MAINE YANKEE

BIOLOGICAL MONITORING REPORT

January - December 1979

ENVIRONMENTAL STUDIES DEPARTMENT

MAINE YANKEE ATOMIC POWER COMPANY

EDISON DRIVE

AUGUSTA, MAINE 04336

April 1980

PREFACE

This report is presented in two parts. Part I contains the results of studies performed by the Ira C. Darling Center, University of Maine from January through June 1979. Part II contains the balance of the results for 1979. These data were collected by Maine Yankee Environmental Studies Department personnel.

TABLE OF CONTENTS

Introduction

This report contains the results of the environmental monitoring programs conducted during 1979 in the vicinity of the Maine Yankee Nuclear Generating Station, Wiscasset, Maine. The study programs in this report, some that have been ongoing for ten years, are designed to determine the major ecological effects of plant operation on the Montsweag Bay - Sheepscot River estuarine system. This work was performed in accordance with the monitoring requirements of the Maine Yankee NPDES permit and State Waste Discharge License and the report is submitted to the U. S. Environmental Protection Agency and the Maine Department of Environmental Protection.

Readers familiar with this series of reports will note that the biological monitoring requirements discussed herein are essentially the same as those that were formerly conducted for the U. S. Nuclear Regulatory Commission (NRC). In January 1979 the NRC determined that the operation of Maine Yankee had no demonstrable adverse impact to the aquatic environment and deleted the environmental technical specifications.

Monthly average reactor thermal power levels since plant startup are shown in Figure 1. Maine Yankee was shut down during two periods in 1979. From 15 March to 5 June, Maine Yankee was shutdown in compliance with an NRC show-cause order that required seismic reanalysis of some piping systems. The reanalysis conclusively showed that the piping systems in question more than adequately satisfied the design basis earthquake criteria. A scheduled outage during September allowed for transformer replacement and maintenance.

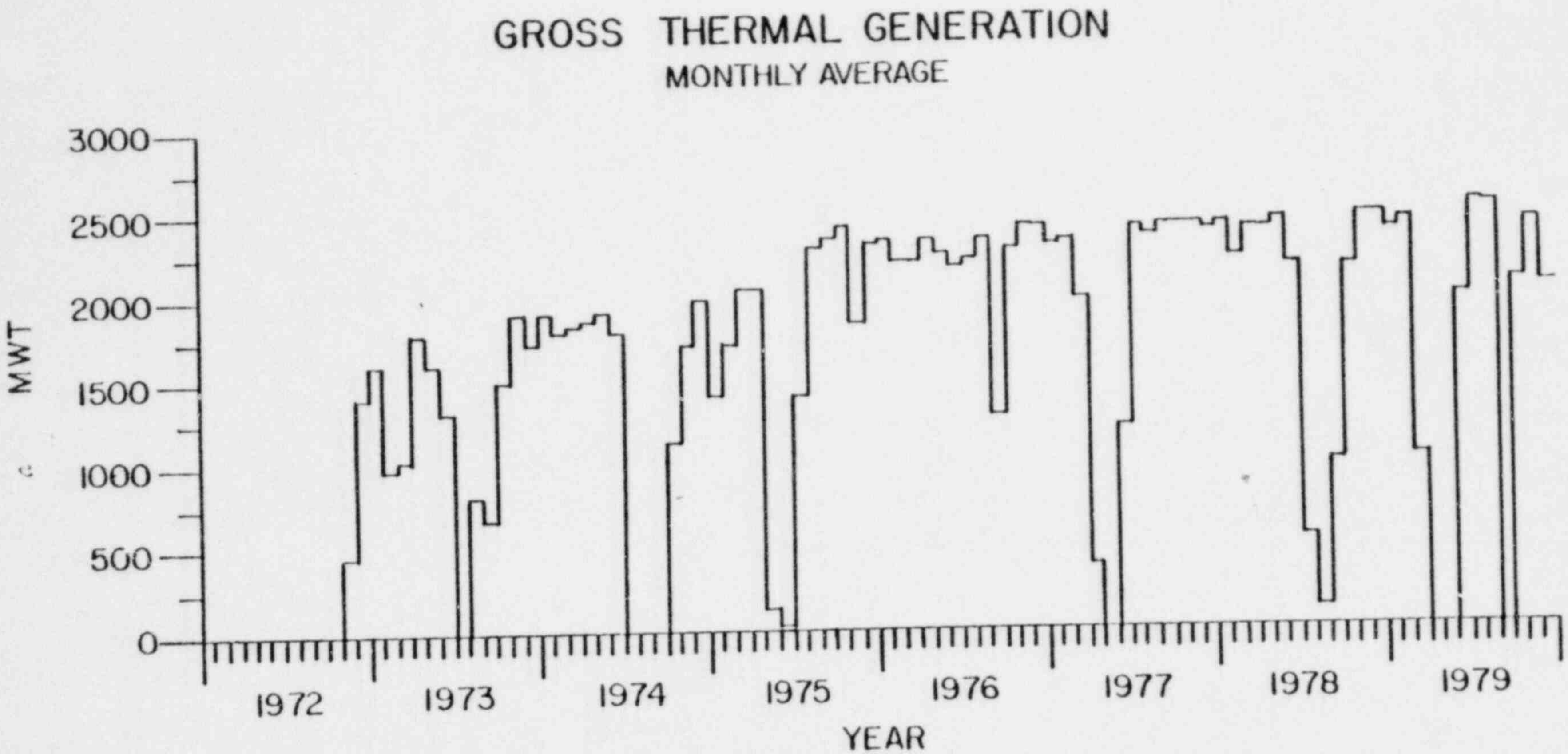

Figure 1. Monthly average thermal power levels at Maine Yankee.

PART I

MONITORING OF THE EFFECTS OF THE CONDENSER COOLING WATER SYSTEM ON PLANKTON AND LARVAL ORGANISMS

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Introduction

The objectives of this study are to determine the abundance and survival of phytoplankton and zooplankton (including ichthyoplankton) entrained by the condenser cooling water at the Maine Yankee Nuclear Generating Station, Wiscasset, Maine, and to assess whether mortality is due to thermal stress, mechanical stress, or both. The study began in July 1972. The present report covers the period 1 January to 30 June 1979 and is divided into two sections. The first concerns monitoring of the condenser cooling system and laboratory studies to determine the thermal tolerance of several species of icthyoplankton. The second is a report of studies of the thermal tolerance of the larvae of *Placopecten magellanicus*, the giant sea scallop, and *Mya arenaria*, the soft-shelled clam.

Phytoplankton, Microzooplankton, and Macrozooplankton

Methods

Samples for the evaluation of the effects of entrainment on phytoplankton and microzooplankton were collected at semimonthly intervals at the plant intake and the discharge weir. During the present report period, no samples could be collected during a plant shutdown (15 March to 6 June).

Ira C. Darling Center Ref. No. 79-7a

Since 11 September 1978, sampling at the plant site has been coordinated with sampling at station M2 in Montsweag Bay for phytoplankton and microzooplankton. In most cases samples were collected on the same day and at approximately the same stage of tide at both sites. The purpose behind coordinating these sampling efforts was to maximize the possibility of sampling the same water mass and the associated planktonic organisms. Phytoplankton and microzooplankton samples collected at M2 and the intake under these conditions generally were similar, though occasionally differences in species composition and density were found. Attempts to coordinate entrainment sampling with ichthyoplankton and macrozooplankton sampling in Montsweag Bay were not successful because of different constraints on the sampling programs.

Since 23 October 1978 intake samples have been collected outside the pumphouse between the trash racks and the traveling screens. Discharge samples were collected in the seal pit before the discharge weir. Samples were collected at low tide; this prevents dilution or contamination of condenser discharge water by water which has already passed over the discharge weir.

In addition to the biological data, temperature, salinity, and dissolved oxygen (D.O.) were measured. Water samples were collected with a 2-liter Van Dorn bottle at the same depth and location as the plankton samples. Temperature was measured with a mercury thermometer or a YSI telethermometer. Salinity was determined in the laboratory using a Beckman RS-7A induction salinometer. Dissolved oxygen was determined using Hach Chemical Co., Ames, Iowa, reagents in a modification of the Winkler method.

Planktonic diatoms and microzooplankton were collected with a 30 cm metered #20 plankton net (76μm mesh). Six tows were taken at each location. The duration of the tows varied with the seasonal density of the plankters, and sample density was kept to a minimum to avoid overcrowding. To minimize the effects of patchiness, tows 1, 3, and 5 were combined for zooplankton, and tows 2, 4, and 6 were combined for diatoms. These combined samples were split in the field with a Folsom splitter to obtain equal subsamples for field and experimental survival determinations. The subsamples were placed in glass containers, diluted, and stored in insulated boxes. Approximately 30 minutes after the last sample was collected at the discharge weir, the discharge samples were screened on a #20 mesh sieve to retain the plankton which was then transferred to intake water at ambient temperature. This procedure simulated the return to ambient temperature experienced as entrained plankton mixes with Montsweag Bay water at the diffuser discharge. To reduce copepod grazing on diatoms, 0.25 ml of a 0.5% solution of rotenone dust in distilled water was added to each 500 ml of phytoplankton subsample (Crippen and Perrier, 1974). Normally there was a delay of approximately one hour between the collection of intake and discharge samples.

As part of a special study to evaluate the effects of the operation of the Ammertap system on planktonic organisms passing through the condenser cooling system, additional plankton samples were collected on 12 June 1979. Sampling was carried out simultaneously at the intake and discharge without the Ammertap system on. The Ammertap system was turned on and additional discharge samples were collected.

Survival determinations were made on field diatom samples 24 hours after collection and on experimental diatom samples 24 hours after testing using the Evans blue staining technique described by Crippen and Perrier (1974). Samples were concentrated and aliquots withdrawn until a minimum of 100 cells had been counted for each species (or genus in some cases) which was sufficient abundant such that this number of cells could be counted in the time available. Identifications and survival determinations were routinely made at 100x in a Palmer cell. This counting chamber which has a volume of 0.1 ml allows the use of higher power objectives when necessary.

A neutral red vital staining technique (Crippen and Perrier, 1974) was used to determine the survival of microzooplankters one and 24 hours after collection of field samples and 24 hours after exposure to elevated temperature for the experimental samples. The 1- and 24-hour survival determinations of the field samples enabled the evaluation of both immediate and delayed effects of entrainment. Gridded Sedgwick-Rafter cells were used as counting chambers for zooplankton survival determinations. Samples were analyzed in a relatively concentrated state and if any organisms were extremely abundant the sample was diluted for counting those organisms. Organisms were identified to species whenever possible.

Water samples were collected for the determination of diatom densities. Three combined 2-liter Van Dorn bottle samples were subsampled. This subsample of approximately 0.8 liters was preserved with Lugol's solution, allowed to settle for 24 hours, and then concentrated. The samples were not analyzed for this period. Zooplankton densities were determined from the volume of water sampled, the volume of the sample, and the number of individuals counted in the survival determinations.

The survival for each intake and discharge sample, field and experimental, was expressed as a percent and was calculated in the following manner:

$$\text{Percent survival} = \frac{\text{Number of living organisms}}{\text{Number of total organisms}} \times 100$$

A corrected percent survival (CPS), which compensates for mortalities due either to natural causes or sampling procedures, was then calculated in the following manner for each pair of intake and discharge samples:

$$CPS = \frac{\text{\% survival in discharge sample}}{\text{\% survival in intake sample}} \times 100$$

Percent survival was not calculated for diatoms if the category being considered had fewer than 100 cells, or for zooplankters if the category had fewer than 30 individuals.

Laboratory experiments subjecting phytoplankton and microzooplankton to a simulated temperature regime (STR) were conducted in conjunction with the field surveys on 12 and 26 June 1979. Samples were exposed to the discharge temperature observed on that date. Other details of the procedure are given in Lindsay and Barker (1975). The experiment was not completed from 1 January to 5 March because high survival in the field samples obviated their analysis. On 26 June the experiment was not completed in the case of the phytoplankton sample because of low survival in the control sample.

Laboratory experiments were conducted to determine the tolerance of larval *Placopecten magellanicus*, the sea scallop, to various time-temperature combinations that might be experienced during entrainment. The effect of acclimation temperature on the resistance of larval *Mya arenaria*, the soft-shelled clam, to thermal stress was also investigated. Additional studies introduced salinity as a factor in affecting survival of the larvae of these two species. Methods were similiar to those described in Lindsay and Barker (1977). Results of these experiments are reported in the second section of this report.

Until July 1978 monitoring studies of zooplankton entrained at Maine Yankee have not included macrozooplankton on a routine basis. This size fraction of zooplankton has been reported only as it occurred incidental to the collection of microzooplankton. The nets used for the collection of microzooplankton are not efficient in the collection of larger organisms which are relatively rare or show avoidance responses. Since July 1978 macrozooplankton has been sorted from quantitative ichthyoplankton samples to determine abundance and species composition. Results for the period 1 July 1978 to 30 June 1979 are included in this report.

Results

Chemical and physical data routinely collected during the 1 January to 30 June 1979 sampling period are given in Table 1. The highest discharge temperature was 35.8°C. Mean ΔT for the period 1 January to 30 June was 17.7°C (standard deviation 1.5°C). Dissolved oxygen concentrations were consistently lower at the discharge seal pit.

The percent survival of those species or genera of diatoms for which 100 cells or more were present at the intake or discharge is presented in Table 2. The CPS could only be calculated when 100 cells or more were counted in both the intake and discharge sample. Summary data for the genera *Chaetoceros*, *Coscinodiscus*, and *Tabellaria* are also presented in Table 2. Survival was high from January until early March. No samples were collected during the shutdown period. In June, after the power plant was back on line, the survival was generally lower. It should be noted that on 26 June survival was low in the intake sample for all species except *Skeletonema costatum*. The resulting high corrected percent survival estimates are probably unrealistic. The laboratory simulations of condenser cooling water temperature exposures, completed only on 12 June, resulted in a similar CPS as that which was found in field samples. Survival was comparable in samples collected with and without the Ammertap system in operation.

The density of microzooplankton, shown in Table 3, was generally low during January and February. There was an increase in density on 5 March when larvae of *Scolecolepides viridis* were abundant. Greatest densities of microzooplankton were found during June. Table 3 gives the density of the categories of microzooplankton for which sufficient numbers were present to calculate percent survival. *Pseudocalanus minutus* copepodites and *Microsetella norvegica* adults and copepodites were the most abundant organisms during January and February. An exception was 20 February when *Acartia* spp. nauplii were more abundant than *Pseudocalanus* copepodites. Large numbers of *Scolecolepides viridis* eggs were present along with relatively large numbers of *Balanus* nauplii on 5 March. The greatest abundance of any one organism during the sampling period was that of *Synchaeta* sp. on 12 June. Also abundant on that date and the following date in June were setiger larvae of unidentified spionids. On 26 June *Acartia* spp. nauplii were the most abundant organisms.

Survival of the primary components of the microzooplankton is shown in Tables 4 and 5. With a few exceptions survival was generally high during January and February. Survival was low on 5 March and lowest during June, particularly for the abundant species. In most cases there was comparable survival between samples examined one hour and those examined 24 hours after transit through the condenser cooling system. The two most obvious inconsistencies were the survival of *Acartia* spp. nauplii on

12 June and the survival of spionid setigers on 26 June. In both cases the survival in the sample examined after 24 hours was higher than the sample examined at one hour after transit through the cooling system.

The macrozooplankton collected during the entrainment study was similar in species composition to those sampled by bouyed and anchored nets in Montsweag Bay (Jaeger, et. al., 1978). Members of the class Crustacea were well represented (see Table 6). The amphipods were one of the most prevelant groups and two species, *Jassa falcata* and *Corophium insidiosum*, were noteworthy in that they were present in almost every sample.

Discussion and conclusions

It appears that during the colder months diatom cell loss was minimal. High survival of diatom species between January and early March is consistent with findings from previous years (Lindsay et al., 1978; Barker et al., 1979). The low survival in early June was also consistent with previous results. Two factors make interpretation of the data difficult but do not change the conclusion of relatively high cell loss during the month of June. The first is the observation that there were fewer cells in the discharge samples taken in June in comparision to the corresponding intake samples. This absence of cells has been reported before (Barker, et al., 1979) and is apparently the result of cell destruction during transit through the condenser cooling system. It would be expected that cell debris would be present in the discharge samples from that month but such was not the case. This discrepancy in cell numbers between the intake and discharge was not found during the colder months of the year which indicates that the cell loss is temperature related. The second factor which makes interpretation of the data difficult was the low survival in the intake sample on 26 June. This was caused by a combination of holding temperature and large numbers of dead zooplankton present in the samples (killed by the addition of rotenone as a measure to reduce grazing).

It appears that though there may be some losses of microzooplankton during the months of January and February, survival was generally high. The mortality within some groups of microzooplankton during the months of March and June was consistent with previous findings (Lindsay et al., 1978; and Barker et al., 1979). It was previously noted (Barker et al., 1979) that differences in tolerance between taxa explained, in part, the observed drop in survival during April and May 1978 when *Pseudocalanus* developmental stages were abundant and exposure temperatures were increasing. This was followed by higher survival in June when *Acartia* developmental stages were present. A similar sequence of events occurred in 1979. In this case the observed mortalities occurred in March, a month earlier than the previous year. This was apparently due to the fact that higher discharge temperatures occured earlier in the year. It is noteworthy that *Acartia* spp. nauplii present on 12 June 1979 exhibited survival comparable to that of the nauplii present during June 1978. It appears that the discharge temperature of 35.8°C present on 26 June was lethal to both nauplii and copepodites of this genus. The copepod *Saphirella* sp. and spionid setigers were the only organisms to survive in reasonable numbers.

The Ammertap system appears to have negligible effect on the microzooplankton.

The numbers of individuals collected in the macrozooplankton samples precludes any conclusions about changes in abundances that may have occurred in Montsweag Bay as the result of losses due to entrainment. A comparison of densities of organisms in buoyed and anchored net samples and entrainment samples shows that the entrainment samples appear to undersample the macrozooplankton. This discrepancy could result from sampling during daylight hours when the macrozooplankton are less active.

Ichthyoplankton

Methods

Plankton tows were taken at the intake and discharge to determine the abundance, species composition, and mortality of entrained larval fishes. During the present report period, no samples could be collected during plant shutdown (15 March to 6 June). The tows were taken by suspending weighted 30 cm and 50 cm diameter #2 mesh (0.36 mm) nets in the water as it was pumped through the plant. Prior to 23 October 1978 intake samples were taken inside the circulating water pumphouse after the water had passed through the traveling screens (1 cm mesh) and just before it entered the pumps. During the present report period, samples were taken outside the pumphouse, before the water passed through the traveling screens. On 5 March, however, intake samples were taken simultaneously both inside and outside the pumphouse for comparision. The discharge samples were collected where the water emerges from the plant at a point just before it passed over a weir into a holding basin which feeds into the submerged multiport diffuser. Sampling was carried out at the same tidal stage each time (low), so that consistancy of tidal conditions would limit the number of variables associated with sampling. On 12 June 1979 discharge samples were collected with the Ammertap system both on and off to compare larval survival. Ichthyoplankton samples were collected concurrently with the phytoplankton and microzooplankton samples so the temperature, salinity, and dissolved oxygen values collected with the latter also apply to the former.

The samples for mortality determination were taken at both the intake and discharge with 30 cm nets. These were short tows, 5 minutes each, to minimize sampling mortality of the larvae. Twelve tows were taken at each station. The contents of the nets were transfered into 0.8 liter glass jars held in portable ice chests. The temperature of the intake samples was held near the ambient by addition of intake water to the ice chest. Discharge samples were cooled rapidly to ambient temperature after about 30 to 60 minutes to simulate the temperature regime to which organisms passing through the diffuser are exposed. This was done by pouring each sample through a 0.27 mm mesh sieve and immediately rinsing the organisms retained on the mesh back into the sample jar with ambient temperature water from the intake. These were then held at or near the ambient temperature in the same manner as the intake samples and transported back to the laboratory. The samples were sorted for live and dead larvae in a shallow glass pan. Any larvae which did not respond to touch by swimming were counted as dead, even if there was still a heartbeat, since larvae in this immobilized condition were presumed to survive no more than a few hours. Live larvae were maintained for 24 hours at ambient temperature to detect delayed mortalities.

Larger samples, for the determination of abundance and species composition of larvae passing through the plant, were obtained at the intake with longer (approximately 2 hours) tows with 50 cm nets. These tows were quantified using General Oceanics digital flowmeters mounted in the net mouths. The samples were treated with tricaine methanesulfonate

("MS-222") to relax the larvae, fixed with 10% buffered formalin, and returned to the laboratory for later sorting, identification, and enumeration.

Also presented in this report are the results of thermal tolerance tests of yolk sac stage larval herring (*Clupea harengus*), smooth flounder (*Liopsetta putnami*), and smelt (*Osmerus mordax*). These experiments utilized the thermal block apparatus described by Barker and Stewart (1977). Larval herring and smooth flounder were obtained by stripping and fertilizing eggs from ripe adults, and the experiments were run in seawater. Larval smelt were obtained by collecting egg masses from Wiley Brook (a tributary of Damariscotta River estuary) after several unsuccessful attempts at stripping and fertilizing the eggs from ripe adults. The smelt larvae were tested for their thermal tolerance in both brook water (fresh) and seawater. Multiple regressions were run on the data to relate mortality to functions of temperature and time duration.

Results and discussion

The numbers of live and dead larval fishes collected in the 5-minute mortality tows are listed in Table 7. The water temperature, salinity, and dissolved oxygen at both the intake and discharge when these tows were made are in Table 1. Nine species of fish larvae and one juvenile species were collected in the mortality tows. Unfortunately, the numbers of individuals caught are not sufficient to warrent conclusions. The plant shutdown during peak larval fish abundance prevented a better evaluation of larval fish entrainment.

The densities of larval fishes in the quantitative intake samples are given in Table 8. The 5 March sample was taken at the beginning of the peak in larval fish abundance and a total of nine species were caught;

the rock gunnel and shorthorn sculpin being the dominant species. The period of peak abundances of winter and smooth flounder larvae, both of which have been important and sometimes dominant in past years, occurred during the plant shut down period (Shaw and DeWitt, 1979).

Table 9 presents the results of comparative 5-minute mortality tows taken inside and outside the traveling screens at the intake as well as the results of 5-minute mortality tows at the discharge with the Ammertap system on and off. There does not seem to be an appreciable difference between the catches and mortalities of larvae sampled inside and outside the screens. No conclusions can be made regarding the effects of the Ammertap system on larval survival at the discharge due to the lack of sufficient numbers of larvae sampled.

The results of the thermal tolerance tests on smelt, smooth flounder and herring yolk sac larvae are given in Tables 10-13 together with the regression equations.

Mortality was observed at temperatures ranging from approximately 25 to 32°C for all three species. The mortality of herring and smelt larvae increased as the duration of the exposure increased. To a lesser extent, the mortality of smooth flounder larvae also increased at longer exposure times. It appears that smelt larvae have a reduced thermal tolerance after making the transition from fresh water, where the adults normally spawn to salt water.

The regression equations given in Tables 10-13 have been calculated for the prediction of mortality at temperatures and durations of exposure other than those tested. The use of these equations should be restricted to the limits of the experiments and should only be considered as approximations. More experimentation must be done to better establish the thermal tolerance of these and other fish larvae.

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Table 1. Sampling dates, chemical and physical data, and densities of organisms for the period of 1 January to 30 June 1979.

NQ = Not Quantified

Date	Location	Temp. °C	ΔT °C	Salinity °/°°	D.O. ppm	Planktonic Diatoms cells/l	Total Diatoms cells/l	Zooplankton organisms/m^3
8 Jan	Intake	3.5	15.0	23.8	NQ	NQ	NQ	1876
	Discharge	18.5		22.6	NQ	NQ	NQ	1988
22 Jan	Intake	2.3	18.5	24.5	11.7	NQ	NQ	NQ
	Discharge	20.8		23.5	10.3	NQ	NQ	1296
5 Feb	Intake	2.3	19.6	21.8	11.6	NQ	NQ	847
	Discharge	21.9		22.2	8.9	NQ	NQ	691
20 Feb	Intake	2.0	17.2	26.0	11.7	NQ	NQ	1050
	Discharge	19.2		26.0	10.8	NQ	NQ	2189
5 Mar	Intake	4.7	17.9	22.4	11.6	NQ	NQ	NQ
	Discharge	22.6		22.4	10.2	NQ	NQ	7840
12 Jun	Intake	17.0	16.9	18.9	8.2	NQ	NQ	NQ
	Discharge	33.9		18.7	7.9	NQ	NQ	32417
26 Jun	Intake	17.2	18.6	24.2	8.5	NQ	NQ	23967
	Discharge	35.8		24.5	8.1	NQ	NQ	31221

Table 2. Survival of primary components of net phytoplankton 24-hours after passage through the condenser cooling system.

IPS = Intake percent survival DPS = Discharge percent survival CPS = Corrected percent survival
– = No cells, survival not calculated X = <100 cells, survival not calculated

	8 Jan			22 Jan			5 Feb			20 Feb			5 Mar			12 Jun			26 Jun		
	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS
Chaetoceros spp.	96	87	91	X	92	X	71	71	100	94	76	81	78	75	96	84	16	19	20	17	85
C. danicus	–	–	–	–	–	–	–	–	–	98	X	X	X	X	X	–	–	–	–	–	–
C. debile	–	–	–	–	–	–	–	–	–	X	–	–	X	X	X	84	24	29	20	28	140
C. decipiens	X	X	X	X	92	X	72	71	99	X	X	X	74	71	96	X	X	X	X	X	X
C. diadema	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	X	X	X	26	X	X
C. laciniosum	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	85	–	–	27	X	X
Coscinodiscus spp.	97	99	102	X	X	X	95	86	91	X	X	X	X	X	X	–	X	–	X	X	X
C. centralis	98	99	101	X	X	X	X	X	X	X	X	X	X	X	X	–	–	–	–	–	–
Fragilaria spp.	–	–	–	–	–	–	–	–	–	X	X	X	X	X	X	93	99	106	–	0	–
Pleurosigma angulatum	X	X	X	X	X	X	55	45	82	55	78	142	56	50	89	–	X	–	X	X	X
Skeletonema costatum	–	–	–	–	–	–	–	X	–	X	–	–	–	–	–	X	X	X	97	70	72
Tabellaria spp.	X	99	X	–	–	–	X	X	X	X	X	X	X	X	X	–	X	–	X	–	–
T. flocculosa	X	99	X	–	–	–	X	X	X	X	X	X	X	X	X	–	X	–	–	–	–
Sample Total	93	91	98	71	78	110	76	70	92	75	79	105	64	56	88	84	43	51	30	23	77

Table 3. Abundance (#/m^3) of primary components of the microzooplankton, 1 January to 30 June 1979.

	8 Jan[1]	22 Jan[2]	5 Feb[1]	20 Feb[1]	5 Mar[2]	12 Jun[2]	26 Jun[1]
Acartia spp. nauplii	16	55	40	286	180	457	4136
Acartia spp. copepodites	156	55	10	164	72	98	3572
Pseudocalanus minutus copepodites	735	287	267	150	222	-	-
Cyclopoid and Harpacticoid nauplii	13	31	36	79	41	660	357
Microsetella norvegica adults and copepodites	527	444	106	1050	448	16	81
Unidentified Harpacticoids	55	51	45	50	103	-	12
Hemicyclops sp. nauplii	-	-	-	-	-	-	887
Saphirella sp. adults and copepodites	-	-	-	-	-	-	518
Synchaeta sp.	6	16	15	21	62	27421	10946
Spionid setigers[3]	-	-	-	-	10	2771	2120
Scolecolepides viridis eggs	-	-	-	-	4825	-	-
Balanus spp. nauplii	-	-	5	10	1489	203	334
Other microzooplankton	368	356	323	376	388	791	1014
Total microzooplankton	1876	1296	847	2189	7840	32417	23967

[1]Density estimates based on 1-hour Intake samples.

[2]Density estimates based on 1-hour Discharge samples.

[3]Not including *Scolecolepides viridis*.

Table 4. Survival of primary components of the microzooplankton 1-hour after passage through the condenser cooling system.

IPS = Intake percent survival DPS = Discharge percent survival CPS = Corrected percent survival
– = No organisms present, survival not calculated X = <30 organisms present, survival not calculated

	8 Jan			22 Jan			5 Feb			20 Feb			5 Mar			12 Jun			26 Jun		
	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS
Acartia spp. nauplii	X	X	X	92	X	X	X	X	X	98	96	98	X	94	X	100	46	46	92	46	50
Acartia spp. copepodites	96	X	X	X	X	X	X	X	X	72	97	135	X	X	X	X	X	X	91	19	21
Pseudocalanus minutus copepodites	98	85	89	92	94	102	96	77	80	90	92	102	95	54	64	X	–	–	X	X	X
Cyclopoid and Harpacticoid nauplii	X	X	X	X	X	X	X	–	–	X	X	X	X	X	X	92	96	104	91	X	X
Microsetella norvegica adults and copepodites	88	62	70	77	81	105	X	X	X	95	94	99	92	52	57	–	–	–	X	X	X
Unidentified Harpacticoids	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	X	X	85	X	X
Hemicyclops sp. nauplii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	91	44	48
Saphirella sp. adults and copepodites	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	96	78	81
Synchaeta sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	85	1	1	86	0	0
Spionid setigers[1]	–	–	–	–	–	–	–	–	–	–	–	–	X	X	X	99	98	99	99	73	74
Scolecolepides viridis eggs	–	–	–	–	–	–	–	–	–	–	–	–	58	30	52	–	–	–	–	–	–
Balanus spp. nauplii	–	–	–	–	–	–	X	X	X	–	X	–	95	87	92	X	X	X	X	X	X

[1]Not including *Scolecolepides viriais.*

Table 5. Survival of primary components of the microzooplankton 24-hours after passage through the condenser cooling system.

IPS = Intake percent survival DPS = Discharge percent survival CPS = Corrected percent survival
– = No organisms present, survival not calculated X = <30 organisms present, survival not calculated

	8 Jan			22 Jan			5 Feb			20 Feb			5 Mar			12 Jun			26 Jun		
	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS	IPS	DPS	CPS
Acartia spp. nauplii	X	X	X	X	X	X	X	X	X	85	87	102	X	X	X	76	71	93	82	33	40
Acartia spp. copepodites	100	X	X	X	X	X	X	X	X	83	94	113	X	X	X	X	X	X	86	11	13
Acartia longiremis adults	–	X	–	X	X	X	–	X	–	81	97	120	X	X	X	–	–	–	–	–	–
Pseudocalanus minutus copepodites	97	93	96	88	89	101	84	58	69	89	81	91	73	9	12	–	–	–	–	–	–
Cyclopoid and Harpacticoid nauplii	X	X	X	–	X	–	X	X	X	X	–	–	X	X	X	91	98	108	X	X	X
Microsetella norvegica adults and copepodites	90	70	78	69	85	123	68	X	X	87	92	106	85	35	41	–	–	–	X	X	X
Unidentified Harpactocoids	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	61	82	134	X	X	X
Hemicyclops sp. nauplii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	85	44	48
Saphirella sp. adults and copepodites	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	96	79	82
Synchaeta sp.	X	X	X	–	X	–	X	X	X	X	X	X	X	X	X	83	0	0	24	0	0
Spionid setigers[1]	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	93	89	96	94	88	94
Scolecolepides viridis	–	–	–	–	–	–	–	–	–	–	–	–	31	7	23	–	–	–	–	–	–
Balanus spp. nauplii	–	–	–	–	–	–	X	X	X	X	X	X	93	87	89	X	86	X	X	X	X

[1]Not including *Scolecolepides viridis*.

Table 6. Species densities of macrozooplankton collected in quantitative tows 1 Sept., 1978 to 30 June, 1979. Densities are given as number of organisms per 100 m^3 of water.

	11 Sept.	26 Sept.	10 Oct.	23 Oct.	20 Nov.	5 Dec.	22 Jan.	5 Feb.	20 Feb.	5 Mar.	12 Jun.	26 Jun.
PHYLUM Annelida												
Class Polychaeta												
Eteone sp.									0.12			
Nereis virens											0.13	
Autolytus sp.						0.96				0.14		0.19
Harmothoe sp.											0.13	
Class Oligochaeta												
unidentified oligochaeta											0.13	
PHYLUM Arthropoda												
Class Crustacea												
Order Caligoida												
unidentified caligoida				0.23		0.14					0.51	
Order Mysidacea												
Mysis stenolepis								0.21				
Neomysis americana					0.14				0.23			0.19
Order Cumacea												
Eudorella pusilla								0.43				
Diastylis sculpta		0.25								0.28		
Oxyurostylis smithi				0.23	0.54		0.17					
Order Amphipoda												
Suborder Hyperiidea												
unidentified Hyperiidea										0.14		
Hyperoche sp.									0.12			
Suborder Gammaridea												
Gammarus lawrencianus									1.04	0.28		
Melita nitida										0.14		
Ampelisca abdita				0.14					0.12			
Orchestia platensis							0.17					
Jassa falcata		0.25	0.62		0.14	0.14	1.00	1.07	0.12	0.14		
Corophium insidiosum	0.09	8.34	8.02	2.01	1.36		2.16	0.86	0.81	0.71	0.38	2.63
Ampithoe valida		0.49					0.17					
Dyopedos monacanthus										0.14		
unidentified amphipoda				0.14								
Order Decapoda												
Crangon septemspinosus	0.46			0.14								
Pandalus montagui										0.43		
PHYLUM Mollusca												
Class Bivalvia												
Modiolus modiolus			1.85		0.27							0.19

Table 7. Numbers of live and dead larval fishes collected in 5-minute tows at the intake and discharge, 1 January 1979 to 30 June 1979.

a = alive d = dead I = Intake D = Discharge

Species		22 Jan. a-d	5 Feb. a-d	20 Feb. a-d	5 Mar. a-d	12 Jun. a-d	26 Jun. a-d
Herring	I	0-1			0-1		
Clupea harengus	D	0-0			0-0		
Pollack	I	0-0			1*-0		
Pollachius virens	D	0-1			0-0		
Rock Gunnel	I		1-0		2-13		
Pholis gunnellus	D		0-1		0-2		
Longhorn Sculpin	I			1-0			
Myoxocephalus octodecemspinosus	D			0-0			
Shorthorn Sculpin	I			2-0	3-8		
M. scorpius	D			0-0	0-0		
Grubby	I						
M. aenaeus	D						
Wrymouth	I				0-2		
Cryptocanthodes maculatus	D				0-1		
Smelt	I				0-1	0-1	0-2
Osmerus mordax	D				0-0	0-0	0-0
3-Spined Stickleback	I					2*-0	
Gasterosteus aculeatus	D					0-1*	
Winter Flounder	I						0-1*
Pseudopleuronectes americanus	D						0-0

*Juvenile fish

Table 8. Species densities of larval fishes collected in quantitative tows and preserved at the intake, 1 January 1979 to 30 June 1979. Densities are given as number of larvae per 100 m^3 of water filtered.

