Chapter 5

Growout of juveniles: transfer from nursery to field

5.1 HOLDING AND GROWOUT FACILITIES

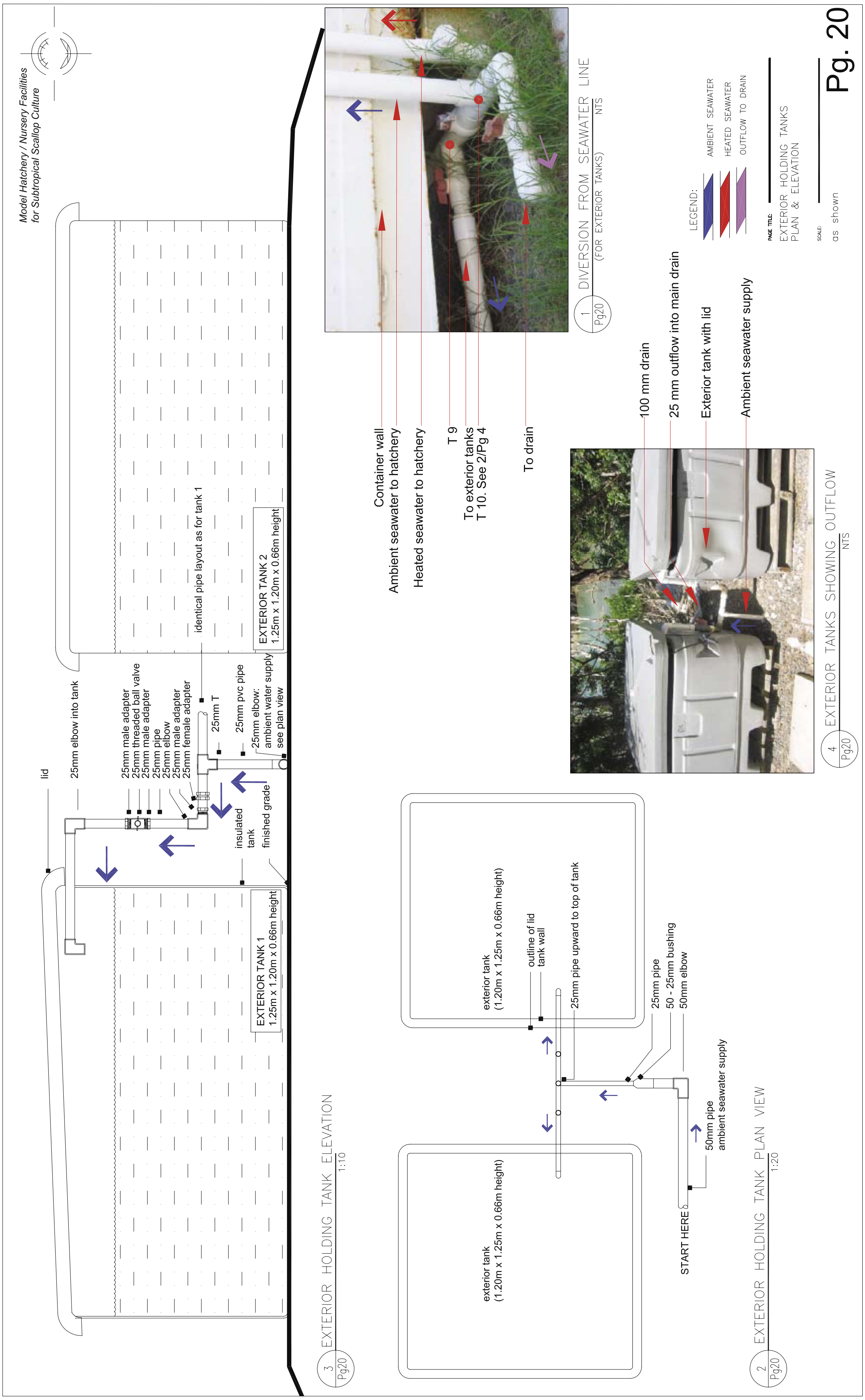
Facilities for holding scallop spat prior to transfer to the field for growout are described below. These exterior facilities can also be used for maintaining adult scallops, or for other purposes. These facilities are found extremely useful when bringing back young juveniles from the field for further sorting on land, if weather conditions do not allow sorting on the boat. The main requirements are cleanliness, as for the rest of the complex, and high water flow. Animals held in these tanks are usually not fed, and for this reason, cannot be kept for extended periods of time. Longline system used in Bermuda is described thereafter; this system is efficient for suspending pearl nets, scallop trays and/or collector bags.

