STOCKING AND REESTABLISHMENT FEASIBILITY DEMONSTRATION: RECRUITMENT OF BAY SCALLOPS IN PANSY BAYOU, SARASOTA BAY, FLORIDA THROUGH SPAWNER TRANSPLANTS

Final Report

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December 15, 1994

Mote Marine Laboratory Technical Report No. 401

Suggested reference Leverone JR. 1994. Stocking and reestablishment feasibility demonstration: recruitment of bay scallops in Pansy Bayou, Sarasota Bay, Florida through spawner transplants. Sarasota Bay National Estuary Program. Mote Marine Laboratory Technical Report no 401. 14 p. Available from: Mote Marine Laboratory Library.

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EXECUTIVE SUMMARY

This project attempted to facilitate bay scallop recruitment within a protected seagrass meadow in Sarasota Bay by following the response of spawner transplants. The study was designed to take advantage of the synchronous spawning cycle of the bay scallop, which is known to be triggered by an autumnal drop in water temperature. By concentrating a sufficient number of adults within a relatively confined body of water, it was predicted that a major spawning event would result in a high percentage of fertilization leading to the production of large numbers of viable larvae.

Spawning stock came from coastal seagrass meadows near Steinhatchee, Florida. Six hundred and fifty transplanted scallops were kept in cages in Pansy Bayou, Sarasota Bay, and monitored for growth, survival and reproductive condition. Temperature was continuously monitored at two sites within the bayou.

Several abrupt drops in temperature occurred toward the end of October. The highest percent mortality (25.4 %) of spawner transplants occurred on November 09. Through the remaining winter months, relative mortality ranged from 3.1 to 9.9 % , increasing to 20.4 and 31.3 % in the spring. Scallops survived in Pansy Bayou through the middle of June.

Six bay scallop juveniles settled on collectors in Pansy Bayou between November 24 and January 17. No juveniles settled on collectors outside the bayou. Fifty five juvenile and subadult scallops were found during the summer. The most scallops (18) were found in Pansy Bayou on June 29. Two other surveys in Pansy Bayou each recovered eight scallops. The highest numbers of scallops per unit effort were also found in Pansy Bayou.

The transfer of spawner stock was planned to coincide with the onset of decreasing water temperatures. Towards the end of October a cold front passed through our area, causing a significant (5°C) drop in water temperature over a three day period. If a major spawning event was to be happen, this was the anticipated signal to initiate it. However, the recruitment of a limited number of spat, coupled with low spawning activity and a large percentage of scallops surviving through the winter, strongly suggests that, although environmental conditions were appropriate and transplanted scallops were poised to respond, a major spawning event did not occur in Pansy Bayou as anticipated.

Independent of whether the spawner transplant had its intended effect of enhancing the recruitment of the subsequent generation of bay scallops, this demonstration proved useful in determining the acceptability of receiving waters to the survival of transplanted bay scallops. Future attempts at reestablishing bay scallops through spawner transplants in Sarasota Bay should consider using Pansy Bayou as a suitable study site.

ACKNOWLEDGEMENTS

This project was accomplished through the assistance and cooperation of several interested parties; and the author would like to express his gratitude by acknowledging their respective participation. The initial collecting trip was successful thanks to the help of Gary Gilliland, Mote Marine Laboratory (MML). During the second collecting trip, Troy Tuckey (MML) and Catherine and Rachael Brey, Florida Marine Research Institute, helped collect and transport scallops to Sarasota. Several college students serving internships at MML assisted in the various field activities throughout the year. Special thanks go to Tammy Hayes, who weathered the cold winter months of sampling without complaint. The following college interns enthusiastically helped with field surveys during the more gentle spring and summer months: Suzanne Dunford, Jason Goldberg, Wendy Coronis, Theresa Kuharich and Kathryn Maggard. Albritton Fruit Company donated a generous supply of citrus bags for use during this project.

Project oversight was the responsibility of Dr. Dave Tomasko, Science Advisor for the Sarasota Bay National Estuary Program. Dr. Tomasko took an active role in the development and implementation of this project, and his involvement in particular aspects of the fieldwork is greatly appreciated. Finally, the author would like to acknowledge the cooperation of the Florida Department of Environmental Protection, Division of Marine Resources in approving an exemption to the No Entry Zone designation in Pansy Bayou for this research project. Primary funding was provided by the U.S. Environmental Protection Agency, Region IV, as an Early Action Demonstration Project through the Sarasota Bay National Estuary Program. This report may be referred to as Mote Marine Laboratory Technical Report #401.

I. INTRODUCTION

The Sarasota Bay National Estuary Program (SBNEP) has established habitat loss as one of the major issues threatening the environmental integrity of the bay. Several main program goals aimed at addressing issues either directly or indirectly related to habitat loss include: 1) the restoration of lost seagrasses and shoreline habitats, and the elimination of further losses, 2) reducing the quantity and improving the quality of stormwater runoff, and 3) restoring and sustaining fish and other living resources in Sarasota Bay. To address these main goals, the SBNEP developed a comprehensive strategy for restoring lost habitat as well as improving existing habitat. Efforts to improve existing habitats have included seawall habitat enhancement projects and seagrass utilization studies. These studies have promoted the SBNEP's objectives by providing data on the capacity of various habitats to support valuable living resources.

The bay scallop, *Argopecten irradians concentricus,* was once a valuable natural resource within Sarasota Bay seagrass meadows. Historical declines in water quality and reductions in seagrass cover have contributed to the disappearance of bay scallops from local waters more than three decades ago. Lately, the SBNEP has begun to include attempts to restore the full "functional capacity" of seagrasses; that is, their ability to support a diverse and integrated fauna, as a goal of habitat restoration and enhancement projects. One historically important faunal component of local seagrass meadows, the bay scallop, has been targeted by the SBNEP for restoration attempts.

