OUT OF DRAFT 2 – IN A SAFE PLACE

# **Appendix**

Additionally, the distribution of urchins is wider, more uniform, and more likely to be within range of resources than the physical shelters provided by rocks and crevices (Day & Branch, 2002b) and therefore, sheltering beneath urchins increases the juvenile abalone’s distribution and access to food resources.

Aquaculture is a major source of protein in Sub-Saharan Africa, a region experiencing rapid population growth, changing lifestyles and preferences, and increased health awareness.(Ngarava et al., 2023). Africa’s contribution to global aquaculture production in 2020 was 1.92% (including animals and algae), with Egypt being the main producer for the continent (FAO, 2022). This figure is small when one considers the size of the continent and crucial role aquatic foods play in contributing to the overall intake of animal proteins in numerous African countries. Employment in aquaculture continues to increase in Africa but remains low compared with employment in the African fishing sector (FAO, 2022).

With the anticipated increase in population growth for the African continent and declines in fisheries projections, the slow growth of aquaculture production poses a significant risk to food security and employment opportunities considering the widespread undernourishment in the region. The untapped potential of the region’s extensive inland waterways and coastlines, coupled with a growing deficit in fish supply, presents a significant opportunity for African aquaculture to meet the rising demand for aquatic foods from a growing and rapidly urbanizing consumer population (Britz & Venter, 2016).

# Actual Values

***Weight***

Table 8.1.1 Descriptive statistics for weight (g) of all tanks, in terms of mean, standard deviation and variance, of *P. angulosus* urchins at the start of the experiment.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Tank | Diet | Temperature | Mean (g) | St. dev (g) | Var (g^2) | n |
| 1 | formulated | warm | 17.62 | 7.1 | 50.3714 | 19 |
| 2 | mixed | warm | 19.28 | 6.46 | 41.764 | 19 |
| 3 | formulated | ambient | 19.32 | 7.23 | 52.2206 | 19 |
| 4 | mixed | ambient | 14.68 | 6 | 35.9936 | 19 |
| 5 | mixed | warm | 17.06 | 6.78 | 45.9281 | 19 |
| 6 | ulva | warm | 17.11 | 5.47 | 29.9299 | 19 |
| 7 | kelp | ambient | 13.89 | 7.97 | 63.5988 | 19 |
| 8 | ulva | ambient | 18.26 | 6.94 | 48.1692 | 19 |
| 9 | ulva | warm | 16.43 | 7.82 | 61.1243 | 19 |
| 10 | kelp | warm | 14.72 | 5.69 | 32.3618 | 19 |
| 11 | kelp | ambient | 18.29 | 6.91 | 47.7743 | 19 |
| 12 | formulated | ambient | 14.97 | 6.4 | 40.942 | 19 |
| 13 | formulated | warm | 22.19 | 6.73 | 45.261 | 19 |
| 14 | mixed | warm | 14.99 | 8.62 | 74.2894 | 19 |
| 15 | ulva | ambient | 13.71 | 8.17 | 66.7072 | 19 |
| 16 | mixed | ambient | 13.64 | 6.63 | 43.9515 | 19 |
| 17 | ulva | warm | 15.85 | 5.82 | 33.8737 | 19 |
| 18 | kelp | warm | 14.75 | 6.88 | 47.3026 | 19 |
| 19 | formulated | ambient | 16.08 | 7.08 | 50.1406 | 19 |
| 20 | kelp | ambient | 19.73 | 9.23 | 85.2745 | 19 |
| 21 | kelp | warm | 17.16 | 5.63 | 31.6559 | 19 |
| 22 | ulva | warm | 18.78 | 8.29 | 68.7347 | 19 |
| 23 | mixed | ambient | 16.76 | 6.5 | 42.2491 | 19 |
| 24 | formulated | ambient | 16.62 | 5.84 | 34.0618 | 19 |
| 25 | mixed | warm | 16.28 | 8.16 | 66.5295 | 19 |
| 26 | formulated | warm | 17.44 | 5.79 | 33.4891 | 19 |
| 27 | ulva | ambient | 17.21 | 5.18 | 26.8821 | 19 |
| 28 | ulva | ambient | 17.83 | 7.92 | 62.7489 | 19 |
| 29 | kelp | warm | 16.18 | 6.89 | 47.5251 | 19 |
| 30 | formulated | warm | 18.45 | 5.87 | 34.5115 | 19 |
| 31 | mixed | ambient | 14.94 | 5.2 | 27.0348 | 19 |
| 32 | kelp | ambient | 19.39 | 8.27 | 68.4083 | 19 |

