EFFECT OF BORROW PITS ON THE ABUNDANCE AND DISTRIBUTION OF FISHES IN THE LOWER BAY OF NEW YORK HARBOR

by

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ABSTRACT

A finfish survey was done on a monthly basis by trawling at three sites in the Lower Bay of New York Harbor. Two of these sites were within borrow pits that had been excavated in the bay floor by subaqueous sand mining operations and one of these was a control site on a nearby sandy shoal that was probably typical of the original pre-mined habitat. The gut contents of winter flounder at each site were also examined. Both the abundance of fishes and the diet of winter flounder were similar at the two pit sites, but differed at the shoal site. Fish catches on the sandy shoal were lower than at the borrow pit sites. Temperature, salinity, dissolved oxygen, and benthic food sources were considered, but none of these parameters alone seemed to control the fish populations in the pits. Since both the pit sites had muddy bottoms while the shoal site had a sandy bottom, substrate characteristics may explain why the catches at the pit sites were similar and generally higher than catches at the shoal site.

INTRODUCTION

There are several large borrow pits in the floor of the Lower Bay of New York Harbor which are the result of subaqueous sand mining operations conducted over the last few decades. The abundance and distribution of fishes in the Lower Bay may be affected by the presence of these pits in two ways. First, the pits may alter the physical environment. The bottom relief is obviously changed but the pits may also affect the distribution of water temperature and dissolved oxygen levels. In addition, the substrate within pits on the West Bank of the Lower Bay differs from that prior to mining. Areas covered by the pits were originally areas of sandy sea floor but are now mud because the pits are very effective traps for fine-grained sediments (Bokuniewicz and Hirschberg, 1982a,b). This could directly affect the abundance of demersal fishes within pits. Moreover, the switch from sand to mud will also change the abundance and composition of benthic macrofauna within the pits. Therefore, the second type of effect that the pits could have on fish populations is due to a change in the fishes' potential food supply by a change in the quantity and quality of the benthic fauna.

This report presents the results of a finfish survey that was done on a monthly basis by otter trawling at two pit sites and one control site in the Lower Bay. This work was intended to complement a similar fish study that was done at the same time by the National Marine Fisheries Service (Pacheco, 1983; National Marine Fisheries Service, 1984). We also conducted a study of the gut contents of winter flounder that were caught at each site during these expeditions. Results of the gut content analyses will also be discussed in this report.

PREVIOUS WORK

The Effects of Borrow Pits on Finfish Populations

Subaqueous borrow pits in coastal waters are usually not in equilibrium with the ambient sedimentary system and often accumulate mud at anomalously high rates. This is true of pits on the West Bank of the Lower Bay (Bokuniewicz and Hirschberg, 1982a, Olsen et al., 1984) as well as in other areas. The accumulation of mud in an otherwise sandy area of the sea floor will cause not only a change in the substrate but also a change in benthic populations (e.g. Cassie and Michael, 1968). Samples taken in a dredged hole on the West Bank of the Lower Bay in 1973 were consistently low in macrofaunal density and diversity (Radosh and Reid, 1980). Samples taken there in 1977 and 1978 did not show distinct trends between dredged and undredged areas but very few organisms were found in the pits (Brinkhuis, 1980) and it was believed that the mud which was accumulating in the pits "was unsuitable for most [benthic] species, either due to the fine-grain nature of the sediments (Swartz and Brinkhuis, 1978) or associated toxic effects of material associated with the organic matter and low oxygen levels" (Brinkhuis, 1980). Based on studies in San Antonio Bay, Texas, Polis (1974) concluded that inadequate substrate conditons and poor or limited food supply in dredged holes negatively affected the diversity and abundance of finfishes. High organic contents of muds accumulating in pits may depress levels of dissolved oxygen. This condition may be aggravated by restricted circulation in the pits. The levels of dissolved oxygen have been found to be generally lower over the pits than they are over the rest of the West Bank (Swartz and Brinkhuis, 1978). In pits in New Jersey and Alabama, Murawski (1969) and Broughton (1977), respectively, found that dissolved oxygen levels during the summer months were too low to sustain fishes. Low oxygen levels in the summer are also reported to be the causes of low finfish populations in subaqueous pits in Maryland (Polis, 1974), Delaware (Daiber et al., 1972), and Texas (Harper, 1973).

Some investigators in other areas reported that water in dredged holes was generally warmer than the surrounding water during early and mid winter. As a result, finfishes were attracted to these areas in the colder months (Broughton, 1977; Murawski, 1969) and these pits may have acted as fish concentrators in the winter. However, Polis (1974) suggested that fishes entering pits to find refuge from colder surface water may become trapped during prolonged winter weather and that an overturn created by denser cold water sinking to the bottom of the pit could induce a fish kill caused by thermal shock. According to Polis (1974) thermal shock has been implied as the cause of winter fish kills.

Finfish Population in the Lower Bay

The Lower Bay is a habitat for permanent resident fishes as well as a seasonal haven for fishes migrating to the Hudson River estuary (Brinkhuis, 1980). There are only a few reports, however, dealing with fishes in the Lower Bay and the adjacent waters of Sandy Hook Bay and Raritan Bay. Brinkhuis (1980) summarizes the results of three recent studies by Croker (1965), Wilk and Silverman (1976), and Wilk et al. (1977) and additional work was done by Gandarillas and Brinkhuis (1981); Pacheco (1983; and the National Marine Fisheries Service (1984). Croker (1965) and Wilk and Silverman (1976) worked in Sandy Hook Bay although the latter study was limited to a single summer. Wilk et al. (1977) did the only study that examined fish distributions throughout the Lower Bay, Sandy Hook Bay and Raritan Bay. Gandarillas and Brinkhuis (1981) confined their work to three areas on Old Orchard Shoal, Romer Shoal, and the East Bank. Pacheco (1983) sampled fish populations at two borrow pits and a control site on the West Bank. Tows were collected approximately biweekly between September 1981 and October 1982. Beginning in November 1982 and continuing until October 1983, this survey was expanded to include additional stations in Sandy Hook Bay, Raritan Bay East Reach Channel, Great Kills, Gravesend Bay, and Romer Shoal (National Marine Fisheries Service, 1984). Based on these studies the most abundant species in this area appear to be anchovies of the genus Anchoa, herrings of the genus Alosa, Pseudopleuronectes americanus, Scophthalmus aquosus, Peprilus triacanthus, Urophycis chuss, U. regius, Merluccius bilinearis, and Cynoscion regalis.

At a hearing held by the New York Department of Environmental Conservation in 1975, sport and commercial fishermen testified that the borrow pits in the Lower Bay were devoid of fishes, but at a public hearing held by the U.S. Army Corps of Engineers in 1981, fishermen testified that fishes are plentiful in and around the borrow pits. It was largely on the basis of the latest testimony by fishermen that this study and the simultaneous study by the National Marine Fisheries Service were begun. In the summer and fall of 1981, we began experimenting with fishing techniques in and around the borrow pit adjacent to the South Chapel Hill Channel that had been proposed to be partially filled with dredged sediment. On three different cruises in July, September, and November 1981 gill nets were set in the pit, on its flanks and on the neighboring sea floor. All these attempts were less than successful due to difficulties with the method and this technique was abandoned. On 18 August we tried our first otter trawl in the pit; the net, however, snagged on some unknown obstacle on the bottom and was lost. The results described in this report were obtained between February 1982 and January 1983 with the following technique.

Procedures

Fishes were collected with a 30-foot by 37-foot semi-balloon otter trawl constructed with 2-inch mesh wings and a 1/4 inch cod-end liner. Three locations were studied in the Lower Bay. These were:

1. Near Old Orchard Shoal approximately between 40°30'16"N; 74°04'19"W and 40°30'57"N; 74°03'48"W. This site is referred to as the shoal site or the control site in this report.

2. In a borrow pit (called the CAC pit) adjacent to the Chapel Hill South Channel approximately between 40°31'25"N; 74°03'28"W and 40°31'25"N; 74°02'46"W. This site is sometimes referred to as the CAC site in this report.

3. In a larger borrow pit on the West Bank south of Swinburne Island approximately between 40°33'09"N; 74°03'25"W and 40°33'41"N; 74°03'12"W. This site is sometimes referred to as the Hoffman-Swinburne site or the HS site in this report.

The sea floor at the site near Old Orchard Shoal was sand, while it was mud at the other two sites. The two sites in the borrow pits were the same locations that were being fished by the National Marine Fisheries Service (Pacheco, 1983; National Marine Fisheries Service, 1984).

Three five-minute trawls were done at each of the three study areas approximately every month. Fishes that were caught on each trawl were classified; their length was measured; and, with the exception of winter flounder, they were returned to the bay. The winter flounder were injected with formalin and later dissected for analysis of their stomach contents.

At each site the temperature, salinity, and dissolved oxygen concentration were measured one meter above the bottom and one meter below the surface. Temperature and salinity were measured with a Beckman (Model RS#5) inductive probe and thermistor temperature sensor. According to the manufacturer's specifications the salinity can be measured to ±0.30 ‰ and the temperature to 0.5°C. Dissolved oxygen concentrations were determined by a standard Winkler titration (Strickland and Parsons, 1972) of water samples that were collected with a water bottle. The dissolved oxygen data for the last two months of the study were an exception; these measurements were made with reagents that were pre-mixed and sealed in evacuated glass ampules (CHEMetrics, Inc., Cat. No. K7510; Gilbert, Behmyer and Castaneda, 1982).

RESULTS

Sampling Schedule

The first catches were taken on 17 February 1982. We had planned to begin fishing in December 1981 but the cruise from 7 December to 9 December was terminated early because of high winds before the otter trawls could be done, and fishing could not be done during a cruise on 19 January 1982 because of ice. Trawls were done on 17 February, 23 March, 20 April, 26 May, 25 June, 30 July, 18 August, 15 September, 14 October, 17 November, and 16 December 1982, and 10 January 1983. Three replicate five-minute trawls were done at each of the three study sites on all these dates except on 25 June and 16 December. On 25 June only one trawl was done at the CAC pit and no trawls were done at the large borrow pit on the West Bank south of Swinburne Island because the net had snagged and was damaged beyond repair. On 16 December the third trawl at the large pit on the West Bank south of Swinburne Island and the trawls at the CAC pit were canceled because our gear had again fouled and was irrevocably damaged.

Winter flounder were collected for stomach content analysis on all cruises between 17 February and 15 September. Additional samples were obtained from the National Marine Fisheries Service. These were collected from the two borrow pit sites on 23 November 1981 and 29 January, 12 February, 9 July, and 26 July 1982.

Reproducibility

Three identical trawls were done at each study site and before proceeding to discuss the data it may be instructive to first consider the variability that was seen among the three replicate trawls. The greatest difference between the total number of fishes caught among the triplicate trawls occurred at the site near Old Orchard Shoal in July where two fishes were caught on one trawl, 272 on another, and seven on the third; the number of fishes caught varied by a factor of 136 between the lowest and highest value caught at this site on 30 July. In general, the difference between the number of fishes caught in triplicate trawls at all sites was large on 30 July. At the borrow pit west of the Chapel Hill Channel the highest number caught (1,158 fishes) was 38.6 times more than the lowest catch (30 fishes) on that date; in the borrow pit south of Swinburne Island the highest catch on that date (904 fishes) was 10.5 times higher than the lowest number caught there (86 fishes). The large difference among replicate trawls was due to a large catch of a highly schooling fish at each site. These were anchovies at the CAC site and scup at both the shoal site and the borrow pit near Swinburne Island. The three trawls with the most similar catches were taken in September at the pit south of Swinburne Island. On this day 540, 581, and 508 fishes were caught here; the highest value being only 1.14 times the lowest catch. On the average the range of values among any three replicate trawls was about equal to the mean value of the catch from those three trawls, or, if we ignore the extremely variable catch at all stations in July, the greatest number of fishes caught in one set of three trawls was about three times higher than the smallest number caught in that set.

Temperature, Salinity, and Dissolved Oxygen Concentration

Temperatures varied little and were not consistently different among study sites during any given month. Overall, temperatures ranged from a minimum of 1.7°C in February to a maximum of 21.6° in August (Fig. 1). During winter, the two borrow pit sites did not have consistently higher temperatures than the site near Old Orchard Shoal and temperatures did not vary by more than about 0.5° among the three sites. However, in mid summer, there was a tendency towards higher temperatures at the shoal site. The maximum difference in temperature between sites was 2.4°C in July.

Salinities were consistently lower at the shoal site than at the pit sites in all months. The maximum difference was 7.3‰ in January, but usually the differences between sites were only 1 to 3‰ (Fig. 2).

Dissolved oxygen concentrations were first measured in June 1982 and the dissolved oxygen concentrations did not vary consistently among the sites between June 1982 and November 1982 (Fig. 3). As expected, the lowest values at all sites were reached in the summer. The pre-mixed chemical ampules were tried simultaneously with the standard titrations in November. The uncertainty in the values determined with the ampules appeared to be 1 to 2 ml/l and the estimates of the dissolved oxygen concentrations made with the ampules seemed to be consistently lower than those determined with the Winkler titration by approximately the same amount. In December 1982 and January 1983 only the ampules were used. The dissolved oxygen concentrations were estimated to be between 4 and 5 ml/l at all sites both in December and in January.

Temperature, salinity, and dissolved oxygen data are presented in tabular form in Appendix A.

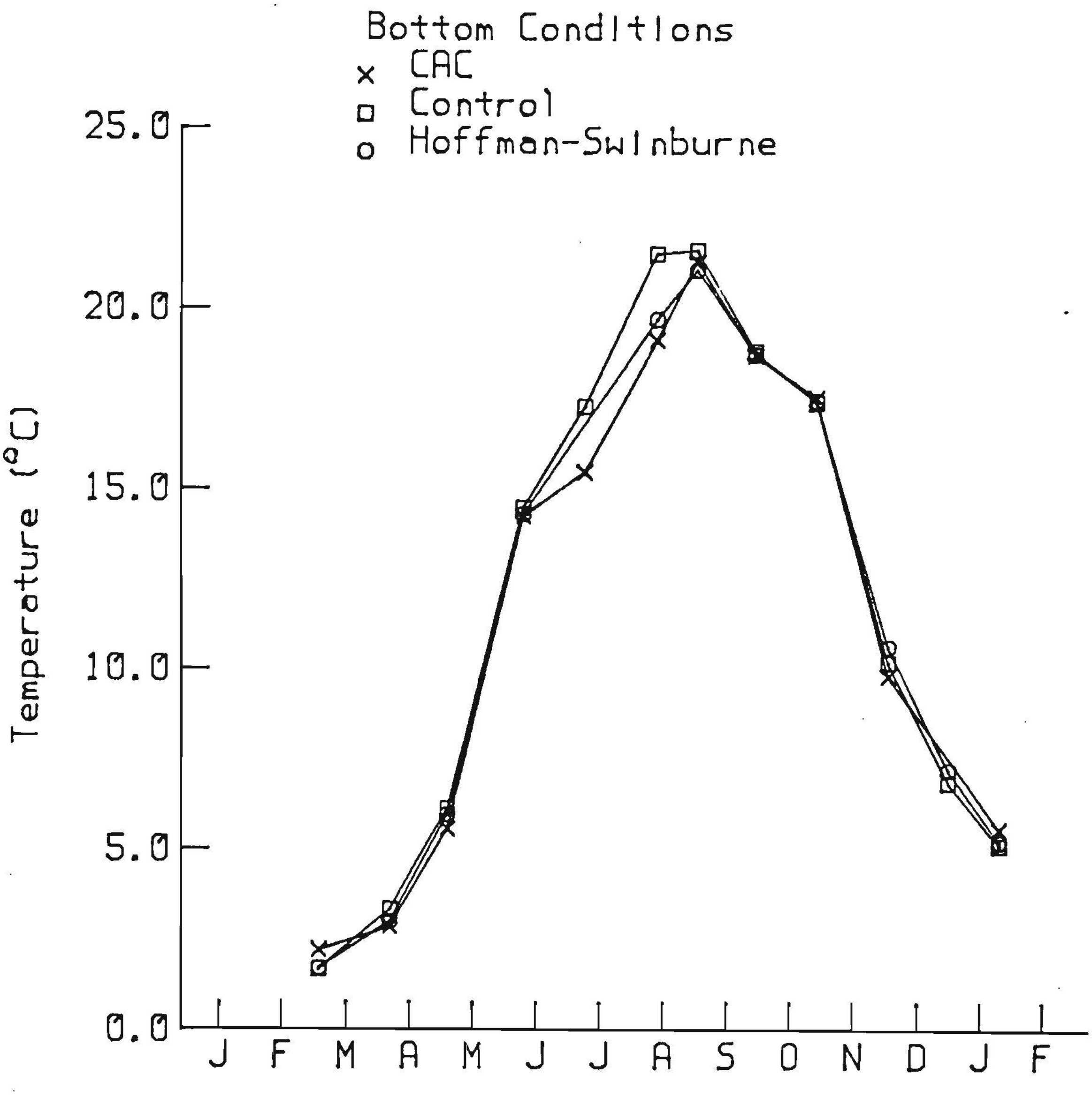
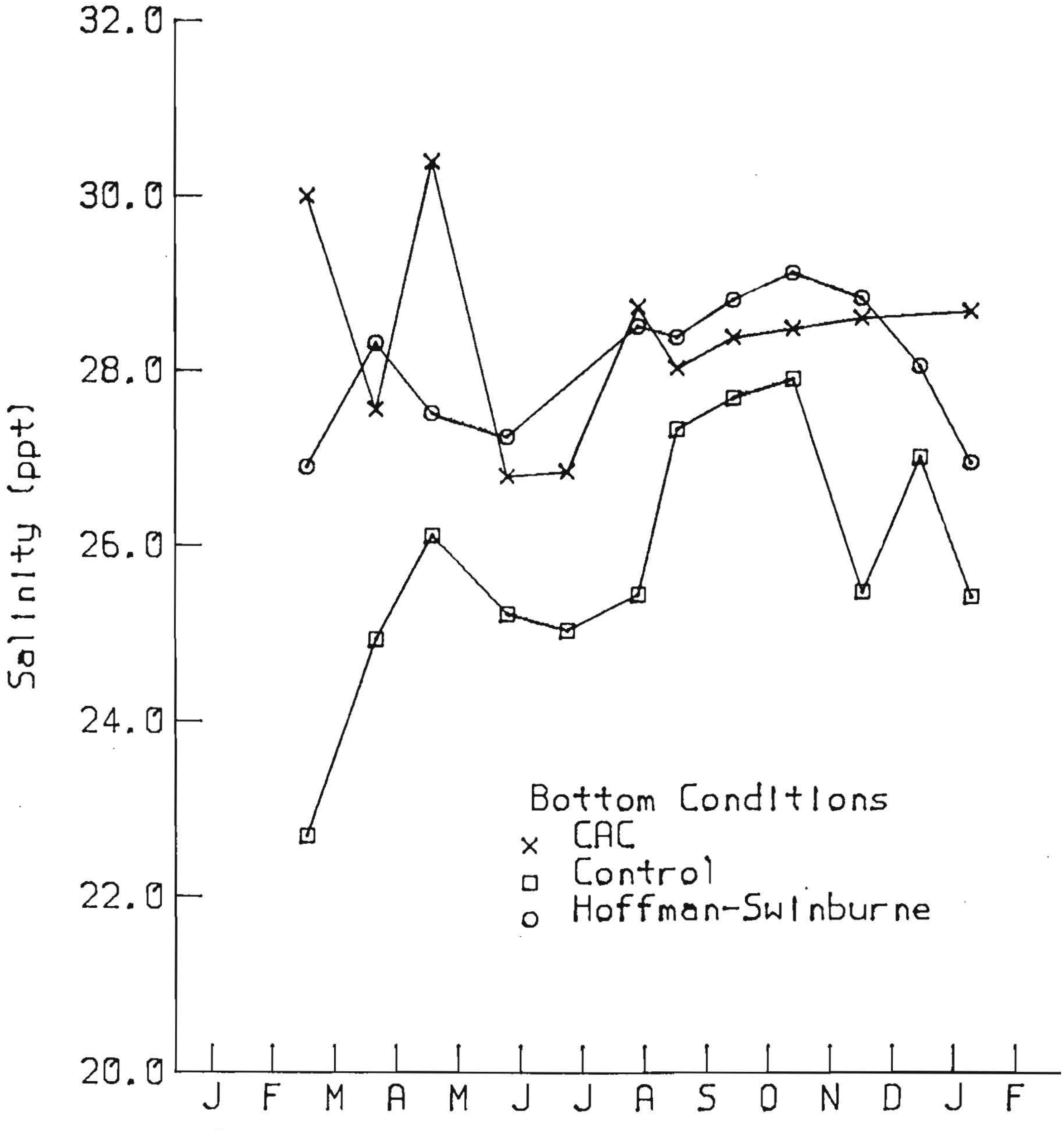

Bottom Conditions
x CAC
□ Control
o Hoffman-Swinburne
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (°C)
J F M A M J J A S O N D J F

Figure 1



32.0
30.0
28.0
26.0
24.0
22.0
20.0
Salinity (ppt)
J F M A M J J A S O N D J F
Bottom Conditions
x CAC
□ Control
o Hoffman-Swinburne

Figure 2

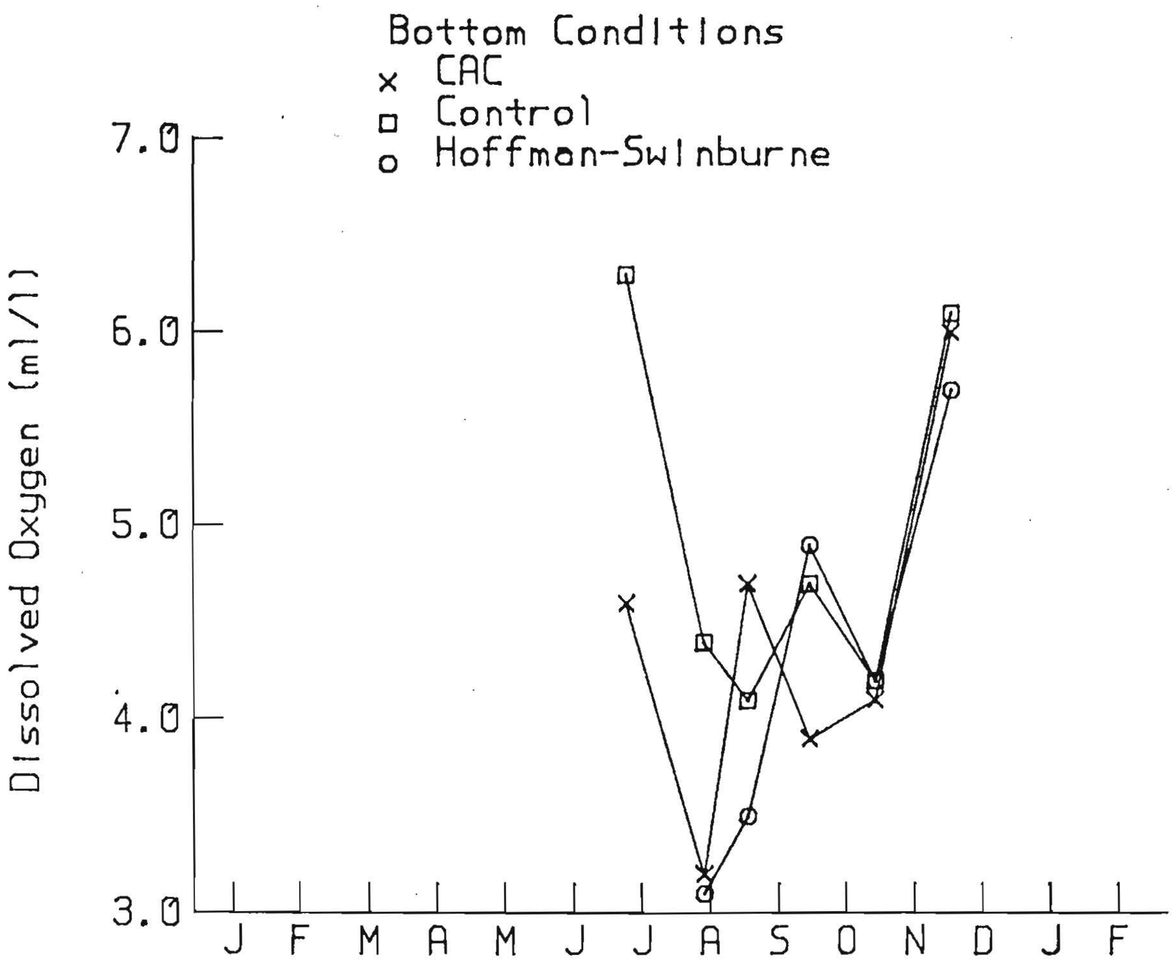

Bottom Conditions
CAC
Control
Hoffman-Swinburne
Dissolved Oxygen (ml/l)
7.0
6.0
5.0
4.0
3.0
J F M A M J J A S O N D J F

Figure 3

Overall Abundance

During our 12-month study, we caught a total of 15,682 individuals belonging to 32 different species or species groups (Appendix B). Because of difficulties encountered in separating juveniles of closely related species while at sea, anchovies (Anchoa spp.) and herrings (Alosa spp.) were identified by genus. Included in these totals are two invertebrate species of commercial importance that were captured in trawls, Homarus americanus and Loligo pealei.

