Production Characteristics and Body Composition of Florida Pompano Reared to Market Size at Two Different Densities in Low-Salinity Recirculating Aquaculture Systems

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Abstract.—The effect of culture density on production characteristics and body composition of Florida pompano *Trachinotus carolinus* reared to market size using recirculating aquaculture systems (RASs) maintained at a salinity of 5% was evaluated in a 110-d growth trial (water temperature = 27.0–28.5°C). Juvenile Florida pompano (mean weight ± SE = 259.0 ± 3.0 g) were stocked into two tanks from each of four separate RASs at an initial nominal density of 6.5 (low density) or 13.0 kg/m³ (high density), equivalent to 200 and 400 fish/tank, respectively. After stocking, fish were fed a 4.7-mm, floating pelleted diet (50% protein, 14% lipid) twice daily at a targeted daily feed rate of 3% body weight per day. At stocking and at 3-week intervals thereafter, 10% of the fish population of each tank was sampled to determine production characteristics, including mean weight, weight gain, specific growth rate, absolute growth rate (AGR), feed conversion efficiency (FCE), biomass, and survival. At termination, fish in all tanks were harvested to determine production characteristics and samples were obtained to determine whole-body composition, energy retention, protein efficiency ratio (PER), protein productive value (PPV), hepatosomatic index, gonadosomatic index, and fillet yield. Results indicated that final weight (570.0 g), weight gain (312.7 g), AGR (2.8 g/d), FCE (25.5%), PER (0.54), and PPV (11.5%) of fish reared at high density were significantly lower than those of fish reared at low density. No differences were observed between density treatments with respect to other measured variables. Additional studies must focus on the development of finishing diets for final stages of Florida pompano production to increase FCE and to determine optimal rearing densities. In addition, research to evaluate the potential of rearing pompano in RASs at salinities lower than 5%, perhaps through environmental or dietary enhancement of critical ions, is warranted.

Florida pompano *Trachinotus carolinus* are found in coastal waters of the Atlantic Ocean from Massachusetts to Brazil and throughout the Gulf of Mexico. The species is especially common along the Florida coasts (Gilbert and Parsons 1986; Watanabe 1995). A high-value carangid, the Florida pompano is prized by both recreational and commercial fishers. In 2006, average dockside price of whole Florida pompano was US$7.68 per kilogram, and depending on time of year and availability the retail price of Florida pompano fillets can exceed $40 per kilogram (NMFS 2007).

Due to their superior market value, interest in Florida pompano culture developed in the United States during the 1960s and 1970s. Research conducted during this period focused largely on developing production methods in various culture systems, including ponds (Berry and Iverson 1967; Moe et al. 1968; Cuevas 1978; Tatum and Trimble 1978), in-pond cages (Marcello and Strawn 1972; Swingle 1972; Tatum 1972, 1973; Smith 1973), and flow-through tanks (Iverson and Berry 1969; Gomez and Scelzo 1982). A common thread of the results of these studies was poor growth and feed conversion of fish greater than 200 g, usually coupled with poor survival, resulting in the inability to produce market-size fish (>450 g). However, in a recent study conducted using small-scale recirculating aquaculture systems (RASs) maintained at a salinity of 23–28%, Weirich et al. (2006) demonstrated that juvenile Florida pompano can be reared at relatively low densities from an initial weight of 17 g to weights in excess of 450 g in 4–5 months.
and to weights in excess of 700 g in 8–9 months; survival was greater than 95%.

