ANNUAL REPORT OF THE BAY SCALLOP PROJECT

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INTRODUCTION

Our bay scallop research program continues to focus on monitoring the abundance of adult scallops at various sites along the Florida west coast. Surveys are conducted during June just prior to the opening of the bay scallop recreational fishing season, and during fall just after the season closes. These surveys are designed to provide an estimate of the effectiveness of bay scallop harvesting regulations implemented prior to the beginning of the 1994 fishing season. In particular, we wish to monitor the recovery of depleted scallop populations inhabiting the fishery closure zone south of the Suwanee River. A necessary component of that evaluation is a complementary assessment of relatively stable scallop populations at sites north of the Suwanee River closure zone. Together, those assessment provide a framework for quantifying natural fluctuations in scallop population abundance and for estimating a minimum viable population size necessary for the survival of local scallop populations.

We also continue to monitor recruitment at a subset of our adult monitoring sites to determine if the intensity of recruitment is a function of the abundance of adults at each site. Recruitment monitoring is a necessary component of our efforts to estimate minimum viable population size. Results from previous years strongly suggest that recruitment rate within each site is a function of adult abundance at that site. The existence of that spawner-recruit relationship underlies our strategy for restoration of bay scallop populations on the west coast of Florida.

ADULT POPULATION SURVEYS

Consistent with previous surveys (e.g., Arnold et al., 1997), our 1997 adult scallop sampling protocol consisted of diver surveys of 20 randomly-located 300 m transects at each of seven study sites (Figure 1). One diver on each side of a transect line searched the area within 1 m of the line along its length; all scallops within that 2 m x 300 m area were counted and shell height (SH = maximum distance from umbo to ventral margin) determined for a maximum of 30 specimens. The total area surveyed at each transect station was 600 m^2, equivalent to 12,000 m^2 per research site. Since 1993 for Homosassa Bay, and since 1994 for all other sites (except Pine Island Sound), stations have been repetitively occupied at each site. For Pine Island Sound, stations were relocated after the 1994 survey in response to suggestions from local fishermen that bay scallops in that area were historically restricted to a relatively small subarea of the Sound. In all cases, we consider interannual samples within each site to be effectively independent because the scallop life span is only one year so each population is essentially replaced each year.

Surveys of adult bay scallop abundance were conducted in Pine Island Sound, Anclote estuary, Homosassa Bay, Steinhatchee, St. Joseph Bay, and St. Andrew Bay/Sound during June, with follow-up surveys conducted in Anclote, Homosassa Bay, Steinhatchee, and St. Joseph Bay during September and October. Additionally, we conducted our first survey (June only) of adult scallops in the area between Anclote and Homosassa ("Hernando" study site) to provide a baseline for assessment of increases in adult abundance that may occur in response to our restoration efforts.

Within each study site, the statistical significance of temporal changes in scallop density was determined using the Kruskal-Wallis procedure, a non-parametric equivalent of the one-way analysis of variance (Sokal & Rohlf, 1995). We used the Statistical Analysis System (SAS Institute, Inc., 1985) procedure NONPAR1WAY, which provides a Chi-square approximation of the Kruskal-Wallis H statistic that is appropriate when sample size exceeds five per group (Sokal & Rohlf, 1995). Individual pairwise comparisons, for sites that exhibited an overall statistically significant difference, were analyzed using the parametric Ryan-Einot-Gabriel-Welsch multiple F test on ranked abundance data (SAS Institute, Inc., 1985; Day & Quinn, 1989).

The interpretation of our adult survey results requires an appreciation of the statistical power underlying our comparisons. Our survey methods are designed to detect large differences in scallop abundance among sites within years and among years within sites. A key component of this strategy is to survey as many sites as possible during a short period of the year just prior to the opening of the recreational fishing season. Our design allows for detection of a change in scallop abundance equivalent to approximately 67% of the standard deviation, at an alpha level of 0.05 and with a power (beta level) of 0.80. Increasing the statistical power of our tests would require the sampling of considerably more stations at each site, with a concomitant decrease in the total number of sites sampled. Unfortunately, scallops tend to occur in clumps, thus the standard deviation of abundance tends to be greater than the mean abundance (Elliott, 1977). As a result, the power of a statistical test is relatively low when compared with that expected for a distribution that exhibits a standard deviation equal to (random distribution) or less than (overdispersed distribution) the mean. We have chosen a compromise between the extent and intensity of our sampling that allows us to draw statistically valid conclusions concerning changes in scallop abundance within and among a variety of historically important local populations.

June Survey

Pine Island Sound: Relative to 1995 and 1996, scallop abundance remained low but stable at the Pine Island Sound study site during 1997. We found scallops at nine of our 20 survey stations in 1997, and eight of those stations yielded more than 1 scallop per transect (Table 1). However, scallop abundance remains low in Pine Island Sound and has not changed significantly over the last three years of our study ($x^2 = 2.6579$, $p = 0.2648$). We did not include 1994 survey results in our statistical analyses because of the aforementioned change in survey station location after the 1994 survey, but we found no scallops in Pine Island Sound during 1994.

Anclote Estuary: Scallops were significantly more abundant at Anclote during 1997 than during any previous year (x^2 = 44.017, p = 0.0001), and average 1997 density was more than an order of magnitude greater than that observed during 1996 (Table 2). At least some scallops were found at every survey station, a pattern similar to that observed during 1994 prior to the almost complete loss of the Anclote scallop population during the June, 1995 red tide event (Arnold et al., 1997). Overall, the Anclote population appears to be responding favorably to the fishery closure implemented in 1994 despite the substantial impact of that 1995 red tide event.

Hernando: Scallops were significantly less abundant at the Hernando study site than at Anclote but abundance did not significantly differ from that recorded at Homosassa (x^2 = 45.635, p = 0.0001; Table 3). It is premature to draw conclusions with only one year of data from the Hernando study site (Table 4), but the lack of suitable habitat may limit scallop abundance in the Hernando region. Personal observation indicates that seagrass beds, a critical component of scallop habitat (Thayer & Stuart, 1974), are less extensive within the Hernando site than within the Anclote (or even the Homosassa) study site. We are obtaining Geographic Information System

(GIS)-based maps of seagrass beds in those areas to assess relative habitat availability.

Homosassa: Scallops remain scarce in the Homosassa region, but results of the 1997 survey provide some evidence of recovery of that population. Scallops were significantly more abundant (x^2 = 16.168, p = 0.0028) at Homosassa in 1997 relative to all previous years since 1993 (Table 5). For the first time since we initiated our surveys, scallops were not significantly less abundant at Homosassa than at the Steinhatchee and St. Joseph Bay study sites (Table 3), although scallop density at Homosassa was only about one-half that observed at Steinhatchee and St. Joseph Bay and less than one-third that recorded from Anclote. We are optimistic that the Homosassa bay scallop population is responding favorably to the 1994 fishery closure.

Steinhatchee: Scallop abundance decreased substantially and significantly (x^2 = 23.079, p = 0.0001) at the Steinhatchee study site during 1997 relative to 1996; overall abundance was even less than that observed during our previous worst year of 1995 (Table 6). As usual, however, even a bad year in Steinhatchee is as good or better than a good year at most other sites, and scallop abundance at Steinhatchee did not differ significantly from that recorded for Anclote, Homosassa, or St. Joseph Bay (Table 3).

St. Joseph Bay: Scallop abundance also decreased substantially and significantly in St. Joseph Bay during 1997 relative to 1996 and 1995 (x^2 = 16.499, p = 0.0009). Although mean scallop abundance declined by almost one order of magnitude between 1996 and 1997, scallops remain at least as abundant in St. Joseph Bay as at any site in Florida (Table 3). Note that scallop abundance in St. Joseph Bay was equally low in 1994 yet expressed substantial density increases in 1995 and 1996 (Table 7).