	23 Jan.	5 Feb.	20 Feb.	5 Mar.	12 June	26 June
Volume Filtered (m^3)	601 m^3	466 m^3	868 m^3	704 m^3	780 m^3	532 m^3
Total Number of Juveniles	0	0	1	2	0	4
Total Number of Larvae	2	7	19	100	20	6
Total Larval Density (larvae/m^3)	.003	0.015	0.022	0.142	0.025	0.011
Clupea harengus	1	1		5	1	4*
Pholis gunnellus		4	5	38		
Myoxocephalus octodecemspinosus		1	4	10		
M. scorpius		1	9	34		
M. aenaeus			1	2		
Gasterosteus wheatlandi			1*			
Pollachius virens	1			1 + 2*		
Cryptacanthodes maculatus				10		
Osmerus mordax					19	5
Alosa pseudoharengus						1

*Juvenile Fish (not included in density calculation)

Table 9. Numbers of live and dead larval fishes collected in 5-minute tows on 5 March 1979 at the intake (both inside and outside the traveling screens) and on 12 June 1979 at the discharge (with and without the Ammertap system).

a = alive d = dead

Species	5 March 1979 Intake		12 June 1979 Discharge	
	Outside screens a-d	Inside screens a-d	Ammertap On	Ammertap Off
Clupea harengus Herring	0-1			
Pollachius virens Pollack	1*-0	1*-0		
Pholis gunnellus Rock Gunnel	2-13	5-2		
Myoxocephalus scorpius Shorthorn Sculpin	3-8	9-2		
Cryptacanthodes maculatus Wrymouth	0-2	4-0		
Osmerus mordax Smelt	0-1		0-1	
Gasterosteus aculeatus 3-Spined Stickleback				0-1*
M. octodecemspinosus Longhorn Sculpin		1-1		
M. aenaeus Grubby		2-0		

*Juvenile fish

Table 10. Experimental values of percent mortality at the given exposure times and temperatures for smelt (*Osmerus mordax*) yolk sac larvae in brook water. The calculated regression equation relating percent mortality to time and temperature is:

$$\sin^{-1}\sqrt{\%\ \text{Mortality}} = 5368.39 + 96.7005(\text{Temperature}) + 0.01292(\text{Time} \times \text{Temperature}) - 2421.90(\ln \text{Temperature})$$

$R^2 = 0.809$

Exposure Time (min.)	Exposure Temperature (°C)	% Mortality
60	32.6	100
60	32.6	100
60	30.8	100
60	30.8	100
60	28.8	62.5
60	28.8	57.1
60	26.8	0
60	26.8	0
60	24.9	0
60	24.9	0
30	32.6	100
30	32.6	100
30	30.8	100
30	30.8	100
30	28.8	40.0
30	28.8	0
30	26.8	0
30	26.8	0
30	24.9	0
30	24.9	0
5	32.4	100
5	32.4	100
5	30.6	7.1
5	30.6	0
5	28.6	7.1
5	28.6	7.1
5	26.6	0
5	26.6	0
5	24.5	6.7
5	24.5	0

Table 11. Experimental values of percent mortality at the given exposure times and temperatures for smelt (*Osmerus mordax*) yolk sac larvae in sea water. The calculated regression equation relating percent mortality to time and temperature is:

$$\sin^{-1}\sqrt{\%\ \text{Mortality}} = -198.832 + 7.22307(\text{Temperature}) + 17.2384(\ln \text{Time})$$

$$R^2 = 0.786$$

Exposure Time (min.)	Exposure Temperature (°C)	% Mortality
60	32.6	100
60	32.6	100
60	30.8	100
60	30.8	100
60	28.8	100
60	28.8	100
60	26.9	88.9
60	26.9	90.9
60	24.9	40.0
60	24.9	50.0
30	32.6	100
30	32.6	100
30	30.8	100
30	30.8	100
30	28.8	100
30	28.8	100
30	26.9	50.0
30	26.9	50.0
30	24.9	40.0
30	24.9	60.0
5	32.4	100
5	32.4	100
5	30.6	40.0
5	30.6	11.1
5	28.6	27.3
5	28.6	11.1
5	26.7	22.0
5	26.7	0
5	24.5	0
5	24.5	14.3

Table 12. Experimental values of percent mortality at the given exposure times and temperatures for smooth flounder (*Liopsetta putnami*) yolk sac larvae. The calculated regression equation relating percent mortality to time and temperature is:

$\sin^{-1}\sqrt{\%\ \text{Mortality}} = 37943.7 + 1461.79(\text{Temperature}) + 0.00400(\text{Time}^2) - 12.6406(\text{Temperature}^2) - 20686.4(\ln \text{Temperature})$ $R^2 = 0.878$

Exposure Time (min.)	Exposure Temperature (°C)	% Mortality
60	34.2	100
60	34.2	100
60	32.0	100
60	32.0	100
60	29.8	100
60	29.8	100
60	27.6	26.7
60	27.6	80.0
60	25.4	7.7
60	25.4	0
30	34.2	100
30	34.2	100
30	32.0	100
30	32.0	100
30	29.8	68.8
30	29.8	90.9
30	27.6	18.8
30	27.6	0
30	25.4	6.7
30	25.4	20.0
5	33.9	100
5	33.9	100
5	30.5	100
5	30.5	46.4
5	28.4	20.0
5	28.4	26.7
5	26.2	6.7
5	26.2	6.7
5	24.0	0
5	24.0	0

Table 13. Experimental values of percent mortality at the given exposure times and temperatures for herring (*Clupea harengus*) yolk sac larvae. The calculated regression equation relating percent mortality to time and temperature is:

$$\sin^{-1}\sqrt{\%\ \text{Mortality}} = 64553.9 + 0.65403(\text{Time}) + 2492.85(\text{Temperature}) - 21.7298(\text{Temperature}^2) - 35201.8(\ln \text{Temperature}) \qquad R^2 = 0.819$$

Exposure Time (min.)	Exposure Temperature (°C)	% Mortality
60	33.0	100
60	33.0	100
60	31.0	100
60	31.0	100
60	29.1	100
60	29.1	100
60	27.0	100
60	27.0	81.2
60	25.0	0
60	25.0	6.7
30	33.0	100
30	33.0	100
30	31.0	100
30	31.0	100
30	29.1	100
30	29.1	100
30	27.0	0
30	27.0	0
30	25.0	0
30	25.0	0
15	33.0	100
15	33.0	100
15	31.0	100
15	31.0	100
15	29.1	12.5
15	29.1	6.7

Table 13. (Continued)

Exposure Time (min.)	Exposure Temperature (°C)	% Mortality
15	27.0	0
15	27.0	0
15	25.0	0
15	25.0	0
5	32.7	100
5	32.7	100
5	29.8	18.8
5	29.8	76.5
5	27.9	6.7
5	27.9	0
5	26.0	0
5	26.0	0
5	24.0	0
5	24.0	0

MORTALITIES OF VELIGER LARVAE OF *Placopecten magellanicus*, THE SEA SCALLOP, AND *Mya arenaria*, THE SOFT-SHELLED CLAM AFTER ACUTE EXPOSURE TO THERMAL AND THERMAL-SALINITY STRESS

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Introduction

Because of the tremendous volume of water used in once-through condenser cooling systems, there is the likelihood that large numbers of planktonic organisms could be entrained with the cooling water. Entrained organisms are exposed to thermal, mechanical, and in some cases chemical stress. If high mortality were associated with that passage, the resulting loss could have a detrimental effect both ecologically and economically. Benthic organisms with meroplanktonic larvae may be especially susceptible to entrainment losses (Enright, 1977; Copeland et al., 1977).

One of the state's more productive scallop beds is located in upper Penobscot Bay, near Sears Island, the proposed site of a power generating station. During the especially successful 1975-76 harvest season, 437 metric tons of scallop meats (worth about 3 million dollars at current retail prices) were landed from this area (Dow, pers. comm.). The sea scallop is essentially a deep water species, (Posgay, 1953; Kennedy and Mihirsky, 1971) and known to be intolerant of chronic high temperature (Dickie, 1958; Culliney, 1974). No information is available, however, on the tolerance of the larvae to the thermal shock that they would experience during entrainment. It is also not known what the tolerance of the larvae is to the combined stress of simultaneous changes in temperature and salinity.

Like the sea scallop, the soft-shelled clam, *Mya arenaria* (Linné), is also abundant near Sears Island, but in contrast it is predominantly found in intertidal areas. It, too, is commercially exploited; ex-vessel value of the 1975 United States east coast catch was 8.7 million dollars, but total landings have declined in recent years (Ritchie, 1977). High entrainment mortality of the larvae could contribute to the decline of adult stocks. Stickney (1964) has studied conditions necessary for successful rearing of soft-shelled clam larvae, and other data are available on the temperature tolerances of both juveniles and adults (Kennedy and Mihursky, 1971), but only limited information on the acute thermal tolerance of the larvae is available (Barker and Stewart, 1978).

The thermal shock experiments of Barker and Stewart (1978) used summer spawned clam larvae reared at 17 to 18°C, a temperature commonly measured in Montsweag Bay (Thompson, 1978) during much of the adults' spawning season in Maine (Ropes and Stickney, 1965). This rearing temperature was warmer than ambient temperatures near Sears Island given by Haefner (1967) for the same period. Therefore it is unclear whether the results of these experiments conducted at the warmer temperature would be pertinent to entrainment of clam larvae at the cooler temperatures characteristic of upper Penobscot Bay. The experiments described here determined the tolerance of early straight-hinge clams to acute thermal shock with acclimation temperatures of 10 to 12°C.

Clam larvae may also occur within a wide range of salinities, as well as temperatures, and conditions of lowered salinity may be expected at estuarine power plants. Therefore the relationships between salinity and the acute thermal tolerance of both clam and sea scallop larvae were investigated. A combination of thermal and salinity shock was used. Clam larvae from two estuarine locations were tested to determine if the salinity of acclimation influenced the relationship between thermal and salinity stress.

Methods

Adult clams and scallops were collected from the Damariscotta River in July, August, and September 1978. Larval rearing techniques and the experimental apparatus and design were similar to those previously reported in Barker and Stewart (1978).

Details of each experiment with the exception of M-3 are summarized in Table 14. The salinity stress was accomplished by subjecting larvae to altered conditions of salinity concurrent with exposures to elevated temperatures. The duration of exposure in these temperature-salinity experiments was 60 minutes. After that period of time the larvae were returned to the original acclimation temperature and salinity. Experiment M-3 was similar to M-5 and M-6. Conditions of the experiment can be obtained from Table 18.

A step-wise multiple regression analysis was performed on the data. The general form of the equation used in the thermal stress experiments was as follows: $y = B_0 + B_1T + B_2M + B_3MT + B_4M^2 + B_5T^2 + B_6M^2T^2 + B_7M^2T + B_8MT^2 + B_9M^3 + B_{10}T^3 + B_{11}M^3T^3 + B_{12}M^3T + B_{13}MT^3 + B_{14}M^3T^2 + B_{15}M^2T^3$, where B_0 is a constant, B_1-B_{15} are regression coefficients, M is time in minutes, T is temperature in °C, and y is the arcsine square root percentage mortality. Observed mortalities in all experiments were transformed to stabilize the variances (Steele and Torrie, 1960). Terms were added to the regression equation by raising M or T to a second or third power and by multiplying M and T or the different combinations of their power. The aim was to obtain the best possible fit of the regression equation to the data. All terms that were significant at an F-level of .01 were included in the equation in a forward step-wise manner.

The regression equations were used to predict mortality for conditions other than those tested. Three dimensional graphs were produced from these values. Combinations outside the range tested, represented as the intersection of dashed lines, are included for continuity (Alderdice, 1972). In some instances the equation gave unrealistic values between 60 and 180 minutes. These values were omitted from the response surface.

The form of the regression equation used for the temperature-salinity experiments was similar to the previous equation with S (Salinity) replacing M (Time) as a variable.

Results

Thermal stress experiments - *Placopecten*

Larval mortality increased with increased temperature and duration of exposure throughout the range of conditions tested (Table 15). Temperatures as high as 32.8°C were tolerated for 5 minutes by 3-day-old *Placopecten* veligers with negligible mortality. The same exposure time and a temperature of 36.6°C resulted in complete mortality. A 30-minute exposure at 31.1°C produced less than 20 percent mortality; mortality was nearly complete between 32 and 33°C. Negligible mortality occured from a 60-minute exposure to 29°C; at 32.4°C mortality was complete. The highest temperature the larvae withstood for 180 minutes was 27.0°C; mortality is complete at 30.3°C. These results show that mortality of *Placopecten* larvae increases over a narrow range of elevated temperature. Increments as small as one degree brought about increases in mortality as great as 50 percent.

No significant difference at the 0.05 level was found between experiments P1 and P2, therefore these data were combined. The r^2 value was 0.814, indicating that 81.4% of the variation of the data was explained by the variables in the equation.

Table 23 gives the order of terms, their significance and regression coefficients, as well as related statistics. Table 26 gives the regression equation for the combined data sets P-1 and P-2. Solution of this equation for each time-temperature combination within the limits of the experiments resulted in a predicted mortality at the specified conditions. Table 27 gives these predicted values, and Figure 1 gives the three-dimensional form of the predicted response surface.

Thermal stress experiments - *Mya*

Results of thermal stress experiments, M-A and M-B (17-18°C acclimated straight-hinge veliger larvae) are given in Table 16. These results have been reported elsewhere (Barker and Stewart, 1978). Regression equations using the model given in this report were calculated and compared. No difference was found at the 0.05 level between the two regression equations so the data were combined and a new regression equation was calculated (Table 23).

A similar procedure was followed for thermal stress experiments M-1 and M-2 (10-12°C acclimated straight-hinge veliger larvae). Results are given in Table 17. No difference was found between the two experiments at the 0.05 level so the data were combined and a new regression equation was calculated (Table 23).

The two resulting regression equations were compared as before and again no difference was found at the 0.05 level. The data sets were combined and a final regression equation was calculated. The equation is given in Table 23 with associated statistics and also in Table 26. Figure 2 was plotted from values calculated with this equation (Table 28).

Temperature-salinity stress experiments

Results of the temperature-salinity stress experiment (P-3) which was conducted with *Placopecten* straight-hinge veliger larvae are given in Table 18. The regression equation is given in Table 26, the equation and associated statistics in Table 25, the predicted values in Table 29, and the plot of those values in Figure 3. Mortality of *Placopecten* larvae increased with increased temperature and decreasing salinity. A comparison of these results with the results of similar experiments performed on *Mya* larvae shows that *Placopecten* larvae are more sensitive to temperature-salinity than are *Mya*.

Results of the temperature-salinity experiments (M-3, M-5, and M-6) which were conducted with *Mya* straight-hinge veligers are given in Tables 19, 20, and 21 respectively. Regression equations were calculated for each set of data. No significant difference at the 0.05 level was found between the regression equations derived from experiments M-5 and M-6 so the data were combined and a new regression equation was calculated (Table 24). The larvae used in experiment M-3 were from the same broodstock as those used in M-5, so data from the three experiments (M-3, M-5, and M-6) were combined and a new regression equation was calculated (Table 25). No significant difference at the 0.05 level was found between the regression equation for the data from M-5 and M-6 when compared with that of M-3, M-5, and M-6. The latter regression equation is given in Table 26, the predicted values in Table 30 and the plot of those values in Figure 4.

Mya larvae reared at low salinity (15°/₀₀) were subjected to similar combinations of temperature-salinity stress. The results of this experiment (Table 22) show that acclimation influences the tolerance of straight-hinge larvae to temperature-salinity stress. The regression equation is given in Table 26, associated statistics in Table 24, the predicted values in Table 31, and the plot of those values in Figure 5.

Discussion

Although larval *Placopecten* have a low thermal tolerance, they could conceivably survive entrainment because of the low preferred spawning temperatures of the adults. At 12°C straight-hinge larvae should survive a 30-minute exposure to a 15 to 17°C ΔT, provided other stresses are minimal. Although larvae acclimated to somewhat higher temperatures might have a slightly increased thermal tolerance, this would be overridden by the higher exposure temperature.

Spawning times for *Mya arenaria* in Maine begin as early as May and continue through August into September (Ropes and Stickney, 1965). Brousseau (1978) reported a probable spawning of *Mya* at the Annisquam River, Massachusetts, in mid-March at sea surface temperatures of 4 to 6°C, and summer spawning at 15 to 18°C. In Maryland, Pfitzenmeyer (1962) observed early umbo larvae in May when mean surface temperature was 21.7°C. In this study, *Mya* reared at 17 to 18°C showed only slightly better resistance to thermal stress than those reared at 10 to 12°C. The cooler acclimated *Mya* larvae were spawned in early May and the highest temperature the adults were exposed to was 10°C. Adult *Mya* that produced the larvae used in the warm acclimated experiments were spawned in mid-summer and should have been accustomed to temperatures near the larval rearing temperature of 17 to 18°C. The nearly identical resistance of the early larvae to thermal shock is interesting considering the different thermal regimes experienced by the adults.

Entrainment of summer spawned *Mya* larvae could be potentially significant in Montsweag Bay, the site of Maine Yankee. July and August surface temperatures routinely exceed 20°C (Lindsay et al., 1978). Exposure at a ΔT of 15°C and the 30-minute transit time at Maine Yankee would bring the larvae close to critical thermal levels. The situation in Penobscot Bay would not be as serious, given the same ΔT and exposure duration, since ambient temperatures are much lower.

The thermal tolerance data given for *Placopecten* and *Mya* are conservative, taking into account the relatively cool acclimation temperatures. The information provided as predicted mortalities in Tables 27 and 31 represents attempts to estimate mortalities at various time-temperature combinations from a single predictive equation and as such does not represent the data exactly. However, if used in conjunction with the raw mortality data, the equations could serve as guidelines for power plant cooling system construction and operation.

The experiments with *M. arenaria* straight-hinge 1- to 2-day-old larvae showed no significant difference in tolerance to temperature-salinity stress when larvae from an upper estuarine environment were compared to those from a lower estuarine environment and the broodstocks were held under identical conditions for 6 months prior to spawning. When the broodstock was taken directly from the upper estuarine site, however, and larvae were spawned and reared at an intermediate salinity, a significant difference in survival was definitely established. It is apparent that conditioning plays an important role in determining the tolerance of *Mya* larvae to this type of stress.

It is unlikely that thermal shock during entrainment would be accompanied by a precipitous change in salinity, as in the temperature-salinity experimental design. Although significant salinity reduction in estuarine areas would not be unexpected, especially in spring, bivalve larvae would either become acclimated or presumably adjust their position to avoid stressful levels (Hidu and Haskin, 1978). Davenport et al. (1975) showed that larvae of *Pecten maximus* were capable of tolerating much lower salinities when fluctuations are gradual rather than abrupt. The temperature-salinity experiments do point out that added sources of stress can result in increased mortality of entrained larvae.

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Table 14. Summary of thermal stress experiments.

Null Hypothesis	Related Exper.	Exper. # Date	Organism Stage of Development	Acclimation Conditions Adults/Larvae	Experimental Conditions Range of Test Temp. (°C)	Duration of Exposure (Minutes)	Salinity (°/₀₀)	Results/Comments
No significant difference in mortality after thermal stress between *Mya* larvae reared at 10-12°C and *Placopecten* reared at 12°C (when both groups are at similar stage of development)	M-1, M-2, P-1, P-2	P-1, P-2 18 Aug. 1978	*Placopecten magellanicus* 3 day straight-hinge veliger larvae	Adults collected at 11-12°C, 30 °/₀₀; larvae reared at 12°C, 31 °/₀₀	P-1, 35.2-29.0 P-2 36.8-	P-1, P-2 5, 30, 60 180 each replicated	31	There was a significant difference at the 0.05 level. *Placopecten* a marine subtidal species clearly has a lower level of tolerance to acute thermal shock compared to *Mya*, an estuarine intertidal species.
No significant difference in mortality after thermal stress between *Mya* larvae reared at 10-12°C and those reared at 17-18°C when adults spawned in early spring and mid-summer, respectively.	M-1, M-2 and two from 1977 M-A, M-B	M-1, M-2 10 May 1978	*M. arenaria* 2 day early straight-hinge veliger larvae	Adults naturally conditioned at 2-6°C, then held at 10°C for 6 days at 28-29 °/₀₀ larvae reared at 10-12°C, 29 °/₀₀	M-1 40.2-30.2 M-2 40.0-31.6	M-1, M-2 5, 30, 60 180 each replicated	29	There was no significant difference at the 0.05 level. Acclimation temperature over an 8°C range at these temperatures had only a minor effect on larval *Mya's* tolerance to thermal shock.
		M-A* 19 Jul. 1977 M-B* 4 Aug. 1977	*M. arenaria* 1 day early straight-hinge veliger larvae	Adults collected intertidally & spawned the same day; larvae reared at 17-18°C, 30-31 °/₀₀	M-A 39.6-30.8 M-B 39.6-30.9	M-A, M-B 5, 30, 60 180 each replicated	30-31	*As reported by Barker and Stewart (1978).

Table 14. Summary of thermal stress experiments. (cont.)

					Experimental Conditions			
Null Hypothesis	Related Exper.	Exper. # Date	Organism Stage of Development	Acclimation Conditions Adults/Larvae	Range of Test Temp. (°C)	Duration of Exposure (Minutes)	Salinity (°/oo)	Results/Comments
No significant difference in mortality after thermal-salinity stress between *Mya* larvae from lower estuarine brood stock and those from upper estuarine broodstock when adults conditioned at same temperatures and salinities	M-5, M-6	M-6 30 May 1978	*M. arenaria* 2 day straight-hinge veliger larvae	Adults collected previous fall from low salinity upper estuarine site held at the Darling Center; naturally conditioned at 1-10°C, 26-31 °/oo; larvae reared at 15°C, 29 °/oo	37.8-25.4	60	29.6, 15.0, 10.2, 5. each replicated	No significant difference at the 0.05 level. Genetic control of salinity tolerance not apparent at this stage. Conditioning appears to be the dominant factor in determining larval resistance to short-term thermal-salinity stress.
No significant difference in mortality after thermal-salinity stress between *Mya* larvae reared at 30 °/oo and those reared at 15 °/oo when adults were conditioned at these respective salinities.	M-6, M-7	M-7	*M. arenaria* 2 day straight-hinge veliger larvae	Adults collected from upper estuarine site (naturally conditioned there) at 3-15 °/oo. Temperature at collection 16-17°C; larvae reared at 15°C, 17.2 °/oo	40.0-27.3	60	26.2, 14.8, 9.9, 5.0 each replicated.	Significant difference at the 0.05 level. Previous acclimation definitely affects short-term salinity tolerance of larvae. Tolerance to elevated temperatures did not appear to be enhanced over larvae of M-6.

Table 14. Summary of thermal stress experiments. (cont.)

Null Hypothesis	Related Exper.	Exper. # Date	Organism Stage of Development	Acclimation Conditions Adults/Larvae	Experimental Conditions			Results/Comments
					Range of Test Temp. (°C)	Duration of Exposure (Minutes)	Salinity (°/oo)	
No significant difference in mortality after thermal-salinity stress between *Mya* and *Placopecten* larvae reared at the same temperature and salinity.	M-5, P-3	M-5 30 May 1978	*M. arenaria* 2 day straight-hinge veliger larvae	Adults collected previous fall from high salinity lower estuarine site, held at the Darling Center. Conditioning and larval rearing same as M-6.	37.8-25.1	60	29.6, 15.0, 10.2, 5.3 each replicated.	Significant difference at 0.05 level. *Placopecten* had a lower tolerance to thermal-salinity stress compared to *Mya*.
		P-3 24 Aug. 1978	*P. magellanicus* 3 day straight-hinge veliger larvae	larvae reared at 15°C, 31 °/oo	33.2-22.1	60	31.2, 15.9, 10.7, 5.3 each replicated.	

Table 15. Percentage mortalities of *P. magellanicus* straight-hinge veliger larvae reared at 12°C after brief exposure to elevated temperatures.

Experiment P-1

Time (min.)	35.2	(35.0)	33.2	(32.8)	31.1	(30.7)	29.0	(28.6)	27.0	(26.6)	C[b] 14.4	EC[c] 12±1
						Temperature (°C)[a]						
180	100		100		99		61		2		3	2
	100		100		100		64		1		2	2
60	100		100		55		6		3		3	2
	100		100		63		5		2		1	1
30	100		98		9		3		2		2	2
	100		97		12		4		6		1	2
5		32		2		1		2		1	3	1
		24		2		3		2		0	2	1

Experiment P-2

Time (min.)	36.8	(36.6)	34.7	(34.5)	32.4	(32.1)	30.3	(30.0)	28.2	(27.9)	15.0	12±1
180	100		100		100		100		31		3	3
	100		100		100		100		33		2	2
60	100		100		100		66		5		2	3
	100		100		100		70		6		4	3
30	100		100		100		18		4		5	2
	100		100		100		15		6		2	2
5		100		16		2		2		2	2	4
		100		16		3		3		1	4	4

Salinity 31.2°/oo

	P-1	P-2
Number of larvae		
Mean of controls	347	385
Standard deviation	29	36

(a) Temperatures in parentheses were corrected for the influence of injection water.

(b) C = Control in block

(c) EC = Control outside of block

Table 16. Percentage mortalities of *M. arenaria* straight-hinge veliger larvae reared at 17 to 18°C after brief exposure to elevated temperature.

Experiment M-A

Time (min.)	Temperature (°C)[a] 39.6	(39.4)	37.2	(36.2)	34.8	(33.8)	32.7	(31.9)	30.8	(30.0)	C[b] 17.6	EC[c] 18±1
180	100		100		36		0		0		2	1
	100		98		11		0		0		3	1
60	100		82		31		0		0		1	0
	100		33		1		0		8		1	1
30	59		22		0		0		0		0	2
	90		35		0		0		0		2	3
5		0		3		24		0		0	8	3
		28		0		13		3		11	3	2

Experiment M-B

Time (min.)	39.6	(39.4)	37.2	(36.2)	34.9	(33.9)	32.7	(31.9)	30.9	(30.1)	18.1	17±1
180	100		97		46		0		0		1	0
	100		100		66		10		2		0	1
60	100		99		38		29		0		0	0
	100		98		49		23		0		1	0
30	100		d		d		0		0		1	3
	100		35		6		0		0		1	3
5		23		2		6		5		26	d	1
		0		24		2		9		0	d	2

	M-A	M-B
Salinity	30.6°/₀₀	31.0°/₀₀

	M-A	M-B
Number of larvae	106	146
Mean of controls	13	16
Standard deviation		

(a) Temperatures in parentheses were corrected for the influence of injection water

(b) C = Control in block

(c) EC = Control outside of block

(d) Sample lost

Table 17. Percentage mortalities of *M. arenaria* straight-hinge veliger larvae reared at 10 to 12 °C after brief exposure to elevated temperatures.

Experiment M-1

	Temperature (°C)[a]										C[b]	EC[c]
Time (min.)	40.2	(40.0)	37.8	(37.6)	35.2	(34.9)	32.6	(32.4)	30.2	(30.0)	14.9	12±1
180	100		100		97		11		13		3	5
	100		100		98		19		3		1	2
60	100		100		64		9		24		5	2
	100		100		37		7		16		2	8
30	100		89		9		9		3		2	2
	100		86		14		8		5		3	1
5		62		10		1		8		0	2	7
		40		15		4		0		2	1	2

Experiment M-2

Time (min.)	42.0	(41.8)	39.5	(39.0)	36.8	(36.1)	34.2	(33.6)	31.6	(31.2)	15.7	12±1
180	100		100		100		16		0		1	5
	100		100		100		24		2		1	2
60	100		100		98		17		0		3	6
	100		100		97		10		0		1	1
30	100		99		25		4		0		2	5
	100		95		39		3		0		1	7
5		81		3		0		5		0	4	3
		68		16		0		6		0	3	2

Salinity 29.0°/°°

	M-A	M-B
Number of larvae		
Mean of controls	208	272
Standard deviation	21	24

(a) Temperatures in parentheses are corrected for the influence of injection water

(b) C = Control in block

(c) EC = Control outside of block

Table 18. Percentage mortalities of *P. magellanicus* straight-hinge veliger larvae acclimated at high salinity after brief exposure to various temerature-salinity combination.

Experiment P-3

Salinity (°/₀₀)	Temperature (°C) 33.2	31.0	28.8	26.5	24.2	22.1	15.2	EC[b] 15±1
31.3	100	99	23	4	c	c	2[a]	3
	100	100	47	9	c	c	6[a]	5
15.9	100	100	100	46	18	c	6	1
	100	100	99	37	14	c	5	2
10.7	100	100	100	100	80	43	16	2
	100	100	100	99	57	35	13	2
5.3	100	100	100	100	100	100	100	2
	100	100	100	100	100	100	100	2

Duration of exposure - 60 min.

Number of larvae	
Mean of controls	483
Standard deviation	71

(a) Control

(b) EC = Control outside of block

(c) Not tested

Table 19. Percentage mortalities of *M. arenaria* straight-hinge veliger larvae acclimated at high salinity after brief exposure to various temperature-salinity combinations.

Experiment M-3

	Temperature (°C)						EC[b]	EC[b]	Time (min.)
Salinity (°/..)	40.1	37.6	35.0	32.4	30.0	14.4	15±1	15±1	60
29.3	100	81	0	1	0	0[a]	0[a]	1[a]	
	100	92	0	3	0	0[a]	1[a]	0[a]	
14.9	100	100	65	9	0	8	12		
	100	100	61	15	0	6	0		
5.1	100	100	100	94	79	0	0		
	100	100	100	97	80	30	19		

Duration of exposure - 60 min.

Number of larvae	
Mean of controls	268
Standard deviation	33

(a) Control

(b) EC = Control outside block

Table 20. Percentage mortalities of *M. arenaria* straight-hinge veliger larvae acclimated at high salinity after brief exposure to various temperature-salinity combinations.

Experiment M-5

Salinity (°/..)	Temperature (°C) 37.8	35.2	32.6	30.2	27.6	25.1	14.9	EC[b] 15±1	EC[b] 15±1
29.6	100	30	4	3	c	c	5[a]	4[a]	5[a]
	100	29	8	4	c	c	3[a]	4[a]	4[a]
15.[illegible]	100	82	32	18	c	c	2	6	
	100	92	35	11	c	c	17	14	
10.2	100	100	74	25	22	25	5	8	
	100	100	74	22	26	12	9	12	
5.3	100	100	100	100	100	92	67	60	
	100	100	100	100	99	94	48	31	

Duration of exposure - 60 min.

Number of larvae
Mean of controls 478
Standard deviation 61

(a) Control

(b) EC = Controls outside of block

(c) Not tested

Table 21. Percentage mortalities of *M. arenaria* straight-hinge veliger larvae acclimated at high salinity after brief exposure to various temperature-salinity combinations.

Experiment M-6

	Temperature (°C)								
Salinity (‰)	37.8	35.4	32.8	30.4	27.9	25.4	15.4	EC[b] 15±1	EC[b] 15±1
29.6	86	7	11	4	c	c	12[a]	0[a]	2[a]
	100	11	7	10	c	c	4[a]	17[a]	5[a]
15.0	100	64	19	15	c	c	6	8	
	100	68	18	17	c	c	8	10	
10.2	100	100	83	5	16	18	14	16	
	100	100	72	16	10	10	5	5	
5.3	100	100	100	86	62	41	13	37	
	100	100	100	100	96	78	10	18	

Duration of exposure - 60 min.

Number of larvae
Mean of controls 589
Standard deviation 43

(a) Control

(b) EC = Control outside of block

(c) Not tested

Table 22. Percentage mortalities of *M. arenaria* straight-hinge veliger larvae acclimated at low salinity after brief exposure to various temperature-salinity combinations.

Experiment M-7

Salinity (°/..)	Temperature (°C) 40.0	37.6	35.0	32.4	29.8	27.3	14.4	EC[b] 15±1
26.2	100	100	93	21	4	14	16	13
	100	100	93	58	14	14	14	20
14.8	100	98	15	13	6	6	12[a]	10
	100	100	25	11	20	17	12[a]	14
9.9	100	100	31	16	17	15	12	22
	100	100	41	22	10	8	18	14
5.0	100	100	91	44	16	14	12	12
	100	100	90	46	15	18	7	10

Duration of exposure - 60 min.

Number of larvae
Mean of controls 328
Standard deviation 43

(a) Control

(b) EC = Control outside of block

Table 23. Statistics of multiple regression of arcsine transformed of percentage mortality on temperature (T) and time (M). B = Regression coefficient; S_b = Standard error of B; $100R^2$ = Coefficient of determination; S_r = Standard error of estimate; Beta = Standard regression coefficient.

Experiments	Species	Constant	Variable	B	S_b	$100R^2$	S_r	Beta
P-1, P-2	*P. magellanicus*	-339.145	T	14.336	6.970	54.2	20.077	1.207
			M	-1.487	7.057×10^{-1}	71.3	19.991	-2.726
			M^2	4.955×10^{-3}	2.420×10^{-3}	77.6	17.792	1.819
			T^3	-2.904×10^{-3}	2.260×10^{-3}	78.0	17.714	-0.748
			M^2T^3	-2.561×10^{-7}	0	78.4	17.695	-3.285
			MT^2	2.354×10^{-3}	6.800×10^{-4}	81.4	16.528	4.566
M-A, M-B	*M. arenaria*	251.874	T^3	3.063×10^{-3}	1.960×10^{-3}	56.8	22.267	1.093
			MT^3	4.701×10^{-6}	0	68.2	19.225	4.492
			M^2T	3.265×10^{-6}	0	76.9	16.507	4.663
			M^3	5.787×10^{-9}	0	77.6	16.358	0.435
			M	-2.096×10^{-1}	4.110×10^{-2}	78.9	15.978	-4.243
			M^3T^3	-1.441×10^{-12}	0	83.5	14.242	-4.996
			T	-10.625	7.107	84.0	14.120	-1.018
M-1, M-2	*M. arenaria*	-78.564	T^2	9.735×10^{-2}	1.393×10^{-1}	62.0	22.280	0.732
			MT^2	1.922×10^{-3}	4.800×10^{-4}	74.2	18.459	4.938
			M^2T^2	-1.260×10^{-5}	0	82.2	15.430	-6.408
			M	-1.016	3.970×10^{-1}	82.3	15.509	-1.912
			M^3T	1.489×10^{-6}	0	83.7	14.962	3.771
			T^3	-7.711×10^{-4}	2.540×10^{-3}	83.8	15.054	-0.316
M-A, M-B M-1, M-2	*M. arenaria*	21.548	T^3	9.708×10^{-4}	1.040×10^{-3}	60.4	22.29[illegible]	0.374
			MT^3	4.890×10^{-5}	1.000×10^{-5}	71.7	18.894	4.682
			M^2T^3	-2.900×10^{-7}	0	78.5	16.524	-5.436
			M	-1.519	3.080×10^{-1}	79.3	16.277	-2.908
			M^2T	2.945×10^{-4}	7.000×10^{-5}	81.7	15.340	4.038
			T	-1.475	3.966	81.7	15.383	-0.148

Table 24. Statistics of multiple regression of arcsine transformed percentage mortality on temperature (T) and salinity (S). B = Regression coefficient; S_b = Standard error of B; $100R^2$ = Coefficient of determination; S_r = Standard error of estimate; Beta = Standardized regression coefficient.

Experiments	Species	Constant	Variable	B	S_b	$100R^2$	S_r	Beta
M-5, M-6	*M. arenaria*	63.106	T^3	-4.024×10^{-3}	1.140×10^{-3}	40.7	24.710	-2.094
			SXT	-7.643×10^{-1}	9.845×10^{-2}	69.1	17.931	-7.165
			S^2T^3	-8.309×10^{-6}	0	76.1	15.850	-3.340
			S^2	1.509×10^{-1}	3.624×10^{-2}	79.5	14.748	1.518
			ST^3	5.038×10^{-4}	9.000×10^{-5}	82.6	13.678	6.482
			T^2	1.832×10^{-1}	4.093×10^{-2}	85.5	12.558	2.254
			S^2T	8.376×10^{-2}	3.590×10^{-3}	86.3	12.257	2.701
M-7	*M. arenaria*	14.437	T^3	1.791×10^{-3}	9.800×10^{-4}	73.9	15.940	1.115
			T	-5.585×10^{-1}	2.386	85.3	12.082	-0.143
			S^3T	5.427×10^{-4}	3.000×10^{-4}	85.7	12.034	4.173
			SXT	-8.896×10^{-1}	5.083×10^{-1}	87.9	11.187	-7.955
			S	10.822	6.575	87.9	11.297	2.777
			S^3	-8.255×10^{-3}	5.310×10^{-3}	87.9	11.383	-1.954
			ST^2	1.465×10^{-2}	9.320×10^{-3}	88.0	11.482	5.048
			S^3T^3	-1.850×10^{-7}	0	88.5	11.327	-1.854

Table 25. Statistics of multiple regression of arcsine transformed percentage mortality on temperature (T) and salinity (S). B = Regression coefficient; S_b = Standard error of B; $100R^2$ = Coefficient of determination; S_r = Standard error of estimate; Beta = Standarized regression coefficient.

Experiments	Species	Constant	Variable	B	S_b	$100R^2$	S_r	Beta
M-3,M-5,M-6	*M. arenaria*	-0.996	T^3	-8.245×10^{-3}	1.510×10^{-3}	42.4	25.643	-4.353
			SXT	-1.102	1.538×10^{-1}	69.8	18.623	-10.419
			S^2T^3	-2.647×10^{-5}	1.000×10^{-5}	76.5	16.490	-11.154
			S^2	-7.736×10^{-3}	6.316×10^{-2}	78.1	15.978	-0.077
			ST^3	8.950×10^{-4}	1.400×10^{-4}	81.0	14.959	12.065
			T^2	3.362×10^{-1}	5.651×10^{-2}	84.3	13.664	4.126
			S^3T^2	2.062×10^{-5}	0	85.1	13.358	7.315
			S	11.181	3.402	86.3	12.859	3.064
P-3	*P. magellanicus*	117.814	T^2	2.458×10^{-1}	1.605×10^{-1}	35.8	24.993	2.276
			S	-11.495	8.727	62.4	19.327	-3.461
			ST^3	5.214×10^{-4}	2.100×10^{-4}	72.0	16.867	4.886
			S^2	4.199×10^{-1}	2.243×10^{-1}	76.6	15.586	4.823
			S^3T	1.511×10^{-4}	2.800×10^{-4}	86.1	12.162	-1.616
			T^3	7.968×10^{-3}	4.230×10^{-3}	88.1	11.385	-2.823
			SXT	3.412×10^{-1}	3.720×10^{-1}	88.1	11.485	-3.036
			S^3T^3	1.236×10^{-7}	0	88.3	11.541	-1.238

Table 26. Predictive equations of arcsine transformed percentage mortality (y) of *P. magellanicus* and *M. arenaria* under conditions noted in Table 14. T = Temperature (°C); M = Time; S = Salinity (°/₀₀).

Experiment	
P-1,2	$y = -339.145 + 14.336T - 1.478M + 4.955\times10^{-3}M^2 - 2.904\times10^{-3}T^3 - 2.561\times10^{-7}M^2T^3 + 2.354\times10^{-3}MT^2$
M-A,B,1,2	$y = 21.548 + 9.708\times10^{-4}T^3 + 4.890\times10^{-5}MT^3 - 2.9\times10^{-7}M^2T^3 - 1.519M + 2.945\times10^{-4}M^2T - 1.475T$
M-3,5,6	$y = 0.996 - 8.245\times10^{-3}T^3 - 1.102S\times T - 2.647\times10^{-5}S^2T^3 - 7.763\times10^{-3}S^2 + 8.950\times10^{-4}ST^3 + 3.362\times10^{-1}T^2 + 2.062\times10^{-5}S^3T^2 + 11.781S$
M-7	$y = 14.437 + 1.791\times10^{-3}T^3 - 5.585\times10^{-1}T + 5.427\times10^{-4}S^3T - 8.896\times10^{-1}S\times T + 10.882S - 8.255\times10^{-3}S^3 + 1.456\times10^{-2}ST^2 - 1.850\times10^{-7}S^3T^3$
P-3	$y = 117.814 + 2.458\times10^{-1}T^2 - 11.459S + 5.214\times10^{-4}ST^3 + 4.199\times10^{-1}S^2 - 1.511\times10^{-4}S^3T - 7.968\times10^{-3}T^3 - 3.412\times10^{-1}S\times T - 1.236\times10^{-7}S^3T^3$

Table 27. Predicted percentage mortalities of *P. magellanicus* at time-temperature combinations within experimental limits.

	Time (min.)						
Temp. (°C)	5	30	60	80	120	150	180
26			0	0	0	2	8
27		0	1	3	9	16	24
28	0	2	9	18	28	37	44
29	2	11	26	41	52	60	63
30	7	25	47	65	75	80	79
31	15	41	68	85	92	93	90
32	24	57	83	97	100	100	97
33	33	72	96	100			99
34	42	84	100				100
35	50	93					
36	57	98					
37	63	100					

Table 28. Predicted percentage mortalities of *M. arenaria* at time-temperature combinations within experimental limits.

	Time (min.)						
Temp. (°C)	5	30	60	90	120	150	180
31	1	0	0	0	1	1	3
32	1	2	4	5	7	9	10
33	2	6	11	16	20	22	22
34	4	12	23	32	38	39	37
35	6	21	39	52	59	59	53
36	9	31	57	73	80	78	69
37	13	44	75	90	95	93	83
38	17	58	90	99	100	100	94
39	23	72	99	100			99
40	29	85	100				100
41	36	94					
42	44	100					

Table 29. Predicted percentage mortalities of *P. magellanicus* at salinity-temperature combinations within experimental limits.