Bay scallop restoration through seeding has shown promise in other parts of the country in supplementing natural scallop stocks (Middleton, 1983). Publicly financed programs to buy seed for the purpose of restocking depleted natural beds or creating spawning stocks have been initiated in several areas now without a natural population (Rhodes, 1991). Blake et al. (1993) have had varying success in seeding shallow grassbeds throughout Tampa Bay with laboratory reared scallops. While most stock enhancement efforts to date have used juvenile hatchery seed, hatchery larvae have been suggested for release into protected, enclosed habitats (Middleton, 1983). However, since there are no longer any local scallop populations to provide recruits to Sarasota Bay seagrasses, scallop restoration efforts would require either the import of scallops from other regions or a local source of hatchery reared seed.

An alternate approach to restoration applies basic principles of ecology to facilitate recruitment and reestablishment of select species. For the bay scallop, this option relies on transplanting scallops from donor areas to suitable locations prior to spawning. The bay scallop is a short-lived semelparous species; they spawn once toward the end of their first year, after which the population as a whole experiences mass mortality. (Specimens older than two years are rare). Spawning appears to be linked to water temperature and food availability (Barber and Blake, 1983). In Florida, bay scallop spawning commences in early October as water temperature begins to drop. By understanding these ecological principles and life history patterns, this approach optimize the bay scallop's inherent recruitment potential to promote recovery.

The current project attempts to facilitate bay scallop recruitment within a protected seagrass meadow in Sarasota Bay by following the response of spawner transplants. The study attempts to take advantage of the synchronous, coordinated spawning cycle of the bay scallop. By concentrating a sufficient number of adults within a relatively confined body of water, it is anticipated that a major spawning event (triggered by an autumnal drop in water temperature) will result in a high percentage of fertilization leading to the production of large numbers of viable larvae. By conducting the project within Pansy Bayou, an enclosed water body with reduced water exchange to Sarasota Bay, it is hoped that the larvae will be retained within the system and settle out in the local seagrass meadows. If successful, then future reseeding efforts would be able to eliminate the necessity for expensive, labor intense hatchery operations to supply the necessary seed material.

The objectives of this project are to: 1) collect, transfer and place bay scallops within a protected and confined grassbed in Sarasota Bay, 2) monitor the survival and reproductive condition of transferred scallops (observing signals of spawning), 3) detect the settlement of bay scallop spat within the surrounding grassbeds, 4) follow the development of juvenile scallops the following spring, and 5) develop public interest in habitat utilization for recreationally important shellfish.

II. MATERIALS AND METHODS

Spawning stock came from coastal seagrass meadows near the mouth of the Steinhatchee River (29° 42.63' N; 83° 31 .00' W) along the Gulf coast of Florida. Approximately 850 scallops were collected on September 14, 1994 and immediately transferred to Mote Marine Laboratory (MML) in a 500 gal, insulated, recirculating transport tank. Transport water was kept cool by the addition of two eight pound bags of ice. Scallops were kept overnight in a 1,000 gal outdoor flow through holding tank. Healthy, responsive scallops were set out in Pansy Bayou on the following day (September 15th). Pansy Bayou, located between New Pass and Big Pass on Sarasota Bay, is an enclosed, quiescent water body containing a 186,000 m^2 meadow of turtle and shoal grass (Figure 1). A second collection trip to Steinhatchee was made on October 3, 1994. An additional 300 scallops were collected and transported to MML in the same manner as above.

Transplanted scallops were kept in cages constructed of galvanized metal cloth. Ten cages were deployed in Pansy Bayou on September 15, 1993 (an additional cage was added to the array on October 4th, after the second collection trip). Each cage was approximately 1' x 2' x 1' and held 65-85 scallops. Cages were arranged in a semicircular fashion along the margins of the grassbed in water 2 - 4 feet deep (MLW). Cages were secured to the bottom by polypropylene line connected to a tie down anchor screwed into the sediment. A surface buoy marked the location of each cage. A Ryan Tempmentor™ thermograph was attached to the anchor of two cages (one located in shallow water and the other in deeper water). Each thermograph kept a continuous temperature record at 15 minute intervals during the entire study.

Adult scallops were inspected biweekly through October. During this initial period, dead scallops were removed from the cages, but no effort was made to count the number of live scallops. This was done to allow for mortality associated with collection, transport and handling. Beginning in November, live and dead scallops were counted and dead scallops removed. Periodically, two individuals from each cage were removed and the gonads prepared for histological examination. Visual inspections of gonadal development were made during each visit.

Collectors were placed within seagrass beds in Pansy Bayou to monitor the metamorphosis and