In general, proportionally more individuals were captured in the pit areas than at the shoal site: 43.4% of all individuals were captured at the CAC pit, 44.4% at the pit south of Swinburne Island, and 12.8% at the shoal site. Anchovies (Anchoa hepsetus and Anchoa michilli) were the most abundant species group captured at all sites and comprised 43.6% of all individuals caught. Butterfish (Peprilus triacanthus) was the second most abundant species comprising 11.9% of individuals, followed by winter flounder (Pseudopleuronectes americanus), 9.86%; weakfish (Cynoscion regalis), 6.02%; herrings (primarily juveniles of Alosa pseudoharengus, Alosa aestivalis, and Alosa sapidissima), 5.59%; red hake (Urophycis chuss), 4.72%; scup (Stenotomus chrysops), 4.57%; silver hake (Merluccius bilinearis), 3.69%; windowpane flounder (Scophthalmus aquosus), 3.18%; and longhorn sculpin (Myoxocephalus octodecemspinosus), 1.39%. These 10 species comprise 94.5% of all individuals caught. Differences in abundances among sites for each of these dominant species will be discussed in detail below.

Seasonal Trends

The average catch per tow showed marked seasonal trends. Catches were low in winter and spring, increased during the summer, and peaked in early fall (Fig. 4). During the summer-fall peak in abundance, average catches at the pit sites were greater than at the shoal site. As will be further elaborated below, this summer-fall peak in abundance is largely due to the presence of anchovies. However, even if anchovies or anchovies and butterfish are removed from the analysis, average catches in the pits were still consistently higher than the shoal site in summer and fall (Figs. 5 and 6).

The average number of species captured per tow also changed seasonally (Fig. 7). Average species number was lowest in winter and spring, increased in summer and reached a maximum in fall, paralleling the trends noted above for average catch per tow. Number of species tended to be less at the shoal site than at the pit sites, especially during summer and fall. The data for catch

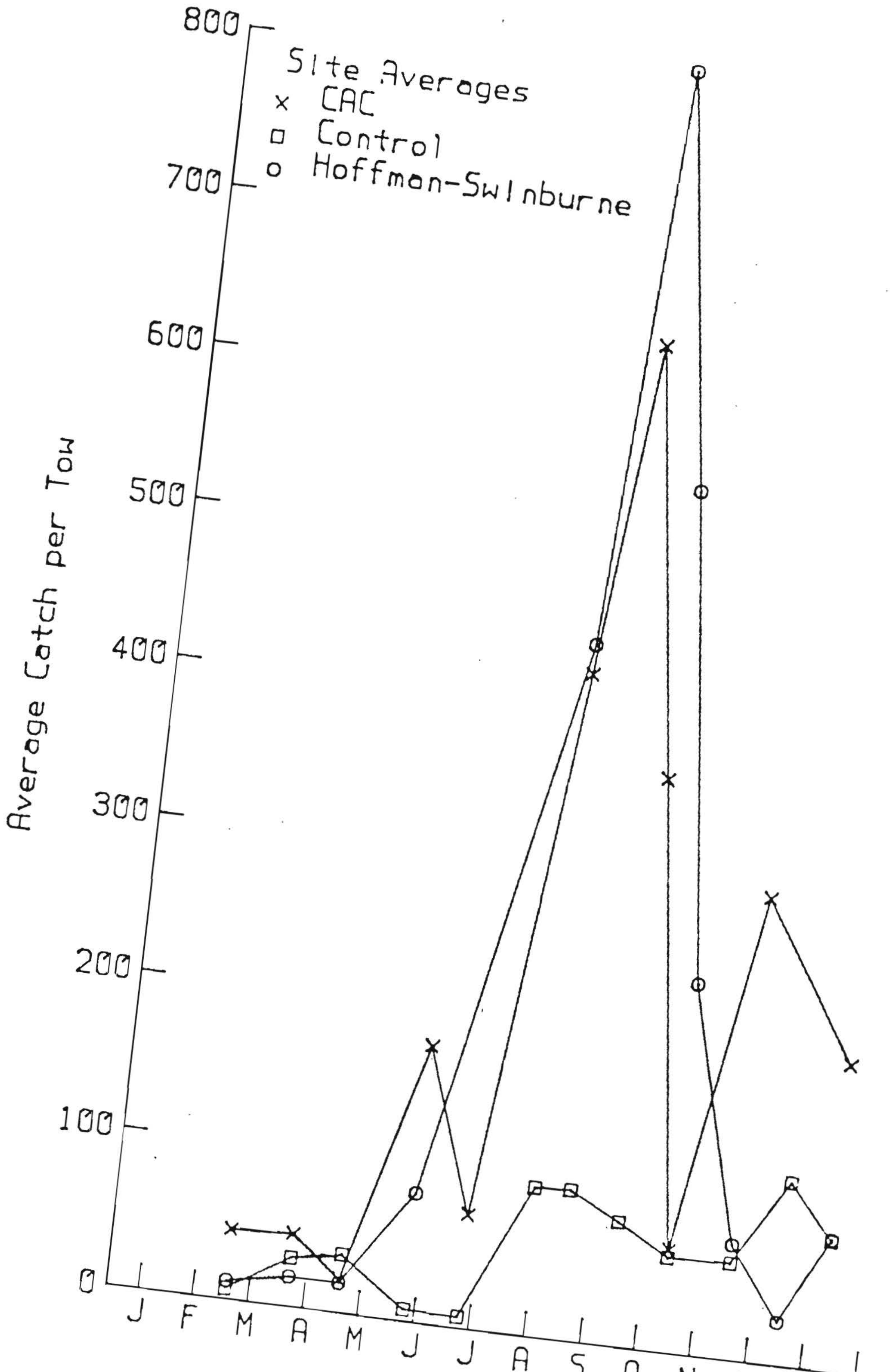

Site Averages
× CAC
□ Control
○ Hoffman-Swinburne
Average Catch per Tow
800
700
600
500
400
300
200
100
0
J F M A M J J A S O N D J F

Figure 4

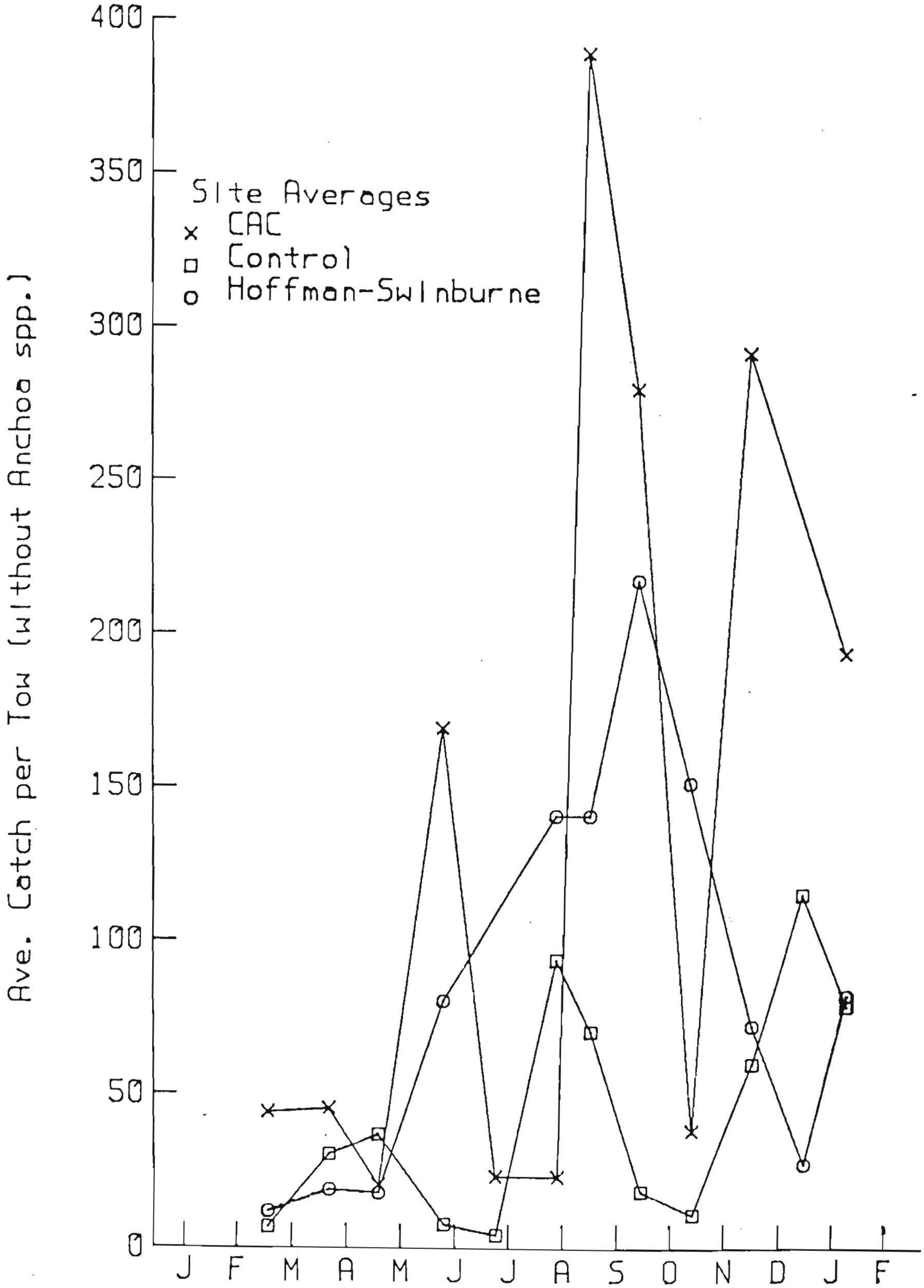
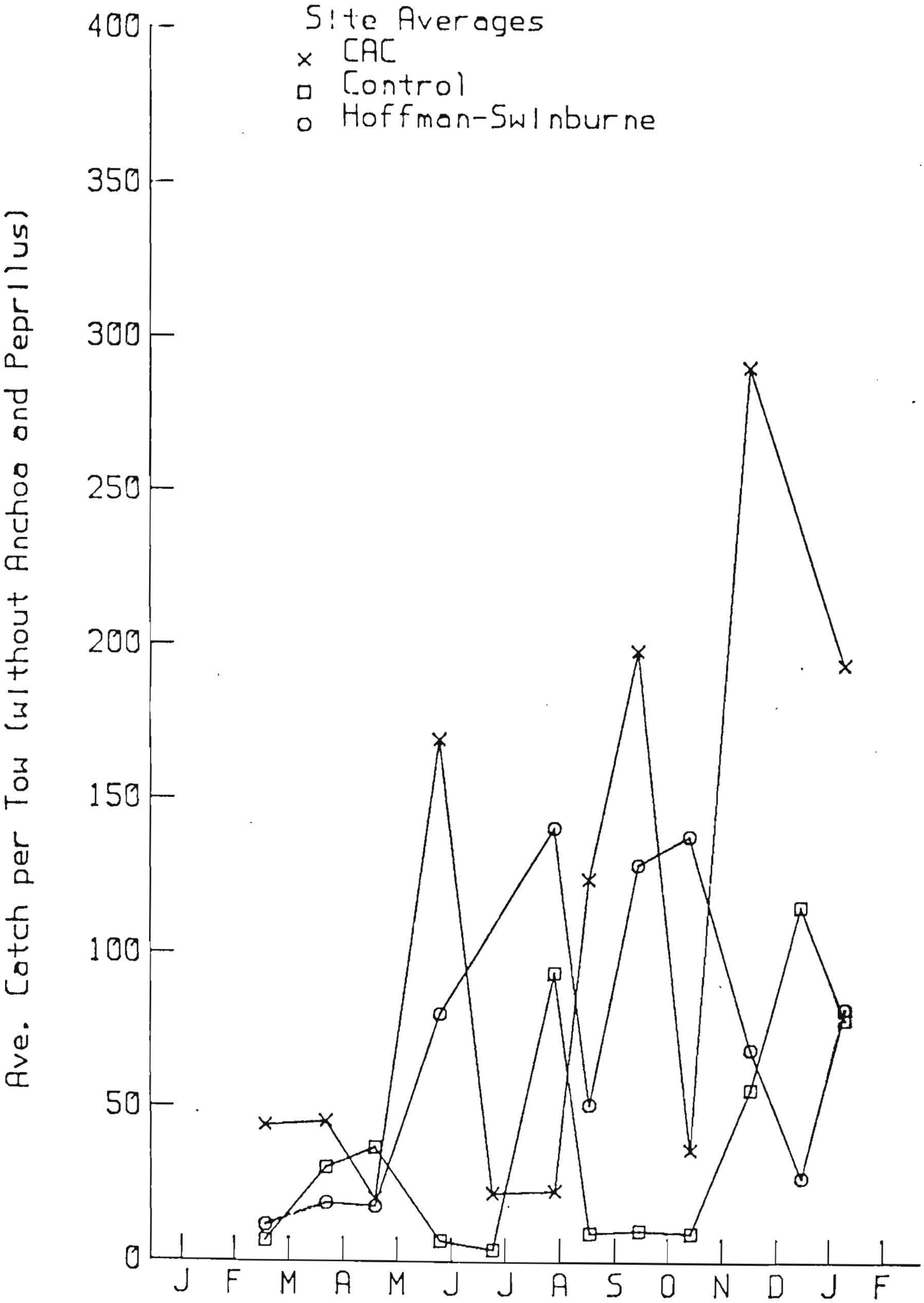
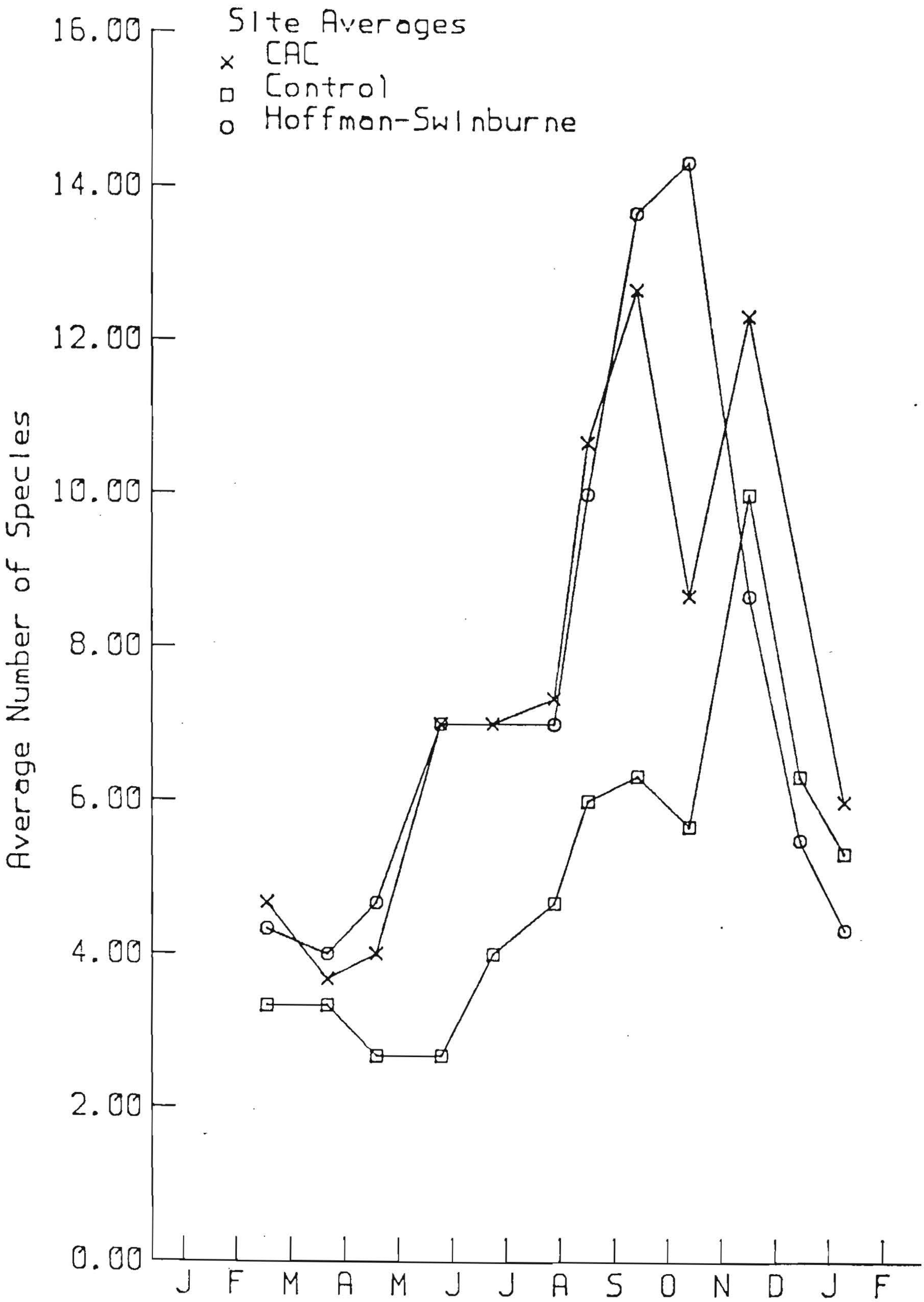

Site Averages
x CAC
□ Control
o Hoffman-Swinburne
Ave. Catch per Tow (without Anchoa spp.)
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D J F

Figure 5



Site Averages
x CAC
□ Control
o Hoffman-Swinburne
Ave. Catch per Tow (without Anchoa and Peprilus)
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D J F

Figure 6


Site Averages
x CAC
□ Control
o Hoffman-Swinburne
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Average Number of Species
J F M A M J J A S O N D J F
Figure 7

per tow by site and species for each month are presented in tabular form in Appendix B.

Seasonal Abundance and Mean Size by Species

The seasonal catches of each of the 10 most abundant species and the mean size of individuals captured are summarized below in descending order. Lobster and fluke are also discussed due to their commercial importance. Mean lengths of individuals caught by species are presented in tabular form in Appendix C.

1. **Anchoa spp.** Anchovies were by far the most abundant species group encountered, even though they were only captured in large numbers during a five-month period. Catches of anchovies were low in winter, increased in summer, peaked in September, and decreased through the fall (Fig. 8). Nearly all specimens captured were adults, probably one year of age. Many more anchovies were captured in the pits than at the shoal site.

2. **Peprilus triacanthus:** Butterfish were captured primarily during August and September (Fig. 9) and, at that time, they were much more abundant at the pits than the shoal site. Most of these fish were juveniles averaging about 5 cm in length during August and September (Fig. 10). Differences in mean lengths among sites were small.

3. **Pseudopleuronectes americanus:** Winter flounder were resident in Lower Bay throughout the year, but seasonal trends were evident. Catches were minimal during mid summer, increased in the fall, peaked in late fall, decreased in mid winter, and increased again in the spring (Fig. 11). During the fall peak in abundance catches at the shoal site were much less than at the pit sites, but no clear pattern was evident during winter, spring, or summer. Mean lengths usually averaged about 15 to 20 cm and included both juveniles and adults. Differences in mean lengths of fish among sites were not evident (Fig. 12).

4. **Cynoscion regalis:** Weakfish were captured primarily during August to November, with the greatest catches in September (Fig. 13). Nearly all specimens were captured at pit locations. With exception of two large adults captured in July, all weakfish collected were juveniles, averaging about 5 cm in August and 10 to 20 cm in November (Fig. 14). Consistent differences in mean length among sites were not evident.

5. **Alosa spp.** Herrings of the genus Alosa were abundant only from November to January. Differences in abundance among the three study sites were not consistent during this period (Fig. 15). Most of the individuals collected were juveniles averaging between 10 and 15 cm in length (Fig. 16).