5.1.1 Exterior holding tanks

Refer to Technical Drawing – page 20. Two square insulated "BONAR" tanks (400 litres volume) are installed outside the hatchery on a wooden base. They are supplied with seawater through an open system, with coarsely filtered seawater diverted from the main line, prior to entry into the hatchery complex. Technical drawing diagram – 1/Pg20 illustrates the main valve regulating the flow to the exterior tanks from the pump house. The relative position of the heated seawater line and ambient seawater line supplying the hatchery can also be seen. Finally, any excess flow, pumped in but not used, is diverted to a main drain pipe, buried sub-surface and not seen in this photo. *This photo is also represented in detail in technical drawing diagram – 2/Pg4.*

Technical drawing, Pg. 20

Exterior holding tanks: Plan & elevation



Plumbing for these tanks is very simple and done using a 50 mm pipe buried in the ground, running to the tanks. As seen in technical drawing diagram – 2/Pg20, a 50 mm elbow is fitted to the supply line, and points upwards to direct the flow of water to the tanks. From there, the pipe is reduced to 25 mm using a 50 mm to 25 mm bushing, and runs in the centre of the two tanks. A T-junction then divides the line into two. The tank elevation diagram (see technical drawing – 3/Pg20) shows the detailed connections for supply. As these tanks are cleaned, emptied and re-filled frequently, a flexible system, allowing complete drainage of the vertical pipe system, is required. The centre T-junction is fitted with a 25 mm female and male adapter threaded into one another, then glued to a clear elbow. This allows for the entire “arm” to swivel, and allows for draining of the supply pipe. The clear elbow allows to monitor any clogging of the coarsely filtered seawater supply. A 25 mm male adapter threads into a 25 mm threaded ball valve and regulates the flow of seawater into each tank. Once again this allows for turning of the pipe system to divert flow away from tank, required when cleaning. Finally a series of two 25 mm elbow direct the flow into the tank, and flow is supplied via a 25 mm inner diameter re-enforced tubing fitted to the pipe, running to the bottom of the tank.

Outflow is through a standpipe at the opposite end of the tank connected to a bottom drain. The drain is sealed with an O-ring and caulking, fitted with a thru-hull fitting, and connected to a 25 mm pipe draining into the main 100 mm drain pipe. This can be seen in technical drawing photo – 4/Pg20.

Despite high exposure to direct sunlight in Bermuda, the insulating capacity of these tanks, and high water flow generated, maintained an adequate environment for scallops throughout the year.

5.1.2 LONGLINES

Calico scallops have shown good shell growth and survival rate, as well as complete reproductive development when reared in suspended cultures. This method is used widely for various scallop species (Bourne, Hodgson and Whyte, 1989; Couturier, Dabinett and Lanteigne, 1989). Animals are reared in nets suspended from longlines in the water column. Longlines consist of two anchor lines and one transverse line with floats. There are various designs in use where transverse lines are maintained at the surface or submerged at various depths. The system in Bermuda consists mainly of a sub-surface transverse line, maintained at approximately 1.5 m depth with 30 cm diameter black floats (Figure 5.1). Each float has a floatation of 14.5 kg; they are spaced every meter and tied securely to the transverse line. The rope used is a floating type