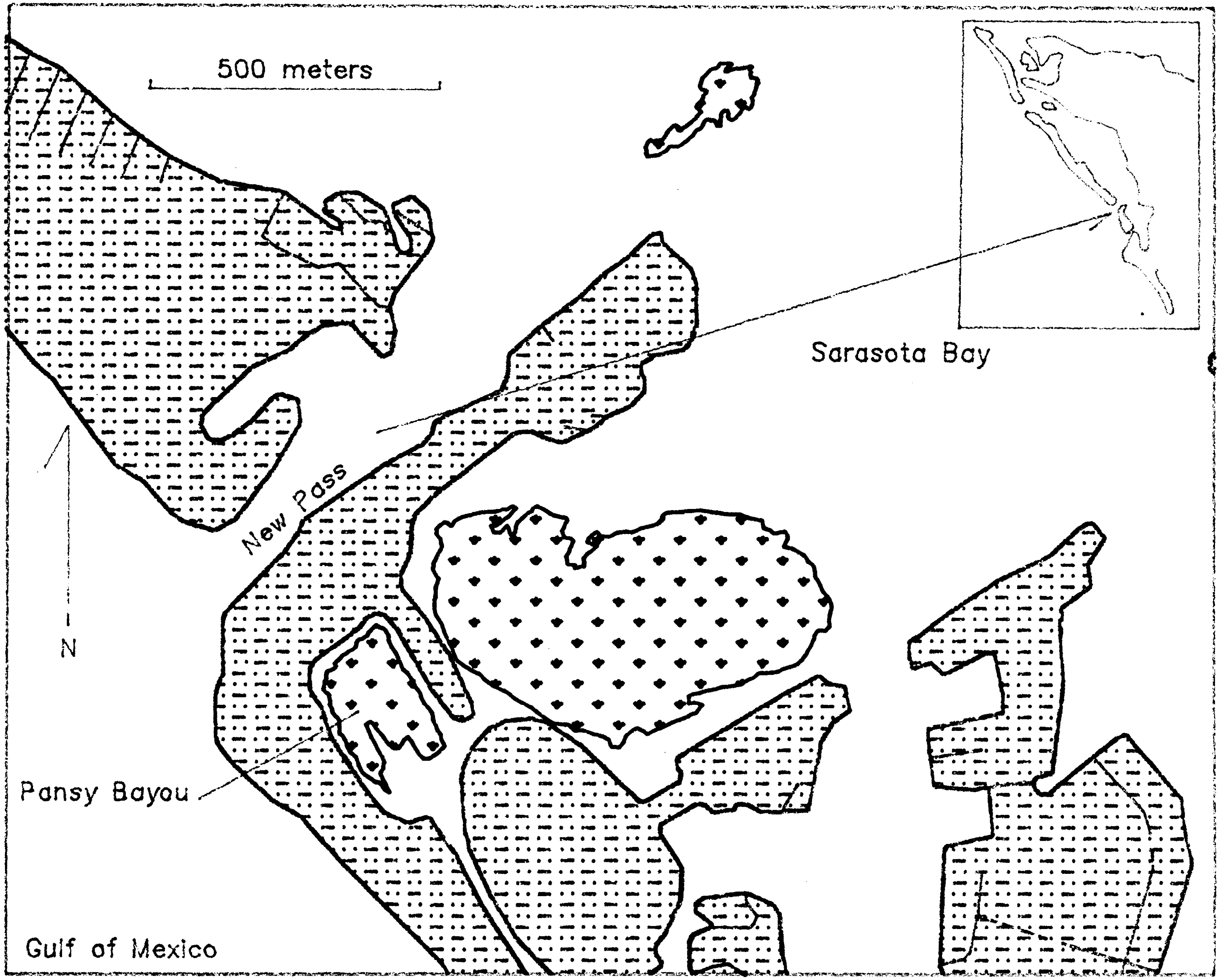

Figure 1. Map of study location showing Pansy Bayou and surrounding grassbeds.

settlement of bay scallop spat. Five pairs of spat collectors were placed within the bayou, while an additional five pairs were placed in an adjacent, larger grassbed to monitor export of scallop larvae (Figure 1). Spat collectors consisted of mesh citrus bags with a two square foot piece of l/4 inch mesh polyethylene plastic placed inside. Each pair of collectors was suspended vertically within the water column by attaching floats to the outside edges. The bags were affixed to polypropylene line anchored to the bay bottom and attached to surface buoys. Seven separate deployments were made between October 4, 1993 and March 25, 1994. The schedule allowed for overlap in the "soak time" of subsequent deployments to increase the chance of catching settling spat (see Figure 2). Collectors were returned to the laboratory and inspected for spat. Individual scallop spat were counted and measured.

Juvenile scallop monitoring began in late April and continued through the middle of July. Three separate seagrass meadows (see Figure 1) were monitored during this phase of the project: Pansy Bayou (186,000 m^2), City Island (818,000 m^2), and New Pass (acreage unknown). All observations were made by snorkeling. Initially, 100 foot transects were used to estimate scallop density. Two divers would swim along either side of the transect line and search for scallops within a one meter swath. After the first two sampling efforts employing this method, no scallops were found. A random search pattern which permitted a more extensive area to be surveyed was then implemented to locate juvenile scallops. This technique also allowed for multiple divers to search at the same time. The total number of scallops was standardized to the amount of time spent searching by an individual diver. Size determinations were made on each scallop found.

Activities relating to this project and the time frame for each activity are displayed in Figure 2.

III. RESULTS

Temperature. Figures 3 and 4 summarize the temperature records at the shallow and deep sites, respectively, in Pansy Bayou from October 13, 1993 through January 3, 1994. Mean daily water temperature was similar at both sites, although greater daily fluctuations were observed at the shallow site. Temperature during this period steadily dropped from 28 to 14° C. Several abrupt drops in temperature occurred during this period; most notably one toward the end of October, in which the mean daily temperature fell from 26 to 18° C. Four subsequent sudden temperature drops were observed through the remainder of 1993.

Mean water temperature at the shallow and deep sites in Pansy Bayou from January 13 through March 31, 1994 are presented in Figures 5 and 6, respectively. Temperatures ranged from 14 to 27° C. Mean daily water temperature was similar at both sites, although greater daily fluctuations were observed at the shallow site. While temperature gradually increased during this time, several recurring cycles of temperature were observed.

Finally, Figure 7 shows mean daily water temperature at the shallow site from April 1 through May 13, 1994. From April 2 to April 7, temperature rose steadily from 20 to 26° C. Thereafter, temperature remained fairly constant (around 27 and 28° C) through May 13.

Adult Scallops. Of the original 1,150 adult scallops collected on September 14th and October 4th, 657 were alive and in place in Pansy Bayou by the end of October, for a 56 % survival rate.

