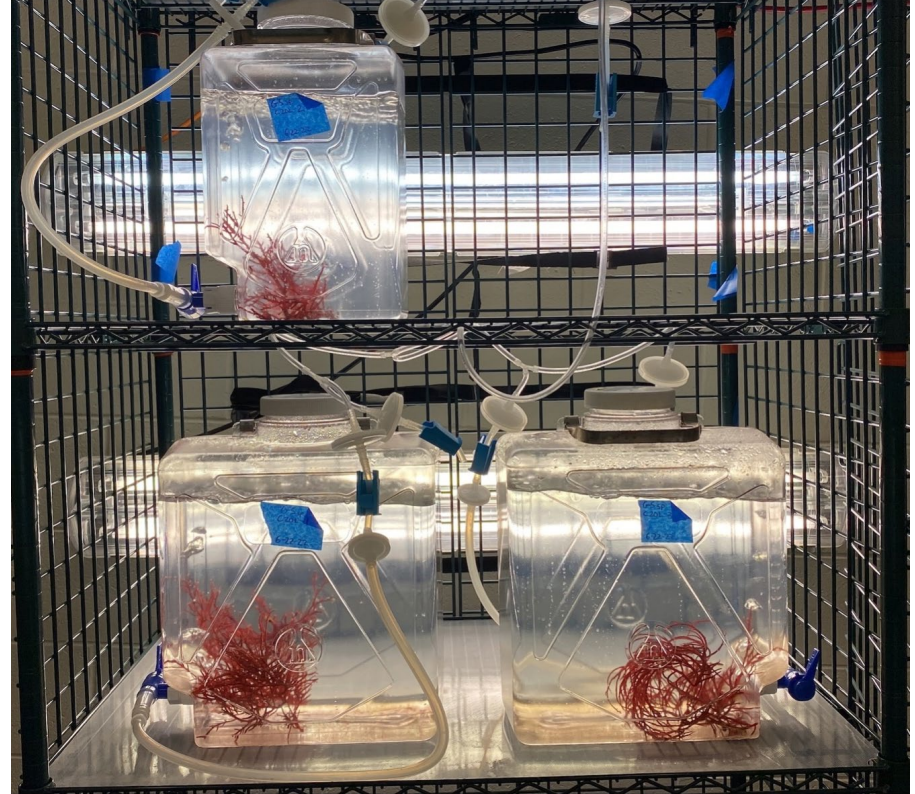
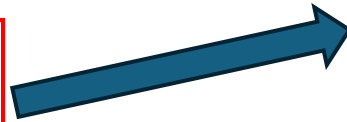
Macroalgae

Graceful Red Weed (*Gracilaria tikvahiae* and spp.)

- Native macroalgal species
- Optimal temp: 68-82° F
- Optimal salinity: 25-33 ppt
- Used for agar, food additive, animal feed, fertilizer, biofuels
- Ecosystem services



