Biofouling

Evaluating the Efficacy of Several Net Coatings in Reducing Biofouling on Culture Gear and Improving Hard Clam Production in Florida

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Introduction: Biofouling

- Process by which submerged objects are colonized by marine organisms (plants and animals) in successional phases
- Various factors affect biomass and composition of community
  - Surface type, location, season
  - Competition, predation
- Dominant colonizing organisms
  - Sessile suspension feeders
    - Soft: tunicates, hydroids, soft corals
    - Hard: oyster, barnacles, tube worms
  - Macroalgae

References: Cook et al. 2006, D'Souza et al. 2010, Railkin 2004, Willemsen 2011

Introduction: Biofouling

- Affects both natural and artificial marine structures
- Affects shellfish culture gear
  - Increases loads
  - Weakens structures
  - Increases maintenance
  - Reduces life span of gear
- Affects cultured shellfish stocks
  - Competes for space and food
  - Alters water flow
  - Reduces nutrient exchange, waste removal, dissolved oxygen
  - Reduces growth and yields
  - Increases mortality

References: Braithwaite et al. 2007, Creswell and McNevin 2008, Watson et al. 2009, Willemson 2012 2011

Introduction: Biofouling

- In Florida, biofouling can be problematic year-round
- Hard clams are cultured on-bottom in polyester mesh bags or under bottom nets
- Some biofouling on the clam shells may occur
- Majority of biofouling colonizes the bags, cover nets, gear

Present State of Knowledge: Biofouling

- Strategies used by the aquaculture industry to control biofouling
  - Mechanical cleaning
    - Spraying, brushing, air drying, dipping of gear in solutions (e.g., acetic acid, brine, lime)
    - Labor intensive, time consuming, increases operating costs
  - Antifouling paints, metal-based biocides
    - Copper (CU_2O), leaches and concentrates in shellfish tissues
  - Coatings, natural and biocide-free (non-toxic)
    - Secondary metabolites from organisms that appear to inhibit fouling
    - Self-polishing surfaces and/or release compounds that interfere with setting

References: Braithwaite et al., 2007, Callow and Callow 2010, Chambers et al. 2006, Clare 1996, CRAB 2011, Fitridge et al. 2012, Munari and Mistri 2007; Rittschof 2000

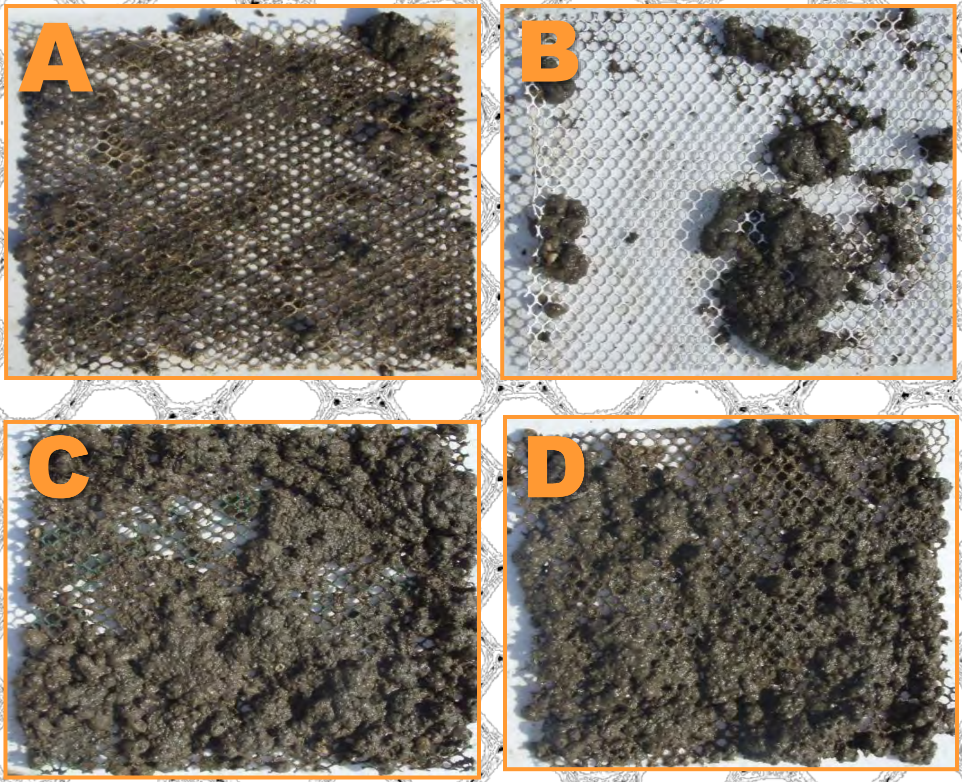
Present State of Knowledge: Biofouling

- In preliminary study, two foul-release, biocide-free coatings were tested on clam bag material in Cedar Key, FL (Cassiano et al. 2012)
  a) Photoactive release
  b) Silicone-based release
  c) Alkyd-based (stiffens mesh)
  d) Uncoated (control)

