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Selection of areas for the commercial collection of spat of the Sydney rock oyster, *Saccostrea commercialis*, in subtropical Moreton Bay, Australia

M. A. Potter

Summary

Seasonal and tidal settlement patterns of the rock oyster *Saccostrea commercialis* and competing barnacles were studied at four locations in Moreton Bay over a 16 month period to select the most promising areas for commercial spat collection, and to provide basic information on spatfall for oyster farmers. A scallop (*Amusium balloti*) shell spat collector adapted from Japanese spat collectors was used throughout the experiment. Spatfall occurred from November to April with a peak in December (early summer) or February. Spatfall was generally heavier in the lower part of the tidal range, and on the upper surfaces of the scallop shells. One of the experimental sites showed excellent promise as a commercial spat collecting area.

INTRODUCTION

Collection of natural spat is an essential component of most oyster culture operations. Consequently spatfall and spatfall prediction have been the subject of many studies for the various cultivated oyster species. In some instances, these studies have resulted in a refined spatfall prediction programme (Wisely, Okamoto and Reid 1978).

Spatfall in the Sydney rock oyster, *Saccostrea commercialis,* has been studied by Thomson (1950) and in the closely related New Zealand rock oyster, *S. glomerata*, by Greenaway (1969), Curtin (1971, 1973) and Dinamani and Lenz (1977). Oyster growers in the long established and well developed oyster farming areas in temperate central New South Wales know from experience when to set out cultch material for spat collection (Korringa 1976).

The oyster industry in subtropical Queensland (27° to 28°S) is dependent on Port Stephens (33°S) in central New South Wales for much of its spat supplies. With a few exceptions, southern Queensland oyster growers lack experience of spat collection techniques and basic information on spat setting. The availability of some detailed information on the subject may encourage more local spat collection.

Climatic differences between subtropical southern Queensland and the more temperate regime in central New South Wales made extrapolation of existing information on the seasonality of oyster spatfall in central New South Wales of questionable value. Oyster spawning patterns and the factors that influence them vary between climatic zones. Increasing temperature is one important factor in spawning of temperate zone oysters (Galtsoff 1964). Another is tidal cycles which Koganezawa (1978) has linked with spawning of *Crassostrea gigas* in Matsushima Bay. In regions subject to monsoonal influences, spawning patterns appear to be strongly influenced by salinity. Wedler (1980) stated that although spawning of *C. rhizophorae* in tropical Colombia was continuous throughout the year, major spawning occurred with rising salinities well after the end of the wet season. On the other hand, Stephen (1980) found that major spawning of *C. madrasensis* in tropical south-west India occurred when salinity was decreasing, with a second (minor) spawning when salinity increased again later in the year. Asif (1980) found that *S. cucullata* in a dry subtropical environment in Pakistan had spawning peaks in January, May and October/November.

The intensity and distribution of spatfall is not uniform throughout the tidal zone, and oyster growers in southern Queensland commonly enquire as to the best intertidal levels at which to position spat collectors. Thus, the pattern of spatfall in relation to tidal levels was also of interest in this study.

Settlement of competitors on cultch material was an unknown factor in Queensland. In New Zealand, barnacles have been described as a competitor by Greenaway (1969). As barnacles were known to be common in at least two of the sites selected for investigation, the settlement patterns of barnacles were of some interest.

The objectives of the present study in Moreton Bay were: (i) to investigate the timing and intensity of oyster spatfall and barnacle settlement, (ii) to investigate the height/density distribution of oyster spatfall and barnacle settlement within the intertidal range and (iii) to identify areas with potential for commercial spat collection.

MATERIALS AND METHODS

Four locations in Moreton Bay where oysters occur naturally were selected for investigation (Figure 1). At each site a galvanised pipe frame was constructed to support a spat collector consisting of a string of 21 clean shells of the scallop *A. balloti* (Figure 2). Collectors used in the experiment were an adaptation of the scallop shell collectors used in the Japanese oyster industry (Korringa 1976).