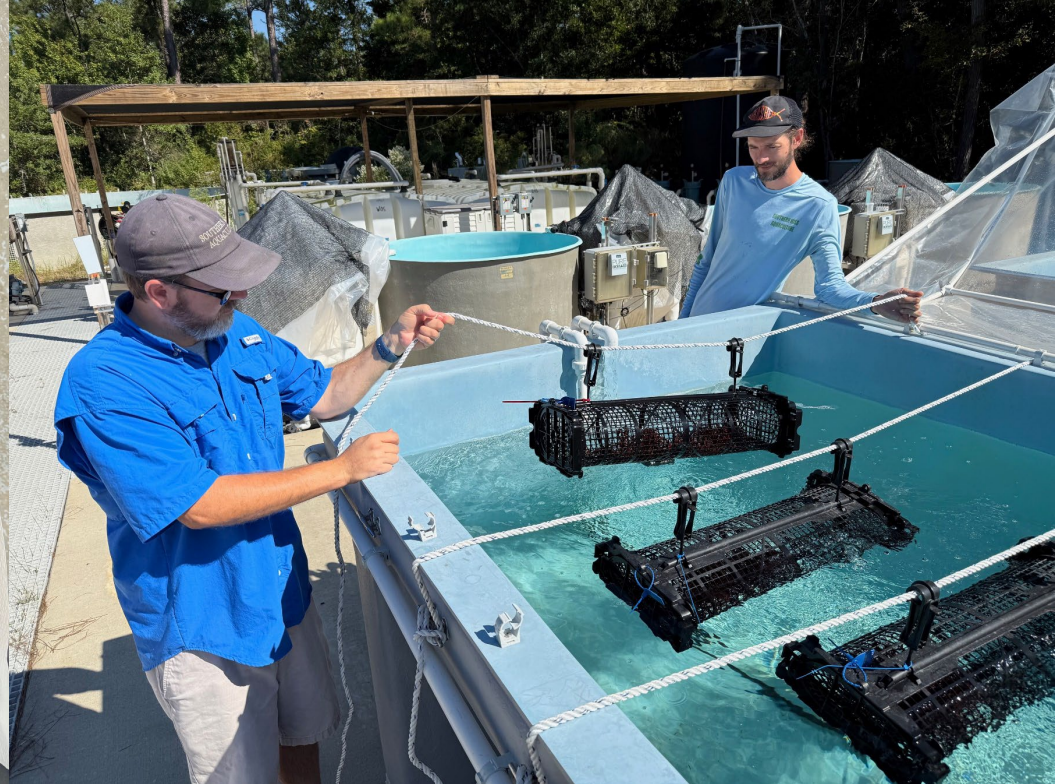
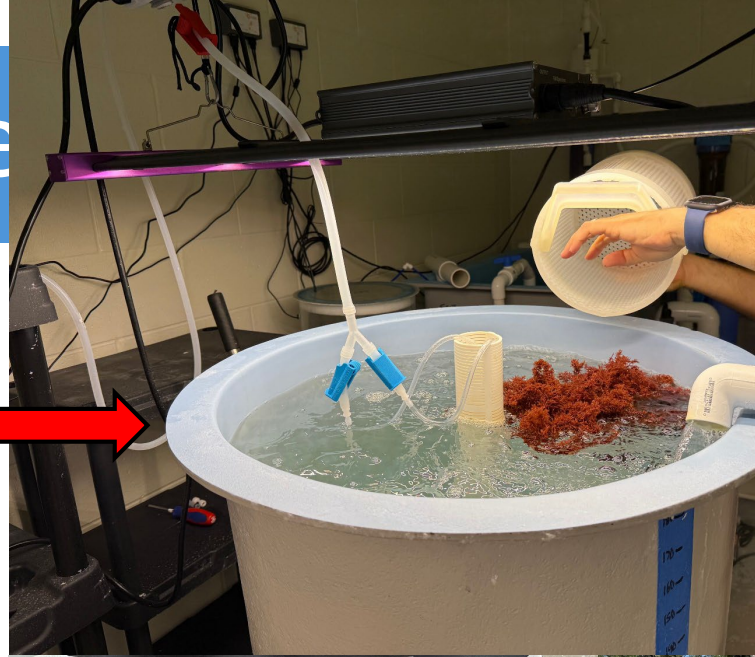
Gracilaria spp. life history