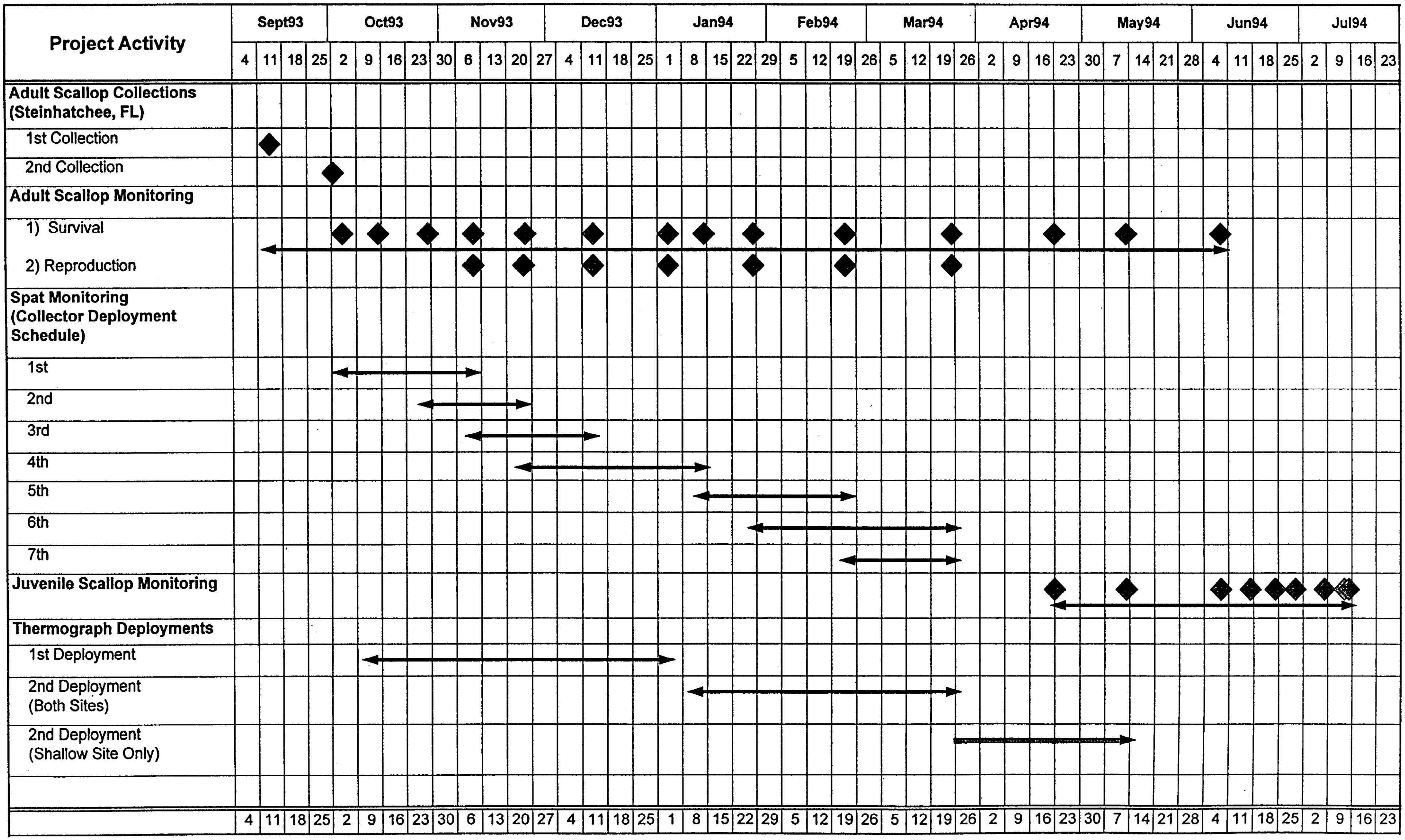

Figure 2. List of Project Activities

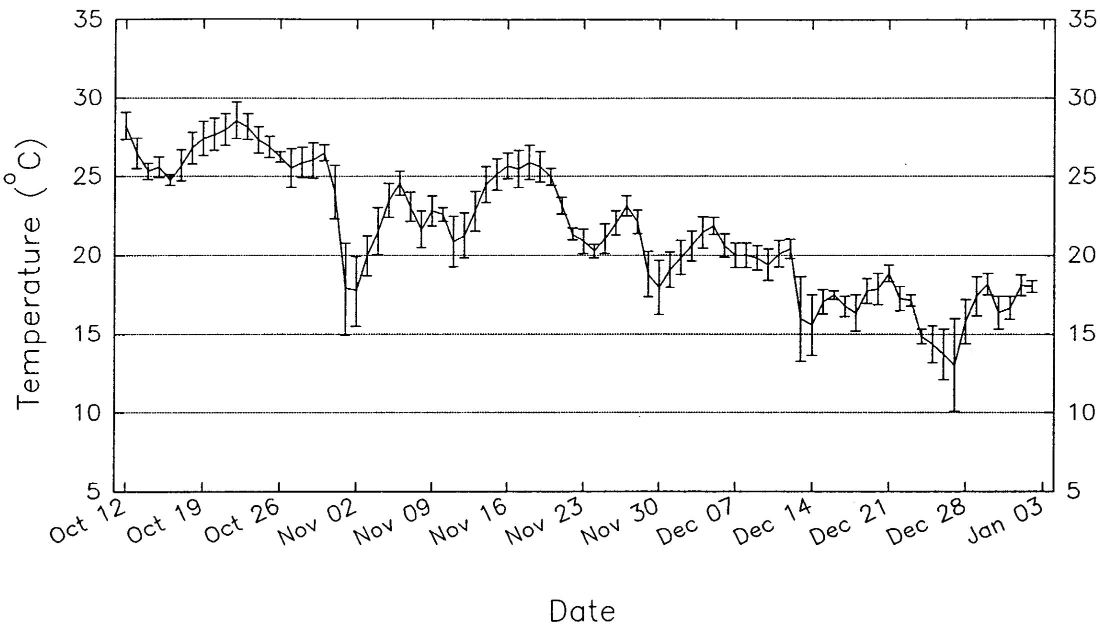

Figure 3. **Daily water temperature (mean ± 1 S.D.) at the shallow site in Pansy Bayou, Sarasota Bay from October 13, 1994 through January 3, 1994. Daily means from 24 hourly measurements.**

