Settlement and recruitment of bay scallops, Argopecten irradians (Lamarck 1819), to artificial spat collectors in the Westport River Estuary, Westport, Massachusetts

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CHAPTER 2

SETTLEMENT AND RECRUITMENT OF BAY SCALLOPS,
ARGOPECTEN IRRADIANS (LAMARCK 1819), TO ARTIFICIAL
SPAT COLLECTORS IN THE WESTPORT RIVER ESTUARY,
WESTPORT, MASSACHUSETTS

Karin A. Tammi1, Scott J. Soares2, Wayne Turner3 and Michael A. Rice1

Abstract

In January 1993, The Waterworks Group initiated the Bay Scallop Restoration Project as an attempt to restore the once prolific bay scallop population within the Westport River Estuary in Massachusetts. This project is a multi-phased endeavor aimed at better understanding recruitment failures of both natural stocks and introduced seed of Argopecten irradians. The main objective of this project is to assess juvenile recruitment (survival to > 4 mm) to artificial spat collectors placed in historically productive scallop beds and within close proximity to adult spawner rafts. Spat collectors (2 to 4 mm plastic-mesh bags) containing monofilament were suspended on 28 to 35-meter floating long lines at 9 locations in the Westport River. A total of 1400 spat collectors were sequentially deployed on 89 long lines from June to August 1993 to determine the timing of peak settlement and recruitment at each study site. The 1993 harvest yielded 4000 scallops of varying shell heights ranging from 4 to 60 mm, with an overall mean of 36.9 mm. The variability in shell height was related to the soaking time of the spat collectors which ranged from 68 to 152 days. The most productive long lines were located in the vicinity of Corey's Island, Horseneck Channel and Canoe Rock. The greatest recruitment was observed at Corey's Island which yielded 1882 scallops averaging 6.1 scallops per collector, with individual long lines harvesting 18.2 scallops per collector. This study indicates that A. irradians will settle on artificial spat collectors containing monofilament, which may offer an alternative tool for resource management and stock enhancement.

Introduction

The bay scallop, Argopecten irradians is an economically important bivalve harvested

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commercially and for recreation in coastal communities along the Atlantic and Gulf coasts of the United States. The total supply of bay scallop meat for the United States between 1983 and 1992 showed a gradual decrease in the annual harvest. In 1983, 2,338,000 lbs of meat were landed compared to 356,000 lbs in 1992. Comparing recent landing records with 1991, the 1992 season decreased by 82,000 lbs (O'Bannon and Holliday, 1993). These nationwide landings indicate a notable decrease in bay scallop stocks within the last decade which needs to be addressed. Historically, Massachusetts has been the leading producer of bay scallops for New England and the nation. Belding (1910) reported that commercial scalloping began in 1872 in Massachusetts. The most abundant scallop beds were found along the south shore of Cape Cod, Buzzards Bay, Martha's Vineyard and Nantucket. Matthiessen (1992) reported that between 1951-1960 Massachusetts landed an impressive on average 915,000 lbs of bay scallops annually. However, between 1981-1990, Massachusetts landed 23% fewer scallops from the earlier decade. Since Matthiessen’s (1992) review, bay scallop harvests have declined further in the 1990’s.

Recruitment Failures

Sporadic recruitment failures have always been reported along the Atlantic coast, with stocks constantly waveriing from year to year (Belding, 1910). A precise cause for the recruitment failure is not known, but evidence suggests that a number of factors are to blame such as nuisance algal blooms (Bricelj et al., 1987; Summerson and Peterson, 1990; Tettelbach and Wenczel, 1991), poor water quality (Stewart et al., 1981), industrial waste (Beaumont et al., 1987), fishing pressure (MacFarlane, 1991), environmental conditions (Gaines and Ross, 1983; Tettelbach and Auster, 1985), habitat loss (Stauffer, 1937; Cottam and Addy, 1947; Marshall, 1960; Fay et al., 1983) and predation (Peterson et al., 1989; Prescott, 1990; Pohle et al., 1991).