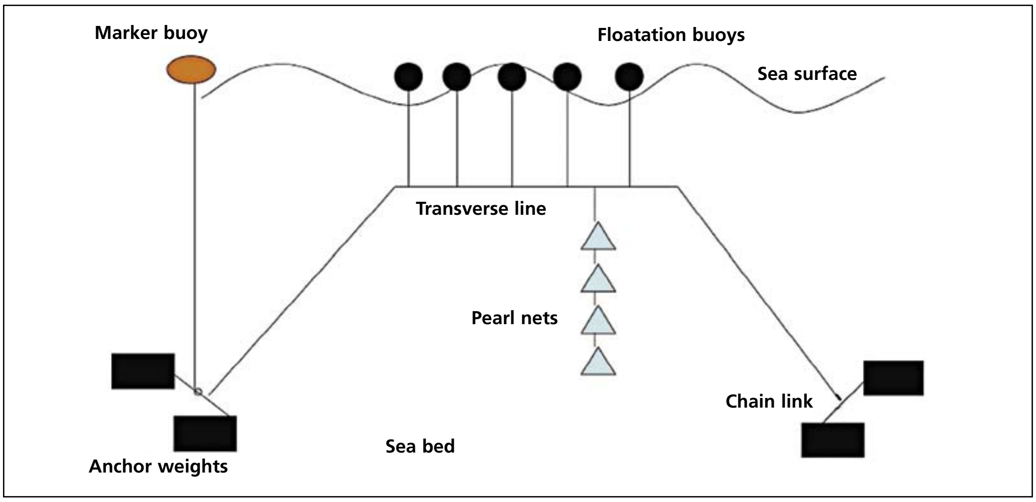


Figure 5.1: Sub-surface longline system used in Bermuda.

rather than sinking type. Maintenance of the line sub-surface serves two purposes: the first is related to the observed better performance of scallops reared below the surface, due most probably to the lack of inhibition from the UV rays. The second reason is related to minimized wave action due to wind, optimizing the longevity of the nets and of the whole system.

Anchor lines are, as a rule, twice as long as the depth of the water, so that in 10 m of water, each anchor line is 20 m long. They are attached to anchors made of any heavy material retrieved locally; in this case, plastic coated lead weights used for ballasts on boats were used, amounting to 68 kg per anchor. A 2 m chain length is connected to the anchors with shackles to facilitate replacing of the longline when needed. The anchor lines themselves are spliced into loops, protected by plastic tubing. Shackles connect the anchor lines to the chain and the plastic tubing avoids chafing of the rope.

In Bermuda, it is found, that a line needs replacing after two years. Square pearl nets are tied together to form a column of nets, with the last net being one metre off the bottom. As scallops grow, densities are reduced within the nets and nets of increasing mesh size are utilized; such that pearl nets of 3, 6 and 12 mm mesh size are used from juvenile to adult/market stage. Thus, in Bermuda, a 90 m longline set in 8 m of water, can support approximately 20 000–25 000 adult scallops. In the initial set-up, it is recommended to order more than the 12 mm nets needed, as some will tear due to bad weather or to predators.

Prior to transfer of spat to the field, longlines have to be prepared and set in selected sites. When selecting a site for scallop growout, the following considerations should be taken into account. Protection from storms, good water quality, high flow of water, water depth, protection from vandalism and other users, distance from nursery or ease of access.

5.1.3 BOTTOM CAGES

As mentioned in Chapter 4, growout of zigzag scallops to 25 mm juveniles is similar to that described for calico scallops. Unfortunately, this species does not fare well in suspended cultures for the rest of its life cycle, and exhibits optimal growth rates when cultured directly on the sandy bottom. Its natural behaviour, recessing in the sand, seems to play a role in limiting fouling on the shell, and enhancing growth. Growout cages used in Bermuda are shown in Figure 5.2. These cages protect scallops from predators as there is mesh on top and sides, but allow scallops to recess on the sandy bottom. Descriptions of the cages experimented with in Bermuda are not given in detail, as this system is not cost efficient. It is extremely labour intensive due to the continuous monitoring of the cages by SCUBA. Survival rate is very dependent on density, and loading density per cage is low (10 scallops per m^2). In order to make growout of zigzag scallops commercially feasible another growout method needs to be devised.

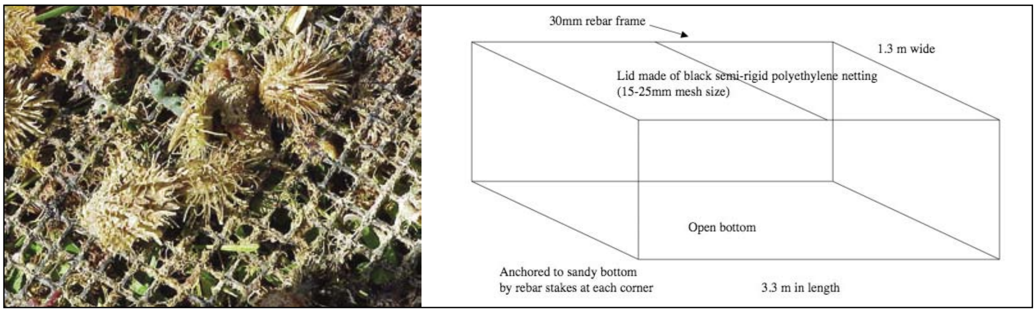


Figure 5.2: Schematic diagram of bottom cages made of rebar and plastic mesh used for protection of sand scallop (*Euvola ziczac*) juveniles and adults. Fouling on meshed lid shown close-up, necessitating retrieval of cages from field.