	Salinity (°/oo)					
Temp. (°C)	5	10	15	20	25	30
15	98	36	2			
16	99	40	3			
17	100	44	5			
18		47	7			
19		52	9	0		
20		57	13	1		
21		62	18	3	0	
22		67	23	6	1	0
23		72	31	11	3	1
24		77	39	18	8	2
25		81	48	28	16	6
26		86	58	40	26	13
27		90	69	54	41	23
28		93	79	69	58	38
29		96	88	83	75	55
30		98	95	94	90	74
31		99	99	100	99	91
32		100	100		100	100

Table 30. Predicted percentage mortalities of *M. arenaria* reared at high salinity at salinity-temperature combinations within experimental limits.

	Salinity (°/oo)					
Temp. (°C)	5	10	15	20	25	30
14	28	8				
15	30	8				
16	33	8				
17	37	8				
18	40	8				
19	45	8				
20	49	8				
21	54	10				
22	59	11				
23	64	14				
24	69	17				
25	74	21				
26	79	26				
27	83	32				
28	87	39	0			
29	90	47	2			
30	93	56	6			0
31	95	65	11			1
32	97	74	20	0		5
33	98	83	31	1		14
34	99	90	44	5	0	27
35	100	96	60	15	5	43
36		99	75	29	15	62
37		100	88	50	31	79
38			98	67	51	93
39			100	85	72	100
40				97	90	

Table 31. Predicted percentage mortalities of *M. arenaria* reared at low salinity at salinity-temperature combinations within experimental limits.

	Salinity (°/oo)					
Temp. (°C)	5	10	15	20	25	30
18						5
19	0					6
20	4					6
21	5	0			0	8
22	5	1			1	9
23	6	1			2	12
24	7	2			2	15
25	9	2	0	0	3	19
26	11	3	1	1	4	24
27	14	4	1	1	6	31
28	18	7	2	3	10	38
29	24	10	4	5	14	46
30	30	14	8	8	20	54
31	37	20	12	13	27	63
32	46	28	19	20	36	72
33	55	37	28	29	46	82
34	65	48	39	40	58	89
35	75	60	51	53	69	95
36	85	73	65	67	81	99
37	93	84	78	80	90	100
38	98	94	90	91	97	
39	100	99	98	98	100	
40		100	100	100		

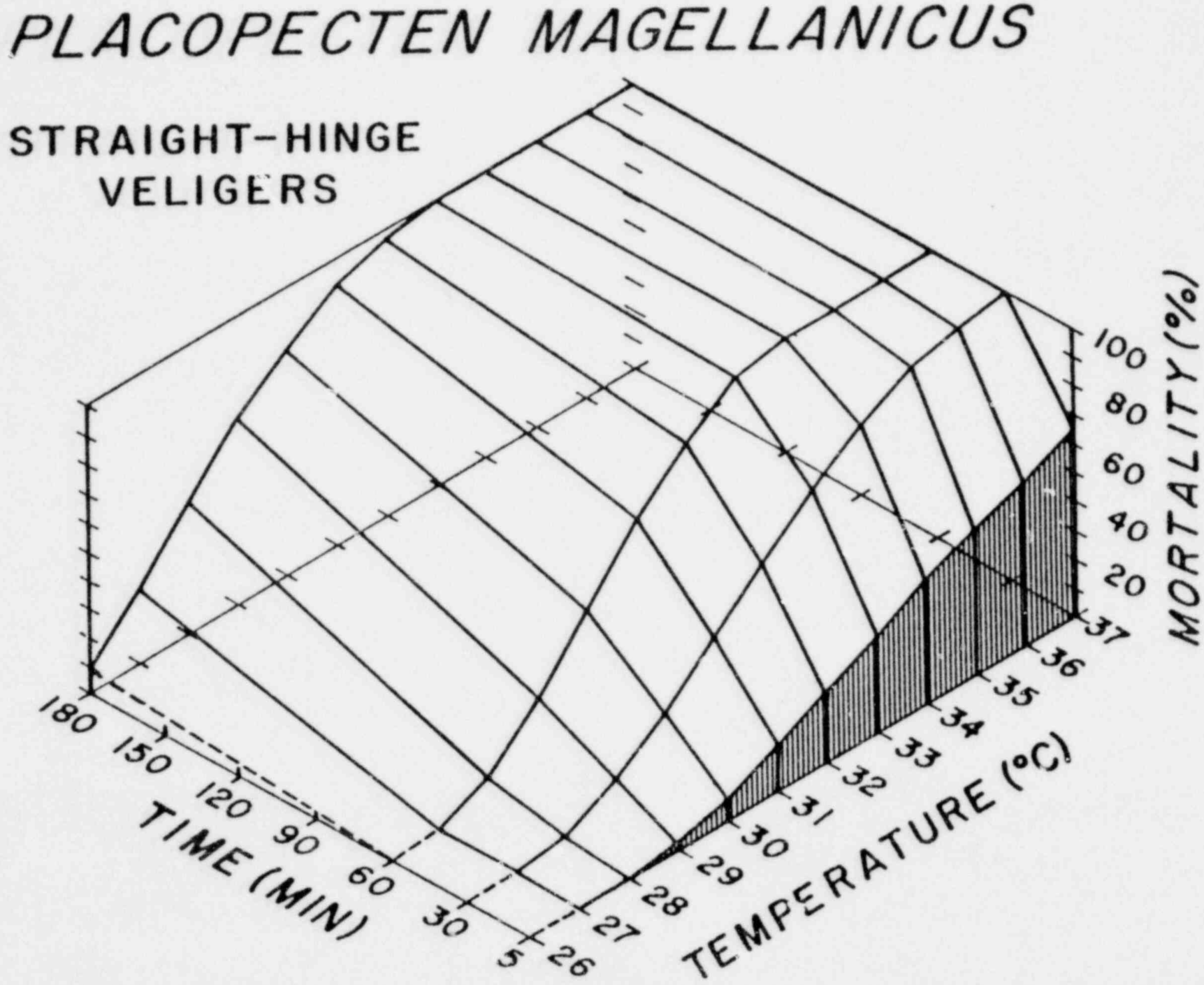
Figure 1. Mortality of *Placopecten magellanicus* straight-hinge veligers as predicted by the regression equation for experiments P-1 and P-2 (see Table 25).

Figure 2. Mortality of *Mya arenaria* straight-hinge veligers as predicted by the regression equation for experiments M-A, M-B, M-1, and M-2 (see Table 25).

Figure 3. Mortality of *Placopecten magellanicus* straight-hinge veligers as predicted by the regression equation for experiment P-3 (see Table 25).

Figure 4. Mortality of *Mya arenaria* straight-hinge veligers reared at high salinity as predicted by the regression equation for experiments M-3, M-5, and M-6 (see Table 25).

Figure 5. Mortality of *Mya arenaria* straight-hinge veligers reared at low salinity as predicted by the regression equation for experiment M-7 (see Table 25).



PLACOPECTEN MAGELLANICUS
STRAIGHT-HINGE VELIGERS
MORTALITY (%)
100
80
60
40
20
TEMPERATURE (°C)
26
27
28
29
30
31
32
33
34
35
36
37
TIME (MIN)
180
150
120
90
60
30
5

Figure 1

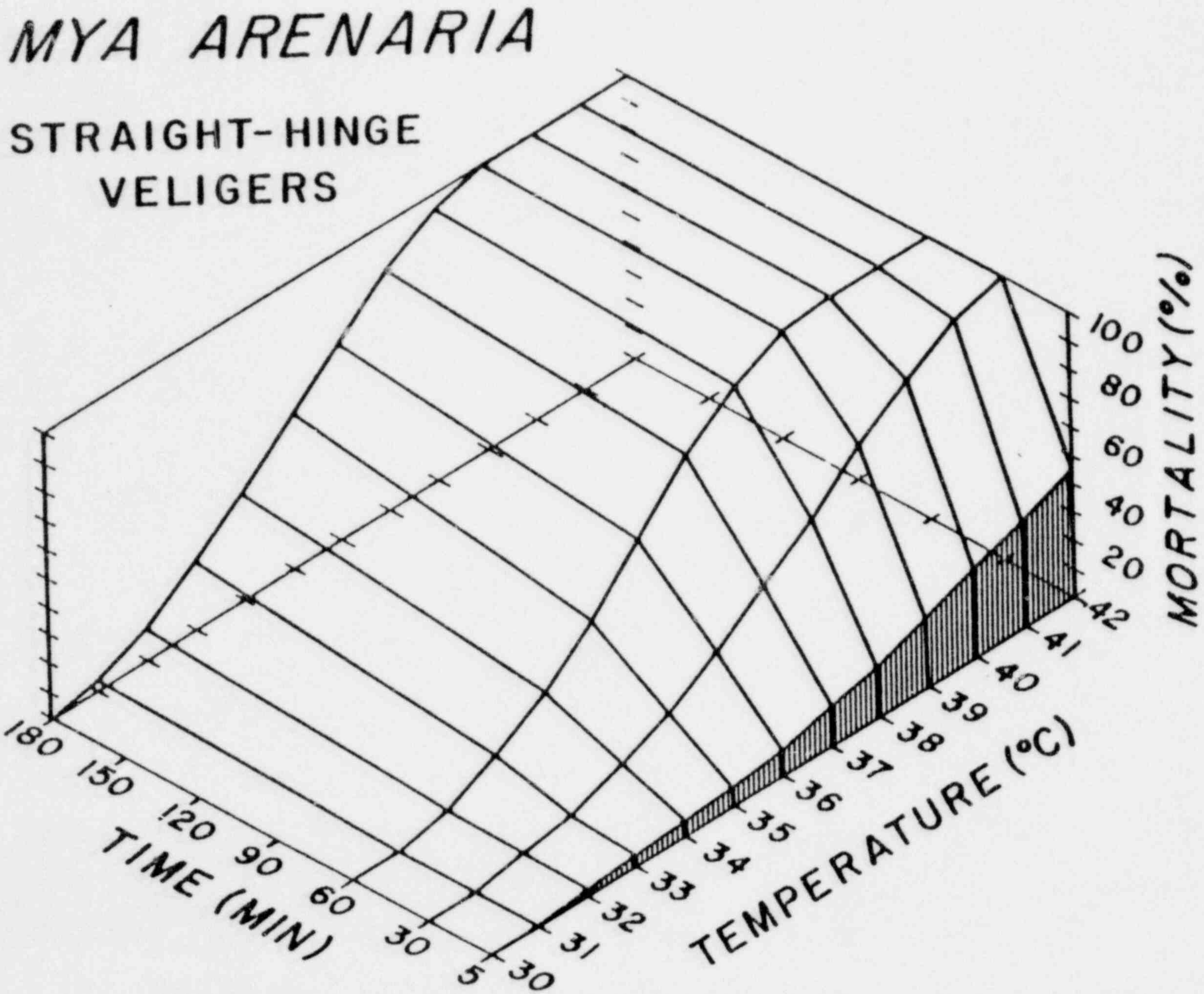

MYA ARENARIA
STRAIGHT-HINGE VELIGERS
MORTALITY (%)
100
80
60
40
20
TIME (MIN)
180
150
120
90
60
30
5
TEMPERATURE (°C)
30
31
32
33
34
35
36
37
38
39
40
41
42

Figure 2

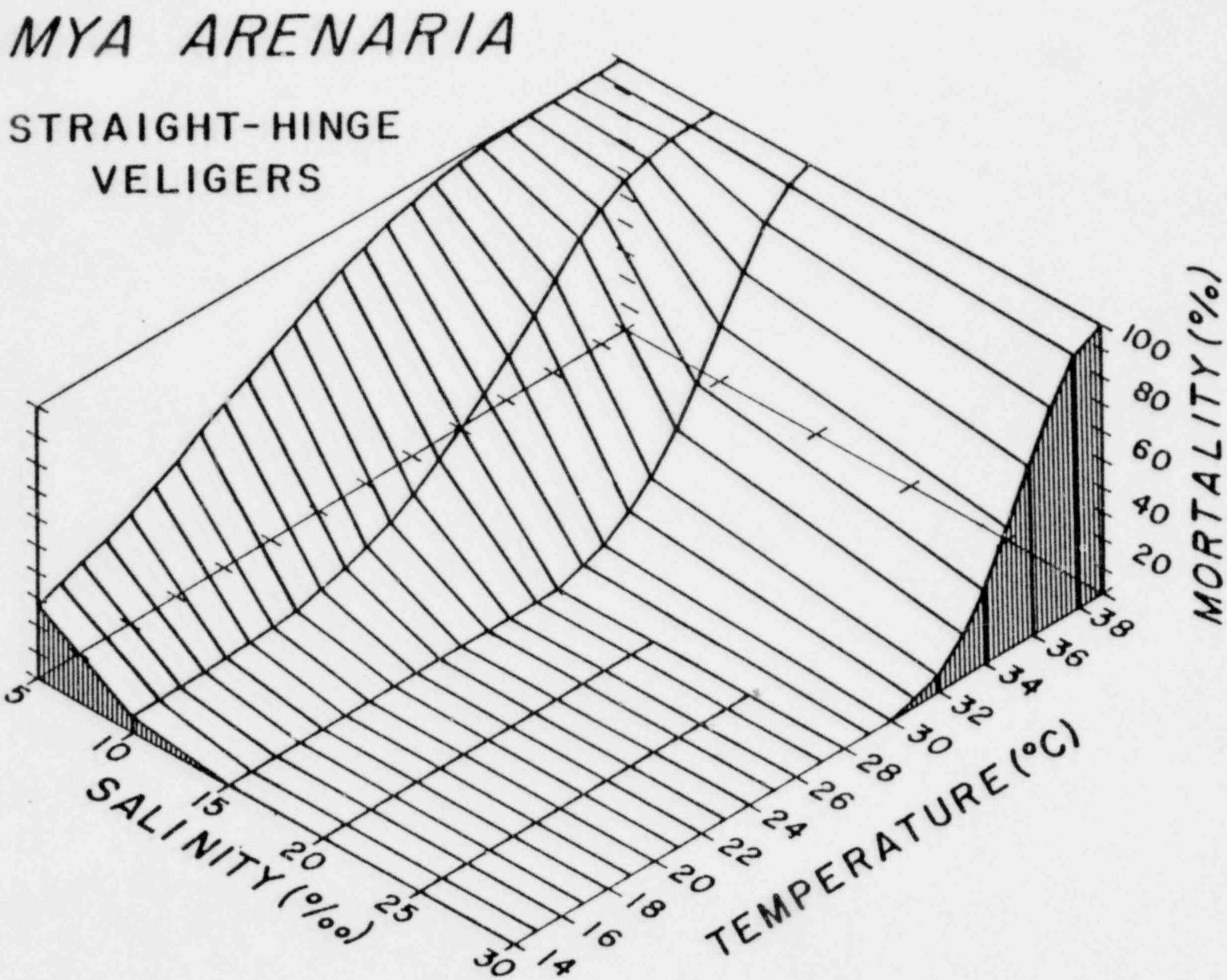
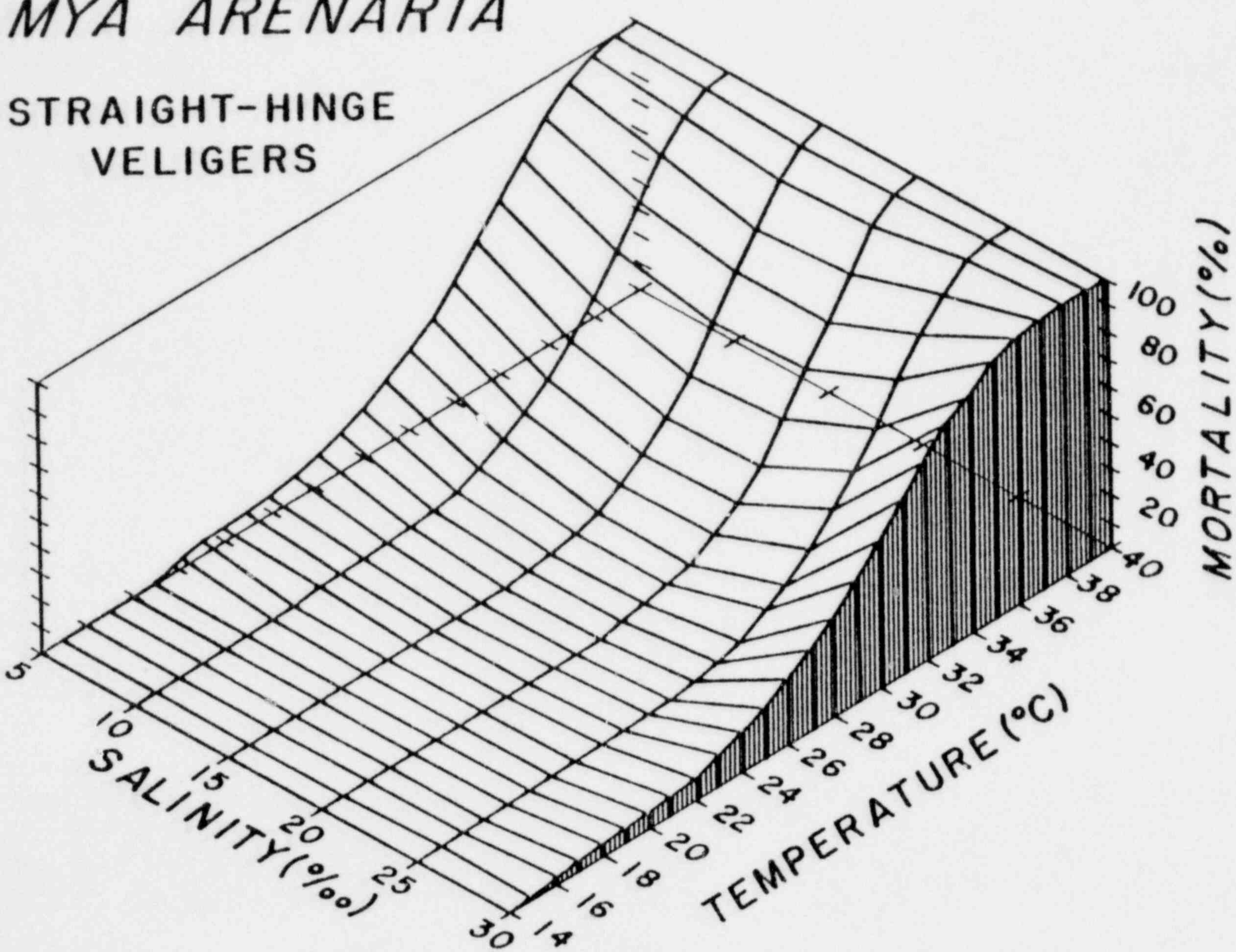

MYA ARENARIA
STRAIGHT-HINGE
VELIGERS
MORTALITY (%)
100
80
60
40
20
SALINITY (‰)
5
10
15
20
25
30
TEMPERATURE (°C)
14
16
18
20
22
24
26
28
30
32
34
36
38

Figure 3


MYA ARENARIA
STRAIGHT-HINGE VELIGERS
MORTALITY (%)
0
20
40
60
80
100
SALINITY (‰)
5
10
15
20
25
30
TEMPERATURE (°C)
14
16
18
20
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26
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30
32
34
36
38
40

Figure 4

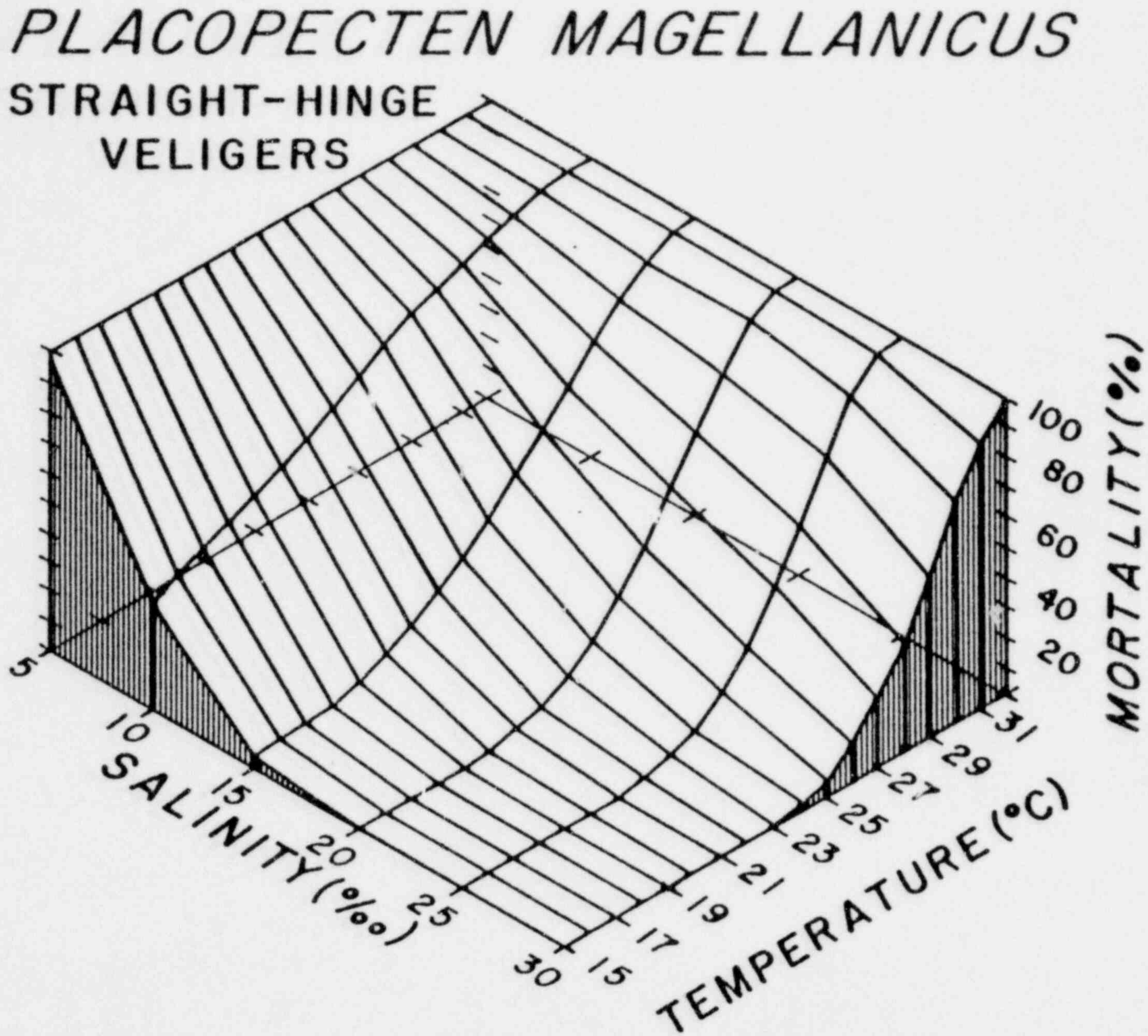

PLACOPECTEN MAGELLANICUS
STRAIGHT-HINGE
VELIGERS
MORTALITY (%)
100
80
60
40
20
SALINITY (‰)
5
10
15
20
25
30
TEMPERATURE (°C)
15
17
19
21
23
25
27
29
31

Figure 5

NUTRIENT CHEMISTRY

Bernard J. McAlice and David J. Carlson

Introduction

The objective of this continuing study is to determine the seasonal changes in temperature, salinity, the major phytoplankton nutrients, and dissolved oxygen in Montsweag Bay and at control stations in order to assess the impact of Maine Yankee on these variables.

In order to continue to assess the impact of causeway removal in 1974, stations S2 and M3 have been maintained.

Methods

Sampling stations are shown in Figure 6. All methods are detailed in the Final Report.

Results

The nitrate, phosphate, silicate and oxygen concentrations are shown in Figures 7, 8, 9 and 10. All the nutrient and oxygen valves were similar to past reporting periods in both times and concentrations of peak values.

Conclusion

Based on these data, there appears to be no effect, from the operation of Maine Yankee, on the cyclical nature of the major nutrients or dissolved oxygen.

Ira C. Darling Center Ref. No. 79-7b

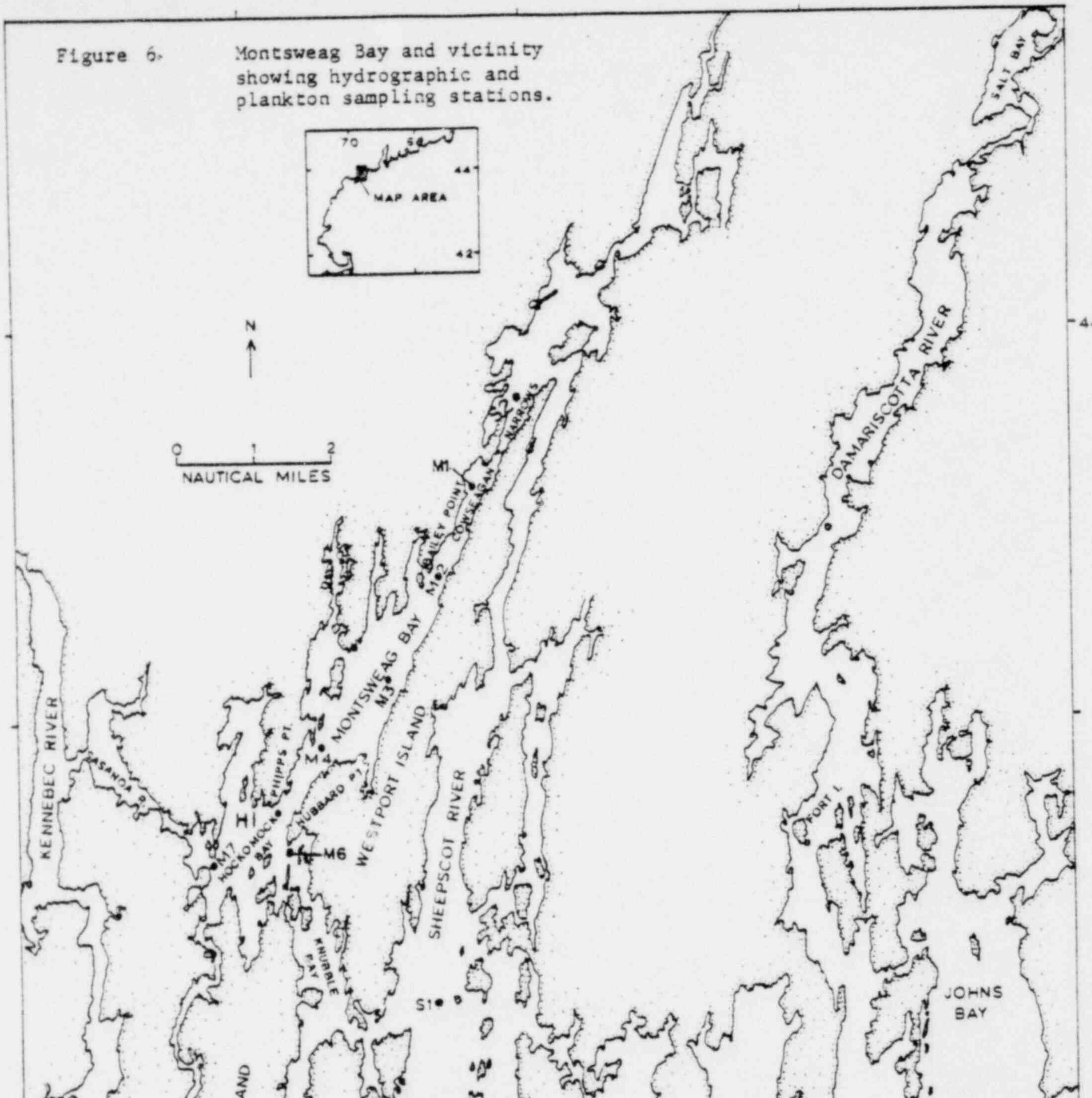


Figure 6. Montsweag Bay and vicinity showing hydrographic and plankton sampling stations.

Figure

Figure 7. Nitrate concentration at stations M2, M3, M- ·
S2, October 1969 to June 1979.

_____ surface ---

Figure 8. Phosphate concentration at stations M2, M3, M4, M7, S1, and S2, October 1969 to June 1979.

_____ surface ----- bottom

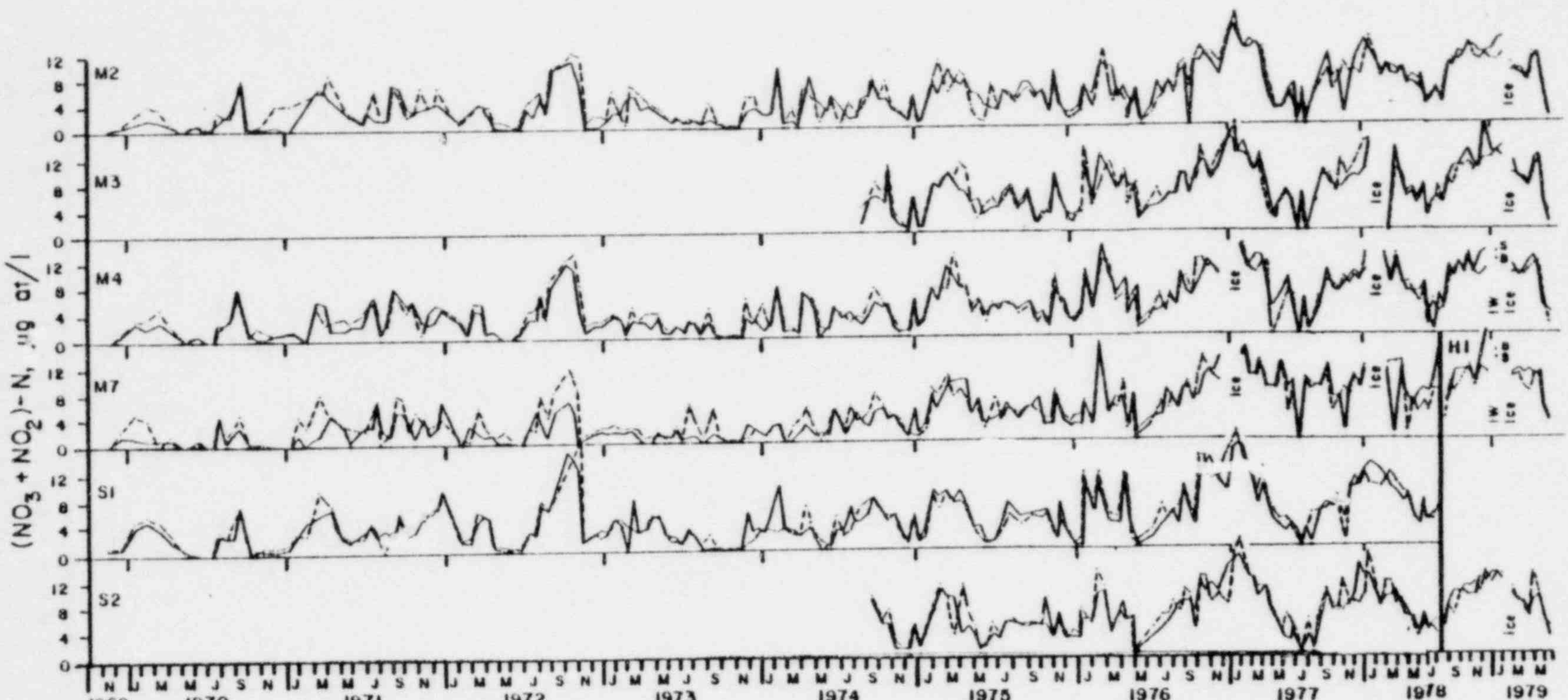
Figure 9. Silicate concentration at station M2, M3, M4, M7, S1, and S2, October 1969 to June 1979.

_____ surface ----- bottom

Figure 10. Dissolved oxygen concentration at stations M2, M3, M4, M7, S1, and S2, October 1969 to June 1979.

_____ su...ace values only

Note: IW = Inclement Weather



(NO$_3$ + NO$_2$)-N, μg at/l
M2
M3
M4
M7
S1
S2
H1
ICE
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 8

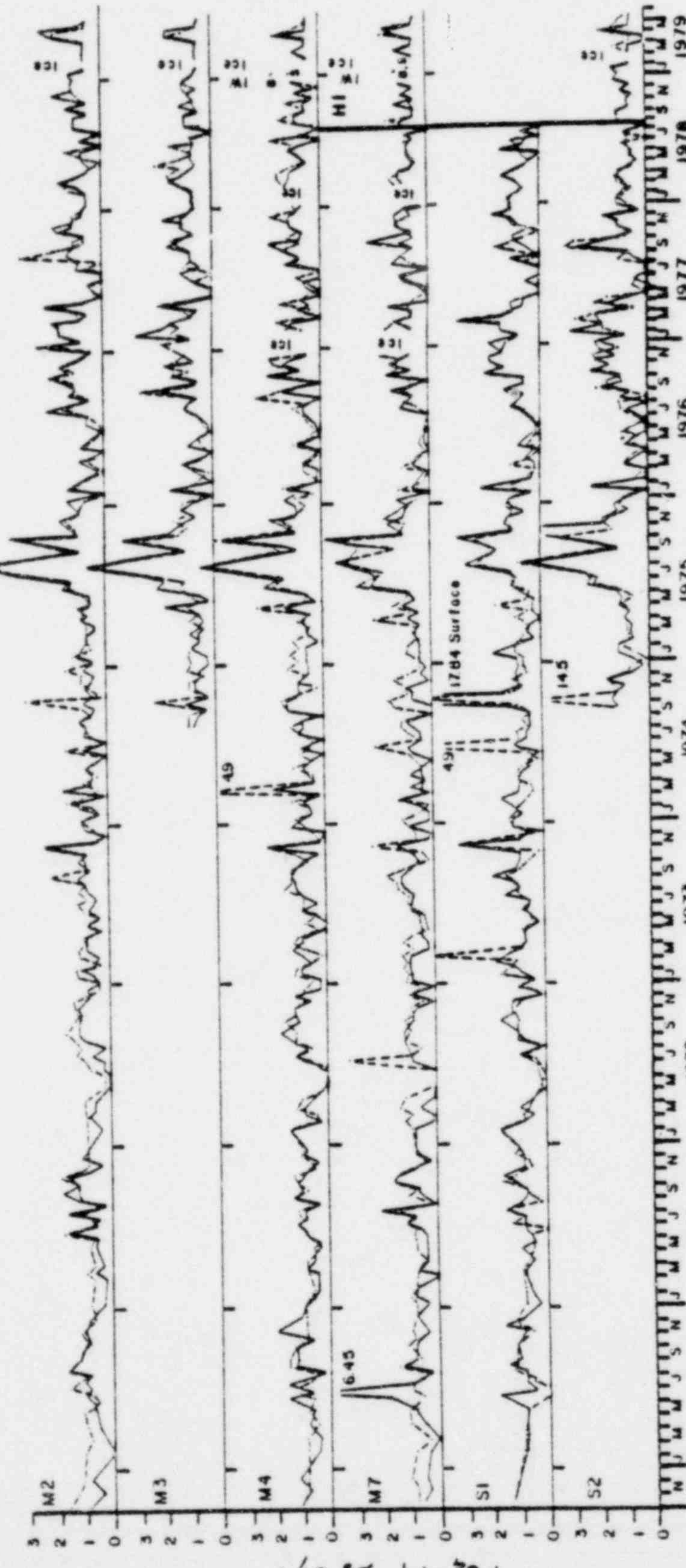
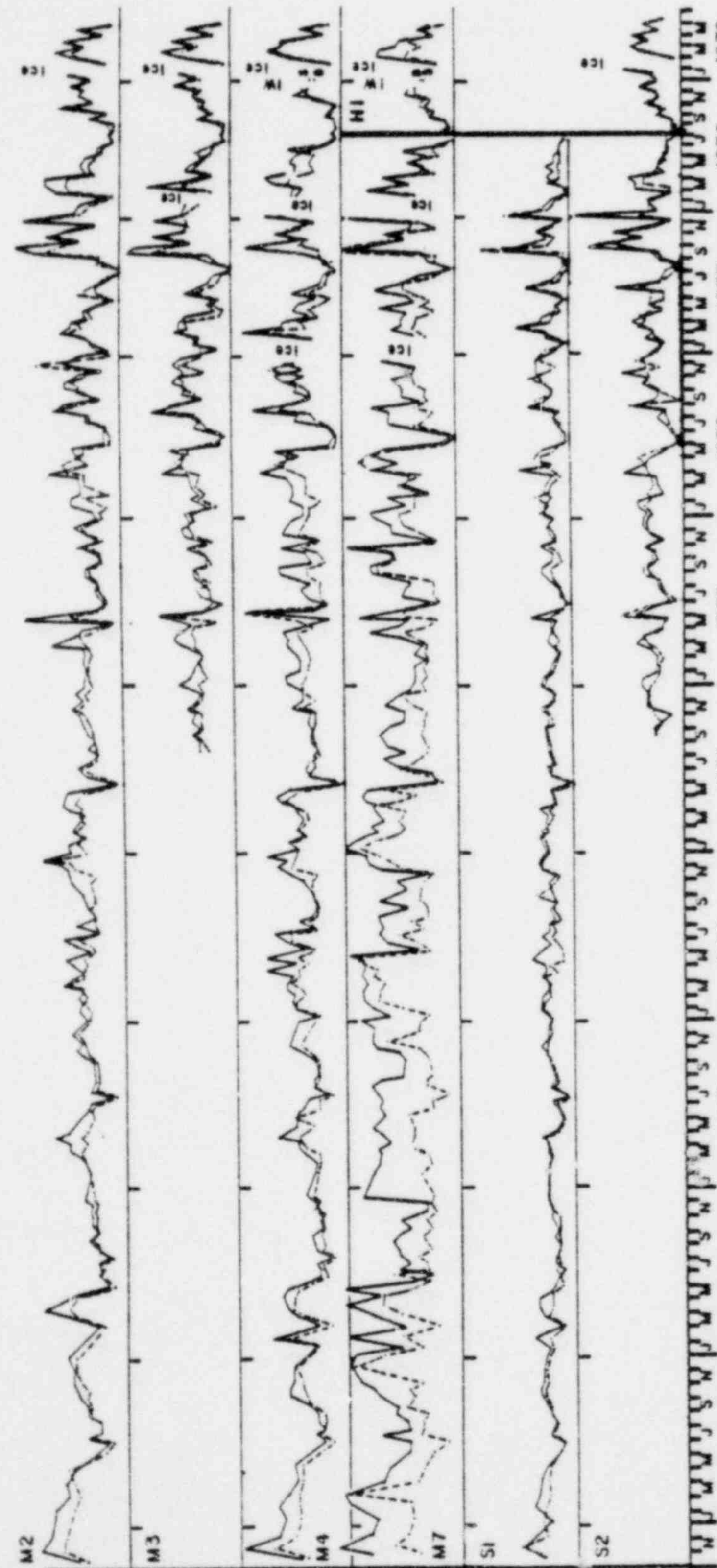
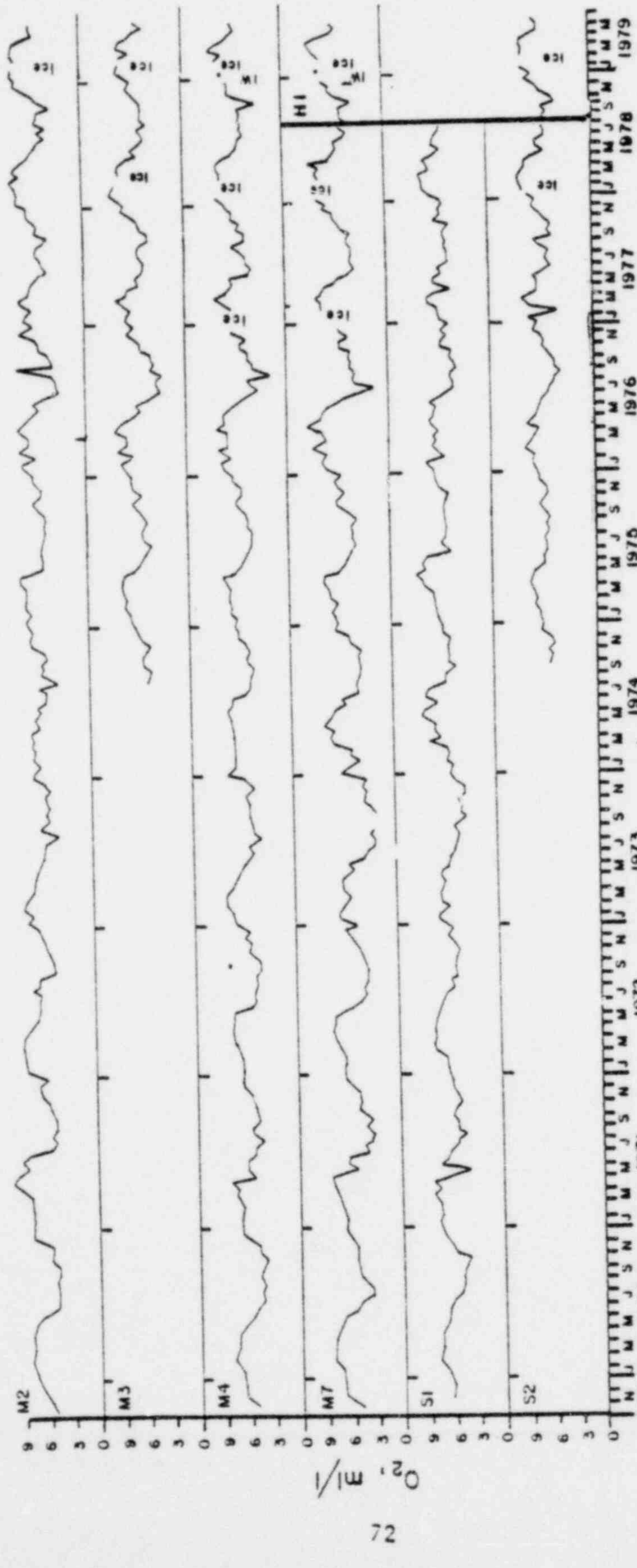

M2
M3
M4
M7
S1
S2
PO4-P, µg at/l
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
645
49
1784 Surface
491
145

Figure 9



M2
M3
M4
M7
S1
S2
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ice
SiO_2-Si, µg at/l

Figure 10


M2
M3
M4
M7
S1
S2
H1
ice
O_2, ml/l
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

MICROZOOPLANKTON

Bernard J. McAlice and Anne L. Heinig

Introduction

The work reported here is part of a continuous study designed to assess the long-term effects of the Maine Yankee Nuclear Generating Station operations on the composition, abundance, and seasonality of microzooplankton populations in Montsweag Bay. This is achieved through studies comparing these populations, with those outside the bay, before and after Maine Yankee went into operation in September 1972. This study has been in progress since October 1969.