In general, it is believed that sporadic recruitment and declining stocks are related to the bay scallop's life span of 20 to 26 months in New England (Belding, 1910; Gutsell, 1931; Roberts, 1978) and 12 to 16 months in the mid-Atlantic (Castagna, 1975). This short life span coupled with the previously mentioned factors are responsible for the decline in scallop harvests. After consecutive years of poor recruitment, spawning stocks are reduced, thereby adversely affecting the fishery over time. Most coastal communities are unable to rebound without some type of management intervention. As a result, many communities implement reseeding or transplanting programs to enhance the natural stocks (Burns, 1990; Tettelbach and Wenczel, 1991). The most common practice is to purchase aquaculture seed from hatcheries. Yet, hatchery reared seed may not survive well when transplanted or reseeded into the estuary prior to the winter season. Consequently, seed purchased to rebuild stocks may not live to spawn (Tettelbach et al., 1990). Furthermore, the availability of seed at affordable prices is often a limiting factor in implementing a reseeding program in some small coastal communities (Sherman, pers. com.) (Figure 1).
Methods Available for Coastal Communities to Enhance Bay Scallop Stocks

Figure 1.

Stock Enhancement: Artificial Spat Collection

As a consequence of fluctuating scallop stocks, many countries such as Japan, Tasmania, New Zealand and Canada have devised various schemes to enhance natural stock. Methods such as reseeding, artificial propagation and artificial spat collectors have been incorporated into management plans. The collection of natural seed with artificial spat collectors, in addition to reseeding, has effectively resulted in stabilizing the scallop fishery. The artificial spat collectors have not been commercially utilized in the United States, but are widely used in Japan (Ito and Byakuno, 1989), Tasmania, New Zealand (Bull, 1989), and Canada (Cropp, 1989) as part of their overall scallop management program. In addition, countries such as Mexico (Verdugo and
Caceres-Martinez, 1991), Scotland (Fraser, 1991), Yugoslavia (Margus, 1991) and Ireland (Burnell, 1991) are utilizing artificial spat collectors to study scallop populations and to assess the potential for establishing a commercial fishery. With the advent of the artificial spat collector, Japan has maintained a commercial scallop fishery by collecting scallop seed in areas which had lost eelgrass beds (Ito and Byakuno, 1989; Ito, 1991).

Artificial spat collectors of similar designs have only been used for experimental purposes in the United States. In North Carolina, Ambrose et al. (1992) used artificial spat collectors of various colors and different surface size to determine factors influencing scallop recruitment to the artificial collector. Researchers on Nantucket Island, Massachusetts collected over 40,000 scallop spat from 90 collectors placed in early July. After reaching 10 to 20mm, the scallops were transferred to larger floating cages. Once the scallops reached 40 to 50mm in shell height, scallops were redistributed onto the shellfish beds (Kelly and Sisson, 1983).

Nevertheless, very few New England coastal communities have attempted to utilize artificial spat collectors to investigate the settlement and recruitment of bay scallops to artificial substrate or as part of a management strategy for long-term stock assessment and enhancement.

Westport Estuary

The Westport River estuary harbors one of the most productive shellfisheries in Massachusetts (Fiske et al, 1968). Historically, Westport has always enjoyed successful bay scallop harvests, rarely experiencing large fluctuations in scallop stock (Figures 2 and 3). In 1985, Westport harvested a record 66,000 bushels of scallops which produced $2.5 million for the local economy (Westport annual Town Report, 1985). However, since the 1985 harvest, only meager amounts of scallops have been harvested. The recent decline in this once prolific resource questions the feasibility of future commercial scalloping in Westport. Furthermore, the harvesting of clams, quahogs and oysters have been drastically reduced due to shellfish bed closures from fecal pollution. The lack of a successful bay scallop set coupled with shellfish closures have hurt the local and regional economy in southern New England. Faced with the decline in scallop stocks, other methods of stock enhancement are needed to maintain bay scalloping.

