

Clam Hybrid Culture

Results of Growout Production Trials

Leslie Sturmer, Shirley Baker, Eric Cassiano
University of Florida, Institute of Food & Agricultural Sciences
John Scarpa, Harbor Branch Oceanographic Institute at FAU



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Improving Shellfish Aquaculture
Production Session
Aquaculture 2010*



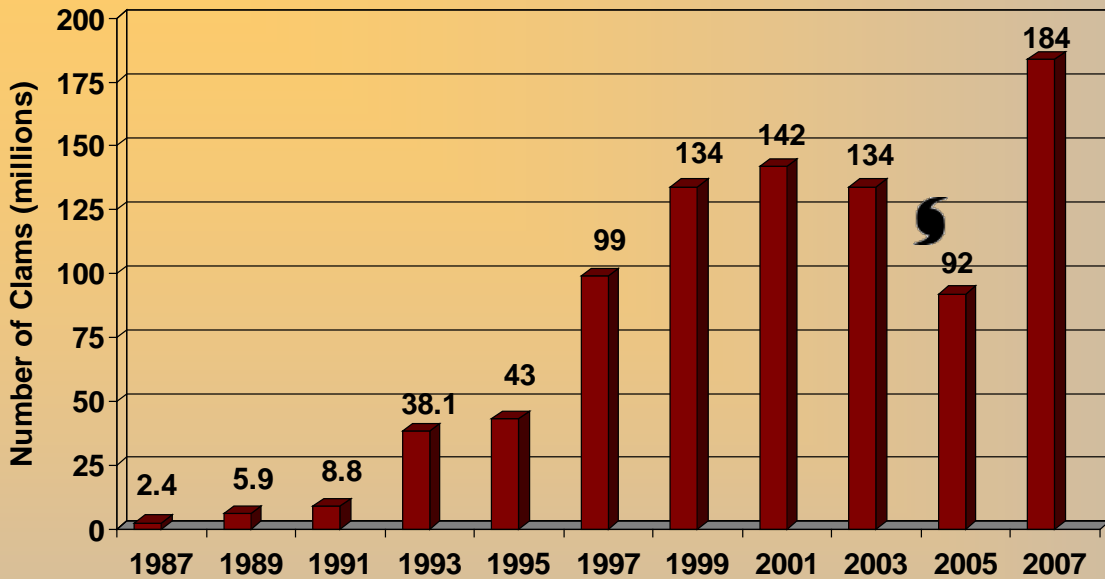
Florida Clam Culture



- Clams grow fast
 - 12-18 month growout from seed (12 mm SL) to littleneck size (25 mm SW) clam
 - One half to third of crop times of other states
 - Year-round growing conditions
 - Subtropical water temperatures
 - High natural productivity levels
- Clams are available year round
 - Plant and harvest continuously



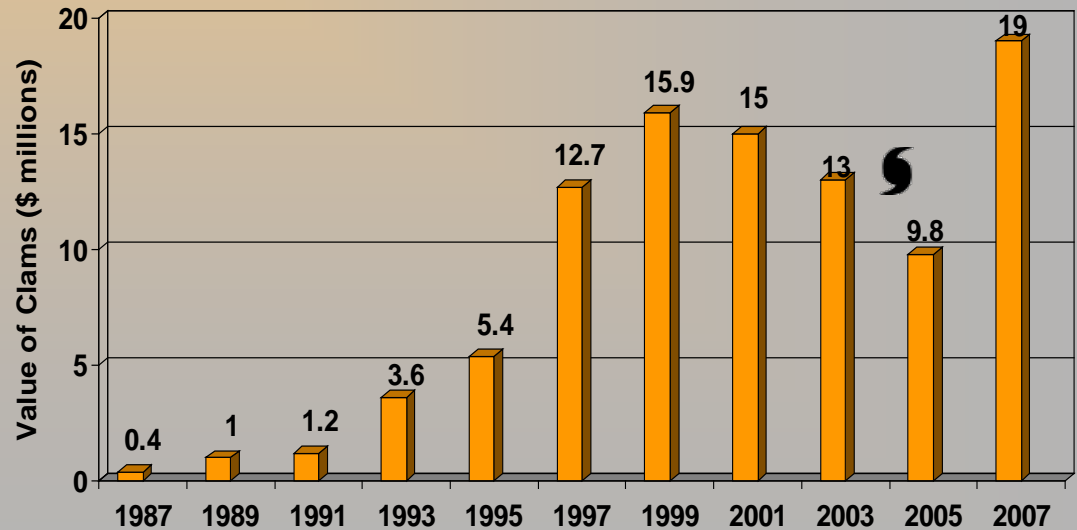
Florida Clam Culture Industry, 1987-2007



Production



Sales Value



1987-2005 Compiled from Florida Agricultural Statistics Service's survey of aquaculturists

2007 Compiled from University of Florida survey of shellfish wholesalers

Why improve upon a good thing?

- Increasing unreliable production
- Increasing summer crop mortalities (>50%)
 - High water temperatures and other environmental stressors during prolonged summer months

Improvement of Cultured Clam Stocks through Hybridization

- Hybridization is a common breeding technique
 - Used in commercial agriculture and finfish aquaculture
- Hybrids have superior traits to either parent species
 - For example, improved growth or environmental resistance
- The use of clam hybridization for “mariculture” potential was examined by Winston Menzel at Florida State University in the 1960-70s
 - Showed hybrids had improved growth, shelf life
 - Little data reported on merit of hybrids for improved survival
- **This project allows for a rigorous examination of clam hybridization**
 - **To improve production**
 - **To assure product quality**

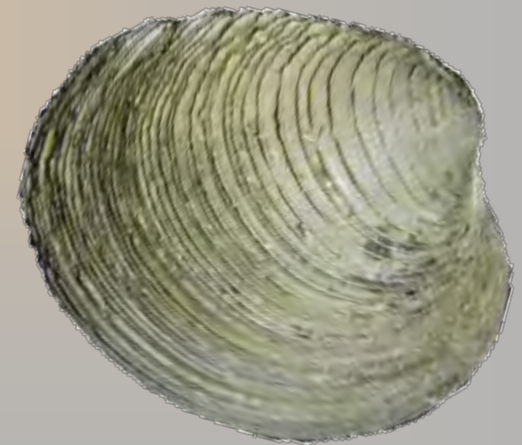


Clam Species

- The northern hard clam supports fisheries and aquaculture industries along Atlantic coast from MA to FL
- The southern quahog found from NC to Caribbean, recreationally fished in FL
 - May have production traits for resisting environmental stressors
 - Not cultured because of their tendency to gape in refrigerated storage
- *Mercenaria* species are normally separated by environmental tolerances, but readily hybridize where they do co-occur or under hatchery conditions