Reference: Cassiano, E., A.Croteau, G. Smith, L.Sturmer, and S.Baker. 2012. Addressing biofouling in Florida's hard clam aquaculture industry: performance of two net coatings. Journal of Shellfish Research 31(1):268A.

Present State of Knowledge: Biofouling

- After 3 months, Trts A and B had significantly less biofouling wet weight and coverage than Trts C and D



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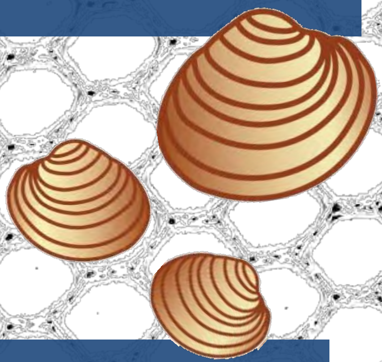
2014-15 Aquaculture Review Council Project



Objectives

- Evaluate effects of biocide-free antifouling coatings on hard clam production at shellfish aquaculture leases
- Assess biofouling levels on treated and untreated clam culture bags after 11 months in growout
- Document man-power associated with post-harvest maintenance of treated and untreated bags
- Conduct a cost benefit analysis of clam culture using bags with foul-release and foul-inhibiting coatings

Methods:
Biocide-free Antifouling Coatings

Treatment	Coating Description
A	Control, none
B	Silicone-based foul release, elastomeric sealant
C	Silicone-based foul release, with nanorepellant structures ("fuzzy")
D	Slicone-based foul release, with fluoropolymer properties to block adhesion ("slick")
E	Commercial, water-based photocatalytic, self-polishing release
F	Experimental, water-based photocatalytic, self-polishing release

Methods: Antifouling Coating Application

- Only one side of bag coated
  - Except Trt F, both sides of bag coated by manufacturer
- Bags tented after application
- Air dried / cured 4-20 days
- Each bag individually weighed
- Three replicate bags per coating treatment
- Three growout test sites
- At one site, two culture periods
- Total 12 growout bags per treatment coated for study

Methods: Field Trials - Planting

- Planted June-July 2014
- Growout seed – 17-21 mm SL
- Stocking density – 1,150/bag
- One bag per treatment in belt randomly assigned
- Three replicate belts per site
- Three lease sites planted
  - Dog Island HDLA, Levy County
  - Gulf Jackson HDLA, Levy County
  - Alligator Harbor AUA, Franklin Cty
- Growout period evaluation
  - Minimum 11 months at all sites
  - At Dog Island site, also evaluated bags after 7 months

Methods:
Field Trials – Harvest and Sampling

- Care taken at harvest not to dislodge fouling
- Production parameters measured at harvest
  – Survival
  – Growth
    - Shell length
    - Shell width
    - Total (individual) weight

Results: Clam Production Dog Island HDLA, Cedar Key

Treatment	Width (mm)	Survival (%)	Yield (lb/bag)	Value ($/bag)
A	26.1	96.4	86.2	94.83
B	26.1	95.1	84.4	92.85
C	26.2	94.2	85.0	93.53
D	26.4	93.7	85.8	94.39
E	27.0	93.4	92.1	101.35
F	26.7	92.1	87.6	96.41
p value	0.6049	0.9309	0.9633	0.9633

Clam production characteristics significantly different if $p<0.05$.

Yield determined by multiplying average clam weight with average number of live clams per bag.