5.2 TECHNIQUES – TRANSFER OF SPAT FROM NURSERY TO FIELD

As two methods for set are used at the BBSR nursery (see Chapter 4), and resulting spat are transferred to the growout sites at different stages, procedures in transfer differ. Spat transferred, following the rapid approach set, are younger and smaller. They are more fragile than those transferred from the raceway system mainly due to their age. Although, success has been obtained in using the natural environment as growout site for young spat, survival rate has been enhanced when spat are reared to a larger size prior to transfer.

5.2.1 Transfer of 1.5 mm spat from 450 litres tank set

Spat set in 450 litres tanks on cultch are transferred to the field when a shell height of 1.5 mm is reached, or approximately 1 month after set (Figure 5.3). As these are very small and can be easily lost or damaged during handling, care is taken to always keep the spat submerged. Cultch is transferred to green collector bags and held in a container filled with ambient saltwater for transport to the growout sites (Figure 5.4).

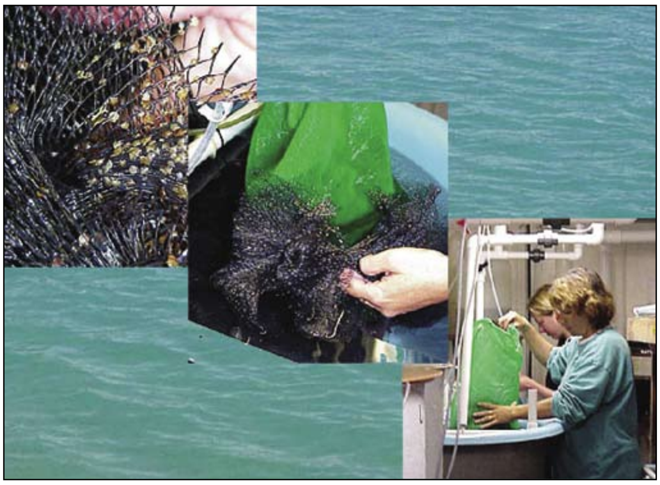


Figure 5.3: Transfer of one month old calico scallop spat in green collector bags for transfer to growout trays.

Figure 5.4: Spat pouches held in seawater prior to transfer to the field.

As outlined in detail in Protocol–16, green collector bags are suspended on longlines using scallop trays. Bags are inserted, one per tray, and trays are stacked one into the other in groups of six (Figure 5.5). The number of trays used in one stack is dependent on water depth, floatation of line, and equipment used for retrieving trays. In Bermuda, all growout handling is done by hand with a small (9 m) outboard motor boat; it is found that as scallops grow and fouling accumulates on trays, groups of six are easiest to handle.

On-site, trays are secured using a 15 mm rope, wrapped around the entire set, in a similar manner to a gift-wrap package. A bridle coming from each corner of the stack ties in the middle to a stainless steel clip. The clip attaches directly to the longline. Other methods can be used for securing a series of trays, dependent on preference of the grower. Transfer of green collector bags to trays, and securing the trays is done quickly on-site, to minimize the time period in which spat are exposed to the air. Trays are thereafter left for a period of 6 weeks in the field. For collecting of spat, trays are

Figure 5.5: Securing of pouches into trays for growout in the field on longlines.

dismantled in the field, collector bags with spat are transferred to containers filled with seawater and transported to the nursery. Upon arrival at the nursery, bags are placed in running seawater in exterior tanks or in 450 litres tanks. Spat are collected by removing mesh from cultch, and shaken into plastic trays filled with seawater. Spat at this time are passed onto a large mesh sieve (3 mm) and distributed by weight to pearl nets. For 3 mm pearl nets, a total of 150 spat (average of 7 mm shell height) are grown for a period of one month. This approximates 23 grams wet weight.