St. Andrew Bay and Sound: Scallops were significantly less abundant in the St. Andrew Bay/Sound system during 1997 relative to each of our three previous study years (χ^2 = 21.563, p = 0.0001). Scallops were most abundant in this system during 1994 (Table 8), but abundance decreased dramatically in 1995 probably in response to heavy precipitation and flooding in the region surrounding St. Andrew Bay during fall 1994. The population appeared to be rebounding in 1996, but our 1997 survey results suggest either that scallop populations within that system fluctuate considerably interannually or that as-yet unidentified conditions again negatively impacted the population.

Fall Survey

Anclote: Fall surveys were conducted in Anclote during 1994 and 1997 (Table 9). In 1994, scallop abundance decreased by approximately 50% between the June and fall surveys, whereas in 1997 scallop abundance increased by approximately 50% between surveys. In neither case was this difference statistically significant (Table 10).

Homosassa: Fall surveys were conducted in Homosassa during 1995, 1996, and 1997 (Table 11). In both 1995 and 1996, scallop density decreased significantly between the June and fall surveys, but during 1997 we observed no significant change in scallop population abundance between June and fall (Table 10). The lack of a significant change may reflect full implementation of bag and season limits instituted prior to the 1995 fishing season. It is not uncommon for changes in fishery regulations to require several years to take effect "on the water". For example, we continue to receive reports of recreational fishing for scallops in the Anclote area although that area has been closed to scalloping for four years. Also note that, for the 1996 Homosassa comparison only, the difference between June and fall abundance becomes non-significant if a critical value adjustment is applied to account for multiple tests of the same hypothesis (multiply the *p* value by the total number of simultaneous tests, in this case 13 [Rice, 1989]).

Steinhatchee: Fall surveys have been conducted each year since 1994 (Table 12), but only during 1994 was there a significant decrease in population abundance between June and fall (Table 10). Both the bag limit and the season length were reduced after the 1994 season. Those changes appear to have been effective in reducing the total take from the fishery and increasing survival into the fall spawning season.

St. Joseph Bay: Surveys have been conducted each year since 1994 (Table 13). We detected significant decreases in population abundance between the two seasons in both 1994 and 1995, but no significant change in either 1996 or 1997 (Table 10). Again, this may reflect changes in fishery regulations instituted after the 1994 season. Delayed public awareness of those changes may explain the continued significant decline observed during 1995.

SIZE DISTRIBUTION

Shell height distribution differed significantly among the seven sites that we surveyed during June (R x C Contingency Test, $x^2 = 516.55$, $p = 0.001$). At that time, scallops collected from St. Joseph Bay and St. Andrew Bay/Sound in the panhandle were considerably smaller than scallops collected from the remaining five (peninsular) sites (Table 14). The existence of smaller scallops at panhandle locations is common knowledge among fishery participants, and has been previously reported by us (Arnold et al., 1995). This pattern remains significant ($x^2 = 386.06$, $p = 0.001$) even when the comparison is made only within the subset of research sites that we survey during both June and fall (i.e., Anclote, Homosassa, Steinhatchee, St. Joseph Bay), but only for June samples. By fall, shell height differences among those four sites have disappeared ($x^2 = 49.14$, $p > 0.10$).

Compensatory shell growth (i.e., faster growth of smaller animals) is common in bay scallops (Auster & Stewart, 1984) and other bivalves (Eldridge & Eversole, 1982) and is probably controlled by ambient temperature and food supply (Barber & Blake, 1983). Similar temporal differences probably characterize somatic growth, as shell and soma follow similar growth trajectories (Barber & Blake, 1983). Delayed growth in panhandle scallops, relative to their peninsular conspecifics, explains the oft-heard complaint among panhandle fishery participants that the scallops are too small for harvest during July. However, although meat yield may not be maximal during July, a July 1 opening date probably has little effect on the ultimate reproductive potential of the population. The bay scallop populations that we survey exhibit no difference in shell size by September, and that date still precedes the autumn spawn.

SPAWNING AND MORTALITY

Mortality research initiated in 1996 was continued at the Steinhatchee study site through March, 1997. We previously reported (Arnold et al., 1997) a major reduction in population density associated with the fall, 1996, spawning event (Figure 2). Following that large mortality event, however, a small percentage of the population (3-6 %) remained alive (Figure 2). The reproductive status of the surviving population was monitored through early June, 1997. Every 3-4 weeks we collected 15 animals from the natural scallop population located at our northern Steinhatchee study area (Arnold et al., 1997; page 10) and processed their gonads for histological analysis. Through mid-November, 1996, we also monitored the reproductive status of scallops held in cages. Unfortunately, during November those cages were invaded by predators that killed the caged scallops. However, until the end of the caging treatment it appeared that those cages were not interfering with either growth (Figure 3), reproductive state (Figure 4), or other readily apparent components of the health of the enclosed scallops.

RECRUITMENT

We continued to monitor spat settement at our northern and southern Steinhatchee study areas through the end of July, 1997. We detected no significant difference in the magnitude of recruitment between the two areas (ANOVA; F=0.05, *p*=0.8232), but recruitment was an order of magnitude lower than that of recent years (Arnold et al., 1997). The temporal pattern of recruitment was typical for Steinhatchee, with the major pulse following the October-November spawning event (Figure 5). We also recorded a secondary pulse of recruitment during the mid to late winter, and a small and seemingly disassociated recruitment event during late spring and early summer of 1997. Spawning and recruitment appeared to be closely related during late 1996 and early 1997 (Figure 5), but the spawning pulse observed during the spring of 1997 either did not translate into a successful recruitment event at Steinhatchee or was not detected by our method of assessing recruitment.

We also continued our recruitment monitoring efforts at the Anclote and Homosassa study sites, but we modified our spat-collector deployment strategy in that area in preparation for the initiation of our scallop restoration program. Instead of deploying triplicate collectors at each of a variety of sites within each of the Anclote and Homosassa study sites, we deployed collectors in triplicate at each of ten equally spaced stations between Anclote and Crystal River. All collector stations were located within seagrass beds in approximately 1.0 m water depth. As usual, collectors were deployed on a six-week overlapping schedule.

Scallop recruitment rate was highest at the southernmost station in Anclote during the October and November deployments, but recruitment rate at the other stations was less than 1/4 that observed at station 1 and in many cases was essentially non-existent (Figure 6). However, recruitment at the southernmost stations exceeded that observed even at Steinhatchee, a factor reflected in our subsequent measures of adult density at those sites in June, 1997.

RESTORATION

In preparation for the extensive bay scallop restoration program that we initiated in July, 1997, we obtained research funds from the Saltonstall-Kennedy program to conduct preliminary restoration research and development in Tampa Bay. The basic premise of this study was to place hatchery-reared scallops (propogated from existing Tampa Bay scallop stocks) in spawner enclosures in an area essentially devoid of natural scallop stocks. We then monitored aspects of reproduction and recruitment to estimate the impact of our spawner introductions on subsequent year-class strength.

During fall, 1997, we sampled 10 randomly located 50 meter transects (total area surveyed on each transect = 100 m^2), in the vicinity of Pinellas Point in lower Tampa Bay. We found no adult scallops within that 1000 m^2 survey area. We then constructed and deployed four predator-exclusion enclosures (1.2 m by 1.2 m by 0.4 m) within an approximately 1.5 m deep subarea of the study site. In late September, 1997, we collected adult scallops from the Anclote area and planted approximately 200 within each of the four enclosures. At the time of transplant and again in late October, 1997, we randomly selected a total of 15 scallops from the four enclosures and returned them to the laboratory for histological preparation and subsequent gonadal analysis. Analysis of those samples has not been completed.