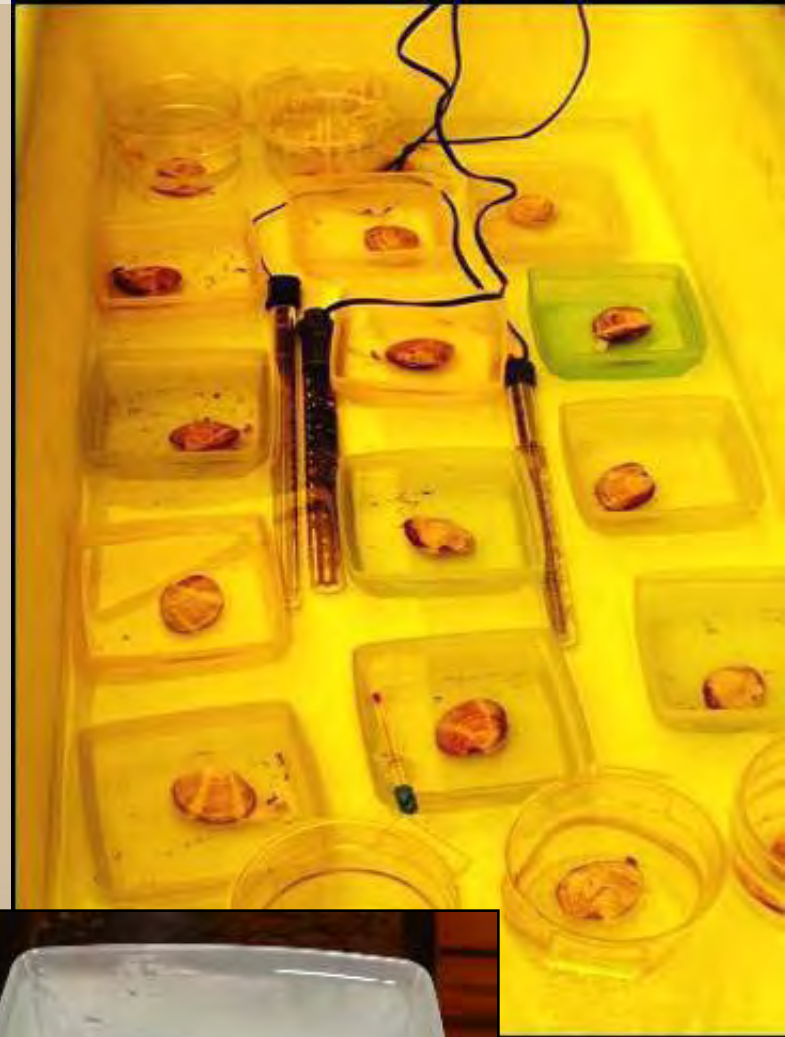
Northern hard clam
Mercenaria mercenaria
notata



Southern quahog
Mercenaria campechiensis

Hatchery Production

- Northern hard clams obtained from a Florida hatchery
- Southern quahogs obtained from the wild (Sarasota), where highly pure populations are known to exist
- Single parent crosses utilized
- Multiple spawns accomplished with different sets of parents, October-December, 2007
- Stock verification by allozyme method
 - Arnold and Geiger, FWC FWRI



Nursing Hybrid Seed

- Standard hard clam protocols used
- Land-based nursing
 - Downwellers
 - March-June 2008
 - Cedar Key, FL
- Field nursing
 - Bottom bags, 4 mm
 - June–September 2008
 - Cedar Key, FL

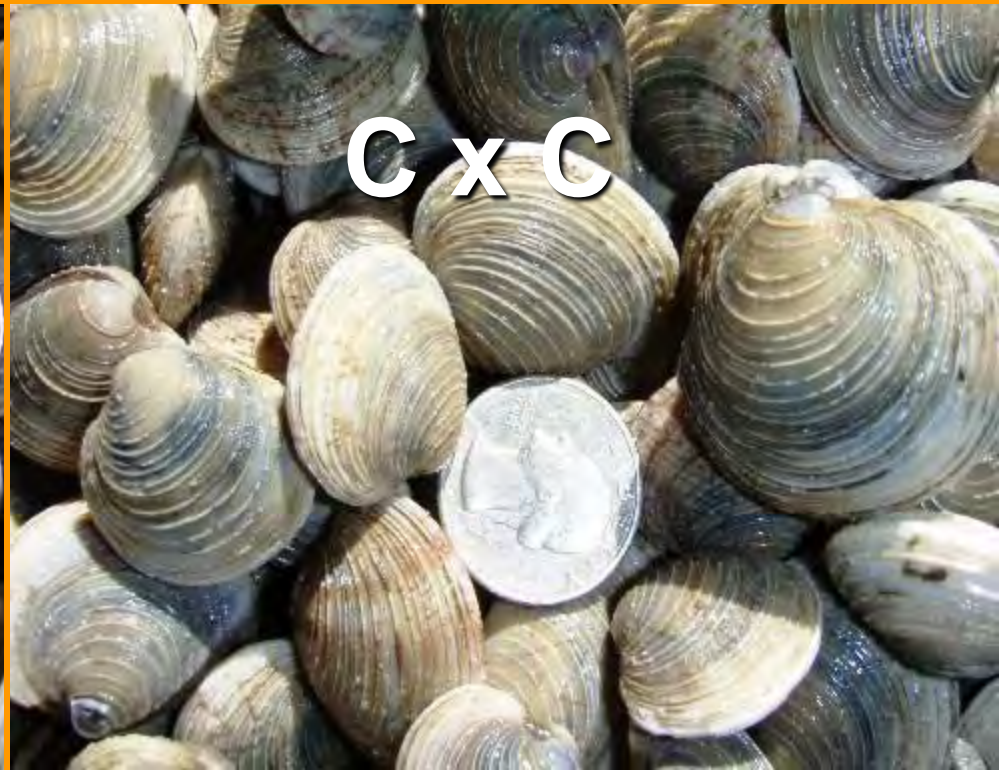


Nursing Hybrid Seed

- Growth differences negligible
- Survival rates not statistical different
- About 600,000 seed from three families nursed for growout evaluation



Stock	Survival (%) Average \pm SD
M x M	72.9 \pm 11.5
M x C	82.4 \pm 16.9
C x M	79.5 \pm 4.6
C x C	86.1 \pm 4.9



Growout Trials

Stock Comparison

- Replicated plants -
Parental stocks and
reciprocal crosses
from 3 families
 - 146K seed
 - Cedar Key, FL
 - Sept 2008-Sept 2009
- Standard planting
procedures
 - Bottom bags, 9 mm
 - Net coated and
covered with wire
 - Stocked at 1150/bag
(72/ft²)



Growout Trials

- Site Comparison
 - 190K distributed to 8 growers in 3 counties
 - Cedar Key, FL
 - SW Florida
 - FL Panhandle
- Gear Comparison
 - Bottom bag
 - Bottom plant
- Stocking Density Comparison
 - Parental stocks and reciprocal crosses from 1 family
 - 88K seed
 - Cedar Key, FL
 - Sept 2008-Sept 2009
 - Bottom bags stocked
 - 960/bag (60/ft²)
 - 1150/bag (72/ft²)
 - 1360/bag (85/ft²)