Table 8.1.2. Descriptive statistics for weight (g) of all tanks, in terms of mean, standard deviation and variance, of *P. angulosus* urchins at the after 4 weeks.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Tank | Diet | Temperature | Mean (g) | St. dev (g) | Var (g^2) | n |
| 1 | formulated | warm | 18.88 | 7.26 | 52.6949 | 19 |
| 2 | mixed | warm | 19.5 | 6.96 | 48.4683 | 19 |
| 3 | formulated | ambient | 20.43 | 7.5 | 56.3237 | 19 |
| 4 | mixed | ambient | 15.05 | 5.92 | 35.0205 | 19 |
| 5 | mixed | warm | 17.64 | 6.53 | 42.6362 | 19 |
| 6 | ulva | warm | 18.05 | 5.63 | 31.7518 | 19 |
| 7 | kelp | ambient | 13.98 | 8.12 | 65.911 | 19 |
| 8 | ulva | ambient | 18.62 | 6.96 | 48.4766 | 19 |
| 9 | ulva | warm | 16.79 | 7.98 | 63.7253 | 19 |
| 10 | kelp | warm | 14.15 | 5.54 | 30.7244 | 19 |
| 11 | kelp | ambient | 17.86 | 7.08 | 50.1473 | 19 |
| 12 | formulated | ambient | 16.41 | 7.1 | 50.4783 | 19 |
| 13 | formulated | warm | 23.14 | 6.72 | 45.1203 | 19 |
| 14 | mixed | warm | 15.48 | 8.61 | 74.198 | 19 |
| 15 | ulva | ambient | 13.9 | 8.31 | 69.116 | 19 |
| 16 | mixed | ambient | 14.25 | 6.93 | 48.0077 | 19 |
| 17 | ulva | warm | 16.39 | 5.8 | 33.6618 | 19 |
| 18 | kelp | warm | 13.93 | 6.96 | 48.4531 | 20 |
| 19 | formulated | ambient | 17.24 | 7.83 | 61.3526 | 19 |
| 20 | kelp | ambient | 19.75 | 8.99 | 80.7613 | 19 |
| 21 | kelp | warm | 17.13 | 5.71 | 32.6232 | 19 |
| 22 | ulva | warm | 19.86 | 7.76 | 60.258 | 19 |
| 23 | mixed | ambient | 17.08 | 6.89 | 47.4139 | 19 |
| 24 | formulated | ambient | 17.67 | 6.16 | 37.928 | 19 |
| 25 | mixed | warm | 16.83 | 8.27 | 68.32 | 19 |
| 26 | formulated | warm | 18.66 | 6.01 | 36.1585 | 19 |
| 27 | ulva | ambient | 17.24 | 6.33 | 40.0348 | 19 |
| 28 | ulva | ambient | 18.26 | 8.04 | 64.5841 | 19 |
| 29 | kelp | warm | 15.85 | 7.04 | 49.5105 | 19 |
| 30 | formulated | warm | 19.49 | 6.28 | 39.4706 | 19 |
| 31 | mixed | ambient | 15.8 | 5.51 | 30.398 | 19 |
| 32 | kelp | ambient | 19.02 | 8.21 | 67.4632 | 19 |

