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# SEASONAL ABUNDANCE OF OYSTER SPAT AND FOUR ANIMAL ASSOCIATES ON AN OYSTER REEF IN THE JAMES RIVER, VIRGINIA.[1]

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***ABSTRACT*** Five species of invertebrates collected at bi-weekly to monthly intervals from an oyster reef in the James River, Virginia, between September 1984 and August 1985 exhibited similar patterns of fluctuation in abundance throughout most of the period. The species were: spat of the oyster *Crassostrea virginica;* two species that feed on oysters, the flatworm *Stylochus ellipticus*, and the gastropod *Boonea impressa*, as well as two others with no known direct trophic interactions with the oyster, the isopod *Cassidinidea lunifrons* and the nudibranch *Doridella obscura*. *B. impressa* was many times more abundant than *S. ellipticus* but because of the difference in feeding habits between the two species it is speculated that *S. ellipticus* has a greater harmful effect on oysters than its abundance would suggest. Densities of all species declined sharply between early October and early November; the decline was probably related to seasonal mortality associated with declining water temperatures. *B. impressa* and *C. lunifrons* were the most abundant species throughout most of the sampling period, but only oyster spat showed a definite high peak in recruitment in 1985. Failure of the data to show reproduction peaks for three of the other species was attributed to incomplete retention of smaller individuals in the 0.5 mm-mesh screen used; large variations in density did not permit clear definition of a peak in *C. lunifrons*. It is recommended that studies of oysters on their reefs include other abundant noncommercial species to provide a stronger foundation for management of the resource than if only the oyster was studied.

***KEY WORDS:*** seasonal abundance, *Crassostrea, Stylochus, Boonea, Cassidinidea, Doridella*

## INTRODUCTION

Reefs and beds of the American oyster *Crassostrea virginica* (Gmelin 1790) harbor a great variety of organisms which form recognizable assemblages (Wells 1961, Larsen 1974a, 1985). Several animals in those assemblages have direct trophic interactions with the oyster; among these are the ectoparasitic pyramidellid gastropod *Boonea impressa* (Say 1822) and the predatory polyclad turbellarian *Stylochus ellipticus* (Girard 1850). Although these species are not entirely dependent on oysters as host or prey, they reduce oyster growth and survival (Loosanoff 1956, Provenzano 1959, Landers and Rhodes 1970, Leathem and Maurer 1975, Robertson and Mau-Lastovicka 1979, White et al. 1984, Ward and Langdon 1986).

Knowledge of the nature and magnitude of the effect of *B. impressa* and *S. ellipticus* on oyster populations is necessary for proper management of that resource and quantification of their seasonal abundance is important because time and extent of changes in their abundance would have a direct impact on survival of oyster spat. The original objective of this study was to estimate the abundance of oyster spat, *B. impressa* and *S. ellipticus* on an oyster reef over one year. Two other species, the isopod *Cassidinidea lunifrons* and the nudibranch *Doridella obscura*, were subsequently included in the study when their consistent incidence in the samples became evident.

The study was conducted at Wreck Shoal, a subtidal oyster reef in the James River, Virginia. The James River estuary provides the oyster industry in Virginia with most of its supply of seed oysters and Wreck Shoal has been one of the most productive reefs in that estuary (Haven and Whitcomb 1983).

## MATERIALS AND METHODS

Wreck Shoal is located between the navigation channel and the northeast shore of the James River, approximately 29 km from the river mouth at Old Point Comfort, in the mesohaline zone of the estuary. Water depth at mean low water over the reef ranges from 1.8 m near shore to 5.5 m near the channel. Our sampling site was located 200 m from the channel (Lat. 37°03.2′ × Long. 76°34.6′) close to sampling site 4 of Larsen (1974a, 1985). The site was divided into 40 plots of 57-$m^2$ each; five randomly-selected plots were sampled at bimonthly or monthly intervals between September 1984 and August 1985.

Samples were collected using a portable suction sampler designed for use on the hard shelly substrate of oyster reefs (Larsen 1974b). The area covered by the sampler was 0.013 $m^2$. The material lifted by suction accumulated in a collection bag with a mesh size of 0.5 mm. Each sample was transferred from the bag to a 4% solution of ethanol in river water for relaxation of the animal specimens. Subsequently they were fixed in 4% formalin, washed through a series of sieves (4.0, 2.0 and 0.5 mm,) and stored separately in 70% ethanol with Rose Bengal. Some of the col-

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lections were sieved through an additional screen with a mesh size of 0.25 mm.