The ability to rear fish at relatively high densities is of importance to commercial aquaculture operations, especially those employing RASs. Although both positive and negative relationships between stocking density and various fish production indices have been documented, the latter is usually the case, as shown by the results of density studies conducted on a variety of marine finfishes, including Atlantic salmon \textit{Salmo salar} (Refstie and Kittelsen 1976; Soderberg et al. 1993), gilthead seabream \textit{Sparus aurata} (Canario et al. 1998), red porgy \textit{Pagrus pagrus} (Maragoudaki et al. 1999), Atlantic halibut \textit{Hippoglossus hippoglossus} (Björnsson 1994), California halibut \textit{Paralichthys californicus} (Merino et al. 2007), European seabass \textit{Dicentrarchus labrax} (Paspatis et al. 2003), common sole \textit{Solea solea} (Howell 1998; Schram et al. 2006), white-spotted rabbitfish \textit{Siganus canaliculatus} (El-Sayed et al. 1995), estuary grouper \textit{Epinephelus salmoides} (Teng and Chua 1979), turbot \textit{Scophthalmus maximus} (Howell 1998; Irwin et al. 1999; Ma et al. 2006), Atlantic cod \textit{Gadus morhua} (Lambert and Dutil 2001; Björnsson and Olafsdottir 2006), silver hake \textit{Merluccius bilinearis} (Helser and Almeida 1997), amarillo snapper \textit{Lutjanus argentiventris} (Guerrero-Tortolero et al. 1999), and yellowtail \textit{Seriola quinque-radiata} (Sakakura and Tsukamoto 1998). The presence of an inverse relationship between stocking density and production performance may be attributed to one or more of a suite of factors, including competition (Brett 1979; Helser and Almeida 1997; Irwin et al. 1999), formation of hierarchical structures and agonistic behaviors (Keenleyside and Yamamoto 1962; Refstie and Kittelsen 1976; Brown et al. 1992; Howell 1998), space limitation (Björnsson 1994; Ewing et al. 1998), and suboptimal water quality (Kindschi and Koby 1994; Zoccarato et al. 1994; Yi et al. 1996).

This study was conducted to compare production characteristics and body composition of juvenile Florida pompano reared to market size in commercial-scale RASs at moderate and high culture densities. Because results of limited research (Allen and Avault 1970; Kumpf 1971) coupled with anecdotal observations made at our research facility suggest that Florida pompano can tolerate and perhaps grow at reduced environmental salinities, fish were reared at a nominal salinity of 5%o.

**Methods**

**Experimental systems.**—Studies were conducted in four replicate RASs located within the Sustainable Tank Aquaculture Recirculating Research Facility (U.S. Department of Agriculture [USDA], Agricultural Research Service), located on the campus of Harbor Branch Oceanographic Institute (HBOI) at Florida Atlantic University, Fort Pierce. Each 45-m³ RAS (Figure 1) consisted of four 8-m³ round, fiberglass culture tanks engineered with a Cornell dual-drain system (Timmons et al. 1998). Primary solids removal was accomplished using a 600-L Wave 36 vortex filter (W. Lim Corp., Mira Loma, California) attached to each tank and a centralized Hydrotech 801 drum filter equipped with a 40-µm screen (Water Management Technologies, Inc., Baton Rouge, Louisiana). Water was circulated by two 1.5-kW pumps through two 0.7-m³ propeller-washed bead filters (PWBFs; Aquaculture Systems Technologies, New Orleans, Louisiana) for biofiltration and fine solids removal. Each RAS also included a 2.2-m³ oxygenation injection cone (Waterline Ltd., Charlottetown, Prince Edward Island), two degassing towers, and a 520-W, multi-lamp ultraviolet sterilization unit (Emperor Aquatics, Inc., Pottstown, Pennsylvania). Polypropylene nets (1.9-cm mesh) were placed over each tank to prevent fish escape. A photoperiod of 12 h light :12 h dark was provided with
overhead fluorescent lights. Two months before initiation of studies, PWBF units were acclimated (seeded) as described by Manthe and Malone (1987). During the study, each of the two PWBF units that serviced each RAS was backwashed every other day on a rotating schedule (Pfeiffer and Malone 2006). Settled sludge was removed from PWBF units, wave vortex filters, and tank bottom drain lines daily. Daily water loss from systems was less than 4% of total system volume. Water used to supply the RASs was obtained from two sources located on the campus of HBOI. Saline water was pumped from a 7-m-deep well adjacent to the Indian River Lagoon, and brackish water was obtained from a 600-m-deep well. Both water sources were subjected to biological and mechanical filtration before entry into experimental units via float valves installed in system sumps. During this study, salinity of the saline and brackish-water sources ranged from 28%o to 33%o and from 0.8%o to 1.5%o, respectively.