To verify the existence of scallop larvae in the vicinity of the study site, and to quantify larval abundance, we established ten larval sampling stations in the area surrounding the scallop enclosures. Just after scallops were transplanted, and then approximately weekly through December, 1997, water samples were obtained at each station from a depth 0.5 meters above the sediment-water interface. At each station, 300 l of water was pumped through a 63 μm net to capture and concentrate any extant scallop larvae. That concentrated sample was then placed on ice, returned to the laboratory, suspended in solution, and preserved at -80° C for subsequent analysis by Dr. Marc Frischer at the Skidaway Institute of Oceanography. In collaboration with us, Dr. Frischer is developing a genetic probe that will detect and quantify bay scallop larvae. That probe will be applied to the Tampa Bay water samples to determine if scallop larvae were present during our study and to estimate the abundance of those larvae. If successful, this technique will be applicable not only to our Tampa Bay study but also to future research on dispersal of bay scallop (specifically) and marine invertebrate (generally) larvae.

To estimate scallop recruitment in the vicinity of our study site, spat collectors were deployed in triplicate at each of six stations during September 1997. Three weeks later an additional three collectors were deployed at each station. Collectors were retrieved and replaced on a three-week overlapping schedule through February, 1998. Collectors have been retrieved through the December 31 recovery sequence, and all recovered collectors are being examined for the presence of juvenile bay scallops. Preliminary results suggest substantial recruitment to those collectors.

A small experiment examining the feasibility of enhancing natural scallop recruitment was established in early November, 1997. Three-dimensional polypropylene mesh tubes were suspended from a PVC frame of dimensions 3 m x 1 m at four randomly chosen stations in the vicinity of our Tampa Bay study area. At four additional sites we deployed controls consisting of empty PVC frames. In March, 1998, we will cut open the polypropylene tubes to allow juvenile scallops that may have settled onto the tubes to drop onto the benthic substrate. Concurrent with the initial adult scallop survey, we surveyed scallop densities at the enhancement sites, and will repeat the survey of the enhancement sites in the spring of 1998 to estimate the contribution of this project to adult scallop abundance in this area.

SUMMARY

Bay scallop population abundance increased considerably at the Anclote and Homosassa study sites located south of the Suwanee River fishery closure zone. At both of those sites, scallop density is as high or higher than has been recorded in any previous study year. This density increase is an undeniably positive development but cannot be considered a trend in this short-lived (12-18 months) species. Furthermore, a similar increase has not been observed in Pine Island Sound although scallop abundance has been stable in that region over the last several years. In contrast, 1997 scallop density is down relative to 1996 in areas north of the closure line. Decreased abundance of bay scallops at those northern sites, especially Steinhatchee and St. Joseph Bay, probably reflects natural variation around a relatively stable mean. Both Steinhatchee and St. Joseph Bay supported very abundant scallop populations in 1996, and it is not surprising that in 1997 densities decreased somewhat from those very high 1996 values. At both Steinhatchee and St. Joseph Bay, similar low densities recorded in previous years have been followed by significantly higher densities in the following year. Overall, 1997 was a good year for the bay scallop metapopulation in Florida, although within individual sites scallop abundance was down.

Bay scallops are broadcast spawners, so successful reproduction is dependent upon an adequate local density of adults to ensure successful fertilization (e.g., Levitan et al., 1992). Although bay scallops are hermaphrodites, self-fertilization is rare and may be genetically ineffective over the long term (Wilbur, 1995). Thus, there is a threshold density below which a local scallop population does not effectively contribute to future generations simply because of the mechanistic inability of pelagically-born sperm to make contact with similarly pelagic eggs (Levitan & Petersen, 1995). Within the Florida west coast metapopulation (*sensu* Hanski and Simberloff, 1997), only those local populations that exceed this threshold density actually contribute to metapopulation maintenance. It has been suggested that a minimum of ten reproductively viable local populations are necessary for the maintenance of a healthy metapopulation (Hanski et al., 1996; Hanski, 1997), although the species-specific determination of minimum viable metapopulation size depends upon the number of extant local populations and habitat availability (Levins, 1969; Hanski et al., 1996). Regardless, we suggest that as few as two reproductively viable local scallop populations have been extant on the Florida west coast in recent years, these being Steinhatchee and St. Joseph Bay. Thus, we are less concerned with stochastic variation in scallop abundance at Steinhatchee and St. Joseph Bay than we are pleased with the continued development of additional reproductively viable populations at Anclote and Homosassa. Over the long term, if we can establish relatively stable local populations in Tampa Bay, at Anclote, and at Homosassa, while maintaining reproductively viable populations at Steinhatchee and St. Joseph Bay, then we will have reasonable confidence that the metapopulation between Tampa Bay and St. Joseph Bay is sustainable and exploitable within bounds. We can then shift effort to re-establishing populations from Tampa Bay south and from St. Joseph Bay west in the hope of achieving a stable bay scallop metapopulation throughout Florida.

We still have not clearly defined what the effective population size is, although we have narrowed the bounds. In general, our recruitment data suggest that from 1993 through 1996 the Tampa Bay, Anclote, and Homosassa populations have not been effective contributors to the scallop larval pool (Arnold et al., submitted). Those populations support scallop densities of less than 5 animals per 600 m^2 at most stations. In contrast, Steinhatchee and St. Joseph Bay support scallop densities above 25 per 600 m^2. Furthermore, although some stations at both Anclote and Homosassa support relatively high scallop densities in most years, the number of those high-density (> 25 scallops per 600 m^2) "patches" is relatively low compared with Steinhatchee and St. Joseph Bay, where high-density patches are numerous (Tables 2, 5-7). Numerous high-density patches may be required for successful reproduction, because the number of patches that actually contribute to the following year class may be small. For that reason, it is imperative that we not reopen the area south of the Suwanee River to recreational harvest until we have established multiple high-density patches within at least two or three local populations such as Anclote and Homosassa. As of 1997, we have not achieved that goal, although we remain optimistic that our restoration efforts coupled with sensible management will allow us to achieve that goal within the next three to five years.

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Figure 1. Map of Florida, showing sample site locations and other important locations referenced in the text.