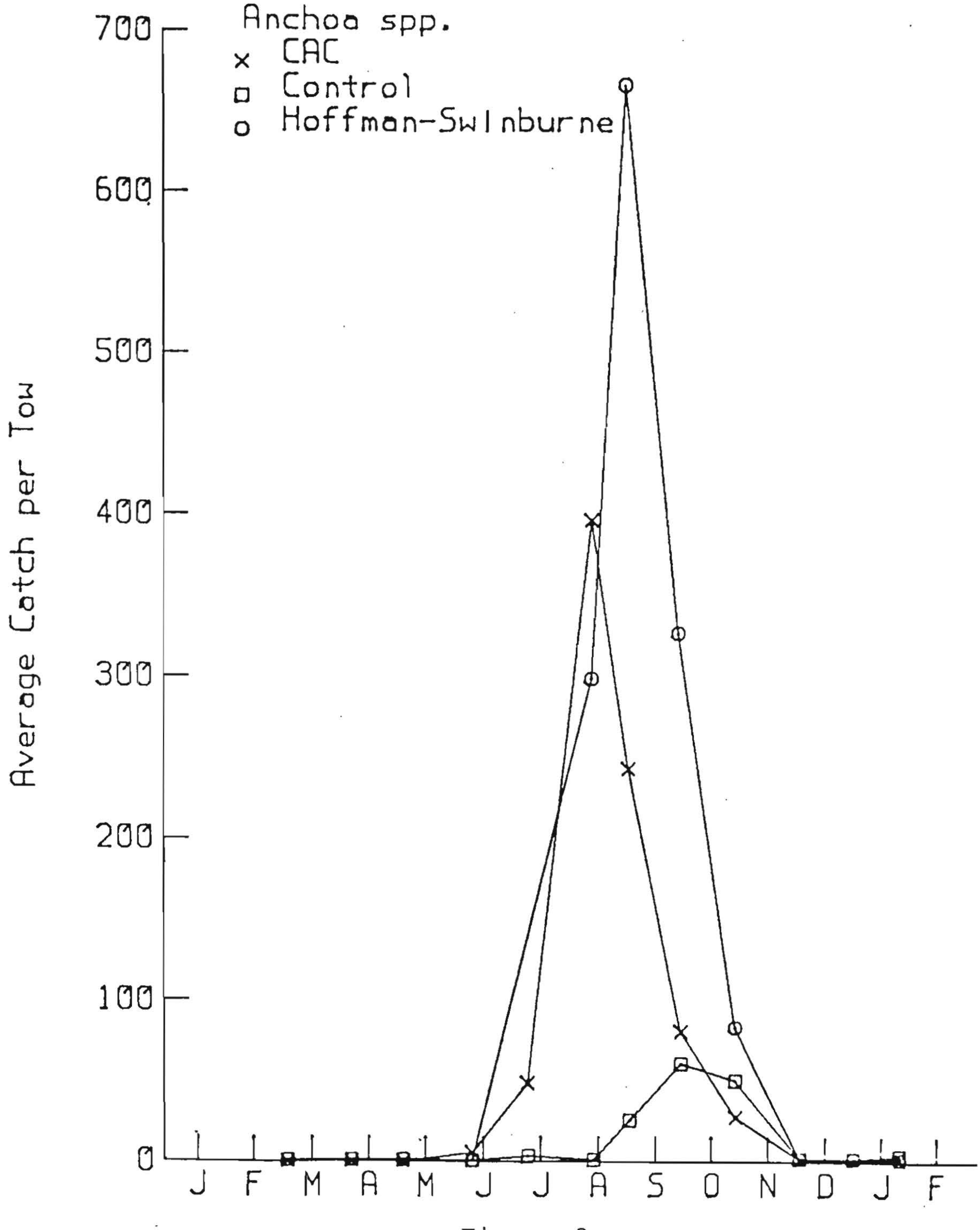
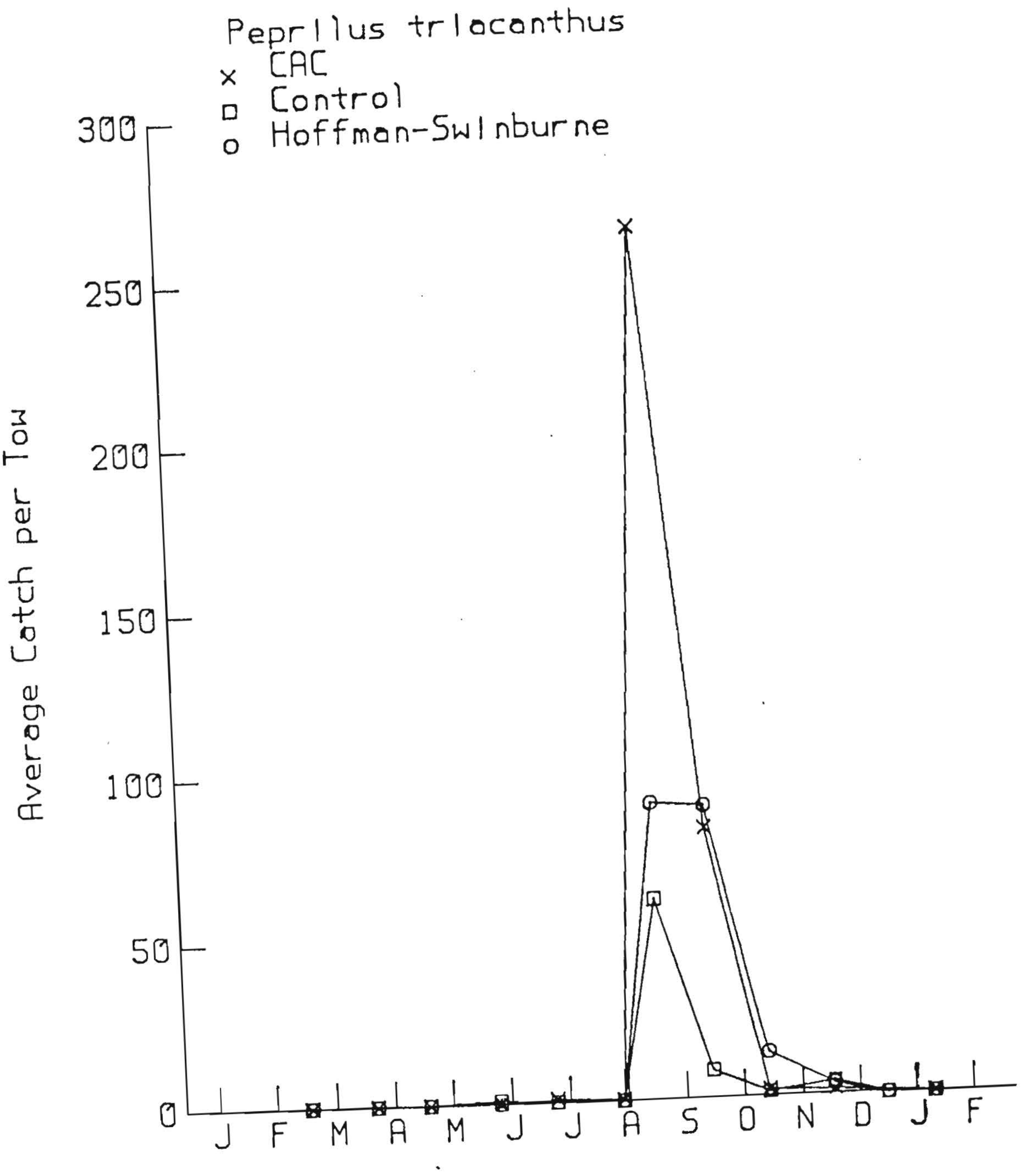
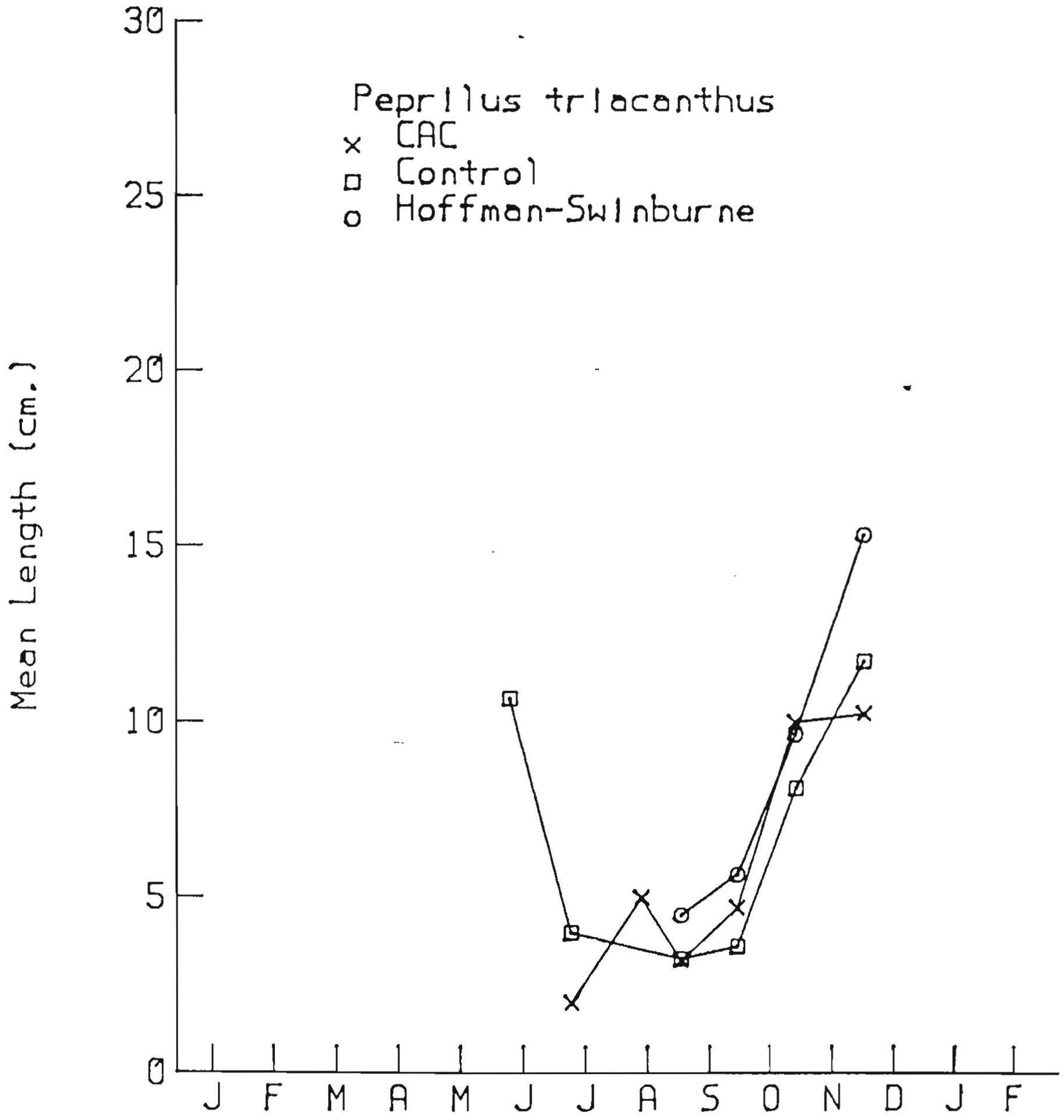

Anchoa spp.
CAC
Control
Hoffman-Swinburne
Average Catch per Tow
700
600
500
400
300
200
100
0
J
F
M
A
M
J
J
A
S
O
N
D
J
F

Figure 8



Peprilus triacanthus
CAC
Control
Hoffman-Swinburne
Average Catch per Tow
300
250
200
150
100
50
0
J
F
M
A
M
J
J
A
S
O
N
D
J
F

Figure 9



Peprilus triacanthus
CAC
Control
Hoffman-Swinburne
Mean Length (cm.)
30
25
20
15
10
5
0
J F M A M J J A S O N D J F

Figure 10

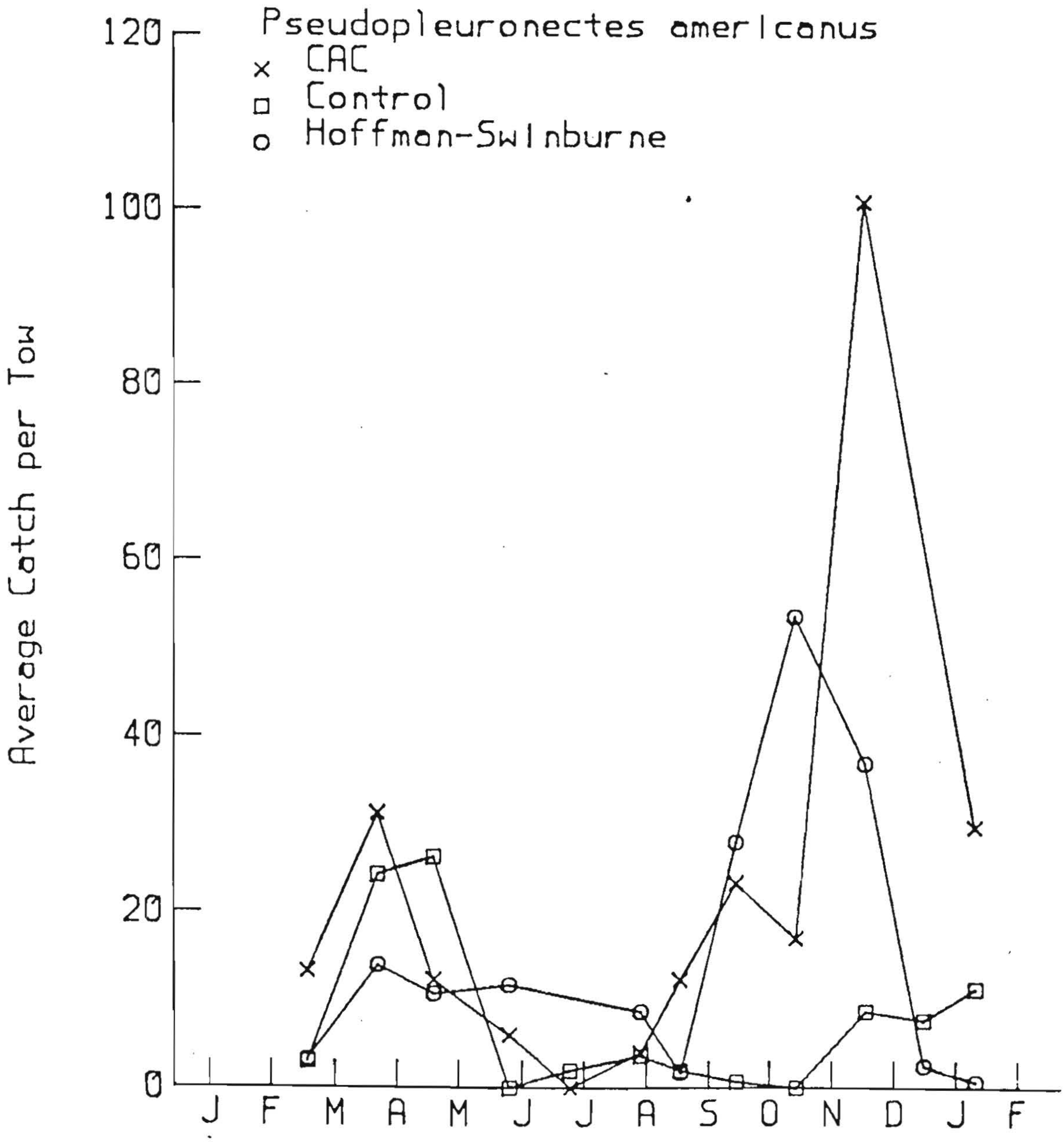

Pseudopleuronectes americanus
CAC
Control
Hoffman-Swinburne
120
100
80
60
40
20
0
Average Catch per Tow
J F M A M J J A S O N D J F

Figure 11

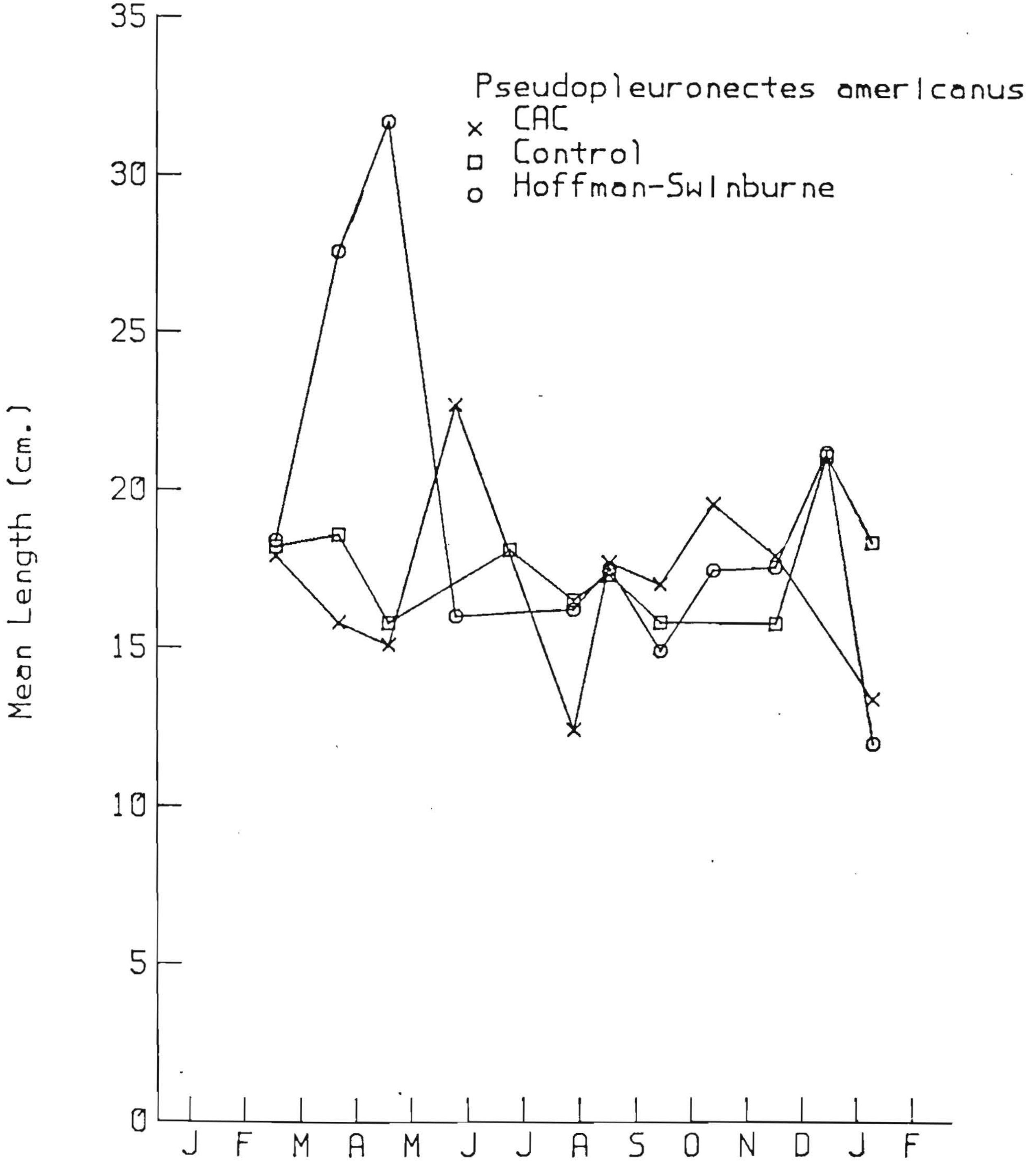

Pseudopleuronectes americanus
CAC
Control
Hoffman-Swinburne
Mean Length (cm.)
35
30
25
20
15
10
5
0
J F M A M J J A S O N D J F

Figure 12

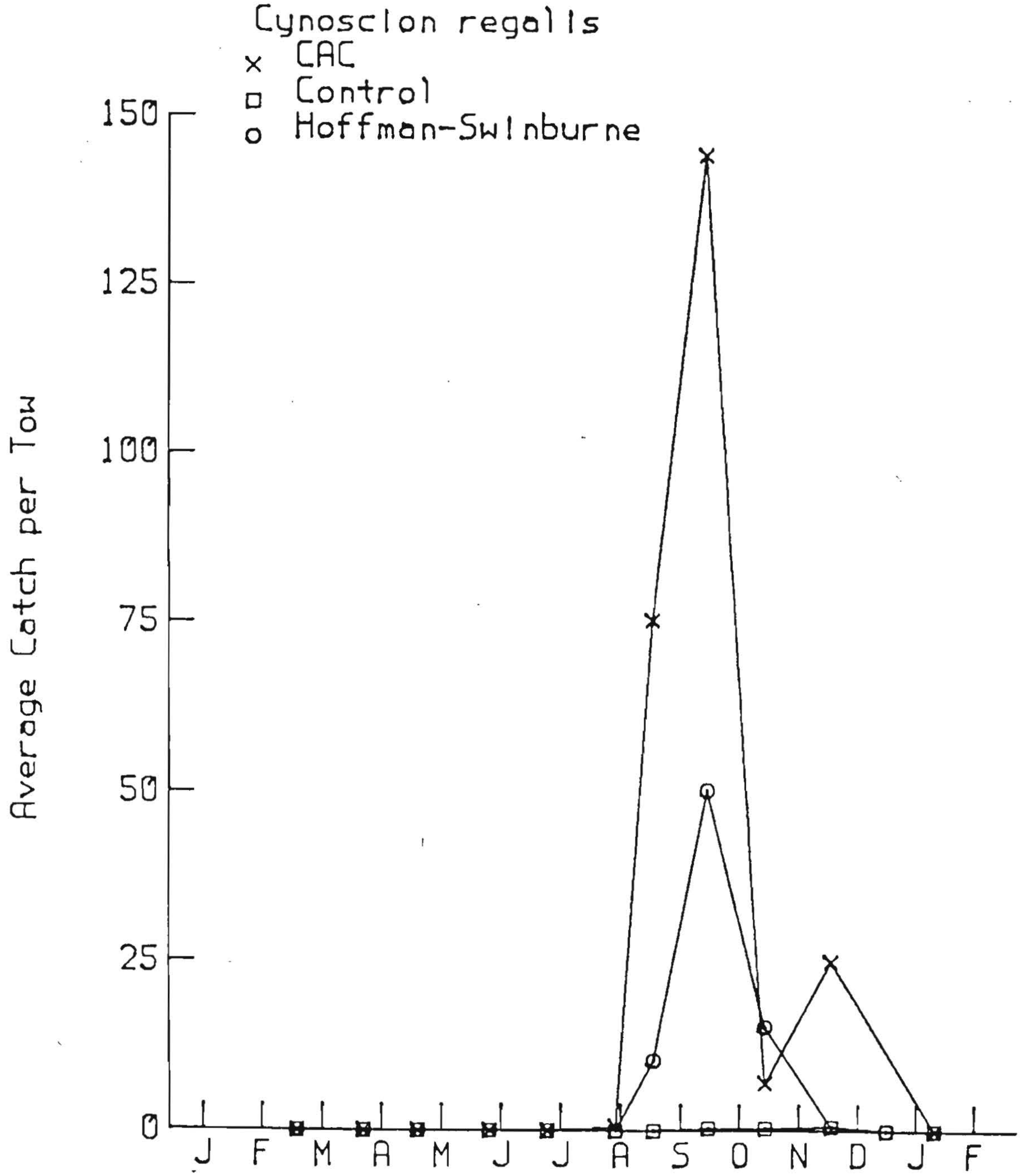

Cynoscion regalis
CAC
Control
Hoffman-Swinburne
Average Catch per Tow
150
125
100
75
50
25
0
J
F
M
A
M
J
J
A
S
O
N
D
J
F