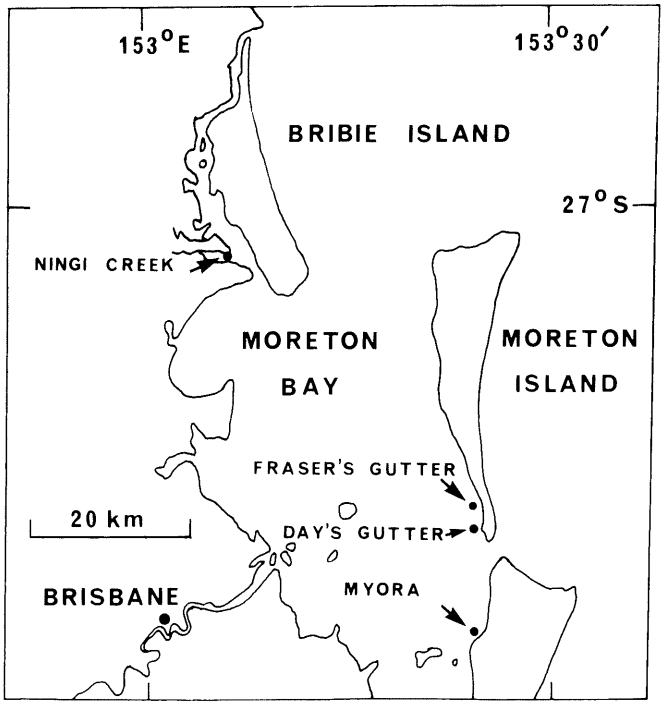

Figure 1. Map of Moreton Bay showing sampling sites.

To eliminate possible effects of substrate colour on settlement success, only the left (lower) valves of *A. balloti*, which are white on both surfaces, were used. Badly marked or damaged shells were rejected, as were shells larger than 11 cm diameter or smaller than 9 cm. Shells were drilled in the centre and arranged vertically in groups of three, convex surface upward, on 3 mm galvanised steel wire with 17 cm plastic conduit spacers between each group of three and with 1.5 cm spacers between the shells in each group. A concrete weight was attached to the bottom of the wire to minimise the effects of wave action and currents. At approximately fortnightly intervals the collectors were removed for spat counting, and were replaced by new collectors.