Methods

Plankton samples were taken at stations S1, S2, M2, M3, M4, and D7. On 25 August 1978 stations S1 and D7 were discontinued and a new station, H1, was occupied, replacing M5, a former chemistry station. H1 acts as a control by monitoring the thermally influenced waters below Maine Yankee in much the same way as the control station S2 monitors those waters above the Maine Yankee plant (Figure 6).

The initial sampling interval was monthly; this was shortened to semimonthly in June 1970. Sampling was begun at S1 and M4 on 29 October 1969, at M2 on 28 March 1972, at M3 on 6 September 1974, and at S2 on 20 September 1974. All stations were usually occupied on the same day, during daylight, and at various tidal stages.

Ira C. Darling Center Ref. No. 79-7c

Hauls were 10-15 min oblique tows with a #20 mesh (~76u) net of 0.5 m mouth diameter (mouth area 0.196 m^2), equipped with a centrally mounted flowmeter. Boat speed during tows was 1-2 m/sec.

Beginning 23 July 1976 a #25 mesh (~64u) net was substituted by mistake. All collections were made with this net size until 3 February 1977, when a #25 net was used at S1, S2, and M4, and a #20 net at M2 and M3. After 3 February 1977 all collections were made with a #20 net. The change in mesh size probably introduced no significant bias for most of the organisms considered here; even the smaller forms, such as copepod nauplii and rotifers would be retained by both nets. However, because of the increased filtration coefficient (Tranter, 1967), and consequent decrease in flow rate, of the #25 net, some net avoidance by larger animals may have occurred (Clutter and Anraku, 1968).

Two counting procedures were used during the study. Before July 1974 the concentrated plankton was transferred to a 10 cm square chamber of the type described by Hopkins (1962). Large organisms were removed and, depending upon the abundance of animals in the collection, one or two 1/25 subsamples were taken for counting. From July 1974 through the present, the concentrated plankton was diluted to a known volume, thoroughly stirred, and a 1 ml Stempel pipette aliquot removed for counting. Organisms in the subsamples were identified and counted at magnifications of 25-500x, as required.

For the Stempel pipette subsamples, dilution volumes were adjusted to try to achieve a count of about 1000 animals in the 1 ml subsamples, but in practice the total counts varied from about 700 to 4000. Beginning 22 January 1976 all samples were routinely filtered through a nylon screen (1 mm mesh) to remove larger organisms for counting. Before this the entire sample was picked through for large forms if their presence was noted; some were certainly missed. From 23 July 1976 on, a species list was established from examination of an eye dropper volume taken from the concentrated sample before dilution and counting. This increased the probability of detecting scarce species.

Errors in zooplankton abundance estimates are introduced both in taking collections in the field (sampling error) and in counting them in the laboratory (subsampling error). The errors associated with subsampling and counting using Hopkins' (1962) chamber appear from his data to be about ±15% of the raw count. For Stempel pipette subsamples, Wiebe et al. (1973) reported a difference of about 6% between subsamples, and Lee and McAlice (1979) found 8%. We did not make an independent evaluation of either method.

We made two assessments of overall sampling variability. On 4 November 1976, at M3, we made five replicate tows with a #25 net. The experiment was repeated at M2 on 19 May 1977, using a #20 net. Each experiment was done during a regular sampling cruise, and tows were made in quick succession over a one-hour period at mid-tide. Towing and Stempel pipette subsampling followed the procedures already described, except that the identities of all collections, including routine station samples, were masked to avoid any bias in counting. Abundance estimates for six major groups were transformed to log (x+1) to eliminate the correlation between mean and variance. Means, standard deviations, and 95% confidence intervals were calculated for the transformed values. Results are summarized in Table 32. The 95% confidence intervals for all copepod groups were greater by about a factor of two in the first experiment. Rotifers and tintinnids had similar intervals in the two experiments. Polychaete setigers were not present in November 1976.

To compare our results with those of other workers, the 95% confidence intervals were expressed as percentages of the raw means by the procedure of Bagenal (1955). Averages were about 50-170% of the raw mean; for the copepod groups taken with the #20 net they were about 55-160%. Wiebe and Holland (1968) reviewed field sampling errors from 13 studies and found 95% confidence intervals of roughly 50-200% of the untransformed mean abundance, as did Silliman (1946) and Lee and McAlice (1979). Sameoto's (1975) data for copepods average 75-150% of the mean; he used paired nets without bridles.

Our results estimated the total sampling variability arising from a combination of factors including plankton patchiness, subsampling variation, and counting errors. From them, we concluded that ±10% of the transformed mean is a reasonable estimate of the 95% confidence interval to be applied to a single observation. Two abundance estimates should not be considered significantly different if they differ by less than this.

Results and Discussion

Data are presented for four stations (S2, M2, M3, and M4) whose samples have been completely, or nearly completely, analyzed from the time the station was first sampled through 31 December 1978 (Figures 11-27). Due to a sample backlog, M2 and M3 are included only through 30 June 1978 and data from 1 January 1974 through 30 June 1974 for M2 are not included because of some unprocessed samples. This report differs from

Report 12 only in the continuation of M4 and S2 graphs through March 1979. In March Anne L. Heinig left for other work, and because of funding uncertainties the position could not be filled.

Throughout the study 11 taxa were selected for graphical analysis on the basis of their general importance, seasonality, and previous history of altered occurrence. Analysis consisted of inspection of the graphs for significant shifts in seasonality or changes in abundance that were coincident with Maine Yankee operation (started 15 September 1972), or with removal of the Cowseagan Narrows causeway (completed in December 1974). Care was taken to examine the local control station (S2) for corresponding faunal changes, and unusual changes occurring in 1978 were also noted. Table 33 summarizes our observations.

We have observed in previous reports that five copepod taxa (*A. hudsonica*, *A. longiremis*, *E. herdmani*, *P. minutus*, and *T. longicornis*) have decreased in abundance after Maine Yankee began operation. During the first half of 1977, it appeared that three of these species (*A. hudsonica*, *E. herdmani*, and *T. longicornis*) were increasing. This trend did not continue.

Of the three species of *Acartia*, *A. longiremis* abundance continues to rise. Its numbers at M4 declined after Maine Yankee went into operation, but recovered to near pre-operational levels in 1975 (McAlice and Gardella, 1975). Its population density dropped steadily again in 1976, and it was rarely found in early 1977 (McAlice and Gardella, 1977). During the latter half of that year however, this species began increasing at both the Montsweag and Sheepscot stations. Coincidentally in 1978, *A. tonsa* showed an overall decrease at M4 from peaks of the previous 2 years, and, at S2, *A. hudsonica* exhibited diminished abundances. It is possible that localized environmental factors such as temperature and salinity favored the development of one species over another.

Pseudocalanus minutus adults are generally more abundant in the Sheepscot than in the Montsweag. There was an increase in abundances at S2 in 1978, but at M4, a decrease in both abundance and seasonality was noted, although changes in juvenile stages at this station were slight.

Decreases were noted for juveniles of other species in both the Montsweag and Sheepscot stations. These have been unalarming and may be attributed to seasonal variation.

The meroplankton is divided into three groups: larvae of cirripeds, bivalve larvae, and polychaete setiger larvae. In the operational period cirriped nauplii continue to appear earlier and stay until early December at M4; the other Montsweag stations resemble M4 in seasonality. Bivalve larvae appeared earlier but did not reach the peaks of the previous 2 years. Polychaete setigers were found in their usual high abundances in the Montsweag Bay from May through July despite a slightly late appearance in the spring.

In general, 1978 could not be considered as productive as the previous year. Despite abundance increases for 9 faunal groups (Table 33) there were decreases for 11 and the remainder exhibited little or no change. Seasonality increases were noted for a few groups including a few whose abundances had decreased.

For the beginning of 1979, the only faunal characteristics worthy of comment were the somewhat greater than usual abundances of developmental stages of *A. longiremis* and *O. similis*, and a decrease in the density of *P. minutis* nauplii and immature copepodids.

Conclusions

The cause for decreases in several of the adult copepods during the operational period is not evident. In previous reports we have mentioned that unidentified influences of the Maine Yankee plant or even size selective predation by planktivorous fish may be contributing factors (McAlice and Gardella, 1976). Regardless of possible causes for the changes in adult copepods, the decreases are not alarming since the abundances of the larval and juvenile stages remain near pre-operational levels.

Some variations in seasonal ranges of a few species have been noted since 1972 at M4, which is the Montsweag station with the longest sampling history. Since we have no indication of elevated temperatures at M4, it is difficult to ascribe these changes to the operation of Maine Yankee.

Except for the decreased abundance of adult copepods, we have seen no major long-term changes in the zooplankton of Montsweag Bay.

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Table 32. Summary of two replicate experiments - Microzooplankton-Montsweag Bay
Experiment #1: Station M-3, 4 Nov. 1976 (5 tows, #25 net) 0-2 m depth.
Experiment #2: Station M-2, 19 May 1977 (5 tows, #20 net) 0-2 m depth.

	1	2	3	4	5	6	7	8
						95% conf. limits as % of mean		n for
	Exper. I.D.	abund. no./m^3	log(x+1)	abund.	log(x+1)	abund.[a]	log(x+1)[b]	$.05\bar{x}_t$[c]
Copepod adults	1	1034	2.96	571	.241	18-423	±23%	21
	2	2072	3.31	441	.102	50-196	± 9%	3
Immature copepodites	1	123	2.00	95	.311	11-589	±43%	75
	2	4145	3.60	1364	.137	39-239	±11%	4
Copepod nauplii	1	1399	3.09	847	.247	18-421	±22%	20
	2	47018	4.65	17259	.143	36-241	± 9%	3
Rotifers	1	213	2.30	84	.165	32-270	±20%	16
	2	515870	5.56	366777	.476	3-1520	±24%	23
Tintinnids	1	43044	4.58	24494	.231	20-387	±14%	8
	2	209876	5.26	112207	.273	16-473	±14%	8
Polychaete setiger	1	-	-	-	-	-	-	-
	2	133504	5.11	45636	.145	38-247	± 8%	2

a. $\frac{\text{antilog}_{10}(\bar{x}-ts_t)}{\bar{x}}$ and $\frac{\text{antilog}_{10}(\bar{x}_t+ts_t)}{\bar{x}}$, where $\bar{x}$ = sample mean from raw (nontransformed) data, $\bar{x}_t$ and s_t are sample mean and standard deviation, respectively, of $\log_{10}$ transformed data, t = student's (t) at .05 for df=4(t-2.776) (Bagenal, 1955).

b. $\frac{\bar{x}_t-ts_t}{\bar{x}_t}$ and $\frac{\bar{x}_t+ts_t}{\bar{x}_t}$

c. Stein's two-stage sample procedure (Steel and Torrie, 1960). $n=\frac{t^2 s_t^2}{d^2}$, where d is the half width of the desired (95%) confidence interval (i.e., $d = 0.5\bar{x}_t$).

Table 33. Observations from inspection of Figures 11-25, indicating changes at stations M2, M3, M4, and S2 coincident with M.Y. (Sep 1972 to Dec 1974), causeway removal (Dec 1974 to present), and 1978 (Jan through Dec 1978).

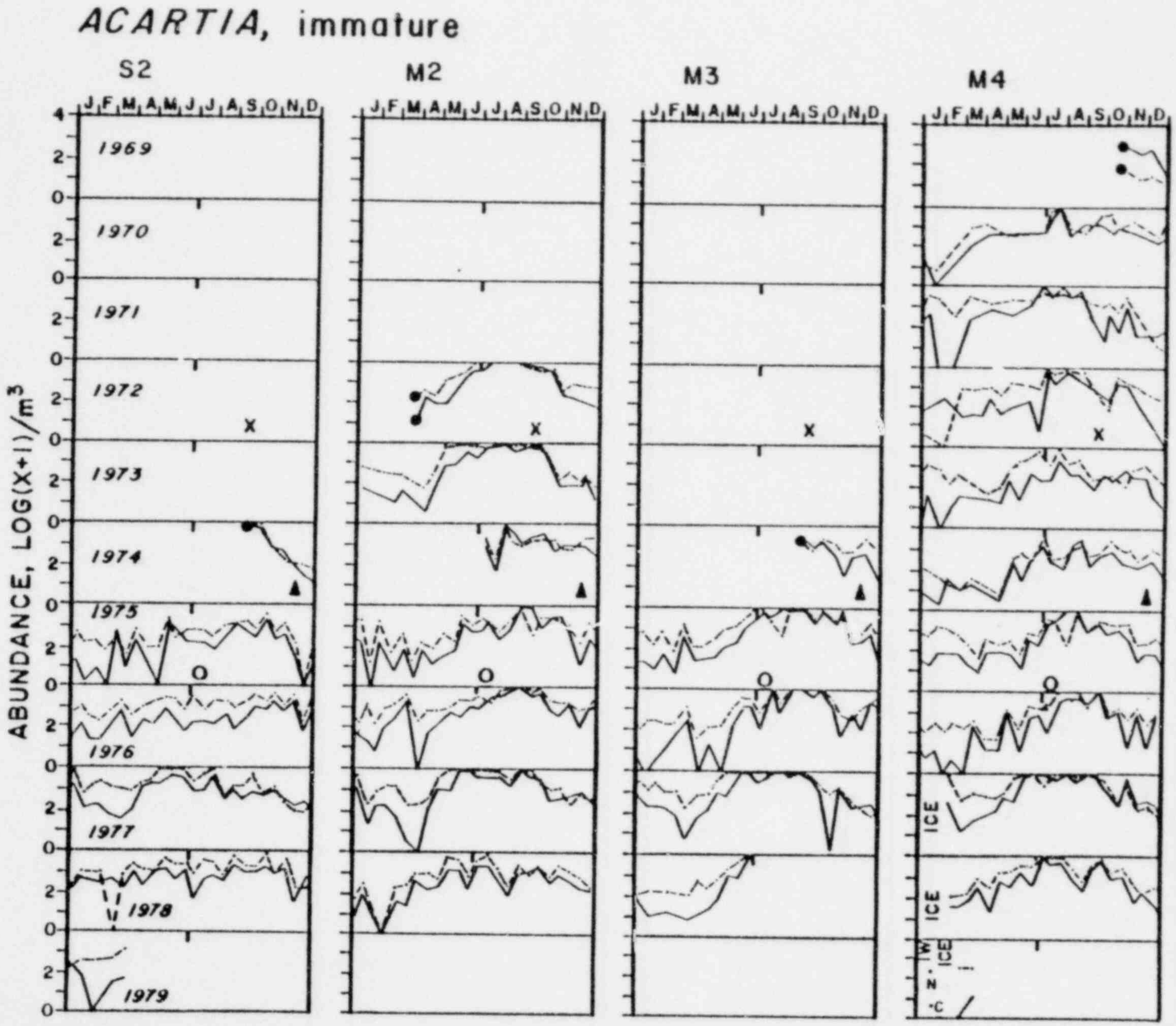
		Seasonality Lengthened			Seasonality Shortened			Abundances Increased			Abundances Decreased		
	Figure	M.Y.	Causeway	1978	M.Y.	Causeway	1978	M.Y.	Causeway	1978	M.Y.	Causeway	1978
Acartia nauplii	11												S2
Acartia copepodid	11												
Acartia hudsonica	12	M4										M4	S2
Acartia longiremis	13			S2,M4						M4,S2	M4		
Acartia tonsa	14	M4		S2						S2			
Eurytemora nauplii	15	M4								M4			
Eurytemora copepodid	15	M4											S2
Eurytemora herdmani	16	M4		S2,M4		M4				S2	M4	M4	
Microsetella norvegica	17												
Pseudocalanus nauplii	18												S2,M4
Pseudocalanus copepodid	18												S2,M4
Pseudocalanus minutus	19					M4	M4			S2	M4	M4	M4
Temora nauplii	20									M4			
Temora copepodid	20			S2,M4									M4
Temora longicornis	21										M4	M4	S2,M4
Rotifers	22												M
Cirriped nauplii	23	M4											M4
Cirriped cyprids	23									S2,M4			
Bivalve larvae	24												S2,M4
Polychaete setigers	25			S2									S2

Figures 11-27. Population abundance of selected species at four stations, October 1969 to June 1979.

_____copepodid
- - -nauplii

● Sampling of station begins
X Maine Yankee began operation
▲ Cowseagan Narrows causeway removed
○ Diffuser discharge began operation

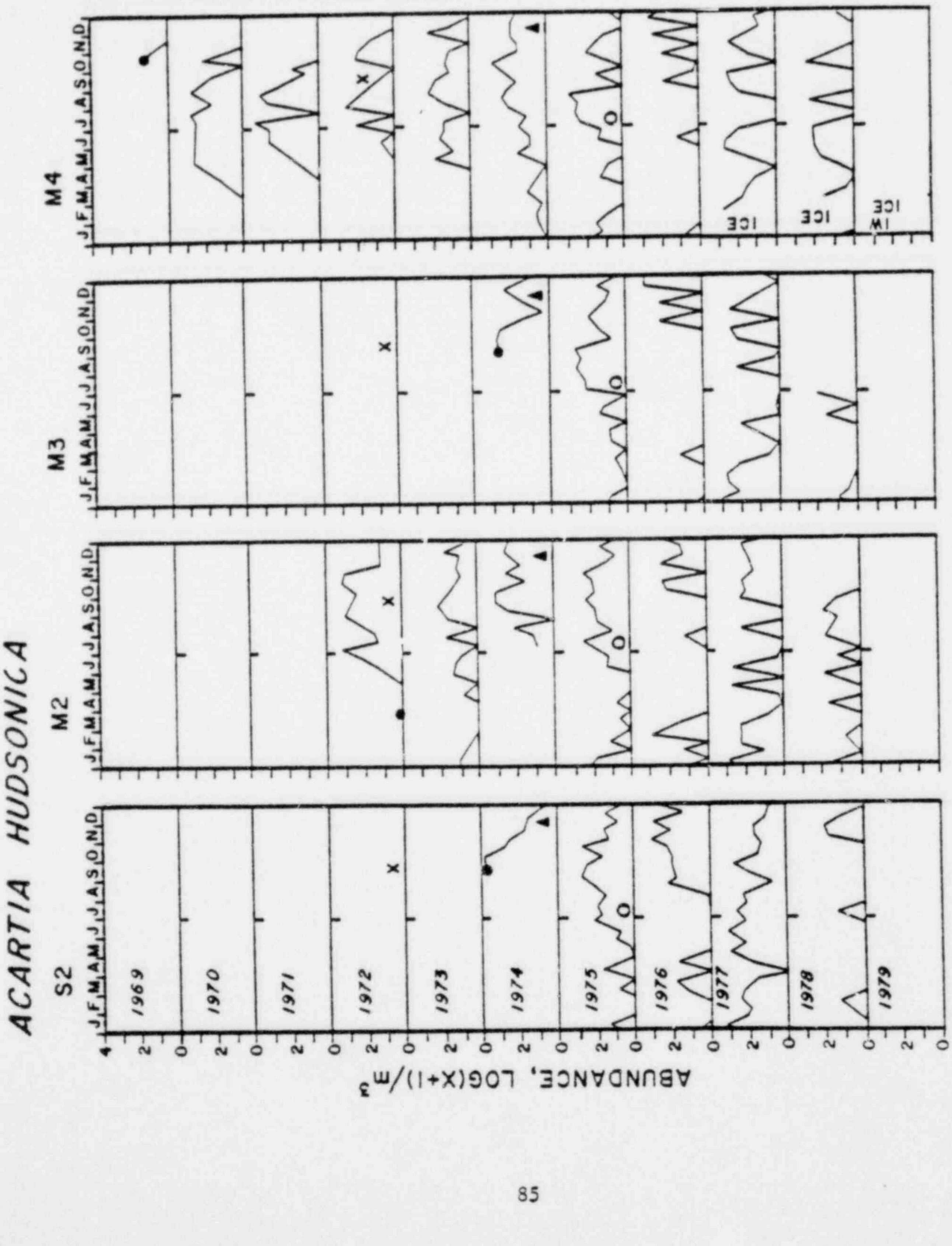
IW = Inclement weather



ACARTIA, immature
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ABUNDANCE, LOG(X+1)/m³
ICE

Figure 11

Figure 12



ACARTIA HUDSONICA
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m3

Figure 13

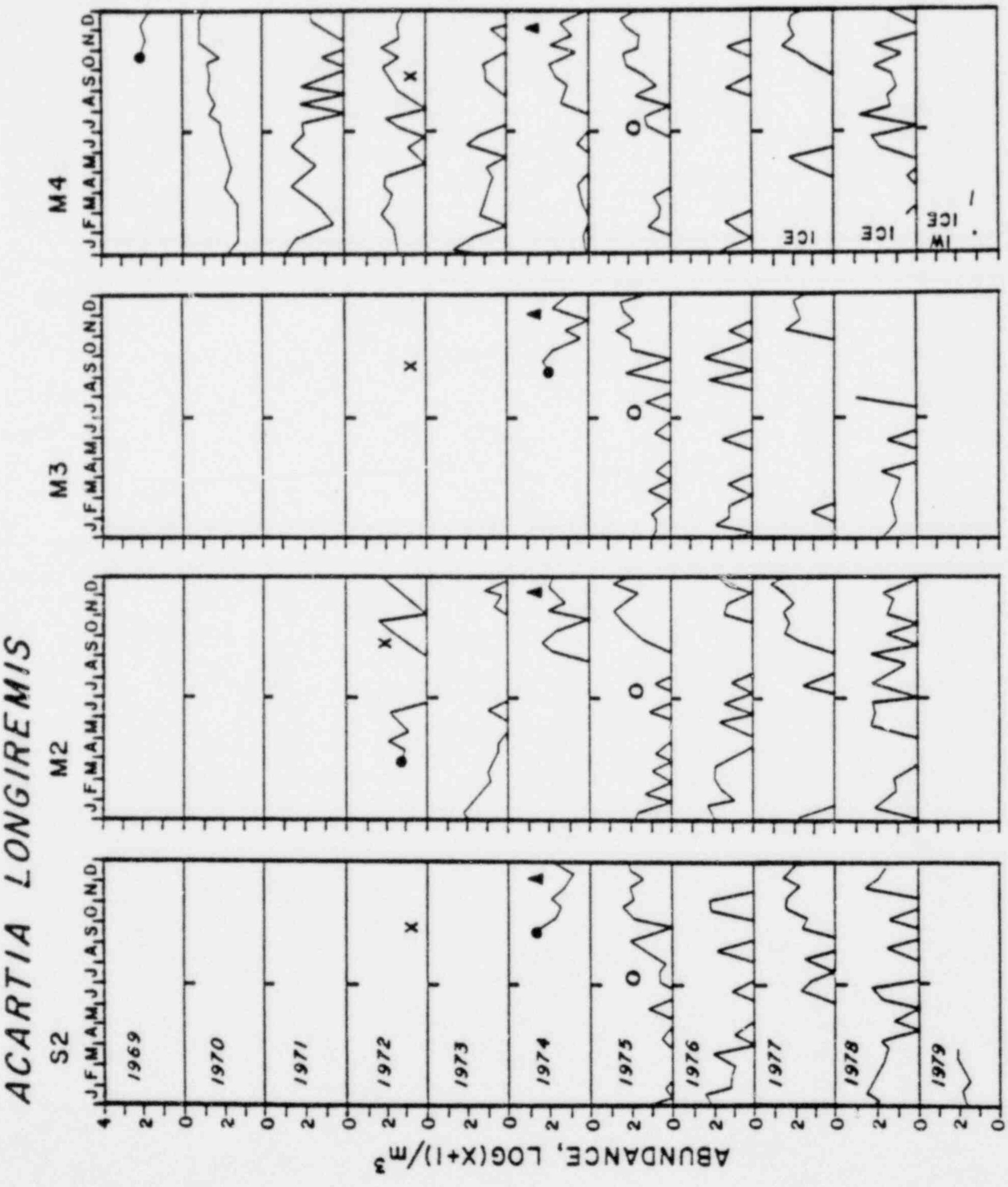
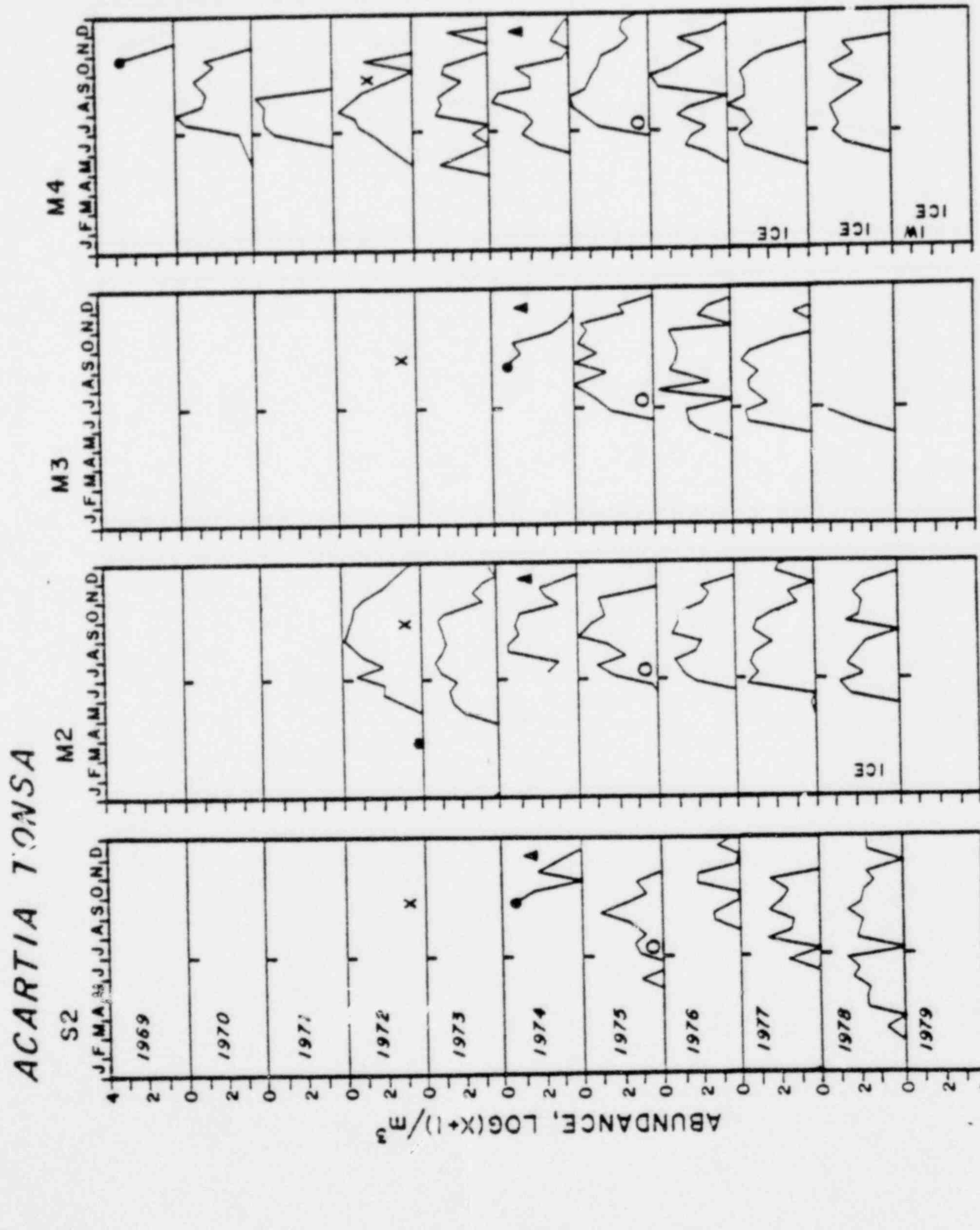

ACARTIA LONGIREMIS
S2
M2
M3
M4
J,F,M,A,M,J,J,A,S,O,N,D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
W
ABUNDANCE, LOG(X+1)/m3

Figure 14


ACARTIA TONSA
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m³

EURYTEMORA, immature

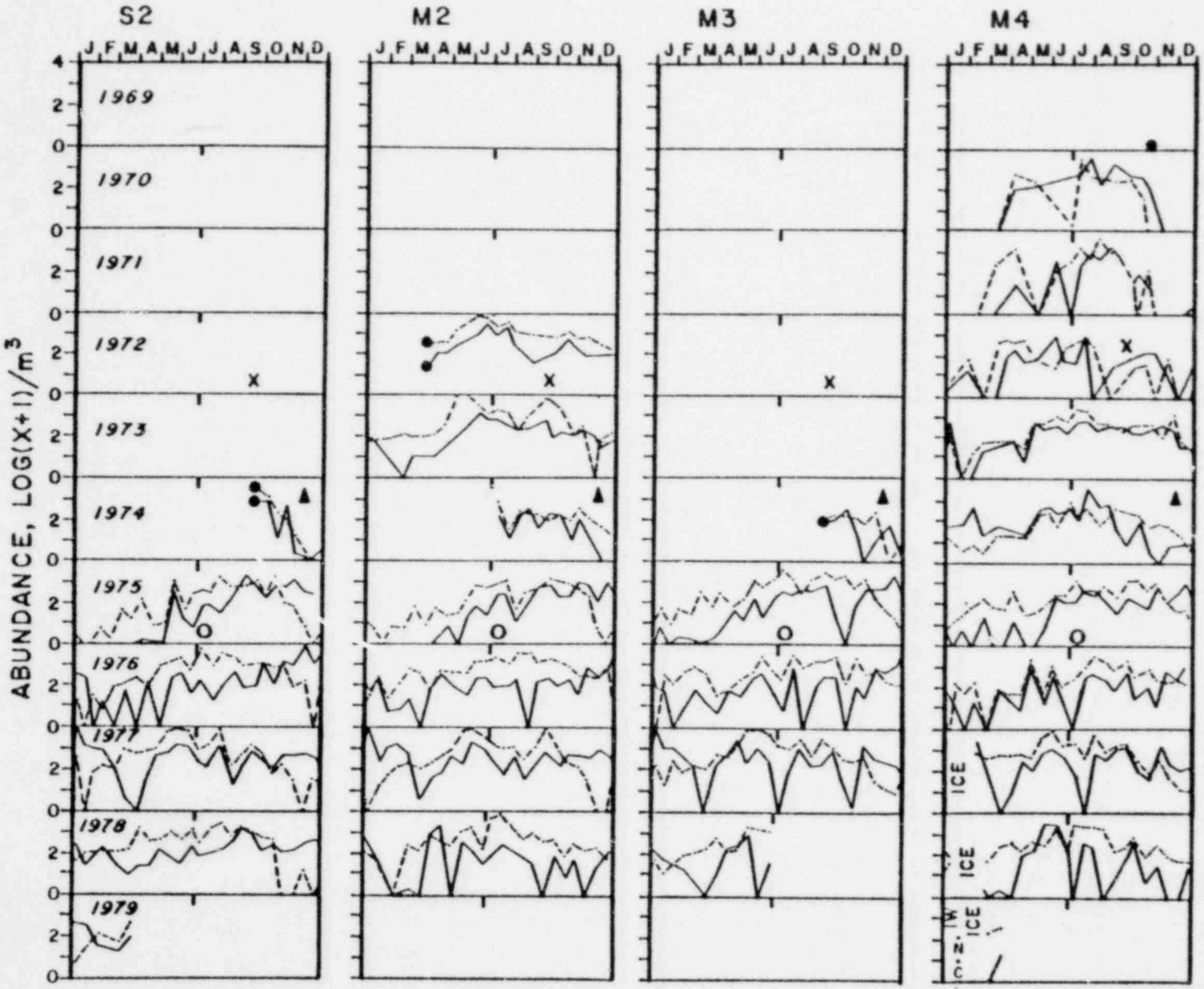
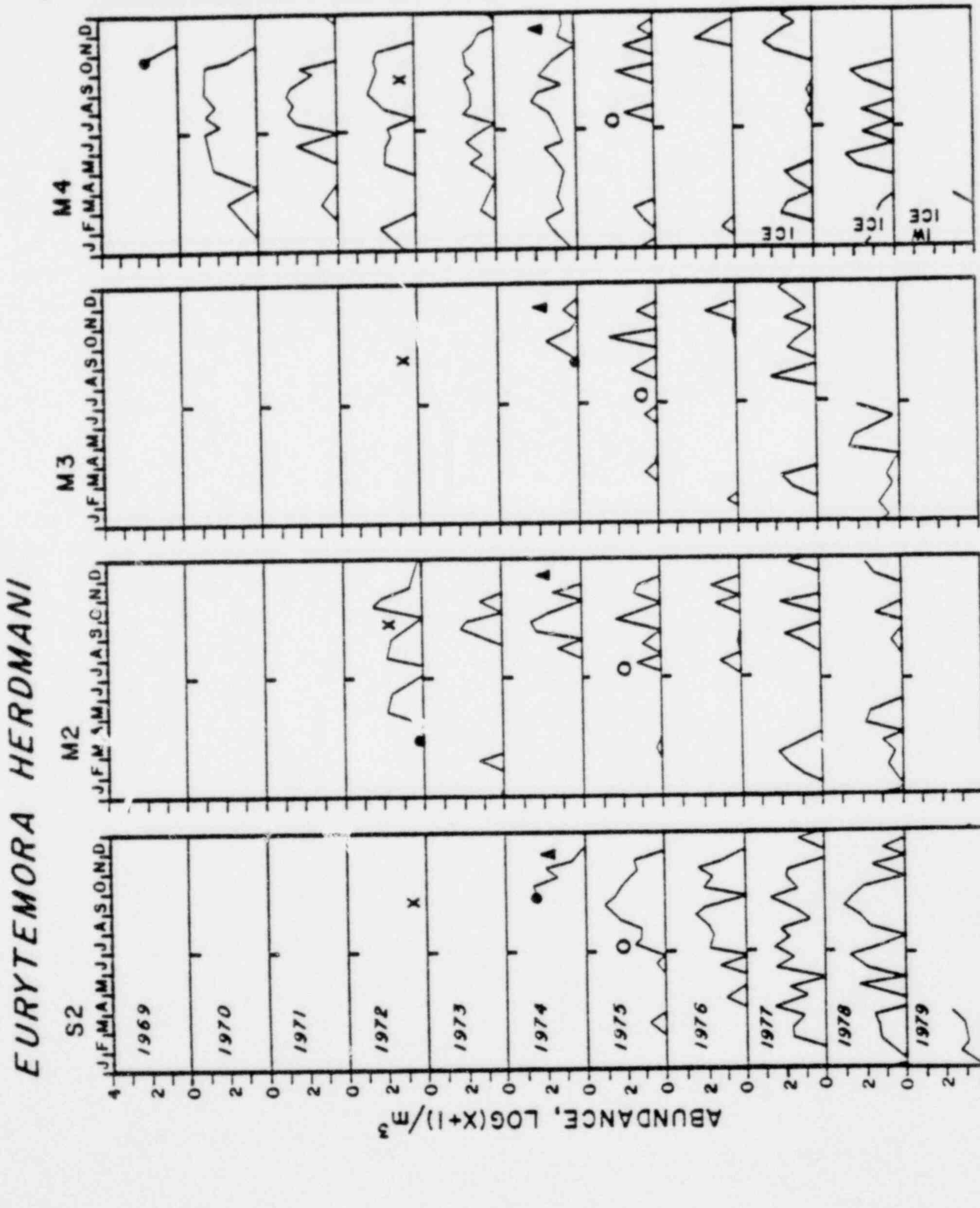