**Experimental design, husbandry, and sampling protocol.**—At the start of a 110-d rearing trial, juvenile Florida pompano reared from eggs produced on-site were stocked into two tanks within each of the four RASs at an initial nominal density of 6.5 (low density) or 13.0 kg/m³ (high density), equivalent to 200 or 400 fish/tank, respectively. Mean (±SE) weight of fish at stocking was 259.0 ± 3.0 g. Density treatments were assigned using a randomized complete block design with four replicates per treatment. At initiation of the rearing trial, 15 fish were collected and stored at −20°C for subsequent analysis of whole-body composition. After stocking, fish were fed a 4.7-mm, floating pelleted diet (50% protein, 14% lipid; Burris Mill and Feed, Franklinton, Louisiana) twice daily at 0830 and 1530 hours. Fish were given 30 min to consume allotted rations at each feeding period. The targeted feed rate throughout the study was 3% body weight per day. At stocking and at 3-week intervals thereafter, 10% of the fish population of each tank was randomly collected and individual weights were recorded to the nearest 1.0 g to determine production characteristics, including mean weight, weight gain, specific growth rate (SGR), feed conversion efficiency (FCE), and biomass. Specific growth rate was calculated using the formula $\frac{[\log_{10} W_t - \log_{10} W_i]/t \times 100}{W_t}$ (where $W_t$ = weight at the end of a sampling period, $W_i$ = initial weight, and $t$ = length of time of the sampling period in days). Feed conversion efficiency was calculated by using the formula $\frac{[g \text{ of wet weight gain}]/[g \text{ dry weight of feed fed}]}{100}$. Mean weight of fish from each treatment was used to recalculate appropriate feed rations for the next 3 weeks. Mortalities were removed and recorded daily as necessary to estimate percent survival at each sampling period. At termination of the rearing trial, the entire population of each tank was harvested and group weights of 10–20 fish/tank were obtained to determine production characteristics and survival. In addition, five fish were obtained from each tank to determine hepato-somatic index (HSI = liver weight/body weight) × 100) and visceral fat; 15 fish were sampled to determine fillet yield, sex, and gonadosomatic index (GSI = [gonad weight/body weight] × 100); and six fish were collected and stored at −20°C for subsequent analysis of whole-body composition. Total length (TL, cm) of individually weighed fish from each tank at stocking and at termination was measured to determine condition factor (K) using the formula 100 × $\sqrt{W/(TL^3)}$ (where $W$ = weight, g). In addition, coefficient of variation (CV = SD/mean) of fish weight for each density treatment at stocking and at termination was determined.

