Assessing somatic growth rate and gonad development of the Cape sea urchin *Parachinus angulosus*

MSc Minor Dissertation Proposal

Aimee Cloete
(CLTAIM001)

Department of Biological Sciences
University of Cape Town

Supervisor (s):
Prof John J. Bolton (Emeritus Professor)
Dr Marissa Brink-Hull (UCT Postdoctoral Research Fellow)
Dr Brett M. Macey (DFFE)

August 2023

Research Proposal

1. Background

The development of the aquaculture industry has resulted in concerns with regards to effluent discharge (Granada et al. 2016), reliance on natural resources as feeds or alternatively, reliance on commercial feeds, which can become costly. Integrated multi-trophic aquaculture (IMTA) is an advanced form of aquaculture which has the potential to reduce environmental impacts, increase profitability and diversify commercial production in a sustainable way. IMTA uses extractive species with commercial value as a biofiltration system; essentially converting the waste products from one species into a valuable resource for another. The implementation of IMTA systems can increase the efficiency of aquaculture systems and contribute to the development of a sustainable aquaculture industry, particularly when species that are ecologically compatible are co-cultured (Kang et al. 2003; Kim et al. 2015).

Commented [BMM1]: Maybe add a definition for IMTA for those readers that are not familiar with the concept

This project is exploring the feasibility of the Cape sea urchin, *Parechinus angulosus*, as a new market product for South Africa which has the potential to be co-cultured with South African abalone, *Haliotis midae*, through an IMTA system. The high value abalone species and the Cape sea urchin have a similar preferred temperature range (12 – 20 °C) (Fricke 1980; Britz et al. 1997; Day and Branch 2002a) and commonly occur together in nature, particularly during the juvenile stages of the abalone life cycle (Day and Branch 2000, 2002a). Laboratory experiments by Day & Branch (2002a) showed that juvenile abalone prefer to shelter beneath urchins rather than under rocks and crevices. One of the reasons for this preference is that there is not sufficient microalgae growth under rocks and crevices to meet the dietary requirements of juvenile abalone (Day & Branch, 2002a) and therefore, the juvenile abalone need to leave their shelter and expose themselves to graze. Juvenile abalone that shelter beneath urchins can reduce or eliminate their exposure to predators such as octopus, rock lobster and predatory fish while grazing (Nepgen, 1982; Smith, 1999; Mayfield et al., 2000). 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 resources.

Previous work done for my honours research project (2022), by the same research group, studied the impacts of urchin waste products on abalone growth and found that supplementing hatchery-reared juvenile abalone diets with Cape sea urchin faecal matter enhanced the growth rates of juvenile abalone. Considering the co-habitation of sea urchins and abalone in natural environments, as well as the potential symbiotic relationships that exist between them, they could be co-cultured as a method of improving animal health through the trophic transfer of microbial communities.

For IMTA systems to succeed, both species being co-cultured should have commercial potential. However, the feasibility of the Cape sea urchin as an additional value-added product has not been investigated as yet. One of the major factors influencing marketability of sea urchins is their gonad colour and texture (Shpigel et al., 2005). The effects of different temperatures and feeding regimes on the growth performance, optimal gonad colour and gonadal somatic index (GSI) of this species has not been assessed. The spinal colour variation of the Cape sea urchin may potentially impact their gonad colour and thus, may add commercial interest to the species. Through the improvement of the culturing protocols for this urchin species, further value could be added to the co-culturing of sea urchins and juvenile abalone and additionally, the Cape sea urchin may diversify the South African aquaculture market.