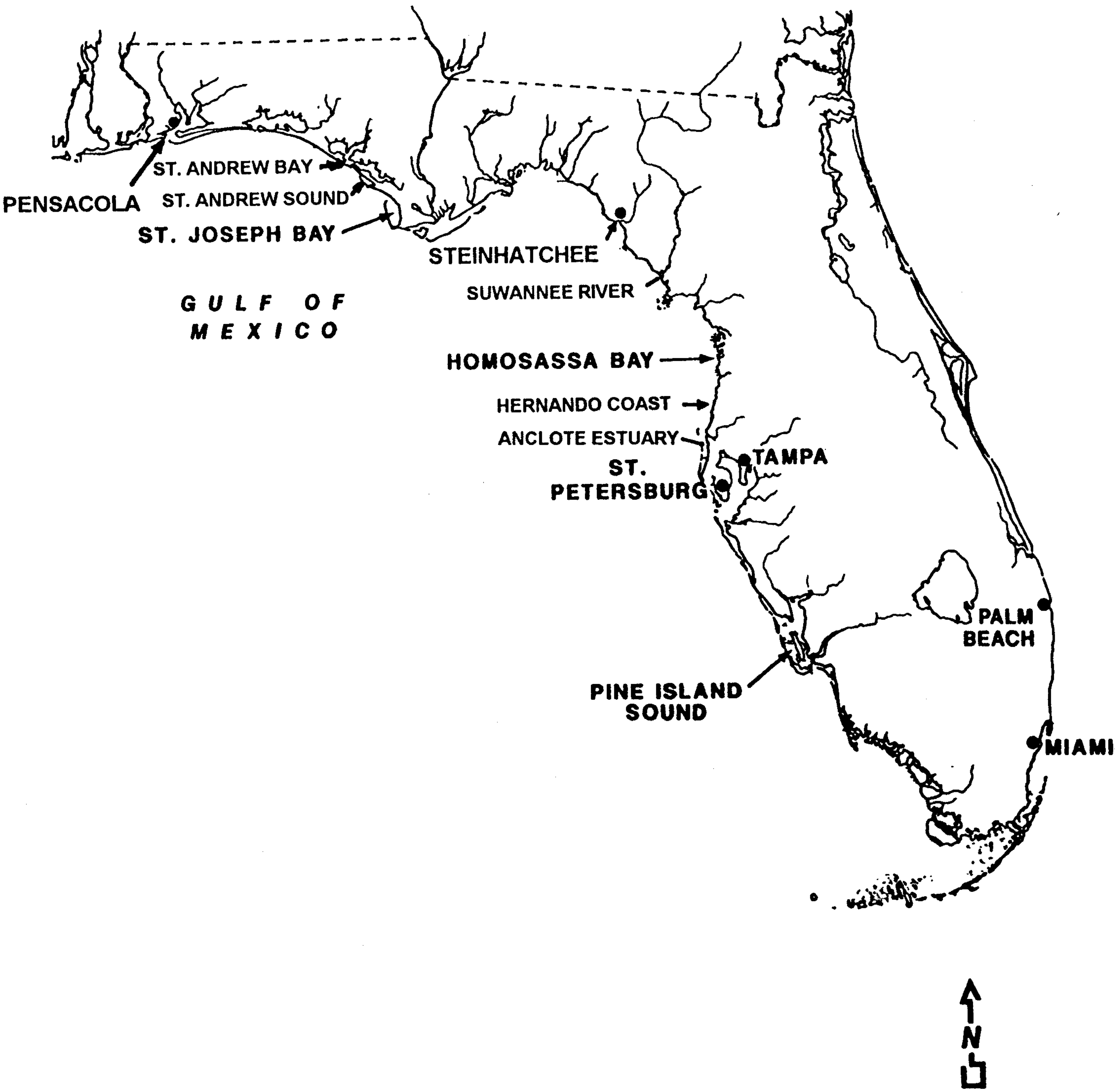
ST. ANDREW BAY
PENSACOLA
ST. ANDREW SOUND
ST. JOSEPH BAY
STEINHATCHEE
SUWANNEE RIVER
GULF OF
MEXICO
HOMOSASSA BAY
HERNANDO COAST
ANCLOTE ESTUARY
TAMPA
ST.
PETERSBURG
PALM
BEACH
PINE ISLAND
SOUND
MIAMI
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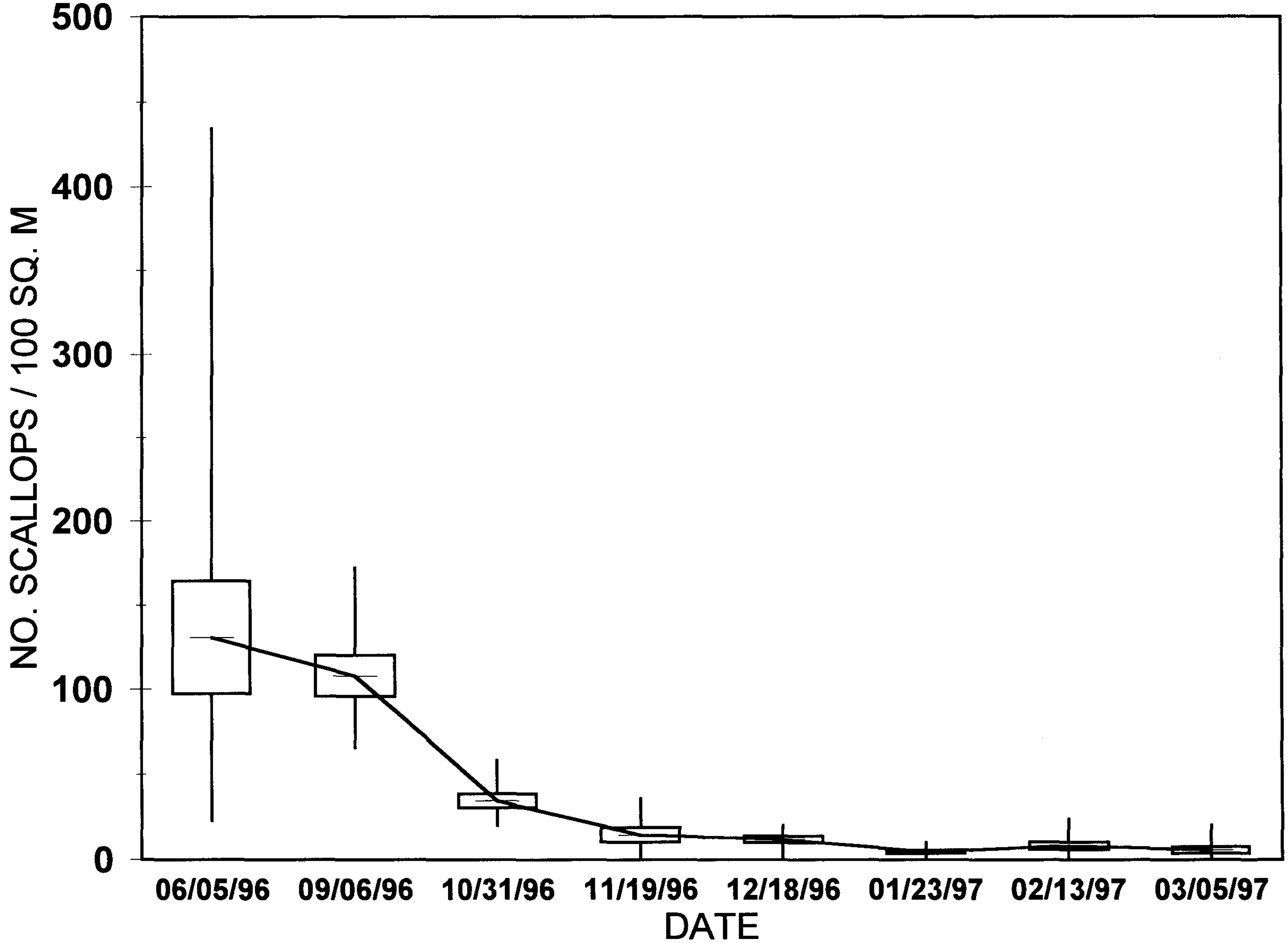
Figure 2. Abundance of bay scallops in the northern Steinhatchee area. Numbers represent mean abundance (horizontal lines) from one 50 meter transect conducted at each of five randomly located stations, ranges of abundance (vertical lines), and standard errors around the mean (boxes).



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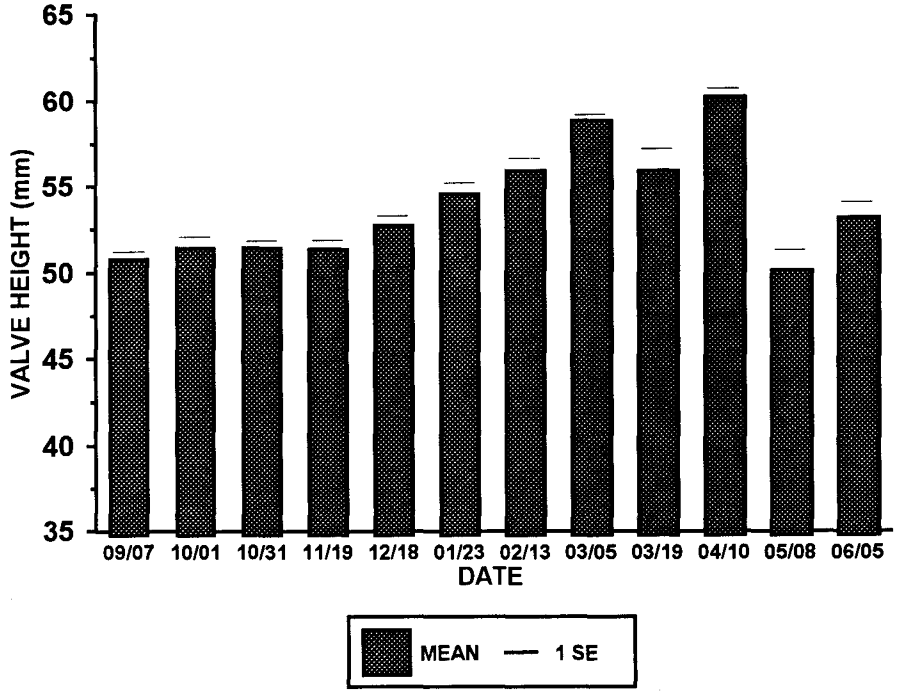
400
300
200
100
0
NO. SCALLOPS / 100 SQ. M
06/05/96
09/06/96
10/31/96
11/19/96
12/18/96
01/23/97
02/13/97
03/05/97
DATE

Figure 3. Shell height (mm) of bay scallops from wild (A) and caged (B) populations in the northern Steinhatchee area, 1996-1997. Caged scallops were killed by invading predators following the 11/19/96 sampling.