Only spat of *Crassostrea virginica* under 20 mm in shell height were included in the study because we were primarily interested in the younger members of the oyster population. Unpublished data collected earlier by one of us (R.M.-A.) showed that newly settled spat at Wreck Shoal did not grow to a height greater than 20 mm in one year. Xanthid and portunid crabs were rare in our samples, possibly because they could evade collection; therefore, we do not present any data for those taxa. Densities of the other organisms are expressed in $m^{-2}$ and 94% confidence intervals are provided.

Nonparametric statistical methods were used in data analysis because of frequent skewed distributions. The median number of animals in the five samples collected on each date was computed as the Hodges-Lehman point estimator associated with Wilcoxon's rank statistic and based on Walsh averages (Hollander and Wolfe 1973). A symmetric two-tailed confidence interval for the median was also computed using a procedure attributed to Tukey (Hollander and Wolfe 1973). The small number of samples limited determination of the confidence interval to a probability level of 93.8%. The upper and lower confidence limits actually corresponded to the range in density for each species on the given date.

Overlap of the median for one sampling date or species by the confidence interval of an adjoining median was assumed to be an indication that a statistical difference would not likely be detectable at the given probability level (McArdle 1987). Lack of an overlap was assumed to be an indication that existence of a significant difference between the two medians was very probable. No other statistical analyses were warranted because of the large variances and lack of variance homogeneity among many of the samples.

## RESULTS

Two easily recognizable animals not included in our original study plan were found consistently in our samples. They were the dorid nudibranch *Doridella obscura* Verril 1870 and the flabellarid isopod *Cassidinidea lunifrons* Richardson 1905. Although there was no indication that these two species had any direct impact on survival and growth of oyster spat, they were added to the study because their constancy and abundance suggested a close association with the oyster reef.

Two types of polyclad turbellarians in the collections were readily distinguished from each other by their shape. One was identified as *Euplana gracilis* (Girard 1850), an elongate flatworm previously reported from the mesohaline and oligohaline zones of the James River (but not from Wreck Shoal) by Larsen (1974a). We only found seven specimens of this species in two samples (four on September 20 and three on October 4) and will not consider it further.

The second type of flatworm was assumed to be *Stylochus ellipticus* (Girard 1850) because separation of *S. ellipticus* from a similar species found in Chesapeake Bay, *Coronadena mutabilis* (Girard 1850), was hindered by the condition of the specimens following preservation. *C. mutabilis*, however, has never been found at Wreck Shoal (J. P. Whitcomb personal communication) and has been reported previously only from higher salinity zones (Lawler 1969, Marsh 1970, 1973, Wass 1972, Andrews 1973, Orth 1976). Although Faubel (1983) proposed that *Stylochus ellipticus* be moved to the genus *Stylochopsis* Verrill 1873, we have chosen to retain the earlier taxonomic combination.

Some of the collections sieved through an additional 0.25 mm screen showed that as many as six times the number of flatworms, twice as many gastropods and an equal number of *D. obscura* were retained in the 0.25 mm screen as were retained in the 0.5 mm screen. The number of *C. lunifrons* was 17 times higher in the 0.5 mm screen as in the 0.25 mm screen. We, however, were not able to modify our sampling design to account for those findings. Oyster spat, which were attached to shells and shell fragments, were easily retained in the large-mesh screens.

The five species included in our study (*Crassostrea virginica, Boonea impressa, Stylochus ellipticus, Cassidinidea lunifrons* and *Doridella obscura*) were present in the samples on all dates (Table 1). Variation in species-specific density between replicate samples was high (Figures 1 and 2, Table 1). A similar pattern was, nevertheless, evident in the seasonal abundance of the five species over time. Their numbers were highest in early October, decreased sharply in late October and, except for a slight peak in mid-November, remained at approximately the same level through May 1985.

Only *C. virginica* spat showed a significant increase in numbers attributable to recruitment through reproduction after May. There was an indication of an increase in abundance of *C. lunifrons* in August but the large variation in numbers prevented any attribution of significance to the increase.