Vegetative propagation

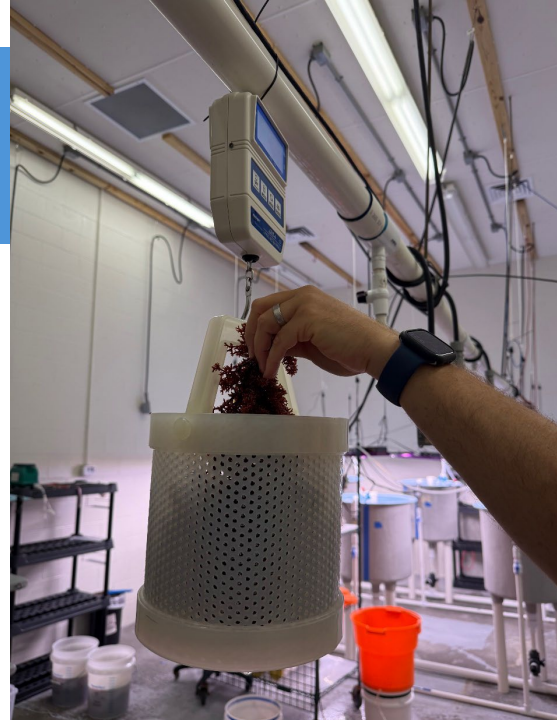
Macroalgae culture

- Indoor RAS
 - Tumble tank cultivation method
 - Ozonation
 - Exogenous nutrient addition
 - Nutrient component optimization
 - Trace Elements
 - Specific nutrients
- Outdoor RAS
 - Mimic indoor methods
 - Trials in baskets to determine stocking densities
 - Growout



Macroalgae production

- 12 baskets, 15L each
- Stocking density: 4-8 g L⁻¹
- Production target:
 - Specific growth rate: 2% day⁻¹
 - Yield: ~1 kg month⁻¹ total



Production summary

- Organisms from locally sourced parentage
- Quarantined and maintained in closed recirculating systems
- Reproduced under controlled conditions
- Subject to health screening
- Transported in insulated live haulers with aeration and water exchange, as appropriate



Red drum culture



Red drum production

- Stocking density for larviculture: 20-25 larvae/L
- Survival at 30-35 DPH: 45-60%
- Size at end of the LR: approx. 0.3 g, 3 cm TL
- Feeding at end of LR: 8% BW decreasing to 5% by 50 DPH and down to 3% by 70 DPH
- Aquafort stocking: 4000 juveniles at 40-60 g, 12-15 cm TL
- Aquafort feeding: 5% BW initially decreasing to 3% BW
- Target harvest size: 800-1000g, 38-45 cm TL, 7-8 mo. culture time

Production Overview:

AquaFort growout

- Red drum fingerling pellet diet will begin at a rate of 5% of body weight per day initially, with multiple daily feedings during the first week of fish deployment. Afterwards, red drum will be fed at a lower rate than the initial fingerling acclimation feed rate (TBD)
 - Growout will last 6-8 months for 2 growout seasons
 - Farm will be visited 3-4 times a week to feed by hand, and also equipped with solar cell automated feeders for feeding during inclement weather when participants can't visit the AquaFort to feed.
 - Farming participants will load feed, clean the nets, clean and maintain oyster cages, and maintain data collection equipment.
- Species will be examined monthly for growth and survival, finfish will be sampled for feed conversion ratios and oysters will be split as they grow to provide adequate space for growth.
- A ROV will be used to inspect net pens for holes and to look for any dead fish, which will be recorded and removed by participants.
- To reach a target harvest weight of 1 kg/fish, stocking would be limited at 15,000 fingerlings at 100-150 g/fish. This is based on max annual production of ~30,000 lbs of fish.

Red drum pellet diet composition for fingerling size and grow out size groups based on pellet data from Rangen™ Red drum Feeds.

Size category	Crude protein	Crude Fat	Crude Fiber	Moisture	Ash	P
Fingerling	55	17	1	12	9	1.2
Grow out	44	13	1	12	9	1.1

Production Overview:

Harvesting

- Animals and macroalgae will be harvested in cooperation with farm participants at the end of the growout season (May) using dipnetting and seining to capture fish in net pen, placed in cooler with saltwater ice slurry for 15-20 minutes.
 - Red drum will be sold by participating farmers at local markets, oysters will be used for research and restoration purposes, but not sold for consumption.
 - Red drum to be sold at market will be identified as separate from wild harvested individuals by the use of numbered external tags placed during harvest. Numbered tags will be controlled and an ID list will be maintained by the lead organizations.