A)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VALVE HEIGHT (mm)
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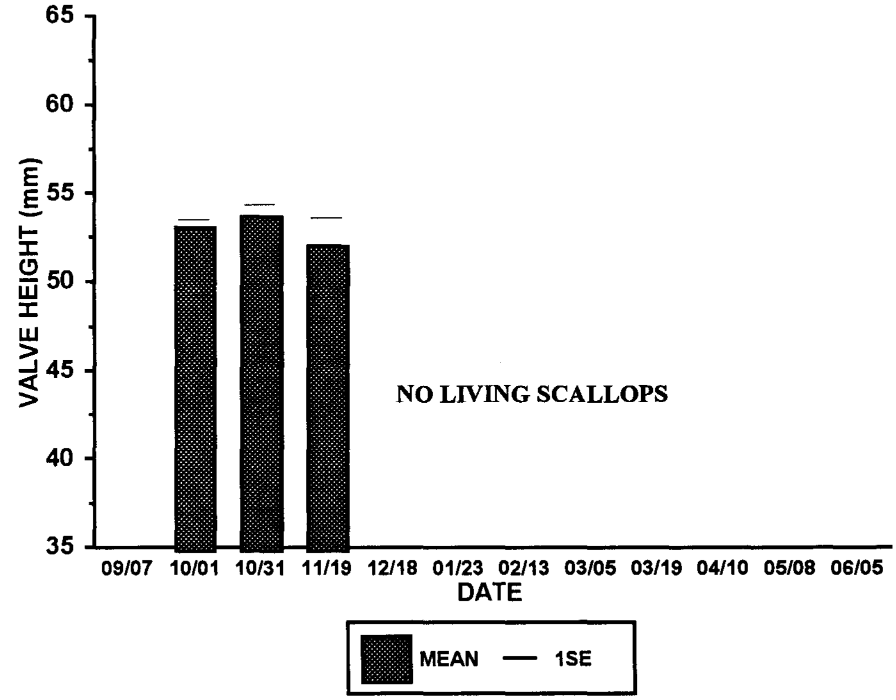
B)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VALVE HEIGHT (mm)
NO LIVING SCALLOPS
09/07 10/01 10/31 11/19 12/18 01/23 02/13 03/05 03/19 04/10 05/08 06/05
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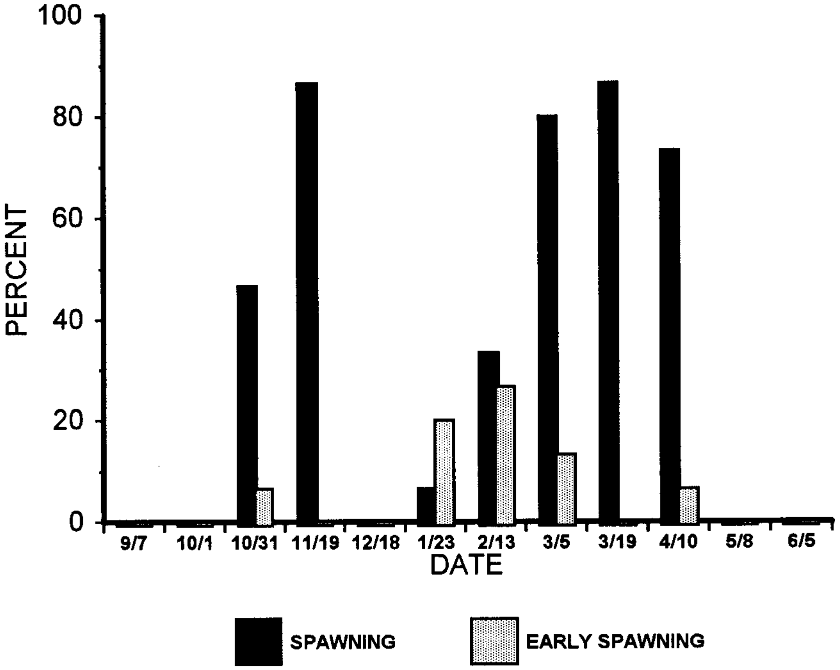
Figure 4. Percentage of bay scallops spawning and just beginning to spawn in uncaged and caged northern Steinhatchee populations by sample date, 1996-1997. Results are reported for the female portion of the gonad only. Caged scallops were killed by invading predators following the 11/19/96 sampling.

A)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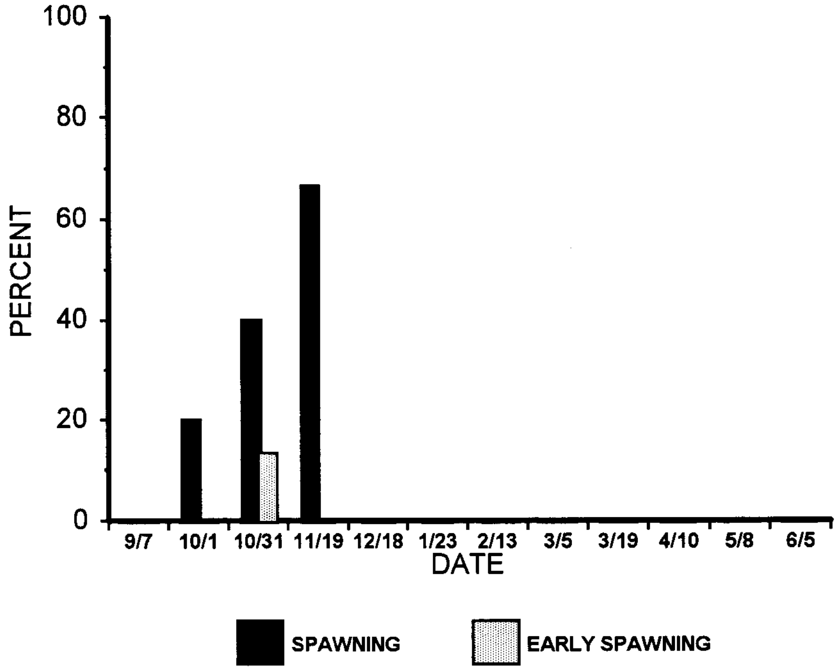
SPAWNING
EARLY SPAWNING