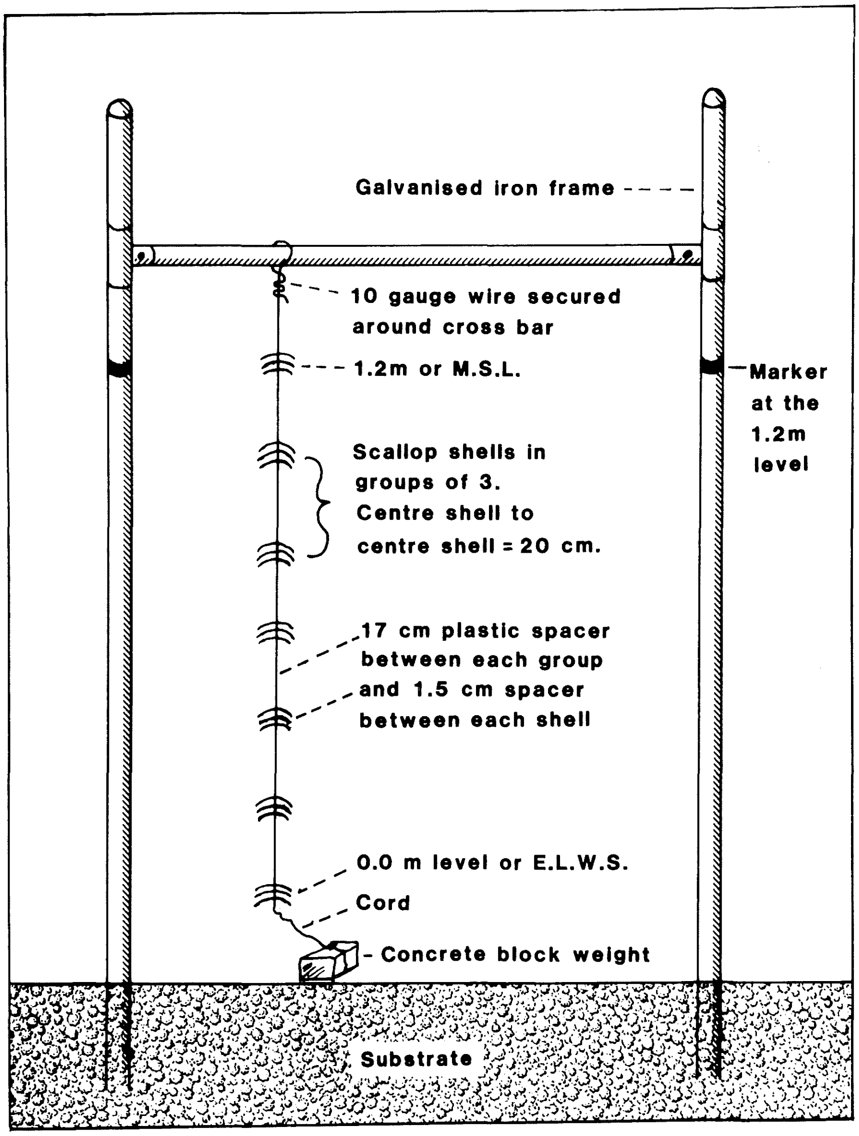

Figure 2. Sketch of collector.

Collectors were attached to the frames so that the centre shell of the top group of 3 was aligned with horizontal markers on the uprights. This ensured the correct positioning of collectors on replacement. The markers were at approximately Mean Sea Level (MSL) (1.2 m) which placed the lowest group of three shells on each collector at Extreme Low Water Spring (ELWS). Intermediate groups were 0.2, 0.4, 0.6, 0.8 and 1.O m above ELWS.

Each time a collector was replaced the salinity and temperature of the surface water were measured, using an American optical salinity refractometer and mercury thermometer respectively.

After two weeks of exposure, both surfaces of the middle shell of each group of three (which had another scallop shell adjacent to both upper and lower surfaces) were examined under a dissecting microscope and the numbers of oyster spat and barnacles counted. Some shells which were fouled with algae, organisms and silt, were carefully cleaned during counting. Spat of the rock oyster, *S. commercialis*, were readily distinguishable from those of other bivalves. No attempt was made to identify barnacle species, but both *Balanus amphitrite* and *Elminius modestus* are known to occur in estuarine areas throughout the region.

The experiment commenced at Ningi Creek, Day's Gutter and Fraser's Gutter in December 1978, and at Myora in late January 1979. The experiment was terminated at Ningi Creek in December 1979 after one year, but sampling at the other three sites was continued until April 1980.

RESULTS

Seasonal settlement of oysters

The settlement rate for each period is shown in Figure 3, as the mean daily catch of spat per collector shell at each site.