*B. impressa* was by far the most abundant of several pyramidellid species in our samples (Cox & McCarthy 1987, MS in preparation); median density was consistently high, ranging between 3100 and 6200 $m^{-2}$ except for a depression to about 1937 $m^{-2}$ in mid-October and early November (Figure 2). Median densities of *B. impressa* and *C. lunifrons* were similar in magnitude in 1984 and were substantially higher in most instances during that period than those of *S. ellipticus* and *D. obscura*. Densities of *S. ellipticus, C. virginica* spat and *D. obscura* were similar throughout the year except in July 1985 when newly-settled oyster spat appeared in the collections.

In 1985, median densities of *B. impressa* were higher than those of the other species except in March and August when no difference was apparent between its density and

**TABLE 1.**

**Total number of individuals of five species of invertebrates in samples collected between September 1984 and August 1985 from the oyster reef at Wreck Shoal in James River, Virginia. Values are for total of five samples on each date that added to an area of 0.065 $m^{-2}$. Range in number among samples is given in parentheses.**

| Coll. Date | *Crassostrea virginica* Spat | *Boonea impressa* | *Stylochus ellipticus* | *Cassidinidea lunifrons* | *Doridella obscura* |
|---|---|---|---|---|---|
| 1984 | | | | | |
| Sep 20 | 111 (16–35) | 298 (11–136) | 75 (3–35) | 520 (44–274) | 35 (1–21) |
| Oct 4 | 162 (16–58) | 451 (45–231) | 105 (6–44) | 637 (61–298) | 180 (20–62) |
| 19 | 41 (3–12) | 168 (11–79) | 38 (3–19) | 188 (21–60) | 49 (1–14) |
| Nov 1 | 16 (2–5) | 122 (2–55) | 27 (1–10) | 96 (10–38) | 15 (1–8) |
| 15 | 56 (6–21) | 304 (45–86) | 45 (4–15) | 254 (32–71) | 25 (2–8) |
| 28 | 21 (1–8) | 190 (14–65) | 23 (0–10) | 123 (11–40) | 22 (1–8) |
| Dec 11 | 30 (4–7) | 236 (7–82) | 32 (0–13) | 143 (9–44) | 56 (2–23) |
| 1985 | | | | | |
| Jan | | | (No Collections Made) | | |
| Feb 11 | 22 (0–9) | 382 (36–131) | 34 (0–16) | 170 (11–58) | 134 (0–42) |
| Mar 13 | 29 (3–9) | 181 (8–57) | 9 (0–3) | 155 (2–58) | 40 (1–14) |
| Apr 23 | 10 (1–3) | 338 (56–91) | 4 (0–2) | 187 (1–72) | 43 (1–29) |
| May 30 | 13 (1–5) | 229 (37–57) | 32 (0–16) | 73 (10–24) | 52 (1–21) |
| Jul 18 | 653 (22–281) | 378 (56–102) | 32 (1–12) | 215 (3–63) | 56 (5–20) |
| Aug 13 | 237 (28–109) | 301 (13–118) | 16 (0–9) | 740 (13–492) | 32 (0–20) |

that of *C. lunifrons*. The greatest range in median density during the 12-month period was shown by *C. lunifrons* and *C. virginica* spat primarily because of the high numbers in the summer of 1985.

Bottom water temperature at Wreck Shoal in 1984 was at its peak (28.7°C) in mid-August 1984 but declined steadily to 14°C by the end of October and reached a low of 4°C in February 1985 (Figure 3). From February onward it increased steadily through August 1985. Temperatures recorded between August and December 1984 and between June and August 1985 were similar to those recorded by others at the same station in 1982, 1983 and 1986. Bottom water salinity fluctuated between 11 and 16‰ from June to November 1984 except for a low point of 6.7% on August 23 (Figure 4A). It was lower than recorded for that period in the previous two years and in the following two (Figure 4A and B). In 1985 salinity was above 14‰ after March and from July to October it was between 17 and 19‰ except for a sharp decrease to 9.7‰ in late August.

