Calico Scallop Culture In Bermuda: A Low Cost, Pilot Hatchery for the Tropics and Subtropics

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ABSTRACT

The potential for large scale aquaculture of the calico scallop, *Argopecten gibbus*, has been investigated in Bermuda since 1997. An initial broodstock of 100 mature individuals was collected from Cape Canaveral, Florida, and transferred to a quarantine system at the Bermuda Biological Station for Research Inc. (BBSR). Hatchery and nursery facilities at BBSR are housed in two 20' insulated fiberglass containers; an independent seawater system allows for the continuous supply of filtered seawater; a temperature control system for seawater further allows for broodstock conditioning and optimal larval rearing. Insulated 1,000 litre tanks are available for larval rearing; post-larval rearing is conducted in 450 L round tanks, and raceways. Using a 4,600 L larval tankage capacity 40,000 5 mm juveniles are generally produced during one spawn. The facilities are compact and efficient, and they may moreover be easily duplicated in any location. *A. gibbus* is a hermaphrodite species, spawning during the winter months. Larval culture for this species was developed, investigating optimal temperature and food ration. The length of larval life is 12 days, and approximately 30% pediveligers are obtained from Day 2 larvae. Settlement is performed either by the use of polyethylene mesh or on 150 μm sieves in the raceway; the former method allows for transfer at sea within 20 - 30 days of settlement, minimizing labour during the nursery phase. Juvenile scallops, 10 - 15 mm shell length, are thereafter grown in suspended cultures. Shell growth rate is rapid, averaging 5 - 7 mm/month, and survival rate from 15 mm to 65 mm shell height is high ranging between 70% and 90%. Reproductively mature and market size individuals are obtained 12months after fertilization. Market demand for fresh local seafood is high in Bermuda, and supply to selected restaurants has received positive feedback. Further assessment of the market demand is conducted at present. The techniques developed for calico scallop culture in subtropical waters are relatively simple and have yielded a high percentage of mature market size individuals; furthermore, the custom designed facilities have proved flexible in use and efficient. In brief, the technology for *A. gibbus* aquaculture may be easily transferred to other sub-tropical and tropical locations, providing a reliable supply of shellfish to tourist-oriented areas.

KEY WORDS: Calico scallop, hatchery, tropical

INTRODUCTION

The potential for large-scale aquaculture of the calico scallop, *Argopecten gibbus*, has been investigated in Bermuda since 1997. The main constraint to the development of the program was the lack of facilities and limited funding available for this purpose. Moreover, there was limited land available for the construction of a proper hatchery, and the approval for building permits is a lengthy process in Bermuda. In light of this, a low cost "temporary" hatchery was built in June 1999 utilizing three refrigerated "reefer" containers. This facility was designed and fitted for larval and post-larval rearing of bivalve species; the main goals were to develop techniques for large-scale production and to conduct experimental work towards optimizing culture techniques for all stages of scallop life cycle. Flexibility of usage was a fundamental part of this model hatchery. The calico scallop was selected as the culture candidate following preliminary investigations indicating a rapid growth rate from juvenile to market size, coupled with a high survival rate (Sarkis et al. unpublished). This paper describes the pilot hatchery concept, and provides a synopsis of calico scallop culture developed at the Bermuda Biological Station for Research Inc. (BBSR) resulting from two seasons' operation in this facility.

PILOT HATCHERY

Hatchery and nursery facilities are compactly arranged in two 20' insulated, air-conditioned, glass-fibre containers with an additional 12' container dedicated to algal culture. Culture facilities comprise:

i) An independent seawater system providing a continuous supply of filtered seawater,
ii) A temperature control system for seawater in support of broodstock conditioning and requirements for larval and juvenile rearing,
iii) 1,000 L insulated, polyethylene and 200 L conical, glass-fibre tanks for standard larval rearing in closed systems, and for experimental rearing in flow-through larvae culture systems,
iv) Flexible usage 450 L round tanks, and stacked raceways for setting pediveligers and growing spat. Raceways may be either connected together as a single open-flow or semi-recirculating system, or used independently of one another, or as holding tanks for a series of small, independent aquaria.

Seawater Supply

Seawater is pumped continuously at a flow of about 50 gallons per minute from 10' depth to a pumphouse, where it flows through a sand filter before supplying the hatchery / nursery and algal facilities. Seawater in excess of requirements bypasses the sand filter and is discharged back into the bay.