Figure 15

Figure 16



EURYTEMORA HERDMANI
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m³

Figure 17

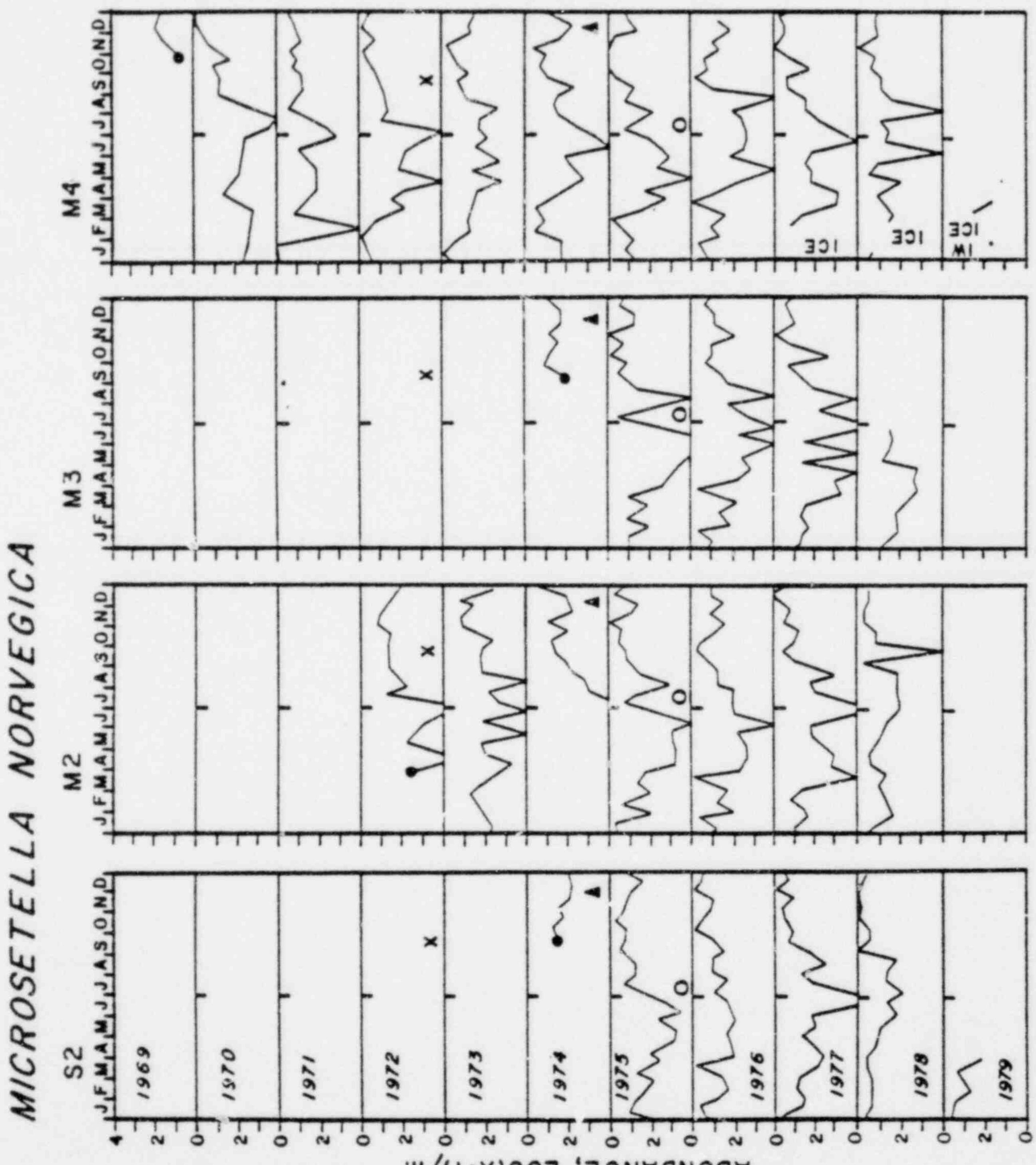

MICROSETELLA NORVEGICA
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
IW
ABUNDANCE, LOG(X+1)/m³

Figure 18

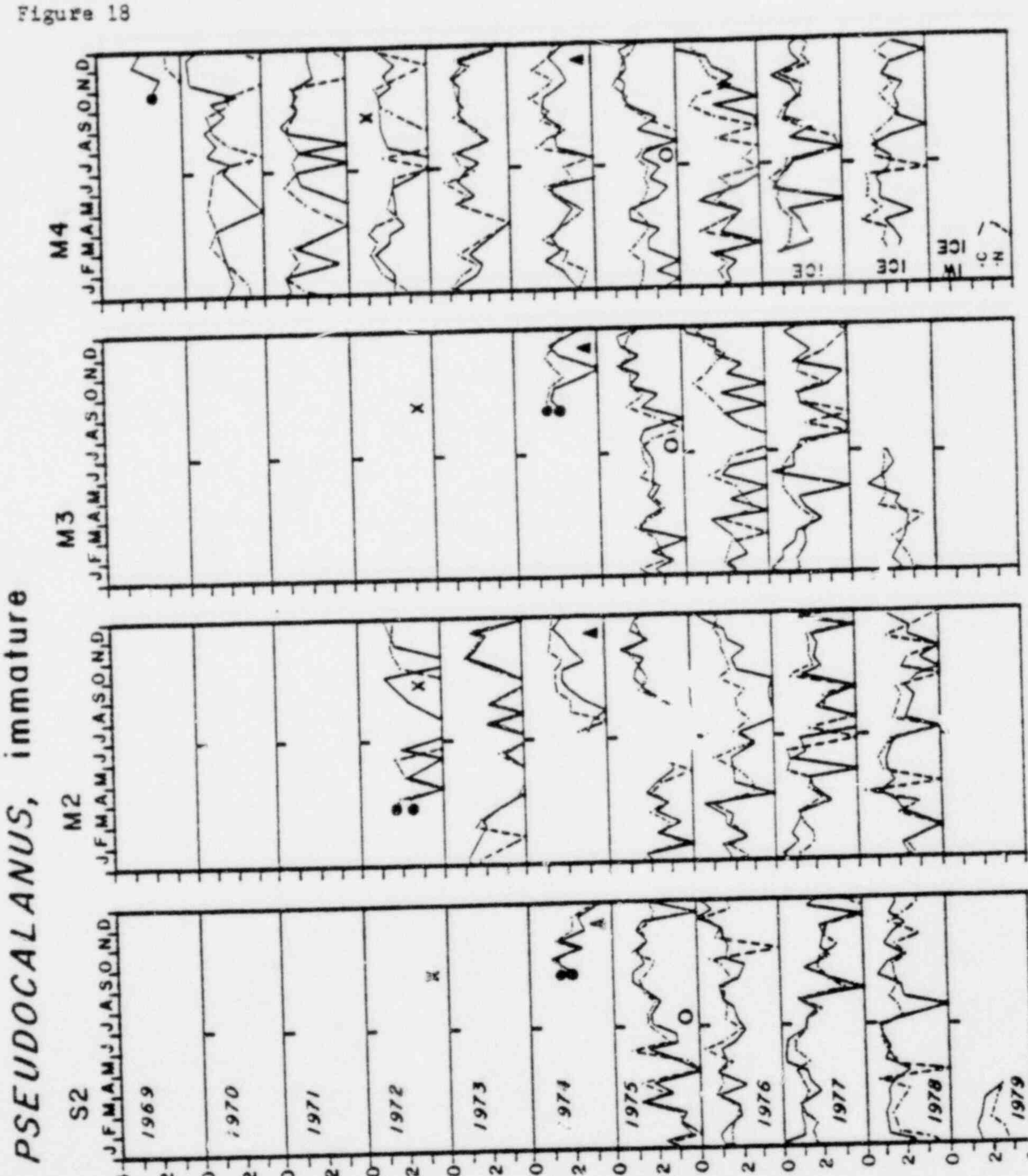

PSEUDOCALANUS, immature
S2
M2
M3
M4
J,F,M,A,M,J,J,A,S,O,N,D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m³

Figure 19

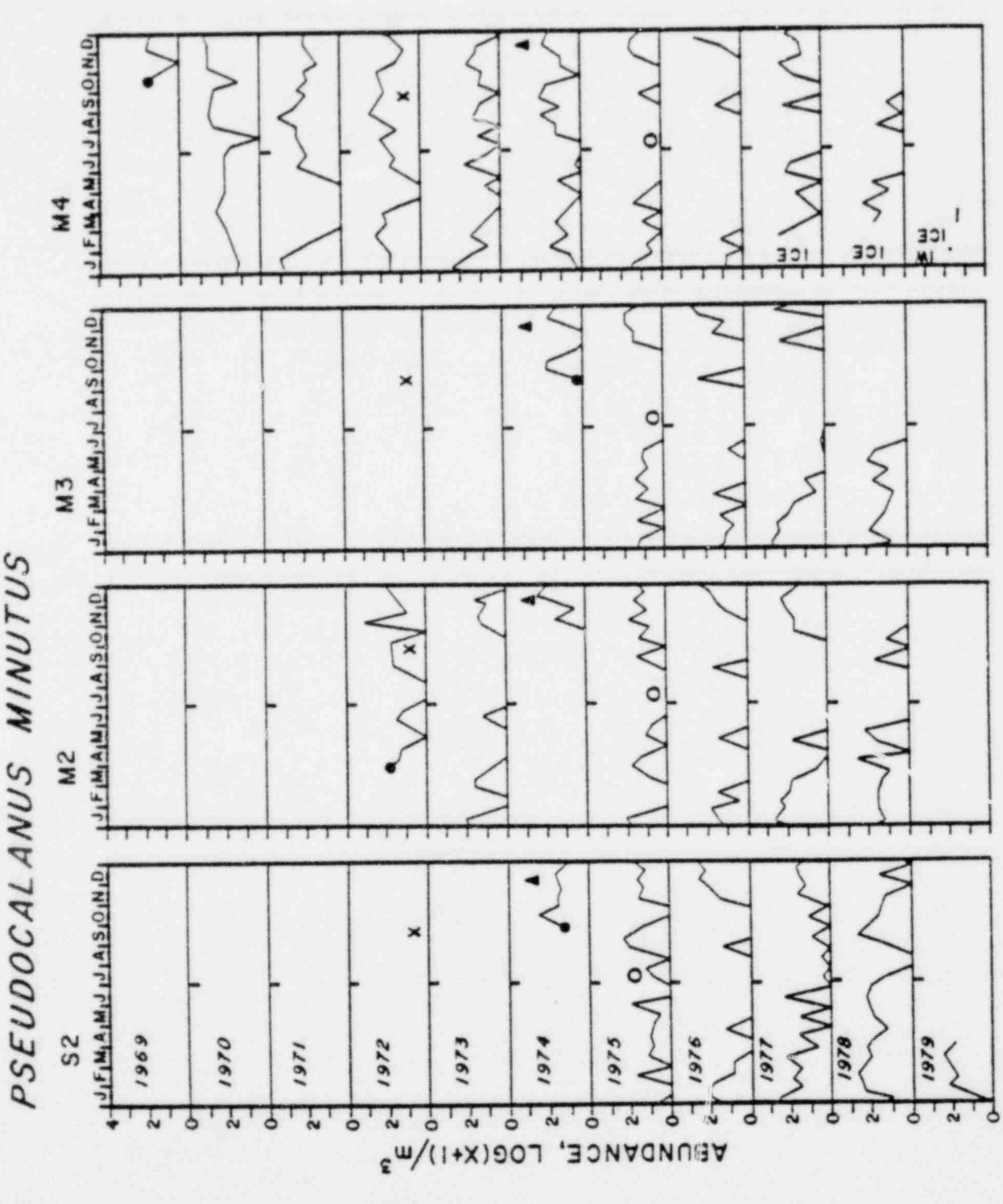

PSEUDOCALANUS MINUTUS
S2
M2
M3
M4
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m³

Figure 20

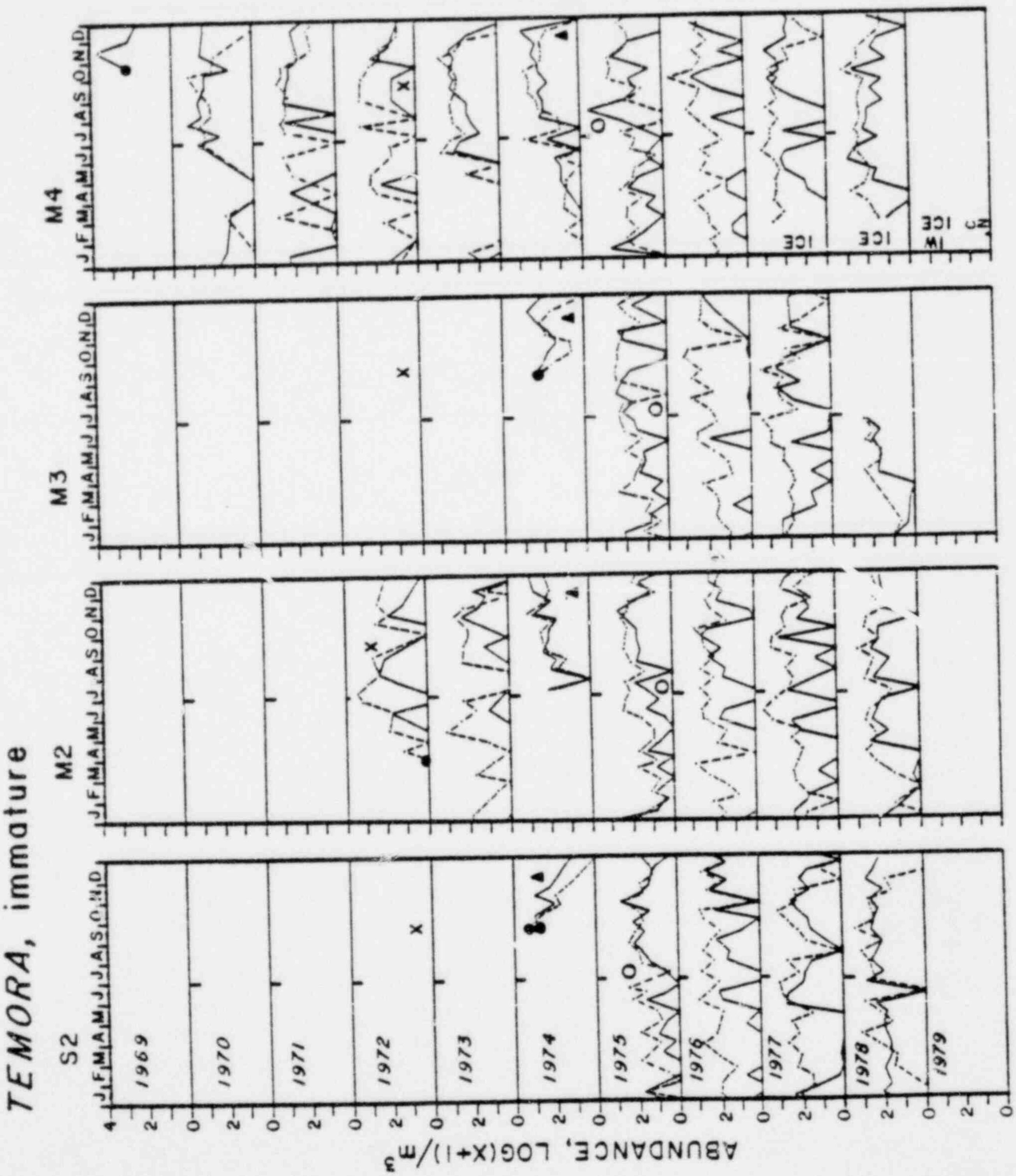

TEMORA, immature
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m³

Figure 21

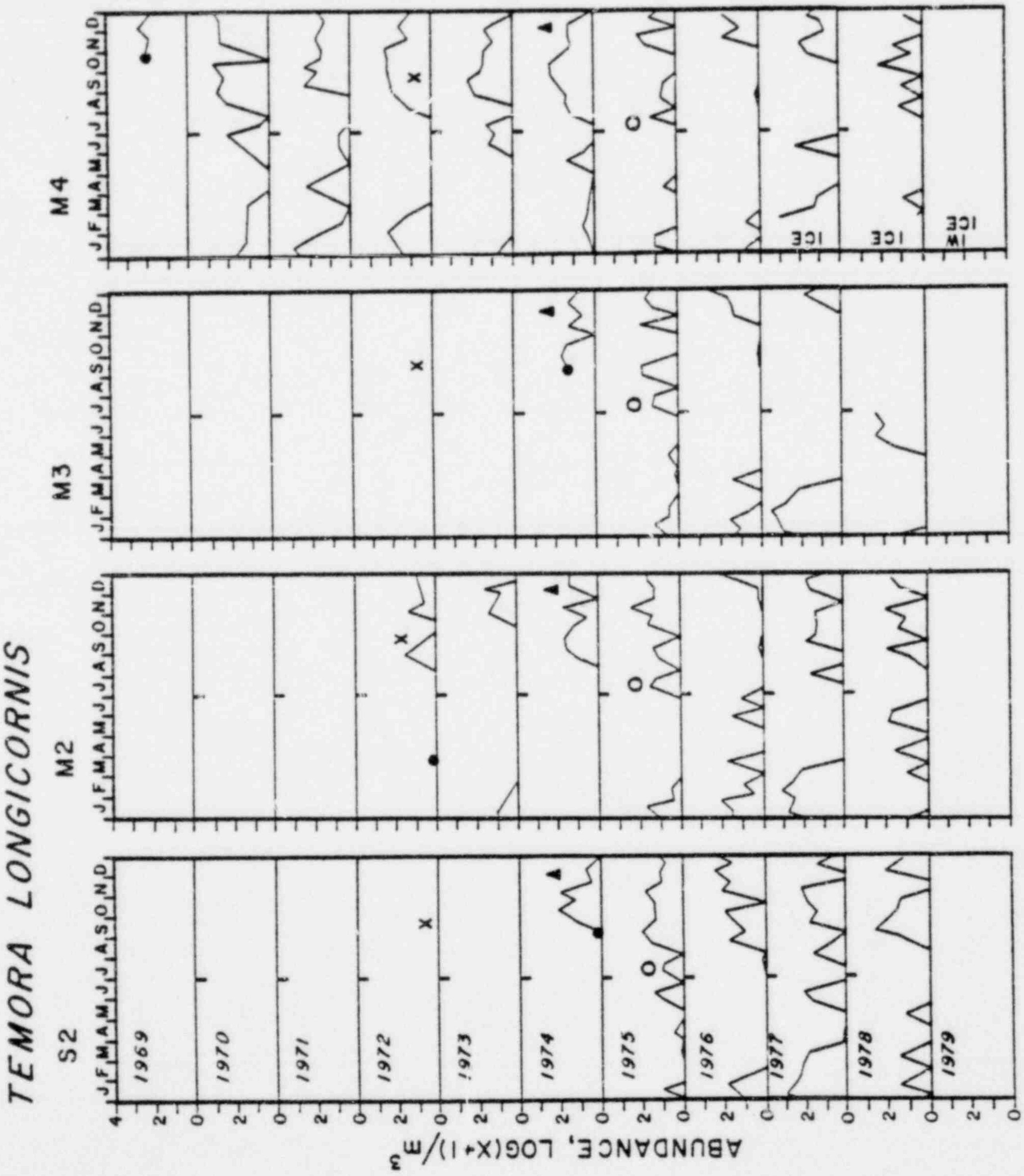
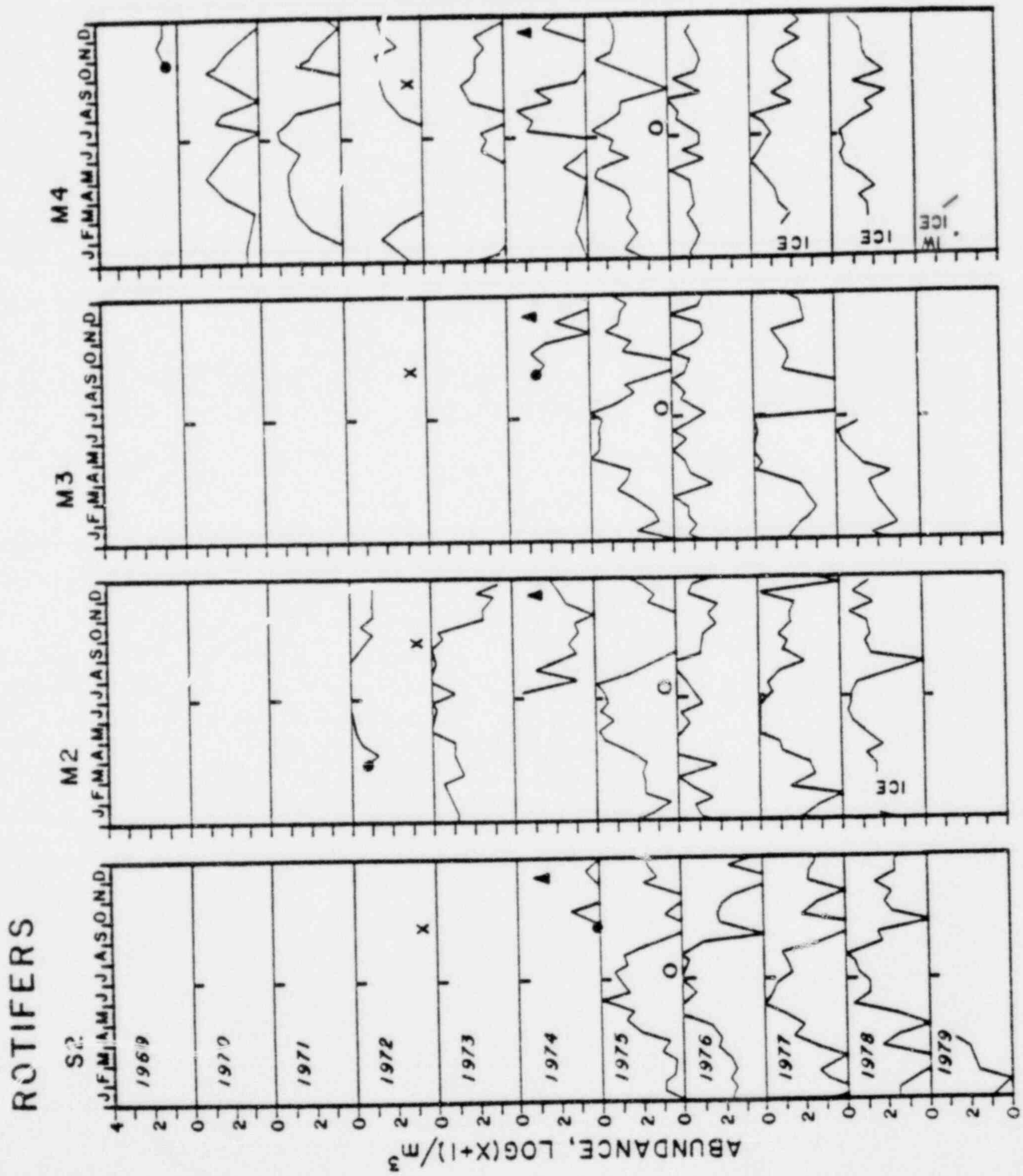

TEMORA LONGICORNIS
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m³
4 2 0 2 0 2 0 2 0 2 0 2 0 2 0 2 0 2 0 2 0 2 0

Figure 22


ROTIFERS
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m3

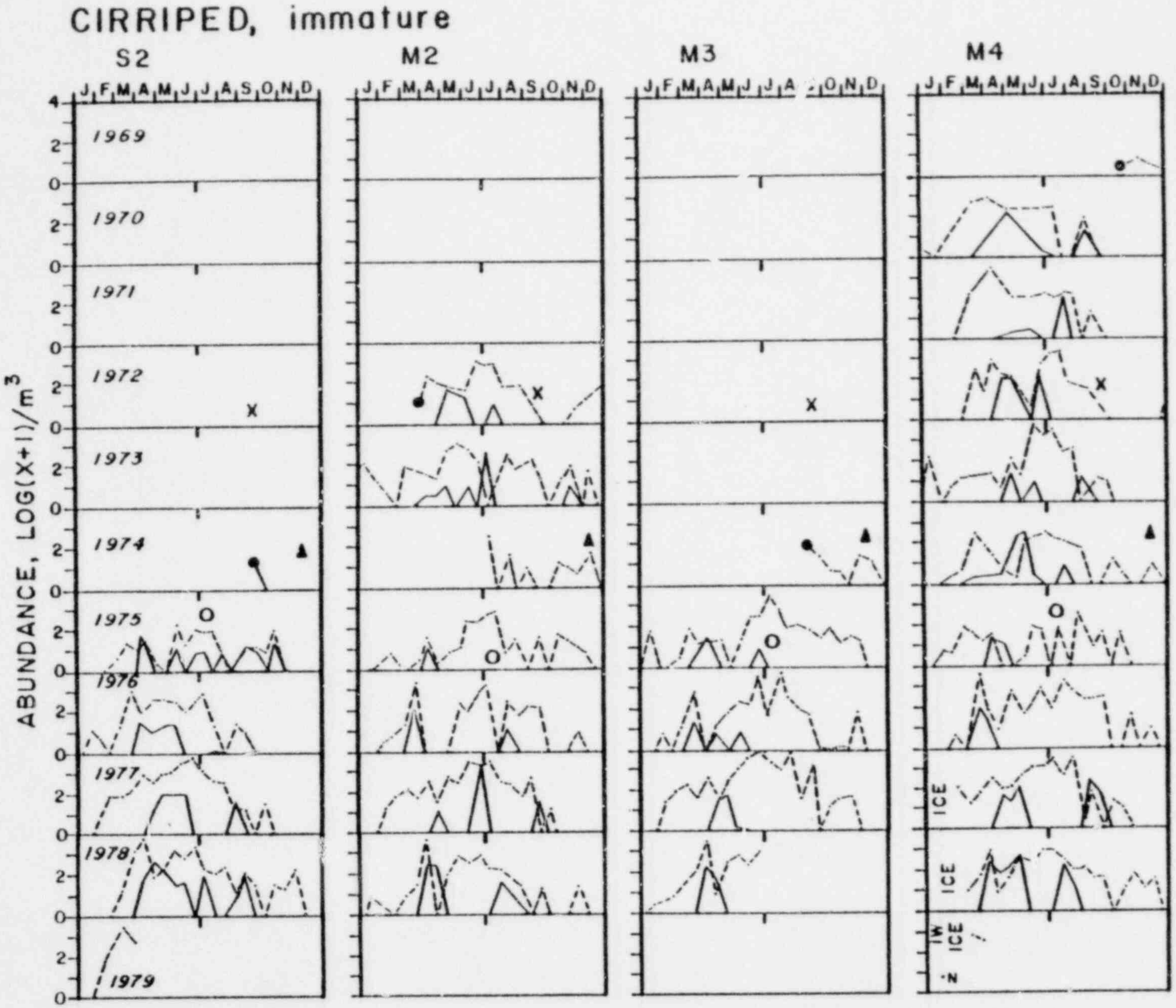
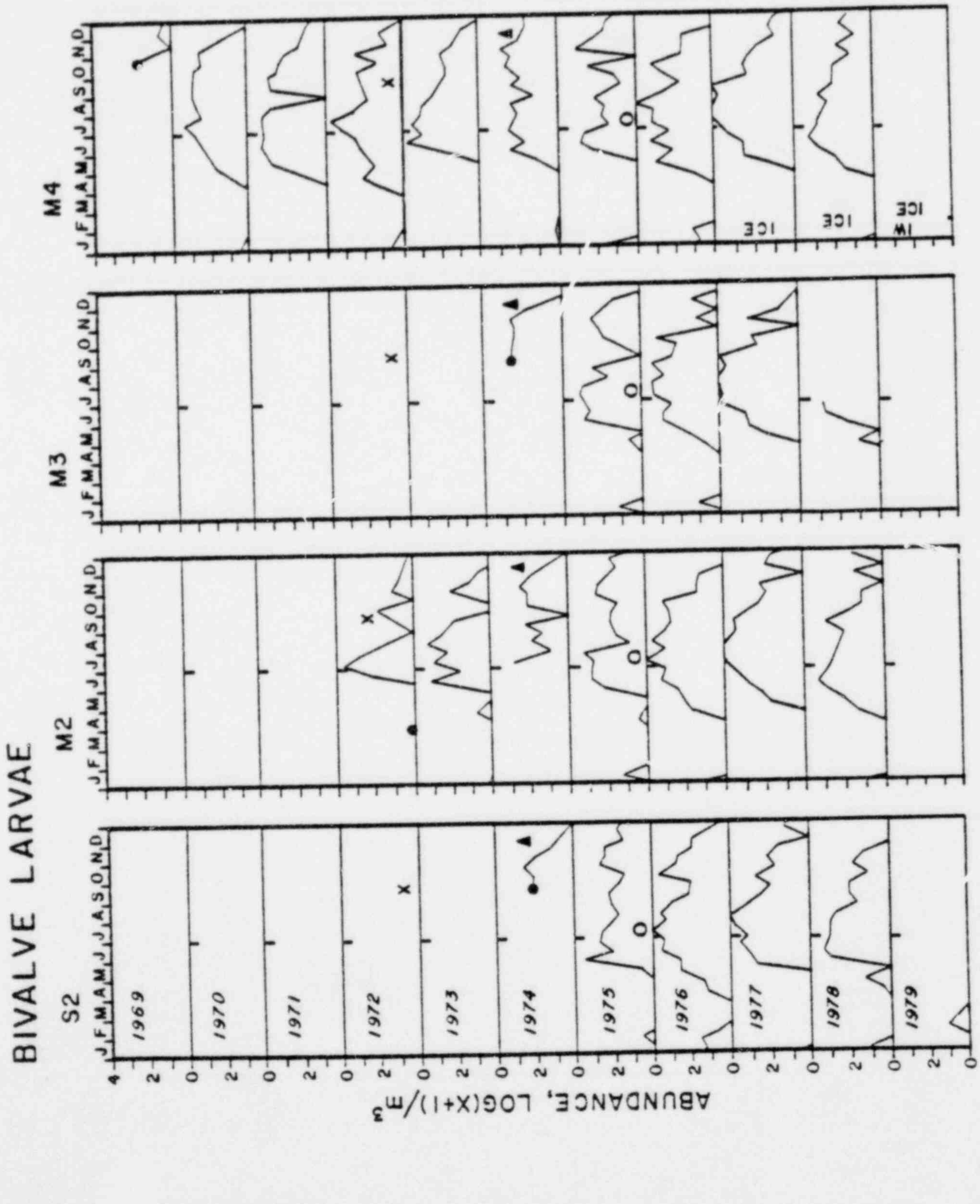

CIRRIPED, immature
S2
M2
M3
M4
J F M A M J J A S O N D
ABUNDANCE, LOG(X+1)/m3
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE

Figure 23

Figure 24


BIVALVE LARVAE
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m³

POLYCHAETE SETIGER LARVAE

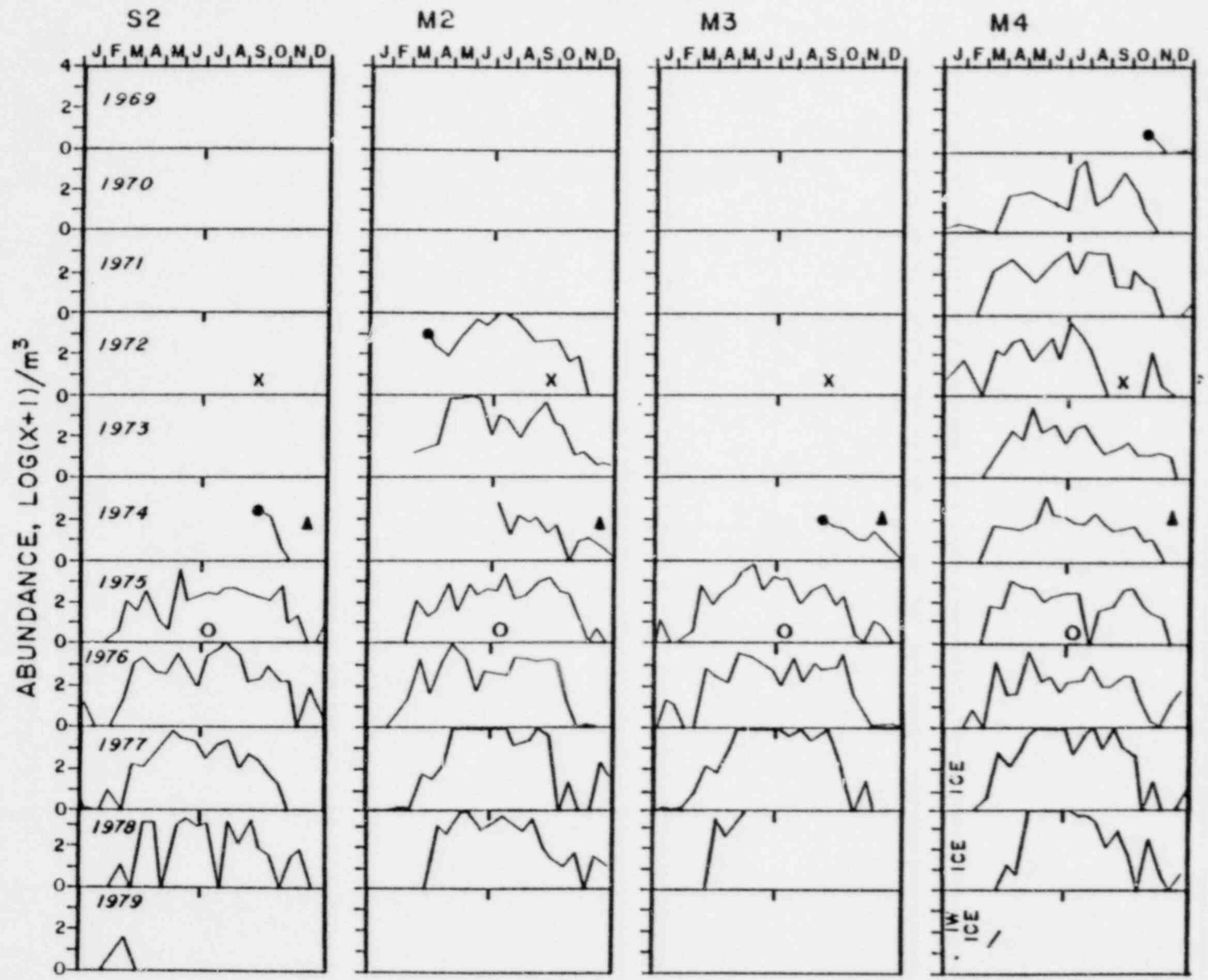


Figure 25

Figure 26

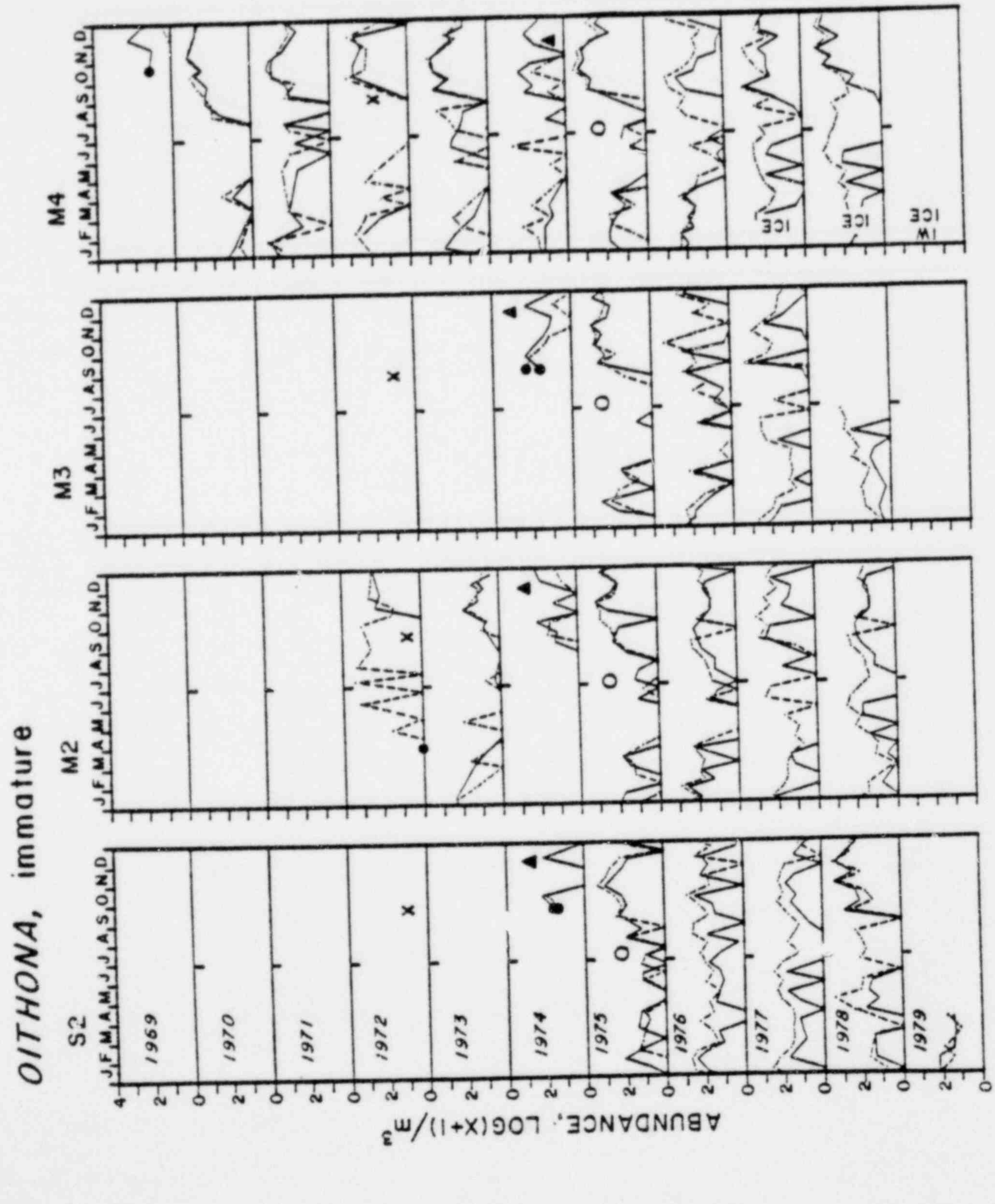
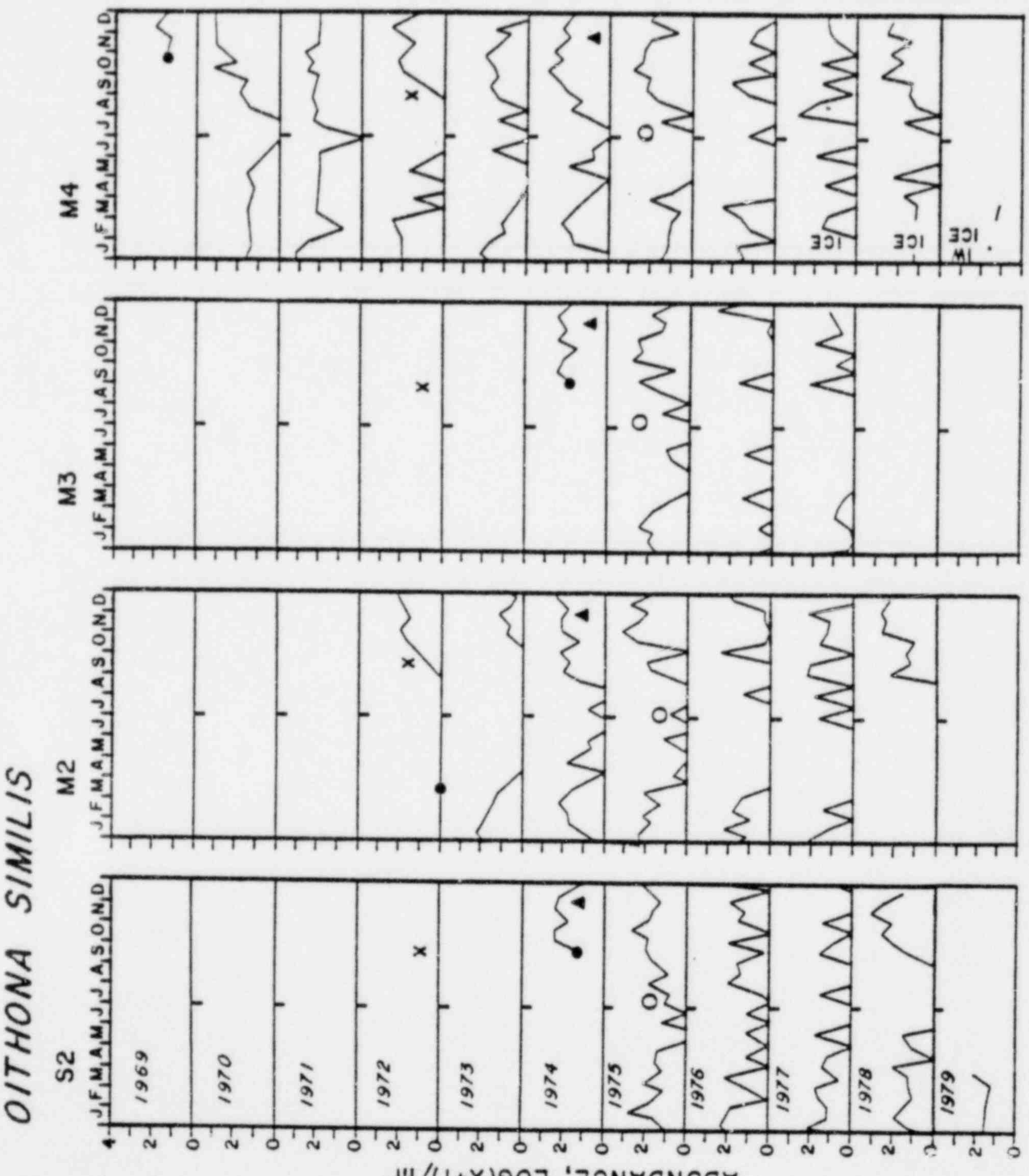