Figure 13

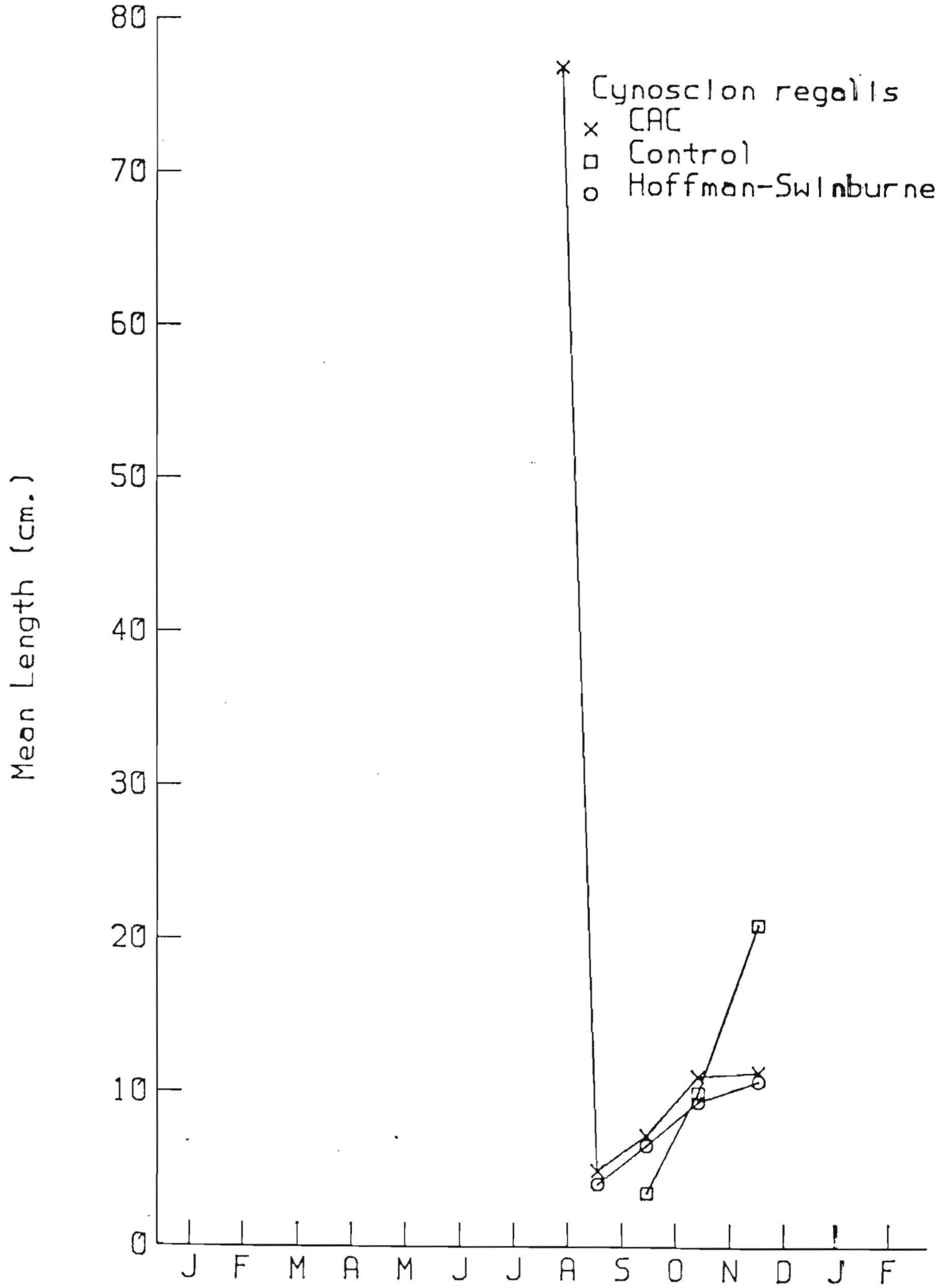

Cynoscion regalis
CAC
Control
Hoffman-Swinburne
Mean Length (cm.)
80
70
60
50
40
30
20
10
0
J
F
M
A
M
J
J
A
S
O
N
D
J
F

Figure 14

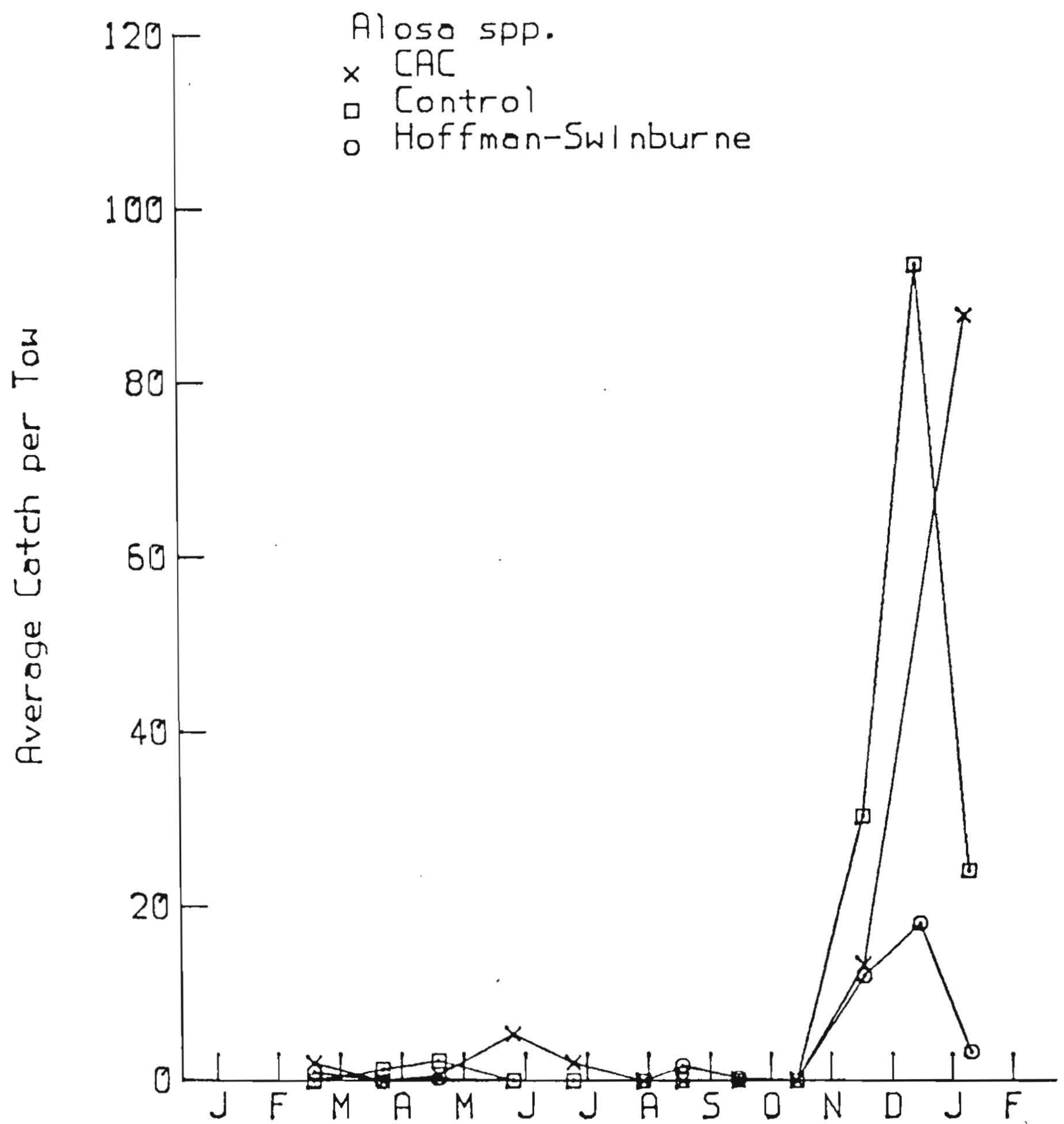

Alosa spp.
x CAC
□ Control
o Hoffman-Swinburne
Average Catch per Tow
120
100
80
60
40
20
0
J F M A M J J A S O N D J F

Figure 15

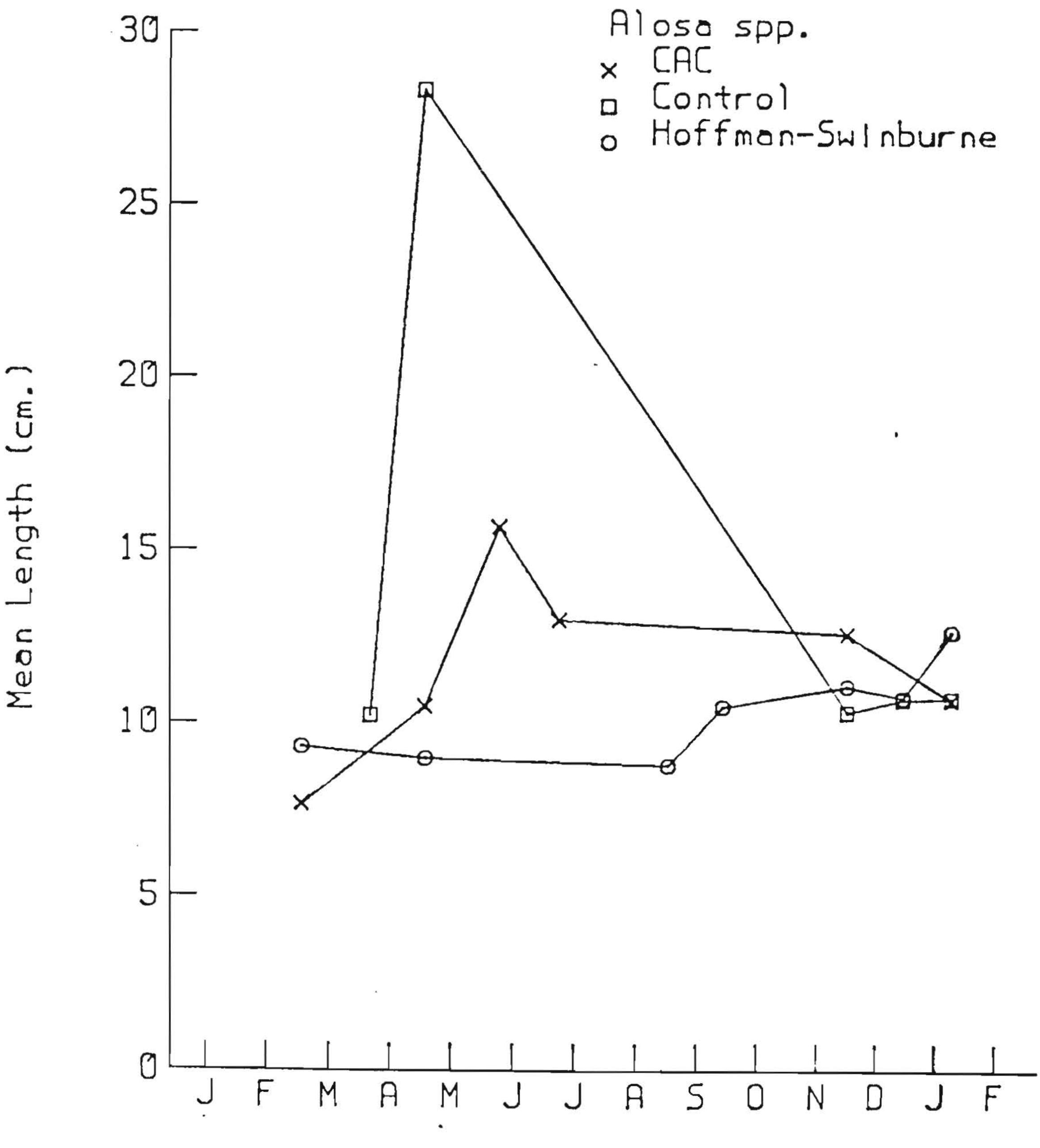

Alosa spp.
CAC
Control
Hoffman-Swinburne
Mean Length (cm.)
30
25
20
15
10
5
0
J F M A M J J A S O N D J F

Figure 16

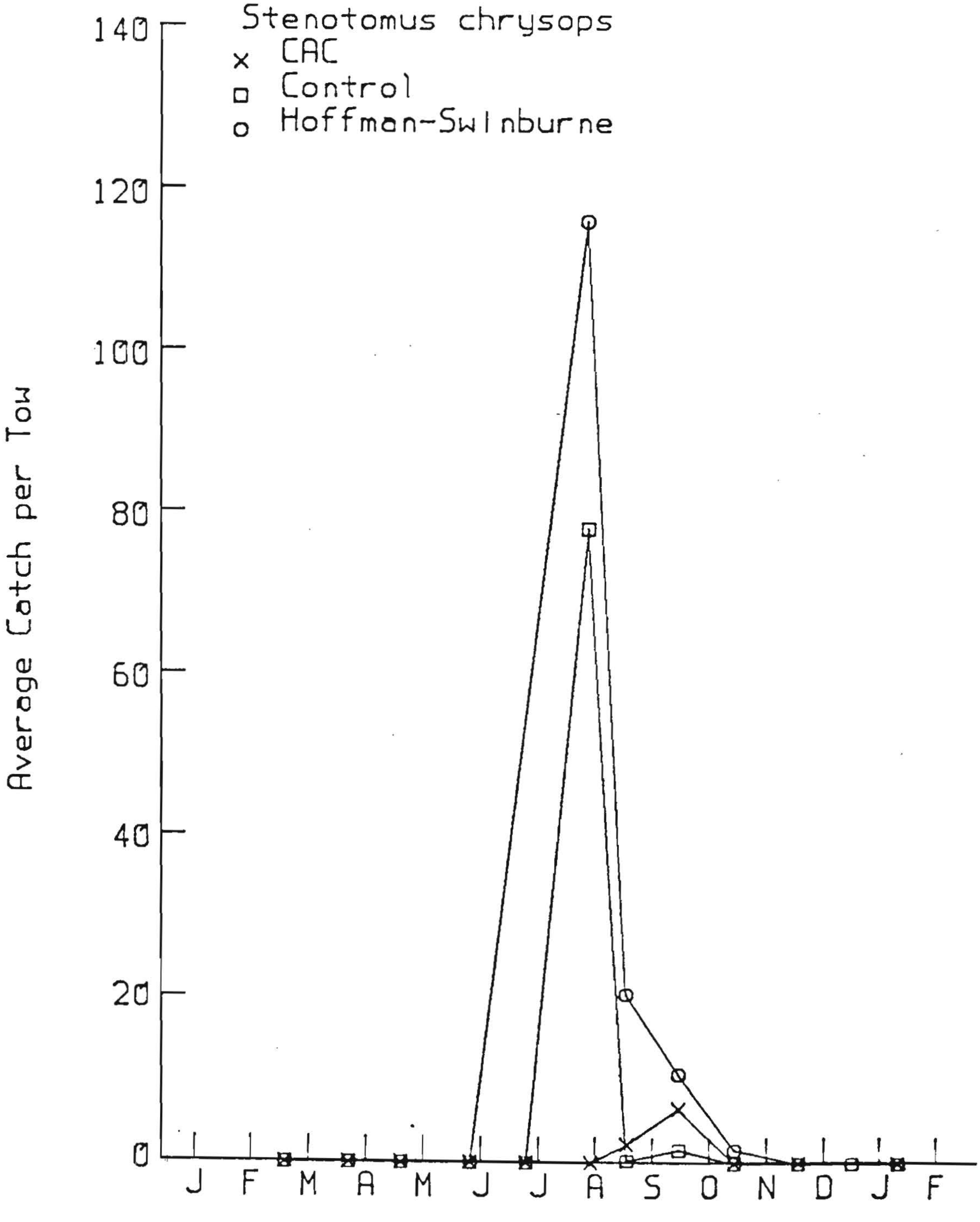

Stenotomus chrysops
x CAC
□ Control
o Hoffman-Swinburne
140
120
100
80
60
40
20
0
Average Catch per Tow
J F M A M J J A S O N D J F

Figure 17

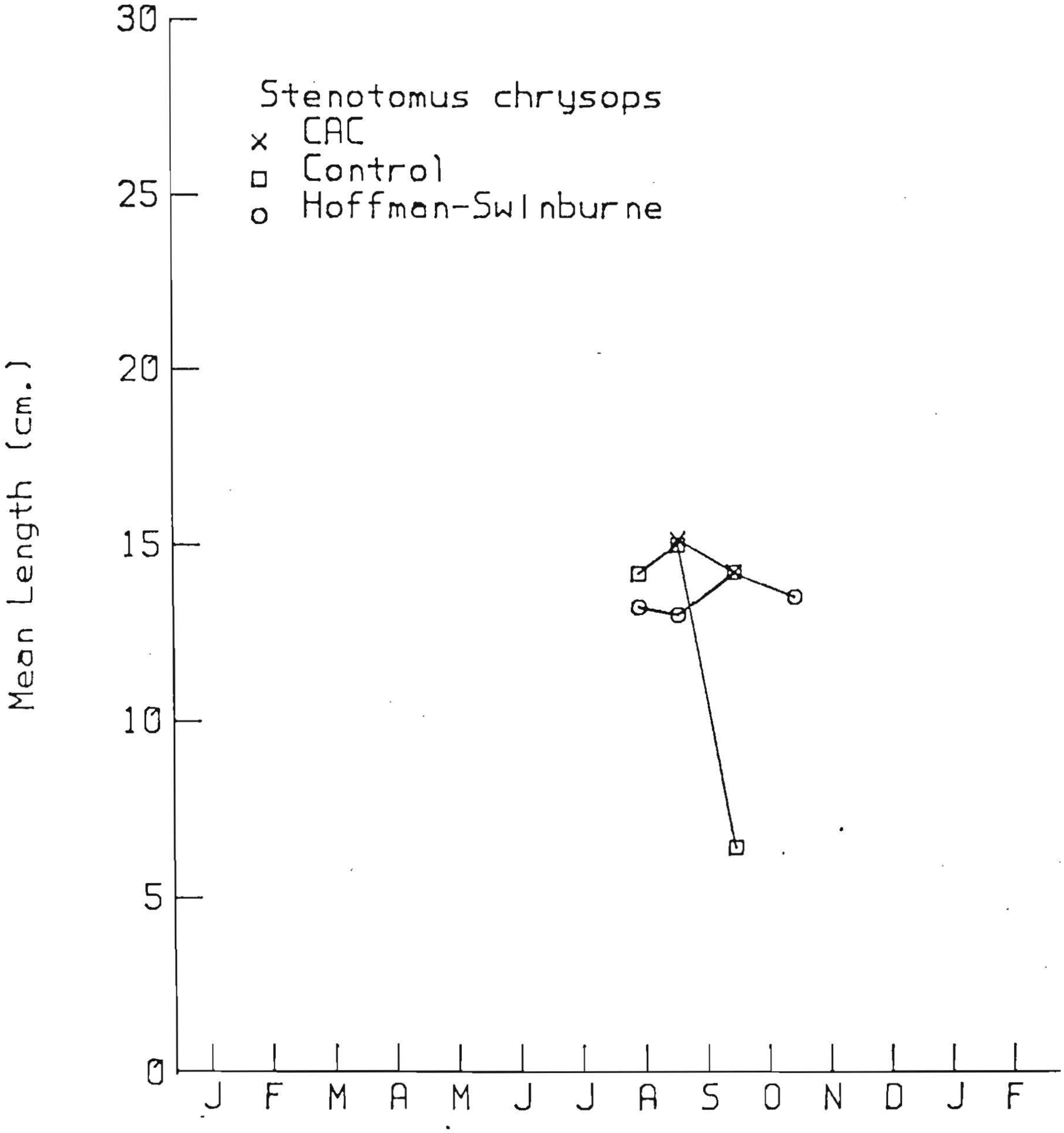
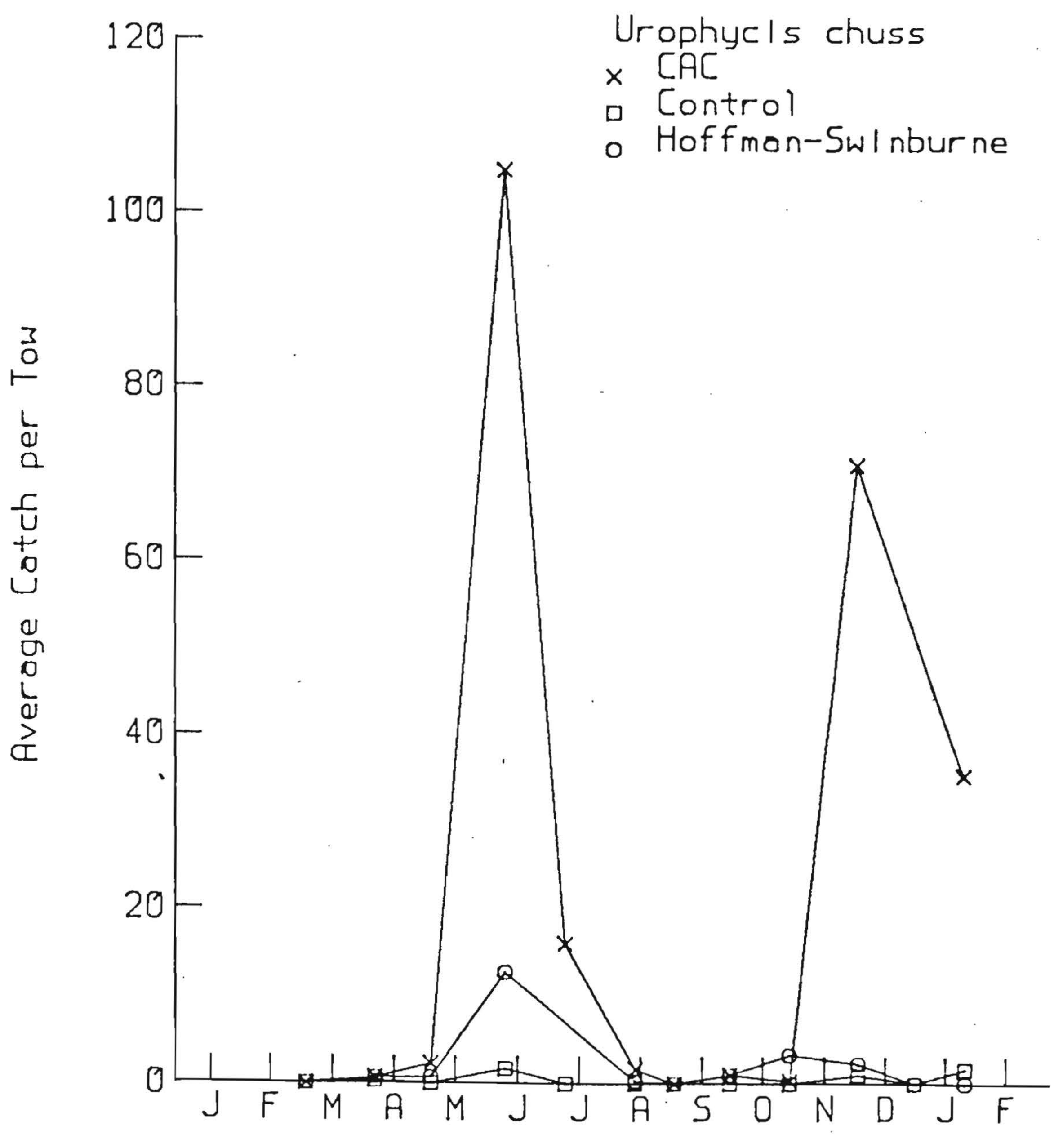