The facility was rapidly and inexpensively set-up by linking together two 20' insulated cargo containers. Internal walls are of glass-fibre, and the floors are ribbed aluminum, allowing for easy cleaning and drainage. A well-serviced and spaceefficient working area of approximately 300 square feet was developed following the installation of pipework for climate control, temperature controlled seawater, as well as freshwater and electrical supply. Independent, multi-stage filtration units providing water filtered to a minimum of 1 μm particle size are installed at key points within the hatchery to allow for flexibility of use.

Seawater temperature is controlled and supplied on demand. Pre-filtered water (to 1 μm) is heated to desired temperature in a semi-recirculating1,000 L insulated tank; within this tank are three, 3 kW titanium immersion heaters individually connected to digital temperature controllers. Heated water is distributed to the hatchery, mainly for larval rearing, by a small pump. The system is able to heat 1,250 L/hour through a temperature differential of 8°C.

Hatchery and Nursery Facilities

One of the interconnected containers forms the hatchery area, accommodating foursemi-square 1,000 L insulated tanks. These are used for conventional, closed system rearing of bivalve larvae. These tanks have proved very reliable in rearing scallop larvae, maintaining temperature within 1°C of the required for a 72 hour period. In addition, there are three 200 L conical tanks currently used for experimental work in flow-through larval rearing. A total tank volume of 4,600 L is available for larval rearing.

The nursery area, occupying the other linked container, has been designed for flexible use in setting procedures and for early nursery culture. Two 450 L circular tanks are available as either closed or open systems for setting larvae on mesh collectors. Two 6' x 2' x 0.5' deep flow-troughs are mounted on a side wall, one above the other, acting as raceways. They are connected to a sump tank of 220 litre capacity fitted with a small pump and 250 W heaters to deliver water to either or both troughs at the required temperature through water delivery pipework. This system is extremely versatile; each raceway can be used independently as an open, closed, or recirculating system. This allows for the setting of larvae on sieves, conducting experiments in a series of independent aquaria, or using both raceways as one larger system with a total capacity of 510 L for early nursery culture of spat.

Broodstock and Holding Tanks

Two air-lift driven, semi-recirculating tanks, each 120 L volume with a sub-sand filtration system, are supplied with coarsely filtered seawater and are utilised for broodstock conditioning. Seawater within each tank may be cooled using a titanium coil, 1/5th HP chiller unit to manipulate the spawning period. The chiller is matched in size with the capacity of the tanks to allow for cooling through a 5°C differential from ambient seawater temperatures.

Additional insulated, 400 L tanks with lids are located outside on a pad fitted with drainage. They are supplied with coarsely filtered, ambient temperature seawater, and are used as holding tanks for animals brought in from the field.

Algae

The independent algal culture container receives UV sterilized, 1 µm filtered seawater at ambient temperatures. Cultures of a variety of useful algae species range in volume from 500 ml flasks to 100 L tanks. They are maintained in a climate-controlled environment with 24 hour illumination, and are continuously supplied with a mixture of air and CO_2. The current maximum output of about 100 L per day is sufficient for the current operations of the hatchery / nursery facility.

SYNOPSIS OF CULTURE METHODOLOGY

Specifications for the hatchery were well known through previous experimental work conducted on scallop culture in Bermuda (Sarkis et al. unpublished). Furthermore, scallop culture is performed on a large-scale for several other species in Japan, Chile, France, Canada, among others (Aoyama 1989, Dao et al. 1993, Bourne et al. 1989, Disalvo et al. 1984)). However, the calico scallop, *Argopecten gibbus*, although an important fishery in Cape Canaveral, Florida, is not to our knowledge cultured on a large-scale or commercially anywhere in the world (Miller et al. 1981). Hence, investigations on food ration, temperature, and reproduction were conducted to develop techniques for juvenile production (Hohn et al. submitted). Further investigations were carried out for optimising transfer of juveniles to the field, and grow-out.

Spawning, Hatchery, and Nursery

Argopecten gibbus is an hermaphroditic species, with a well defined spawning period lasting from January to May in Bermuda. Reproduction, therefore, coincides with minimal water temperatures, and spawning is associated with a slight increase in ambient temperature above 18°C.