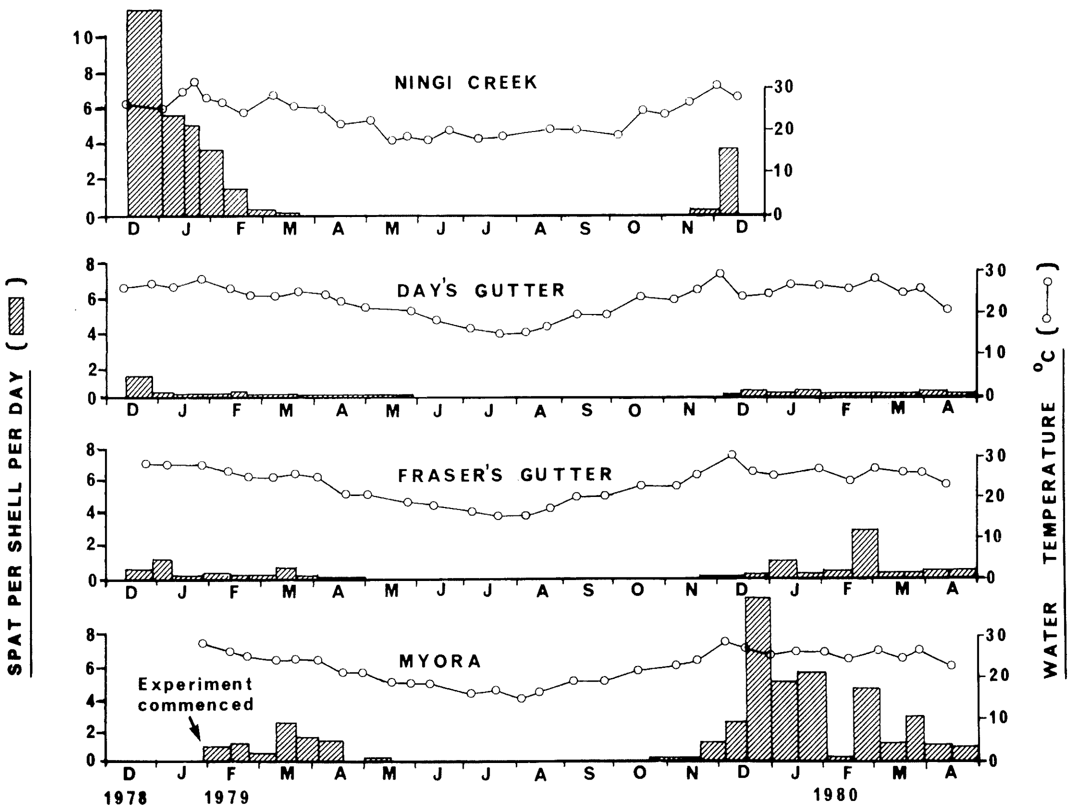

Figure 3. Mean daily catch of spat of the oyster *Saccostrea commercialis* per collector shell at each of four sites in Moreton Bay. Surface water temperatures for each site are also shown.

Oyster spat settlement at Ningi Creek occurred in summer and early autumn (December-March). The heaviest spat settlement of the experiment was recorded at Ningi Creek during the first sampling period from mid December 1978 to January 1979. Individual shells had total counts in excess of 400 spat/shell for this whole period. Averaged over the seven levels of the collector, the mean catch per shell for this period was 250 spat/shell. No spatfall occurred between late March and mid November at Ningi Creek.

Spat settlement at Day's Gutter was low throughout the experiment. The highest individual shell count was only 36 spat with a mean for the collector of 18 spat/shell, during the first sampling period in December 1978.

At Fraser's Gutter spat settlement occurred over an extended period from mid November to late April. There were two minor spatfall peaks in both seasons. The maximum count of 86 spat on an individual shell occurred during the February-March 1980 sampling period, with a mean for the collector during that period of 37 spat/shell.

Extended settlement also occurred at Myora. Settlement there was considerably heavier than at either Day's Gutter or Fraser's Gutter. The peak settlement period was in the latter half of December 1979. For this period the highest individual shell count was 341 spat, and the mean for the collector was 143 spat/shell.

Where data has been collected for sites for two seasons (Figure 3), differences in spatfall intensity are generally apparent between the two seasons.

Vertical settlement of oysters

Figure 4 shows the vertical settlement pattern of *S. commercialis* spat at each site expressed as a percentage of the total spatfall for that site. At the three sites with the greatest spatfall (Ningi Creek, Myora and Fraser's Gutter), the heaviest concentrations of spat occurred at lower levels of the collector. Maximum set at these sites was at the second lowest level, which was 0.2 m above ELWS. At Day's Gutter maximum set was at the third lowest level. Generally, apart from the lowest level, there was an inverse relationship between height above ELWS and spat settlement with any given level having a greater settlement than the one above it.