Comparison of Production Characteristics

- Sampling every 4 months and at harvest (12 months)
- Growth – SL, SW, total and dry meat weight
- Survival
- Condition index – measure of degree of fattening or nutritive status
- Histology – determine gonadal stage and reproductive potential



Commercial Market Sizes

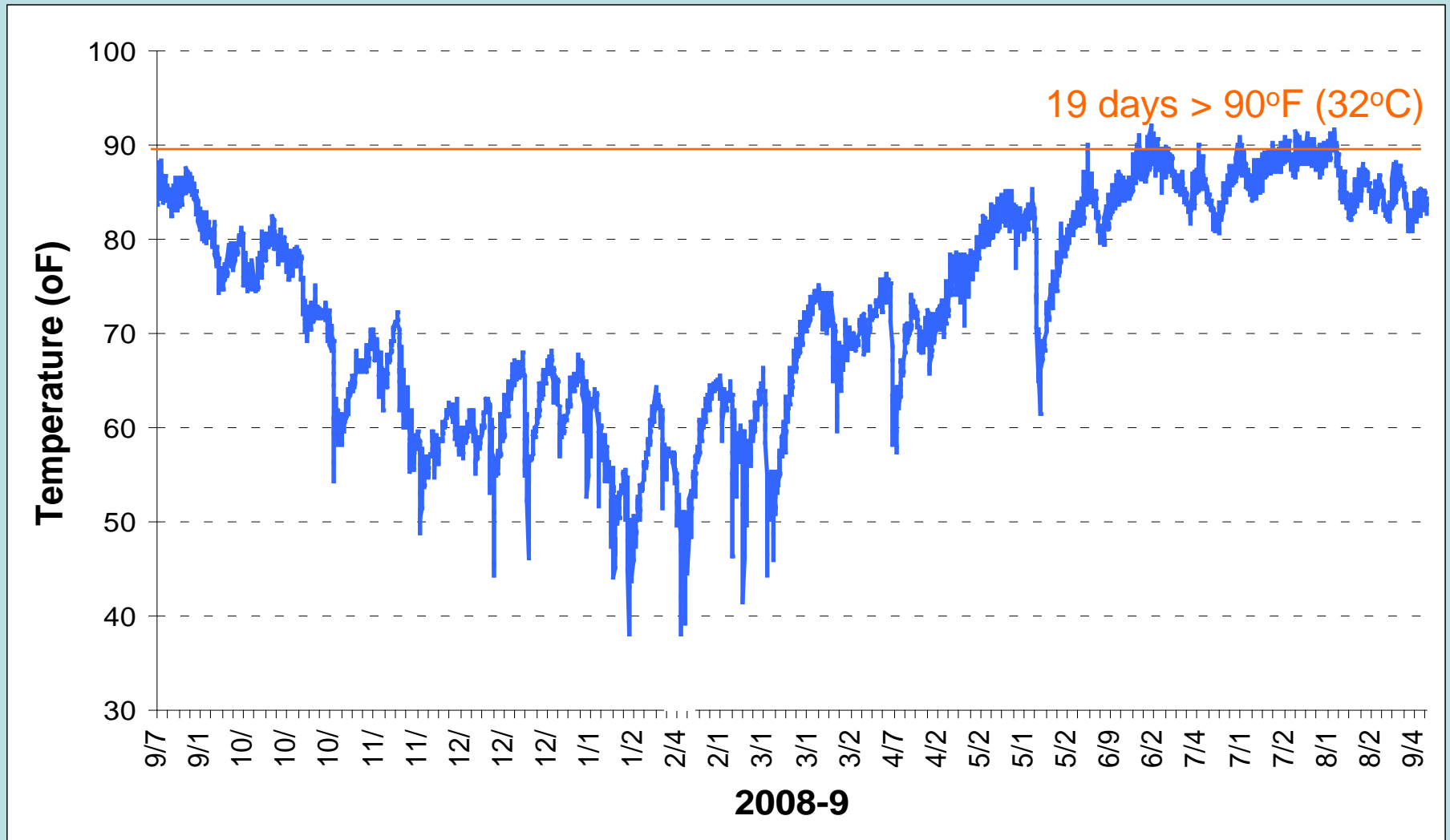


Common Name	Shell Width/ Hinge Size (inches)	Number per Pound
Littleneck	1"	10-13
7/8 inch	7/8"	14-18
Pasta	3/4"	18-25



Water Temperature (°F)

Dog Island Lease Area, Cedar Key
September 2008- September 2009



Water temperature measured every 30 minutes with YSI 6600 data sonde

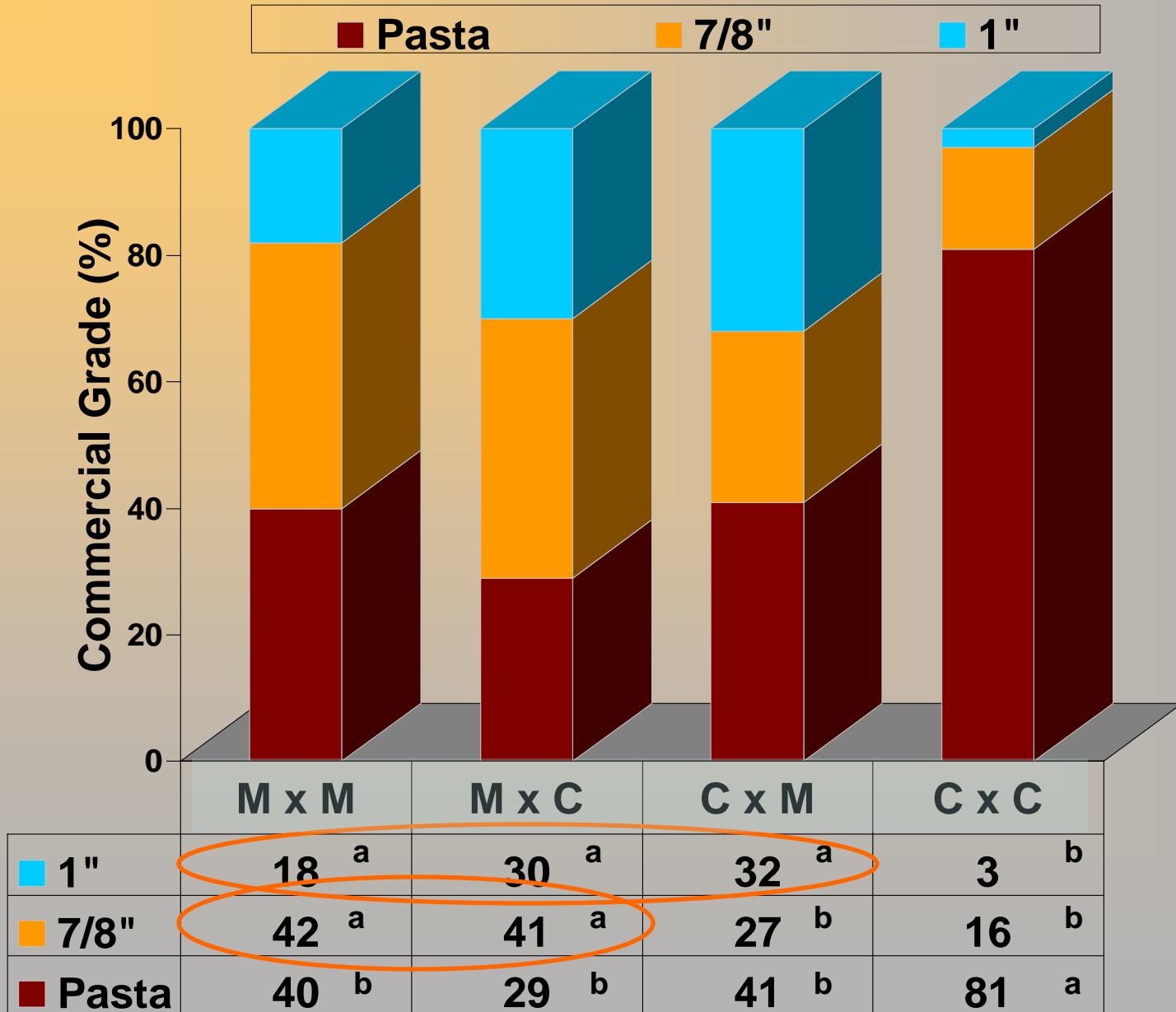
Harvest Results (12 months)–All Families

