Influence of Grow-out Density and Nursery System on Growth Rates of Juvenile Queen Conch, *Strombus gigas*

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ABSTRACT

As natural populations of queen conch are depleted, aquaculture of conch may prove necessary for restocking efforts or for supplementing the wild catch. In aquaculture systems rapid growth and high culture density of juveniles are economic necessities. We examined growth of juvenile queen conch for 19 weeks at two densities (50 and 150 conch/m^2) and in three grow-out systems: rectangular fiberglass tanks, cages within tanks, and upwell chambers. We also tested the effect of size heterogeniety on growth conch held in cages and upwells. Conch growth in homogeneous (mean size=61.8, range 60.6-63.2 mm shell length, SL) size treatments, held at 50 conch/m^2, was compared to growth in high and low density treatments (mean size=61.5, range=51.7-69 mm SL). Initial mean size of conch was 61.5 mm shell length. Up to 15 conch/treatment were tagged for weekly, repeated measurement. Greatest growth occurred in homogeneous-size caged treatments (14.8-17.6 mm total growth); tank treatments had the least growth (8.5-12.6 mm total growth). Conch in high density tank treatments had the lowest growth. No significant difference in growth among any upwell treatments was found (13.5-15.3 mm total growth). Density alone had little effect on growth in cages. Placement of cages within tanks relative to water inflow may have an equal or greater effect on growth than density. Although upwell treatments exhibited generally greater growth than other treatments, the cost and complexity of upwells systems may be prohibitive. The slow growth in tank treatments may have been due to excessive handling associated with tank cleaning. Cage treatments may reduce stress or shell damage due to handling. Cost of cage systems may be offset by higher growth rates of juvenile conch, particularly if conch are separated into size classes.

Key words: aquaculture, density-dependent growth, queen conch, *Strombus gigas*

INTRODUCTION

A moratorium on the taking of queen conch, *Strombus gigas*, has been in effect in the Florida Keys since 1986. During the moratorium, the overall queen conch population within the Florida Keys has remained relatively stable, but has not recovered to fishable levels (Glazer and Berg, 1994). The Florida Department of Environmental Protection (FDEP) has initiated a restocking program using hatchery-reared juvenile queen conch as seed. This paper presents results from ongoing grow-out studies at the FDEP conch nursery facility.

Among the concerns of any aquaculture facility are maximizing growth and number of animals in the facility. The latter should be accomplished without serious compromise of the former. Our nursery system utilizes fiberglass tanks for juvenile conch grow-out. Slow growth and damage to shells of the animals due to handling have been recurring problems in this system (FDEP, unpublished data). In an effort to increase growth in and reduce handling stress to animals in the nursery, we compared growth of juvenile conch in three nursery systems at two grow-out densities.

METHODS

Weekly growth of juvenile queen conch was examined for 19 weeks in three nursery grow-out systems: fiberglass tanks (0.76 x 1.1 meters, water depth 10 cm), Vexar mesh cages within tanks (three cages/tank, 1.1 x 0.76 x 0.08 meters) and an upwelling/downwelling system (0.3 meter diameter x 0.25 meter high pvc cylinders with 1000 micron Nitex mesh bottoms plumbed so that water flow could be either down through the screen or reversed to upwell through the screen). Oyster shell (1-2.5 mm particle size) covered the screens of upwell treatments to a depth of 2-3 mm for retention of food within the upwell. Conch were held in these systems at 50 conch/m^2 (low density) or at 150 conch/m^2 (high density). We also examined growth of conch held in treatments in which all conch were initially homogeneous in size (culled by size) versus growth of conch in initially heterogeneous (unculled) size treatments. Culled treatments had 50 conch/m^2. Culled treatments were not performed in tanks due to space limitations. All treatments were replicated within each system. Tanks and upwells were selected randomly for treatment replicates. Tanks containing cage treatments each had low density, high density, and culled treatments randomly positioned within the tank.