PROTOCOL–16

TRANSFER AND RETRIEVAL OF SPAT ON CULTCH TO FIELD

1. Prepare cooler or other container for transport on boat to growout site. Clean with fresh water and fill with ambient seawater.
2. Load boat with scallop trays, cut rope for securing, clips and tools. Prepare top trays with bridles and clips (see Figure 5.5).
3. Place green collector bag in 450 litres set tank and, with cultch remaining submerged in tank, transfer gently to collector bag. Fill collector bag to approximately 2/3. Close collector bag with drawstring.
4. Carefully transfer collector bag to transport container.
5. Repeat procedure until all cultch is removed from 450 litres tank.
6. Carry transport container to boat and fill to rim with ambient seawater once on board.
7. Immediately travel to growout site.
8. Upon arrival, prepare 7 trays; bottom tray should have a weight secured for stability (use twine or cable ties for securing 2.5 kg weight). Top tray has ready-made bridle. Begin transfer of green collector bag to tray: place one bag on tray, stack second tray on top, add one collector bag, and stack another tray, etc., until 6 trays have been filled with collector bags.
9. Add top tray with bridle.
10. Wrap rope around stack as for a gift-wrap.
11. Clip tray onto longline.
12. Leave for growth for a period of 6–8 weeks.
13. When ready for collecting and sorting, prepare outdoor tanks or 450 litres with clean seawater. Return to site with transport containers.
14. On-site, remove tray stack. Dismantle and transfer green collector bags to transport container filled with seawater.

15. Upon arrival to hatchery, transfer bags to prepared tanks.
16. For removal of spat, prepare trays with flowing seawater; place bags in tray and remove cultch, shaking off and picking spat.
17. All collected spat is left in trays.
18. Pour water and spat into 3 mm sieve to collect all spat.
19. Sample 150 spat on mesh, blot dry and weigh.
20. Transfer to pearl net.
21. Weigh out sub-samples of same weight for transfer to pearl nets.
22. Maintain pearl nets in flowing seawater (exterior tanks or 450 litres) until transfer to the field.
23. For transport of nets to growout sites, hold nets in containers filled with seawater. Pearl nets are attached in series of six, dependent on water depth, floatation and method of retrieval. Keep at least 1 m distance between last net and seabed.
24. Nets are hung on longline using clips or by a secure knot.

5.2.2 Transfer of 2–4 mm spat from raceway to longlines

Procedures for spat set in the raceway and transferred to the field at a size too small to be placed directly into 3 mm pearl nets (2-4 mm) is similar to that described in Section 5.2.1 above. Care is taken not to damage the spat and to maintain them continually submerged during transfer. As they are too small for 3mm pearl nets, insert pouches made of window fly screen material are used as inserts into scallop trays (Figure 5.6). This material is of larger mesh size than the collector bags, allowing for increased seawater flow for larger spat, and reduces the degree of clogging by fouling. Pouches are rectangular in shape with dimensions similar to that of the tray; pouches are sewn on three sides; the fourth side is closed using Velcro for ease of opening and closing. Spat are collected from the sieves as outlined previously. A sub-sample of 400 spat is weighed in a first instance; thereafter, aliquots of similar weight are taken and distributed in each pouch. Remainder of transfer is conducted as described from step 6 on in Protocol–16. The older and larger the spat at transfer from the nursery to the field, the shorter the time period required for growth to 7 mm (and ready for growout in pearl nets). For raceway spat, transferred approximately two months after set, an intermediate growout period of one month is usually required in trays. Following this intermediate growout phase, spat are retrieved from the field and brought to the nursery for assessment of survival, and are re-distributed into 3 mm pearl nets.

Figure 5.6: Transferring 2–4 mm spat into fly-screen pouches used as inserts for growout trays.