Average \pm Standard Deviation

Stock	Shell Width (mm)	Total Weight (g)	Dry Meat Wt. (g)	Survival (%)	Production (lbs/bag)
M x M	23.1 $\pm 1.2^b$	26.8 $\pm 3.7^a$	0.59 $\pm 0.09^{bc}$	93.3 $\pm 15.4^a$	62.8 $\pm 9.6^a$
M x C	24.3 $\pm 0.8^a$	30.2 $\pm 2.7^a$	0.73 $\pm 0.08^a$	99.5 $\pm 8.3^a$	76.1 $\pm 8.2^a$
C x M	23.3 $\pm 3.1^{ab}$	27.5 $\pm 9.1^a$	0.68 $\pm 0.20^{ab}$	90.9 $\pm 23.5^{ab}$	67.2 $\pm 33.0^a$
C x C	20.4 $\pm 1.3^c$	17.3 $\pm 3.0^b$	0.52 $\pm 0.10^c$	72.3 $\pm 25.3^b$	32.5 $\pm 13.9^b$

Note: ANOVA were performed using the PROC GLM procedure of SAS. Treatment means were considered significantly different when $p \leq 0.05$. Tukey's test groupings are displayed

Harvest Results (12 months) – All Families



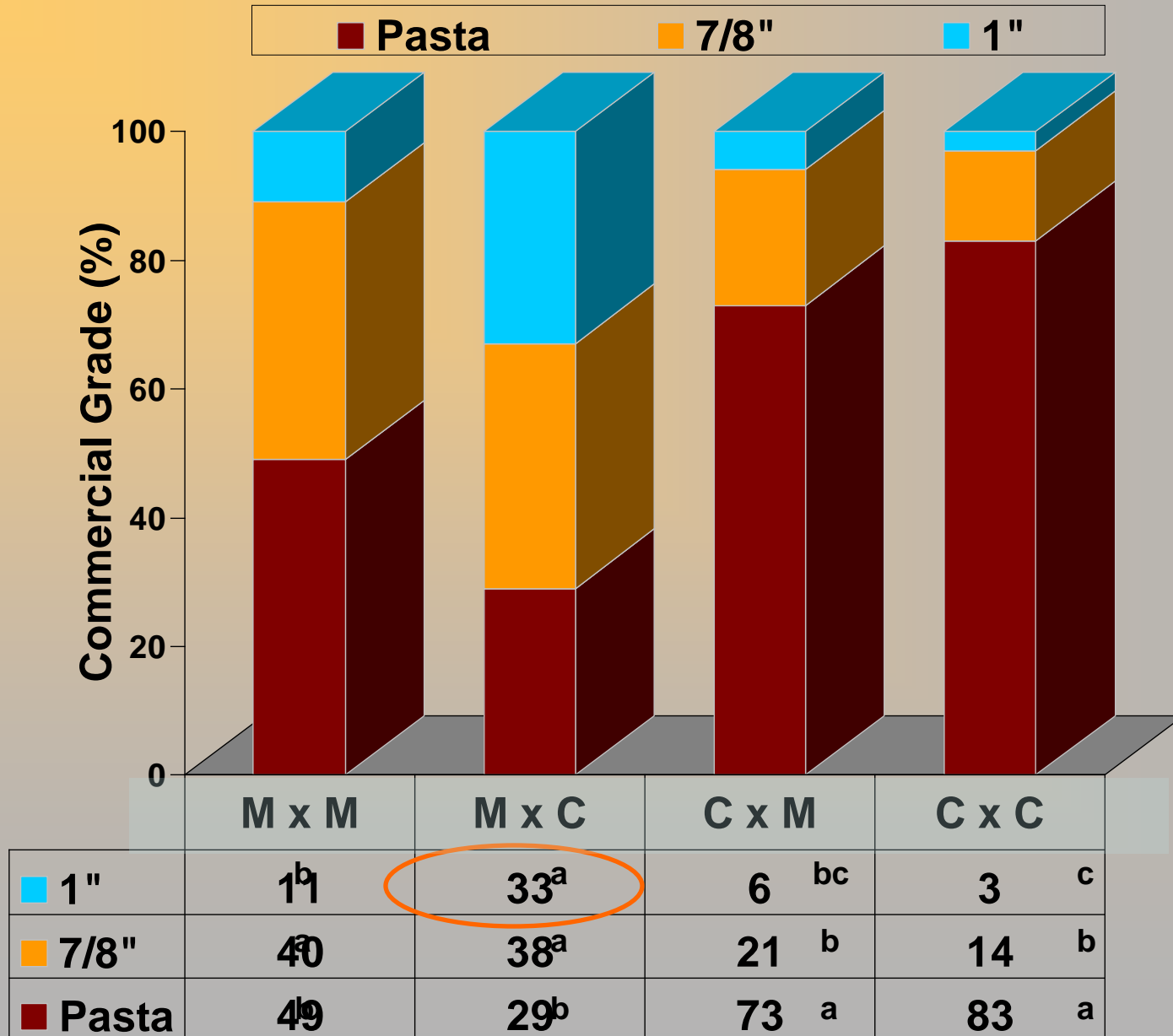
Harvest Results (12 months) – Family A

Average \pm Standard Deviation

Stock	Shell Width (mm)	Total Weight (g)	Dry Meat Wt. (g)	Survival (%)	Production (lbs/bag)
M x M	22.6 $\pm 1.2^b$	25.8 $\pm 3.6^b$	0.58 $\pm 0.08^b$	81.8 $\pm 11.3^{ab}$	53.0 $\pm 6.6^b$
M x C	24.5 $\pm 0.7^a$	31.0 $\pm 2.2^a$	0.76 $\pm 0.05^a$	96.8 $\pm 9.9^a$	75.8 $\pm 5.4^a$
C x M	20.7 $\pm 2.2^{bc}$	19.4 $\pm 5.6^c$	0.56 $\pm 0.13^{ab}$	68.4 $\pm 7.6^b$	34.4 $\pm 13.0^c$
C x C	20.1 $\pm 1.5^c$	16.5 $\pm 3.2^c$	0.50 $\pm 0.10^b$	72.5 $\pm 26.7^{ab}$	32.1 $\pm 16.3^c$

Note: ANOVA were performed using the PROC GLM procedure of SAS. Treatment means were considered significantly different when $p \leq 0.05$. Tukey's test groupings are displayed.