OITHONA, immature
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m3

Figure 27


OITHONA SIMILIS
S2
M2
M3
M4
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ABUNDANCE, LOG(X+1)/m³

MACROZOOPLANKTON

Bernard J. McAlice, Gilbert B. Jaeger, Margaret A. Hunter and Janet L. Mason

Introduction

This report is part of a comprehensive study of the ecology of Montsweag Bay which was initiated prior to operation of the Maine Yankee Nuclear Generating Station. The purpose of this continuing research is to study the effects of the thermal effluent discharge from the plant on the spatial and temporal abundance and distribution of the macrozooplankton of Montsweag Bay. Relationships between the macrozooplankton and temperature, salinity, and depth of capture are being studied. In accordance with the Nuclear Regulatory Commission Technical Specification 1.7C2 samples were taken monthly at two Montsweag Bay (HS,MS) and two control stations (SS,BS), ice conditions permitting.

Sampling Methods

The present sampling regime was established in March 1975 when replicate buoyed and anchored net stations were discontinued (DeWitt et al., 1976).

Stationary net sampling stations (Hauser, 1973) are designated Montsweag South (MS) and Halftide South (HS) in Montsweag Bay, and Sheepscot South (SS) and Bridge South (BS) in the Sheepscot River (Figure 28). The sampling gear (Figure 29) is essentially that described by Graham and Venno (1968), modified to a three net system (DeWitt et al., 1975). A flowmeter is mounted in the mouth of each net to record the amount of water filtered.

Ira C. Darling Center Ref. No. 79-7d

Collections are made monthly, within the limits of technical specifications, on nights when the fullest possible tidal cycle occurs between sunset and sunrise. Nets are set and retrieved at slack tide, and cod ends replaced between sets so that the gear fishes both flood and ebb tides separately. Collections are field fixed with 10% buffered formalin and temporarily stored in 5% buffered formalin. Standard techniques are used to pick, sort, identify, and count the catch. After being processed, collections are preserved in 70% isopropyl alcohol.

Temperature and salinity are measured at each net level before and after each set, and flowmeter readings are taken. Analysis of collections made from January through June 1979 at HS, Montsweag South surface (MS-1), SS, and Bridge South surface (BS-1) are reported here. Ice conditions prevented collecting at MS-1 during February 1979. Other collections which were lost or discarded were SS-2 flood in January, SS-3 flood in February, SS-3 ebb in May, and HS-2 ebb in April.

Because differences between pre-plant operational, plant operational and post-causeway removal periods have been analyzed and documented (Jaeger et al., 1978), this report deals mainly with comparisons of data collected after the causeway was removed.

Statistical Methods

Absolute abundance and relative abundance data for each station were analyzed using SPSS computer programs with appropriate transformations made to stabilize variances (Arcsin $\sqrt{\quad}$ for relative abundances and $\sqrt{(\text{Abun}/100\ \text{m}^3) + 1/2}$ for absolute abundances). Comparisons were made between years for the January-June period only for the post-causeway removal years 1975-1979. These months were blocked in various ways to reduce the effect of seasonality, and data were evaluated statistically by Model 1 (fixed effects) one-way ANOVA using a significance level of 0.05. Previous tests showed that transformed data sometimes failed to meet the assumptions of normality and homogeneity of variances demanded by ANOVA. Comparisons of results with those of the nonparametric Kruskal-Wallis test, however, showed the F-test to give reasonable results and if anything to perform conservatively (Jaeger et al., 1978). Tukey's w-test was used to delineate where differences in data among years actually occurred.

Eight major groups encompassing all species in collections, ten important species, total abundance, temperature, and salinity were selected for testing. Data for flood and ebb tides, and for all net levels at HS and SS, were combined to give more cases when it was determined by multivariate analysis that in most instances there was no significant difference between these parameters.

Results and Discussion

Previous studies indicated that the effects of the heated effluent on macrozooplankton were negligible, as were the effects of entrainment (Jaeger et al., 1978).

The results discussed here deal with data collected since January 1975, when the Cowseagan Narrows causeway was completely removed. The most important changes which occurred in the abundance and relative abundance of the macrozooplankton are reviewed here.

Various blocking methods used are included in the tables for comparison. However, the only method discussed here is the testing of months separately.

No trends in abundance of macrozooplankton in relation to temperature changes were apparent except in spring when increasing temperatures heralded the arrival of new broods of young (Table 34). Results of statistical tests vary considerably according to the method of blocking used. All months together gave the least significant differences while testing them individually gave the most. It is felt that the most important results were those obtained from testing months separately. However, the highly significant differences found between different years when using this method probably do not represent unusual temperature patterns. Temperatures taken at surface stations (MS-1 and BS-1) show fewer significant differences because of fewer cases involved and a greater natural variation between readings.

Significant differences often occurred, but no particular trends were evident in salinity data for this study interval (Table 35).

Significant variations were found in total abundance (Tables 36-37). The greatest differences were caused by larger than normal catches in 1977. *Calanus finmarchicus, Tortanus discaudatus* and *Sagitta elegans* were among the species responsible for high counts.

Significant variations in abundance and relative abundance for the major groups in HS, MS-1, SS, and BS-1 collections for the January through June interval, 1975 to 1979, are summarized in Tables 38-53. Variations for selected species are shown in Tables 54-73.

The lower number and level of significant differences between and among years in surface collections again was attributed to fewer data cases with larger variances between them.

A review of the analysis of abundance and relative abundance data reveals few discernible trends, but rather an array of mixed results. Analysis of data from HS collections show Decapoda and the amphipod species *Dycpedos* spp. to have undergone considerable variation during the 1975-1979 interval. These differences are not recognizable as any trend nor can they be shown to have been the result of great variation in abundance during a single year, but probably reflect normal variation in species abundance and composition (which occurs during a span of years for data from a particular month or season). There were few differences for Cumacea, miscellaneous organisms, *Crangon septemspinosus*, *Oxyurostylis smithi*, *Diastylis sculpta*, and *Eudorella pusilla*. The other species and species groups tested showed moderate differences between or among years. These were Mysidacea, Copepoda, Amphipoda, Chaetognatha, *Neomysis americana*, *Calanus finmarchicus*, *Gammarus lawrencianus*, *Ampelisca* spp., and *Corophium* spp.

Results of tests for relative abundance data from HS collections are shown in Tables 38-73. Results did not always coincide with those for abundances of the same animals. Relative abundances of Copepoda, Cumacea, Amphipoda, and *O. smithi* had greatest variation. Mysidacea, Decapoda, Chaetognatha, *G. lawrencianus*, *Corophium* spp., and *Dyopedos* spp. underwent moderate variations, while few changes occurred for Isopoda, miscellaneous animals, *N. americana*, *C. septemspinosus*, *C. finmarchicus*, *D. sculpta*, *E. pusilla*, and *Ampelisca* spp. The Cumacea, as individual species as well as a group, appeared to be the most stable component of collections and, except for the relative abundance of *O. smithi*, little significant variation occurred in members of this group.

The observed changes which occurred in the fauna in collections at SS were generally different from those found in HS collections (Tables 38-73). The total number of changes and the degree of severity were similar, but the distributions were quite different as might be expected. The strongest similarity between the stations was in the Cumacea, for which few variations in catch were observed. Greatest variation was . . the Copepoda for both abundance and relative abundance. This was primarily attributed to great variation in *C. finmarchicus*. The Mysidacea and Chaetognatha also underwent marked changes in abundance, as did Amphipoda for relative abundance. These were the most apparent significant changes and beyond these there were no unexpected results.

Conclusions

Effects of temperature and salinity on the long term trends of abundance and relative abundance of macrozooplankton were difficult to see. Our analyses indicated no trends in population changes over the years, but rather a scattering of significant differences between and among years. It must be assumed that natural variation in estuarine macrozooplankton populations is large and unpredictable. An interesting contradiction to this generality was the stability of the cumaceans both as a group and as individual species at both HS and SS.

Although much variation occurred in populations during this test period, we did not identify any trends which might result in long term increases or decreases in species abundance.

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_____. 1976. Macrozooplankton and Ichthyoplankton. pp. 45-163. *In*: Maine Yankee Atomic Power Co. Semiann. Envir. Surveillance Rep. 9, Docket No. 50-309. Maine Yankee Atomic Power Co., Augusta, Maine.

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Hauser, W.J. 1973. Larval fish ecology of the Sheepscot River-Montsweag Bay estuary, Maine. PhD. thesis. University of Maine, Orono, Maine. 79 pp.

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TEMPERATURE

Table 34.

HS / MS-1

Seasonal Blocks	HS Signif. ('F' test)	HS C°-years in increasing order (Tukey's w)	MS-1 Signif. ('F' test)	MS-1 C°-years in increasing order (Tukey's w)
All months	0.2911	75 79 76 78 77	0.8541	75 76 79 78 77
Jan-Feb-Mar	0.1599	75 79 76 78 77	0.9595	79 75 78 76 77
Apr-May-Jun	0.9808	76 79 75 77 78	0.9904	79 76 78 75 77
Jan-Feb	0.1409	75 79 78 76	0.2076	78 79 75 76
Mar-Apr	0.2110	79 76 75 77 78	0.8911	79 76 75 77 78
May-Jun	0.0976	76 77 75 79 78	0.9955	76 79 78 77 75
Jan	0.0437*	75 79 76 78	0.6778	75 76 79
Feb	0.0002**	78 79 75 76	0.1609	76 78 75
Mar	0.0001**	75 76 77 79 78	0.1792	75 77 76 79 78
Apr	0.0000**	79 76 75 78 77	0.0088**	79 76 78 75 77
May	0.0000**	79 76 77 75 78	0.0183*	79 76 75 77 78
Jun	0.0380*	78 75 76 77 79	0.0593	78 76 77 79 75

SS / BS-1

Seasonal Blocks	SS Signif. ('F' test)	SS C°-years in increasing order (Tukey's w)	BS-1 Signif. ('F' test)	BS-1 C°-years in increasing order (Tukey's w)
All months	0.7758	79 78 75 77 76	0.9713	79 78 75 76 77
Jan-Feb-Mar	0.0008**	77 79 78 75 76	0.5706	77 79 78 75 76
Apr-May-Jun	0.8033	79 75 78 77 76	0.9711	79 75 78 76 77
Jan-Feb	0.0000**	77 79 78 75 76	0.0003**	77 79 78 75 76
Mar-Apr	0.3374	79 76 75 77 78	0.9645	79 76 75 78 77
May-Jun	0.2010	77 79 78 75 76	0.9360	79 75 77 78 76
Jan	0.0000**	77 79 75 76 78	0.0317*	77 79 78 75 76
Feb	0.0000**	78 79 77 75 76	0.0261*	77 78 79 76 75
Mar	0.0000**	77 76 75 79 78	0.0335*	77 75 76 78 79
Apr	0.0000**	79 76 75 78 77	0.0068**	79 76 78 75 77
May	0.0000**	79 77 75 76 78	0.0526	79 77 76 75 78
Jun	0.0000**	78 75 77 79 76	0.2382	78 75 77 79 76

Table 35

SALINITY

	HS		MS-1	
Seasonal Blocks	Signif. ('F' test)	PPT-years in increasing order (Tukey's w)	Signif. ('F' test)	PPT-years in increasing order (Tukey's w)
All months	0.0000**	78 77 76 75 79	0.0293*	78 77 76 79 75
Jan-Feb-Mar	0.0000**	77 78 76 79 75	0.0000**	77 78 79 76 75
Apr-May-Jun	0.0099**	78 75 76 77 79	0.2462	78 75 76 77 79
Jan-Feb	0.0000**	78 76 79 75	0.0086**	78 79 76 75
Mar-Apr	0.0003**	77 78 76 75 79	0.0523	77 78 76 79 75
May-Jun	0.0000**	75 78 77 79 76	0.0058**	75 78 76 79 77
Jan	0.0000**	78 76 79 75	0.0589	76 75 79
Feb	0.0071**	78 76 75 79	0.0052**	76 78 75
Mar	0.0000**	77 78 76 75 79	0.0124*	77 78 76 79 75
Apr	0.0077**	76 78 77 79 75	0.1924	78 76 77 79 75
May	0.0639	75 78 79 77 76	0.1637	75 76 79 78 77
Jun	0.0001**	78 75 77 76 79	0.0000**	78 75 77 76 79

	SS		BS-1	
Seasonal Blocks	Signif. ('F' test)	PPT-years in increasing order (Tukey's w)	Signif. ('F' test)	PPT-years in increasing order (Tukey's w)
All months	0.0000**	78 77 76 75 79	0.0188*	78 77 75 76 79
Jan-Feb-Mar	0.0000**	78 77 79 76 75	0.0110*	78 77 76 79 75
Apr-May-Jun	0.1591	78 75 77 76 79	0.1321	75 78 77 76 79
Jan-Feb	0.0000**	78 76 79 77 75	0.0486*	78 76 79 77 75
Mar-Apr	0.0000**	78 77 79 76 75	0.0457*	78 77 75 76 79
May-Jun	0.0262*	75 78 76 77 79	0.1156	75 78 77 76 79
Jan	0.0042**	78 79 76 77 75	0.0370*	78 79 77 76 75
Feb	0.0000**	78 76 79 75 77	0.0062**	76 78 75 79 77
Mar	0.0000**	78 77 79 75 76	0.0042**	78 77 79 75 76
Apr	0.2204	78 77 76 79 75	0.5693	78 75 76 77 79
May	0.3210	75 78 76 77 79	0.7588	75 78 76 77 79
Jun	0.0332*	75 78 77 76 79	0.0950	75 78 77 76 79

Table 36. TOTAL ABUNDANCE

HS

SEASON	ABUNDANCE Signif.	Years in increasing order				
All months	0.0001**	76	78	79	75	77
Jan-Feb-Mar	0.0025**	78	75	76	79	77
Apr-May-Jun	0.0028**	76	79	75	78	77
Jan-Feb	0.0000**	78	79	75	76	77
Mar-Apr	0.1580	78	76	75	77	79
May-Jun	0.0052**	76	79	75	78	77
Jan	0.3985	78	76	79	75	
Feb	0.0000**	78	79	75	76	77
Mar	0.1313	77	75	76	78	79
Apr	0.1523	78	76	75	79	77
May	0.0042**	79	76	78	75	77
Jun	0.0529	76	79	75	77	78

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order				
All months	0.7793	76	78	75	77	79
Jan-Feb-Mar	0.5164	77	78	75	76	79
Apr-May-Jun	0.3392	76	79	78	75	77
Jan-Feb	0.3750	77	79	78	75	76
Mar-Apr	0.4560	78	76	77	75	79
May-Jun	0.3508	76	75	79	78	77
Jan	0.8827	75	76	79		
Feb	0.2404	77	78	75	76	
Mar	0.6430	78	77	76	75	79
Apr	0.2597	78	79	76	77	75
May	0.2725	76	75	78	77	79
Jun	0.6066	76	75	79	78	77

Table 37. TOTAL ABUNDANCE

SS

SEASON	ABUNDANCE Signif.	Years in increasing order				
All months	0.0083**	79	76	77	78	75
Jan-Feb-Mar	0.0184*	79	78	76	75	77
Apr-May-Jun	0.0414*	76	79	77	75	78
Jan-Feb	0.0000**	79	78	76	75	77
Mar-Apr	0.1170	77	76	79	75	78
May-Jun	0.0783	76	79	77	78	75
Jan	0.0082**	78	79	76	75	77
Feb	0.0000**	79	78	76	75	77
Mar	0.4614	77	79	76	75	78
Apr	0.1043	76	79	75	77	78
May	0.1215	76	77	75	79	78
Jun	0.0075**	79	76	78	77	75

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order				
All months	0.2110	76	79	78	75	77
Jan-Feb-Mar	0.0751	78	76	79	75	77
Apr-May-Jun	0.0691	76	79	77	75	78
Jan-Feb	0.2382	78	75	76	79	77
Mar-Apr	0.1210	76	78	79	77	75
May-Jun	0.4210	77	76	79	75	78
Jan	0.6750	79	75	78	77	76
Feb	0.0018**	78	76	75	79	77
Mar	0.5978	78	76	79	75	77
Apr	0.0538	76	79	77	78	75
May	0.0347*	76	77	75	79	78
Jun	0.2309	79	77	78	76	75

Table 38.

MYSIDACEA

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.2300	76 77 79 75 78	0.3597	76 75 77 79 78
Jan-Feb-Mar	0.3396	78 79 76 77 75	0.5927	76 75 79 78 77
Apr-May-Jun	0.0582	76 77 75 79 78	0.0006**	77 76 75 79 78
Jan-Feb	0.3680	78 79 77 76 75	0.4791	76 77 79 78 75
Mar-Apr	0.4166	75 78 79 76 77	0.4773	75 76 79 78 77
May-Jun	0.0061**	76 77 79 75 78	0.000**	77 76 75 79 78
Jan	0.1260	76 79 78 75	0.0863	76 79 78 75
Feb	0.0048**	78 75 79 77 76	0.0175*	78 77 75 79 76
Mar	0.5606	76 79 78 75 77	0.6158	75 76 79 78 77
Apr	0.0289*	75 78 79 77 76	0.0040**	75 77 79 78 76
May	0.2136	76 77 75 79 78	0.000**	77 75 76 79 78
Jun	0.0003**	76 77 75 79 78	0.000**	76 77 75 79 78

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.9576	79 78 76 75 77	0.1319	77 76 78 79 75
Jan-Feb-Mar	0.1809	78 79 77 75 76	0.6748	77 76 78 79 75
Apr-May-Jun	0.7692	76 75 79 77 78	0.2234	77 75 76 79 78
Jan-Feb	0.2286	78 79 77 75 76	0.2886	77 78 79 75 76
Mar-Apr	0.1746	78 79 75 76 77	0.4637	76 79 75 78 77
May-Jun	0.5256	76 75 79 77 78	0.2241	77 76 75 79 78
Jan	0.5643	76 75 79	0.3178	76 75 79
Feb	0.0654	78 75 77 76	0.5344	77 78 75 76
Mar	0.1986	78 76 79 75 77	0.4590	76 79 78 75 77
Apr	0.2341	78 79 75 77 76	0.3195	75 77 79 78 76
May	0.6007	77 76 75 79 78	0.1681	77 75 79 76 78
Jun	0.0183*	79 76 75 77 78	0.0418*	76 77 79 78 75

Table 39. MYSIDACEA

SS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0206*	76 78 77 79 75	0.0324*	76 78 79 75 77
Jan-Feb-Mar	0.3895	76 79 78 77 75	0.5118	79 75 76 77 78
Apr-May-Jun	0.0242*	76 77 78 79 75	0.0013**	78 76 79 77 75
Jan-Feb	0.0002**	79 78 75 76 77	0.2680	79 75 78 77 76
Mar-Apr	0.0119*	76 77 75 79 78	0.1104	76 77 75 78 79
May-Jun	0.0000**	78 76 77 79 75	0.0004**	78 76 79 77 75
Jan	0.0143*	79 78 75 76 77	0.4565	75 79 77 76 78
Feb	0.0009**	79 78 75 76 77	0.2344	79 75 78 77 76
Mar	0.0282*	76 77 79 75 78	0.0003**	76 77 79 78 75
Apr	0.0184*	75 77 76 79 78	0.4861	76 75 77 78 79
May	0.0034**	78 76 77 79 75	0.0002**	78 76 79 77 75
Jun	0.0000**	78 77 76 79 75	0.1055	76 78 77 79 75

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.3273	79 76 78 77 75	0.4353	77 78 79 76 75
Jan-Feb-Mar	0.3774	76 79 78 77 75	0.4001	79 77 76 75 78
Apr-May-Jun	0.8692	78 79 76 77 75	0.3353	78 77 76 75 79
Jan-Feb	0.6046	79 78 75 77 75	0.2391	79 77 75 76 78
Mar-Apr	0.6596	76 78 77 79 75	0.7554	76 77 75 78 79
May-Jun	0.1238	77 78 75 79 75	0.2698	78 77 76 79 75
Jan	0.7411	79 76 77 78 75	0.2085	79 76 78 77 75
Feb	0.2791	78 79 76 75 77	0.3692	79 77 75 78 76
Mar	0.0795	76 77 78 79 75	0.0020**	76 77 75 79 78
Apr	0.7138	79 75 76 77 78	0.1625	75 78 79 77 76
May	0.3398	77 76 78 75 79	0.3013	78 77 76 75 79
Jun	0.0216*	78 77 79 76 75	0.5444	78 77 76 79 75

Table 40. DECAPODA

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0008**	78 76 77 79 75	0.2767	76 79 77 78 75
Jan-Feb-Mar	0.0180*	78 77 75 76 79	0.4167	76 77 78 75 79
Apr-May-Jun	0.0005**	76 78 79 77 75	0.5586	76 79 77 78 75
Jan-Feb	0.0082**	78 79 75 77 76	0.4191	76 78 77 75 79
Mar-Apr	0.0001**	76 78 77 75 79	0.0387*	77 76 78 79 75
May-Jun	0.0184	79 76 77 78 75	0.6049	79 76 77 78 75
Jan	0.1673	78 76 79 75	0.0763	76 78 79 75
Feb	0.0023**	78 75 79 77 76	0.0054**	78 77 75 79 76
Mar	0.0364*	77 76 78 75 79	0.1920	77 76 78 75 79
Apr	0.0008**	78 76 79 77 75	0.0001**	78 76 77 79 75
May	0.0109**	79 76 77 75 78	0.5301	76 79 77 75 78
Jun	0.0246*	78 76 79 77 75	0.0005**	78 77 79 76 75

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0686	78 76 77 75 79	0.5620	78 76 77 75 79
Jan-Feb-Mar	0.8040	78 77 76 75 79	0.3141	78 79 76 75 77
Apr-May-Jun	0.0329*	76 78 77 79 75	0.4933	76 77 78 75 79
Jan-Feb	0.4102	78 79 77 75 76	0.1986	78 79 76 75 77
Mar-Apr	0.0475*	78 76 77 79 75	0.4281	76 78 77 79 75
May-Jun	0.2608	76 77 78 75 79	0.0892	77 75 78 76 79
Jan	C.9029	75 76 79	0.7397	76 75 79
Feb	0.2084	78 77 75 76	0.4195	78 77 76 75
Mar	0.5479	78 76 77 75 79	0.5834	77 76 79 78 75
Apr	0.0340*	78 76 77 79 75	0.4744	76 78 77 79 75
May	0.2671	77 75 76 78 79	0.1939	77 75 79 78 76
Jun	0.5642	76 75 79 77 78	0.0372*	77 76 78 79 75

Table 41. DECAPODA

SS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0404*	79 77 76 78 75	0.6351	76 79 78 77 75
Jan-Feb-Mar	0.5395	79 78 77 75 76	0.6802	78 77 75 76 79
Apr-May-Jun	0.0220*	79 76 77 78 75	0.4522	79 76 78 77 75
Jan-Feb	0.0245*	78 79 77 76 75	0.6778	78 76 77 75 79
Mar-Apr	0.1154	77 76 78 79 75	0.0139*	78 76 77 75 79
May-Jun	0.0118*	79 76 77 78 75	0.4362	79 76 77 78 75
Jan	0.1952	76 75 78 79 77	0.0978	76 75 78 77 79
Feb	0.0008**	78 79 77 76 75	0.0014**	78 77 79 75 76
Mar	0.5101	77 79 75 76 78	0.5884	78 75 79 77 76
Apr	0.0069**	76 77 78 75 79	0.0013**	76 78 77 75 79
May	0.1185	79 76 77 75 78	0.3823	79 76 77 78 75
Jun	0.0307*	79 76 77 78 75	0.6565	79 75 77 78 76

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0744	76 79 77 78 75	0.5208	78 76 77 79 75
Jan-Feb-Mar	0.4264	78 76 77 79 75	0.5245	78 76 77 79 75
Apr-May-Jun	0.0604	79 76 77 78 75	0.4114	79 76 77 78 75
Jan-Feb	0.1250	78 76 79 75 77	0.4914	78 76 77 79 75
Mar-Apr	0.0232*	76 78 77 79 75	0.1148	76 77 78 79 75
May-Jun	0.2362	79 77 76 75 78	0.4551	79 77 78 76 75
Jan	0.0324*	78 76 79 77 75	0.5032	78 76 79 77 75
Feb	0.1438	78 76 79 77 75	0.0605	77 78 79 75 76
Mar	0.4143	78 77 76 79 75	0.0471*	77 75 78 76 79
Apr	0.0806	76 78 79 77 75	0.0215*	76 78 77 79 75
May	0.2911	77 79 76 75 78	0.3349	79 77 76 75 78
Jun	0.2170	79 78 77 76 75	0.6540	79 78 77 76 75

Table 42.

COPEPODA

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0000**	76 79 75 78 77	0.0144*	76 79 75 78 77
Jan-Feb-Mar	0.0002**	79 76 75 78 77	0.4034	76 79 75 77 78
Apr-May-Jun	0.0040**	76 79 75 78 77	0.0451*	79 76 75 78 77
Jan-Feb	0.0000**	79 76 78 75 77	0.5137	76 75 79 78 77
Mar-Apr	0.0032**	79 76 77 75 78	0.0155*	76 79 77 75 78
May-Jun	0.0652	76 75 79 77 78	0.1605	79 76 75 78 77
Jan	0.2808	76 79 78 75	0.3224	76 75 79 78
Feb	0.0000**	79 78 76 75 77	0.0001**	79 76 78 77 75
Mar	0.0754	79 77 76 75 78	0.0000**	79 76 77 78 75
Apr	0.0036**	76 79 78 75 77	0.0434*	76 79 77 75 78
May	0.0598	76 75 79 77 78	0.0046**	76 75 77 78 79
Jun	0.0301*	79 76 75 78 77	0.0270*	79 76 78 75 77

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0447*	79 76 78 77 75	0.1661	79 76 75 78 77
Jan-Feb-Mar	0.1396	79 78 76 77 75	0.0261*	79 78 76 77 75
Apr-May-Jun	0.1879	76 79 75 77 78	0.4603	76 79 75 78 77
Jan-Feb	0.6490	79 78 76 77 75	0.1804	76 79 78 75 77
Mar-Apr	0.0027**	79 76 78 77 75	0.0976	79 76 78 77 75
May-Jun	0.2446	75 76 79 77 78	0.5676	75 79 78 77 76
Jan	0.7876	75 76 79	0.9316	76 75 79
Feb	0.2428	78 76 77 75	0.1090	76 78 77 75
Mar	0.2187	79 78 76 77 75	0.000**	79 78 77 76 75
Apr	0.1074	76 79 78 77 75	0.000**	76 79 77 75 78
May	0.1400	77 76 75 79 78	0.3363	77 75 76 79 78
Jun	0.3789	76 77 78 75 79	0.4570	79 75 78 77 76

Table 43. COPEPODA

SS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0007**	76 79 75 77 78	0.0094**	79 76 75 77 78
Jan-Feb-Mar	0.0000**	79 76 75 78 77	0.0262*	79 76 75 78 77
Apr-May-Jun	0.0323*	76 77 79 75 78	0.0038**	76 79 77 75 78
Jan-Feb	0.0000**	79 76 78 75 77	0.1228	79 75 76 78 77
Mar-Apr	0.0000**	76 79 77 75 78	0.0000**	79 76 77 75 78
May-Jun	0.2255	76 77 75 79 78	0.0209*	79 76 75 77 78
Jan	0.0004**	79 76 78 75 77	0.0009**	76 79 75 78 77
Feb	0.0000**	79 78 76 75 77	0.1294	79 75 78 76 77
Mar	0.0027**	79 76 75 77 78	0.0000**	79 76 75 77 78
Apr	0.0000**	76 79 77 75 78	0.0385*	76 77 79 75 78
May	0.0050**	76 75 77 78 79	0.0006**	76 75 77 79 78
Jun	0.0411*	79 76 78 77 75	0.0000**	79 75 77 78 76

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0640	76 79 75 78 77	0.2827	79 75 76 77 78
Jan-Feb-Mar	0.0011**	79 76 78 75 77	0.0035**	79 76 75 78 77
Apr-May-Jun	0.1086	76 75 77 79 78	0.4343	79 75 76 77 78
Jan-Feb	0.0073**	79 78 76 75 77	0.2770	79 76 75 78 77
Mar-Apr	0.1437	76 79 78 75 77	0.0119*	79 76 75 77 78
May-Jun	0.3463	75 76 77 79 78	0.4651	79 75 76 77 78
Jan	0.6330	79 75 76 78 77	0.3694	76 79 75 78 77
Feb	0.0303*	78 79 76 75 77	0.0958	79 75 77 78 76
Mar	0.2430	79 76 78 75 77	0.0194*	79 76 75 78 77
Apr	0.0079**	76 79 77 75 78	0.1476	76 77 79 75 78
May	0.0098**	76 75 77 79 78	0.0698	75 76 77 78 79
Jun	0.0522	79 75 78 77 76	0.4713	79 75 76 78 77

Table 44. ISOPODA

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0117*	76 78 77 75 79	0.1808	78 76 75 77 79
Jan-Feb-Mar	0.7603	75 78 76 79 77	0.3648	78 76 75 79 77
Apr-May-Jun	0.0014**	76 78 77 75 79	0.5753	78 76 77 75 79
Jan-Feb	0.0771	78 79 76 75 77	0.1745	78 79 76 75 77
Mar-Apr	0.0130*	76 75 77 78 79	0.2529	75 76 77 78 79
May-Jun	0.0494*	78 77 76 75 79	0.0737	78 77 76 79 75
Jan	0.1570	76 78 79 75	0.0474*	76 78 79 75
Feb	0.1592	78 75 79 76 77	0.3273	78 75 79 76 77
Mar	0.3102	75 77 76 78 79	0.5616	77 75 78 76 79
Apr	0.0073**	76 75 78 77 79	0.2946	76 75 77 78 79
May	0.4191	77 78 79 76 75	0.5452	78 77 79 76 75
Jun	0.0548	76 78 77 75 79	0.1099	78 76 77 79 75

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.2850	75 76 79 78 77	0.0620	75 76 79 77 78
Jan-Feb-Mar	0.4663	75 76 77 78 79	0.0349*	75 76 79 77 78
Apr-May-Jun	0.2674	79 76 75 78 77	0.6437	79 75 76 77 78
Jan-Feb	0.3141	75 76 79 78 77	0.3214	75 76 79 78 77
Mar-Apr	0.8781	75 76 78 77 79	0.5662	79 75 76 77 78
May-Jun	0.4639	76 75 79 78 77	0.7109	75 76 77 79 78
Jan	no animals		no animals	
Feb	0.6021	75 76 78 77	0.6150	75 76 78 77
Mar	0.7527	75 76 77 78 79	0.0854	75 76 77 79 78
Apr	0.4715	79 78 75 76 77	0.5868	79 75 76 78 77
May	0.3241	76 75 77 79 78	0.0656	75 76 77 79 78
Jun	0.0424*	75 79 76 78 77	0.9586	78 75 79 76 77

Table 45. ISOPODA

SS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.9086	76 78 75 [illegible] 77	0.1089	78 75 76 77 79
Jan-Feb-Mar	0.9175	75 77 79 76 78	0.8254	77 78 75 76 79
Apr-May-Jun	0.5376	76 78 75 79 77	0.0200*	78 75 76 79 77
Jan-Feb	0.0753	79 78 75 77 76	0.2374	78 79 77 75 76
Mar-Apr	0.7305	76 75 79 78 77	0.2641	76 78 75 79 77
May-Jun	0.5827	76 78 75 77 79	0.0092**	75 78 76 77 79
Jan	0.2639	79 75 77 78 76	0.7720	79 77 78 75 76
Feb	0.1938	78 79 77 75 76	0.2510	78 75 77 79 76
Mar	0.5926	76 75 77 79 78	0.1053	76 77 75 78 79
Apr	0.3875	79 78 75 76 77	0.0529	78 79 76 75 77
May	0.1806	75 79 76 78 77	0.0572	75 76 78 79 77
Jun	0.3483	78 76 77 75 79	0.0485*	78 75 76 77 79

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.3117	76 77 78 79 75	0.5459	77 75 76 78 79
Jan-Feb-Mar	0.2464	75 77 78 76 79	0.1025	no animals 75 77 78 76 79
Apr-May-Jun	0.3140	76 77 78 79 75	0.9292	77 76 78 79 75
Jan-Feb	0.1553	no animals 75 77 78 79 76	0.0174*	no animals 75 77 78 79 76
Mar-Apr	0.4665	76 78 75 77 79	0.1412	76 75 77 78 79
May-Jun	0.2808	77 76 78 79 75	0.5334	77 78 76 79 75
Jan	0.5885	75 77 78 76 79	0.5970	no animals 75 77 78 76 79
Feb	0.0377*	77 78 79 75 76	0.0000**	75 77 78 79 76
Mar	0.3150	no animals 75 76 77 78 79	0.0002**	75 76 77 78 79
Apr	0.4352	76 78 79 75 77	0.5319	76 75 78 79 77
May	0.7730	76 78 75 77 79	0.9118	78 77 76 75 79
Jun	0.1324	77 76 79 78 75	0.1275	77 79 76 78 75