30
25
20
15
10
5
0
Mean Length (cm.)
Stenotomus chrysops
x CAC
□ Control
o Hoffman-Swinburne
J
F
M
A
M
J
J
A
S
O
N
D
J
F

Figure 18



Urophycis chuss
CAC
Control
Hoffman-Swinburne
Average Catch per Tow
120
100
80
60
40
20
0
J F M A M J J A S O N D J F

Figure 19

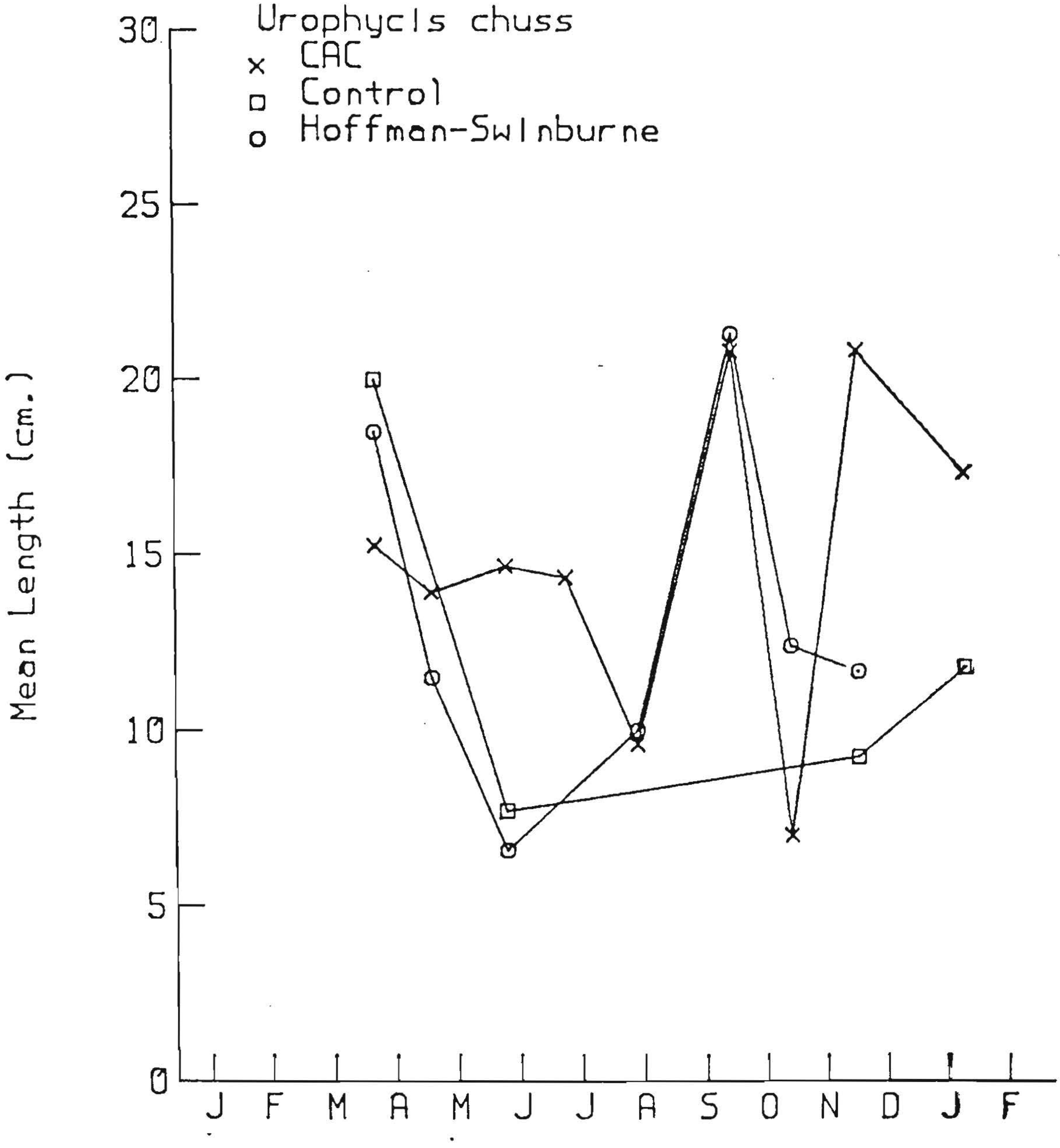

Urophycis chuss
CAC
Control
Hoffman-Swinburne
Mean Length (cm.)
30
25
20
15
10
5
0
J F M A M J J A S O N D J F

Figure 20

6. **Stenotomus chrysops.** Scup were abundant only in July, August, and September (Fig. 17). The greatest catches were at the borrow pit south of Swinburne Island and at the shoal site. Most individuals were about 15 cm in length and consistent differences in mean lengths among sites were not evident (Fig. 18).

7. **Urophycis chuss:** Red hake displayed a bimodal peak in abundance. Maximum catches occurred in May and June and again in November (Fig. 19). Most red hake were captured from the CAC pit during both periods of abundance. Mean lengths of red hake varied between 5 and 20 cm and consisted of both juveniles and adults (Fig. 20). Differences among sites were not apparent.

8. **Merluccius bilinearis:** Silver hake were caught primarily during November, December, and January (Fig. 21). The largest catches occurred at the two pit sites. Most of the fish caught were juveniles between 5 and 15 cm long (Fig. 22).

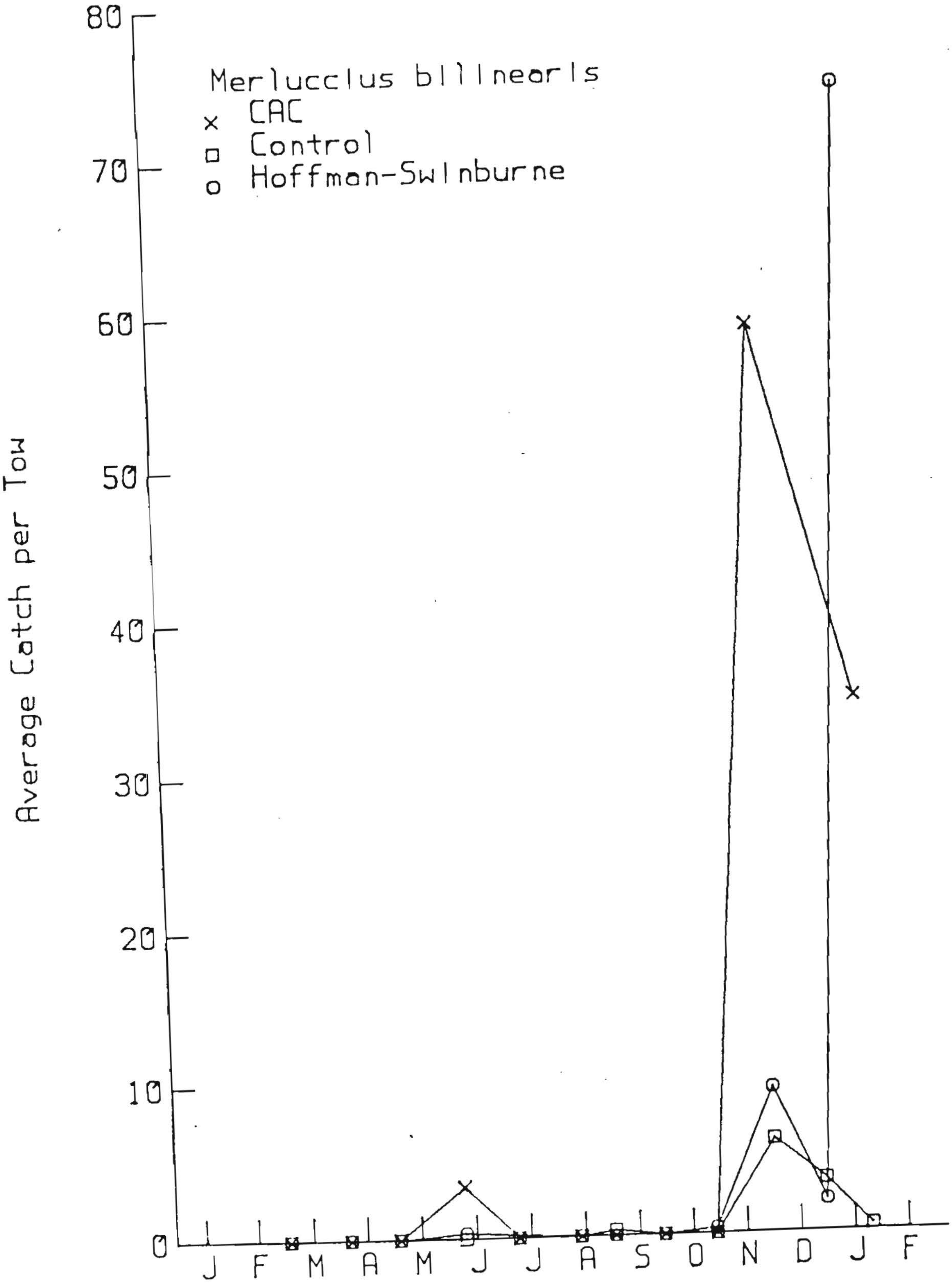
9. **Scophthalmus aquosus:** Windowpane flounder were resident throughout the year (Fig. 23). Largest catches were at the CAC pit in spring but differences among sites were not consistent. Mean length of fish caught varied between 10 and 30 cm and consisted of both juveniles and adults (Fig. 24). Mean lengths were similar among sites.

10. **Myoxocephalus octodecemspinosus.** Longhorn sculpins were prevalent only in December and January, but were resident in low numbers throughout the year. Maximum catches were at the shoal site (Fig. 25). Individuals collected consisted of both juveniles and adults (Fig. 26).

Other commercially important species.

1. **Paralichtys dentatus:** Fluke were collected primarily in summer and early fall (Fig. 27). During this period abundances were generally higher at the borrow pit sites than at the shoal site. Most of the fish caught were adults averaging 35 to 45 cm in length (Fig. 28). Mean lengths were similar at the different sites.

2. **Homarus americanus:** The American lobster was resident in low numbers throughout the year (Fig. 29). More lobsters were caught at the borrow pit sites but the numbers caught at all the sites were low. Body lengths (head to tail) usually were between about 20 cm and 30 cm (Fig. 30); these individuals were close to legal size.



Merlucclus bl11nearls
CAC
Control
Hoffman-Swlnburne
Average Catch per Tow
80
70
60
50
40
30
20
10
0
J
F
M
A
M
J
J
A
S
O
N
D
J
F

Figure 21

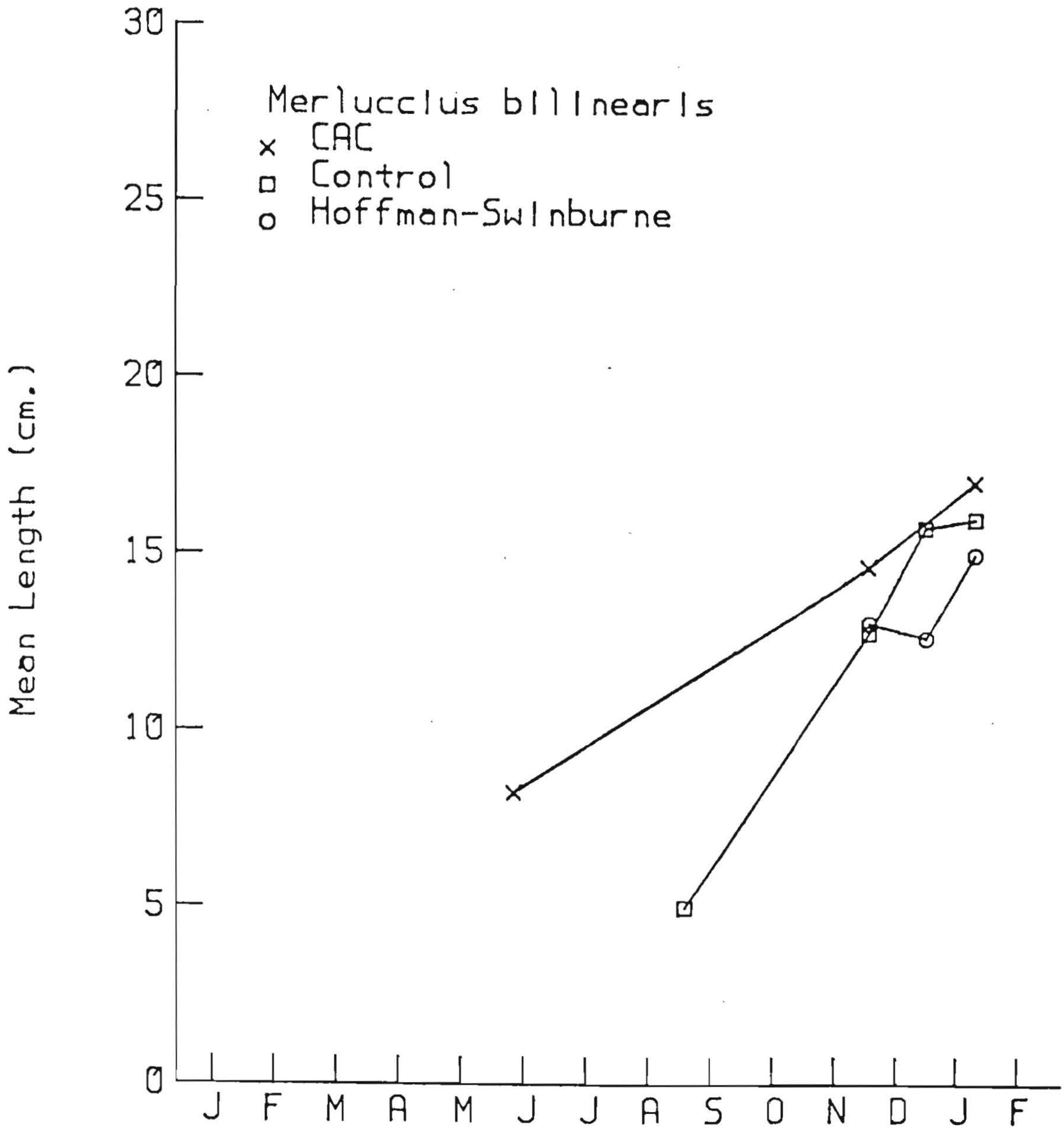
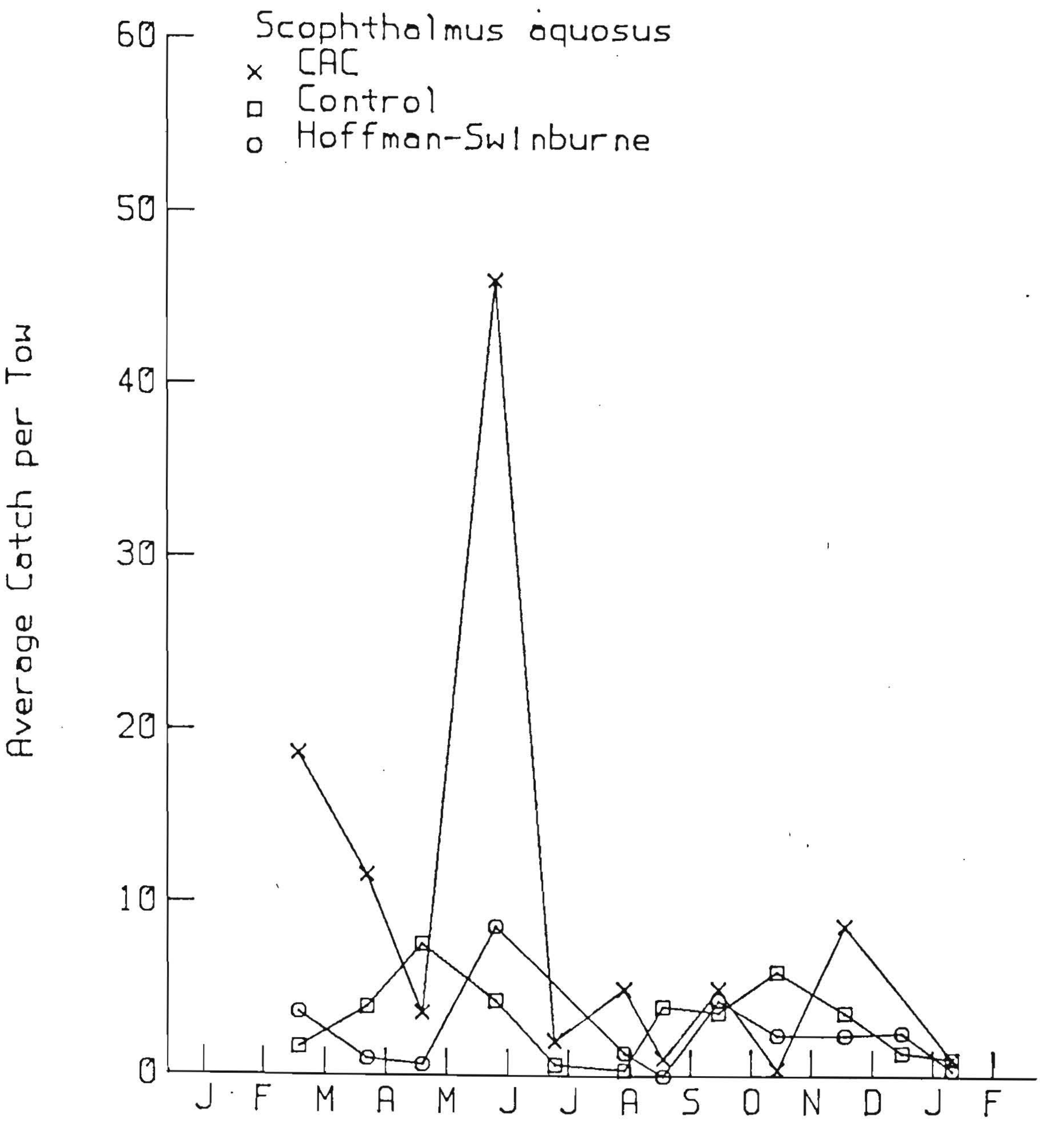
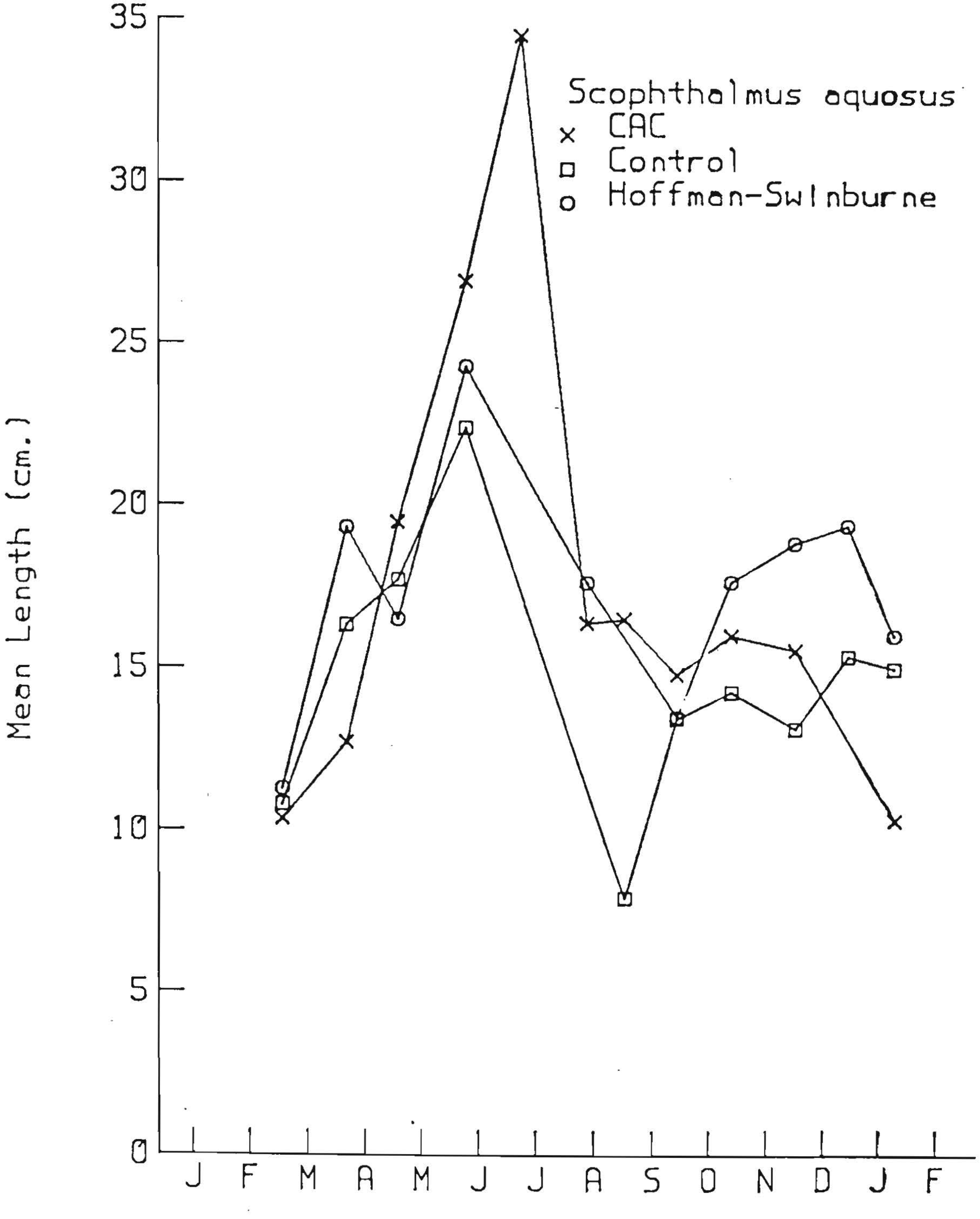