A broodstock of 20 animals is induced to spawn by thermal shock. Release of gametes generally occurs within 60 minutes of exposure to warm water at 25°C. Each female releases approximately 5.8 million eggs. The basic protocol for larval rearing follows that used for other bivalve species (Bourne et al. 1989). Larvae are reared in 1,000 L insulated tanks at an initial density of 10 larvae/ml, decreasing to 2 larvae/ml towards the end of larval life. Larval life is relatively short, ranging from 12 to 14 days at a rearing temperature of 24°C (Figure 1); at this time, pediveligers attain a shell length of 210 ± 15 μm (Sarkis and Helm 2001). Approximately 25 - 35% of Day 2 larvae survive to metamorphosis; this is comparable to development recorded for other species, ranging from 10 - 20 % in *Argopecten irradians* and up to 50% for *Placopecten magellanicus* (Couturier et al. 1996).

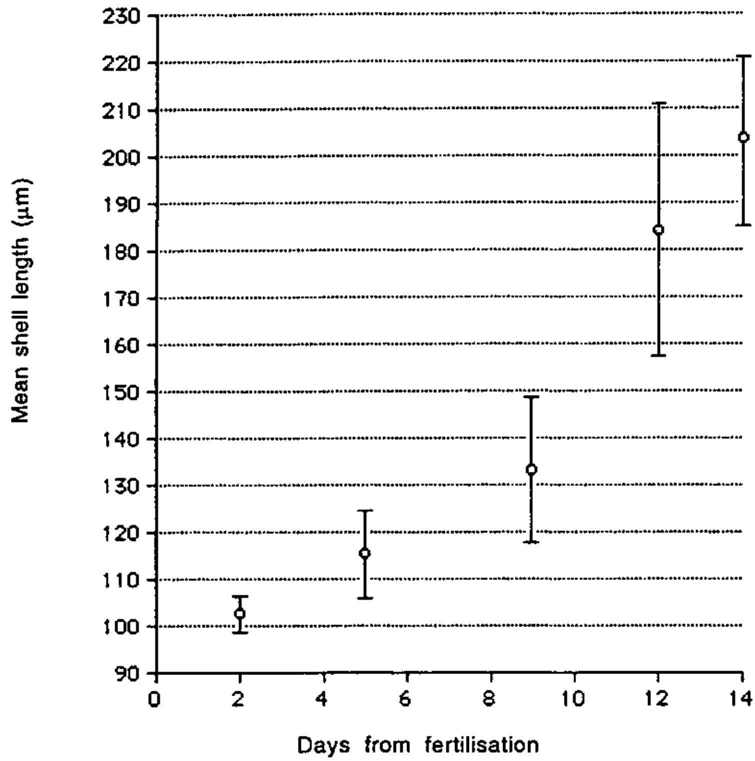

Figure 1. Mean shell length (± s.d.) for *Argopecten gibbus* larvae reared at BBSR in a typical production run. (n = 50)

Settlement:

Pediveligers are set following two different methodologies at BBSR:

i) The first is geared towards minimal labour requirement at the nursery stage, and is for all intensive purposes referred to as "remote set" technique. Circular 450 L tanks are packed with soaked bundles of lightweight, polyethylene mesh (cultch), and filled with 1µm filtered seawater; pediveligers are transferred to these setting tanks, at a density ranging from 2 - 4 larvae/ml. Metamorphosing scallops are allowed to settle on the provided cultch, and are maintained for a period of 20 - 30 days, reaching approximately 1 mm in size, before transfer to longlines in the field. For the first seven days the tanks are operated as closed systems, after which they are set as semi-recirculating systems with partial through-flow and air-lift driven recirculation. Upon transfer to the field, cultch is packed loosely in collector bags. Bags are thereafter suspended on longlines using Irish scallop trays.

ii) The second method is more conventional and optmizes survival rate to 2 - 3 mm prior to transfer to the field. Pediveligers are set in 150 µm meshbased sieves in the raceway, and reared for a period of 2 - 3 months. Although survival is considered to be better with this method, the required labor is greater, as is the quantity of algae produced daily. The growth and survival at 22°C of a batch of pediveligers set in four sieves in the raceway at an average density of 80,000 spat per sieve, is shown over a six-week period in Figure 2. Improved growth rate and survival can be expected through grading and reducing density as the spat grow.

With the installed 4,600 L larval tankage, four million pediveligers are produced on average from one spawning; the raceway system allows for the maintenance and growth of approximately 420,000 post-larvae < 500µm shell height. A total of 250,000 3 mm spat may currently be reared using existing facilities. The current constraint for increasing production is the larval and post-larval tankage capacity.