## DISCUSSION

Densities of the five species included in this study were characterized by large variations among samples collected on the same date. Differences in bottom texture (i.e., relative concentration of shells and oysters) within the oyster reef were probably the primary factor responsible for those variations. Earlier investigations showed that the density of benthic epifauna increased with increases in concentration of shelly substrate (Barnes et al. 1973, Dauer et al. 1982, Larsen 1974a, 1985). In his study of James River oyster reefs, Larsen (1974a, 1985) reported differences in bottom texture between reefs separated by distances of several kilometers while Haven and Whitcomb (1983) and De Alteris (1986) described differences within the same reef. Underwater observations by divers conducting research at our work site revealed that the differences were evident within distances of a few meters. In spite of the large variations in numbers of animals between samples, similar seasonal abundance patterns were evident among the species studied.

These species are consistent components of the oyster reef assemblage and thus, probably share similar ecological requirements, biological interdependencies and adaptations to the physical conditions of that habitat in the sense suggested by MacGinitie (1939), Swartz (1972) and Roughgarden and Diamond (1986). The four species other than the oyster included in this study do not depend exclusively on the oyster for their food nor are they found exclusively on oyster reefs (Allen 1958, Landers and Rhodes 1970, Larsen 1974a, Orth 1976, Schultz 1978, Maurer et al. 1979). They do find, however, an abundant supply of their preferred prey in the oyster reef: barnacles, oysters and other molluscs for *B. impressa* and *S. ellipticus* (Allen 1958, Landers and Rhodes 1970) and encrusting bryozoans for *D. obscura* (Franz 1967, Perron and Turner 1977, Todd 1981). We found no reference in the literature to food preferences of *C. lunifrons* but Schultz (1969) stated that most free-living marine isopods are scavengers; as such this species should not lack for food in the oyster reef.

The consistently high abundance of *Boonea impressa* throughout the year could be a significant factor in its potential impact on *Crassostrea virginica* spat and juveniles. Wells (1959) and White et al. (1984) reported that reproduction and recruitment of *B. impressa* in North Carolina and Texas occurred more or less continuously throughout the year. White et al. (1984) also found that oyster popula-