5.2.3 Transfer of spat >4 mm

Spat reared in the raceway for a longer time period, whether it is in the indoor or outdoor system are ready to be transferred directly to 3 mm pearl nets. The larger the spat become, the easier they are to collect, and the more tolerant they become to handling. Nonetheless, care is still taken to minimize air exposure during handling. Spat from all sieves are pooled. An initial sub-sample of 150 spat is weighed; once the

Figure 5.7: Spat reared in raceway until 4–9 mm shell height and ready for direct transfer into pearl nets for growout. Pearl nets shown suspended from experimental system.

weight is known, spat are distributed into pearl nets by weight. This is more time efficient than counting spat per net. For calico and zigzag spat, sub-samples of 23 grams resulted in approximately 150 spat per pearl net. Once spat are distributed, pearl nets are closed and held in flowing seawater until transfer to the field. In Bermuda, pearl nets are usually prepared one day, prior to transfer to the field. On the day of transfer, nets are transported in containers filled with seawater. On site, nets are tied in series of six or seven and connected to the longline using a clip or simply tied. Spat are left in 3 mm pearl nets for a period of one month.

5.3 TECHNIQUES – GROWOUT OF JUVENILES

Calico and zigzag scallop juveniles grow quickly at a rate of approximately 5 mm per month. The first few months of growout are therefore labour intensive, in that biomass needs to be regularly controlled to maintain an optimal growth rate. A schedule is given below describing the time between transfers and pearl net size. Once scallops reach a size of approximately 40 mm, at a density of 30 scallops per net, maintenance becomes less labour intensive, involving monthly checks for rips and tears and control of fouling.

5.3.1 Calico scallop growout

Transfer of juvenile scallops to larger size pearl net is conducted on the boat. Large containers of seawater are prepared on board (minimum of two); series of pearl nets are brought on board and scallops removed. Dead scallops are discarded and live animals are transferred to holding containers. Collected scallops are re-distributed into a pearl net of larger mesh size (6 mm) at a density of 75 scallops per net. Series of nets are then re-suspended on longlines. Scallops remain in these nets for a period of one month. Thereafter, they are transferred to 9 mm nets at a density of 40 scallops per net. They can be maintained up to two months at this density and in this net size; after which they are transferred to 12 mm nets at densities of 30 scallops per net.

Calico scallops average 5 mm per month in shell growth between 3 to 9 months of age; shell growth decreases thereafter allowing for energy utilization during gametogenesis in 10 months old individuals; as spawning period occurs during the winter months (December to May in Bermuda), shell growth remains minimal at this time, but increases once again during the second summer period. Calico scallops have a life span of approximately 2.5 years in Bermuda and can attain a maximal shell height of 65 mm during their second year of growth. The expected growth curve for calico scallops reared on longlines in Bermuda waters is given in Figure 5.8.

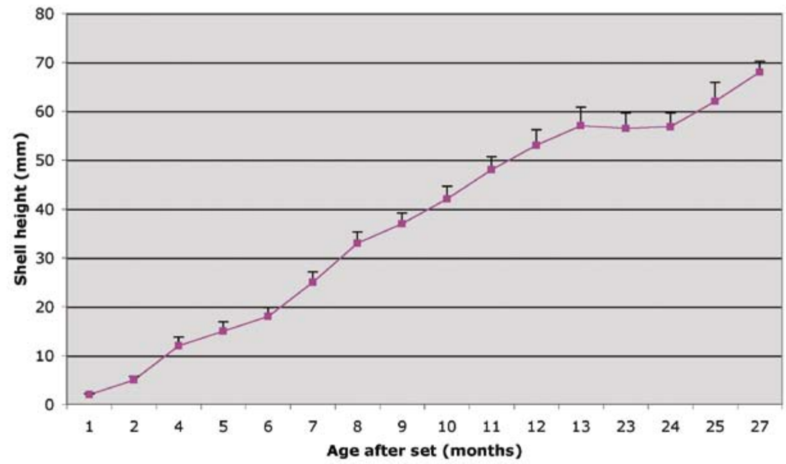


Figure 5.8: Shell growth of calico scallop, *A. gibbus*, juveniles reared on longlines in Bermuda.

For maintenance and control of fouling, monthly checks are made on the longlines. Wear and tear in the line is checked, along with rips in nets. Depending on season and water temperature, nets need to be cleaned monthly (during summer months), and every three months (during winter months). A saltwater power washer (electric motor driven on board) is used for cleaning of nets; it can be connected to the battery of an outboard engine, and nets can be cleaned with scallops remaining inside. This is a much quicker and efficient way of cleaning with no mortality ensued by scallops. Care must be taken to minimize the pressure in order to avoid damaging the scallops when using this method.