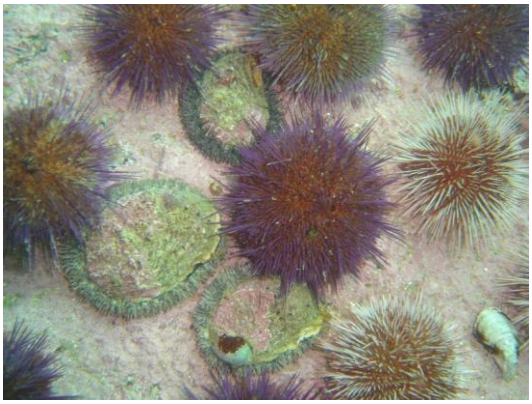

Figure 1: Image of juvenile abalone (Haliotis midae) sheltering beneath Cape sea urchins (Parechinus angulosus) in Simon's Town, Cape Town, South Africa (Peter Southwood, 2005).

2. Study aim and objectives

2.1. Aim

The aim of the study is to assess the potential of the Cape sea urchin, *Parechinus angulosus*, as an additional value-added product from an integrated aquaculture system.

2.2. Objectives:

2.2.1. Assess somatic growth and gonad development of the Cape sea urchin held at different temperatures: ambient and 17°C.

2.2.2. Assess the effects of different diets on somatic growth and gonad development of the Cape sea urchin: *Ulva lacinulata* (U), *Ecklonia maxima* kelp (K) , 20U formulated feed (F), and a combination of the forementioned diets (U, K, F) rotated on a weekly basis to form a mixed diet (M).

2.2.3. Evaluate gonad quality (colour, texture, firmness), under the above-mentioned temperatures and feeding regimes, to assess the feasibility of gonad enhancement and marketability of the Cape sea urchin.

2.2.4. Assess feed conversion rate, under the above-mentioned temperatures and feeding regimes, of the Cape sea urchin.

2.2.5. Assess nutritional components of Cape sea urchin faecal matter under different feeding regimes, to correlate urchin faecal matter nutritional components with juvenile abalone nutritional requirements.

3. Proposed timeline

Details of Timeline Stages	**Date**
Begin study and writing of introduction and methods	12th June 2023
Project proposal due	31st July 2023
Data and statistical analysis	1st October – 1st November 2023
First draft – Introduction and methods	October 2023
First draft – Results	1st –11th November 2023
First draft – Discussion and conclusion	11th November – 1st December
Final draft	February 2023

Commented [JB2]: Great!

4. Materials and methods

4.1. Culturing conditions and feeding regimes:

- The sea urchins (*Parechinus angulosus*) will be collected from in front of the Marine Research Aquarium in Sea Point (n = 650) and stocked into oyster mesh baskets (L x W x D: 40 x 29 x 16 cm; mesh size: 6 mm) suspended in tanks (L x W x H: 42 x 36 x 30 cm) at 20 animals per basket. Equal ratios of animals with different test colours will be collected (pink, light purple, dark purple and red).
- Four feeding regimes will be tested in quadruplicate: *Ulva* (U), kelp (K), a formulated feed containing 20% *Ulva* (F), as well as a combination of the forementioned diets (U, K, F) rotated on a weekly basis to form a mixed diet (M), resulting in a total of 16 tanks (320 sea urchins). All feeds will be administered ad libitum.
- These feeding regimes will be duplicated across two temperatures: ambient incoming water (temperature will be continuously recorded) and a consistent temperature of 17°C (temperature controlled using a heat pump). Therefore, a total of 32 tanks will be stocked with sea urchins, equating to 640 sea urchins for inclusion in the study. Animals will be collected one month prior to starting the growth trial to incrementally increase the water temperature to 17°C for this set of tanks and wean the animals off of their natural diets before the start of the experiment. Treatments will be randomly assigned to tanks.
- Animals will be provided with constant water supply and aeration. Tanks will be cleaned twice a week or as needed and daily biosecurity checks will be performed.

Table 1. Tank treatment allocation (F: formulated feed, M: mixed diet, U: ulva, K: kelp). Shaded tanks receive heated water, unshaded tanks receive water at ambient temperature.