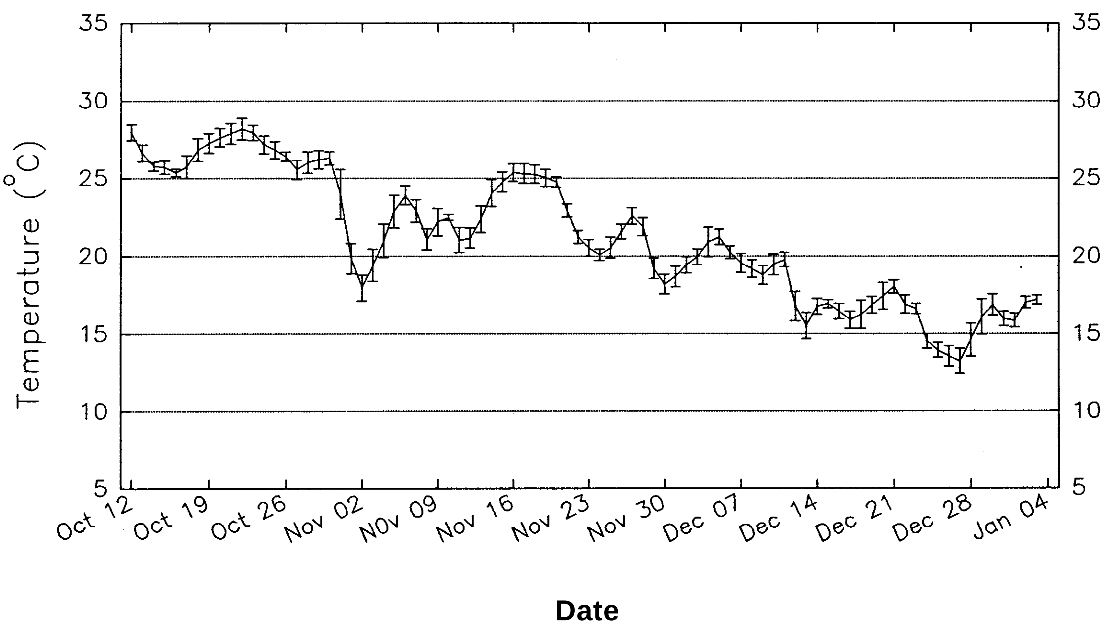

Figure 4. Daily water temperature (mean ± 1 S.D.) at the deep site in Pansy Bayou, Sarasota Bay from October 13, 1993 through January 3, 1994. Daily means from 24 hourly measurements.

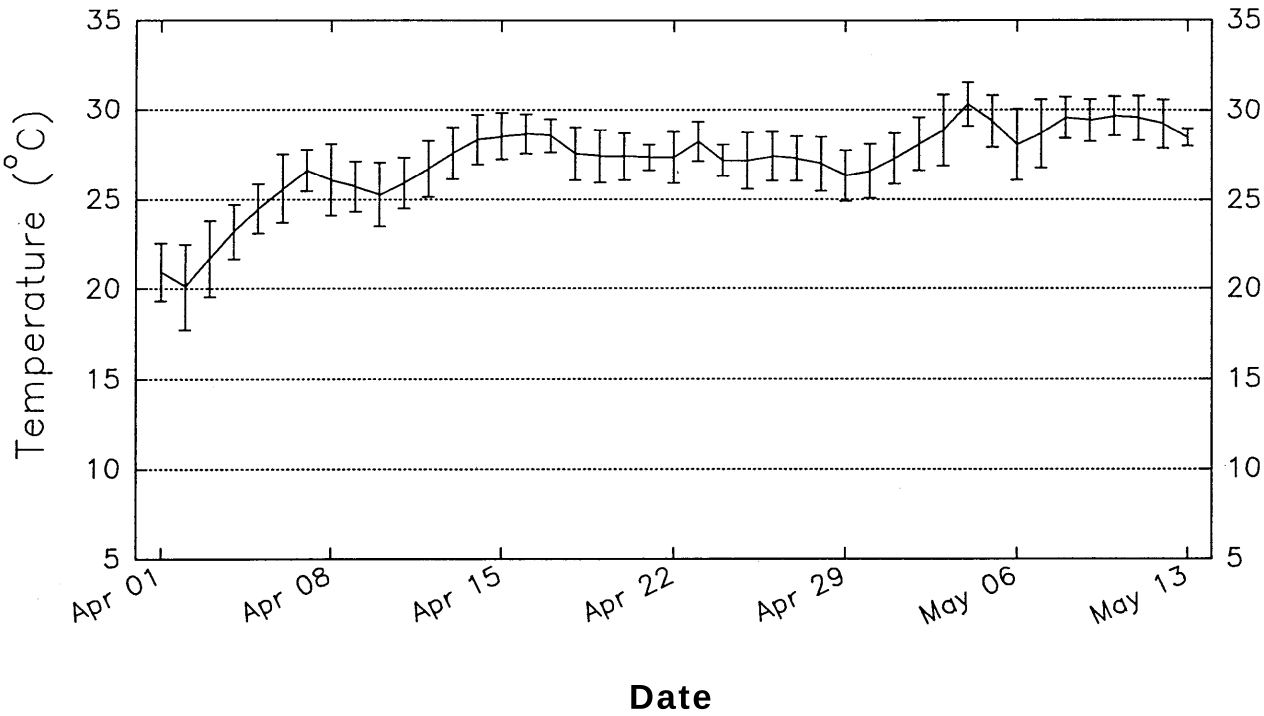

Figure 7. Daily water temperature (mean ± 1 S.D.) at the shallow site in Pansy Bayou, Sarasota Bay from April 1, 1994 through May 13, 1994. Daily means from 24 hourly measurements.

This rate represents the percent of individuals that survived the cumulative stresses of collection, transport, holding, placement and adjustment in Pansy Bayou after one month.

Figure 8 shows the total number of adult bay scallops enclosed in Pansy Bayou from November 9, 1993 through March 25, 1994. Four hundred and five scallops were alive toward the end of November, and 306 scallops were still alive by January 3, 1994. Eighty four scallops were removed during this time (approximately 20 per monitoring visit) to monitor reproductive condition. During the January 13 visit, three cages were discovered vandalized, accounting for the loss of 86 individuals. Twelve percent of the total number of scallops on November 9 were still alive on March 25, 1994. Scallops survived in Pansy Bayou through the middle of June.

The mean number of live and dead scallops in Pansy Bayou from November 9, 1994 through March 25, 1994 is displayed in Figure 9. The highest percent mortality (25.4 %) occurred on November 09. Through the remaining winter months, relative mortality (defined as the total number of dead scallops divided by the total number of live scallops the previous sampling) ranged from 3.1 (January 28) to 9.9 % (November 24). Relative mortality increased to 20.4 and 31.3 % for February 23 and March 25, respectively.