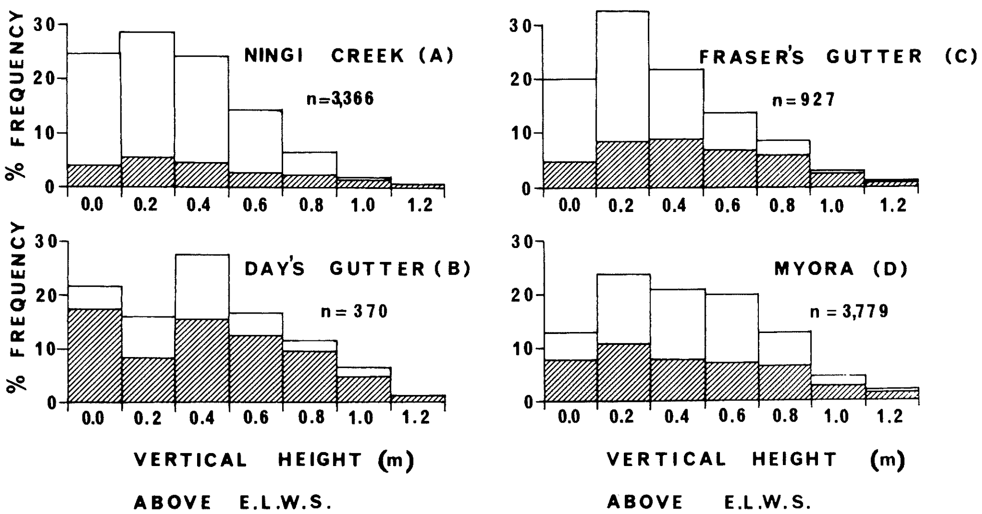

Figure 4. Vertical distribution of spatfall of *Saccostrea commercialis* on the collectors at each of the four sites in Moreton Bay. Spat caught on the upper surfaces of the scallop shells are unshaded while that caught on under surfaces are shown as shaded.

Spat settlement was not evenly distributed between the upper and under surfaces of the scallop shells. At lower levels of the collector (0.0, 0.2 and 0.4 m above ELWS) settlement was heavier on the upper surfaces of the shells. At the two highest levels (1.0 and 1.2 m above ELWS) settlement was heavier on the under surfaces of the shells. The Day's Gutter site was an exception to this pattern. There, spat settlement was greater on the under surface of the collector shells at all levels in the water column.

Competitors

Barnacle settlement was insignificant at Day's Gutter and Fraser's Gutter, but was extremely heavy at Ningi Creek (Figure 5). Myora also had some barnacle settement but in more moderate numbers. The density of barnacle settlement was generally greater lower in the water column and on the under surface of the scallop shells (Figure 6).

Fouling with algae and other organisms, which also increased silt accretion, was common at all sites during the summer. Fouling was most dense at the lowest two levels of the collectors and on the upper surfaces of the scallop shells.

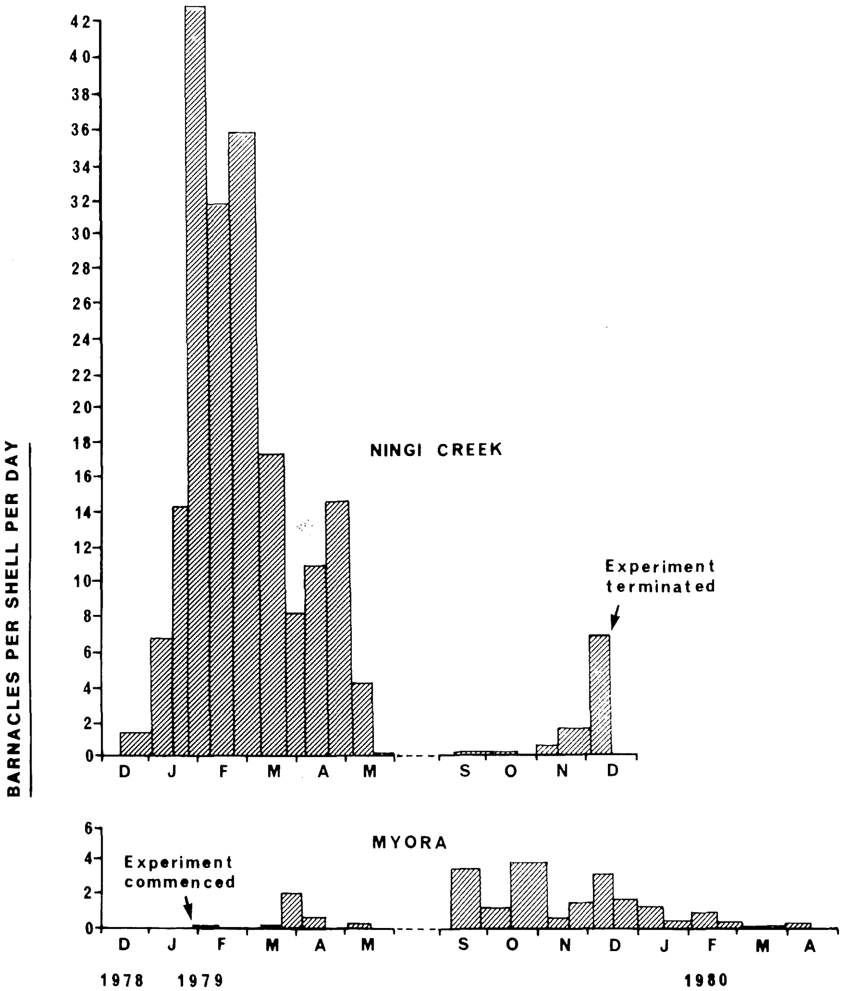

Figure 5. Mean daily settlement of barnacles per collector shell at Ningi Creek and Myora.