Merlucclus bIlIneorIs
x CAC
□ Control
o Hoffman-SwInburne
Mean Length (cm.)
30
25
20
15
10
5
0
J F M A M J J A S O N D J F

Figure 22



Scophthalmus aquosus
x CAC
□ Control
o Hoffman-Swinburne
60
50
40
30
20
10
0
Average Catch per Tow
J F M A M J J A S O N D J F

Figure 23



35
30
25
20
15
10
5
0
Mean Length (cm.)
J F M A M J J A S O N D J F
Scophthalmus aquosus
× CAC
□ Control
o Hoffman-Swinburne

Figure 24

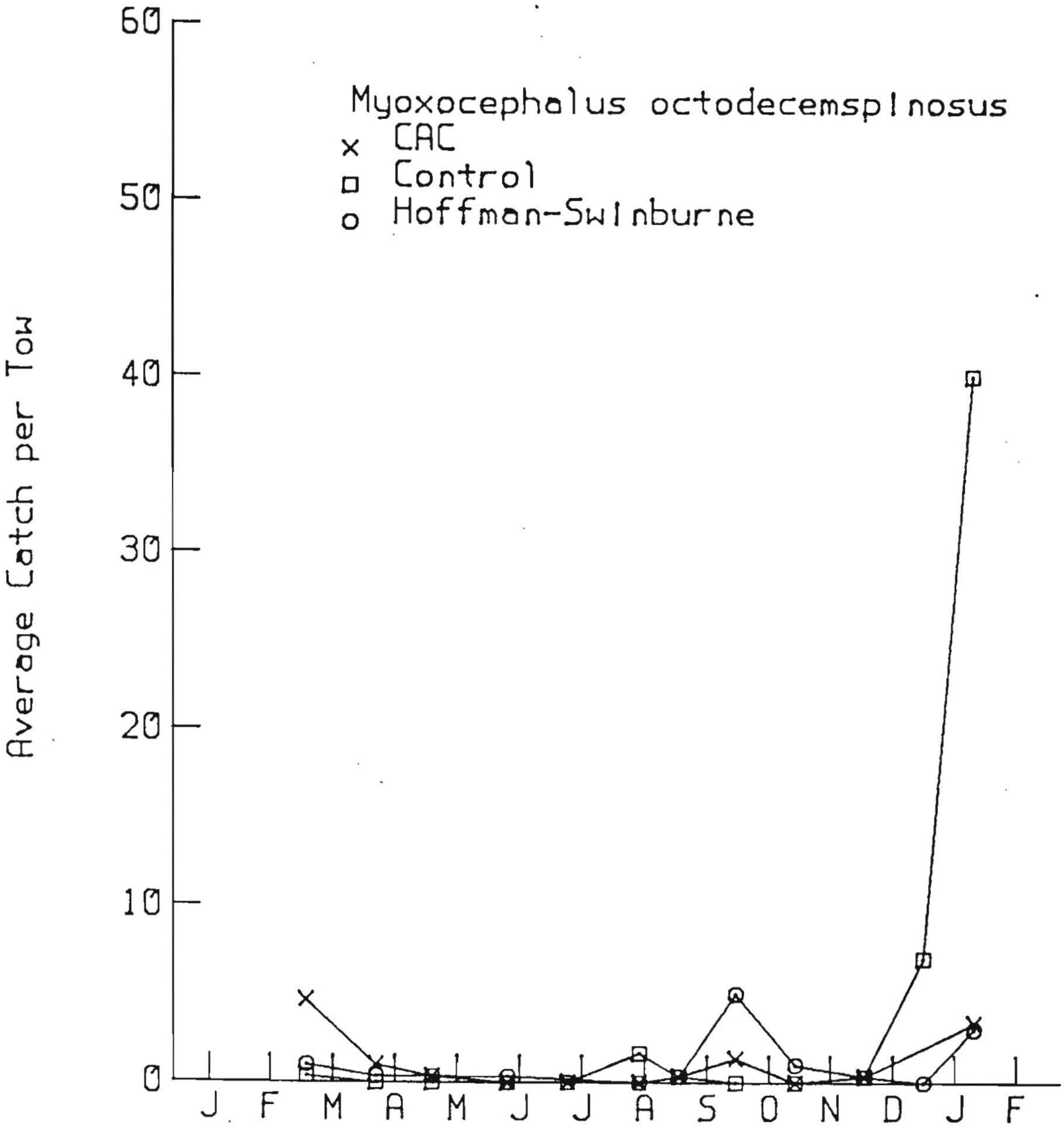

Myoxocephalus octodecemspinosus
CAC
Control
Hoffman-Swinburne
Average Catch per Tow
60
50
40
30
20
10
0
J F M A M J J A S O N D J F

Figure 25

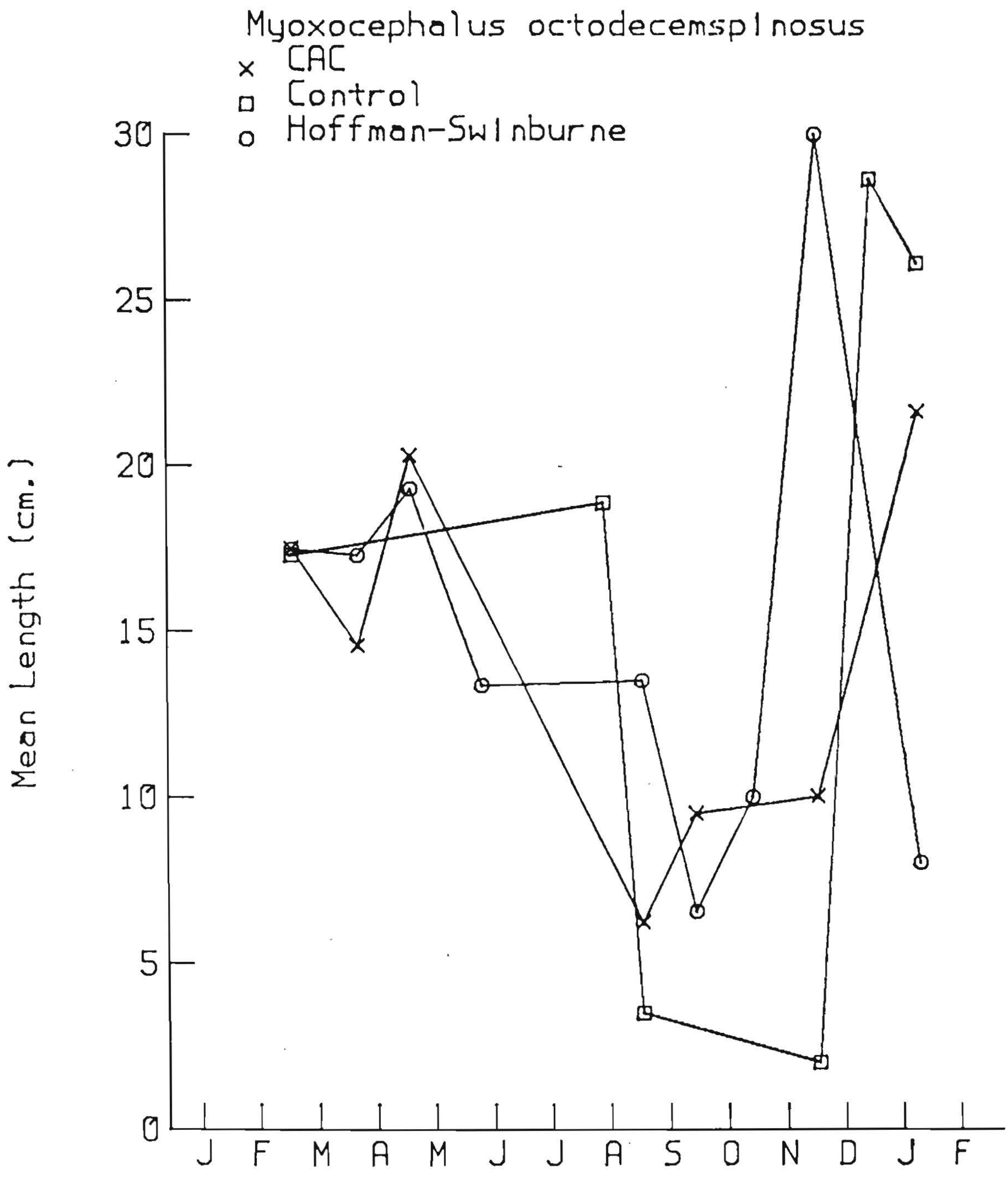
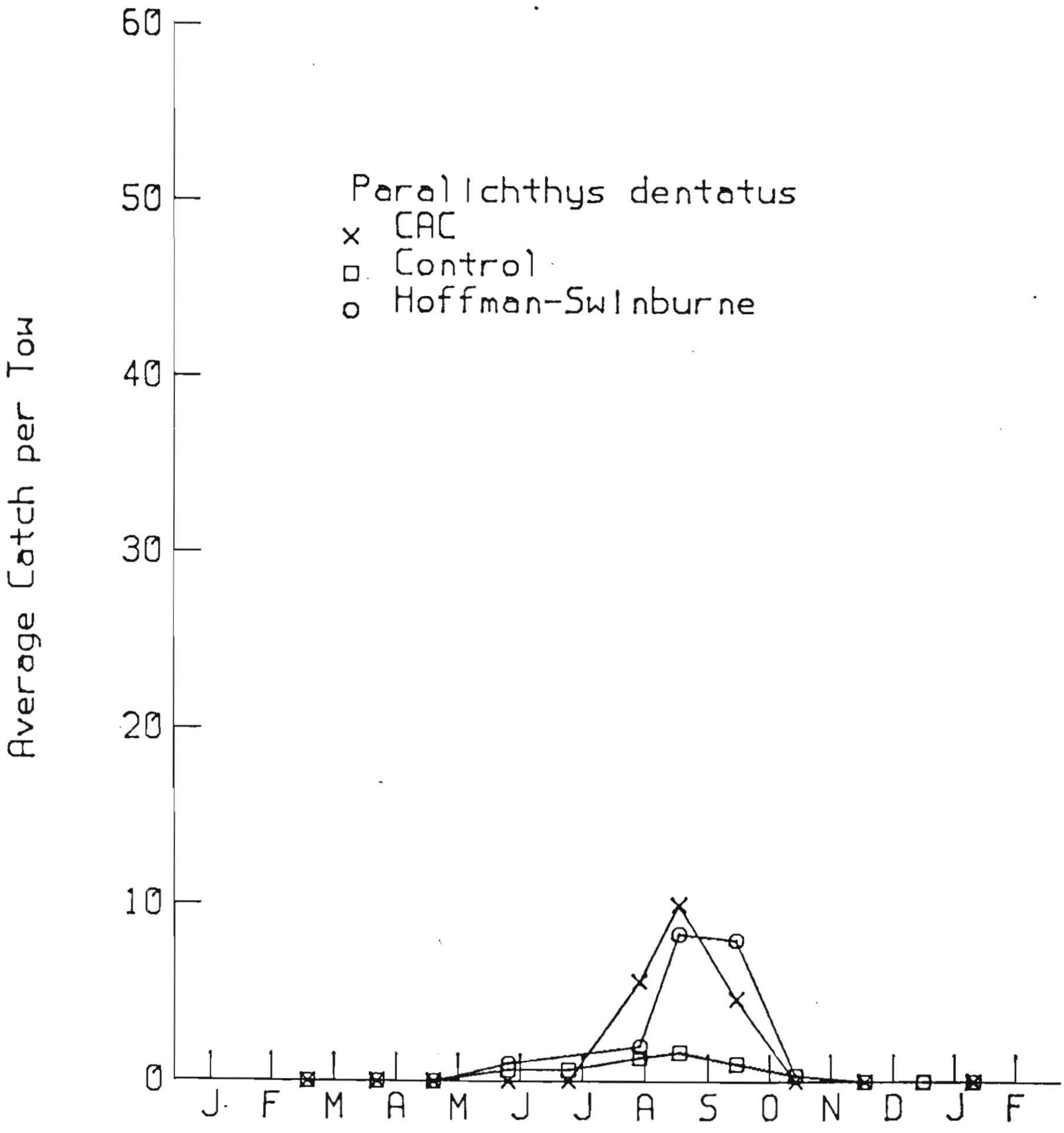

Myoxocephalus octodecemspinosus
CAC
Control
Hoffman-Swinburne
Mean Length (cm.)
30
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
J
F

Figure 26



Paralichthys dentatus
× CAC
□ Control
o Hoffman-Swinburne
Average Catch per Tow
60
50
40
30
20
10
0
J F M A M J J A S O N D J F

Figure 27

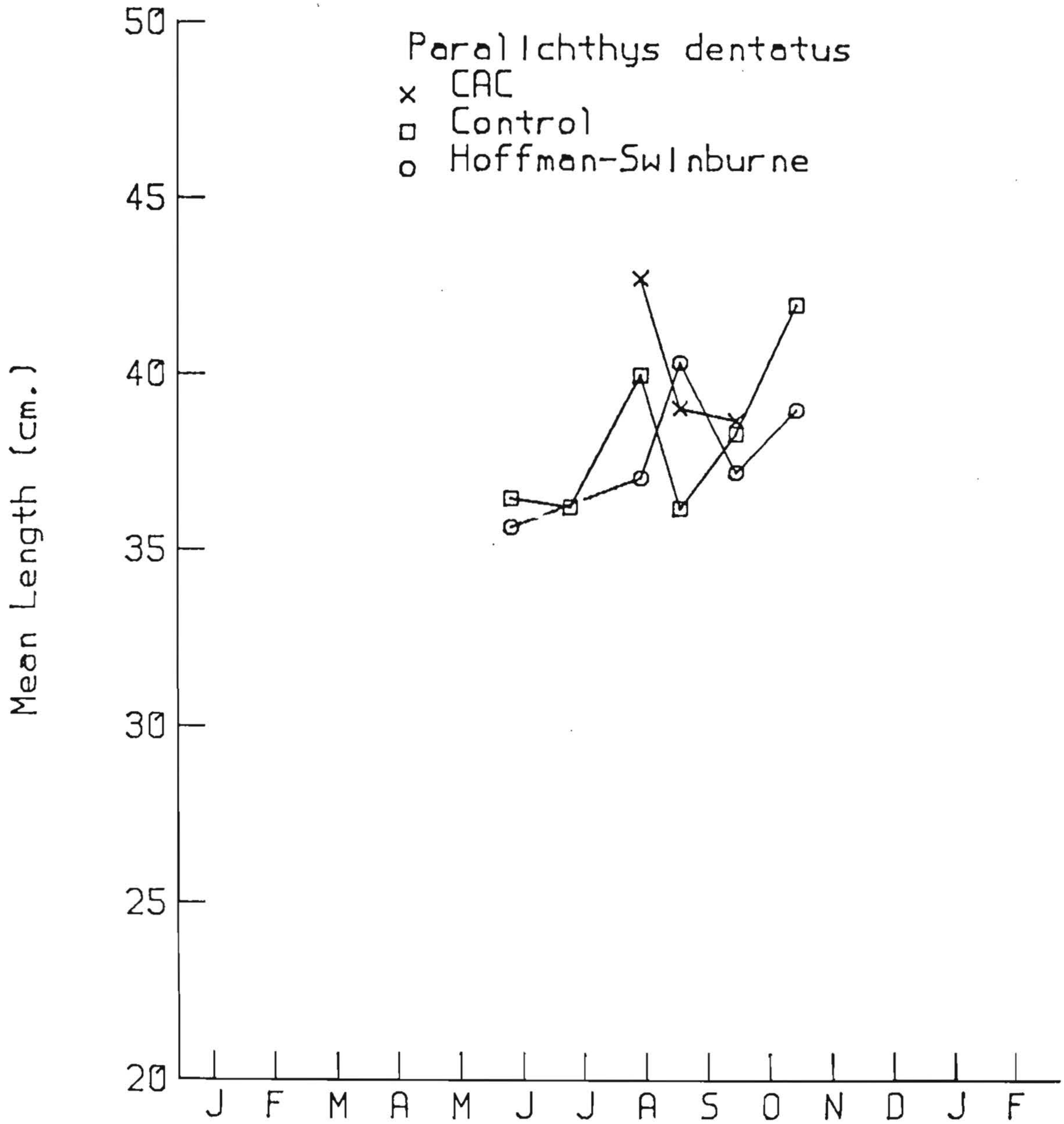

Paralichthys dentatus
CAC
Control
Hoffman-Swinburne
Mean Length (cm.)
50
45
40
35
30
25
20
J F M A M J J A S O N D J F

Figure 28

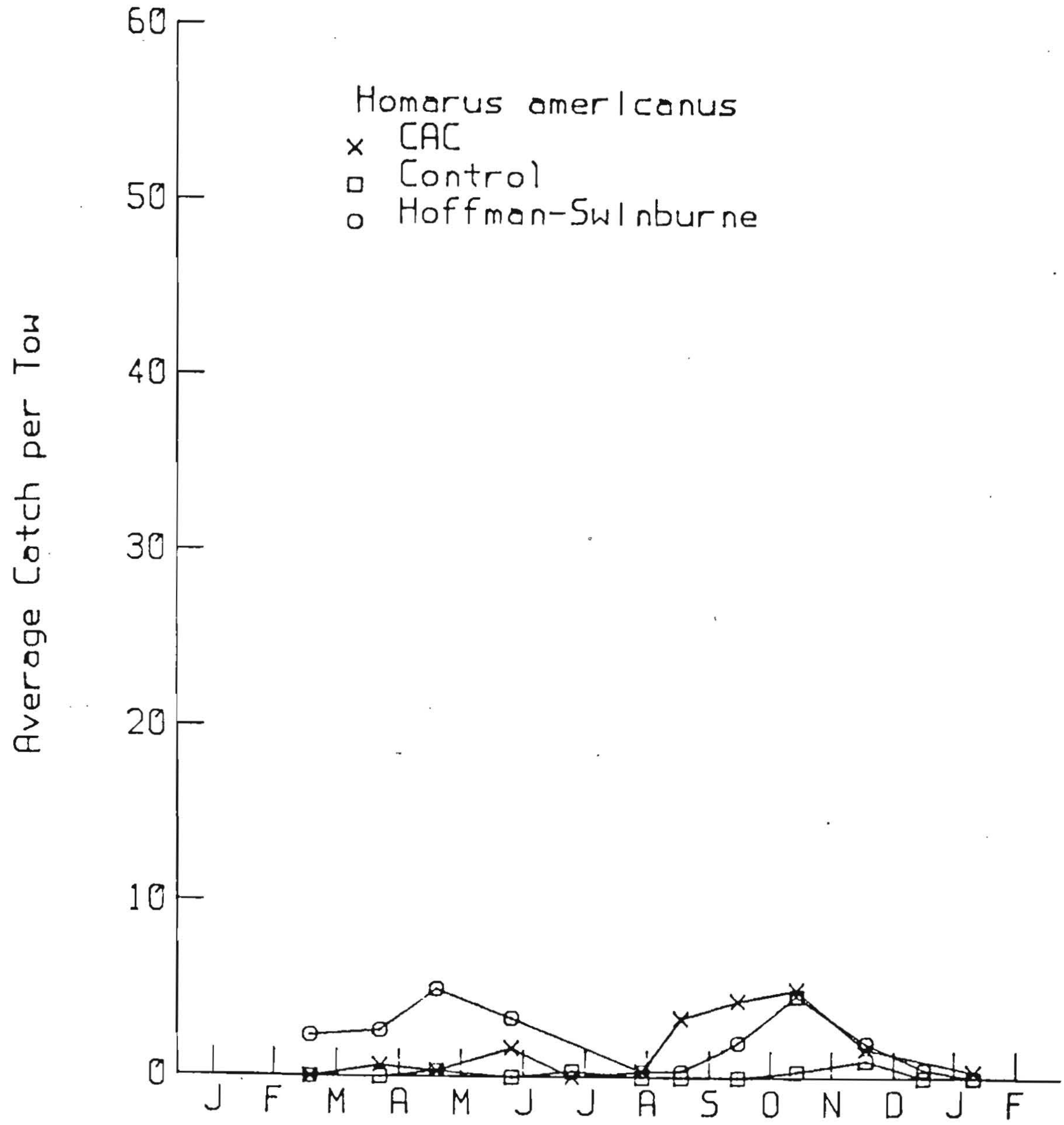
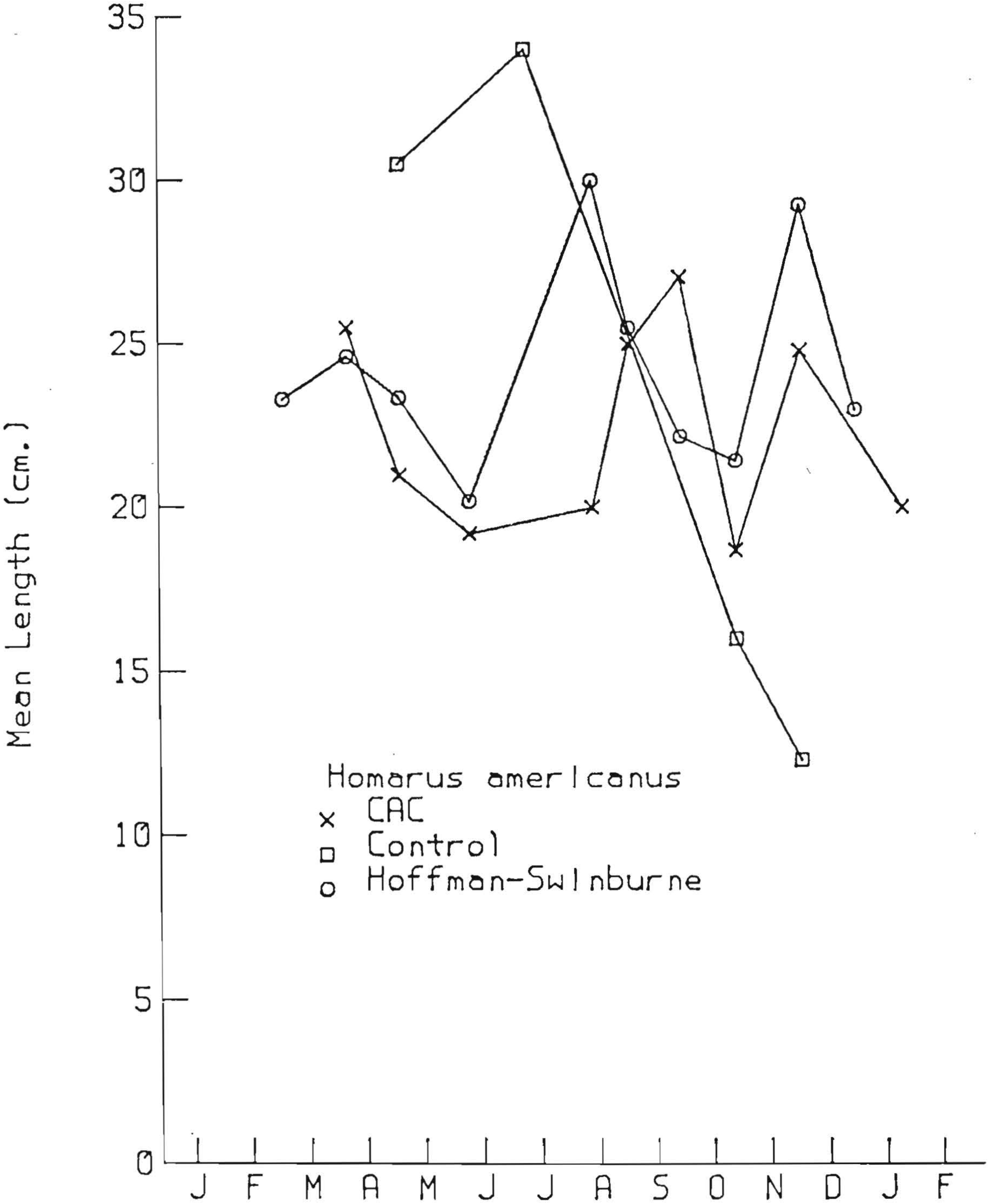

Homarus americanus
CAC
Control
Hoffman-Swinburne
Average Catch per Tow
60
50
40
30
20
10
0
J F M A M J J A S O N D J F

Figure 29



35
30
25
20
15
10
5
0
Mean Length (cm.)
Homarus amerIcanus
CAC
Control
Hoffman-SwInburne
J F M A M J J A S O N D J F

Figure 30

Stomach Contents of Winter Flounder

The results for the total number of winter flounder analyzed, total weights and numbers of food items, and gut content weights are given in Table 1. Because relatively few winter flounder were taken in some months, the data were grouped by season. Even with this grouping, in some seasons there were too few fish available for reliable interpretation of results. This was the case for the control site in the fall and winter. At all sites, highest values were obtained in the spring both in terms of weight and number of food items.