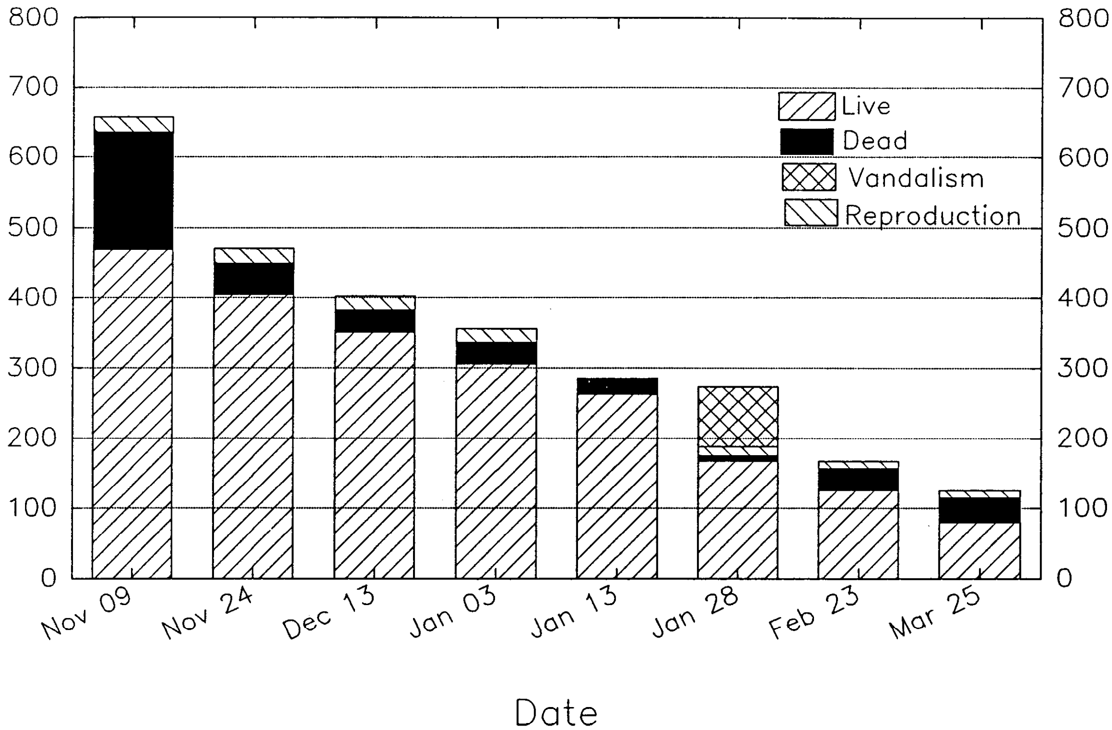

Figure 8. Total number of scallops enclosed in Pansy Bayou, Sarasota Bay, from November 9, 1993 through March 25, 1994.

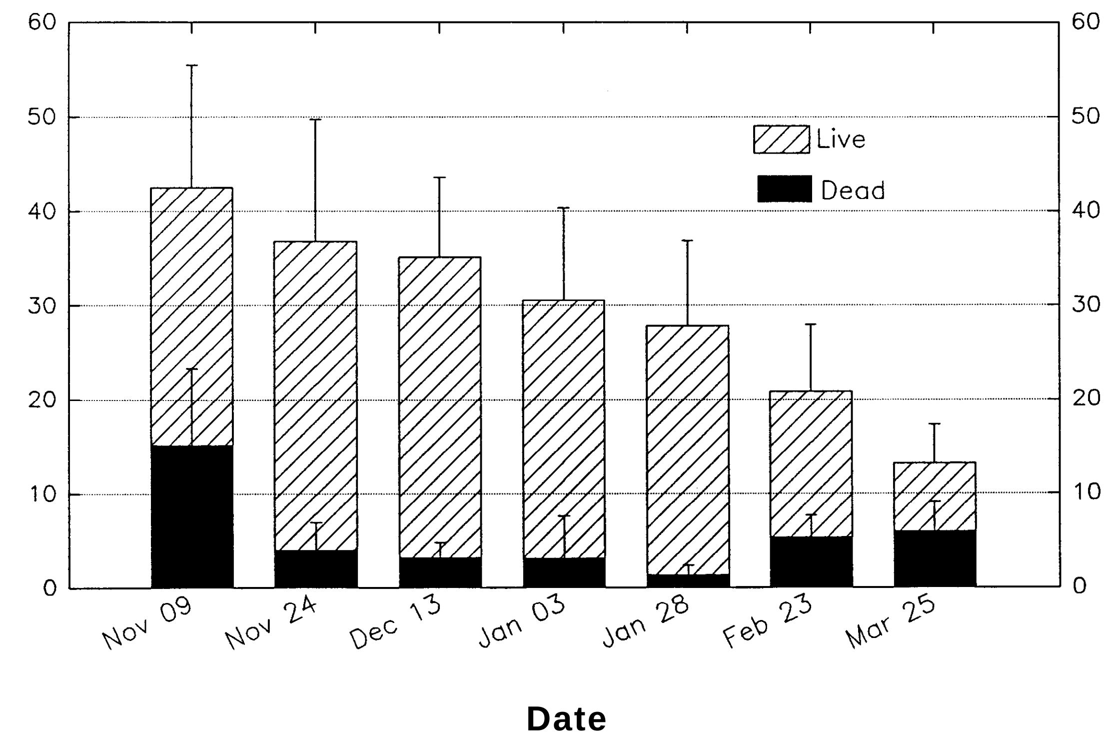

Figure 9. Mean number of live and dead scallops per cage during deployment in Pansy Bayou, Sarasota Bay, from November 9, 1993 through March 25, 1994.

Visual inspection of gonadal development throughout the study revealed a high percentage of ripe, well developed gonads. This condition was observed in most scallops at the beginning of the study and persisted throughout the late fall and winter, with only an occasional indication of partially spent gonads in several scallops. During February and March, approximately half the surviving scallops observed had spent gonads.