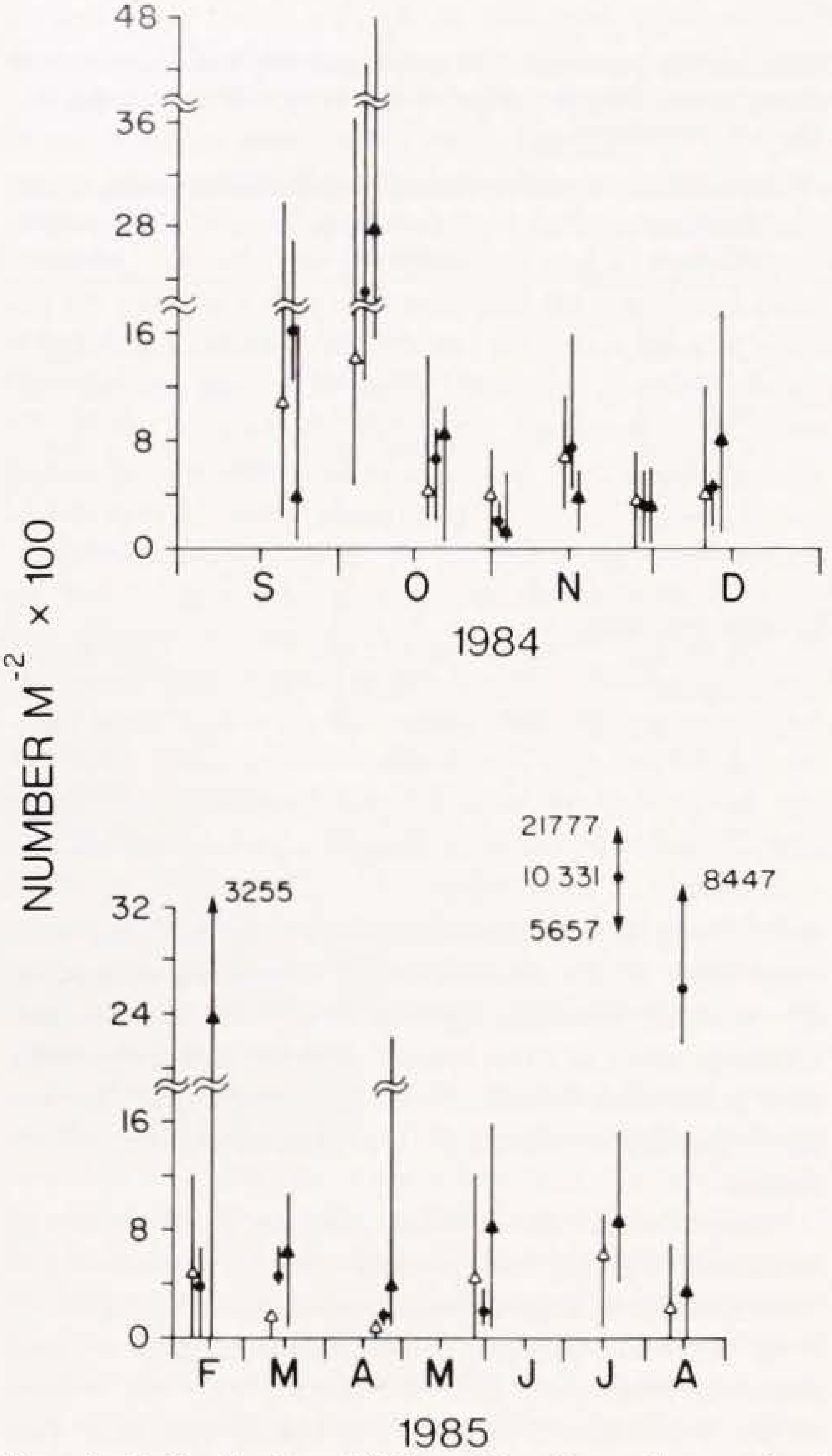


Figure 1. Median density and 94% confidence interval for samples of *Crassostrea virginica* spat <20.1 mm (●), *Doridella obscura* (▲) and *Stylochus ellipticus* (△) collected at Wreck Shoal, James River, Virginia, between September 1984 and August 1985.