B)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3/5
3/19
4/10
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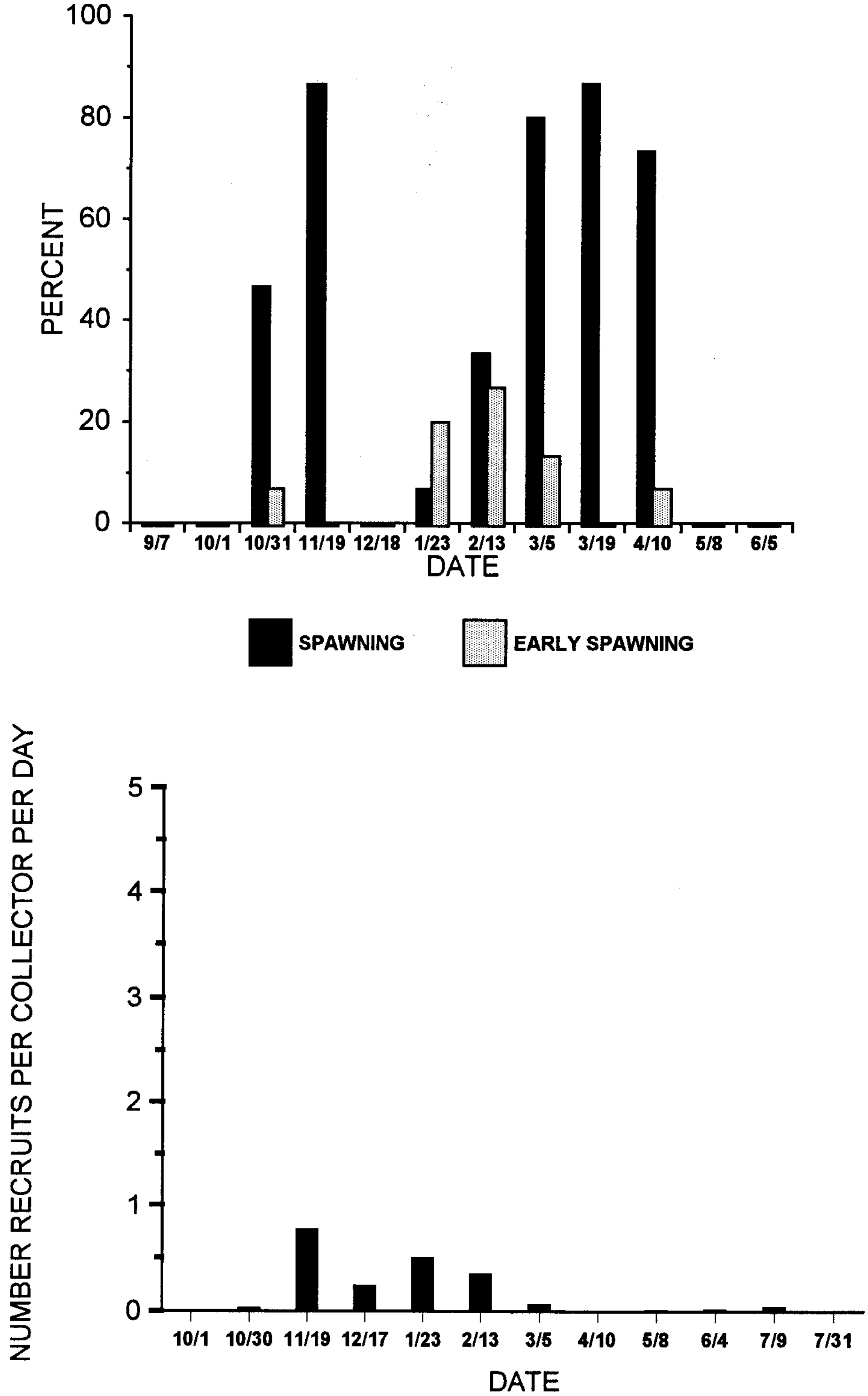
6/5
DATE
SPAWNING
EARLY SPAWNING

Figure 5. Relationship between (A) spawning (as reported in Figure 4) and (B) mean recruitment of bay scallops from the northern Steinhatchee population, 1996-1997.

A)

B)



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20
0
PERCENT
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10/31
11/19
12/18
1/23
2/13
3/5
3/19
4/10
5/8
6/5
DATE
SPAWNING
EARLY SPAWNING
5
4
3
2
1
0
NUMBER RECRUITS PER COLLECTOR PER DAY
10/1
10/30
11/19
12/17
1/23
2/13
3/5
4/10
5/8
6/4
7/9
7/31
DATE

Figure 6. Recruitment of bay scallops (*Argopecten irradians*) to artificial spat collectors deployed in approximately 1 m water depth along the Florida west coast between Anclote and Crystal River. Station 1 is southernmost.

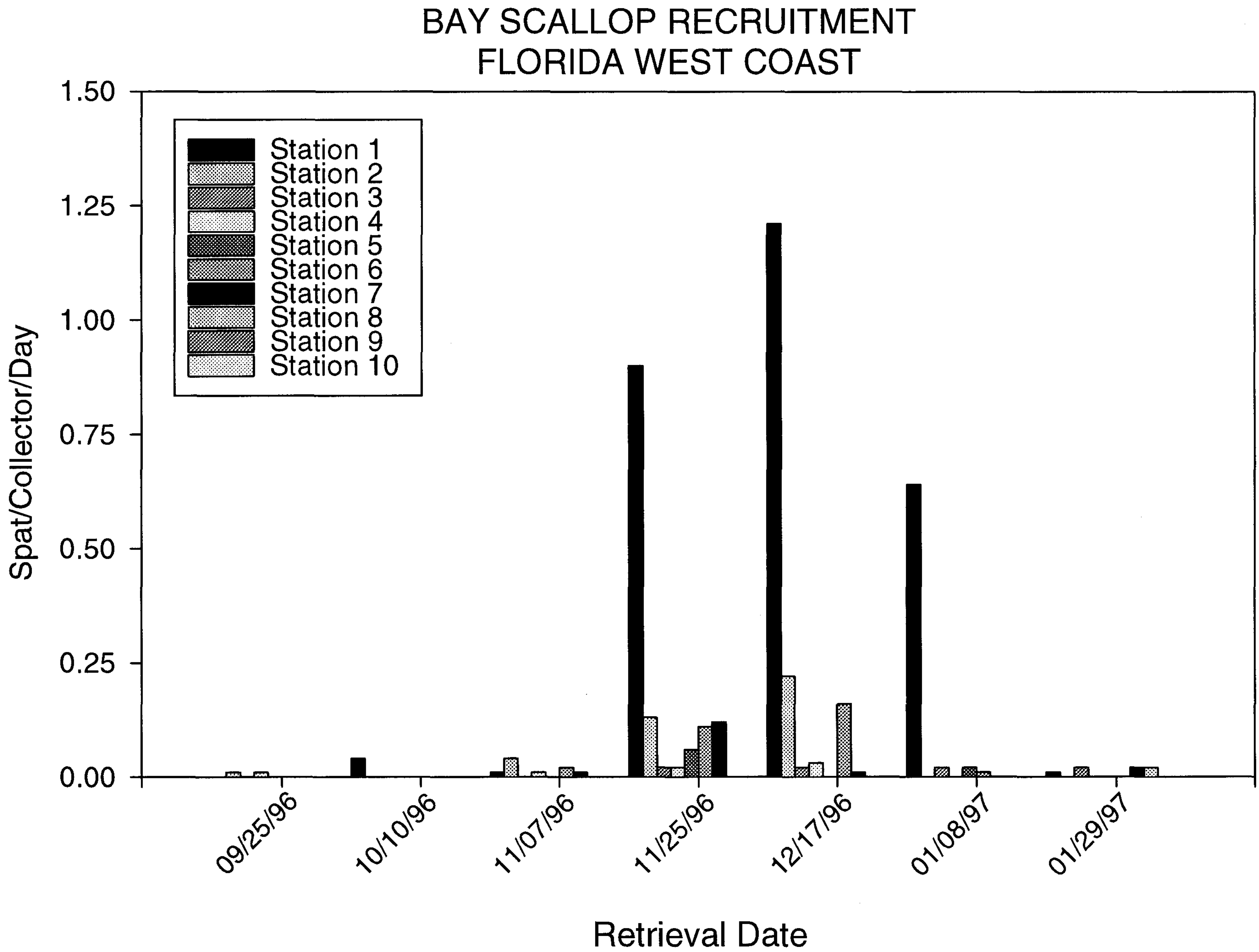
BAY SCALLOP RECRUITMENT
FLORIDA WEST COAST
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7
Station 8
Station 9
Station 10
Spat/Collector/Day
1.50
1.25
1.00
0.75
0.50
0.25
0.00
09/25/96
10/10/96
11/07/96
11/25/96
12/17/96
01/08/97
01/29/97
Retrieval Date

Table 1. Adult bay scallop density at each of 20 stations sampled at the Pine Island Sound study site during June surveys of 1994, 1995, 1996, and 1997.