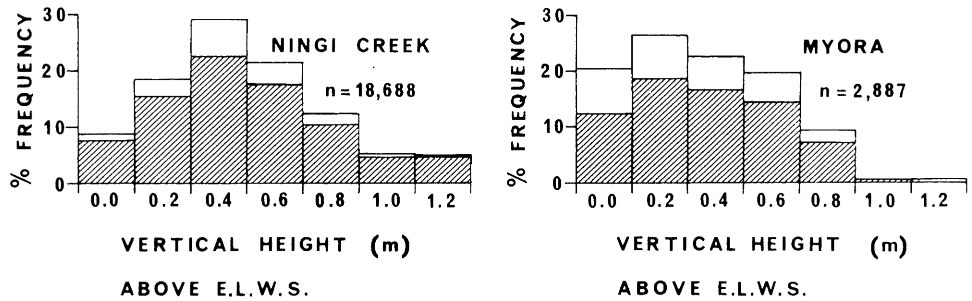

Figure 6. Vertical distribution of barnacle settlement on the collectors at Ningi Creek and Myora. Barnacles caught on the upper surfaces are unshaded while those caught on under surfaces are shown as shaded.

Temperature and salinity

Water temperature (Figure 3) ranged from 15.5°C in early August at Fraser's Gutter to 32.5°C at Ningi Creek in January. Spatfall did not occur when surface water temperatures were less than 21°C.

Salinity varied between 32‰ and 37‰ at all sites with one exception in January 1979 at Ningi Creek where it dropped to 20‰.

DISCUSSION

The spat settling season in Moreton Bay extends from November to March, which is approximately the same period that Thomson (1950) found for the same species at Port Hacking, south of Sydney in 1945-46. In Thomson's study maximum set occurred in March, but in the present study spatfall peaks occurred in December at the two sites (Ningi and Myora) with the highest overall spatfall. Interestingly though, peak spatfall for the 1979-80 season at Fraser's Gutter was in late February with a minor peak early in January. The limited data suggest (Figure 3) that there is variation in spatfall timing and intensity from year to year, as well as between geographic locations.

In order to assess the suitability of the different sites for commercial spat collection it is necessary to make a judgement of what constitutes an adequate catch for commercial purposes. This would be influenced by the catching and cultivation methods being used. Scallop shell spat collectors have only been used previously on an experimental basis for collecting *S. commercialis* spat (Wisely, Holliday and Reid 1979) although no mention was made of spat densities obtained in that study. In Tasmania, Sumner (1979) reported *C. gigas* spat catches of 196 per 1000 cm^2 (or 55 spat per shell) for round scallop shell (*Pecten commercialis*) garlands set out in the intertidal zone. The cultch material was exposed for the entire spat setting season and spatfall was estimated at the end of the season. Sumner stated that 30 spat per 1000 cm^2 (or 8.4 spat per shell) is considered economically viable in Tasmania. Wisely *et al.* (1978) reported that Japanese authorities regarded 200 spat per shell as a good density for *C. gigas* raft culture. A settlement of 50 to 100 spat per shell was described as being reasonable numbers.

The comparative figures for *C. gigas* in Tasmania and Japan are not as dissimilar as they at first appear. The Tasmanian spat counts, taken a month after spatfall finished, should properly be compared with Japanese seed oyster counts. If approximately 25% of Japanese spat survived the first month after settlement, the lower end of the range mentioned by Wisely *et al.* would give approximately 12 seed oysters per shell after one month.

There are some difficulties in attempting to utilise this information in the present experiment. The species of oyster being studied is different and the climate of the study area is subtropical rather than temperate. However, it provides an indication of the general range of acceptable spat densities for scallop shell collectors. As an objective of this experiment was to select good commercial spat collecting areas, and being cognizant of year to year variations, I have therefore chosen a mean of 100 spat/shell in a sampling period as being an acceptable figure.