Winter flounder diets broken down to the level of major taxonomic groups are given in Table 2. Stomach contents were analyzed in terms of percentages by weight, frequency of occurrence, and number of prey items. Rankings were assigned independently in each category. At the CAC pit and the Hoffman-Swinburne site, winter flounder fed primarily on polychaetes and secondarily on crustacea and molluscs. At the control site, excluding the data for fall and winter when very few fishes were collected, crustacea seemed to be the most important component in the diet, ranking first in four of six cases. In the spring at this site, polychaetes ranked third behind both crustacea and molluscs. During the summer at the control site, values obtained for crustacea and polychaetes were very similar. These results suggest that the winter flounder diet differed between the control site and the two borrow pit sites.

An attempt was also made to relate the diet of winter flounder to the benthic populations identified by Cerrato and Scheier (1984) at the CAC pit and the control site. Winter flounder diets were broken down to species level whenever possible. Analyses were again performed in terms of percentages by weight, frequency of occurrence, and number of prey items. The results for the top five groups in each category, season, and site are given in Table 3. In the benthic study by Cerrato and Scheier (1984), Asabellides oculata, Streblospio benedicti, and Mulinia lateralis were identified as dominant fauna at the CAC pit, and at the control site the dominants were Nepthys picta, Aricidea catherinae, and Tellina agilis. With the exception of A. oculata, none of these species are listed as major components of the winter flounder diet at either the CAC pit or the control site. This suggests that winter flounder were feeding selectively.

Cerrato and Scheier (1984) found that A. oculata was a dominant species at the CAC pit, and abundances for this polychaete species often exceeded that found at the control site by an order of magnitude or more. In Table 3, A. oculata is clearly the major component of the winter flounder diet at the CAC pit. This species of polychaete appears to be a less important part of

TABLE 1

Summary of results for total numbers of winter flounder analyzed, total weights and numbers of food items, and gut content weight

	Total Wt. of Gut Contents (gm)	Total Wt. of Food Items (gm)	Total # of Food Items	Total # of Fish Analyzed	Total # of Empty Stomachs
West Bank pit					
Spring	18.33	10.96	3047	55	0
Summer	3.80	1.79	401	47	2
Fall	8.65	1.08	429	55	0
Winter	2.23	.31	483	56	16
Swinburne					
Spring	36.77	15.57	5346	49	0
Summer	1.44	.78	154	39	5
Fall	1.69	.56	218	26	0
Winter	1.40	.48	255	13	2
Control site					
Spring	13.33	12.22	2407	38	4
Summer	.69	.43	134	22	2
Fall	.20	.20	na	2	0
Winter	.05	.00	2	7	4

na = not applicable. Plant material and colonial animals cannot be counted as individual items.

TABLE 2.

Seasonal diet of winter flounder by major taxonomic groups.

		% by Weight	Rank	% by Freq. of Occurrence	Rank	% by Number	Rank
West Bank pit							
Spring:							
	Polychaetes	57.1	1	90.9	1	58.2	1
	Crustacea	41.5	2	67.3	2	31.7	2
	Molluscs	1.3	3	41.8	3	9.7	3
	Misc. Animals	.1	4	5.5	4	.4	4
	Plants	0		0		na	
Summer:							
	Polychaetes	60.8	1	70.2	1	65.3	1
	Crustacea	29.7	2	63.8	2	30.9	2
	Molluscs	7.4	3	19.1	3	3.5	3
	Misc. Animals	.2	5	2.1	4.5	.2	4
	Plants	1.7	4	2.1	4.5	na	
Fall:							
	Polychaetes	29.5	2	63.6	1	60.4	1
	Crustacea	16.6	3	54.5	2	31.2	2
	Molluscs	9.4	4	34.5	3	5.4	3
	Misc. Animals	5.8	5	1.8	5	3.0	4
	Plants	38.7	1	10.9	4	na	
Winter:							
	Polychaetes	76.2	1	44.6	1	82.6	1
	Crustacea	18.0	2	23.2	2	6.6	3
	Molluscs	5.5	3	17.9	3	10.8	2
	Misc. Animals	.3	4	1.8	4	na	
	Plants	0		0		na	
Swinburne site							
Spring:							
	Polychaetes	92.4	1	90.0	1	97.7	1
	Crustacea	5.6	2	36.7	2	1.8	2
	Molluscs	.4	4	10.2	4	.5	3
	Misc. Animals	1.5	3	20.4	3	na	
	Plants	0		2.0	5	na	
Summer:							
	Polychaetes	67.6	1	59.0	1	77.3	1
	Crustacea	21.4	2	33.3	2	18.2	2
	Molluscs	10.0	3	28.2	3	9.1	3
	Misc. Animals	.1	4	2.6	4	.6	4
	Plants	0		0		na	
Fall:							
	Polychaetes	27.1	2	55.7	1	98.2	1
	Crustacea	1.3	4	7.7	3.5	.9	2.5
	Molluscs	1.6	3	7.7	3.5	.9	2.5
	Misc. Animals	0		0		0	
	Plants	70.0	1	38.5	2	na	
Winter:							
	Polychaetes	98.7	1	38.5	1	98.8	1
	Crustacea	.8	2	23.0	2	7.8	2
	Molluscs	.4	3	7.7	3	3.9	3
	Misc. Animals	0		0		0	
	Plants	0		0		na	

		% by Weight	Rank	% by Freq. of Occurrence	Rank	% by Number	Rank
Control site							
Spring:							
	Polychaetes	1.8	3	10.5	3	2.7	3
	Crustacea	95.5	1	86.8	1	89.0	1
	Molluscs	2.6	2	26.3	2	8.2	2
	Misc. Animals	.1	4	7.9	4	.1	4
	Plants	0		0		na	
Summer:							
	Polychaetes	33.9	1	45.5	2	56.0	1
	Crustacea	32.8	2	50.0	1	41.8	2
	Molluscs	9.7	4	22.7	3	2.2	3
	Misc. Animals	8.8	5	9.1	5	na	
	Plants	14.8	3	13.6	4	na	
Fall:							
	Polychaetes	0		0		0	
	Crustacea	0		0		0	
	Molluscs	0		0		0	
	Misc. Animals	0		50.0	2	na	
	Plants	100.0	1	100.0	1	na	
Winter:							
	Polychaetes	0		0		0	
	Crustacea	100.0	1	33.3	1	100.0	1
	Molluscs	0		0		0	
	Misc. Animals	0		0		0	
	Plants	0		0		na	

na = not applicable. Plant material and colonial animals cannot be counted as individual items.

TABLE 3.

Seasonal diet of winter flounder by species.

	% by Weight	Rank	% by Freq. of Occurrence	Rank	% by Number	Rank
West Bank pit						
Spring:						
Gammarus lawrencianus	40.9	1	54.5	2	30.9	2
Asabellides oculata	36.8	2	76.4	1	53.2	1
Nepthys sp.	20.0	3	20.0	4	1.7	4
Mytilidae	.9	4	36.4	3	7.4	3
Mactridae	.2	5	14.5	5	.5	5
Summer:						
Asabellides oculata	38.9	1	68.1	1	60.1	1
Crangon septemspinosus	8.9	2	12.8	4	1.7	4
Ovalipes sp.	8.0	3	8.5	5	1.7	4
Glysera sp.	7.9	4	14.9	3	1.7	4
Gammarus lawrencianus	6.8	5	31.9	2	12.0	2
Fall:						
Plants	38.7	1	18.2	1.5	na	
Glycera sp	12.1	2	7.3	4	2.1	3
Amplisca sp.	6.7	3	10.9	3	18.4	1
Bryozoans	5.8	4	1.8	5	na	
Asabellides oculata	5.1	5	18.2	1.5	9.8	2
Winter:						
Asabellides oculata	53.7	1	37.5	1	58.4	1
Maldanidae	13.8	2	25.0	2	20.9	2
Polychaeta	8.7	3	8.9	5	3.3	4
Gammaridae	8.0	4	10.7	4	2.5	5
Bivalvia	4.8	5	17.9	3	10.8	3
Swinburne site						
Spring:						
Asabellides oculata	92.2	1	89.8	1	97.6	1
Gammarus lawrencianus	3.9	2	22.4	2	1.6	2
Hydrozoa	1.5	3	14.3	3	na	
Crangon septemspinosus	1.4	4	8.2	5	.1	4
Mytilis edulis	.4	5	10.2	4	.5	3
Summer:						
Asabellides oculata	26.7	1	38.5	1	38.3	1
Pherusa affinis	24.6	2	7.7	2.5	20.1	2
Glycera sp.	8.8	3	5.1	4.5	1.3	5
Ovalipes ocellatus	5.4	4	5.1	4.5	3.2	3.5
Pectinaria sp.	4.5	5	7.7	2.5	3.2	3.5
Fall:						
Plants	70.0	1	38.5	1.5	na	
Asabellides oculata	12.5	2	38.5	1.5	92.2	1
Nepthys sp.	6.1	3	15.4	3	2.8	2
Glycera sp.	5.2	4	11.5	4	2.3	3
Pherusa affinis	2.9	5	3.8	5	.5	4
Winter:						
Asabellides oculata	98.7	1	38.5	1	97.6	1
Gammarus lawrencianus	.6	2	7.7	3.5	.4	4
Maldanidae	.2	4	7.7	3.5	1.2	2
Mytilidae	.2	4	7.7	3.5	.4	4
Gammaridae	.2	4	7.7	3.5	.4	4

	% by Weight	Rank	% by Freq. of Occurrence	Rank	% by Number	Rank
Control site						
Spring:						
Gammarus lawrencianus	82.1	1	82.4	1	83.0	1
Crangon septemspinosus	3.3	2	5.3	5	.1	5
Bivalve siphons	2.1	3	10.5	2	.7	4
Ampelisca sp.	1.8	4	7.9	3.5	5.9	2
Asabellides oculata	1.7	5	7.9	3.5	2.7	3
Summer:						
Plants	14.8	1	13.6	3	na	
Crangon septemspinosus	13.8	2	4.5	5	.7	3
Ampelisca sp.	13.6	3	27.3	1	35.1	1
Asabellides oculata	12.2	4	22.7	2	34.3	2
Hydrozoa	8.8	5	9.1	4	na	
Fall:						
Plants	100.0	1	100.0	1	na	
Bryozoans	0		50.0	2	na	
Winter:						
Amphipoda	100.0	1	33.3	1	100.0	1

na = not applicable. Plant material and colonial animals cannot be counted as individual items.

the diet at the control site. These data suggest that the fishes were actively feeding at the borrow pit sites where they were captured. However, this result is certainly not definitive for two reasons. First, it is based only on one species of prey item. The second reason is that winter flounder do appear to feed selectively, and hence the gut content results may not necessarily parallel the relative abundance of A. oculata in the benthos.

DISCUSSION AND CONCLUSIONS

Our results suggest that fish abundance at the borrow pit sites was greater than at the shoal site. This is apparent by examining both the yearly total catches from the three sites (Appendix B), the seasonal trends in catches (Fig. 4), and the catches of individual species (Figs. 8 - 30). Differences between the pit sites and the shoal site were greatest during late summer and fall when total seasonal abundance was highest (Fig. 4). Differences among sites were not as clear during winter and spring when total abundance was low. Of the 10 most abundant species, anchovies, butterfish, winter flounder, weakfish, red hake, and silver hake, each appeared to be more abundant in the pits. However, mean size of individuals captured did not differ among sites for any species.

The overall seasonal trends in catches and relative abundance of different species reported herein are similar to those in previous investigations in Lower Bay. Wilk et al. (1977) conducted a comprehensive survey of fish distribution throughout the Lower Bay complex. Although their data are strictly tabulations, Brinkhuis (1980) has recently summarized their findings. Number of species and number of individuals were greatest during the fall. The 10 most common species captured during this period were Anchoa mitchilli, Alosa sapidissima, A. pseudoharengus, Cynoscion regalis, Engraulis eurystole, Peprilus triacanthus, Pseudopleuronectes americanus, Paralichthys dentatus, Urophycis chuss, and Urophycis regius. The spring and summer months were found to have the fewest number of species and fewest number of individuals. A subsequent study in Lower Bay by Gandarillas and Brinkhuis (1981) displayed similar trends. Hence, seasonal trends in abundance and species composition reported in this study are similar to those previously published.

The results of our study do not support previous speculations by other authors concerning the influence of subaqueous borrow pits on fish distribution and abundance. Murawski (1969) and Broughton (1977) reported that water in dredged holes was warmer than surrounding waters in winter and may thereby attract fishes. They further reported that dissolved oxygen levels during summer were low in pits in both New Jersey (Murawski, 1969) and Alabama (Broughton, 1977), and were not high enough to support fishes. Other investigators also believe that low oxygen levels caused fishes to avoid pits in the summer (Daiber et al., 1972; Harper, 1973; Polis, 1974). Our results, however, do not concur with these hypotheses. The pits studied in Lower Bay did not appear to have higher water temperatures during winter and did not act as fish concentrators in winter. In fact, differences among our shoal site and the pit sites were negligible in winter. Instead, we found that fish abundance in the borrow pits began increasing in late July and August when dissolved oxygen concentrations were near a yearly minimum. This increase in abundance was due largely to an influx of juveniles of several species that had probably been spawned in spring, and to an influx of anchovies. These data suggest that fishes are not avoiding the pits in Lower Bay due to low concentrations of oxygen. Changes in fish abundance during the year merely reflected the seasonal movement patterns of fishes on the Lower Bay as a whole. The fish assemblages of the Lower Bay do not represent geographically restricted populations but consist primarily of migratory species that appear only for a few months of the year.

In order to search for possible effects of the pits on the feeding of fishes, the stomach contents of winter flounder were compared among sites and to the results of the benthic survey by Cerrato and Scheier (1984). The data suggest differences in diet between the shoal site and the two borrow pits. It was also determined that, with the exception of Asabellides oculata, none of the dominant species in the benthic survey were major components in the diet of winter flounder. Even considering A. oculata alone, the distribution of winter flounder did not correlate well with the abundance of this benthic species. Few winter flounder were collected in July despite the high numbers of A. oculata in the benthic samples at the CAC pit. In November 1982, winter flounder peaked in the CAC pit but no A. oculata were found in benthic samples during this time. While the evidence suggests that winter flounder were feeding on the benthic fauna present on the pit floor, it does not appear that the benthic organisms in the pits are exerting a controlling influence on the fishes.

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APPENDIX A

DATE	DISSOLVED OXYGEN (ml/l) CAC	DISSOLVED OXYGEN (ml/l) CONTROL	DISSOLVED OXYGEN (ml/l) HS	TEMPERATURE (C) CAC	TEMPERATURE (C) CONTROL	TEMPERATURE (C) HS	SALINITY (ppt.) CAC	SALINITY (ppt.) CONTROL	SALINITY (ppt.) HS
FEB	---	---	---	2.19	1.68	1.70	30.00	22.70	26.90
MAR	---	---	---	2.85	3.36	2.99	27.56	24.94	28.32
APR	---	---	---	5.59	6.17	6.00	30.40	26.13	27.52
MAY	---	---	---	14.30	14.53	14.36	26.80	25.23	27.25
JUN	4.6	6.3	---	15.49	17.32	-----	26.85	25.04	-----
JUL	3.2	4.4	3.1	19.15	21.55	19.72	28.73	25.45	28.51
AUG	4.7	4.1	3.5	21.32	21.65	21.09	28.04	27.34	28.39
SEPT	3.9	4.7	4.9	18.72	18.86	18.75	28.39	27.70	28.82
OCT	4.1	4.2	4.2	17.55	17.42	17.48	28.49	27.92	29.13
NOV	6.0	6.1	5.7	9.84	10.22	10.64	28.61	25.48	28.84
DEC	---	---	---	----	6.90	7.26	-----	27.02	28.06
JAN	---	---	---	5.61	5.16	5.26	28.68	25.42	26.95

JANUARY 1983 SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.				0			8	8				0
Peprilus triacanthus				0				0				0
Pseudopleuronectes americanus	51	18	20	89	15	16	3	34	1	1		2
Cynoscion regalis				0				0				0
Alosa spp.	47	3	213	263	22	34	16	72	4	3	3	10
Urophycis chuss	32		74	106	3	2		5				0
Stenotomus chrysops				0				0				0
Merluccius bilinearis	29	4	71	104		1		1	65	99	60	224
Scophthalmus aquosus		3		3		2	1	3		1		1
Myoxocephalus octodecemspinosus	2	5	3	10	90	9	21	120	4	4	1	9
Paralichthys dentatus				0				0				0
Homarus americanus	1			1				0				0
Prionotus evolans	4			4	1			1				0
Leiostomus xanthurus				0				0				0
Etropus microstomus				0				0				0
Paralichthys oblongus				0				0				0
Centropristis striata		1		1				0				0
Loligo pealei				0				0				0
Mustelus canis				0				0				0
Tautogolabrus adspersus				0				0				0
Urophycis regius				0				0				0
Brevoortia tyrannus				0				0				0
Ammodytes americanus				0				0				0
Sphaeroides maculatus				0				0				0
Pomatomus saltatrix				0				0				0
Menidia menidia				0				0				0
Syngnathus fuscus				0				0	1			1
Conger oceanicus				0				0				0
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsonius				0				0				0
Number of Species	7	6	5		5	6	5		5	5	3	
Catch per Tow	166	34	381		131	64	49		75	108	64	
SITE SUMMARY												
Average number of species				6.00				5.33				4.33
Average Catch per Tow				193.67				81.33				82.33

DECEMBER 1982

SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.				0			1	1				0
Peprilus triacanthus				0				0				0
Pseudopleuronectes americanus				0	11	5	7	23	1	4		5
Cynoscion regalis				0				0				0
Alosa spp.				0	68	55	158	281	12	24		36
Urophycis chuss				0				0				0
Stenotomus chrysops				0				0				0
Merluccius bilinearis				0	5		5	10	1	3		4
Scophthalmus aquosus				0	1		3	4		5		5
Myoxocephalus octodecemspinosus				0	6	9	6	21				0
Paralichthys dentatus				0				0				0
Homarus americanus	NO			0				0		1		1
Prionotus evolans				0				0				0
Leiostomus xanthurus	TRAWLS			0				0				0
Etropus microstomus				0	1	2	2	5		1		1
Paralichthys oblongus	TAKEN			0				0		1		1
Centropristis striata				0				0				0
Loligo pealei				0				0			TRAWL	0
Mustelus canis				0				0				0
Tautogolabrus adspersus				0		1		1			#3	0
Urophycis regius				0				0				0
Brevoortia tyrannus				0				0			NOT	0
Ammodytes americanus				0				0				0
Sphaeroides maculatus				0				0			TAKEN	0
Pomatomus saltatrix				0				0				0
Menidia menidia				0	1			1	1			1
Syngnathus fuscus				0				0				0
Conger oceanicus				0				0				0
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsonius				0				0				0
Number of Species	0	0	0		7	5	7		4	7	0	
Catch per Tow	0	0	0		93	72	182		15	39	0	
SITE SUMMARY												
Average number of species				.00				6.33				3.67
Average Catch per Tow				.00				115.67				27.00

NOVEMBER 1982

SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.	1			1	1	1		2				0
Peprilus triacanthus	3	1		4	9	2	1	12	5		5	10
Pseudopleuronectes americanus	44	45	214	303	3	8	15	26	46	20	45	111
Cynoscion regalis	60	10	5	75	2			2			2	2
Alosa spp.	18	22		40	15	40	36	91	9	10	17	36
Urophycis chuss	46	65	102	213	1	1	1	3	2		5	7
Stenotomus chrysops				0				0				0
Merluccius bilinearis	105	54	18	177		4	14	18	7	7	14	28
Scophthalmus aquosus	8	15	3	26		3	8	11	1	1	5	7
Myoxocephalus octodecemspinosus	1			1	1			1			1	1
Paralichthys dentatus				0				0				0
Homarus americanus	1	1	3	5	2	1		3	5		1	6
Prionotus evolans				0				0				0
Leiostomus xanthurus	4			4				0				0
Etropus microstomus	2	1	1	4	2	2	3	7	1	2	1	4
Paralichthys oblongus	7	1	3	11		1	1	2			2	2
Centropristis striata		1	1	2				0				0
Loligo pealei				0				0				0
Mustelus canis				0				0				0
Tautogolabrus adspersus	1			1				0				0
Urophycis regius	4		5	9				0				0
Brevoortia tyrannus		1		1				0	1			1
Ammodytes americanus				0			1	1				0
Sphaeroides maculatus				0				0				0
Pomatomus saltatrix				0				0				0
Menidia menidia				0	1			1			1	1
Syngnathus fuscus				0				0				0
Conger oceanicus				0				0				0
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0				0
Synodus foetens				0			1	1				0
Hippocampus hudsionius				0				0				0
Number of Species	15	12	10		10	10	10		9	5	12	
Catch per Tow	305	217	355		37	63	81		77	40	99	
SITE SUMMARY												
Average number of species				12.33				10.00				8.67
Average Catch per Tow				292.33				60.33				72.00