The purpose of this research is to investigate settlement and recruitment of bay scallops to artificial spat collectors at various study sites throughout the Westport River estuary. The goal of the Bay Scallop Restoration Project is to collect sufficient numbers of juvenile spat to be placed in protective grow-out rafts at propagation areas in the estuary. The juvenile spat collected from artificial collectors will be used as spawning stock. This preliminary research provides insight into the feasibility of implementing artificial spat collectors and spawner rafts as long-term enhancement tools that could help restore bay scallop stocks in the Westport estuary.
Figure 2

Massachusetts

Westport River

Buzzards Bay

Figure 3

Shaded Areas Represent Historic Bay Scallop Beds in the Westport River Estuary
(Fiske et al., 1988)
Material and Methods

During the summer of 1993, spatlines containing 20 to 25 individual spat collectors were deployed at 9 study sites within the Westport Estuary (Figure 4). Artificial spat collectors
consisted of (2mm - 4mm) 50 lb. plastic mesh onion bags filled with monofilament (*Figure 5*). Spat collectors were weighted in order to maintain a vertical soaking position. Horizontal spatlines 28 - 35 meters long were sequentially deployed between June and August 1993. Each spatline was color coded by date to aid in the determination of soaking time. A total of 89 spatlines and 1,400 spat collectors were deployed into both branches of the Westport River. Spatlines were strategically located within close proximity to adult scallops held in spawner rafts and in the vicinity of historic scallop beds seen in *Figure 2*. Each raft contained approximately 300 sexually mature adult scallops. Spatlines and collectors were retrieved in September and October 1993. Spat collectors were opened and several quantitative and qualitative variables were analyzed from each collector, noting the location and time. Juvenile scallops were counted and shell height (mm) was measured with hand held calipers (0.05 mm) precision. Fouling and predatory organisms were also identified.

*Figure 5*
Results and Discussion

Spat Settlement

Settlement of scallops to artificial spat collectors was successful in the summer of 1993. A summary of each site is shown in Table 1. Of the 4,002 scallops collected, Corey's Island displayed the highest recruitment of any study site, harvesting a total of 1,882 in 19 spatlines. The average number of scallops/collector for this location was 6.1 (Figure 6). Individual spat collectors deployed in July averaged 18.1 scallops/collector with the greatest overall recruitment of 32 scallops in one collector. The second best collection site was Horseneck Channel which harvested a total of 621 scallops, averaging 2.16 scallops/collector. Canoe Rock also displayed favorable recruitment harvesting 491 scallops/collector and averaging 2.58 scallops/collector. In general, the highest recruitment values were observed at Corey’s Island, Canoe Rock, Hick’s Cove and Horseneck Channel spatlines deployed on July 4th and July 18th (Figure 7). The analysis of the individual spatlines deployed at Corey’s Island showed that July 4th had greater recruitment than July 18th (Figure 8).

In summary, during the summer of 1993, bay scallop spawning in the Westport Estuary may have occurred during late June and mid-July. Maximum recruitment estimates were observed for those spatlines deployed the week of July 4th and July 18th with Corey’s Island representing the best study site, having the highest total recruitment value of 1882 scallops.

### Summary of Westport River Research

**Results of Summer 1993**

<table>
<thead>
<tr>
<th>LOCATIONS</th>
<th># SPATLINES DEPLOYED</th>
<th>TOTAL SCALLOPS HARVESTED</th>
<th>MEAN SCALLOPS PER COLLECTOR</th>
<th>MEAN SHELL HEIGHT (mm)</th>
<th>RANGE OF SOAKING TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>CANOE ROCK</td>
<td>12</td>
<td>491</td>
<td>2.58</td>
<td>37.1</td>
<td>108 - 152</td>
</tr>
<tr>
<td>COREYS ISLAND</td>
<td>19</td>
<td>1882</td>
<td>6.1</td>
<td>25</td>
<td>75 - 114</td>
</tr>
<tr>
<td>HICK’S COVE</td>
<td>6</td>
<td>341</td>
<td>3.04</td>
<td>32.2</td>
<td>93 - 100</td>
</tr>
<tr>
<td>HORSENECK CH.</td>
<td>19</td>
<td>621</td>
<td>2.15</td>
<td>29.8</td>
<td>89 - 118</td>
</tr>
<tr>
<td>JUG ROCK</td>
<td>6</td>
<td>131</td>
<td>1.51</td>
<td>26.9</td>
<td>68</td>
</tr>
<tr>
<td>MASQUESATCH</td>
<td>3</td>
<td>32</td>
<td>0.65</td>
<td>30.7</td>
<td>122</td>
</tr>
<tr>
<td>RAM ISLAND</td>
<td>5</td>
<td>183</td>
<td>3.21</td>
<td>31.5</td>
<td>88</td>
</tr>
<tr>
<td>SOUTHARD SHORE</td>
<td>16</td>
<td>158</td>
<td>0.62</td>
<td>30.4</td>
<td>93 - 100</td>
</tr>
<tr>
<td>SPEAKING ROCK</td>
<td>3</td>
<td>163</td>
<td>3.01</td>
<td>29.1</td>
<td>80</td>
</tr>
<tr>
<td>TOTALS</td>
<td>89</td>
<td>4002</td>
<td>NA</td>
<td>36.9 mm</td>
<td>68 - 152</td>
</tr>
</tbody>
</table>