JUNE BAY SCALLOP SURVEY
PINE ISLAND SOUND
1994-1997
#/600M²

STATION	1994	1995	1996	1997	MEAN	S.D.
1	0	0	0	0	0.00	0.00
2	0	0	0	0	0.00	0.00
3	0	0	0	0	0.00	0.00
4	0	0	0	0	0.00	0.00
5	0	0	0	0	0.00	0.00
6	0	0	1	0	0.25	0.50
7	0	0	1	1	0.50	0.58
8	0	0	0	0	0.00	0.00
9	0	0	0	0	0.00	0.00
10	0	1	0	3	1.00	1.41
11	0	1	0	0	0.25	0.50
12	0	34	1	5	10.00	16.15
13	0	9	0	4	3.25	4.27
14	0	0	0	15	3.75	7.50
15	0	1	0	5	1.50	2.38
16	0	1	0	2	0.75	0.96
17	0	0	9	9	4.50	5.20
18	0	0	3	0	0.75	1.50
19	0	1	0	2	0.75	0.96
20	0	1	0	0	0.25	0.50
MEAN	0.00	2.45	0.75	2.30	1.38	
S.D.	0.00	7.69	2.07	3.87		4.46

Table 2. Adult bay scallop density at each of 20 stations sampled at the Anclote estuary study site during June of 1994, 1995, 1996, and 1997.

JUNE BAY SCALLOP SURVEY
ANCLOTE
1994-1997
#/600M^2

STATION	1994	1995	1996	1997	MEAN	S.D.
1	1	0	4	43	12.00	20.74
2	72	0	3	49	31.00	35.36
3	15	0	2	307	81.00	150.81
4	0	0	0	1	0.25	0.50
5	106	0	0	20	31.50	50.55
6	3	0	0	4	1.75	2.06
7	21	0	0	1	5.50	10.34
8	14	0	12	136	40.50	63.97
9	2	3	0	4	2.25	1.71
10	1	0	1	30	8.00	14.67
11	1	0	2	27	7.50	13.03
12	14	0	0	1	3.75	6.85
13	12	0	0	8	5.00	6.00
14	0	0	11	14	6.25	7.32
15	1	0	1	141	35.75	70.17
16	5	0	23	87	28.75	40.07
17	9	0	6	20	8.75	8.38
18	1	0	3	42	11.50	20.37
19	1	0	0	8	2.25	3.86
20	14	0	0	4	4.50	6.61
MEAN	14.65	0.15	3.4	47.35	16.39	
S.D.	26.80	0.67	5.82	74.05		43.04

Table 3. Results of the Ryan-Einot-Gabriel-Welsch Multiple F Test comparing adult scallop abundance from all sites sampled along the Florida west coast during June, 1997. Stations sharing a common letter designation were not significantly different at alpha = 0.05. N = 20 for all sites.

Site	Mean Abundance	Grouping
Anclote	47.35	A
St. Joseph Bay	27.30	AB
Steinhatchee	25.90	AB
Homosassa	15.20	AB
Hernando	14.25	BC
Pine Island Sound	2.30	C
St. Andrew Bay/Sound	1.85	C

Table 4. Adult bay scallop density at each of 20 stations sampled at the Hernando study site during June of 1997.

JUNE BAY SCALLOP SURVEY
HERNANDO
1997
#/600M^2

STATION	1997
1	3
2	11
3	134
4	80
5	9
6	1
7	0
8	0
9	1
10	3
11	0
12	0
13	10
14	1
15	10
16	2
17	8
18	6
19	6
20	0
MEAN	14.25
S.D.	33.13

Table 5. Adult bay scallop density at each of 20 stations sampled at the Homosassa study site during June of 1993, 1994, 1995, 1996, and 1997.

JUNE BAY SCALLOP SURVEY
HOMOSASSA
1993-1997
#/600m²

STATION	1993	1994	1995	1996	1997	MEAN	S.D.
1	4	3	0	0	9	2.83	3.43
2	13	38	9	2	17	13.17	13.76
3	4	5	9	5	18	6.83	6.18
4	9	1	4	0	19	6.83	6.97
5	5	0	14	5	15	6.50	6.60
6	4	0	1	9	7	3.50	3.83
7	4	1	2	5	5	2.83	2.14
8	8	5	27	4	27	12.17	11.65
9	3	3	7	4	13	6.50	3.99
10	3	19	3	2	58	15.00	22.01
11	10	0	1	0	5	2.83	3.97
12	0	0	1	3	0	0.67	1.21
13	8	23	6	2	12	8.67	8.09
14	4	15	0	9	23	9.33	8.41
15	24	4	1	2	7	6.33	9.00
16	13	3	3	0	6	4.50	4.55
17	20	3	1	6	0	5.50	7.40
18	8	9	3	3	55	17.67	20.49
19	2	5	2	1	8	3.50	2.59
20	0	0	0	0	0	0.33	0.82
MEAN	7.30	6.85	4.70	3.10	15.20	6.78	
S.D.	6.28	9.82	6.43	2.79	16.01		9.68

Table 6. Adult bay scallop density at each of 20 stations sampled at the Steinhatchee study site during June of 1994, 1995, 1996, and 1997.

JUNE BAY SCALLOP SURVEY
STEINHATCHEE
1994-1997
#/600M^2

STATION	1994	1995	1996	1997	MEAN	S.D.
1	189	13	528	1	182.75	245.69
2	284	48	36	5	93.25	128.45
3	89	16	128	103	84.00	48.12
4	338	14	269	13	158.50	169.79
5	650	14	1879	25	642.00	876.60
6	234	22	210	37	125.75	111.74
7	81	4	73	3	40.25	42.56
8	0	1	0	3	1.00	1.41
9	169	44	498	23	183.50	219.35
10	10	0	76	1	21.75	36.45
11	1	0	0	0	0.25	0.50
12	281	0	415	30	181.50	200.26
13	10	8	41	6	16.25	16.58
14	259	4	119	7	97.25	120.38
15	120	1	65	6	48.00	56.11
16	1	30	71	30	33.00	28.79
17	13	23	118	42	49.00	47.55
18	133	3	44	14	48.50	58.94
19	121	313	284	135	213.25	99.31
20	85	27	151	34	74.25	57.33
MEAN	153.40	29.25	250.25	25.90	114.70	
S.D.	159.05	68.31	414.65	34.94		240.27

Table 7. Adult bay scallop density at each of 20 stations sampled at the St. Joseph Bay study site during June of 1994, 1995, 1996, and 1997.

JUNE BAY SCALLOP SURVEY
ST. JOE BAY
1994-1997
#/600M^2

STATION	1994	1995	1996	1997	MEAN	S.D.
1	16	1	4	2	5.75	6.95
2	2	1	64	10	19.25	30.10
3	12	6	2	3	5.75	4.50
4	1	2	0	0	0.75	0.96
5	8	67	2	2	19.75	31.63
6	15	205	114	19	88.25	90.29
7	5	114	55	7	45.25	51.33
8	265	348	156	93	215.50	113.36
9	61	118	43	11	58.25	44.88
10	7	711	363	111	298.00	313.29
11	0	5	759	10	193.50	377.02
12	5	233	1136	40	353.50	531.21
13	3	195	354	62	153.50	155.93
14	19	270	820	10	279.75	379.79
15	5	11	44	1	15.25	19.60
16	9	14	228	14	66.25	107.86
17	2	44	282	2	82.50	134.47
18	1	25	230	0	64.00	111.27
19	2	17	179	7	51.25	85.39
20	279	257	103	142	195.25	85.97
MEAN	35.85	132.20	246.90	27.30	110.56	
S.D.	81.87	175.47	312.22	41.53		202.16

Table 8. Adult bay scallop density at each of 20 stations sampled at the St. Andrew Bay study site during June of 1994, 1995, 1996, and 1997.