**Whole-body composition and nutritional indices.**—Standard procedures were used for determining proximate components of fish and the diet fed during the rearing trial (AOAC 2003). Pooled whole-body samples were minced in a meat grinder and further homogenized using mortar and pestle. Two samples from each homogenized pool were taken for moisture analysis and dried at 105°C for 24 h. Tissues remaining in the pooled samples were analyzed for crude protein, crude lipid, ash, and gross energy. Nitrogen was determined by combustion (TruSpec N-elemental analyzer; Leco Corp., St. Joseph, Michigan) and crude protein calculated as N × 6.25. Ash was determined following incineration at 600°C for 2 h. Crude lipid was determined gravimetrically after conducting chloroform : methanol extraction (Bligh and Dyer 1959) in a Soxhlet apparatus. Gross energy was determined by adiabatic bomb calorimetry (Parr 1266; Parr Instruments Co., Moline, Illinois). In addition to proximate components, energy retention, protein efficiency ratio (PER), and protein productive value (PPV) were determined. Energy retention was calculated using the formula $\frac{W_t \times E_t - W_i \times E_i}{FI \times E}$ (where $W_t$ = weight at the end of a sampling period; $W_i$ = initial weight; FI = feed intake; and $E_t$, $E_i$, and $E$ = energy content of the diet, fish at termination of the rearing trial, and fish at initiation of the rearing trial, respectively). Protein efficiency ratio was calculated using the formula $(g \text{ of wet weight gain})/(g \text{ of protein intake})$. Protein productive value was calculated using the formula $\frac{W_t \times P_t - W_i \times P_i}{FI \times P}$ (where $P$, $P_t$, and $P_i$ = protein content of the diet, fish at termination of the rearing trial, and fish at initiation of the rearing trial, respectively).
**Water quality.**—Temperature, salinity, and pH of each RAS sump and dissolved oxygen of each culture tank were measured twice daily at 0900 and 1700 hours during the rearing trial. Total ammonia nitrogen (TAN), nitrite-nitrogen (NO₂⁻-N), and alkalinity of each RAS were measured daily at 1000–1200 hours. Calcium content of each RAS was measured every other day. Temperature and dissolved oxygen were measured using a LDO HQ10 meter (Hach Co., Loveland, Colorado), and salinity and pH were measured using a YSI Model 556 meter (Yellow Springs Instruments Inc., Yellow Springs, Ohio). Levels of TAN and NO₂⁻-N were determined using Hach colorimetric assays (methods 8155 and 8153, respectively) conducted with a Hach D/R 2500 spectrophotometer. Alkalinity and calcium were determined using Hach digital titration methods 8203 and 8204, respectively. Sulfate, potassium, and magnesium concentrations were measured at initiation and termination of the experiment using Hach methods 8051, 8049, and 8204, respectively. Water temperature ranged from 27.0°C to 28.5°C. Salinity was maintained within 10% of a nominal value of 5‰. Postfeeding dissolved oxygen levels were maintained above 70% saturation, and TAN and NO₂⁻-N were maintained at levels below 0.6 and 1.5 mg/L, respectively. Alkalinity and calcium were maintained at approximately 300 mg/L (as CaCO₃) and 200 mg/L, respectively. The pH ranged from 7.1 to 7.8. Sodium bicarbonate was added daily to systems to maintain alkalinity and pH as described by Loyless and Malone (1997). Calcium chloride was added periodically to maintain calcium levels.

**Statistical analyses.**—Statistical analyses were performed using SigmaStat version 3.0 software (SPSS, Inc., Chicago, Illinois). Percentage data were arcsine–square root transformed before analysis. All data were subjected to analysis of variance, and means separation was achieved using Tukey’s studentized range test at a significance level of 0.05. Differences in CV weights between density treatments were inferred by using the F-test of variances (Zar 1984).

**Results**

Significant differences in mean weight and weight gain among density treatments were evident on days 87 and 110 of the rearing trial (Table 1). Final mean weight of fish reared at low density (632.2 g) was greater than that of fish reared at high density (570.0 g). Final weight gain of fish reared at low density (371.5 g) was also greater than that of fish reared at high density (312.7 g). No significant differences in SGR existed among density treatments. Values decreased with time over the course of the trial, and final SGR of fish reared at low and high density was 0.81% and 0.74% per day, respectively. Significant differences existed, however, with respect to absolute growth rate (AGR) at days 87 and 110 (data not shown). Final AGR of fish reared at low density (3.4 g/d) was greater than that of fish reared at high density (2.8 g/d). Feed conversion efficiency decreased steadily with time during the trial, but no differences existed among density treatments until day 110. At this time, FCE of fish reared at low density (29.0%) was greater than that of fish reared at high density (25.5%). Significant differences in feed consumption of fish reared at each density were observed at days 66, 87, and 110 (data not shown). Overall feed consumption of fish reared at low density (1.18 ± 0.02 kg of feed consumed/fish) was greater than that of fish reared at high density (1.11 ± 0.01 kg/fish). Final mean tank biomass of low- and high-density treatments was 14.2 and 25.5 kg/m³, respectively. No significant differences with respect to survival existed among density treatments. Final survival of fish reared at low and high density was 89.6% and 89.2%, respectively.

Initial K of fish reared at low and high density was 2.86 ± 0.03 and 2.81 ± 0.02, respectively. Final K of fish reared at low and high density was 3.22 ± 0.03 and 3.23 ± 0.02, respectively. No differences in K existed.