Table 1
Recruitment of Bay Scallops to Artificial Substrate in The Westport River

Results of Summer 1990

Mean # Scallops/Collector

CANOE  COREYS  HICKS COVE  HORSENECK  JUG ROCK  MASQUESANTCH  RAM ISLAND  SOUTH SHORE  SPEAK ROCK

Study Sites

Figure 6
Recruitment of Bay Scallops to Spatlines in the Westport Estuary Deployed from June to August

Results Summer 1993

Figure 7
Growth Measurements

The juvenile scallops harvested from the collectors ranged from 4 to 60 mm in shell height, with an overall average of 36.9 mm. The difference in shell heights related to the soaking time of the long lines which ranged from 68 to 152 days. Canoe Rock displayed the largest shell height averaging 37.1 mm with the longest soaking time of 152 days, whereas Corey's Island averaged 25 mm scallops with a maximum soaking time of 114 days (Table 1.). A frequency distribution of spatlines deployed at Corey's Island exhibited a difference with respect to the size classes observed. Spatlines deployed on the northwest side of Corey's Island were smaller than the scallops collected from the northeast spatlines. However, northwest spatlines were deployed on July 18th, one week shorter than the northeast spatlines which may explain for the difference in shell height (Figure 8).

Lastly, normalization of the shell height measurements was conducted in order make a comparison of possible scallop growth at each study site. Scallop heights were normalized to a soaking time of 89 days. The 89 period represented the modal soaking time observed for all spatlines. As a result, the mean shell height for all locations using the 89 days was approximately 30.2 mm (Figure 9.). Jug Rock displayed the largest scallop height approximately 34 mm. The Masquesatch study area displayed a lower value which may relate to having 3 spatlines and harvesting only 32 scallops with great variation in size.

Normalizing of growth measurements only suggests possible growth potential and not an actual growth rate of scallops within at the study sites. Since individual growth rates and settlement times vary in estuary systems, determining these factors becomes difficult without larval sampling and marking individual spats for growth monitoring.
Recruitment of Bay Scallops to Artificial Collectors
Individual Spatline Productivity at Coreys Island

Figure 8
Fouling Index

A fouling index was created to assess the "cleanliness" of the artificial spat collector. Collectors were rated on a scale of 1 to 5, with 1 representing a clean bag and 5 a heavily fouled bag. Collectors were closely examined with respect to this index. Spatlines and collectors with longer soaking time were heavily fouled and given a rating of 5. A majority of the spat collectors from Canoe Rock, Corey's Island and Horseneck Channel had soaking times over 100 days. As a result, these collectors were given ratings ranging from 3 to 5. The remaining locations displayed a variety of ratings from 1 to 5. The Jug Rock study site had the cleanest collectors averaging 2.5 relating to the shortest soaking time of only 68 days.
Fouling and Predatory Organisms

A variety of fouling and predatory organisms were collected outside and inside the spat collectors. A summary of these organisms can be seen in Table 2. Organisms defined as fouling in nature were mostly marine invertebrates and algae. *Mogula* spp., *Ciona* spp., *Styela partita*, *Microciona prolifer*, *Didemnum* spp., *Botryllus schlosseri*, *Crisia* and *Enteromorpha* spp. were among the fouling organisms that settled on the exterior of the collector bag and inside on the monofilament.