Scallop spat. Spat collectors were deployed between October 4, 1993 and March 25, 1994. A total of six bay scallop spat were found on collectors between November 24 and January 17. All spat were found on collectors placed inside Pansy Bayou (collectors 1 through 5); no spat were found on collectors outside the bayou (collectors 6 through 10). Spat ranged in size from 4.3 to 12.0 mm in shell height. The following schedule summarizes the results from the spat collection deployment.

November 10:	Spat collection I. Collector 5B: 1 spat (9.3mm). Collector 4A: 1 spat (6.6mm).
November 24:	Spat collection II. Collector 4B: 2 spat (4.4 and 4.3 mm).
December 13 :	Spat collection III. No spat.
January 17:	Spat collection IV. Collector 2B: 1 spat (12.0mm). Collector 3B: 1 spat (9.4mm).
February 23:	Spat collection V. No spat.
March 25:	Spat collections VI and VII. No spat.

Juvenile scallops. Monitoring for juvenile scallops began in the spring when it was expected that recruited scallops would be large enough to see. The first two juvenile survey were conducted on April 23 and May 13. No scallops were found during these surveys, which consisted of a pair of divers swimming repeated 100' transects. In order to increase the search area per survey, a random search pattern was employed for all subsequent surveys. This approach also allowed the employment of additional divers in the survey. The results of the juvenile surveys are shown in Figure 10. The total numbers of scallops per survey are displayed as stippled bars (different stippling patters represent different grassbeds). The numbers of scallops were also standardized to the number per diver per hour and displayed as solid bars.

Fifty five scallops were found during the surveys. The most scallops (18) were found in Pansy Bayou on June 29. Two other surveys in Pansy Bayou each recovered eight scallops. The highest numbers of scallops per unit effort were also located in Pansy Bayou (June 29 and July 13). Overall, the number of scallops found per hour per diver was one.

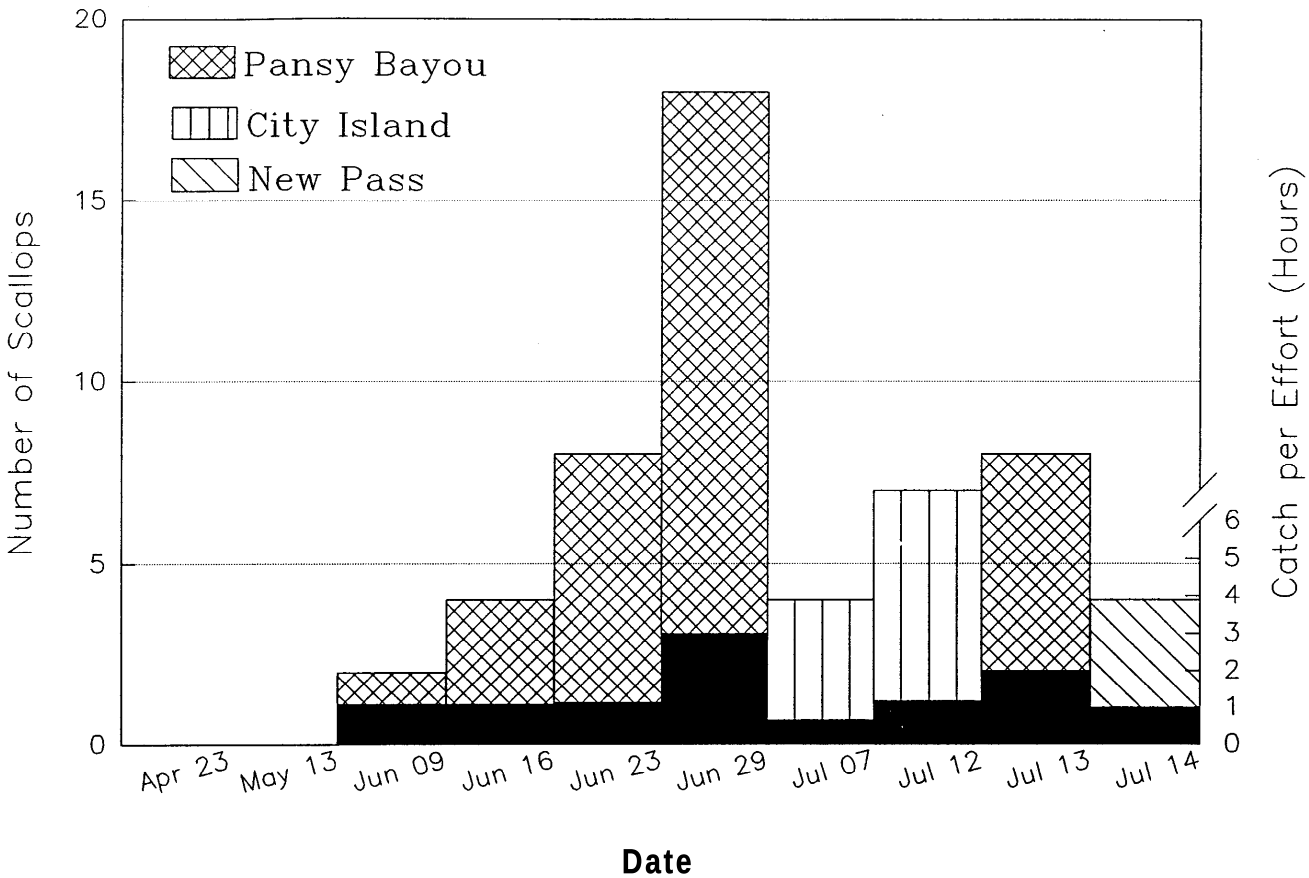

Figure IO. Total number of bay scallops (stippled bars) and number per unit effort (solid bars) collected from three separate grassbeds in Sarasota Bay between April 23 and July 14, 1994.

IV. DISCUSSION

This project was designed to demonstrated the feasibility of spawning captive scallops as a means of facilitating recruitment and stocking within a protected seagrass meadow in Sarasota Bay. By taking advantage of the synchronous, coordinated spawning cycle of the scallop, and ensuring there are enough animals for successful fertilization, the probability for an effective spawn should be high.