F 1	M 2	F 3	M 4
M 5	U 6	K 7	U 8
U 9	K 10	K 11	F 12
F 13	M 14	U 15	M 16
U 17	K 18	F 19	K 20
K 21	U 22	M 23	F 24
M 25	F 26	U 27	U 28
K 29	F 30	M 31	K 32

Commented [JB3]: Don't you use the spellcheck? (can also select English or American).

4.2. Measurements and/or sampling:

- Measure sea urchins (test diameter and wet weight) to calculate growth rates across feeding regimes and temperatures every month.
- Measure feed conversion rates monthly.
- Monitor temperature in each tanks every half hour using an automated temperature logger.
- Dissect one urchin per replicate every second month to assess gonad weight, colour, and quality across feeding regimes and temperatures:
    - Calculate gonad somatic index (GSI): (gonad weight/urchin weight) x 100.
    - Measure gonad colour using a hand-held fibre-optic spectrophotometer.
- Correlate gonad characteristics with urchin test colour.
- Collect faecal matter when tanks are cleaned for faecal matter nutritional component assessment.

4. References

Commented [MB4]: Italicize species names in the below list

Britz P. J., Hecht T., Mangold S., 1997 Effect of temperature on growth, feed consumption and nutritional indices of *Haliotis midae* fed a formulated diet. Aquaculture 152: 191–203.

Day E., Branch G. M., 2000 Relationships between recruits of abalone *Haliotis midae*, encrusting corallines and the sea urchin *Parechinus angulosus*. South African Journal of Marine Science: 137–144.

Day E., Branch G. M., 2002a Influences of the sea urchin *Parechinus angulosus* (Leske) on the feeding behaviour and activity rhythms of juveniles of the South African abalone *Haliotis midae* Linn. Journal of Experimental Marine Biology and Ecology 276: 1–17.

Day E., Branch G. M., 2002b. Effects of sea urchins (*Parechinus angulosus*) on recruits and juveniles of abalone (*Haliotis midae*). Ecological Monographs 72: 133–149.

Fricke A. H., 1980. Aspects of Population Structure of *Parechinus Angulosus* (Leske), Around the Cape Peninsula. South African Journal of Zoology 15: 177–185.

Granada L., Sousa N., Lopes S., Lemos M. F. L., 2016 Is integrated multitrophic aquaculture the solution to the sectors' major challenges? – a review. Reviews in Aquaculture 8: 283–300.

Kang K. H., Kwon J. Y., Kim Y. M., 2003 A beneficial co-culture : charm abalone *Haliotis discus hannai* and sea cucumber *Stichopus japonicus*. Aquaculture 216: 87–93.

Kim T., Yoon H. S., Shin S., Oh M. H., Kwon I., Lee J., Choi S. D., Jeong K. S., 2015 Physical and biological evaluation of co-culture cage systems for grow-out of juvenile abalone, *Haliotis discus hannai*, with juvenile sea cucumber, *Apostichopus japonicus* (Selenka), with CFD analysis and indoor seawater tanks. Aquaculture 447: 86–101.

Mayfield, S., Branch, G.M. and Cockcroft, A.C., 2000. Relationships among diet, growth rate, and food availability for the South African rock lobster, *Jasus lalandii* (Decapoda, Palinuridea). Crustaceana, pp.815-834.

Nepgen, C.S., 1982. Diet of predatory and reef fish in False Bay and possible effects of pelagic purse-seining on their food supply. Fisheries bulletin: Contributions to oceanography and fisheries biology-Republic of South Africa, Dept. of Agriculture and Fisheries.

Shpigel, M., McBride, S.C., Marciano, S., Ron, S. and Ben-Amotz, A., 2005. Improving gonad colour and somatic index in the European sea urchin *Paracentrotus lividus*. Aquaculture, 245(1-4), pp.101-109.

Smith, C.D., 1999. Population biology and ecology of octopuses in the Southwestern Cape: a study towards the establishment of a small-scale octopus fishery (Master's thesis, University of Cape Town).