**Table 1.**—Mean (±SE) weight, weight gain, specific growth rate (SGR), feed conversion efficiency (FCE), tank biomass, and survival of Florida pompano (initial weight = 258.3 g) reared at two different densities in low-salinity recirculating aquaculture systems. For each sample day, low- and high-density means sharing the same letter are not significantly different (P > 0.05).

<table>
<thead>
<tr>
<th>Day</th>
<th>Density</th>
<th>Weight (g)</th>
<th>Weight gain (g)</th>
<th>SGR (%/d)</th>
<th>FCE (%)</th>
<th>Biomass (kg/m³)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Low</td>
<td>328.1 ± 5.9 z</td>
<td>68.9 ± 4.2 z</td>
<td>1.10 ± 0.1 z</td>
<td>42.0 ± 2.4 z</td>
<td>7.9 ± 0.1 z</td>
<td>95.7 ± 0.8 z</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>332.3 ± 4.4 z</td>
<td>75.0 ± 5.9 z</td>
<td>1.22 ± 0.1 z</td>
<td>45.7 ± 3.6 z</td>
<td>16.0 ± 0.3 y</td>
<td>95.7 ± 0.7 z</td>
</tr>
<tr>
<td>42</td>
<td>Low</td>
<td>418.0 ± 7.9 z</td>
<td>157.4 ± 7.5 z</td>
<td>1.13 ± 0.04 z</td>
<td>42.3 ± 1.7 z</td>
<td>9.9 ± 0.2 z</td>
<td>93.9 ± 0.6 z</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>399.4 ± 6.4 z</td>
<td>142.3 ± 7.4 z</td>
<td>1.04 ± 0.04 z</td>
<td>38.4 ± 1.9 z</td>
<td>18.9 ± 0.5 y</td>
<td>94.0 ± 0.6 z</td>
</tr>
<tr>
<td>66</td>
<td>Low</td>
<td>489.3 ± 10.7 z</td>
<td>228.6 ± 4.9 z</td>
<td>0.96 ± 0.02 z</td>
<td>34.1 ± 0.6 z</td>
<td>11.2 ± 0.1 z</td>
<td>91.9 ± 1.6 z</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>475.5 ± 7.9 z</td>
<td>218.2 ± 5.0 z</td>
<td>0.93 ± 0.05 z</td>
<td>34.1 ± 2.3 z</td>
<td>21.9 ± 0.8 y</td>
<td>91.7 ± 0.8 z</td>
</tr>
<tr>
<td>87</td>
<td>Low</td>
<td>581.6 ± 14.2 z</td>
<td>321.0 ± 18.9 z</td>
<td>0.92 ± 0.04 z</td>
<td>34.7 ± 1.8 z</td>
<td>13.2 ± 0.3 z</td>
<td>90.4 ± 1.4 z</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>521.7 ± 8.5 y</td>
<td>264.4 ± 12.8 y</td>
<td>0.81 ± 0.03 z</td>
<td>30.5 ± 1.4 z</td>
<td>23.7 ± 0.4 y</td>
<td>90.6 ± 0.7 z</td>
</tr>
<tr>
<td>110</td>
<td>Low</td>
<td>632.2 ± 8.0 z</td>
<td>371.5 ± 7.9 y</td>
<td>0.81 ± 0.02 z</td>
<td>29.0 ± 0.9 z</td>
<td>14.2 ± 0.2 z</td>
<td>89.6 ± 1.8 z</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>570.0 ± 12.3 y</td>
<td>312.7 ± 11.7 y</td>
<td>0.74 ± 0.02 z</td>
<td>25.5 ± 0.6 y</td>
<td>25.5 ± 0.4 y</td>
<td>89.2 ± 0.6 z</td>
</tr>
</tbody>
</table>
between density treatments at either sampling period. Initial CV of fish weight was 0.18 and 0.19 for low- and high-density treatments, respectively. Final CV of fish weight was 0.23 and 0.22 for low- and high-density treatments, respectively. No differences in CV existed between density treatments at either sampling period.