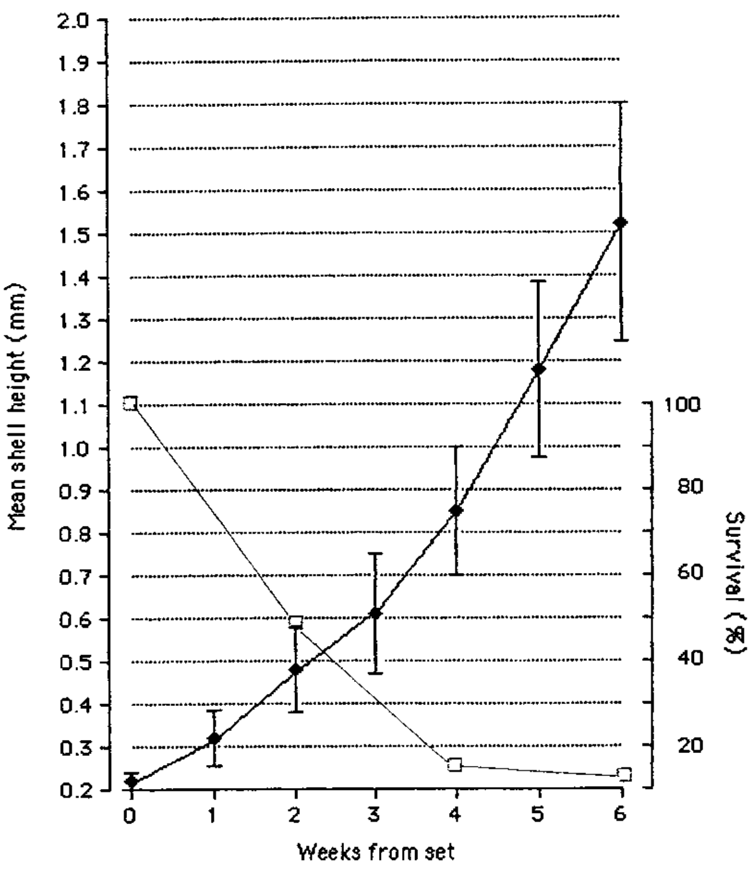

Figure 2. Shell growth (± s.d.) and survival rate of *Argopecten gibbus* post-larvae reared in a raceway system for a 6-week period following Day of set. (n = 50)

Growout

Spat transferred to the field following remote setting technique are left for a period of eight weeks on longlines. At this time, spat are picked from the cultch, measured and counted. Mean shell height at this time is 11.4 ± 1.4 mm. Survival rate over the eight-week period is difficult to assess, but 600 - 2500 spat are routinely picked from the mesh cultch within an individual collector bag. Juvenile scallops are thereafter distributed for growth to adult size. At present, 40,000 5 mm juveniles are generally produced during one culture cycle from a single spawning.

Grow-out is performed in Japanese pearl nets. Mesh size and density vary with scallop size such that 10 mm scallops are transferred to 3 mm nets at a density of 150 per net. Numbers are gradually reduced to 70 individuals/net in July, and to 40 individuals/net in September to allow for rapid growth. Shell height increases to 48.0 ± 2.7mm in seven months; and reaches a maximum of 58.3 ± 4.5mm for 21-month old scallops. Growth rate ranges from 5 - 9 mm/month. Maximum rates are associated with high sea surface temperatures (29.5°C) during July and August. Survival rate from 15 mm to the maximum size of about 65 mm shell height is good, ranging between 70% and 90%. Reproductively mature and market size individuals are obtained 12 months after fertilization. The life span of *Argopecten gibbus* in Bermuda is in the order of 24 to 30 months.

CONCLUSIONS

The techniques developed for calico scallop culture in sub-tropical waters are relatively simple and have proved capable of yielding a high percentage of mature, market-size individuals. In order to obtain a greater production with this system, the number of tanks only needs to be increased, but techniques remain the same. The custom-designed facilities are space-economic and have proved flexible in use as well as very cost-efficient. This basic technology can easily be duplicated in any location adjacent to a seawater source in other sub-tropical and tropical locations. In this way, a reliable supply of a potentially valuable shellfish species may be produced through low technology and environmentally friendly means. Alternatively, the concept lends itself as an effective experimental wet laboratory at modest cost compared with building in bricks and mortar.

Further information and photographs of the hatchery can be found at:

http://www.bbsr.edu/Studies_of_Bermuda_s_Air___Wat/aquaculture/aquacultur e.html

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