Table 8.1.3. Descriptive statistics for weight (g) of all tanks, in terms of mean, standard deviation and variance, of *P. angulosus* urchins at the after 8 weeks.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Tank | Diet | Temperature | Mean (g) | St. dev (g) | Var (g^2) | n |
| 1 | formulated | warm | 19.99 | 7.41 | 54.867 | 19 |
| 2 | mixed | warm | 20.47 | 6.89 | 47.4198 | 19 |
| 3 | formulated | ambient | 22.72 | 8.32 | 69.2303 | 16 |
| 4 | mixed | ambient | 16.59 | 6.01 | 36.1658 | 19 |
| 5 | mixed | warm | 18.87 | 6.23 | 38.8186 | 19 |
| 6 | ulva | warm | 19.3 | 5.38 | 28.9925 | 19 |
| 7 | kelp | ambient | 13.88 | 8.18 | 66.8324 | 19 |
| 8 | ulva | ambient | 19.68 | 7.56 | 57.108 | 16 |
| 9 | ulva | warm | 17.37 | 7.87 | 61.9862 | 19 |
| 10 | kelp | warm | 14.94 | 5.36 | 28.6934 | 12 |
| 11 | kelp | ambient | 17.97 | 7.99 | 63.7908 | 12 |
| 12 | formulated | ambient | 18.27 | 7.11 | 50.615 | 19 |
| 13 | formulated | warm | 23.97 | 6.55 | 42.952 | 19 |
| 14 | mixed | warm | 16.86 | 8.62 | 74.3562 | 19 |
| 15 | ulva | ambient | 15.18 | 8.18 | 66.9169 | 16 |
| 16 | mixed | ambient | 15.97 | 7.14 | 51.034 | 17 |
| 17 | ulva | warm | 17.15 | 5.56 | 30.9516 | 19 |
| 18 | kelp | warm | 15.25 | 7.71 | 59.4627 | 15 |
| 19 | formulated | ambient | 19.17 | 8.13 | 66.1694 | 18 |
| 20 | kelp | ambient | 21.57 | 8.6 | 73.9394 | 14 |
| 21 | kelp | warm | 16.74 | 5.79 | 33.4755 | 19 |
| 22 | ulva | warm | 20.67 | 7.63 | 58.2224 | 18 |
| 23 | mixed | ambient | 18.5 | 7.34 | 53.8874 | 19 |
| 24 | formulated | ambient | 19.75 | 6.7 | 44.8302 | 17 |
| 25 | mixed | warm | 18.6 | 8.52 | 72.6662 | 19 |
| 26 | formulated | warm | 20.1 | 6.08 | 36.9106 | 19 |
| 27 | ulva | ambient | 19.51 | 5.45 | 29.7481 | 16 |
| 28 | ulva | ambient | 19.21 | 8.21 | 67.4352 | 19 |
| 29 | kelp | warm | 17.25 | 7.4 | 54.8009 | 13 |
| 30 | formulated | warm | 21.51 | 5.87 | 34.4628 | 18 |
| 31 | mixed | ambient | 17.04 | 5.8 | 33.5914 | 19 |
| 32 | kelp | ambient | 20.79 | 6.49 | 42.1843 | 13 |

Table 8.1.4. Descriptive statistics for weight (g) of all tanks, in terms of mean, standard deviation and variance, of *P. angulosus* urchins at the after 13 weeks.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Tank | Diet | Temperature | Mean (g) | St. dev (g) | Var (g^2) | n |
| 1 | formulated | warm | 20.31 | 7.27 | 52.9097 | 18 |
| 2 | mixed | warm | 21.58 | 6.96 | 48.4486 | 17 |
| 3 | formulated | ambient | 24.17 | 8.44 | 71.2403 | 15 |
| 4 | mixed | ambient | 18.63 | 6.13 | 37.5615 | 18 |
| 5 | mixed | warm | 20.74 | 6.27 | 39.3043 | 18 |
| 6 | ulva | warm | 20.25 | 5.78 | 33.3526 | 17 |
| 8 | ulva | ambient | 21.21 | 7.65 | 58.5474 | 14 |
| 9 | ulva | warm | 18.46 | 7.79 | 60.7417 | 19 |
| 12 | formulated | ambient | 19.56 | 7.34 | 53.9176 | 18 |
| 13 | formulated | warm | 24.29 | 6.43 | 41.294 | 18 |
| 14 | mixed | warm | 17.9 | 8.29 | 68.7212 | 18 |
| 15 | ulva | ambient | 16.74 | 8.14 | 66.1864 | 14 |
| 16 | mixed | ambient | 17.36 | 8.09 | 65.4172 | 13 |
| 17 | ulva | warm | 17.93 | 5.47 | 29.9158 | 18 |
| 19 | formulated | ambient | 20.66 | 8.6 | 73.9368 | 16 |
| 22 | ulva | warm | 21.31 | 7.76 | 60.2145 | 17 |
| 23 | mixed | ambient | 20.53 | 8.22 | 67.5477 | 18 |
| 24 | formulated | ambient | 20.85 | 6.96 | 48.4965 | 15 |
| 25 | mixed | warm | 19.97 | 8.66 | 74.9715 | 18 |
| 26 | formulated | warm | 20.94 | 6.09 | 37.0816 | 18 |
| 27 | ulva | ambient | 21.41 | 5.01 | 25.057 | 13 |
| 28 | ulva | ambient | 20.38 | 8.14 | 66.33 | 19 |
| 30 | formulated | warm | 22.6 | 5.99 | 35.8858 | 17 |
| 31 | mixed | ambient | 18.51 | 6.18 | 38.24 | 18 |