Predatory organisms such as *Carcinus maenas*, *Libinia dubia*, *Panopeus* spp., *Tautog onitis* and *Opsanus tau* were found inside the spat collectors feeding on *Panopeus* spp., mud crabs. It could not be determined whether these predators had also fed on the juvenile scallops within the collectors.

<table>
<thead>
<tr>
<th>Common Names</th>
<th>Scientific Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Crab</td>
<td><em>Carcinus maenas</em></td>
</tr>
<tr>
<td>Spider Crab</td>
<td><em>Libinia dubia</em></td>
</tr>
<tr>
<td>Mud Crab</td>
<td><em>Panopeus</em> spp.</td>
</tr>
<tr>
<td>Sea Grapes</td>
<td><em>Molgula</em> spp.</td>
</tr>
<tr>
<td>Sea Vase</td>
<td><em>Ciona intestinalis</em></td>
</tr>
<tr>
<td>Sea Squirts</td>
<td><em>Styela partita</em></td>
</tr>
<tr>
<td>Red Beard Sponge</td>
<td><em>Microciona prolifer</em></td>
</tr>
<tr>
<td>White Crust</td>
<td><em>Didemnum</em> spp.</td>
</tr>
<tr>
<td>Golden Star Tunicate</td>
<td><em>Botryllus schlosseri</em></td>
</tr>
<tr>
<td>Red Crust</td>
<td><em>Cryptosula</em> spp.</td>
</tr>
<tr>
<td>Jointed Tube Bryozoans</td>
<td><em>Crisia</em> spp.</td>
</tr>
<tr>
<td>Hollow Green Weeds</td>
<td><em>Enteromorpha</em> spp.</td>
</tr>
<tr>
<td>Tautog</td>
<td><em>Tautog onitis</em></td>
</tr>
<tr>
<td>Cunner</td>
<td><em>Taughtolabrus adspersus</em></td>
</tr>
<tr>
<td>Blennies</td>
<td><em>Ophioblennies atlanticus</em></td>
</tr>
<tr>
<td>Oyster Toad Fish</td>
<td><em>Opsanus tau</em></td>
</tr>
</tbody>
</table>

*Table 2*
Conclusion

This study determined that A. irradians will settle on artificial spat collectors containing monofilament in the Westport Estuary. Our results indicated that the maximum settlement time occurred during mid-July, similar to other research in New England (Belding, 1910; Gutsell, 1931; Kelley and Sisson, 1983). In addition, we determined that Corey's Island, Horseneck Channel and Canoe Rock were the most productive study sites and therefore, the best areas to deploy spat collectors in the future. The greatest overall recruitment was observed at Corey's Island yielding 1882 scallops. Historically, Corey's Island has been the most productive scallop bed for the estuary known by researchers and local fisherman (Fiske et al., 1968; Sherman pers. com., 1993). Lastly, fouling and predation may influence scallop settlement and actual recruitment estimates for all study sites.

This preliminary research displayed a high degree of variability with respect to the number of spat collectors and spatlines deployed at each of the study sites. Along with the biotic and physical factors, this variability greatly influenced the actual assessment of productivity, settlement and recruitment values, and growth rate estimates determined for the 9 study areas. Research conducted in the future will focus on improving the methods from this 1993 experimental study. In addition, larval sampling and monthly spat settlement will be monitored thoroughly as will water chemistry, current and food availability. Applying these techniques will further advance the accuracy of determining the optimal settlement and recruitment times of scallops to artificial spat collectors.

This research indicates that spat collectors may be a means to predict recruitment into the bay scallop fishery. Secondly, juvenile scallops harvested from spat collectors could be utilized for other grow-out applications to enhance natural stocks. Consequently, the implementation of spat collectors into an overall management plan could be a method employed by coastal communities to improve, stabilize and restore bay scallops in Southern New England.

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Literature Cited


**Personal Communications**

Gary Sherman, Westport Shellfish Constable, Fall 1993