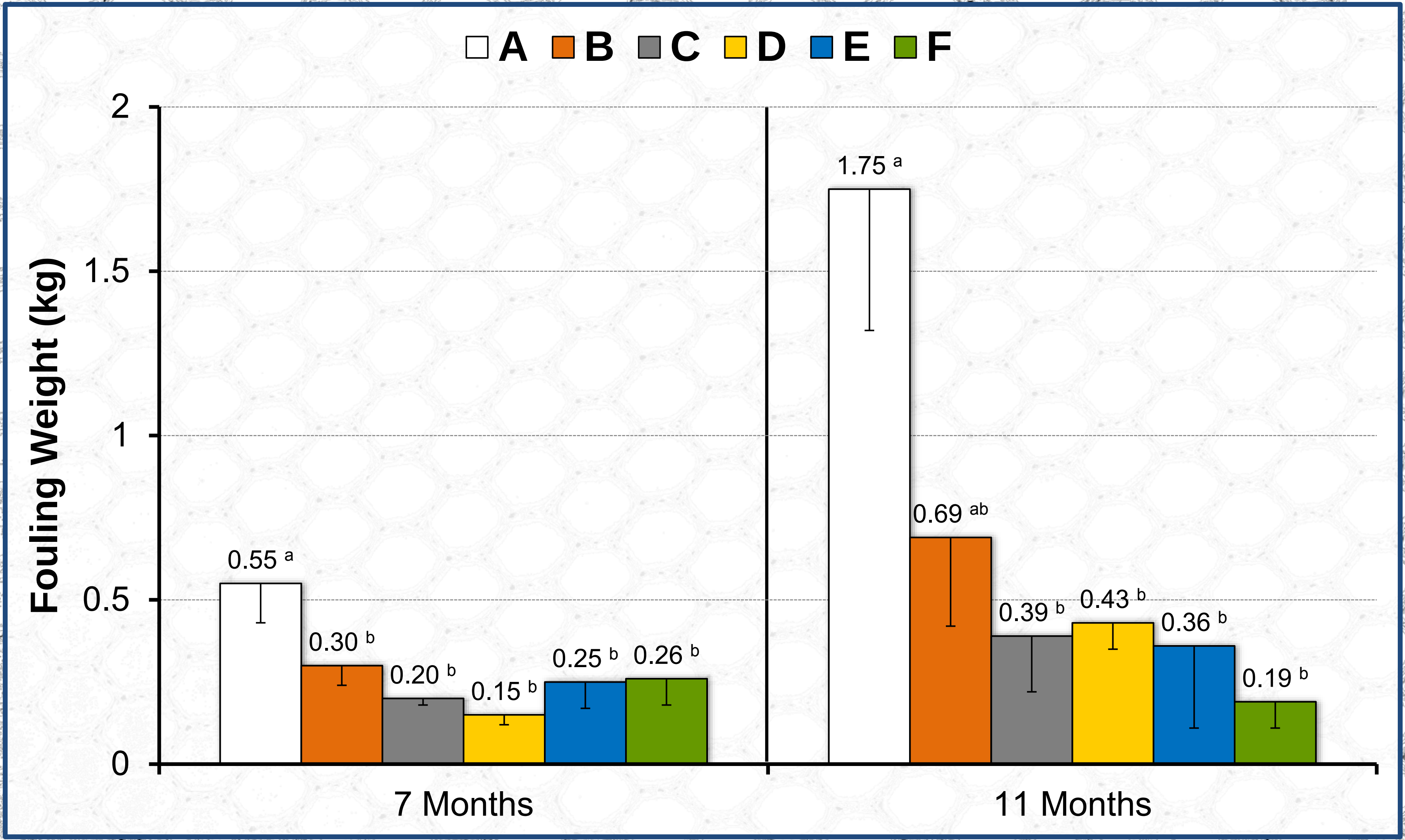
Value assessed by using current price obtained from shellfish wholesaler of $1.10 per pound.

Methods:
Biofouling Weights of Culture Bags

- Clam bags weighed indivi-dually 4 hours after harvest
  - Allow excess water to drain
- Using weights of bags prior to deployment, weight of fouling organisms determined
- Data analyzed by general linear modeling analyses and Tukey's HSD post-hoc test
- Differences significant if $p<0.05$