Harvest Results (12 months) – Family A



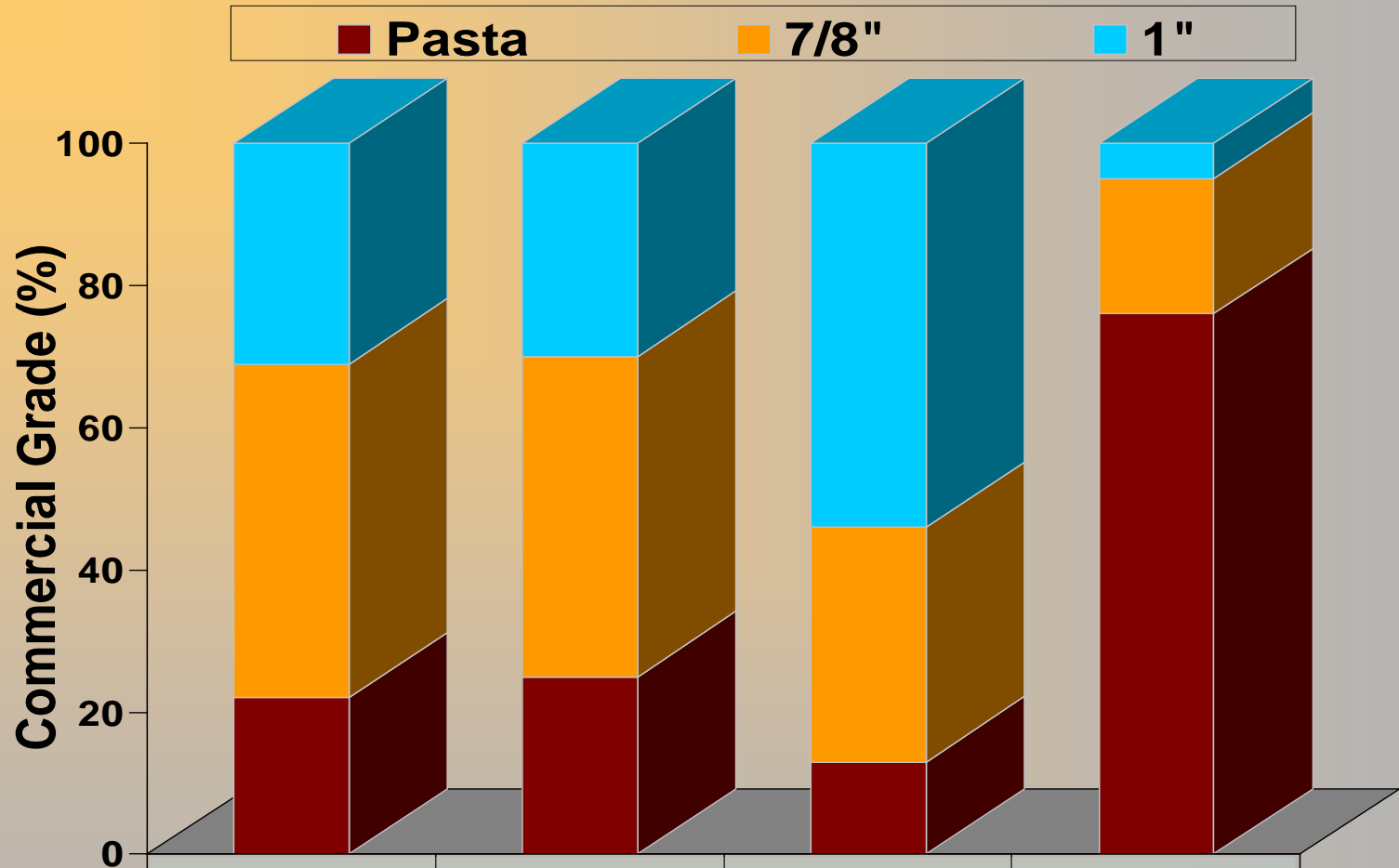
Harvest Results (12 months) – Family C

Average \pm Standard Deviation

Stock	Shell Width (mm)	Total Weight (g)	Dry Meat Wt. (g)	Survival (%)	Production (lbs/bag)
M x M	24.1 ± 0.6 ^{bc}	29.8 ± 1.7 ^b	0.67 ± 0.09 ^b	92.9 ± 3.0 ^a	70.1 ± 3.3 ^b
M x C	24.3 ± 0.7 ^{ab}	30.5 ± 2.3 ^{ab}	0.77 ± 0.03 ^{ab}	104.1 ± 6.8 ^a	80.4 ± 7.7 ^b
C x M	25.6 ± 1.3 ^a	34.4 ± 4.4 ^a	0.89 ± 0.06 ^a	110.2 ± 10.9 ^a	95.3 ± 7.0 ^a
C x C	21.0 ± 1.3 ^c	18.4 ± 3.3 ^c	0.60 ± 0.11 ^b	59.0 ± 20.9 ^b	28.1 ± 12.8 ^c

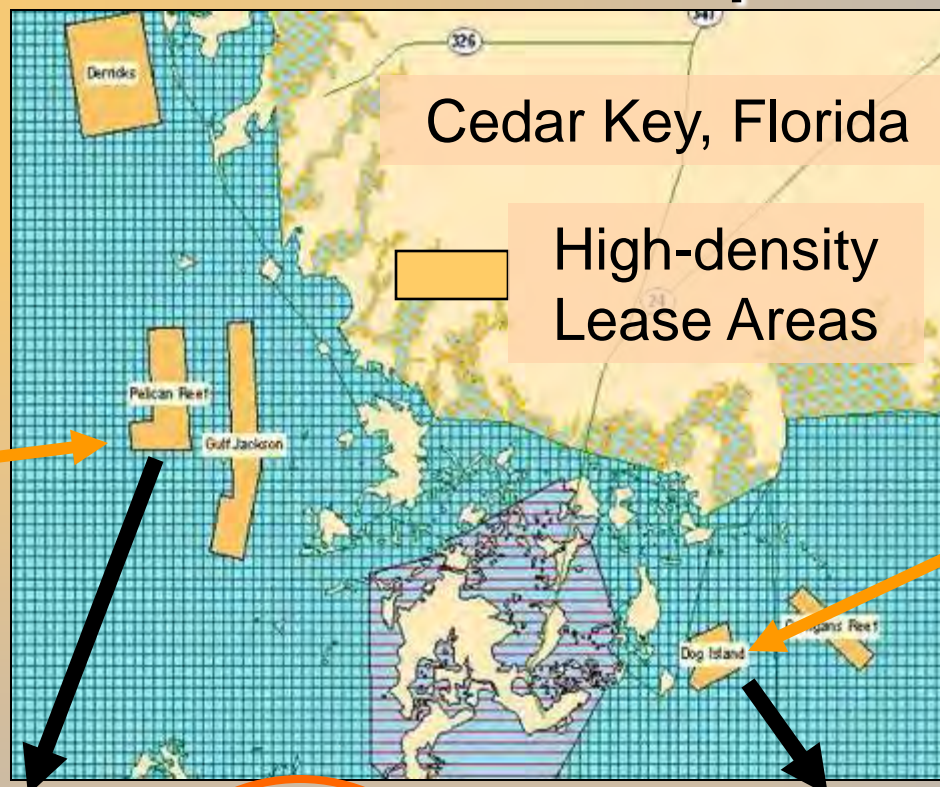
Note: ANOVA were performed using the PROC GLM procedure of SAS. Treatment means were considered significantly different when $p \leq 0.05$. Tukey's test groupings are displayed.