Up to 15 conch/replicate treatment were tagged for repeated measurement. Conch were fed ground Mazuri Platinum Koi food to which 15% (by weight) ground oyster shell was added. Daily rations were based upon a length/wet meat weight relationship (FDEP, unpublished data) and varied between 2 and 7.5% of the wet weight of the conch. Rations were determined daily based upon the amount of food remaining from the previous day.

All treatments had flow-through, sand-filtered sea water. Water flow was maintained at equivalent volumes for all treatments. Treatments were cleaned daily to remove feces and uneaten food. On a weekly basis tanks were scrubbed to remove any algal growth, cages were replaced with clean cages, and upwells were scrubbed and the oyster shell replaced.

Data were analyzed using Kruskal-Wallis one-way analysis of variance (Zar, 1984) due to heteroscedasticity of the data. Where multiple comparisons tests were appropriate, Dunn's multiple comparisons test (Dunn, 1964; Zar, 1984) was used. The Kruskal-Wallis tests were performed using the SPSS statistical package (SPSS Inc., 1993).

RESULTS

Initial size of conch in high and low density treatments ranged from 51.7 to 69 mm shell length (mean=61.5 mm). Mean initial size of conch in homogeneous size (culled) treatments was 61.8 mm shell length (range=60.6 to 63.2 mm). There was no statistical difference among the replicate treatments in initial conch size (K-W: X^2=17.1457, df=15 $p>0.05$).

Differences in total growth were examined between treatment replicates. Significant differences in growth were found in two cases: between replicate high density cage treatments (K-W:X^2=4.3907, df=1, $p=0.0361$) and between replicate culled-cage treatments (K-W: X^2=15.7929, df=1, $p=0.001$). In each case, the replicate with greatest conch growth was the replicate cage positioned near the water inflow of a tank (inflow cage); the replicate cage with conch of lower total growth was positioned away from the water inflow end (away cage) of a tank. Replicates of these treatments were considered separately in other analyses; replicates in all other treatments were combined for further analyses. Throughout the data analyses, replicates or treatments which were not significantly different were combined in subsequent analyses.

Total conch growth in upwells was not significantly different between density treatments (K-W: X^2=0.2586, df=1, $p>0.05$), however growth differences were apparent in tank and cage density treatments. Conch in low density tank treatments grew significantly more than conch in high density tank treatments (K-W: X^2=34.1484, df=1, $p<0.0001$). Total growth in the cage density treatments was not significantly different between low density treatment and high density (inflow) cage (Dunn: Q=1.568, $p>0.05$). Conch growth in the high density (away) cage treatment was significantly less than growth in the other cage density treatments (Dunn: Q=4.03, $p<0.001$).

No growth differences were found among conch in high density, low density, or culled upwell treatments (K-W: X^2=1.1726, df=2, $p>0.05$). All upwell treatments were combined in further analyses. Culled and unculled cage treatments differed greatly in conch total growth (K-W: X^2=53.535, df=4, $p<0.0001$). Conch in the high density (away) cage treatment grew the least. The culled-cage (inflow) treatment showed significantly higher growth than the other treatments (Table 1A).

Significant differences in conch total growth were found among grow-out systems (K-W: X^2=104.8987, df 6, $p<0.0001$). Conch in the high density tank treatment had the lowest total growth. Greatest total growth was found in conch from the culled-cage (inflow) treatment (Table 1B).

Table 1. Dunn's multiple comparisons test for: A. Significant differences among cage density treatments. B. Significant differences among systems. Treatment 1=high density tanks, 2=high density cage (away from inflow), 3=low density tanks, 4=low density cage and high density cage (inflow), 5=upwells, 6=culled-cage (away from inflow), 7=culled-cage (inflow). Lines connect treatments with no statistical difference in growth.