Table 46. CUMACEA

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0187*	75 79 78 76 77	0.1348	75 77 76 79 78
Jan-Feb-Mar	0.2687	75 76 78 79 77	0.2683	75 77 76 79 78
Apr-May-Jun	0.0638	79 75 78 76 77	0.2585	75 78 79 77 76
Jan-Feb	0.2278	77 75 78 79 76	0.2034	75 77 79 76 78
Mar-Apr	0.0292*	75 78 76 79 77	0.1142	76 75 79 78 77
May-Jun	0.4626	79 76 78 75 77	0.6336	75 78 79 77 76
Jan	0.0316*	76 75 78 79	0.0208*	75 76 79 78
Feb	0.0002**	75 78 79 77 76	0.2021	75 77 79 78 76
Mar	0.1304	75 76 78 79 77	0.0210*	76 79 75 78 77
Apr	0.1776	75 78 79 76 77	0.0067**	75 79 78 77 76
May	0.0513	75 76 78 79 77	0.0019**	75 76 77 78 79
Jun	0.1113	79 78 76 75 77	0.0033**	79 78 75 77 76

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.4376	75 79 76 78 77	0.1029	75 79 76 77 78
Jan-Feb-Mar	0.2151	75 77 79 78 76	0.0936	75 76 79 77 78
Apr-May-Jun	0.5208	79 76 75 78 77	0.7055	79 75 78 77 76
Jan-Feb	0.0369*	77 75 79 78 76	0.1444	75 77 79 76 78
Mar-Apr	0.8619	78 75 76 79 77	0.7418	76 79 75 77 78
May-Jun	0.3333	76 79 75 78 77	0.5580	79 75 78 76 77
Jan	0.1437	75 76 79	0.5672	75 76 79
Feb	0.1176	77 75 78 76	0.1116	75 77 76 78
Mar	0.1483	76 75 78 79 77	0.3391	76 75 79 77 78
Apr	0.9238	78 79 77 76 75	0.9936	78 77 79 76 75
May	0.3347	76 75 77 78 79	0.2984	75 76 77 78 79
Jun	0.6173	76 79 75 78 77	0.0001**	79 78 75 77 76

Table 47. CUMACEA

SS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0090**	79 77 76 78 75	0.0304*	77 78 79 75 76
Jan-Feb-Mar	0.0058**	79 78 77 76 75	0.0013**	77 78 76 79 75
Apr-May-Jun	0.1091	79 77 76 75 78	0.4345	77 78 79 75 76
Jan-Feb	0.0005**	79 78 77 76 75	0.0001**	77 78 79 76 75
Mar-Apr	0.6999	79 76 77 75 78	0.6087	78 79 76 77 75
May-Jun	0.2607	79 77 76 78 75	0.4759	77 78 75 79 76
Jan	0.0021**	77 79 76 78 75	0.0025**	77 76 78 79 75
Feb	0.0428*	79 78 77 76 75	0.0152*	77 78 79 75 76
Mar	0.3703	76 77 78 79 75	0.0775	76 78 77 79 75
Apr	0.3793	79 75 77 76 78	0.3385	79 78 75 77 76
May	0.6443	75 79 77 76 78	0.1925	79 75 78 77 76
Jun	0.1587	79 77 76 78 75	0.2615	77 78 75 76 79

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.1781	76 78 79 77 75	0.4943	77 78 76 75 79
Jan-Feb-Mar	0.1128	78 76 79 77 75	0.4338	77 76 78 79 75
Apr-May-Jun	0.2648	76 77 79 78 75	0.5708	77 78 75 76 79
Jan-Feb	0.5312	76 78 79 75 77	0.4086	77 76 78 75 79
Mar-Apr	0.3088	76 78 79 77 75	0.9987	75 77 79 76 78
May-Jun	0.8353	77 76 79 78 75	0.5774	77 78 75 76 79
Jan	0.8818	76 77 79 78 75	0.1014	76 77 78 79 75
Feb	0.2924	78 76 75 79 77	0.5585	77 75 79 78 76
Mar	0.5017	78 76 79 77 75	0.8121	78 76 79 77 75
Apr	0.1281	76 79 77 78 75	0.8313	75 77 79 76 78
May	0.8997	76 79 77 78 75	0.8233	78 77 79 75 76
Jun	0.5103	77 79 78 76 75	0.5496	77 75 78 76 79

Table 48. AMPHIPODA

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.0003**	78 75 76 79 77	0.0972	76 78 75 77 79
Jan-Feb-Mar	0.0000**	75 78 76 77 79	0.0283*	76 75 77 78 79
Apr-May-Jun	0.0001**	78 79 76 75 77	0.0000**	78 79 75 76 77
Jan-Feb	0,0003**	78 75 77 76 79	0.3010	76 77 75 78 79
Mar-Apr	0.0005**	76 75 78 77 79	0.0022**	76 75 78 77 79
May-Jun	0.0000**	78 79 76 75 77	0.0000**	78 79 75 76 77
Jan	0.1373	76 78 75 79	0.0364*	76 78 75 79
Feb	0.0000**	78 75 77 76 79	0.0000**	75 77 78 76 79
Mar	0.0000**	76 75 77 78 79	0.0001**	76 75 77 78 79
Apr	0.1691	78 76 79 75 77	0.2003	78 79 77 76 75
May	0.0012**	79 78 76 75 77	0.0000**	78 79 75 77 76
Jun	0.0158*	76 78 75 79 77	0.0144*	78 75 76 77 79

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years of increasing order
All months	0.4396	76 75 78 77 79	0.1509	78 76 75 79 77
Jan-Feb-Mar	0.2670	77 75 78 76 79	0.1040	76 78 75 77 79
Apr-May-Jun	0.6160	76 75 79 78 77	0.0918	78 79 75 77 76
Jan-Feb	0.3722	78 77 75 79 76	0.3124	78 75 76 77 79
Mar-Apr	0.4940	78 76 77 75 79	0.3997	76 78 77 75 79
May-Jun	0.3637	76 75 79 78 77	0.5155	78 75 79 76 77
Jan	0.8611	76 75 79	0.2666	76 75 79
Feb	0.0414*	78 77 75 76	0.1109	78 75 77 76
Mar	0.4554	76 75 77 78 79	0.0003**	76 75 77 78 79
Apr	0.0533	78 79 77 76 75	0.0672	78 79 77 75 76
May	0.1341	78 76 75 79 77	0.0560	78 79 76 75 77
Jun	0.1834	79 75 76 78 77	0.5797	75 76 77 79 78

Table 49.

AMPHIPODA

SS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0023**	76 78 79 77 75	0.0088**	78 76 75 77 79
Jan-Feb-Mar	0.0003**	76 78 75 79 77	0.0001**	76 78 75 77 79
Apr-May-Jun	0.0002**	79 76 78 77 75	0.0049**	78 79 77 76 75
Jan-Feb	0.0002**	76 78 75 79 77	0.0124*	75 76 77 78 79
Mar-Apr	0.1101	76 75 78 77 79	0.0025**	78 75 76 77 79
May-Jun	0.0000**	79 76 78 77 75	0.0023**	78 79 77 76 75
Jan	0.0011**	76 75 78 79 77	0.0464*	76 75 78 79 77
Feb	0.1917	78 76 75 79 77	0.0418*	75 77 78 76 79
Mar	0.0131*	76 78 75 77 79	0.0005**	78 76 75 77 79
Apr	0.4790	75 76 77 79 78	0.1685	78 75 79 77 76
May	0.0421*	79 76 78 77 75	0.0006**	79 78 77 75 76
Jun	0.0000**	79 76 78 77 75	0.0003**	78 76 77 79 75

BS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.3620	76 78 79 77 75	0.7187	76 77 78 75 79
Jan-Feb-Mar	0.2709	76 75 78 79 77	0.0357*	76 75 77 78 79
Apr-May-Jun	0.0137*	77 76 79 78 75	0.3912	78 77 79 76 75
Jan-Feb	0.5993	76 75 79 78 77	0.3772	76 75 77 79 78
Mar-Apr	0.1314	76 78 75 77 79	0.0049**	75 76 78 77 79
May-Jun	0.0261*	77 79 76 78 75	0.4314	77 79 78 76 75
Jan	0.6658	79 75 76 77 78	0.0822	76 79 75 77 78
Feb	0.2996	76 78 75 79 77	0.5550	77 75 76 79 78
Mar	0.2536	76 78 75 77 79	0.0087**	76 75 78 77 79
Apr	0.2306	76 77 78 79 75	0.0361*	78 77 75 76 79
May	0.1805	79 77 78 76 75	0.0575	79 78 77 76 75
Jun	0.2613	77 76 79 78 75	0.2344	77 76 78 75 79

Table 50.

CHAETOGNATHA

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.1284	78 79 75 76 77	0.0252*	79 77 75 76 78
Jan-Feb-Mar	0.0016**	78 79 75 76 77	0.4197	77 78 79 75 76
Apr-May-Jun	0.0088**	79 75 77 78 76	0.0003**	79 75 77 76 78
Jan-Feb	0.0000**	78 76 79 75 77	0.1440	76 78 75 79 77
Mar-Apr	0.0173*	79 77 78 75 76	0.5018	79 75 77 78 76
May-Jun	0.1451	79 78 75 77 76	0.0026**	79 77 76 75 78
Jan	0.0511	78 75 79 76	0.1074	78 75 79 76
Feb	0.0000**	76 78 79 75 77	0.0012**	76 79 78 75 77
Mar	0.0001**	77 79 78 75 76	0.4208	77 78 79 75 76
Apr	0.0425*	79 75 77 78 76	0.0853	79 75 76 77 78
May	0.1687	79 76 77 75 78	0.0395*	79 77 76 75 78
Jun	0.0152*	79 78 75 77 76	0.0010**	79 78 75 77 76

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.1961	77 79 78 76 75	0.2244	77 79 75 76 78
Jan-Feb-Mar	0.0968	77 79 78 75 76	0.1291	77 79 78 75 76
Apr-May-Jun	0.6191	79 78 76 75 77	0.1454	79 75 77 76 78
Jan-Feb	0.5184	77 79 76 78 75	0.2577	77 76 75 79 78
Mar-Apr	0.3403	77 79 78 76 75	0.3502	79 77 76 78 75
May-Jun	0.2267	75 79 78 77 76	0.0741	75 77 79 76 78
Jan	0.0162*	75 76 79	0.3672	75 76 79
Feb	0.1855	77 76 78 75	0.4905	77 76 75 78
Mar	0.0706	77 78 79 75 76	0.0896	77 79 78 75 76
Apr	0.4524	79 77 78 76 75	0.2292	79 77 76 75 78
May	0.8515	75 77 79 78 76	0.3754	75 77 79 76 78
Jun	0.5714	76 75 79 78 77	0.0887	75 79 78 77 76

Table 51. CHAETOGNATHA

SS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.0738	79 78 76 77 75	0.0003**	79 76 77 75 78
Jan-Feb-Mar	0.0372*	79 78 75 76 77	0.5078	79 75 78 77 76
Apr-May-Jun	0.0024**	79 77 76 78 75	0.0000**	79 76 77 75 78
Jan-Feb	0.0009**	78 79 76 75 77	0.4328	79 78 76 75 77
Mar-Apr	0.0010**	79 77 75 78 76	0.0660	79 77 75 78 76
May-Jun	0.0028**	79 77 76 78 75	0.0002**	79 76 78 77 75
Jan	0.0311*	78 79 75 77 76	0.0444*	78 75 77 79 76
Feb	0.0000**	76 79 78 75 77	0.3332	79 76 78 75 77
Mar	0.0006**	79 77 78 75 76	0.5390	75 79 77 78 76
Apr	0.0000**	79 77 75 76 78	0.0300*	79 77 75 78 76
May	0.0373*	79 76 77 78 75	0.1560	79 76 78 75 78
Jun	0.0012**	79 77 76 78 75	0.0000**	79 77 76 78 75

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.6123	78 79 75 76 77	0.0494*	79 75 77 78 76
Jan-Feb-Mar	0.2818	78 79 75 76 77	0.4186	77 79 78 75 76
Apr-May-Jun	0.1998	79 77 76 75 78	0.0081**	79 75 77 76 78
Jan-Feb	0.2585	78 75 79 76 77	0.2559	78 77 76 75 79
Mar-Apr	0.3779	79 77 78 76 75	0.2138	77 79 75 78 76
May-Jun	0.4765	79 77 75 76 78	0.0015**	79 75 77 76 78
Jan	0.0694	78 75 79 77 76	0.0302*	78 77 75 79 76
Feb	0.0111*	76 78 79 75 77	0.1019	76 78 79 77 75
Mar	0.1277	78 79 77 76 75	0.0348*	79 77 78 75 76
Apr	0.5011	77 79 76 78 75	0.0784	77 79 75 78 76
May	0.0011**	75 79 76 77 78	0.0001**	75 79 76 77 78
Jun	0.1826	79 77 75 78 76	0.0000**	79 75 77 76 78

Table 52. MISCELLANEOUS

HS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order					RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order				
All months	0.0003**	76	79	75	78	77	0.0256*	75	76	79	77	78
Jan-Feb-Mar	0.2060	75	76	77	78	79	0.1064	75	76	79	77	78
Apr-May-Jun	0.0002**	76	79	75	78	77	0.3931	75	76	79	77	78
Jan-Feb	0.8393	75	76	78	79	77	0.5426	75	76	77	79	78
Mar-Apr	0.1725	76	75	79	78	77	0.09[illegible]1	75	76	79	77	78
May-Jun	0.0014**	76	79	75	78	77	0.4022	75	79	76	78	77
Jan	0.4218	78	75	79	76		0.6871	75	79	78	76	
Feb	0.7369	76	75	77	78	79	0.2953	76	75	77	79	78
Mar	0.0715	75	76	77	79	78	0.0798	75	76	79	77	78
Apr	0.0770	76	75	79	78	77	0.0362*	76	75	79	77	78
May	0.0000**	76	79	78	75	77	0.1012	76	79	77	75	78
Jun	0.1352	75	76	79	78	77	0.3189	75	78	79	77	76

MS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order					RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order				
All months	0.3286	76	79	75	78	77	0.5175	75	76	77	79	78
Jan-Fab-Mar	0.6494	77	76	75	79	78	0.6243	77	75	76	79	78
Apr-May-Jun	0.2610	76	79	78	75	77	0.6463	76	75	78	79	77
Jan-Feb	0.6891	79	77	76	78	75	0.8302	75	76	79	78	77
Mar-Apr	0.3533	76	78	75	79	77	0.4303	76	77	75	79	78
May-Jun	0.7110	76	79	75	77	78	0.5781	75	78	79	77	76
Jan	0.1682	75	76	79			0.6019	75	76	79		
Feb	0.1846	77	76	78	75		0.1806	76	78	77	75	
Mar	0.3121	77	76	75	78	79	0.2959	77	75	76	79	78
Apr	0.3009	76	78	79	75	77	0.4231	76	75	79	77	78
May	0.2223	76	79	77	78	75	0.9094	79	76	77	78	75
Jun	0.1897	75	79	78	76	77	0.4751	75	78	79	77	76

Table 53. MISCELLANEOUS

SS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0000**	76 75 79 77 78	0.0001**	76 75 77 78 79
Jan-Feb-Mar	0.0455*	76 75 79 77 78	0.0000**	76 75 77 78 79
Apr-May-Jun	0.0000**	76 75 79 78 77	0.0253*	76 75 79 78 77
Jan-Feb	0.0063**	76 75 79 78 77	0.0036**	76 75 77 78 79
Mar-Apr	0.0007**	75 76 79 77 78	0.0011**	75 76 77 78 79
May-Jun	0.0000**	76 79 75 77 78	0.0339*	76 75 79 78 77
Jan	0.7590	75 76 79 78 77	0.2512	76 75 77 78 79
Feb	0.0015**	76 75 79 78 77	0.0253*	76 75 78 77 79
Mar	0.0705	76 75 77 79 78	0.0009**	75 76 77 78 79
Apr	0.0000**	75 76 79 78 77	0.0018**	75 76 78 79 77
May	0.0017**	76 79 77 75 78	0.0567	76 79 78 75 77
Jun	0.0055**	76 75 79 78 77	0.0000**	75 76 78 77 79

BS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0858	76 75 79 77 78	0.0370*	75 77 79 79 78
Jan-Feb-Mar	0.3705	76 75 79 77 78	0.0122*	77 76 75 79 78
Apr-May-Jun	0.0725	76 75 79 77 78	0.0331*	75 76 79 78 77
Jan-Feb	0.3213	76 75 77 79 78	0.0054**	77 76 75 79 78
Mar-Apr	0.1251	76 75 78 79 77	0.2138	75 76 77 79 78
May-Jun	0.4771	76 79 75 77 78	0.1003	75 76 79 78 77
Jan	0.2097	77 79 75 76 78	0.0082**	77 76 79 75 78
Feb	0.4498	76 75 78 79 77	0.0908	76 75 77 79 78
Mar	0.5162	76 78 75 79 77	0.2187	76 75 77 78 79
Apr	0.0065**	76 75 79 78 77	0.0096**	75 76 79 78 77
May	0.1350	76 79 75 77 78	0.1430	79 76 78 75 77
Jun	0.1883	75 79 76 77 78	0.0000**	75 76 79 77 78

Table 54. *NEOMYSIS AMERICANA*

HS

SEASON	ABUNDANCE Signif.	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.2642	76	77	79	75	78	0.4572	79	76	78	75	77
Jan-Feb-Mar	0.2777	78	79	76	77	75	0.4920	76	78	75	79	77
Apr-May-Jun	0.0871	76	77	79	75	78	0.0354*	79	78	77	75	76
Jan-Feb	0.3436	78	79	77	76	75	0.4970	76	78	77	79	75
Mar-Apr	0.1402	79	75	78	76	77	0.5557	78	79	75	76	77
May-Jun	0.0073**	76	77	79	75	78	0.0549	79	77	76	75	78
Jan	0.1155	76	79	78	75		0.0847	76	79	78	75	
Feb	0.0056**	78	75	79	77	76	0.0057**	78	77	75	79	76
Mar	0.4558	76	79	78	75	77	0.7613	76	78	75	79	77
Apr	0.0030**	79	78	75	77	76	0.1945	79	78	75	77	76
May	0.0433*	79	76	77	75	78	0.0118*	79	77	75	76	78
Jun	0.0003**	76	77	75	79	78	0.0000**	76	77	75	79	78

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.9368	79	78	76	75	77	0.4614	78	79	77	76	75
Jan-Feb-Mar	0.1599	78	79	75	77	76	0.7822	78	79	77	76	75
Apr-May-Jun	0.8922	76	79	75	77	78	0.6520	77	79	78	75	76
Jan-Feb	0.2215	78	79	77	75	76	0.3494	79	77	78	75	76
Mar-Apr	0.3046	78	79	75	76	77	0.3882	78	79	76	75	77
May-Jun	0.6073	76	75	79	77	78	0.3021	77	75	79	78	76
Jan	0.5456	76	75	79			0.6052	76	75	79		
Feb	0.0684	78	75	77	76		0.5353	77	78	75	76	
Mar	0.3076	78	76	79	75	77	0.5912	76	78	79	75	77
Apr	0.1890	78	79	77	75	76	0.5561	78	79	77	75	76
May	0.8706	77	75	76	79	78	0.2158	77	75	79	78	76
Jun	0.5637	76	75	79	77	78	0.0412*	76	77	79	78	75

Table 55. *NEOMYSIS AMERICANA*

SS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.0016**	79 76 78 77 75	0.0229*	75 78 76 79 77
Jan-Feb-Mar	0.0001**	79 76 78 75 77	0.0216*	75 79 76 78 77
Apr-May-Jun	0.0046**	78 77 76 79 75	0.4071	78 75 76 79 77
Jan-Feb	0.0002**	79 78 76 75 77	0.0150*	75 79 78 76 77
Mar-Apr	0.0406*	79 76 75 78 77	0.0577	75 79 76 78 77
May-Jun	0.0006**	78 77 76 79 75	0.2870	78 76 75 79 77
Jan	0.0049**	79 76 78 75 77	0.4337	75 79 76 78 77
Feb	0.0001**	78 79 75 76 77	0.0273*	75 79 78 76 77
Mar	0.0203*	76 79 78 75 77	0.2039	76 75 78 79 77
Apr	0.1042	79 75 77 76 78	0.1565	75 79 76 78 77
May	0.4648	78 76 79 75 77	0.0105*	78 75 76 79 77
Jun	0.0000**	78 77 76 79 75	0.1947	77 76 78 79 75

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.1788	79 76 78 77 75	0.0908	78 79 76 77 75
Jan-Feb-Mar	0.3922	79 76 78 75 77	0.7149	78 79 76 75 77
Apr-May-Jun	0.1317	78 79 77 76 75	0.0693	78 77 79 76 75
Jan-Feb	0.4488	79 76 78 77 75	0.8560	79 76 75 78 77
Mar-Apr	0.1424	79 78 76 75 77	0.0406*	78 79 75 76 77
May-Jun	0.1900	78 77 79 76 75	0.2823	78 77 76 79 75
Jan	0.5328	79 76 77 78 75	0.1376	76 79 78 77 75
Feb	0.1847	78 75 76 79 77	0.4663	75 78 79 77 76
Mar	0.4362	76 79 75 78 77	0.7654	78 79 76 75 77
Apr	0.2289	78 79 76 75 77	0.0885	78 79 75 77 76
May	0.0764	76 78 79 77 75	0.2021	76 78 77 79 75
Jun	0.0255*	78 77 79 76 75	0.5472	78 77 76 79 75

Table 56. *CRANGON SEPTEMSPINOSA*

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.0051**	78 77 76 79 75	0.6755	77 76 79 76 75
Jan-Feb-Mar	0.0277*	78 77 75 76 79	0.2967	76 77 75 78 79
Apr-May-Jun	0.0126*	78 79 77 76 75	0.3278	79 77 78 76 75
Jan-Feb	0.0091**	78 79 75 77 76	0.4383	76 78 77 75 79
Mar-Apr	0.1158	76 78 77 75 79	0.8791	78 76 77 75 79
May-Jun	0.0557	79 77 76 78 75	0.2309	79 77 76 78 75
Jan	0.1671	78 76 79 75	0.0765	76 78 79 75
Feb	0.0022**	78 75 79 77 76	0.0085**	78 77 75 79 76
Mar	0.0571	76 78 77 75 79	0.6437	76 77 75 78 79
Apr	0.3425	78 79 77 76 75	0.2206	78 79 77 75 76
May	0.0830	79 77 76 78 75	0.1235	79 77 76 75 78
Jun	0.0206*	78 76 79 77 75	0.0003**	78 77 79 76 75

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.1120	78 76 77 75 79	0.4364	76 78 77 79 75
Jan-Feb-Mar	0.7238	78 76 77 75 79	0.6273	78 77 76 79 75
Apr-May-Jun	0.1781	76 78 77 75 79	0.6814	76 79 78 77 75
Jan-Feb	0.3561	78 79 77 75 76	0.2843	78 77 79 76 75
Mar-Apr	0.3473	78 76 77 79 75	0.3756	76 78 79 77 75
May-Jun	0.2043	76 77 78 75 79	0.8302	77 76 79 78 75
Jan	0.8874	75 76 79	0.7203	76 75 79
Feb	0.1908	78 77 75 76	0.5686	78 77 76 75
Mar	0.5349	76 78 75 77 79	0.4351	76 78 79 77 75
Apr	0.1660	78 79 76 77 75	0.7155	78 79 76 77 75
May	0.0050**	76 77 78 75 79	0.8189	77 76 79 78 75
Jun	0.3756	76 77 78 75 79	0.0113*	77 76 78 79 75

Table 57. *CRANGON SEPTEMSPINOSA*

SS

SEASON	ABUNDANCE Signif.	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.0056**	79	78	77	76	75	0.0897	76	78	79	75	77
Jan-Feb-Mar	0.0002**	78	76	79	77	75	0.0040**	76	78	75	77	79
Apr-May-Jun	0.0257*	79	77	78	76	75	0.5626	76	79	78	75	77
Jan-Feb	0.0069**	78	79	76	77	75	0.0446*	78	76	75	77	79
Mar-Apr	0.0382*	76	78	77	79	75	0.0074**	76	78	79	77	75
May-Jun	0.0113*	79	77	78	76	75	0.7821	79	76	78	75	77
Jan	0.1397	76	75	78	79	77	0.0366*	76	75	78	77	79
Feb	0.0004**	78	79	76	77	75	0.0125*	78	77	76	79	75
Mar	0.0003**	76	78	77	79	75	0.0128*	76	78	77	79	75
Apr	0.5886	79	76	77	75	78	0.5596	76	79	77	75	78
May	0.1724	79	77	76	78	75	0.5299	79	76	78	75	77
Jun	0.0014**	79	77	78	76	75	0.0080**	77	78	79	75	76

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.0103*	78	79	77	76	75	0.0153*	78	79	76	77	75
Jan-Feb-Mar	0.0080**	78	76	79	77	75	0.0002**	78	76	77	79	75
Apr-May-Jun	0.1566	77	79	78	76	75	0.2548	79	77	78	76	75
Jan-Feb	0.0177*	78	79	76	75	77	0.0013**	78	76	79	77	75
Mar-Apr	0.1387	76	78	77	79	75	0.7852	78	79	76	77	75
May-Jun	0.1372	77	79	78	76	75	0.3713	79	77	78	76	75
Jan	0.0292*	78	76	79	77	75	0.5308	78	76	79	77	75
Feb	0.1099	78	79	76	75	77	0.0000**	78	77	79	75	76
Mar	0.0379*	76	78	77	79	75	0.4799	78	76	77	79	75
Apr	0.2157	76	77	79	75	78	0.6242	79	77	76	75	78
May	0.1250	79	77	76	78	75	0.0380*	79	78	77	76	75
Jun	0.0567	77	78	79	76	75	0.4505	77	78	79	76	75

Table 58. *CALANUS FINMARCHICUS*

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.0053**	76 79 75 78 77	0.0599	76 79 75 77 78
Jan-Feb-Mar	0.0454*	79 76 78 75 77	0.4336	76 77 79 75 78
Apr-May-Jun	0.0169*	76 75 79 77 78	0.1045	79 76 75 77 78
Jan-Feb	0.0000**	79 76 78 75 77	0.5384	76 75 79 77 78
Mar-Apr	0.1109	79 76 77 75 78	0.0494*	76 79 77 78 75
May-Jun	0.0383*	76 75 79 77 78	0.3430	79 75 76 78 77
Jan	0.3259	76 79 75 78	0.2912	76 75 79 78
Feb	0.0000**	79 78 76 75 77	0.0018**	79 76 77 78 75
Mar	0.1498	79 77 75 76 78	0.4953	77 76 79 78 75
Apr	0.0070**	76 79 78 77 75	0.0708	76 79 77 78 75
May	0.0157*	76 75 77 79 78	0.1723	75 76 77 78 79
Jun	0.0799	79 76 75 77 78	0.1417	79 75 76 78 77

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.0754	79 76 77 78 75	0.4141	77 79 76 75 78
Jan-Feb-Mar	0.1476	79 77 78 76 75	0.0059**	77 79 78 76 75
Apr-May-Jun	0.3163	76 79 77 75 78	0.1957	76 75 79 77 78
Jan-Feb	0.6117	79 78 77 76 75	0.2856	77 76 79 78 75
Mar-Apr	0.0098**	79 76 77 78 75	0.2111	77 79 76 78 75
May-Jun	0.2171	75 76 79 77 78	0.4835	75 79 76 77 78
Jan	0.8333	75 76 79	0.9561	76 75 79
Feb	0.1232	78 77 76 75	0.5103	77 76 78 75
Mar	0.2051	79 77 78 76 75	0.0000**	77 79 78 76 75
Apr	0.1626	76 79 78 77 75	0.0000**	76 77 79 78 75
May	0.1293	77 76 75 79 78	0.3435	75 77 76 79 78
Jun	0.0653	75 79 76 78 77	0.3010	75 79 76 78 77

Table 59. *CALANUS FINMARCHICUS*

SS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.0057**	76 79 75 77 78	0.0665	79 76 77 75 78
Jan-Feb-Mar	0.0002**	79 76 75 77 78	0.0118*	79 76 75 77 78
Apr-May-Jun	0.0663	76 77 75 79 78	0.3449	76 79 77 75 78
Jan-Feb	0.0000**	79 78 76 75 77	0.1165	79 75 76 78 77
Mar-Apr	0.0000**	79 77 76 75 78	0.2327	76 79 77 75 78
May-Jun	0.2321	76 77 75 79 78	0.0591	79 75 76 77 78
Jan	0.0000**	79 76 75 78 77	0.0000**	76 79 75 78 77
Feb	0.0000**	79 78 76 75 77	0.1316	79 75 77 78 76
Mar	0.0002**	79 76 77 75 78	0.0000**	79 76 77 75 78
Apr	0.0000**	77 76 79 75 78	0.3936	76 77 79 75 78
May	0.0026**	76 75 77 78 79	0.0001**	76 75 77 79 78
Jun	0.0440*	79 76 78 77 75	0.0000**	79 75 77 78 76

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.1941	76 75 79 77 78	0.2623	79 75 76 77 78
Jan-Feb-Mar	0.0191*	79 76 75 78 77	0.0085**	79 77 76 75 78
Apr-May-Jun	0.1785	76 77 75 79 78	0.4977	79 75 76 77 78
Jan-Feb	0.0005**	79 75 76 78 77	0.1063	76 79 75 78 77
Mar-Apr	0.0017**	76 79 77 78 75	0.0385*	76 77 79 75 78
May-Jun	0.2861	75 76 77 79 78	0.4805	79 75 76 77 78
Jan	0.0745	79 75 76 78 77	0.1063	76 79 75 78 77
Feb	0.0013**	79 78 76 75 77	0.0004**	79 75 77 78 76
Mar	0.1689	79 77 76 75 78	0.0160*	79 77 76 75 78
Apr	0.0030**	76 77 79 78 75	0.0163*	76 77 79 75 78
May	0.0075**	75 76 77 79 78	0.0081**	75 76 77 78 79
Jun	0.0448*	79 75 77 78 76	0.4770	79 75 77 76 78

Table 60. *OXYUROSTYLIS SMITHI*

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.0135*	75 78 79 76 77	0.0126*	75 78 76 77 79
Jan-Feb-Mar	0.0947	75 79 76 78 77	0.0003**	75 76 77 79 78
Apr-May-Jun	0.0404*	78 79 75 76 77	0.0068**	78 75 79 77 76
Jan-Feb	0.0083**	75 77 79 78 76	0.0359*	75 76 77 79 78
Mar-Apr	0.0325*	75 78 76 79 77	0.0090**	75 76 78 79 77
May-Jun	0.2803	78 79 76 75 77	0.0072**	78 75 77 79 76
Jan	0.0002**	76 75 79 78	0.0222*	76 75 79 78
Feb	0.0000**	75 79 78 77 76	0.0002**	75 77 79 78 76
Mar	0.1081	75 76 78 79 77	0.0046**	75 76 78 79 77
Apr	0.1800	75 78 79 76 77	0.1522	75 78 79 77 76
May	0.0681	78 75 76 77 79	0.0069**	78 75 77 76 79
Jun	0.0503	79 78 76 75 77	0.0001**	78 79 75 77 76

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.3511	78 75 79 76 77	0.4400	75 77 76 79 78
Jan-Feb-Mar	0.2855	75 77 78 79 76	0.4067	75 77 76 79 78
Apr-May-Jun	0.2978	78 79 76 75 77	0.1091	78 79 77 75 76
Jan-Feb	0.2074	77 75 79 78 76	0.2892	75 77 76 79 76
Mar-Apr	0.8558	78 75 79 76 77	0.4949	76 75 79 78 77
May-Jun	0.2484	78 79 76 75 77	0.1311	78 79 75 77 76
Jan	0.5615	75 76 79	0.4529	75 76 79
Feb	0.0495*	77 75 78 76	0.5319	77 75 78 76
Mar	0.1491	75 76 78 79 77	0.4537	76 75 79 78 77
Apr	0.8777	78 79 77 76 75	0.9317	78 79 77 76 75
May	0.3173	76 78 77 75 79	0.5661	78 75 77 76 79
Jun	0.0478*	79 78 75 76 77	0.0006**	79 78 75 77 76

Table 61. *OXYUROSTYLIS SMITHI*

SS

SEASON	ABUNDANCE		RELATIVE ABUNDANCE	
	Signif.	Years in increasing order	Signif.	Years in increasing order
All months	0.1474	79 77 76 78 75	0.7754	79 75 76 77 78
Jan-Feb-Mar	0.0066**	75 76 79 77 78	0.1390	75 76 77 79 78
Apr-May-Jun	0.0498*	79 78 77 76 75	0.4504	79 78 76 77 75
Jan-Feb	0.0093**	79 77 75 76 78	0.1422	77 75 79 76 78
Mar-Apr	0.0529	75 79 77 78 76	0.3089	75 76 79 78 77
May-Jun	0.0133*	79 78 76 77 75	0.1172	78 79 76 77 75
Jan	0.0003**	76 77 79 75 78	0.0084**	77 75 76 79 78
Feb	0.5050	79 78 75 77 76	0.7045	79 78 75 77 76
Mar	0.1452	75 76 79 78 77	0.0306*	75 76 78 79 77
Apr	0.0014**	79 75 77 78 76	0.4967	79 75 77 78 76
				no animals
May	0.2703	76 78 79 77 75	0.0866	76 78 79 75 77
Jun	0.0775	79 78 76 77 75	0.3250	78 79 76 77 75

BS-1

SEASON	ABUNDANCE		RELATIVE ABUNDANCE	
	Signif.	Years in increasing order	Signif.	Years in increasing order
All months	0.6916	79 76 75 77 78	0.9968	79 75 76 77 78
Jan-Feb-Mar	0.4646	76 75 79 77 78	0.7335	77 76 75 79 78
Apr-May-Jun	0.1512	79 78 77 76 75	0.6889	78 79 75 76 77
Jan-Feb	0.3292	77 76 75 79 78	0.2109	77 76 79 78 75
Mar-Apr	0.3207	78 76 75 79 77	0.4233	75 78 79 76 77
May-Jun	0.5181	79 78 77 76 75	0.9304	78 79 76 75 77
Jan	0.2116	77 76 75 79 78	0.0123*	77 76 75 79 78
Feb	0.7334	79 78 77 76 75	0.6033	79 77 78 76 75
Mar	0.0861	75 76 78 79 77	0.0000**	75 76 78 79 77
Apr	0.3054	78 79 77 76 75	0.6776	79 78 77 75 76
May	0.8850	76 78 79 75 77	0.8429	78 79 76 75 77
Jun	0.1084	79 77 78 76 75	0.7037	77 79 78 76 75

Table 62. *DIASTYLIS SCULPTA*

HS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0079**	78 77 76 75 79	0.0917	77 78 76 79 75
Jan-Feb-Mar	0.0134*	78 77 76 75 79	0.0659	78 77 76 79 75
Apr-May-Jun	0.0157*	77 76 79 78 75	0.4800	77 79 76 78 75
Jan-Feb	0.0055**	78 77 76 75 79	0.1639	78 77 76 75 79
Mar-Apr	0.0078**	77 79 76 78 75	0.0351*	77 76 79 78 75
May-Jun	0.8731	79 77 76 78 75	0.8579	77 79 75 78 76
Jan	0.0008**	78 76 75 79	0.1057	78 75 76 79
Feb	0.3046	78 79 76 77 75	0.5643	78 76 75 77 79
Mar	0.6173	77 79 78 76 75	0.1247	77 78 79 76 75
Apr	0.0045**	77 76 79 78 75	0.1365	77 76 79 78 75
May	0.5129	76 79 77 78 75	0.8380	77 76 79 75 78
Jun	0.3049	75 78 79 77 76	0.1535	75 78 79 77 76

MS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.1445	78 79 77 76 75	0.1803	79 78 77 76 75
Jan-Feb-Mar	0.2590	78 79 77 75 76	0.2969	78 77 79 76 75
Apr-May-Jun	0.2140	77 79 78 76 75	0.6903	79 78 76 77 75
Jan-Feb	0.3460	78 79 75 77 76	0.3765	77 78 75 79 76
Mar-Apr	0.0040**	76 77 78 79 75	0.0025**	78 79 77 76 75
May-Jun	0.7086	75 77 79 78 76	0.7279	75 79 78 76 77
Jan	0.0160	75 76 79	0.5499	75 76 79
Feb	0 757	78 77 75 76	0.6273	77 78 75 76
Mar	0.3090	78 79 76 77 75	0.2655	78 79 77 76 75
Apr	0.1961	76 77 78 79 75	0.0000**	76 77 78 79 75
May	0.9054	75 77 79 78 76	0.8189	75 79 78 76 77
Jun	no numbers		no numbers	

Table 63. *DIASTYLIS SCULPTA*

SS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0000**	79 77 78 76 75	0.4261	76 79 75 77 78
Jan-Feb-Mar	0.0000**	79 77 78 76 75	0.0021**	77 78 79 76 75
Apr-May-Jun	0.0551	79 77 78 76 75	0.4296	76 79 75 77 78
Jan-Feb	0.0000**	79 78 77 76 75	0.0031**	77 78 79 76 75
Mar-Apr	0.2262	77 79 76 78 75	0.4368	76 78 77 79 75
May-Jun	0.0685	79 77 78 76 75	0.7941	76 79 75 78 77
Jan	0.0023**	77 79 76 78 75	0.2408	77 78 76 79 75
Feb	0.0047**	79 78 77 76 75	0.0012**	77 79 78 75 76
Mar	0.1878	76 77 79 78 75	0.1663	78 76 77 79 75
Apr	0.3272	79 77 75 76 78	0.4683	76 79 77 78 75
May	0.7784	79 77 75 78 76	0.4792	76 79 75 78 77
Jun	0.0613	79 78 77 76 75	0.2446	77 78 76 75 79