Table 8.1.5. Descriptive statistics for weight (g) of all tanks, in terms of mean, standard deviation and variance, of *P. angulosus* urchins at the after 18 weeks.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Tank | Diet | Temperature | Mean (g) | St. dev (g) | Var (g^2) | n |
| 1 | formulated | warm | 20.86 | 7.17 | 51.3513 | 18 |
| 2 | mixed | warm | 22.55 | 6.89 | 47.4575 | 16 |
| 3 | formulated | ambient | 23.53 | 8.24 | 67.8439 | 15 |
| 4 | mixed | ambient | 21.52 | 7.5 | 56.2624 | 18 |
| 5 | mixed | warm | 22.25 | 5.98 | 35.7588 | 18 |
| 6 | ulva | warm | 22.37 | 6.82 | 46.5223 | 17 |
| 8 | ulva | ambient | 22.42 | 7.84 | 61.4795 | 13 |
| 9 | ulva | warm | 19.07 | 7.61 | 57.8832 | 19 |
| 12 | formulated | ambient | 20.38 | 7.11 | 50.5622 | 18 |
| 13 | formulated | warm | 24.49 | 6.32 | 39.9653 | 18 |
| 14 | mixed | warm | 19.62 | 8.2 | 67.1733 | 18 |
| 15 | ulva | ambient | 18.51 | 7.76 | 60.2014 | 12 |
| 16 | mixed | ambient | 18.81 | 8.37 | 70.0828 | 12 |
| 17 | ulva | warm | 19.23 | 5.2 | 27.0423 | 18 |
| 19 | formulated | ambient | 22.6 | 8.48 | 71.8704 | 13 |
| 22 | ulva | warm | 21.73 | 7.43 | 55.1716 | 16 |
| 23 | mixed | ambient | 22.94 | 7.92 | 62.655 | 17 |
| 24 | formulated | ambient | 21.98 | 7.4 | 54.727 | 15 |
| 25 | mixed | warm | 21.31 | 8.42 | 70.9714 | 18 |
| 26 | formulated | warm | 19.57 | 5.89 | 34.7206 | 18 |
| 27 | ulva | ambient | 22.35 | 5.44 | 29.6476 | 13 |
| 28 | ulva | ambient | 21.3 | 8 | 63.9325 | 18 |
| 30 | formulated | warm | 22.64 | 5.74 | 32.9467 | 17 |
| 31 | mixed | ambient | 19.62 | 6.86 | 47.1272 | 18 |