A. Treatment:	high density (away)	high density (inflow)	low density	culled (away)	culled (inflow)
mean total growth (mm)	11.34	12.76	13.23	14.76	17.63

B. Treatment:	1	2	3	4	5	6	7
mean total growth (mm)	8.48	11.34	12.62	13.08	14.09	14.76	17.63

DISCUSSION

A wide range of juvenile conch growth was recorded for the three grow-out systems and two densities examined. Converting data from the present study to daily growth and comparing among earlier studies examining growth of similarly sized juvenile conch, growth rates recorded in this study were within the range of published growth rates (Figure 1). That conch growth in this study is comparable to earlier observed growth may be somewhat surprising given that weekly mean low temperatures (average low temperatures recorded on a minimum/maximum thermometer) were less than 20° C during five weeks of this study. Weekly mean high temperatures were less than 21° C during four weeks.

Conch growth was minimal in both high and low density tank treatments. Handling of the conch during cleaning, particularly when tanks were scrubbed, may have contributed to physiological stress resulting in poor growth. Handling may have directly caused shell damage resulting in energy expenditure on shell repair rather than on growth. Conch often moved to the water inflow end of of the tanks creating an effective density much higher than the test densities and perhaps reducing growth. Improved water flow, through the use of spray bars, may improve conch growth by keeping the animals dispersed throughout the tank.

Conch in all upwell treatments grew well compared to other systems. Upwells are expensive to build, however, and hold few animals >60 mm as

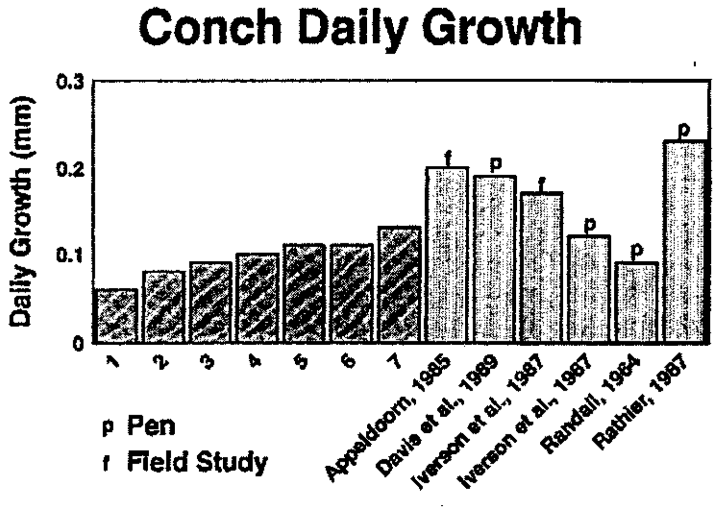

Figure 1. Daily growth of conch in mm. 1=high density tank s, 2=high density cage (away from water inflow), 3=low density tanks, 4=low density cag es and high density cage (near water inflow), 5=upwells, 6=culled-cage (away from water inflow), 7=culled-cage (near water inflow). Diagonally shaded bars are mean daily growth rates from the present study. Vertically shaded bars are rates from earlier work with juvenile conch. P=data from conch grown in pens on natural habitat, f=growth data measured in the field.

currently designed. Maintainence is high due to weekly replacement of oyster shell. This system is probably not practical for grow-out of large, 0+ year class (>50 mm) conch.

Growth in cage treatments varied widely and was influenced by density, water flow, and culling. Conch in the high density (inflow) cages had growth equal to that in low density cages while conch in the high density (away) cages grew poorly, suggesting a density/water flow interaction. Conch in culled-cages had the highest growth of any treatment. Intraspecific competition among different size classes of conch may result in small conch being outcompeted for food. Given that the meat weight/conch length ratio does not increase linearly, rations based upon conch mean size (and therefore mean weight) may result in insufficient rations where heterogeniety of conch sizes exist. Water flow remained a factor affecting growth in the culled treatment. Significantly greater growth was recorded from conch in the culled-cage (inflow) than the culled-cage (away).

Improved water flow using spray bars may increase conch growth in cages throughout a tank. Such improvement in water flow, combined with culling animals into size classes and the apparent value of cages in reducing handling appear to be practical methods for improving conch growth in a tank based nursery. Additional growth studies with greater replication and an emphasis on density effects on culled treatments is warranted.

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