JUNE BAY SCALLOP SURVEY
ST. ANDREW BAY
1994-1997
#/600M^2

STATION	1994	1995	1996	1997	MEAN	S.D.
1	1	4	12	1	4.50	5.20
2	5	13	6	5	7.25	3.86
3	70	16	155	9	62.50	67.42
4	244	8	23	0	68.75	117.22
5	50	1	20	2	18.25	22.90
6	96	20	13	0	32.25	43.30
7	144	6	2	0	38.00	70.71
8	173	13	11	0	49.25	82.70
9	149	8	39	1	49.25	68.52
10	68	0	26	1	23.75	31.86
11	69	5	5	0	19.75	32.92
12	6	2	6	4	4.50	1.91
13	6	2	56	8	18.00	25.46
14	24	2	2	0	7.00	11.37
15	0	9	7	0	4.00	4.69
16	0	1	0	0	0.25	0.50
17	2	0	0	0	0.50	1.00
18	5	3	1	0	2.25	2.22
19	24	1	13	3	10.25	10.56
20	0	1	5	3	2.25	2.22
MEAN	56.80	5.75	20.10	1.85	21.13	
S.D.	70.77	5.82	34.78	2.74		44.52

Table 9. Adult bay scallop density at each of 20 stations sampled at the Anclote study site during fall of 1994 and 1997.

SEPTEMBER BAY SCALLOP SURVEY
ANCLOTE
1994-1997
#/600M^2

STATION	1994	1997	MEAN	S.D.
1	3	33	18.00	21.21
2	36	4	20.00	22.63
3	22	292	157.00	190.92
4	0	1	0.50	0.71
5	44	22	33.00	15.56
6	0	3	1.50	2.12
7	13	29	21.00	11.31
8	0	88	44.00	62.23
9	0	0	0.00	0.00
10	2	42	22.00	28.28
11	2	41	21.50	27.58
12	0	4	2.00	2.83
13	0	7	3.50	4.95
14	1	9	5.00	5.66
15	9	182	95.50	122.33
16	0	607	303.50	429.21
17	3	47	25.00	31.11
18	5	40	22.50	24.75
19	0	0	0.00	0.00
20	3	5	4.00	1.41
MEAN	7.15	72.80	39.98	
S.D.	12.58	144.81		106.77

Table 10. Results of Wilcoxon paired comparison of density differences between June and fall sampling efforts at each of the Anclote, Homosassa, Steinhatchee, and St. Joseph Bay study sites.

Site	Year	June #/600m^2)	Fall (#/600m^2)	% Change	x^2	p
Anclote	1994	14.65	7.15	-51.2	2.0634	0.1509
Anclote	1997	47.35	72.80	+53.8	0.0007	0.9784
Homosassa	1995	4.70	0.50	-89.4	15.348	0.0001
Homosassa	1996	3.10	1.35	-56.4	5.8825	0.0153
Homosassa	1997	15.20	15.80	+4.0	0.0029	0.9568
Steinhatchee	1994	153.40	23.15	-84.9	13.460	0.0002
Steinhatchee	1995	29.25	24.80	-15.2	0.1340	0.7144
Steinhatchee	1996	250.25	121.05	-51.6	3.2394	0.0719
Steinhatchee	1997	25.90	46.80	+80.7	0.2512	0.6163
St. Joe Bay	1994	35.85	1.30	-96.4	18.618	0.0001
St. Joe Bay	1995	132.20	18.50	-86.0	10.156	0.0014
St. Joe Bay	1996	246.90	227.10	-8.0	1.1714	0.2791
St. Joe Bay	1997	27.30	19.65	-28.0	0.2006	0.6542

Table 11. Adult bay scallop density at each of 20 stations sampled at the Homosassa study site during fall of 1995, 1996, and 1997.

SEPTEMBER BAY SCALLOP SURVEY
HOMOSASSA
1995-1997
#/600m^2

STATION	1995	1996	1997	MEAN	S.D.
1	0	0	0	0.00	0.00
2	0	0	9	3.00	5.20
3	0	6	8	4.67	4.16
4	0	0	50	16.67	28.87
5	0	1	38	13.00	21.66
6	2	1	9	4.00	4.36
7	0	0	4	1.33	2.31
8	0	1	28	9.67	15.89
9	1	0	13	4.67	7.23
10	4	1	35	13.33	18.82
11	0	0	2	0.67	1.15
12	0	3	1	1.33	1.53
13	0	0	9	3.00	5.20
14	0	1	29	10.00	16.46
15	3	1	1	1.67	1.15
16	0	1	21	7.33	11.85
17	0	4	4	2.67	2.31
18	0	7	43	16.67	23.07
19	0	0	11	3.67	6.35
20	0	0	1	0.33	0.58
MEAN	0.50	1.35	15.80	5.88	
S.D.	1.15	2.06	15.77		11.49

Table 12. Adult bay scallop density at each of 20 stations sampled at the Steinhatchee study site during fall of 1994, 1995, 1996, and 1997.

SEPTEMBER BAY SCALLOP SURVEY
STEINHATCHEE
1994-1997
#/600M^2

STATION	1994	1995	1996	1997	MEAN	S.D.
1	1	6	439	4	112.50	217.68
2	48	105	60	87	75.25	25.97
3	100	25	65	79	67.25	31.63
4	61	18	139	5	55.75	60.44
5	45	25	767	5	210.50	371.36
6	25	12	48	27	28.00	14.90
7	61	3	183	9	64.00	83.50
8	0	0	0	6	1.50	3.00
9	0	11	3	130	36.00	62.84
10	0	6	29	0	8.75	13.79
11	0	0	0	1	0.25	0.50
12	1	30	62	1	23.50	29.08
13	0	7	31	6	11.00	13.69
14	0	25	39	0	16.00	19.34
15	0	1	46	17	16.00	21.46
16	0	58	69	136	65.75	55.76
17	0	47	33	148	57.00	63.79
18	26	0	35	70	32.75	28.93
19	18	112	176	163	117.25	71.70
20	77	5	197	42	80.25	83.20
MEAN	23.15	24.80	121.05	46.80	53.95	
S.D.	31.30	32.74	183.11	57.02		104.63

Table 13. Adult bay scallop density at each of 20 stations sampled at the St. Joseph Bay study site during fall of 1994, 1995, 1996, and 1997.

SEPTEMBER BAY SCALLOP SURVEY
ST. JOE BAY
1994-1997
#/600M^2

STATION	1994	1995	1996	1997	MEAN	S.D.
1	0	1	0	0	0.25	0.50
2	0	0	1	0	0.25	0.50
3	0	1	94	24	29.75	44.24
4	0	0	86	0	21.50	43.00
5	0	1	30	0	7.75	14.84
6	0	0	51	32	20.75	25.18
7	1	1	8	18	7.00	8.04
8	7	150	11	70	59.50	66.86
9	5	2	1	25	8.25	11.30
10	11	21	28	35	23.75	10.24
11	0	3	190	2	48.75	94.17
12	0	37	1534	59	407.50	751.39
13	0	55	1324	61	360.00	643.25
14	1	37	439	44	130.25	206.69
15	0	0	0	5	1.25	2.50
16	0	0	12	6	4.50	5.74
17	1	16	137	4	39.50	65.32
18	0	4	238	4	61.50	117.68
19	0	31	187	4	55.50	88.74
20	0	10	171	0	45.25	83.97
MEAN	1.30	18.50	227.10	19.65	66.64	
S.D.	2.94	34.95	426.98	23.17		230.25

Table 14. Mean shell height (mm) for scallops collected from various sites along the Gulf of Mexico coast of Florida during June, 1997 and fall, 1997 adult surveys.

Site	June	Fall
Pine Island Sound	49.4 (5.2)	n/a
Anclote	51.8 (7.5)	64.0 (7.0)
Hernando	50.2 (5.8)	n/a
Homosassa	50.6 (5.8)	58.8 (6.4)
Steinhatchee	48.5 (6.2)	59.4 (5.5)
St. Joseph Bay	43.1 (7.2)	64.4 (6.8)
St. Andrew Bay/Sound	38.0 (6.6)	n/a