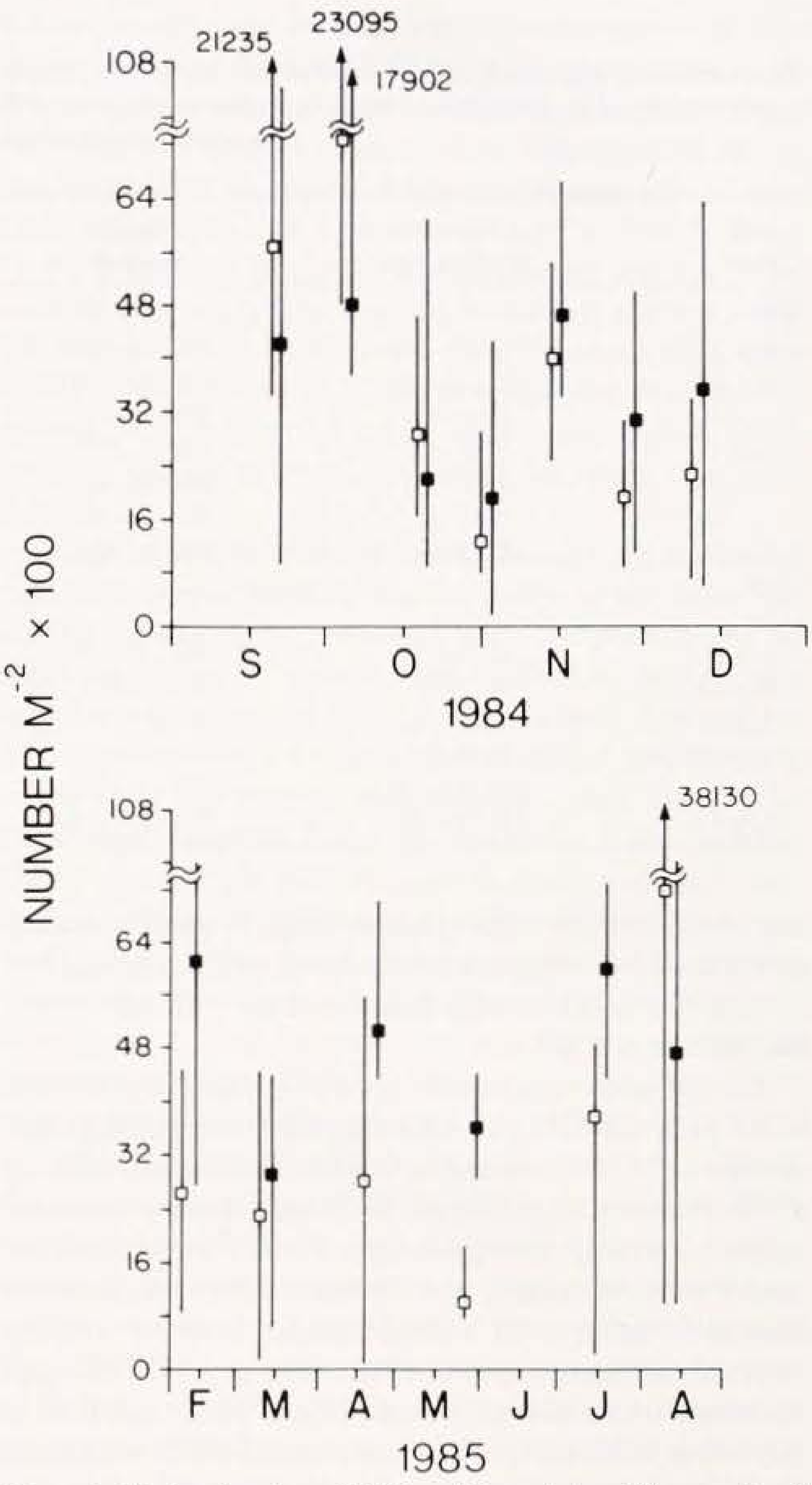


Figure 2. Median density and 94% confidence interval for samples of *Boonea impressa* (■) and *Cassidinidea lunifrons* (□) collected at Wreck Shoal, James River, Virginia, between September 1984 and August 1985.

tions were parasitized by *B. impressa* at all times of the year. The same may be true (except perhaps for the colder winter periods) in James River reefs harboring this gastropod as indicated by the persistent high densities observed at Wreck Shoal.

Though *S. ellipticus* densities were much lower than those of *B. impressa*, their impact on oysters may nevertheless be greater than numbers alone would suggest. Predation by *S. ellipticus* is certain to cause the death of its oyster prey (Provenzano 1959) while the parasitic effect of *B. impressa* is unlikely to be fatal and tends to be transitory (White et al. 1984). Although the actual impact of *B. impressa* and *S. ellipticus* on survival of oyster spat has not been quantified, the magnitude of their densities on Wreck Shoal are sufficiently high to raise concern about their potential harmful effect on new recruits to the oyster population.

The most notable change in abundance among the species studied was the sharp reduction observed in October 1984. We interpret this as a mortality event because no consistent recovery in numbers was evident in the succeeding months; the mortality was probably associated with the seasonal decrease in water temperature recorded at that time. Water salinity in 1984 was not unusually low when compared with long-term annual and seasonal averages of 12–14‰ given by Andrews (1973), Larsen (1974a), Haven and Whitcomb (1983).