On this basis spatfall at Ningi Creek appears to be more than ample for commercial purposes, with mean spat counts of more than double the selected figure. Myora also had good spatfall, with spat counts in the peak sampling period exceeding the required figure.

Fraser's Gutter, and particularly Day's Gutter, appear to have insufficient spat for commercial purposes. Whilst Fraser's Gutter would not be chosen as a site with good potential on the parameters selected, it may be of some use to oyster farmers who find it convenient to operate in this area. The data suggests, however, that there is an element of risk in relying heavily on this area for spat collection. Spat distribution within the collectors was mostly as anticipated. In a study of *C. virginica*, Medcof (1955) found an overall tendency for spatfall to increase with depth. The exception to the general trend in the present study, was at the lowest level where spatfall was less than the level above, but this may have been due to such factors as decreased current flow near the bottom and increased siltation. Generally the bottom four levels (0.0 0.6 m above ELWS) collected between 82% and 91% of the spat.

The patterns of spat settlement on upper or under surfaces of cultch material have been examined by a number of workers. Most studies in the literature (Thomson 1950; Galtsoff 1964; Dinamani and Lenz 1977) report heavier spat settlement on the under surfaces of various types of collectors, but some (Bonnot 1937; Butler 1955) report heavier settlement on upper surfaces. The distribution can be altered by changing the collector design as Shaw (1967) found that settlement of *C. virginica* was heavier on under surfaces when collecting plates were 10 cm apart, but was heavier on upper surfaces when plates were only 2.5 cm apart.

For scallop shell cultch, Sumner (1979) found that spatfall of *C. gigas* was greater on under surfaces when positioned in the intertidal zone, but heavier on upper surfaces for cultch placed out under rafts. He attributed this difference to increased fouling on the under surface of raft-borne cultch. While this may be a contributing factor, it does not completely explain the heavier settlement on upper surfaces of raft-borne cultch. In the present investigation, spatfall was heaviest on the upper surfaces of scallop shells at the second lowest level. Fouling was also heavier on the upper surfaces at lower levels. The results in Figure 4 suggest that *S. commercialis* spat have a preference for settling on upper surfaces of *A. balloti* scallop shells, but that this preference is reduced and eventually reversed as the period of tidal exposure to air increases. Day's Gutter is again an exception which cannot be adequately explained.

Barnacle settlement was insignificant at Day's Gutter and Fraser's Gutter and therefore unlikely to compete for space with settling oyster larvae. At Myora, although barnacle settlement was much heavier it was not of sufficient density to interfere with oyster spat settlement during the period investigated. At Ningi Creek however, barnacle settlement was extremely heavy, completely covering scallop shells during the peak of barnacle settlement. This result was quite surprising. While initial observations had noted that barnacles were quite common at Ningi Creek, there was little to suggest that such overwhelming barnacle settlement was likely to occur on cultch material.

Oyster and barnacle larvae settled at slightly different times. Peak oyster spatfall at Ningi Creek occurred in December, whereas heavy barnacle settlement did not commence until January. Because of the limitations of the data, it is not possible to say whether this phenomenon is an annual event or whether it was a freak event. If it proves to be an annual event then the value of Ningi Creek as an area for commercial spat collection would be severely reduced. For oyster growers who find it convenient to work in this area some advantage might be taken of the differences in timing and patterns of oyster and barnacle settlement. For example, growers could catch spat at lower levels and then raise the level to minimise heavy barnacle settlement.

Fouling and siltation were heaviest at the two lowest levels of the collectors. The second lowest level was usually the best level for spat settlement, but had collectors been exposed in the water for longer periods, fouling at this level may have inhibited further spat settlement. Hence spat collectors placed out at the beginning of the spatfall season, rather than just prior to the expected peak period, may be relatively ineffective at the lower levels.

CONCLUSION

Of the four sites investigated Myora has the most potential for commercial spat collection. Oyster spatfall is adequate, and barnacle settlement is only moderate in this area. The best period for oyster spatfall was in late December and the best height was 0.4 to 0.6 m above ELWS.

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Mr M. A. Potter is an officer of the Department of Primary Industries, Fisheries Research Branch, stationed at the Southern Fisheries Research Centre, P.O. Box 76, Deception Bay, Q 4508.