# SGR Values

Table 8.2.1. SGR’s (%growth/day) of all tanks

(A: week 0 – week 4, B: week 4 0 week 8, C: week 8 – week 13, D: week 13 – week 18)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Tank | Diet | Temperature | Treatment | SGR\_A | SGR\_B | SGR\_C | SGR\_D |
| 1 | formulated | warm | fw | 0.24 | 0.2 | 0.05 | 0.07 |
| 2 | mixed | warm | mw | 0.04 | 0.17 | 0.17 | 0.12 |
| 3 | formulated | ambient | fa | 0.19 | 0.37 | 0.19 | -0.07 |
| 4 | mixed | ambient | ma | 0.09 | 0.34 | 0.36 | 0.4 |
| 5 | mixed | warm | mw | 0.12 | 0.23 | 0.3 | 0.2 |
| 6 | ulva | warm | uw | 0.18 | 0.23 | 0.15 | 0.28 |
| 7 | kelp | ambient | ka | 0.02 | -0.02 | 0 | 0 |
| 8 | ulva | ambient | ua | 0.07 | 0.19 | 0.23 | 0.15 |
| 9 | ulva | warm | uw | 0.07 | 0.12 | 0.19 | 0.09 |
| 10 | kelp | warm | kw | -0.14 | 0.19 | 0 | 0 |
| 11 | kelp | ambient | ka | -0.08 | 0.02 | 0 | 0 |
| 12 | formulated | ambient | fa | 0.32 | 0.37 | 0.21 | 0.11 |
| 13 | formulated | warm | fw | 0.14 | 0.12 | 0.04 | 0.02 |
| 14 | mixed | warm | mw | 0.11 | 0.29 | 0.19 | 0.25 |
| 15 | ulva | ambient | ua | 0.05 | 0.3 | 0.31 | 0.28 |
| 16 | mixed | ambient | ma | 0.15 | 0.39 | 0.26 | 0.22 |
| 17 | ulva | warm | uw | 0.12 | 0.16 | 0.14 | 0.19 |
| 18 | kelp | warm | kw | -0.2 | 0.31 | 0 | 0 |
| 19 | formulated | ambient | fa | 0.24 | 0.37 | 0.23 | 0.25 |
| 20 | kelp | ambient | ka | 0 | 0.3 | 0 | 0 |
| 21 | kelp | warm | kw | -0.01 | -0.08 | 0 | 0 |
| 22 | ulva | warm | uw | 0.19 | 0.14 | 0.1 | 0.05 |
| 23 | mixed | ambient | ma | 0.07 | 0.28 | 0.33 | 0.31 |
| 24 | formulated | ambient | fa | 0.21 | 0.38 | 0.17 | 0.15 |
| 25 | mixed | warm | mw | 0.11 | 0.34 | 0.22 | 0.18 |
| 26 | formulated | warm | fw | 0.23 | 0.26 | 0.13 | -0.19 |
| 27 | ulva | ambient | ua | 0.01 | 0.43 | 0.29 | 0.12 |
| 28 | ulva | ambient | ua | 0.08 | 0.17 | 0.18 | 0.12 |
| 29 | kelp | warm | kw | -0.07 | 0.29 | 0 | 0 |
| 30 | formulated | warm | fw | 0.19 | 0.34 | 0.15 | 0 |
| 31 | mixed | ambient | ma | 0.19 | 0.26 | 0.26 | 0.16 |
| 32 | kelp | ambient | ka | -0.07 | 0.31 | 0 | 0 |

Table . Gonad histology of *P. angulosus* male testes and female ovaries depicting the respective gonad maturity stages ((1) recovery, (2) growing, (3) premature, (4) mature, (5) partly spawned, and (6) spent)

|  |  |  |
| --- | --- | --- |
| Gonad maturity stage | Male testes | Female ovaries |
| 1. Recovery |  |  |
| 1. Growing |  |  |
| 1. Premature |  |  |
| 1. Mature |  | A close-up of a cell  Description automatically generated |
| 1. Partly spawned | A close-up of a microscope  Description automatically generated | A close-up of a microscope  Description automatically generated |
| 1. Spent | A close-up of a microscope  Description automatically generated | A close-up of a microscope  Description automatically generated |

\*\*I don’t know where to put this:\*\*\*

## African and South African aquaculture

|  |
| --- |
| **Survival rate (%)**  **(mean ± se)** |
| 100.00 ± 0.00 |
| 100.00 ± 0.00 |
| 100.00 ± 0.00 |
| 100.00 ± 0.00 |
| 98.68 ± 1.32 |
| 100.00 ± 0.00 |
| 100.00 ± 0.00 |
| 100.00 ± 0.00 |
| 92.11 ± 3.40 |
| 98.68 ± 1.32 |
| 97.37 ± 2.63 |
| 100.00 ± 0.00 |
| 88.16 ± 3.95 |
| 98.68 ± 1.32 |
| 76.32 ± 8.18 |
| 76.32 ± 8.18 |
| 90.79 ± 3.31 |
| 98.68 ± 1.32 |
| 93.42 ± 6.58 |
| 98.68 ± 1.32 |
| 84.21 ± 5.26 |
| 98.68 ± 1.32 |
| 88.16 ± 4.49 |
| 98.68 ± 1.32 |
| 90.79 ± 7.56 |
| 98.68 ± 1.32 |
| 81.58 ± 4.59 |
| 97.37 ± 2.63 |
| 85.53 ± 5.84 |
| 96.05 ± 2.52 |
| 90.79 ± 7.56 |
| 98.68 ± 1.32 |
| 81.58 ± 4.56 |
| * 1. ± 2.63 |