OCTOBER 1982 SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.	9	40	30	79	100	32	15	147	72	106	67	245
Peprilus triacanthus	3	1	1	5	1	3		4	21	12	7	40
Pseudopleuronectes americanus	21	28	2	51				0	61	50	50	161
Cynoscion regalis	6	15		21	1			1	6	36	4	46
Alosa spp.				0				0				0
Urophycis chuss		1		1				0	3	6	1	10
Stenotomus chrysops				0				0	1	2	2	5
Merluccius bilinearis				0				0			1	1
Scophthalmus aquosus	1			1	4	3	11	18	3	2	2	7
Myoxocephalus octodecemspinosus				0				0		3		3
Paralichthys dentatus				0		1		1			1	1
Homarus americanus	3	10	2	15	1			1	4	3	7	14
Prionotus evolans				0				0				0
Leiostomus xanthurus		6	1	7				0	37	57	13	107
Etropus microstomus	1			1			2	2	8	8	15	31
Paralichthys oblongus	1	2	2	5	1		1	2	8	1	7	16
Centropristis striata		1		1				0		2	2	4
Loligo pealei				0				0			1	1
Mustelus canis		1		1				0		4		4
Tautogolabrus adspersus	2			2				0	1			1
Urophycis reglus				0				0				0
Brevoortia tyrannus				0				0				0
Ammodytes americanus				0				0				0
Sphaeroides maculatus				0				0			1	1
Pomatomus saltatrix		2		2				0				0
Menidia menidia				0				0				0
Syngnathus fuscus				0		1		1			1	1
Conger oceanicus				0				0				0
Lepophidium cervinum				0		1	1	2				0
Morone saxatilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsionius				0				0				0
Number of Species	9	11	6		6	6	5		12	14	17	
Catch per Tow	47	107	38		108	41	30		225	292	182	
SITE SUMMARY												
Average number of species				8.67				5.67				14.33
Average Catch per Tow				64.00				59.67				233.00

SEPTEMBER 1982

SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.	78	56	105	239	3	170	6	179	290	452	235	977
Peprilus triacanthus	106	84	55	245	6	3	16	25	118	51	97	266
Pseudopleuronectes americanus	2	23	45	70	1	1		2	18	32	34	84
Cynoscion regalis	387	37	9	433		1		1	62	9	80	151
Alosa spp.				0				0	1			1
Urophycis chuss	1	1	1	3				0	2		1	3
Stenotomus chrysops	4	7	9	20	4		1	5	9	9	15	33
Merluccius bilinearis				0				0				0
Scophthalmus aquosus	7	4	4	15		3	8	11	5	3	5	13
Myoxocephalus octodecemspinosus		3	1	4				0		5	10	15
Paralichthys dentatus	7		7	14		3		3	12	10	2	24
Homarus americanus		5	8	13				0	2		4	6
Prionotus evolans	6		1	7		1		1			1	1
Leiostomus xanthurus				0				0				0
Etropus microstomus		3	1	4	3		1	4	3	2	3	8
Paralichthys oblongus	3		3	6				0	8	4		12
Centropristis striata			1	1	1			1		1		1
Loligo pealei				0				0				0
Mustelus canis				0				0				0
Tautogolabrus adspersus				0				0				0
Urophycis regius				0				0				0
Brevoortia tyrannus				0				0				0
Ammodytes americanus				0				0				0
Sphaeroides maculatus	1		1	2	2			2		1		1
Pomatomus saltatrix	2		1	3				0	10		20	30
Menidia menidia				0				0				0
Syngnathus fuscus				0				0		1		1
Conger oceanicus				0				0				0
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0			1	1
Synodus foetens				0				0				0
Hippocampus hudsionius				0				0		1		1
Number of Species	12	10	16		7	7	5		13	14	14	
Catch per Tow	604	223	252		20	182	32		540	581	508	

SITE SUMMARY	CAC TOTAL	CNTL TOTAL	HS TOTAL
Average number of species	12.67	6.33	13.67
Average Catch per Tow	359.67	78.00	543.00

AUGUST 1982

SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.	182	414	132	728	13	24	36	73	691	385	922	1998
Peprilus triacanthus	565	180	51	796	44	47	92	183	115	24	131	270
Pseudopleuronectes americanus	12	6	19	37	3		3	6	2		3	5
Cynoscion regalis	39	178	9	226				0	3	7	21	31
Alosa spp.				0				0	1	2	2	5
Urophycis chuss				0				0				0
Stenotomus chrysops	6	1		7	1			1	1	61		62
Merluccius bilinearis				0		1		1				0
Scophthalmus aquosus	2	1		3	2	6	4	12				0
Myoxocephalus octodecemspinosus		1		1		1		1		1		1
Paralichthys dentatus	5	15	10	30	2	3		5	6	2	17	25
Homarus americanus	6	1	3	10				0		1		1
Prionotus evolans				0				0	1			1
Leiostomus xanthurus				0				0				0
Etropus microstomus	1	4	1	6			1	1	1			1
Paralichthys oblongus				0				0				0
Centropristis striata		2		2				0	3	3		6
Loligo pealei	23	24		47		1		1				0
Mustelus canis	1			1				0	2		1	3
Tautogolabrus adspersus		1	1	2				0		8		8
Urophycis regius				0				0				0
Brevoortia tyrannus				0				0				0
Ammodytes americanus				0				0	1			1
Sphaeroides maculatus				0				0				0
Pomatomus saltatrix				0				0			2	2
Menidia menidia				0				0				0
Syngnathus fuscus				0				0				0
Conger oceanicus				0				0				0
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsionius				0				0				0
Number of Species	11	13	8		6	7	5		12	10	8	
Catch per Tow	842	828	226		65	83	136		827	494	1099	
SITE SUMMARY												
Average number of species				10.67				6.00				10.00
Average Catch per Tow				632.00				94.67				806.67

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JULY 1982 SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.	50	1134	7	1191				0	894			894
Peprilus triacanthus	1			1				0				0
Pseudopleuronectes americanus	3	3	6	12	2	8	1	11	4	12	10	26
Cynoscion regalis	1	1		2				0				0
Alosa spp.				0				0				0
Urophycis chuss	5			5				0			1	1
Stenotomus chrysops				0		234	1	235		295	54	349
Merluccius bilinearis				0				0				0
Scophthalmus aquosus	5	5	5	15			1	1	1	3		4
Myoxocephalus octodecemspinosus				0		5		5				0
Paralichthys dentatus	5	5	7	17		1	3	4	1	3	2	6
Homarus americanus	1			1				0	1			1
Prionotus evolans				0		2		2				0
Leiostomus xanthurus				0				0				0
Etropus microstomus				0				0				0
Paralichthys oblongus				0				0				0
Centropristis striata				0		17	1	18		12	3	15
Loligo pealei				0				0				0
Mustelus canis		2	5	7				0	2	1	12	15
Tautogolabrus adspersus				0		4		4				0
Urophycis regius		5		5				0	1	.	2	3
Brevoortia tyrannus		3		3				0				0
Ammodytes americanus				0				0				0
Sphaeroides maculatus	1			1		1		1				0
Pomatomus saltatrix				0				0			2	2
Menidia menidia				0				0				0
Syngnathus fuscus				0				0				0
Conger oceanicus				0				0				0
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsionius				0				0				0
Number of Species	9	8	5		1	8	5		7	6	8	
Catch per Tow	72	1158	30		2	272	7		904	326	86	
SITE SUMMARY												
Average number of species				7.33				4.67				7.00
Average Catch per Tow				420.00				93.67				438.67

JUNE 1982

SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.	48			48	4	3		7				0
Peprilus triacanthus	1			1	1			1				0
Pseudopleuronectes americanus				0	1	3	2	6				0
Cynoscion regalis				0				0				0
Alosa spp.	2			2				0				0
Urophycis chuss	16			16				0				0
Stenotomus chrysops				0				0				0
Merluccius bilinearis				0				0				0
Scophthalmus aquosus	2			2		2		2				0
Myoxocephalus octodecemspinosus				0				0		NO		0
Paralichthys dentatus		TRAWLS		0		1	1	2				0
Homarus americanus				0	1			1		TRAWLS		0
Prionotus evolans		#2 AND #3		0				0				0
Leiostomus xanthurus				0				0		TAKEN		0
Etropus microstomus		NOT TAKEN		0				0				0
Paralichthys oblongus				0				0				0
Centropristis striata	1			1		1		1				0
Loligo pealei				0				0				0
Mustelus canis	1			1				0				0
Tautogolabrus adspersus				0				0				0
Urophycis regius				0				0				0
Brevoortia tyrannus				0				0				0
Ammodytes americanus				0				0				0
Sphaeroides maculatus				0				0				0
Pomatomus saltatrix				0				0				0
Menidia menidia				0				0				0
Syngnathus fuscus				0				0				0
Conger oceanicus				0				0				0
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsonius				0				0				0
Number of Species	7	0	0		4	5	2		0	0	0	
Catch per Tow	71	0	0		7	10	3		0	0	0	
SITE SUMMARY												
Average number of species				2.33				3.67				.00
Average Catch per Tow				71.00				6.67				.00

MAY 1982 SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.	14		2	16				0				0
Peprilus triacanthus				0	3			3				0
Pseudopleuronectes americanus	5	4	9	18				0	5	12	18	35
Cynoscion regalis				0				0				0
Alosa spp.	2	3	11	16				0				0
Urophycis chuss	130	95	90	315		1	4	5	3	19	16	38
Stenotomus chrysops				0				0				0
Merluccius bilinearis	2	5	3	10				0			1	1
Scophthalmus aquosus	50	34	54	138	1	5	7	13	10	5	11	26
Myoxocephalus octodecemspinosus				0				0			1	1
Paralichthys dentatus				0	1		1	2	1	1	1	3
Homarus americanus	1	1	3	5				0		1	9	10
Prionotus evolans				0				0	7	19	85	111
Leiostomus xanthurus				0				0				0
Etropus microstomus				0				0				0
Paralichthys oblongus				0				0				0
Centropristis striata				0				0				0
Loligo pealei				0				0				0
Mustelus canis				0				0				0
Tautogolabrus adspersus				0				0				0
Urophycis regius				0				0				0
Brevoortia tyrannus	6			6				0				0
Ammodytes americanus				0				0	1			1
Sphaeroides maculatus				0				0				0
Pomatomus saltatrix				0				0				0
Menidia menidia				0				0				0
Syngnathus fuscus				0				0				0
Conger oceanicus				0				0			15	15
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsonius				0				0				0
Number of Species	8	6	7		3	2	3		6	6	9	
Catch per Tow	210	142	172		5	6	12		27	57	157	
SITE SUMMARY												
Average number of species				7.00				2.67				7.00
Average Catch per Tow				174.67				7.67				80.33

APRIL 1982 SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.				0				0	1		1	2
Peprilus triacanthus				0				0				0
Pseudopleuronectes americanus	14	6	17	37	29	37	13	79	17	14	1	32
Cynoscion regalis				0				0				0
Alosa spp.	2			2			7	7	1			1
Urophycis chuss	2	4	1	7				0	1		1	2
Stenotomus chrysops				0				0				0
Merluccius bilinearis				0				0				0
Scophthalmus aquosus	2		9	11	12	9	2	23	1		1	2
Myoxocephalus octodecemspinosus	1			1				0	1			1
Paralichthys dentatus				0				0				0
Homarus americanus			1	1			1	1	6	5	4	15
Prionotus evolans				0				0				0
Leiostomus xanthurus				0				0				0
Etropus microstomus				0				0				0
Paralichthys oblongus				0				0				0
Centropristis striata				0				0				0
Loligo pealei				0				0				0
Mustelus canis				0				0				0
Tautogolabrus adspersus				0				0				0
Urophycis regius				0				0				0
Brevoortia tyrannus				0				0				0
Ammodytes americanus				0				0				0
Sphaeroides maculatus				0				0				0
Pomatomus saltatrix				0				0				0
Menidia menidia				0				0				0
Syngnathus fuscus				0				0				0
Conger oceanicus		2		2				0				0
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsionius				0				0				0
Number of Species	5	3	4		2	2	4		7	2	5	
Catch per Tow	21	12	28		41	46	23		28	19	8	
SITE SUMMARY												
Average number of species				4.00				2.67				4.67
Average Catch per Tow				20.33				36.67				18.33

MARCH 1982 SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.				0				0				0
Peprilus tricanthus				0				0				0
Pseudopleuronectes americanus	40	40	14	94	14	26	33	73	15	18	9	42
Cynoscion regalis				0				0				0
Alosa spp.				0		3	1	4				0
Urophycis chuss		2		2		1		1	1	1		2
Stenotomus chrysops				0				0				0
Merluccius bilinearis				0				0				0
Scophthalmus aquosus	1	26	8	35	1	3	8	12	1	1	1	3
Myoxocephalus octodecimspinosus	2	1		3				0		1		1
Paralichtys dentatus				0				0				0
Homarus americanus		1	1	2				0	1	2	5	8
Prionotus spp.				0				0				0
Leiostomus xanthurus				0				0				0
Etropus microstomus				0				0				0
Paralichtys oblongus				0				0				0
Centropristis striata				0				0				0
Loligo pealei				0				0				0
Mustelus canis				0				0				0
Tautoglabrus adspersus				0				0				0
Urophycis chuss				0				0				0
Brevoortia tyrannus				0				0				0
Ammodytes americanus				0				0				0
Sphaeroides maculatus				0				0				0
Pomatus saltatrix				0				0				0
Menidia menidia				0				0				0
Syngnathus fuscus				0		1		1				0
Conger oceanicus				0				0				0
Lepophidium cervinum				0				0				0
Morone saxitilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsionius				0				0				0
Number of Species	3	5	3		2	5	3		4	5	3	
Catch per Tow	43	70	23		15	34	42		18	23	15	
SITE SUMMARY												
Average number of species				3.67				3.33				4.00
Average Catch per Tow				45.33				30.33				18.67

FEBURARY 1982

SPECIES	CAC #1	CAC #2	CAC #3	CAC TOTAL	CNTL #1	CNTL #2	CNTL #3	CNTL TOTAL	HS #1	HS #2	HS #3	HS TOTAL
Anchoa spp.				0				0				0
Peprilus triacanthus				0				0				0
Pseudopleuronectes americanus	5	5	30	40	2	5	2	9	5	3	2	10
Cynoscion regalis				0				0				0
Alosa spp.	1	1	4	6				0	2		1	3
Urophycis chuss				0				0				0
Stenotomus chrysops				0				0				0
Merluccius bilinearis				0				0				0
Scophthalmus aquosus	6	10	40	56	2	1	2	5	3	4	4	11
Myoxocephalus octodecemspinosus	5		9	14	1			1	3			3
Paralichthys dentatus				0				0				0
Homarus americanus				0				0	1	2	4	7
Prionotus evolans				0				0				0
Leiostomus xanthurus				0				0				0
Etropus microstomus				0				0				0
Paralichthys oblongus				0				0				0
Centropristis striata		1	1	2				0		1		1
Loligo pealei				0				0				0
Mustelus canis				0				0				0
Tautogolabrus adspersus				0				0				0
Urophycis regius				0				0				0
Brevoortia tyrannus				0				0				0
Ammodytes americanus	14			14		2	2	4				0
Sphaeroides maculatus				0				0				0
Pomatomus saltatrix				0				0				0
Menidia menidia				0			1	1				0
Syngnathus fuscus				0				0				0
Conger oceanicus				0				0				0
Lepophidium cervinum				0				0				0
Morone saxatilis				0				0				0
Synodus foetens				0				0				0
Hippocampus hudsionius				0				0				0
Number of Species	5	4	5		3	3	4		5	4	4	
Catch per Tow	31	17	84		5	8	7		14	10	11	
SITE SUMMARY												
Average number of species				4.67				3.33				4.33
Average Catch per Tow				44.00				6.67				11.67

APPENDIX C

Alosa spp.

Cruise Date	CAC # Measured	CAC Mean Length	CONTROL # Measured	CONTROL Mean Length	HS # Measured	HS Mean Length
Febuary	6	7.67			3	9.33
March			4	10.25		
April	2	10.5	7	28.36	1	9
May	16	15.69				
June	2	13				
July						
August					5	8.8
September					1	10.5
October						
November	40	12.6	92	10.36	36	11.1
December			60	10.72	33	10.77
January	43	10.7	56	10.75	9	12.67
YEAR SUMMARY						
# MEASURED	109		219		88	
MEAN LENGTH		12.00		11.13		10.91

Peprilus triacanthus

Cruise Date	CAC # Measured	CAC Mean Length	CONTROL # Measured	CONTROL Mean Length	HS # Measured	HS Mean Length
Febuary						
March						
April						
May			3	10.67		
June	1	2	1	4		
July	1	5				
August	61	3.19	150	3.26	65	4.5
September	60	4.69	25	3.6	65	5.66
October	5	10	4	8.13	40	9.64
November	4	10.25	12	11.75	10	15.35
December						
January						
YEAR SUMMARY						
# MEASURED	132		195		180	
MEAN LENGTH		4.35		4.04		6.66

All Lengths in Cm.

Pseudopleuronectes americanus

	CAC		CONTROL		HS	
Cruise Date	# Measured	Mean Length	# Measured	Mean Length	# Measured	Mean Length
Febuary	40	17.9	9	18.2	10	18.4
March	94	15.8	76	18.6	42	27.6
April	47	15.1	79	15.8	31	31.7
May	18	22.7			35	16
June			6	18.1		
July	12	12.4	10	16.5	26	16.2
August	36	17.7	6	17.3	5	17.5
September	70	17	2	15.8	84	14.9
October	51	19.56			161	17.44
November	93	17.93	26	15.77	111	17.55
December			23	21.09	5	21.2
January	63	13.4	34	18.35	2	12
YEAR SUMMARY						
# MEASURED	524		271		512	
MEAN LENGTH		16.80		17.54		14.85

Cynoscion regalis

	CAC		CONTROL		HS	
Cruise Date	# Measured	Mean Length	# Measured	Mean Length	# Measured	Mean Length
Febuary						
March						
April						
May						
June						
July	2	77				
August	78	4.9			31	4.03
September	29	7.22	1	3.5	47	6.54
October	21	11.05	1	10	46	9.41
November	68	11.35	1	21	2	10.75
December						
January						
YEAR SUMMARY						
# MEASURED	198		3		126	
MEAN LENGTH		8.60		11.50		7.04

All Lengths in Cm.

Urophycis chuss

Cruise Date	CAC # Measured	CAC Mean Length	CONTROL # Measured	CONTROL Mean Length	HS # Measured	HS Mean Length
Febuary						
March	2	15.25	1	20	2	18.5
April	7	13.93			2	11.5
May	129	14.67	5	7.7	38	6.57
June	16	14.34				
July	5	9.6			1	10
August						
September	3	20.83			3	21.33
October	1	7			10	12.4
November	211	20.85	2	9.25	7	11.68
December						
January	40	17.33	5	11.8		
YEAR SUMMARY						
# MEASURED	414		13		63	
MEAN LENGTH		18.02		10.46		9.37

Merluccius bilinearis

Cruise Date	CAC # Measured	CAC Mean Length	CONTROL # Measured	CONTROL Mean Length	HS # Measured	HS Mean Length
Febuary						
March						
April						
May	10	8.25				
June						
July						
August			1	5		
September						
October						
November	171	14.63	18	12.78	28	13.05
December			10	15.75	4	12.63
January	44	17.02	1	16	60	14.98
YEAR SUMMARY						
# MEASURED	225		30		92	
MEAN LENGTH		14.82		13.62		14.29

All Lengths in Cm.

Myoxocephalus octodecimspinosus

Cruise Date	CAC # Measured	CAC Mean Length	CONTROL # Measured	CONTROL Mean Length	HS # Measured	HS Mean Length
Febuary	51	17.5	161	17.3	93	17.48
March	26	14.58			111	17.29
April	23	20.3			5	19.3
May					63	13.37
June						
July			34	18.88		
August	2	6.25	1	3.5	1	13.5
September	4	9.5			21	6.57
October					3	10
November	1	10	1	2	1	30
December			21	28.67		
January	10	21.6	50	26.12	9	8
YEAR SUMMARY						
# MEASURED	117		268		307	
MEAN LENGTH		17.03		15.10		15.53

Paralichtys dentatus

Cruise Date	CAC # Measured	CAC Mean Length	CONTROL # Measured	CONTROL Mean Length	HS # Measured	HS Mean Length
Febuary						
March						
April						
May			2	36.5	3	35.67
June			2	36.25		
July	17	42.76	4	40	6	37.08
August	30	39.05	5	36.2	25	40.34
September	14	38.71	3	38.33	23	37.22
October			1	42	1	39
November						
December						
January						
YEAR SUMMARY						
# MEASURED	61		17		58	
MEAN LENGTH		40.01		37.85		38.50

All Lengths In Cm.

Scophthalmus aquosus

Cruise Date	CAC # Measured	CAC Mean Length	CONTROL # Measured	CONTROL Mean Length	HS # Measured	HS Mean Length
Febuary	55	10.36	5	10.8	11	11.27
March	31	12.71	12	16.33	3	19.33
April	11	19.5	23	17.72	2	16.5
May	137	26.95	13	22.42	26	24.29
June	2	34.5				
July	13	16.38			4	17.63
August	3	16.5	12	7.92		
September	15	14.8	11	13.45	12	13.5
October	1	16	18	14.28	7	17.64
November	25	15.56	11	13.14	7	18.86
December			4	15.38	5	19.4
January	3	10.33	3	15	1	16
YEAR SUMMARY						
# MEASURED	296		112		78	
MEAN LENGTH		19.67		15.18		13.43

Stenotomus chrysops

Cruise Date	CAC # Measured	CAC Mean Length	CONTROL # Measured	CONTROL Mean Length	HS # Measured	HS Mean Length
Febuary						
March						
April						
May						
June						
July			123	14.17	132	13.23
August	7	15.14	1	15	62	13
September	20	14.2	5	6.4	33	14.21
October					5	13.5
November						
December						
January						
YEAR SUMMARY						
# MEASURED	27		129		232	
MEAN LENGTH		14.44		13.88		13.31

All Lengths in Cm.

Homarus americanus

	CAC		CONTROL		HS	
Cruise Date	# Measured	Mean Length	# Measured	Mean Length	# Measured	Mean Length
Febuary					7	23.29
March	2	25.5			8	24.63
April	1	21	1	30.5	15	23.37
May	5	19.2			10	20.2
June			1	34		
July	1	20			1	30
August	10	25			1	25.5
September	13	27.04			6	22.17
October	15	18.67	1	16	14	21.43
November	5	24.8	3	12.33	6	29.25
December					1	23
January	1	20				
YEAR SUMMARY						
# MEASURED	53		6		69	
MEAN LENGTH		22.90		19.58		23.17

All Lengths in Cm.

DUE DATE ____________