The large number of flatworms, gastropods and nudi-

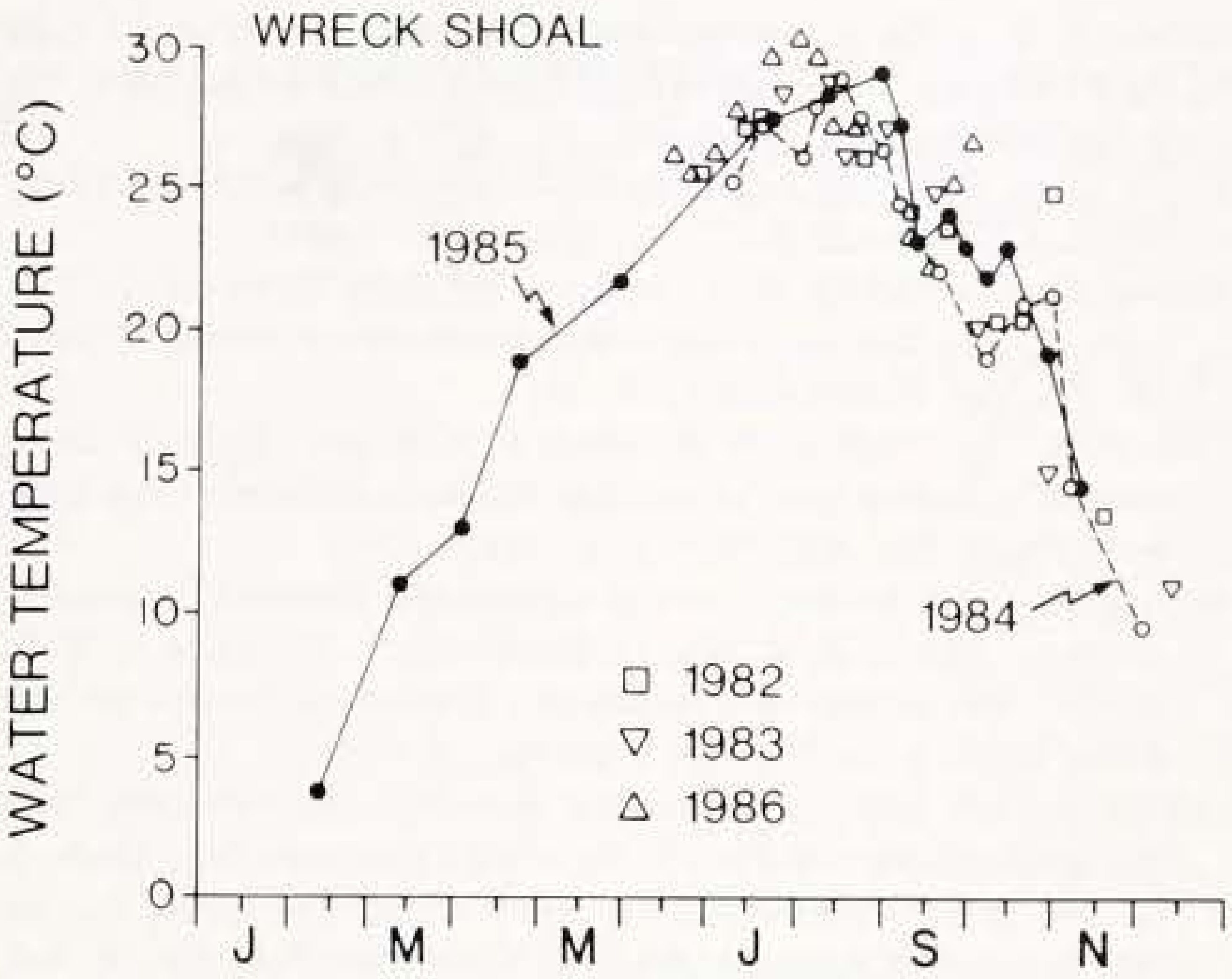


**Figure 3. Bottom water temperature on given dates for period 1982–1986 at Wreck Shoal, James River, Virginia.**

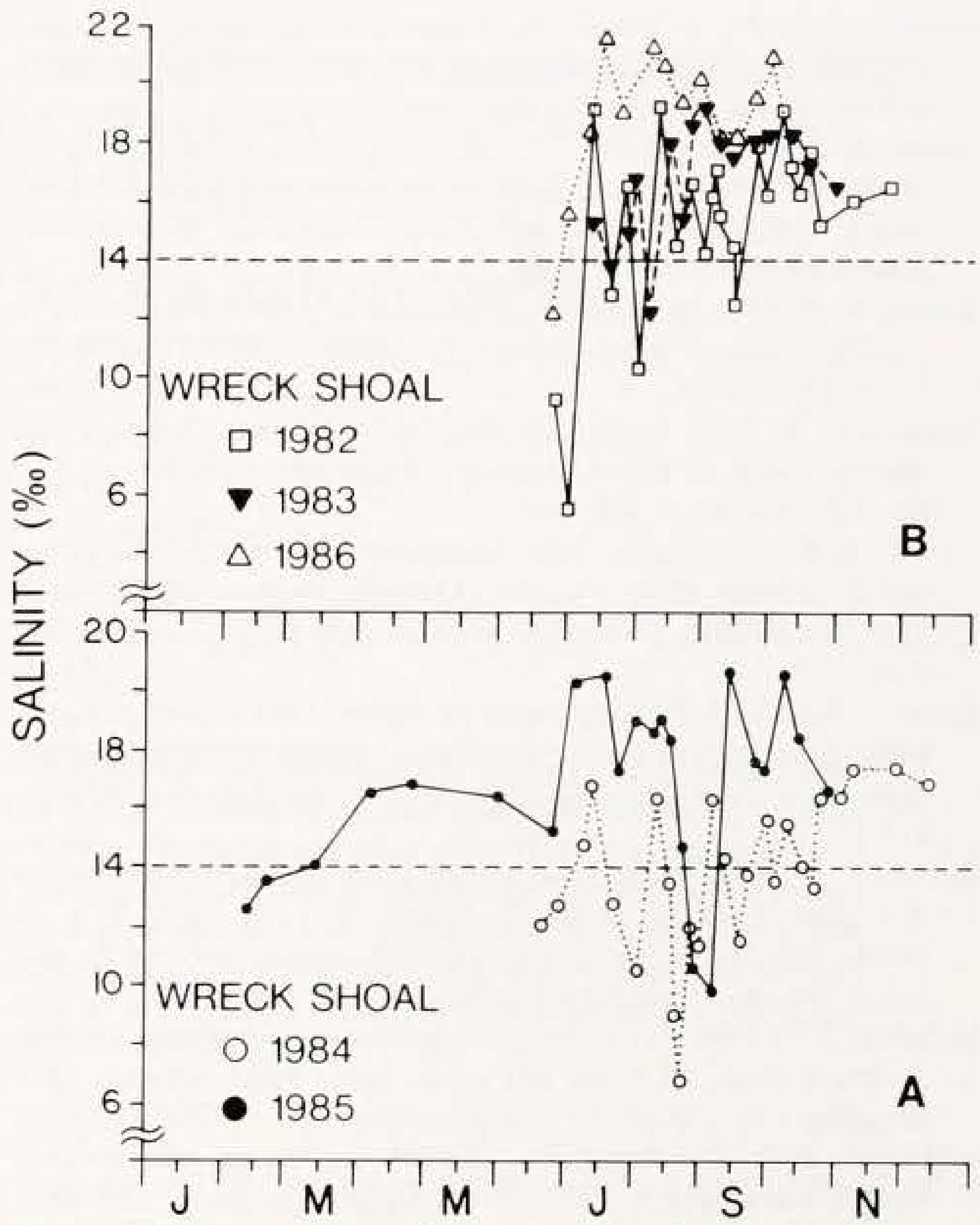


**Figure 4. Bottom water salinity on given dates for period 1982–1986 at Wreck Shoal, James River, Virginia.**

branchs that passed through the 0.5 mm screen in collections sieved through an additional 0.25 mm screen indicates that many of the smaller individuals of those populations were excluded from our data. The actual numbers were probably even higher than those retained in the 0.25 mm screen because many may have already been lost through the 0.5 mm mesh of the sampler collection bag. The oyster was the only species with a clear peak in recruitment in 1985; that peak occurred in July. Inasmuch as the oyster was the only species not affected by the choice of screen size, the absence of distinct recruitment peaks of the other species in 1985 could be attributed to loss of the smaller individuals through the 0.5 mm screen. Our experience during this study emphasizes the need to use a 0.25 mm screen in future studies of oyster reef epifauna as was recommended by Maurer and Watling (1973) and McLusky (1981).

This study has shown evidence of a close relationship in seasonal fluctuations in abundance of oyster spat and four other major members of the faunal assemblage on an oyster reef. We have at present very little knowledge about the life history and ecological relationships of most of the organisms that share the oyster reef habitat. Oyster associates on the reef most likely depend on the oyster to a greater extent than the oyster depends on them (Puffer and Emerson 1953, Andrews and Wood 1967, Boesch 1971, Maurer and Watling 1973, Dayton 1984). Most of them are small annual species and are subject to great variations from year to year because they are more susceptible to environmental changes than are larger species (Thorson 1957, MacArthur and Connell 1966). An extended absence or depressed abundance, however, of species associated with the oyster on the reefs may forecast conditions potentially harmful to the oyster population.

Studies that include the non-exploited species in an ecosystem containing a commercially valuable species are not usually undertaken by managers of natural resources and their scientific advisors even though they may provide a more solid foundation for future management decisions than studies that exclude those species (May 1984). Therefore, it appears advisable to include all or most of the major components of the oyster reef assemblage in future studies of that ecosystem as was implied by Andrews and Wood (1967) and Carriker (1967) and suggested by Swartz (1972) and Maurer and Watling (1973).

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