The success of a study requiring the transplant of spawner stock is initially dependent on the ability of the transplants to survive transfer from the donor site and introduction into a new environment. The relative survival rate (56%) of transferred adult scallops after one month in Pansy Bayou is encouraging for future studies and enhancement projects involving long distance relocation endeavors.

The transfer of spawner stock was planned to coincide with the onset of decreasing water temperatures, which is believed to be the main stimulus triggering spawning in Florida bay scallops (Barber and Blake, 1983). Water temperature at the donor site (Steinhatchee, Fl) during collection in early October was 29-30°C. Water temperature in Pansy Bayou (Sarasota, Fl) was 28°C when scallops were transferred. Throughout October, water temperature in Pansy Bayou varied between 26 and 28°C. These slight variations in temperature were not expected to trigger a main spawning event, and during this period, observations of reproductive condition indicated that, indeed, this did not happen. Towards the end of October, a cold front passed through our area, causing a significant (5°C) drop in water temperature over a three day period. If a major spawning event was to happen, this was the anticipated signal to initiate it. Although predicting changes in water temperature (usually associated with stochastic meteorological events) is difficult, and planning a study dependent on these unpredictable events is risky, in this case, it appears that environmental conditions were appropriate for a successful spawn.

After acclimation in Pansy Bayou, spawner scallop survival remained high throughout the late fall and early winter. The highest percent mortality (25.4%) occurred prior to November 9. Afterward, mortality varied from 3.1 to 9.9% per month until the spring. The ability of bay scallops to survive for extended periods after long distance transplant is promising for two reasons. First, it illustrates the connection between the condition or quality of local seagrasses and their ability to support critical living resources. An important outcome of this project is the that water quality and habitat conditions in Pansy Bayou and surrounding grassbeds appear well suited for the reestablishment of bay scallop populations through either natural or artificial processes. As long as bay conditions continue to show signs of recovery, the potential for natural resource recovery will also continue to improve. Second, it establishes the transport of spawner stock from available donor sites as a viable option in enhancement efforts. Future projects will not necessarily be limited to the use of cultured scallops, with their reduced genetic variability, as the only viable source of donor material.

Scallop settlement rate is most frequently monitored with artificial substrates, referred to as spat collectors (Eckman, 1987). Recruitment to spat collectors is a good reflection of settlement pattern and is used to monitor the timing of spawning as well as being a reliable index of relative settlement intensity (Ambrose, et al., 1992). The timing of scallop settlement in this project coincided with the pattern typically found in Florida populations (Barber and Blake, 1983;

Sastry, 1961). Spat were found in the present study between mid-November and the beginning of January. More interestingly, all spat were recruited onto collectors within Pansy Bayou where adult spawners were enclosed. Since preliminary surveys recovered no adult scallops in Pansy Bayou or surrounding grassbeds (surveys conducted in September, 1993), it is presumed that scallops recruited onto spat collectors in Pansy Bayou came from the transplanted spawner stock. The recovery of a limited number of spat suggests minor spawning activity within the bayou. This suggestion is partially supported by observations on gonadal development among spawner stock, whereby most examined scallops appeared ripe with little evidence of spent gonads associated with complete spawning. Furthermore, the absence of mass spawning may also be partially reflected in the high survival rate of transplants. After spawning, nutrient reserves in the southern bay scallop are virtually depleted, possibly contributing to the fact that most scallops are unable to sustain themselves through the following winter (Barber and Blake, 1981). In summary, the recruitment of a limited number of spat, coupled with low spawning activity and a large percentage of scallops surviving through the winter, strongly suggests that, although environmental conditions were appropriate and transplanted scallops were poised to respond, a major spawning event did not occur in Pansy Bayou as anticipated.

Recruitment patterns revealed a low, but appreciable number of juvenile and subadult scallops in Pansy Bayou and surrounding grassbeds. Both in terms of total numbers and catch per unit effort, Pansy Bayou contained more scallops throughout the summer than two nearby, similar grassbeds (in terms of seagrass composition). These adjacent grassbeds (designated City Island and New Pass, respectively) are within reasonable distance to Pansy Bayou to expect fair water exchange among them. If one assumes that all juvenile recruitment to the area was a result of spawner transplanting, then the observed pattern of juvenile distribution fits nicely with expected results. Pansy Bayou was selected as the most optimal location because of its presumed limited water exchange with Sarasota Bay, thus increasing chances for larvae to be retained within the bayou during their brief planktonic life. Larvae that are transported out of Pansy Bayou would still have a reasonable chance to metamorphose and settle out in adjacent grassbeds. Future attempts at reestablishing bay scallops through spawner transplants in Sarasota Bay should consider using Pansy Bayou as a suitable study site.

The innovative approach of this project came from the attempt to seed grassbeds through natural processes, taking advantage of the scallop's synchronous spawning cycle. A simple modification to this strategy that would eliminate the chance associated with relying on natural signals to induce spawning would be to induce spawning in transplants by intragonadal injections of serotonin (hydroxytryptamine; 5-HT). This method of artificial induction has been very successful in a number of bivalve shellfish, including the bay scallop (Gibbons and Castagna, 1984). In this way, spawning could be verified by the ability to actually observe the release of gametes (perhaps by temporary holding in floating plexiglass enclosures). By holding several dozen scallops within temporary enclosures during hormonal injections, the release of gametes from several individuals would induce gamete release in the remaining scallops, a phenomenon commonly observed and employed in hatchery operations (Castagna and Duggan, 1971; Castagna, 1975). Spawning success would then be monitored by spat settlement and juvenile recruitment. Additionally, the ability to distinguish between recruits from spawner transplants and those from natural sources will be essential in evaluating the effectiveness and success of ***in situ*** fertilization. The development of a noninvasive genetic "tag" for labeling second generation production is receiving increased attention from hatchery finfish and shellfish researchers. This research will have applications extending well beyond the hatchery.

Independent of whether the spawner transplant had its intended effect of enhancing the recruitment of the subsequent generation of bay scallops, this demonstration proved useful in determining the acceptability of receiving waters to the survival of transplanted bay scallops. Wherever seagrass habitat seems adequate and where historical data show abundant bay scallops, it would be appropriate for shellfisheries managers to consider application of this technique.

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