Harvest Results (12 months) – Family C



	M x M	M x C	C x M	C x C
1"	31 ^b	30 ^b	54 ^a	5 ^c
7/8"	47 ^a	45 ^a	33 ^{ab}	19 ^b
Pasta	22 ^b	25 ^b	13 ^b	76 ^a

Growers Site Comparisons



**Pelican Reef
Lease Area**

**Dog Island
Lease Area**

2009	Temp °F (\pm SD)	Salinity ppt (\pm SD)
June	85.3 (2.6)	19.5 (5.7)
July	86.2 (2.1)	18.8 (4.5)
August	86.8 (2.6)	26.3 (1.9)

2009	Temp °F (\pm SD)	Salinity ppt (\pm SD)
June	85.8 (2.5)	21.2 (3.1)
July	86.3 (2.1)	21.8 (2.8)
August	86.6 (2.5)	25.4 (1.6)

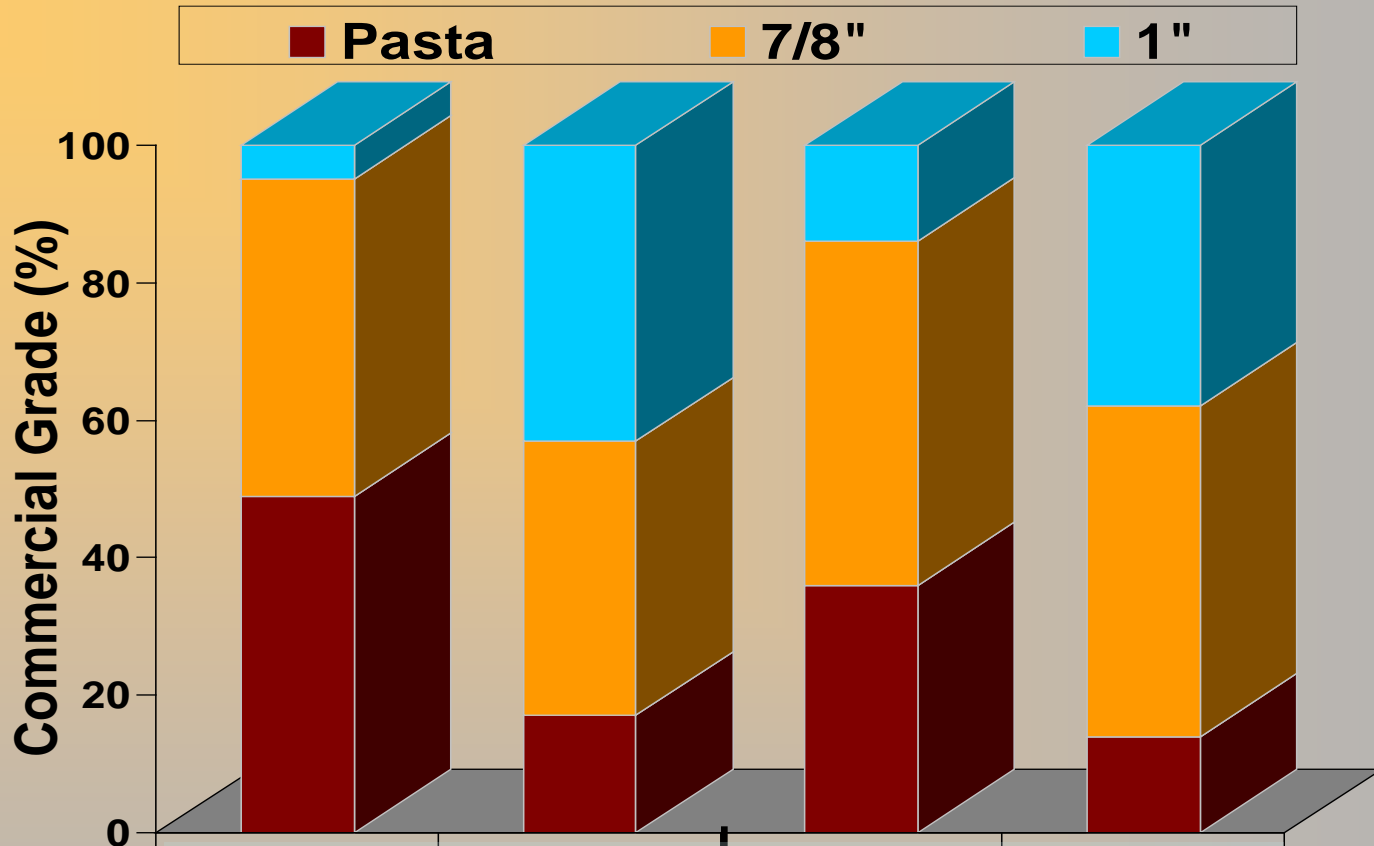
Harvest Results(12 months) – **Grower A**

Average \pm Standard Deviation

Stock	Shell Width (mm)	Shell Length (mm)	Total Weight (g)	Survival (%)	Production (lbs/bag)
M x M (Family A)	21.9 $\pm 0.2^b$	41.9 $\pm 0.5^b$	22.7 $\pm 0.7^b$	52.2 $\pm 8.5^b$	31.3 $\pm 5.0^b$
M x C (Family A)	25.7 $\pm 0.9^a$	46.9 $\pm 1.7^a$	34.5 $\pm 3.4^a$	90.2 $\pm 6.6^a$	82.0 $\pm 5.0^a$
M x M (Family C)	23.3 $\pm 0.4^b$	42.1 $\pm 1.0^b$	25.0 $\pm 1.6^b$	49.9 $\pm 7.3^b$	33.2 $\pm 6.8^b$
C x M (Family C)	24.6 $\pm 0.2^a$	43.5 $\pm 0.6^a$	28.8 $\pm 0.4^a$	86.2 $\pm 20.8^a$	65.1 $\pm 15.0^a$

Note: T tests were performed using the PROC TTEST procedure of SAS. Treatment means were considered significantly different when $p \leq 0.05$.