Proximate composition of the commercial diet fed to fish during the rearing trial is shown in Table 2, and whole-body composition of Florida pompano sampled from each density treatment at the conclusion of the rearing trial is presented in Table 3. No significant differences in whole-body composition were observed among density treatments. No significant differences in energy retention, HSI, and fillet yield existed among density treatments (Table 4). However, PER of fish reared at low density (0.61) was greater than that of fish reared at high density (0.54). In addition, PPV of fish reared at low density (13.7%) was greater than that of fish reared at high density (11.5%).

Selected across-treatment production variables for male and female Florida pompano sampled at the conclusion of the rearing trial are presented in Table 5. No significant gender-based differences were detected with respect to percentage contribution to the population (i.e., sex ratio), final weight, and fillet yield. The GSI of male fish (0.53%), however, was lower than that of female fish (1.19%).

Discussion

Rearing density clearly affected mean weight and mean weight gain of Florida pompano in the present study, although differences between treatments with respect to these characteristics did not become apparent until the latter segment of the rearing trial. Specifically, final weight and weight gain of Florida pompano reared in low-salinity RASs at high density were 9.8% and 15.8% less, respectively, than those of fish reared at low density. Although no differences among density treatments existed with respect to SGR, overall AGR of fish reared at high density was 17.6% less than that of fish reared at low density, and the increase in mean biomass of high-density tanks was 22.3% less than that of low-density tanks. The inverse relationship between rearing density on production and growth of Florida pompano observed in this study is in agreement with results obtained from density studies conducted with turbot (Irwin et al. 1999), California halibut (Merino et al. 2007), Atlantic cod (Lambert and Dutil 2001), common sole (Howell 1998; Schram et al. 2006), gilthead seabream (Canario et al. 1998), red porgy (Maragoudaki et al. 1999), and European seabass (Paspatis et al. 2003). In the case of turbot, California halibut, Atlantic cod, and common soles, investigators observed that the size variation increased with increased rearing density. Increasing CV of size or weight is indicative of the establishment of social interactions, hierarchies, and territorial borders (Jobling 1994). Such behaviors result in suppression of growth due to competition for food between individuals (Jobling and Baardvik 1994; Jobling 1995), which

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low density</th>
<th>High density</th>
</tr>
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<tbody>
<tr>
<td>Gross energy (cal/g)</td>
<td>6,204 ± 26</td>
<td>6,293 ± 31</td>
</tr>
<tr>
<td>Dry matter (%)</td>
<td>39.8 ± 0.3</td>
<td>39.9 ± 0.4</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>4.1 ± 0.2</td>
<td>4.3 ± 0.2</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>44.6 ± 0.6</td>
<td>43.4 ± 0.9</td>
</tr>
<tr>
<td>Lipid (%)</td>
<td>52.7 ± 0.4</td>
<td>53.2 ± 0.8</td>
</tr>
<tr>
<td>Percentage of population</td>
<td>52.5 ± 5.4 z</td>
<td>47.5 ± 5.4 z</td>
</tr>
<tr>
<td>Final weight (g)</td>
<td>553.2 ± 16.3 z</td>
<td>599.5 ± 17.4 z</td>
</tr>
<tr>
<td>Fillet yield (%)</td>
<td>39.6 ± 0.7 z</td>
<td>39.2 ± 0.7 z</td>
</tr>
<tr>
<td>Gonadosomatic index (%)</td>
<td>0.53 ± 0.05 z</td>
<td>1.19 ± 0.13 y</td>
</tr>
</tbody>
</table>

Table 2.—Proximate composition of the commercial diet fed to Florida pompano during a 110-d experimental rearing trial. Values are expressed on a dry weight basis.

Table 3.—Whole-body composition (mean ± SE; expressed on a dry weight basis) of Florida pompano reared at two different densities in low-salinity recirculating aquaculture systems. None of the variables differed significantly between low- and high-density treatment groups (P > 0.05).

Table 4.—Selected dietary efficiency variables, hepatosomatic index (HSI), and fillet yield of Florida pompano reared at two different densities in low-salinity recirculating aquaculture systems. Within a row, values (mean ± SE) sharing the same letter are not significantly different (P > 0.05).