5.3.2 Zigzag scallop growout

Zigzag spat are treated in a similar manner to calico scallops until the size of 25 mm.The recessive nature of zigzag scallops seen in Figure 5.9 favours bottom rather than suspended culture (Figure 5.10). These results are in accordance with others reported in the literature, notably the investigation on zigzag scallops by Lodeiros and Himmelman (1994). Thus at 25 mm and above, zigzag

Figure 5.9: Adult zigzag scallops, *E. ziczac*, showing natural recessive behaviour in the sand.

juveniles are reared directly on the sandy bottom, enclosed by a cage, protecting scallops from predation. This is a much more labour intensive method of rearing, as all labour needs to be conducted by SCUBA diving. Cages are made of 20 mm rebar, and meshed on top and sides with plastic 15 mm to 25 mm mesh depending on size of scallops. The bottom is left open, allowing scallops to recess directly into the sand. Cages are of 2.5x1.5 m, yielding a surface area of 3.75 m^2.

The first transfer of 25 mm juveniles to bottom cages (15 mm mesh size) entails the collection of spat from pearl nets. Initial density is of 400 juveniles per cage. Juveniles only remain at such a high density for a period of one month. They then have to be collected by SCUBA, and thinned out to 200 juveniles per cage; again they remain as such for 1-month period, and are then transferred to a 25 mm cage at the final density of 100 per cage. This remains a high density, and periodically, scallops have to be collected and the cage moved. High density of scallops alters the composition of the substrate, leading to hypoxia or anoxia of the sediment, becoming an unfavourable environment for growth. Controlling fouling for cages has to be done monthly by SCUBA using a scrub brush for removal of epiphytes. Although this is intensive, it results in a noticeably faster growth rate than pearl net rearing. The difficulty in commercializing bottom culture lies in developing a time efficient and cost efficient system. To the author's knowledge, such a system for large scale rearing of the sand scallop has not been developed to date.

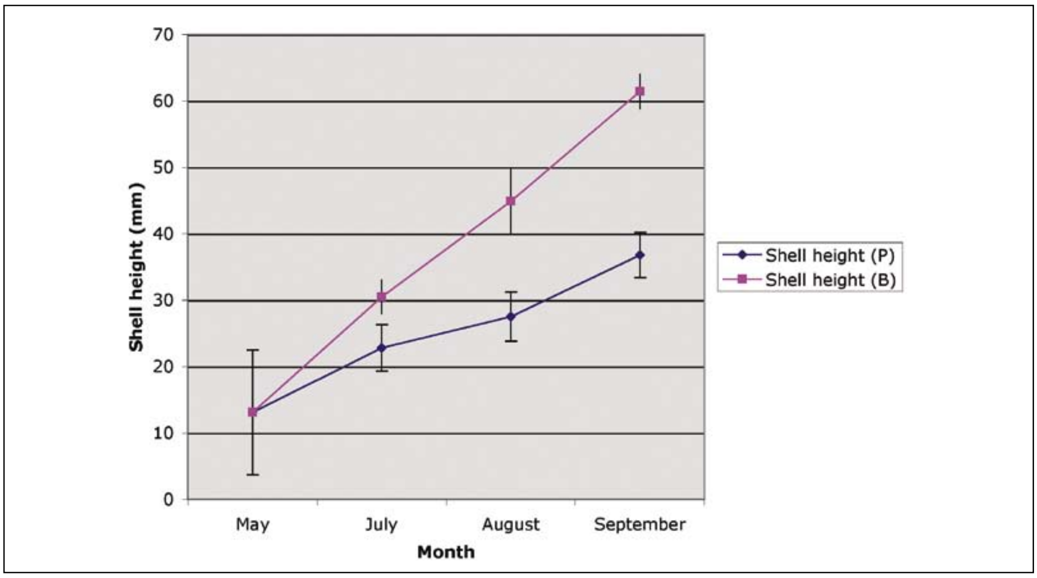


Figure 5.10: Comparative growth between zigzag scallops cultured directly on the sandy bottom (B) and suspended in pearl nets (P).