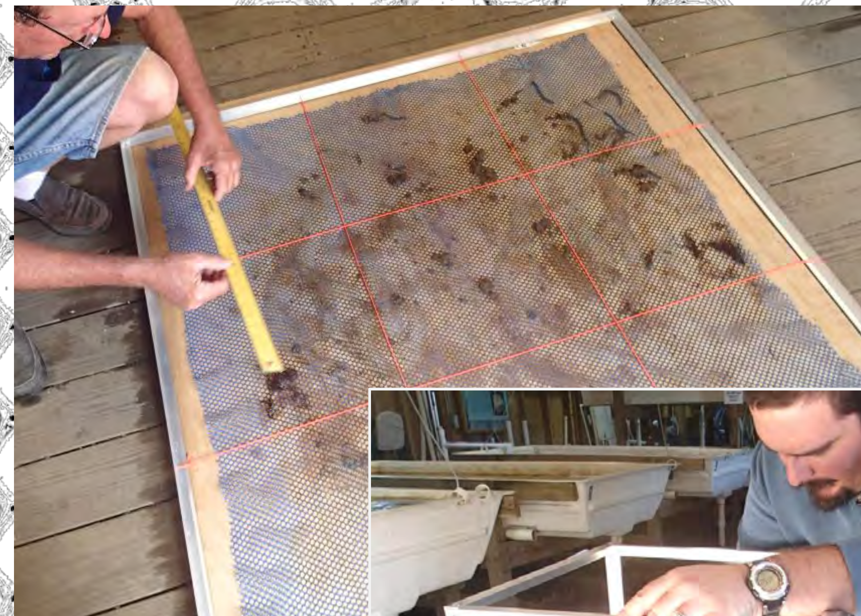
Results:

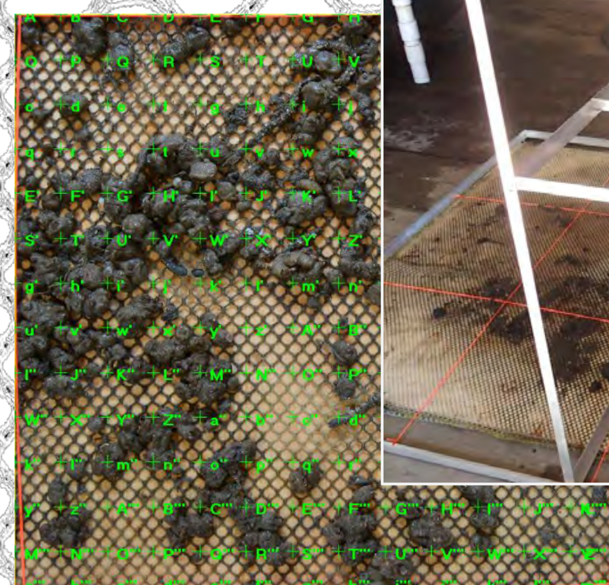
Biofouling Weights of Culture Bags

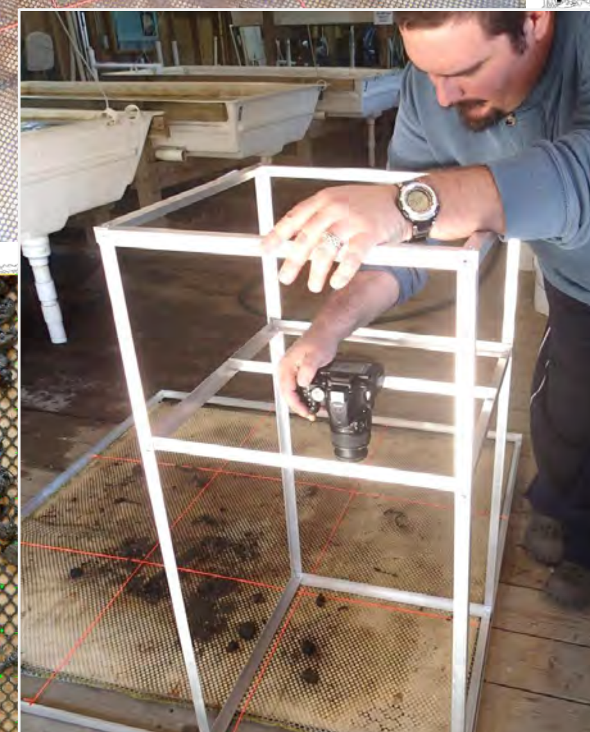


Methods: Biofouling Coverage of Bags

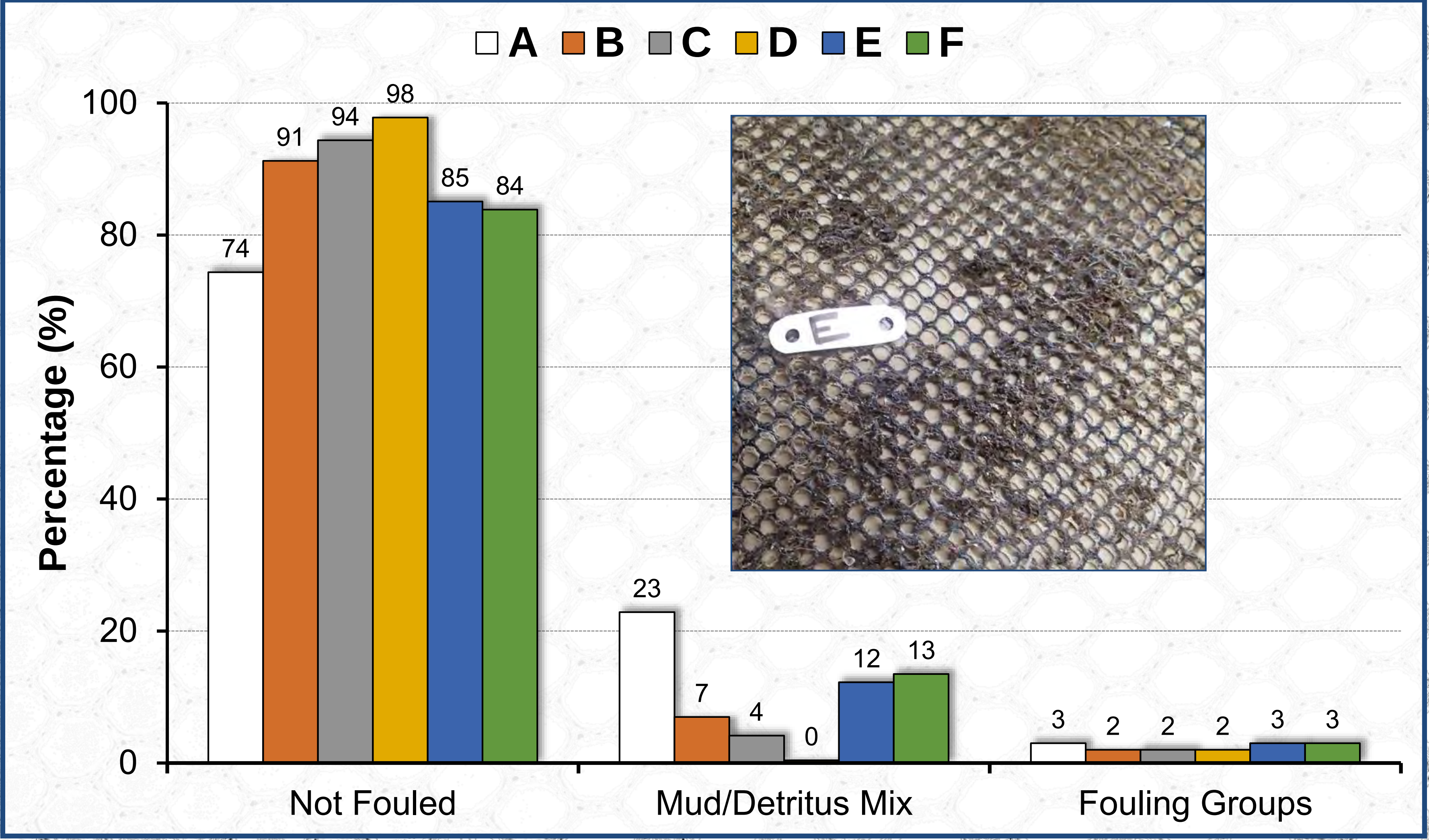
- Two Dog Island replicates evaluated at 7 and 11 months
- After weighing, a grid of nine sections placed on each bag
- Each section photographed, measured, standardized
- Sections analyzed using Coral Point Counter software
  - 117-200 points per grid
- CPC code developed
  - Not Fouled points
  - Fouled points
    - Mud / detritus mix
    - Dominate fouling groups