Integrated Multi-Trophic Aquaculture • Initial Stakeholder Engagement • Species Information

Megan Gima, Angelos Apeitos, Egan Rowe, Reginald Blaylock



EASTERN OYSTER (*Crassostrea virginica*)

DISTRIBUTION

- Gulf of St. Lawrence to the Gulf of Mexico to Yucatan Peninsula of Mexico, Brazil, Argentina and Venezuela.

HABITAT

- Estuarine, shallow saltwater bays and lagoons. Inhabits intertidal zones to water 35 feet deep.

MORPHOLOGY

- Sessile, broadcast spawning bivalve averaging 3-5 inches, reaching 8 inches. Hinged flat top shell and cupped bottom shell. Exterior of shell is white, off-white, brown, green, and purple.

TEMPERATURE

- Surviving 28 to 120°F for short durations. Optimal range: 68-86°F.

SALINITY

- Surviving 3 to 40 ppt. Optimal range: 10-28 ppt.

USES

- Ecological and economic significance. Utilized for half-shell and pre-shucked markets. Creates reef habitats for fish, invertebrates, macrofauna, and birds. An adult oyster filters 50 gallons of water per day.



WHITE CROAKER (*Genyonops tectirostris*)

DISTRIBUTION

- Massachusetts to Key West, Florida, and along the Gulf Coast to Tuxpan, Mexico.

HABITAT

- Larvae migrate from offshore to inshore environments with currents. Juveniles and young adults live in estuaries, adults migrate offshore.

MORPHOLOGY

- Iridescent silver-gray with a copper cast that is darker on top. One or more oscillated spots on upper sides often between the dorsal fin and the tail.

TEMPERATURE

- 52-95°F, optimal 70-90°F. Mid-late fall spawners when temperature is 72-81°F.

SALINITY

- Euryhaline (Fry-young adult), 27-35 ppt. (Larvae and Spawning Adults) 30-35 ppt.

USES

- Consumption (fresh, frozen). Cooked whole/ processed, raw. Sport fish for recreational angling/restoration.



GREEN SEAWEED (*Ulva* spp.)

DISTRIBUTION

- North American coastline from the maritime provinces of Canada to southern Mexico.

HABITAT

- Common in estuaries or bays, intertidal or shallow subtidal areas, attached or free floating, at 3-164 feet in depth.

MORPHOLOGY

- Highly variable, flattened thallus typically 4-6 inches tall, which is comprised of rounded branches irregularly or dichotomously branched, color ranges from dark green to shades of red and brown.

TEMPERATURE

- 32-95°F with an optimal range of 68-82°F.

SALINITY

- Euryhaline with an optimal range of 25-33 ppt.

USES

- Agar, food additive, vegetable, animal feed, fertilizer, biofuels, model organism for Gulf of Mexico research and development.

ACKNOWLEDGEMENTS

This project is funded through an award provided by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration and the Gulf States Marine Fisheries Commission.

Site information:

IMTA cage site characteristics

- Average depth of ~11m (36 ft)
- Geologic characteristics:
 - Relatively uniform sandy sediments, comprised of similar grain size.
 - No seafloor features or complex habitat.
 - Sub-bottom geologic profiles showed penetration of up to 45m, with a homogenous subsurface in first 5m and no clear signal of significant buried rocks or any other material in the first few meters.
 - No indication of significant areas of accumulation of unconsolidated sediment.
- Environmental characteristics - Fall-Spring (NDBC buoy station 42012, ~40 km SE from IMTA site)
 - Temp- 15-31°C (59-88°F)
 - Salinity- 27-30 ppt

Bathymetric surface for IMTA cage site (m). Results are from 'Baseline environmental survey for IMTA' report by the Hydrographic Science Research Center at USM.