Table 5.—Selected production variables (mean ± SE) of male and female Florida pompano reared in low-salinity recirculating aquaculture systems. Within a row, values sharing the same letter are not significantly different (P > 0.05).
would tend to reduce overall production. In the present study, CV of final weight and K did not differ between density treatments, suggesting that growth and production were affected by factors other than development of agonistic behaviors. Reduced production and growth at high densities without an effect on size variation also occurred in gilthead seabream (Canario et al. 1998), red porgy (Maragoudaki et al. 1999), and European seabass (Paspatis et al. 2003). Canario et al. (1998) speculated that in the absence of intraspecific competition, as assessed by lack of variation in their study, reduced growth at increasing rearing density may have been the result of other factors, such as differences in water quality. In the present study, dissolved oxygen levels remained above 70% saturation in each tank and TAN and NO$_3$-N were assumed to be equal between levels remained above 70% water quality. In the present study, dissolved oxygen levels were constant and NO$_3$-N was below 1 mg/L in all tanks. The CV of final weight and K did not differ between density treatments, suggesting that growth and production would tend to reduce overall production. In the present study, CV of final weight and K did not differ between density treatments, suggesting that growth and production were affected by factors other than development of agonistic behaviors. Reduced production and growth at high densities without an effect on size variation also occurred in gilthead seabream (Canario et al. 1998), red porgy (Maragoudaki et al. 1999), and European seabass (Paspatis et al. 2003). Canario et al. (1998) speculated that in the absence of intraspecific competition, as assessed by lack of variation in their study, reduced growth at increasing rearing density may have been the result of other factors, such as differences in water quality. In the present study, dissolved oxygen levels remained above 70% saturation in each tank and TAN and NO$_3$-N were assumed to be equal between levels remained above 70% water quality. In the present study, dissolved oxygen levels were constant and NO$_3$-N was below 1 mg/L in all tanks. The CV of final weight and K did not differ between density treatments, suggesting that growth and production would tend to reduce overall production.

In this study, FCE values of Florida pompano reared at both densities were similar to those reported by Weirich et al. (2006) but were low compared with those of other marine species (Tucker 1998). It is possible that fish were meeting their energy requirement before ingesting sufficient protein required for rapid growth, especially during the latter segment of the rearing trial. The effect of protein sparing in diets containing high lipid levels has been well documented in fish nutrition studies (Halver and Hardy 2002).

Anecdotal evidence, including observations made at our facility, suggest that growth of female Florida pompano is greater than that of males. Sexual dimorphism in size is common in a number of marine fishes (Tucker 1998), and the tendency of females to grow larger than males has been reported for various species, including Atlantic salmon (Nævdal et al. 1983), Atlantic halibut (Sigourney et al. 2006), European seabass (Saillant et al. 2001), and turbot (Imsland et al. 1997). In the present study, however, no gender-based differences with respect to percentage contribution to the population, final weight, or fillet yield were detected.

Results of this study demonstrated that Florida pompano can be cultured to market size at reduced environmental salinities. Although a direct comparison cannot be made, production characteristics of this study agree with those reported by Weirich et al. (2006) for Florida pompano reared at a salinity of 23–28%. While limited research has been conducted to investigate the possibility of rearing marine species at low salinities, studies conducted thus far have shown that production and survival can be enhanced via maintenance of critical ions, including calcium, magnesium, and potassium (Forsberg and Neil 1997; Atwood et al. 2003; Cheng et al. 2005, 2006). In the present study, sulfate, potassium, and magnesium concentrations approximated levels expected from diluted natural seawater, while calcium levels were amended and maintained at a level that approximated the concentration expected at a salinity of 15%o (Spotte 1979).

This study demonstrates that Florida pompano can be reared to market size in low-salinity RASs. While increased density reduced overall production, additional studies are warranted to determine optimal rearing density on an economical basis. In addition, research must concentrate on the development of finishing diets for final stages of Florida pompano production to increase FCE. Furthermore, additional research is needed to evaluate the potential of rearing Florida pompano in RASs at salinities lower than 5%, perhaps...
through environmental or dietary enhancement of critical ions.

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