Grade (12 months) – Grower A



	M x M	M x C	M x M	C x M
Family	A	A	C	C
1"	5 ^b	43 ^a	14 ^b	38 ^a
7/8"	46 ^a	40 ^a	50 ^a	48 ^a
Pasta	49 ^a	17 ^b	36 ^a	14 ^b

Product Quality



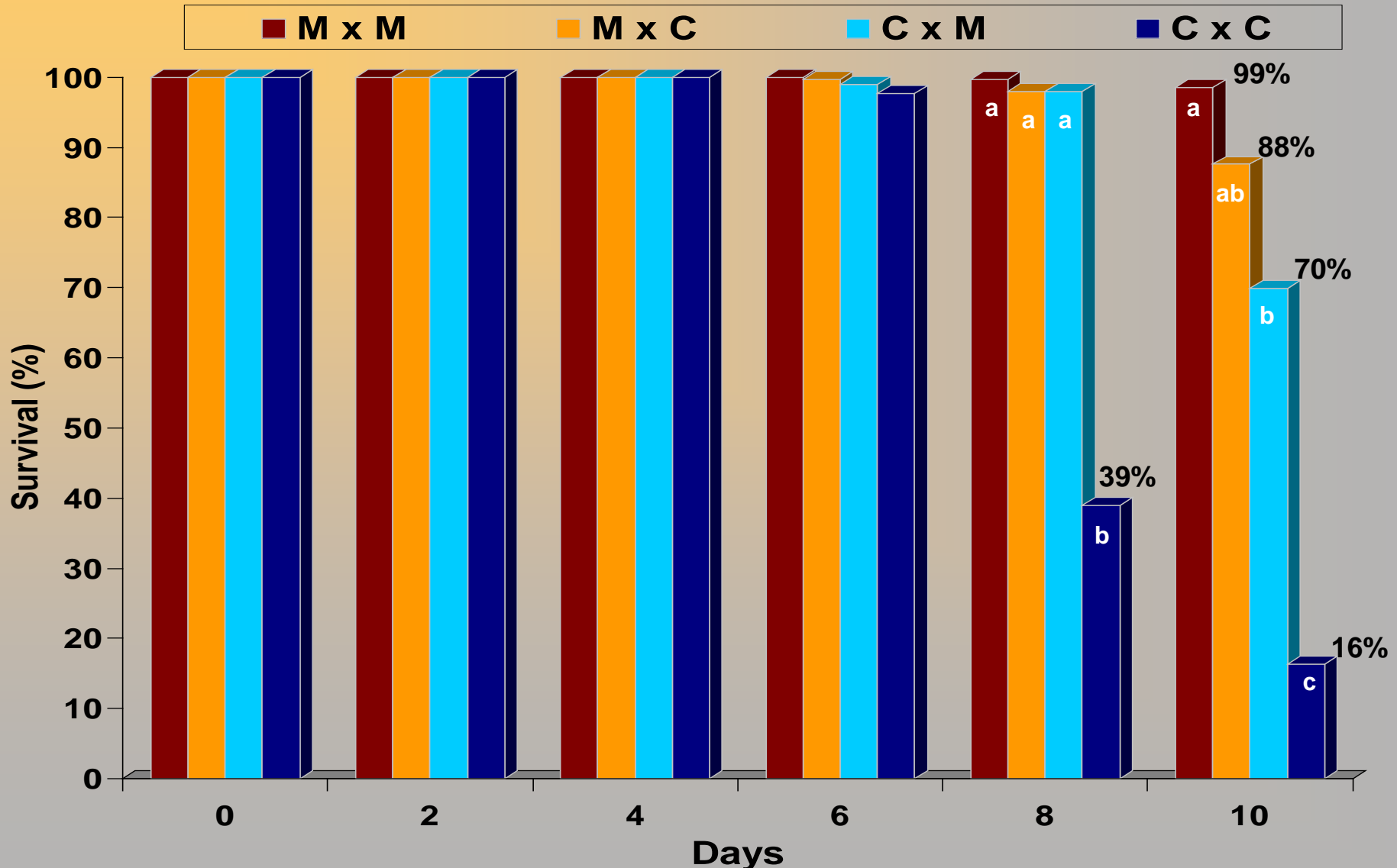
- Consumer acceptance
- Sensory evaluation and profiling

- Document shelf life
 - Survival in refrigerated storage (45°F)



Shelf Life: Survival in 45°F Storage

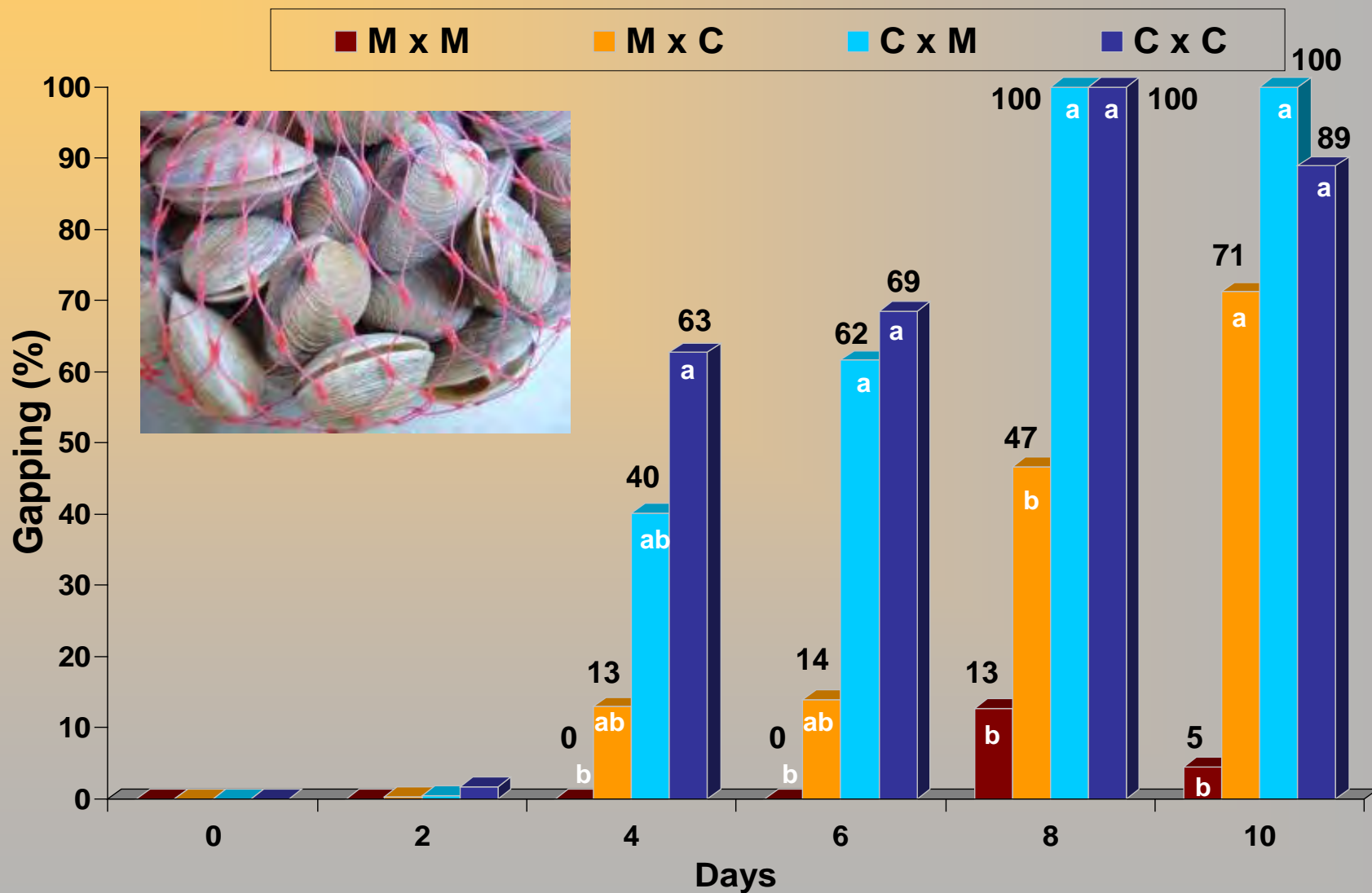
Average of Families A,B,C – Harvested at 84.6°F