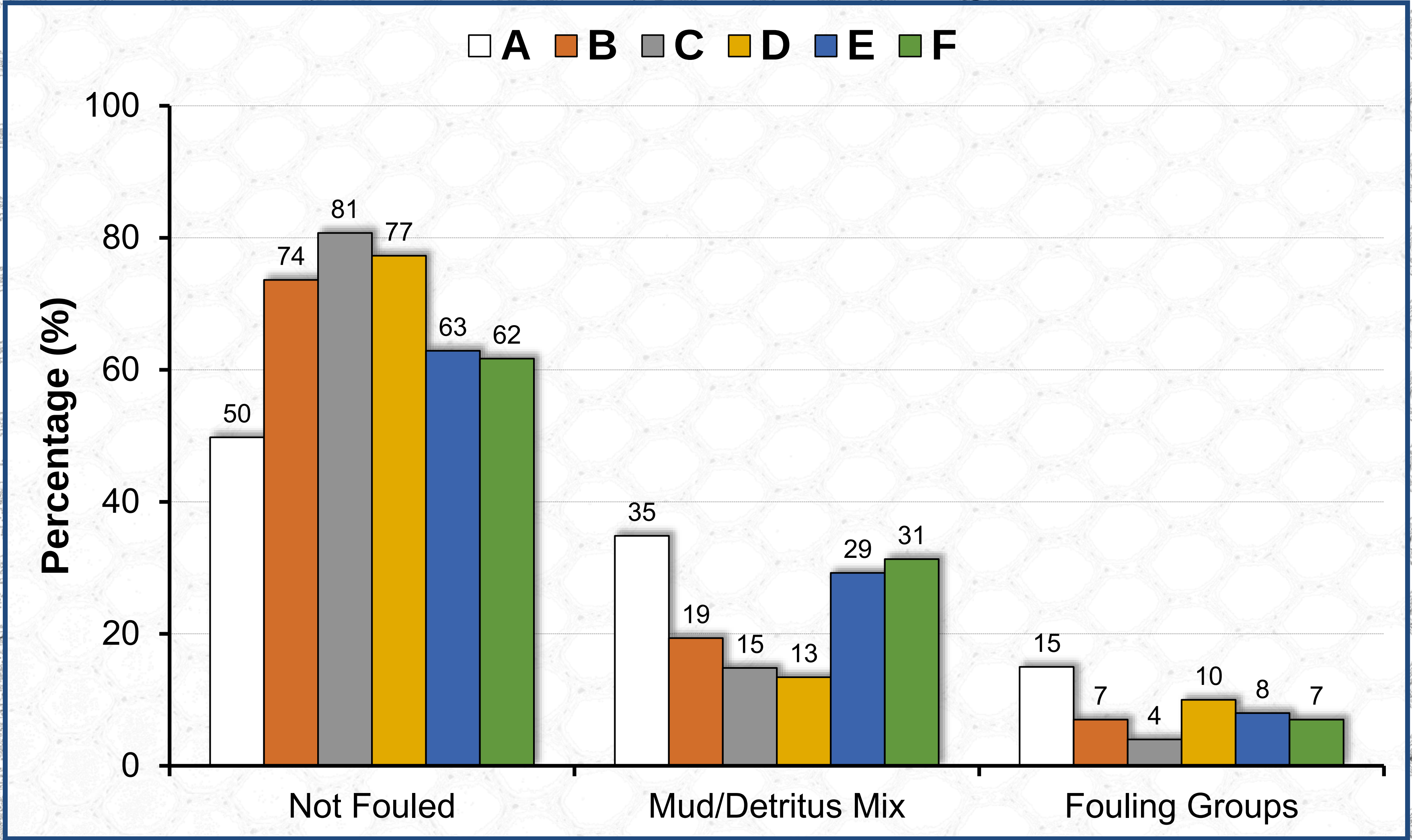




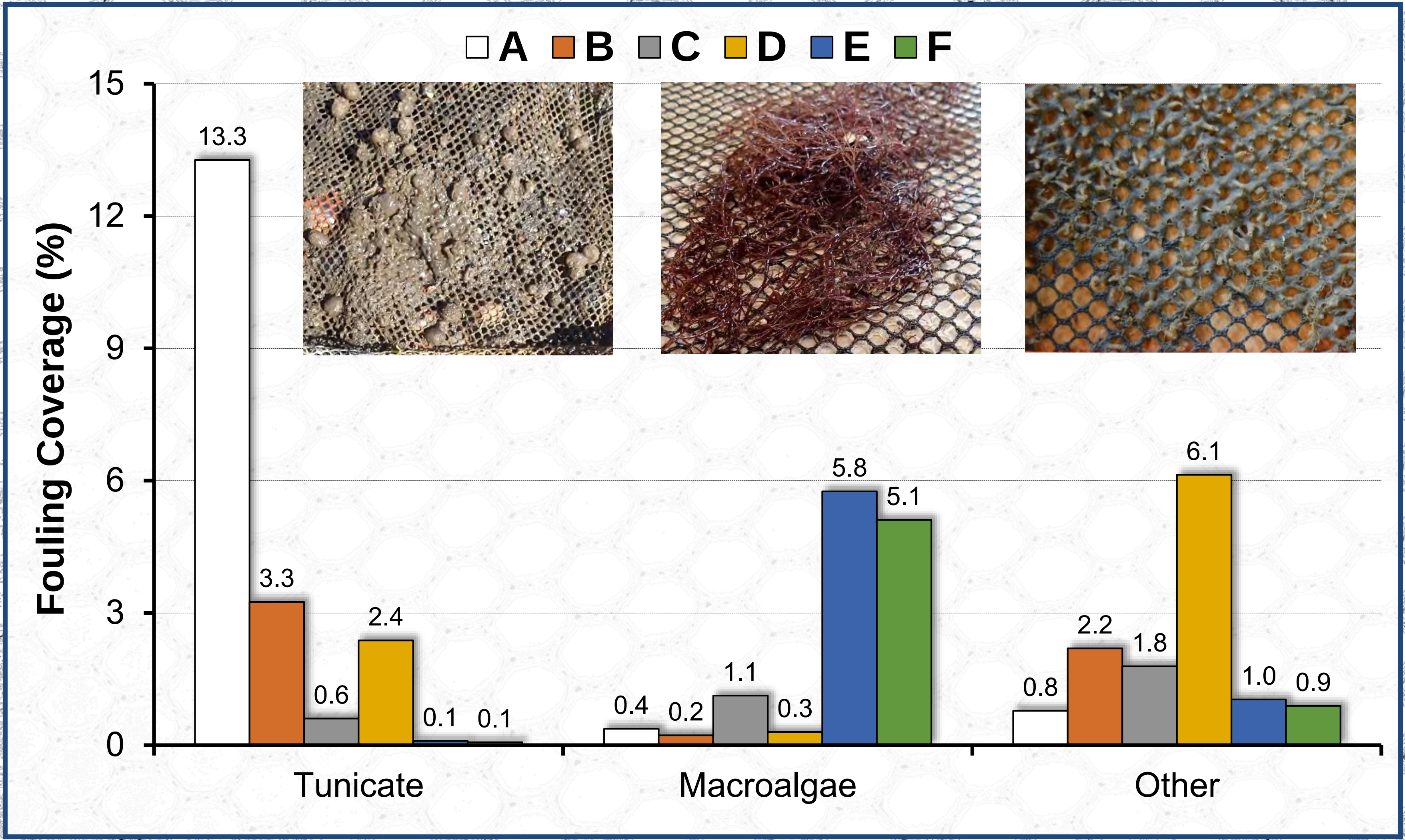
Results: Biofouling Coverage of Culture Bags after 7 Months



Results: Biofouling Coverage of Culture Bags after 11 Months



Results: Biofouling Coverage of Culture Bags after 11 Months



Methods:
Post-harvest Maintenance of Bags

- Two Dog Island replicates evaluated at 11 months
- Three-step process to remove biofouling from bags
  1) After 24 hours post-harvest, shake each bag over tarp for a set amount of time
  2) Air-dry for three weeks, then repeat first step
  3) Remaining organisms removed by hand
- Time and effort documented

Results:

Time and Costs to Clean Clam Bags

Treatment	Cleaning Time per Bag (min)	Bags Cleaned per Hour (#)	Cleaning Cost per Bag ($)
A	10.8	5.6	1.45
B	5.1	13.3	0.60
C	3.8	15.8	0.51
D	3.8	16.2	0.50
E	3.9	15.4	0.52
F	3.2	18.9	0.43

Used a minimum wage of $8.05 to calculate cleaning costs.

Methods: Cost–Benefit Analysis

- Potential benefits include
  - Higher clam yields
  - Increased dockside value
  - Lower maintenance costs
  - Culture gear life extended
    - Due to project time frame, bag life not evaluated
- Costs include
  - Biocide-free, antifouling coating
  - Labor to apply coating
    - Not considered due to process used in this study
  - Labor to clean bag after harvest

Results:

Costs of Biocide-free Antifouling Coatings

Treatment	Volume to Coat 12 bags (gal)	Price ($/gal)	Cost ($/bag)
A	--	--	--
B	1	118.74	9.90
C	1.5	204.41	25.55
D	1	450.00	37.50
E	0.75	28.00	1.75
F	--	--	--

Requested price quotes for largest volume (up to 50 gal drum) sold by manufacturers.

Treatments B, C, D recommended by FIT Antifouling Coatings Research Facility, where researchers test antifouling systems for ship performance; only available in volumes of five gallons or less.