5.4 TECHNIQUES – TRANSPORT OF JUVENILES

Scallops produced in hatcheries or collected from natural settlements normally require transportation to other sites for continued culture. Scallops are particularly difficult to transport as they are usually sub-littoral organisms, unlike oysters or mussels, and seldom encounter aerial exposure. In part, for this reason, stress associated with transport often causes mortalities. Several methods of transport have been attempted; two of the most common are the use of insulated boxes with material soaked in seawater, referred to as dry transport, (Ventilla, 1982; Maguire, Cashmore and Burnell, 1999; Maeda-Martinez, Siscard and Reynoso-Granados, 2000), and vivier lorry, where animals are transported in seawater with a continuous oxygen flow (Maguire, Cashmore and Burnell, 1999). Although some success is obtained, survival reported in the literature does not exceed 61 percent immediately following 19 hours of simulated dry transport (Maeda-Martinez, Siscard and Reynoso-Granados, 1999), and increased mortality (up to 51 percent) is often seen in subsequent months during growout (Maguire, Cashmore and Burnell, 1999). As for transporting in seawater, high densities cause a rapid deterioration in quality of holding seawater by reducing dissolved oxygen and increasing ammonia and bacterial levels, leading to gill tissue damage (Maguire, Cashmore and Burnell, 1999).

In Bermuda, due to the small size of the island, transport to growout site can be easily conducted by holding scallops in seawater-filled containers on-board a boat. However, because of interest expressed by other Caribbean islands to rear tropical scallop species and consequent need for transport of spat or adults, procedures for optimal transport were investigated. These procedures were tested for both the sand scallop and the calico scallop, aiming for maximal survival following 24 hours transport time and following transfer to the field.

Details of the experiments conducted are reported in Sarkis, *et al.*, 2005. The procedures are based on methods used for fish transport in the aquarium trade. The methodology developed has been used in two real life situations for the sand scallop. In both cases, scallop spat were taken by air to another site; the total duration of the trip – from packing of scallops to unloading of scallops in the receiving nursery – was of 16 hours. Survival rate upon arrival was >90 percent. It was found that for successful transport of scallop spat, care must be taken to minimize stress during transport, and enhance tolerance of spat to stress by acclimation prior and post transport. Starvation and gradual acclimation to lower temperature, prior to transport, allow for a reduction in metabolic rate, reducing oxygen consumption, amount of excretia and accumulation of acidity, carbon dioxide and ammonia during transport. Low temperatures during transport maintain a low metabolic rate, minimizing oxygen consumption throughout the duration. Following transport, gradual acclimation to ambient temperature minimizes recovery stress, possibly enhancing long term survival. Shell growth of scallops transferred to the natural environment was not affected by simulated transport. The protocol developed is given in detail below (Protocol–17). This procedure should become easily adaptable to various scallops species, with additional insight into some of the species-specific physiological requirements.

PROTOCOL–17

PROCEDURE FOR LONG TRANSPORT PERIODS OF JUVENILE SCALLOPS

1. Do not feed scallops to be transported for 24 hours prior.
2. Acclimatize juvenile scallops to cold water (14 °C) for a minimum period of 6 hours (without feeding).
3. Make a false bottom of polystyrene to fit the cooler, in order to avoid direct contact of scallops with gel packs. Drill several holes in false bottom to allow cooling of entire container.
4. Weigh 160 grams sub-samples of spat (in tarred mesh, blotted dry as in Protocol–14).
5. Fill 1 litre zip-lock bags with 600 ml of 1 µm filtered cold seawater (14 °C).
6. Add scallops to zip-lock bag. Partially close bag.
7. Fill zip-lock bag with oxygen using Pasteur pipette fitted to oxygen regulator and bottle. Close zip-lock bag.

8. Place zip-lock bag into second bag for additional security. Use duct tape to secure closure and avoid any potential tearing or opening.
9. Cool a polystyrene box (60x30x40 cm) to 14 °C using four gel packs. Install false bottom on top of the gel packs and place scallop bags on it.
10. Secure lid of polystyrene box with tape.
11. Following transport do a visual assessment of scallop behaviour and mortality. Record temperature in bag.
12. Transfer scallops into a cold water bath (14 °C) and gradually increase seawater temperature ambient over a 12-hour period.
13. Maintain spat in running seawater once ambient temperature is reached.
14. Following a minimum 3-day acclimation to ambient temperature spat can be transferred to the field.
15. If spat is kept for longer than 3 days, complimentary food supply should be added as described in Appendix 21.