Note: A repeated measures analysis (PROC GLIMMIX) was performed ($p \leq 0.0001$).

Shelf Life: Gapping in 45°F Storage

Average of Families A, B, C

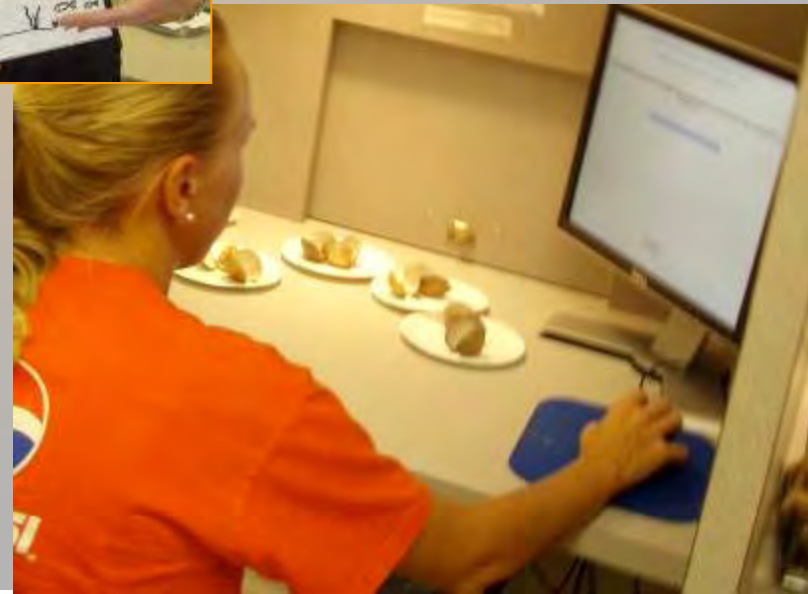


Note: A repeated measures analysis (PROC GLIMMIX) was performed ($p=0.0237$).

Consumer Acceptance Study

- Blind test of cooked clams
 - Acceptability
 - Flavor
 - Texture
- Rate according to scale of
 - 1 (dislike extremely) to 9 (like extremely)
- Rank in order of preference
 - 1, 2, 3, 4
- 90 responses compiled

Conducted on University of Florida campus by Dr. Charles Sims and Laura Garrido, UF Food Science and Human Nutrition



Consumer Acceptance Results

Stock	Acceptability*	Flavor*	Taste*
M x M	5.8	5.6	5.4
M x C	6.0	5.8	5.7
C x M	5.6	5.6	5.4
C x C	5.8	5.6	5.4

* No significant differences among clam stocks

Stock	M x C**	C x C	M x M	C x M**
Ranking	195	222	239	244
Analysis	b	ab	ab	a

** Friedman Analysis of Rank and Tukey's HSD at 5% significance level

Sensory Evaluation and Profile

- Blind tasting by UF trained panel using standards
- Characterization of raw clams
 - Appearance
 - Aroma
 - Basic Tastes
 - Flavor
 - Aftertaste
 - Texture, Meat
 - Mouth feel
- Scale of 1-10



Conducted by Dr. Steve Otwell and Laura Garrido,
UF Aquatic Food Products Lab

Results: Sensory Profile of Raw Clams

Ratings	Scale	M x M	M x C	C x M	C x C
Appearance	1-10				
Volume of Flesh	Not covered-Full	5.50	6.58	7.25	7.5
Plumpness	Flaccid-Plump	6	6.25	6.83	6.83
Aroma	1-10				
Briny	Not-Extremely	4.25	3.25	3.42	7.50
Metallic	Not-Extremely	3.25	1.5	1.50	6.83
Basic Tastes	1-10				
Salty	Not-Ext. (>10)	10.08	10.25	10.58	10.50
Umami	Not-Extremely	3.75	4	3.08	4.17
Flavor	1-10				
Seaweed	Not-Extremely	2.33	2.92	3	3.5
Chicken-Liver-Like	Not-Extremely	2.75	2.67	2.58	2.42
Earthy	Not-Extremely	1.83	1.83	2	2
Aftertaste	1-10				
Metallic	Not-Extremely	3.5	3	2.83	2.17
Astringent	Not-Extremely	2.08	1	1.75	2.08
Texture, Meat	1-10				
Firmness	Mushy-Ext.Firm	6.08	5.58	6.50	7
Chewiness	Not-Extremely	4.92	5.42	5.83	6.60
Mouthfeel	1-10				
Detect Grit	Not-Extremely	2.42	1.33	2.00	0.90

Summary

- Hybridization may offer improved clam production performance
 - MxC \uparrow SW and DryMtWt
- Genetic background played a significant role in responses
 - Family A, MxC \uparrow SW, TW, DMtWt, Prod
 - Family C, CxM \uparrow SW, TW, DMtWt, Prod



Sunshine Clam (M X C)

TropiClam (C X M)



- Environmental conditions at growing sites also played a role in responses
 - Grower A, Hybrids $>$ MxM
- Shelf life acceptable
 - 10 days for MxC, 8 days for CxM
- Gapping in refrigerated storage problematic
 - By day 8 for MxC, day 4 for CxM

Acknowledgements

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- Cedar Key Aquaculture Association
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See you next year!

A sunset scene over a body of water. The sun is low on the horizon, creating a bright, shimmering reflection on the water's surface. The sky is filled with soft, golden light and scattered clouds. In the foreground and middle ground, there are several wooden structures, possibly piers or docks, silhouetted against the bright light. The overall mood is peaceful and serene.

- Initial report on backcrossing F1 hybrids with hard clams, 2009-10
 - Spawning
 - Land-based nursing
 - Field nursing