No pricing available at time of study for Treatment F coating.

Results: Cost–Benefit Analysis

- Total costs lowest for uncoated (control) bags despite longer cleaning time and costs
- Among coated bags, treatment E had lowest total costs
- Production results had large variation, no significant benefits realized
- Excessive rainfall in winter/spring of 2014 resulted in lower and fluctuating salinities at field sites
- Settlement patterns of dominate fouling organisms disrupted
- Fouling biomass lower than anticipated in this study
- One commercial coating may be cost-effective, if it’s application not only reduces biofouling but improves production
- Under different environmental conditions and higher biofouling levels, this coating may offer viable fouling control

Manufacturers of Biocide-free Antifouling Coatings

Treatment	Coating Description	Manufacturer
A	Control, none	--
B	Silicone foul release, elastomeric	CSL Silicones, Inc.
C	Silicone foul release, nanorepellant	Jotun Paints, Inc.
D	Silicone foul release, fluoropolymer	International Paint
E	Commercial, water-based photocatalytic, self-polishing release	Netminder®
F	Experimental, water-based photocatalytic, self-polishing release	Netminder®

Treatment F is currently the commercial formula used by Netminder.

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Shellfish growers must adhere to their lease agreement and BMPs. Nets and net coatings placed in state waters must be clean and free of pollutants (Chapter 5L-3, FAC). Information gained may be used by coating manufacturers in seeking approval of the DACS Division of Aquaculture for specific use on shellfish culture gear and placement on “approved product list.”


ADAM H. PUTNAM
COMMISSIONER OF AGRICULTURE

Shellfish Nets and Net Coatings

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Netting is Critical to Clam Farming

Regulatory Facts

- The discharge of pollutants (including oil of any kind or in any form, gasoline, pesticides, ammonia, chlorine, and derivatives thereof) into or upon any coastal waters, estuaries, tidal flats, beaches, and lands adjoining the seacoast of the state is prohibited.
- The use of petroleum derived coatings on clam bags, cover nets, markers and any other associated equipment placed on sovereign submerged lands is prohibited.
- New shellfish production equipment must be approved by the Department.

Inside this bulletin:

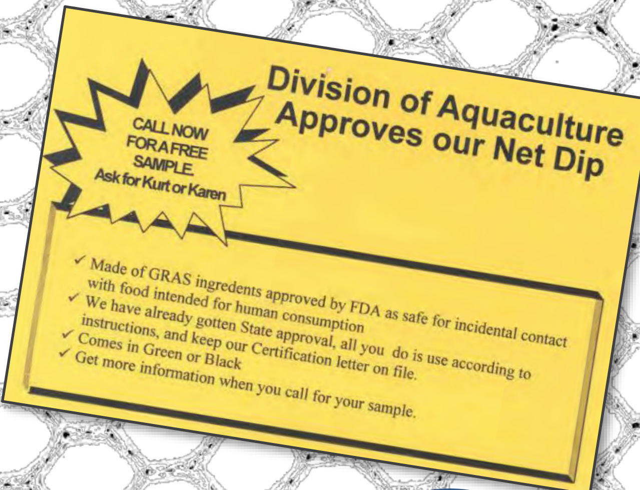
Hard clam farmers use submerged state lands to plant their crops and take advantage of Florida's coastal waters that are rich in phytoplankton. These microscopic plants are a natural and abundant food source for clams, oysters, mussels and scallops. Farm-raised hard clams are usually enclosed in polyester mesh bags that are secured to the bottom. The bags conveniently contain the clams for ease of handling and protect them from a variety of predators. Sediments naturally filter through the mesh and the clams dig down into the bottom for protection. To feed, clams push their siphon up through the mesh to filter out phytoplankton, dissolved organic matter, and organic particles.

Low tide briefly exposes an array of planted clam bags.

To enhance predator protection and reduce wear and tear, some farmers treat the clam nursery and grow out bags with various colored (i.e., black or green) or clear coatings to stiffen the fabric. Skates, rays, black drum, and blue crab are efficient clam predators that can cut through untreated, exposed netting or crush clams inside the bags and consume the soft meats. Untreated polyester mesh is also weakened through physical scouring by wave and current-driven sediments. Holes appear or the weakened netting tears during harvest that results in the spilling of a valuable crop on board harvest vessels or at sea causing the loss of months of work and investment.

Different mesh sizes are used to protect clams during production.

Aquaculture BMPs Regulate Nets and Net Coatings



Questions?