BS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0218*	78 76 79 77 75	0.2615	78 76 77 75 79
Jan-Feb-Mar	0.0021**	78 76 77 79 75	0.0683	78 77 76 79 75
Apr-May-Jun	0.1074	76 78 77 79 75	0.2986	78 76 77 75 79
Jan-Feb	0.0111*	78 76 79 75 77	0.1455	78 77 76 79 75
Mar-Apr	0.0190*	78 77 76 79 75	0.0817	76 78 77 79 75
May-Jun	0.6478	78 76 77 79 75	0.1090	78 77 75 76 79
Jan	0.0842	78 76 77 79 75	0.2395	78 76 77 79 75
Feb	0.1842	78 76 75 79 77	0.4714	77 78 79 75 76
Mar	0.0630	78 77 76 79 75	0.3129	78 77 76 79 75
Apr	0.0759	76 79 77 78 75	0.0000**	76 77 79 78 75
May	0.6838	78 76 79 77 75	0.4194	78 77 79 75 76
Jun	0.6273	78 77 75 79 76	0.5486	78 77 75 76 79

Table 64. *EUDORELLA PUSILLA*

HS

SEASON	ABUNDANCE Signif.	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.1044	76	75	78	79	77	0.1397	76	75	77	78	79
Jan-Feb-Mar	0.3483	76	75	78	79	77	0.1274	75	76	78	77	79
Apr-May-Jun	0.4788	76	75	79	78	77	0.6674	76	77	75	78	79
Jan-Feb	0.0699	78	76	77	75	79	0.3526	75	76	77	78	79
Mar-Apr	0.5147	75	76	79	77	78	0.8277	76	75	77	78	79
May-Jun	0.0773	76	75	79	78	77	0.5857	76	75	77	78	79
Jan	0.0713	76	78	79	75		0.0041**	76	78	79	75	
Feb	0.0027**	75	78	76	77	79	0.0000**	75	77	76	79	78
Mar	0.4068	75	76	79	77	78	0.4455	75	76	78	79	77
Apr	0.9342	76	75	78	79	77	0.4642	77	76	78	79	75
May	0.0547	76	75	79	78	77	0.1008	76	75	78	79	77
Jun	0.7599	77	76	79	75	78	0.9340	77	75	78	79	76

MS-1

SEASON	ABUNDANCE Signif	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.3466	76	77	75	79	78	0.1033	76	79	77	75	78
Jan-Feb-Mar	0.5348	76	77	75	78	79	0.4921	76	77	75	79	78
Apr-May-Jun	0.3834	76	79	77	75	78	0.2564	76	79	77	75	78
Jan-Feb	0.6969	76	77	75	79	78	0.6912	76	77	75	79	78
Mar-Apr	0.6135	76	77	78	75	79	0.5014	76	77	79	75	78
May-Jun	0.5023	76	79	75	77	78	0.2544	76	79	78	77	75
Jan	0.8209	76	75	79			0.8301	76	75	79		
Feb	0.4789	75	76	77	78		0.4789	75	76	77	78	
Mar	0.8714	76	77	75	78	79	0.8951	76	77	79	75	78
Apr	0.7303	76	77	78	79	75	0.7376	76	77	79	75	78
May	no animals						0.0965	76	78	79	77	75
Jun	0.2839	75	76	79	77	78	0.0629	75	76	79	77	78

Table 65. *EUDORELLA PUSILLA*

SS

SEASON	ABUNDANCE Signif.	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.3870	75	76	79	77	78	0.2241	75	78	76	77	79
Jan-Feb-Mar	0.3224	75	78	76	77	79	0.1614	78	75	77	76	79
Apr-May-Jun	0.4043	76	75	79	77	78	0.3784	75	76	77	78	79
Jan-Feb	0.2717	78	75	79	76	77	0.1680	78	75	77	76	79
Mar-Apr	0.0066**	76	75	79	77	78	0.1509	75	76	78	77	79
May-Jun	0.8345	77	76	79	75	78	0.3890	77	75	78	76	79
Jan	0.0256*	78	75	77	76	79	0.0307*	78	77	75	76	79
Feb	0.1668	78	75	79	76	77	0.4572	78	75	77	76	79
Mar	0.1065	76	75	77	78	79	0.0093**	76	75	78	77	79
Apr	0.0121*	76	75	79	78	77	0.3534	75	76	79	78	77
May	0.7250	75	77	76	79	78	0.3144	75	79	78	77	76
Jun	0.1755	77	76	79	78	75	0.1310	77	75	78	76	79

BS-1

SEASON	ABUNDANCE Signif.	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.3194	76	75	78	79	77	0.4492	75	76	77	78	79
Jan-Feb-Mar	0.4347	76	75	78	79	77	0.3363	76	77	75	79	78
Apr-May-Jun	0.7432	76	75	77	79	78	0.6196	75	76	77	78	79
Jan-Feb	0.7522	76	75	78	77	79	0.3252	77	76	75	79	78
Mar-Apr	0.3639	76	75	79	78	77	0.0043**	75	76	79	77	78
May-Jun	0.9262	76	77	78	75	79	0.6777	76	75	77	78	79
Jan	0.7541	77	76	79	78	75	0.1623	76	77	79	78	75
Feb	0.4946	76	75	78	77	79	0.2545	75	77	76	79	78
Mar	0.16511	76	75	78	79	77	0.2086	75	76	79	77	78
Apr	0.0208*	76	75	79	77	78	0.1268	75	76	77	79	78
May	0.9457	76	78	77	75	79	0.7172	78	77	75	79	76
Jun	0.1899	76	75	77	78	79	0.5592	76	75	77	78	79

Table 66. *GAMMARUS LAWRENCIANUS*

HS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0001**	77 75 78 76 79	0.2500	76 77 75 78 79
Jan-Feb-Mar	0.0000**	75 78 76 77 79	0.0146*	76 75 77 78 79
Apr-May-Jun	0.5400	77 79 78 75 76	0.8151	77 78 79 75 76
Jan-Feb	0.0002**	78 75 77 76 79	0.1607	76 75 77 78 79
Mar-Apr	0.0013*	76 75 77 78 79	0.8887	76 75 77 78 79
May-Jun	0.2566	77 76 75 79 78	0.0892	77 76 78 79 75
Jan	0.0866	76 78 75 79	0.0029**	76 75 78 79
Feb	0.0000**	75 78 77 76 79	0.0000**	75 78 77 76 79
Mar	0.0000**	76 75 77 78 79	0.1741	76 75 77 78 79
Apr	0.1289	78 79 [illegible] 77 76	0.6238	79 78 75 77 76
May	0.0000**	79 77 78 75 76	0.0010**	77 79 75 78 76
Jun	0.0070**	77 76 75 78 79	0.1437	77 76 78 75 79

MS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.4035	77 76 75 78 79	0.7394	77 76 79 78 75
Jan-Feb-Mar	0.2655	77 75 78 [illegible] 79	0.3503	76 78 75 77 79
Apr-May-Jun	0.7329	77 76 79 75 78	0.5025	77 79 78 76 75
Jan-Feb	0.4776	78 77 75 79 76	0.3465	78 76 75 79 77
Mar-Apr	0.5028	76 77 78 75 79	0.6070	76 79 78 77 75
May-Jun	0.5037	77 76 75 79 78	0.2833	77 76 75 79 78
Jan	0.7617	76 75 79	0.0697	76 75 79
Feb	0.0386*	78 77 75 76	0.2209	78 75 77 76
Mar	0.4547	76 75 77 78 79	0.3554	76 75 77 78 79
Apr	0.1270	78 79 77 76 75	0.5076	79 78 77 75 76
May	0.5918	75 78 77 79 76	0.0169*	77 78 79 75 76
Jun	0.3117	77 76 75 79 78	0.3721	77 76 75 79 78

Table 67. *GAMMARUS LAWRENCIANUS*

SS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.4107	78 76 77 79 75	0.3597	78 76 79 77 75
Jan-Feb-Mar	0.0477*	76 78 75 77 79	0.3203	76 78 77 79 75
Apr-May-Jun	0.1252	79 78 77 76 75	0.3631	78 79 76 75 77
Jan-Feb	0.0026**	78 77 79 76 75	0.2121	77 78 76 79 75
Mar-Apr	0.0409*	76 75 78 77 79	0.1216	76 78 75 79 77
May-Jun	C.0480*	79 77 76 78 75	0.2895	79 76 78 77 75
Jan	0.0000**	76 79 77 78 75	0.0206*	76 77 78 79 75
Feb	0.0632	78 77 75 76 79	0.2570	78 77 75 79 76
Mar	0.0018**	76 75 78 77 79	0.0013**	76 75 78 77 79
Apr	0.4263	78 79 75 76 77	0.4231	78 76 79 75 77
May	0.3824	79 77 78 75 76	0.0861	79 76 78 77 75
Jun	0.0503	79 76 78 77 75	0.1073	78 76 77 75 79

BS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.2335	76 77 75 78 79	0.2272	76 77 78 79 75
Jan-Feb-Mar	0.1326	76 75 78 77 79	0.0394*	76 79 78 75 77
Apr-May-Jun	0.4007	77 76 79 75 78	0.3444	77 78 79 75 76
Jan-Feb	0.5857	76 77 75 78 79	0.6889	76 79 78 77 75
Mar-Apr	0.1889	76 78 75 77 79	0.0596	76 75 78 77 79
May-Jun	0.4861	77 75 79 76 78	0.4147	77 79 78 75 76
Jan	C.2922	76 79 77 75 78	0.0256*	76 79 77 75 78
Feb	0.0098**	78 75 76 77 79	0.5217	78 75 77 76 79
Mar	0.0526	76 75 78 77 79	0.0000**	76 75 77 78 79
Apr	0.2127	76 78 77 79 75	0.1125	78 77 76 75 79
May	0.3743	79 77 75 78 76	0.0155*	79 78 75 77 76
Jun	0.5076	77 76 75 79 78	0.3516	77 76 75 78 79

Table 68. *AMPELISCA* spp.

HS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.0000**	78 79 76 75 77	0.0045**	78 79 76 75 77
Jan-Feb-Mar	0.0016**	78 79 75 77 76	0.0030**	78 79 75 77 76
Apr-May-Jun	0.0000**	78 79 76 75 77	0.0218*	78 76 79 75 77
Jan-Feb	0.0001**	78 79 77 75 76	0.0005**	78 79 75 77 76
Mar-Apr	0.0335*	76 78 79 75 77	0.1436	76 78 79 75 77
May-Jun	0.0000**	78 79 76 75 77	0.1154	78 76 75 79 77
Jan	0.0674	78 79 76 75	0.0467*	78 79 76 75
Feb	0.0001**	75 78 79 77 76	0.0000**	78 75 79 77 76
Mar	0.4758	79 76 78 75 77	0.3306	79 76 78 75 77
Apr	0.0676	76 78 79 75 77	0.1639	76 78 79 77 75
May	0.0006**	78 79 76 75 77	0.1369	78 76 79 75 77
Jun	0.0020**	78 76 75 79 77	0.5594	75 76 78 79 77

MS

SEASON	ABUNDANCE Signif.	Years in increasing order	RELATIVE ABUNDANCE Signif.	Years in increasing order
All months	0.0782	76 75 78 79 77	0.9613	78 75 79 76 77
Jan-Feb-Mar	0.7747	77 79 78 75 76	0.8014	77 79 75 76 78
Apr-May-Jun	0.0733	76 78 75 79 77	0.5545	78 79 76 75 77
Jan-Feb	0.5744	75 77 78 79 76	0.5744	75 77 78 79 76
Mar-Apr	0.1404	78 79 76 75 77	0.4977	78 79 76 77 75
May-Jun	0.0358*	75 76 78 79 77	0.5003	75 78 76 79 77
Jan	no animals		no animals	
Feb	0.4789	75 77 78 76	0.4789	75 77 78 76
Mar	0.7819	79 76 77 78 75	0.3974	76 77 79 78 75
Apr	0.0402*	78 79 76 75 77	0.2331	78 79 76 77 75
May	0.1462	75 78 76 79 77	0.5770	75 78 79 76 77
Jun	0.3781	76 75 78 79 77	0.4657	78 76 75 79 77

Table 69. *AMPELISCA* spp.

SS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0032**	79 78 76 77 75	0.1978	79 78 76 75 77
Jan-Feb-Mar	0.5212	75 79 78 77 76	0.2306	75 79 78 76 77
Apr-May-Jun	0.0005**	79 78 76 77 75	0.0493*	78 76 79 77 75
Jan-Feb	0.3145	79 75 77 78 76	0.2070	75 79 77 78 76
Mar-Apr	0.1016	79 76 75 78 77	0.0124*	79 78 76 75 77
May-Jun	0.0000**	79 78 76 77 75	0.1008	76 78 79 77 75
Jan	0.4456	75 76 79 77 78	0.4944	no animals 75 76 77 79 78
Feb	0.1698	78 79 77 75 76	0.0147*	78 79 77 75 76
Mar	0.1644	75 76 79 78 77	0.0085**	75 76 79 78 77
Apr	0.4421	79 76 75 78 77	0.2645	79 78 76 75 77
May	0.0137*	79 78 76 75 77	0.0019**	79 78 75 76 77
Jun	0.0001**	76 78 79 77 75	0.0000**	76 77 78 79 75

BS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.1541	79 76 77 78 75	0.5012	79 78 76 77 75
Jan-Feb-Mar	0.1115	78 77 79 76 75	0.2827	78 79 77 75 76
Apr-May-Jun	0.2223	79 76 77 78 75	0.4349	79 78 76 75 77
Jan-Feb	0.0372*	no animals 77 78 79 76 75	0.1151	no animals 77 78 79 76 75
Mar-Apr	0.1513	78 76 79 75 77	0.4233	79 76 75 78 77
May-Jun	0.1240	79 76 77 78 75	0.5609	79 78 77 76 75
Jan	0.0016**	no animals 76 77 78 79 75	0.0000**	no animals 76 77 78 79 75
Feb	0.4150	77 78 79 75 76	0.0001**	75 77 78 79 76
Mar	0.7291	75 78 77 76 79	0.7386	75 78 79 76 77
Apr	0.0745	76 79 78 75 77	0.2321	76 79 75 78 77
May	0.4178	79 78 75 76 77	0.4662	79 78 75 77 76
Jun	0.0144*	77 76 79 78 75	0.0728	77 76 78 79 75

Table 70. *COROPHIUM* spp.

HS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0000**	75 79 78 76 77	0.0000**	75 79 76 78 77
Jan-Feb-Mar	0.0010**	75 79 78 76 77	0.0002**	75 76 79 78 77
Apr-May-Jun	0.0004**	75 79 78 76 77	0.0000**	75 79 76 78 77
Jan-Feb	0.0153*	78 79 75 76 77	0.2548	78 75 79 76 77
Mar-Apr	0.0216*	79 76 75 78 77	0.0000**	79 76 75 78 77
May-Jun	0.0001**	75 79 78 77 76	0.0000**	75 79 78 77 76
Jan	0.5699	76 78 75 79	0.4219	76 78 75 79
Feb	0.1898	75 79 78 76 77	0.1538	75 79 78 76 77
Mar	0.1054	75 76 79 78 77	0.0001**	75 76 79 78 77
Apr	0.0355*	76 79 75 78 77	0.0069**	79 76 75 78 77
May	0.0142*	75 79 76 77 78	0.0075**	75 79 77 76 78
Jun	0.0002**	75 79 78 77 76	0.0000**	75 79 78 77 76

MS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.6284	79 75 76 77 78	0.5371	79 76 75 77 78
Jan-Feb-Mar	0.2635	76 78 79 75 77	0.1556	76 78 79 75 77
Apr-May-Jun	0.5311	79 75 77 76 78	0.3657	79 75 77 76 78
Jan-Feb	0.5897	76 78 79 77 75	0.4284	76 78 79 75 77
Mar-Apr	0.6396	76 79 78 77 75	0.4783	76 79 78 75 77
May-Jun	0.3874	75 79 77 76 78	0.2078	75 79 77 76 78
Jan	no animals		no animals	
Feb	0.2907	76 78 77 75	0.1390	76 78 77 75
Mar	no animals		0.4857	75 76 78 79 77
Apr	0.6084	76 79 77 78 75	0.7349	76 79 77 78 75
May	0.1919	76 79 77 75 78	0.8524	79 77 76 75 78
Jun	0.2067	75 79 77 78 76	0.1176	75 79 77 78 76

Table 71. *COROPHIUM* spp.

SS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.3529	75 76 78 79 77	0.0007**	75 76 78 77 79
Jan-Feb-Mar	0.0013**	75 76 78 77 79	0.0006**	no animals 75 76 78 77 79
Apr-May-Jun	0.3980	75 79 76 78 77	0.0110*	75 76 78 79 77
Jan-Feb	0.0971	75 76 78 77 79	0.0330*	no animals 75 76 78 77 79
Mar-Apr	0.1367	76 75 78 79 77	0.0310*	76 75 78 79 77
May-Jun	0.7401	75 79 78 77 76	0.0377	75 76 78 77 79
Jan	0.4427	75 76 78 79 77	0.3666	no animals 75 76 78 79 77
Feb	0.0650	75 76 77 78 79	0.0271*	75 76 77 78 79
Mar	0.0106*	75 76 77 78 79	0.0301*	75 76 77 78 79
Apr	0.0711	76 79 75 78 77	0.0198*	76 79 75 78 77
May	0.5269	75 76 79 77 78	0.0734	75 76 79 78 77
Jun	0.7045	75 79 78 77 76	0.1971	75 77 78 76 79

BS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.9827	75 79 77 76 78	0.9184	78 76 75 77 79
Jan-Feb-Mar	0.5410	no animals 75 76 78 77 79	0.7277	no animals 76 78 75 77 79
Apr-May-Jun	0.9266	75 79 77 76 78	0.9610	78 75 77 76 79
Jan-Feb	1.0000	no animals	0.4380	no animals 76 77 78 79 75
Mar-Apr	0.4317	76 75 78 79 77	0.2202	76 75 78 79 77
May-Jun	0.8246	77 75 79 78 76	0.2925	78 77 75 79 76
Jan	1.0000	no animals	1.0000	no animals
Feb	1.0000	no animals	0.4857	76 77 78 79 75
Mar	0.5543	75 76 78 77 79	0.5981	75 76 78 77 79
Apr	0.5009	76 75 79 78 77	0.2155	76 75 79 78 77
May	0.5969	78 76 79 75 77	0.3251	78 77 79 75 76
Jun	0.5452	77 75 79 78 76	0.6055	75 77 78 76 79

Table 72. *DYOPEDOS* spp.

HS

SEASON	ABUNDANCE Signif.	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.0001**	78	76	77	75	79	0.0000**	78	75	77	76	79
Jan-Feb-Mar	0.0013**	78	77	75	76	79	0.0946	78	75	76	77	79
Apr-May-Jun	0.0057**	78	79	76	77	75	0.0002**	78	77	75	76	79
Jan-Feb	0.0195*	78	77	75	79	76	0.2335	78	75	77	79	76
Mar-Apr	0.0000**	78	76	77	75	79	0.0016**	76	78	75	77	79
May-Jun	0.0003**	78	79	75	77	76	0.0000**	78	77	79	75	76
Jan	0.3701	78	79	76	75		0.5047	78	79	76	75	
Feb	0.0009**	78	77	75	76	79	0.0372*	75	77	78	76	79
Mar	0.0002**	78	76	77	75	79	0.0485*	78	76	75	79	77
Apr	0.0122*	78	76	77	79	75	0.0873	76	78	75	77	79
May	0.0141*	78	79	77	76	75	0.0002**	78	77	79	75	76
Jun	0.0003**	78	79	75	76	77	0.0072**	78	79	75	77	76

MS-1

SEASON	ABUNDANCE Signif.	Years in increasing order					RELATIVE ABUNDANCE Signif.	Years in increasing order				
All months	0.2238	78	76	77	79	75	0.2578	78	76	77	79	75
Jan-Feb-Mar	0.4739	76	78	77	75	79	0.7990	78	76	77	79	75
Apr-May-Jun	0.2972	78	79	77	76	75	0.3571	78	76	77	79	75
Jan-Feb	0.7626	76	77	78	79	75	0.7627	76	77	78	79	75
Mar-Apr	0.1391	78	77	76	79	75	0.0612	78	76	77	79	75
May-Jun	0.6608	78	76	79	75	77	0.9035	78	75	79	77	76
Jan	no animals						no animals					
Feb	0.4789	76	77	78	75		0.4789	76	77	78	75	
Mar	0.5827	76	78	77	79	75	0.7158	78	77	76	79	75
Apr	0.2499	78	77	79	76	75	0.1197	78	76	77	79	75
May	0.5080	78	75	77	76	79	0.5974	75	77	78	79	76
Jun	0.5676	76	78	79	75	77	0.5981	76	78	79	75	77

Table 73. *DYOPEDOS* spp.

SS

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.0002**	78 76 79 77 75	0.2365	78 76 75 79 77
Jan-Feb-Mar	0.0013**	76 78 75 77 79	0.3309	75 78 76 77 79
Apr-May-Jun	0.0000**	79 76 78 77 75	0.2057	76 78 79 75 77
Jan-Feb	0.0318*	78 75 76 77 79	0.5558	75 78 76 79 77
Mar-Apr	0.0002**	76 75 78 77 79	0.0079**	78 75 76 77 79
May-Jun	0.0000**	79 78 76 77 75	0.1916	76 79 78 75 77
Jan	0.0815	76 78 75 79 77	0.4534	76 75 78 77 79
Feb	0.028[illegible]*	75 78 76 77 79	0.5825	75 79 77 78 76
Mar	0.0016**	76 75 78 77 79	0.0784	78 76 75 77 79
Apr	0.1921	75 76 78 77 79	0.2186	78 75 77 76 79
May	0.0113*	79 76 78 77 75	0.2472	76 79 75 78 77
Jun	0.0000**	79 78 76 77 75	0.3097	78 76 79 77 75

BS-1

SEASON	ABUNDANCE Signif.	ABUNDANCE Years in increasing order	RELATIVE ABUNDANCE Signif.	RELATIVE ABUNDANCE Years in increasing order
All months	0.1772	78 76 77 79 75	0.9251	76 77 79 75 78
Jan-Feb-Mar	0.3360	76 75 78 77 79	0.4126	76 75 77 78 79
Apr-May-Jun	0.0058**	77 78 79 76 75	0.2104	79 78 77 76 75
Jan-Feb	0.2716	75 76 77 78 79	0.4083	76 75 77 79 78
Mar-Apr	0.2345	76 78 75 77 79	0.0535	76 78 75 77 79
May-[illegible]	0.0028**	79 77 78 76 75	0.1153	79 78 77 76 75
Jan	0.7251	75 77 76 79 78	0.6280	75 77 76 79 78
Feb	0.0750	76 75 78 77 79	0.5382	76 75 77 78 79
Mar	0.4981	76 78 75 79 77	0.2142	76 75 78 77 79
Apr	0.2072	76 77 78 75 79	0.1170	77 78 76 75 79
May	0.0898	79 77 78 76 75	0.0128*	79 78 77 76 75
Jun	0.2747	79 78 77 76 75	0.4454	79 78 77 76 75

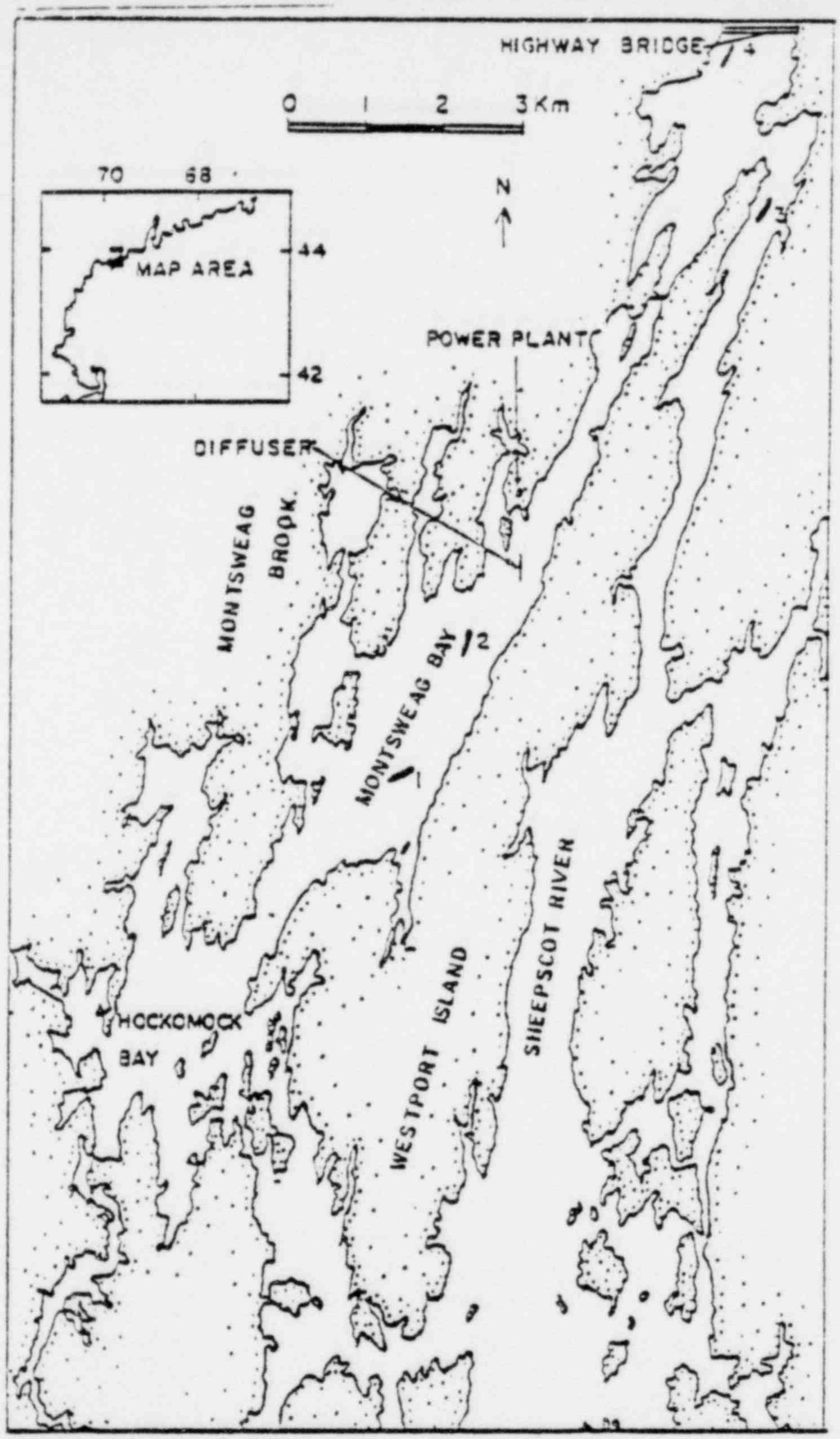


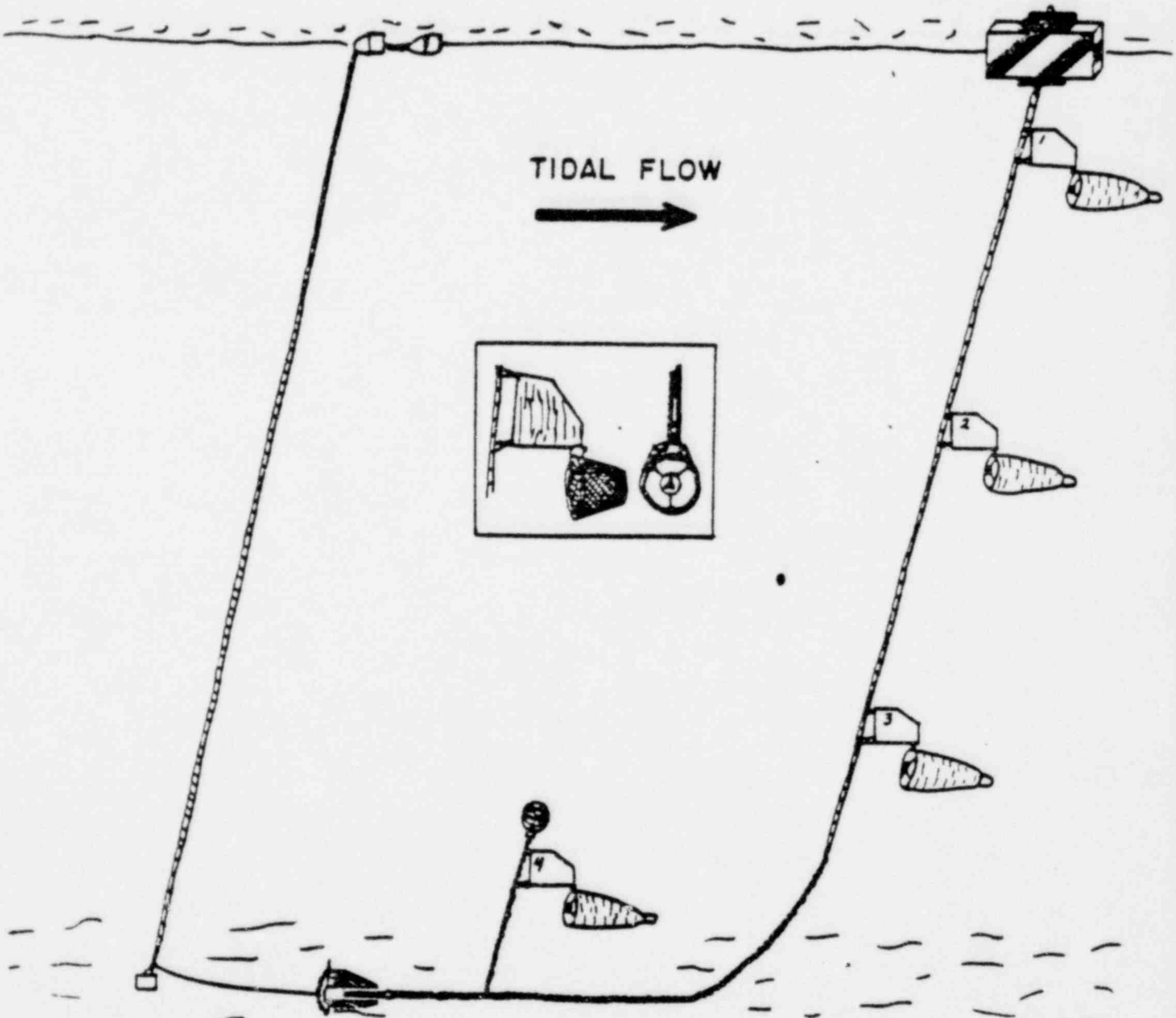
Figure 28. Sheepscot River and Montsweag Bay estuary system with sampling stations and diffuser location indicated. Inset shows locations on the Maine coast.

Stations:
1. Montsweag (MS)
2. Halftide (HS)
3. Sheepscot (SS)
4. Bridge (BS)

Figure 29. Normal fishing attitude of a single set of buoyed and anchored sets for sampling larval fishes and macrozooplankton in the water column (modified from Graham and Venno, 1968).

Insert: Arrangement of vane, net hanger and ring.

Note: A fourth net, located on the bottom chain was discontinued due to a high occurrence of grounding, making its data unreliable.



NET PHYTOPLANKTON

Bernard J. McAlice and Faye D. Jones

Introduction

The objective of this continuing study is to assess the effects of the operation of the Maine Yankee Nuclear Generating Station on the species composition, abundances, and spatial and temporal distributions of the phytoplankton populations in Montsweag Bay. The assessment is made from comparisons between Montsweag Bay populations and control populations outside the influence of Maine Yankee, combined with comparisons of pre-operational and operational populations.

Methods

Plankton samples were taken at stations D7, S1, S2, M2, M3, M4, and H1 (Figure 6). The initial sampling interval was monthly; this was shortened to semimonthly in June 1970. Sampling was begun at S1 and M4 on 29 October 1969, at M2 on 28 March 1972, at M3 on 6 September 1974, and at S2 on 20 September 1974. All stations were usually occupied on the same day, during daylight, and at various tidal stages. M2 was established to give data close to the power plant outfall. The planned change to a diffuser discharge dictated the establishment of M3; M2 and M3 were about 2 km apart, on either side of the diffuser, close to the boundaries of the mixing zone. M4 was about 3.2 km south of M3. Stations S1 and D7, originally established

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Ira C. Darling Center Ref. No. 79-7e

as local and regional control stations, did not fulfill their intended roles and were discontinued on 9 August 1978. On that date S2 was moved south about 1.3 km, and H1 was established in Hockomock Bay at the entrance to Montsweag Bay. Stations H1 and S2 now serve as control stations outside the influence of the thermal effluent.

Phytoplankton were collected with a #20 mesh (~76μ) net of 0.5 m mouth diameter, using 15 min oblique tows at 1-2 m/sec. Beginning 23 July 1976 a #25 mesh (~64μ) net was substituted by mistake. All collections were made with this net until 3 February 1977, when a #25 net was used at S1, S2, and M4, and a #20 net at M2 and M3. After 3 February 1977 all collections were made with a #20 net. We do not believe that the change in mesh size introduced any significant bias. Collections were preserved at once with 4% buffered formalin.

The percentage composition of the flora was determined by counting aliquots of the concentrated sample either in a Sedgwick-Rafter cell or under a cover slip. Counting was continued until at least 10^3 cells were counted, then continued until a strip across the Sedgwick-Rafter cell, or several strips across the cover slip, yielded no new species. The rest of the aliquot was usually scanned for scarce species. Identifications were made at 400x or 1000x.

Besides the net tows, 6.0 liter or 7.5 liter Van Dorn bottle collections were made near the surface and about 1 m above the bottom (at 9 m depth at S1 and S2) at each station. A 500 ml aliquot from each bottle was preserved with Lugol's iodine solution. Until April 1975, 1 ml from each aliquot was counted completely in a Sedgwick-Rafter cell and the average of surface and bottom counts taken as an estimate of phytoplankton abundance at each station. In April 1975 we compared such abundance estimates with those obtained by counting 1 ml from a mixture of 5 ml each of surface and bottom samples. No differences were found, and we thereafter used the faster method. From each 500 ml aliquot 15 ml were kept for reference.

Before August 1974, 10 ml from each preserved water bottle sample were filtered onto a 0.45μ Millipore filter and cleared and mounted as described by Moore (1963). These filter discs were intended to provide a way to quantify some of the rarer species, and some early counts were made from them. Unfortunately, only the more robust forms survived filtering and mounting undistorted. It was, for example, virtually impossible to distinguish among several species of *Chaetoceros* on the filter discs. The preparations also had a brief shelf life, which made them useless as a reference collection for even the more heavily silicified species.

The aims of this work were to establish baselines for, and to detect any changes in, the relative abundances and seasonal succession of the components of the planktonic flora. This was best done by considering the net collections, which contained the plankters concentrated from a volume of water of order 10^4 greater than that taken with a water bottle. The problems associated with small-scale spatial heterogeneity (McAlice, 1970) were minimized.

The net collections did not furnish good estimates of absolute abundance, however. Quantitative estimates of population densities were made from the Sedgwick-Rafter cell counts. The percentage composition of the flora being known, an estimate of population density of each species in the net collections could then be made.

Diversity indices have been widely used to define the degree of structure or organization of natural communities, and have been proposed as indicators of water quality (Wilhm and Dorris, 1968). Such indices probably have little biological significance, but they do give an idea of the extent to which a population is dominated by one or a few species. We calculated the common information theoretic index H' and its evenness component J' (Pielou, 1966) from each net collection count.

Results and Discussion

This report presents data for population densities of net phytoplankton, degrees of dominance, and abundances of six selected species for the entire study period October 1969 to June 1979, at experimental stations M4 and M2. Analysis of the data consists of comparing the current 6-month interval, January-June 1979 with the previous study period.

Population densities of net phytoplankton in Montsweag Bay during January-June 1979 were consistent with past seasonal trends (Figure 30). Variable low population densities were observed during late fall and winter, and variable high densities occurred from spring to early fall. The percentages contributed to the phytoplankton populations by the dominant species at M4 and M2 were similar to those of past years (Figure 31).

Two hundred ninety taxa belonging to six classes have been found in the phytoplankton populations during this study. Six species were selected for graphic analysis in an attempt to monitor changes in the planktonic flora. These species were chosen as predominant in the estuarine phytoplankton populations. Abundances and degrees of dominance of *Asterionella formosa*, *Chaetoceros debile*, *Fragilaria* sp., *Melosira moniliformis*, *M. nummuloides*, and *Skeletonema costatum* are shown in Figures 32-37.

Fragilaria sp. and *S. costatum* have shown similar trends in abundance, degrees of dominance, and occurrence in Montsweag Bay over the course of this study. The slight decline in cell density of *S. costatum* can probably be ascribed to normal annual variability. *Fragilaria* sp. failed to appear at M2 in late fall 1978; however, it was observed in November 1978 at M4.

The abundance and occurrence of *M. moniliformis* in Montsweag Bay have remained relatively constant. *M. moniliformis's* degree of dominance decreased in 1977 and remained low in 1978 and 1979. It has appeared as a dominant only once in 1979.

Since Maine Yankee began operation, *A. formosa* and *M. nummuloides* have maintained relatively constant mean population densities in Montsweag Bay. They have increased their frequencies of occurrence and degrees of dominance. During January-June 1979 *A. formosa* appeared as a dominant every month. In April and May 1979 it accounted for 90% of the total phytoplankton population in Montsweag Bay. *M. nummuloides* occurred as a dominant during 10 months of 1976. Since then its occurrence as a dominant has decreased significantly. To date it has occurred as a dominant only once in 1979. This population trend is probably an instance of ordinary long term variability.

C. debile has experienced a reduced frequency of occurrence and a decreased magnitude of dominance in Montsweag Bay since Maine Yankee commenced operation. It appeared to have returned to its previous level of dominance in May 1978, when it accounted for 92% of the total phytoplankton. In 1979 *C. debile* accounted for only 50% of the early summer phytoplankton population. The variability of *C. debile's* degree of dominance in the early summer phytoplankton population in Montsweag Bay appears to be a natural phenomenon of its population.

Conclusions

Any environmental stress inflicted by Maine Yankee upon the planktonic flora in Montsweag Bay has resulted in no major alteration in the phytoplankton populations. Despite the considerable annual variability in abundances and occurrence patterns of phytoplankters, characteristic trends have persisted.

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Figure 30. Total phytoplankton population density at stations M4 and M2, October 1969 to June 1979.

- ● Sampling of station begins
- X Maine Yankee began operation
- ▲ Cowseagan Narrows causeway removed
- O Diffuser discharge began operation
- NA Data not available
- IW Inclement weather

Figure 30

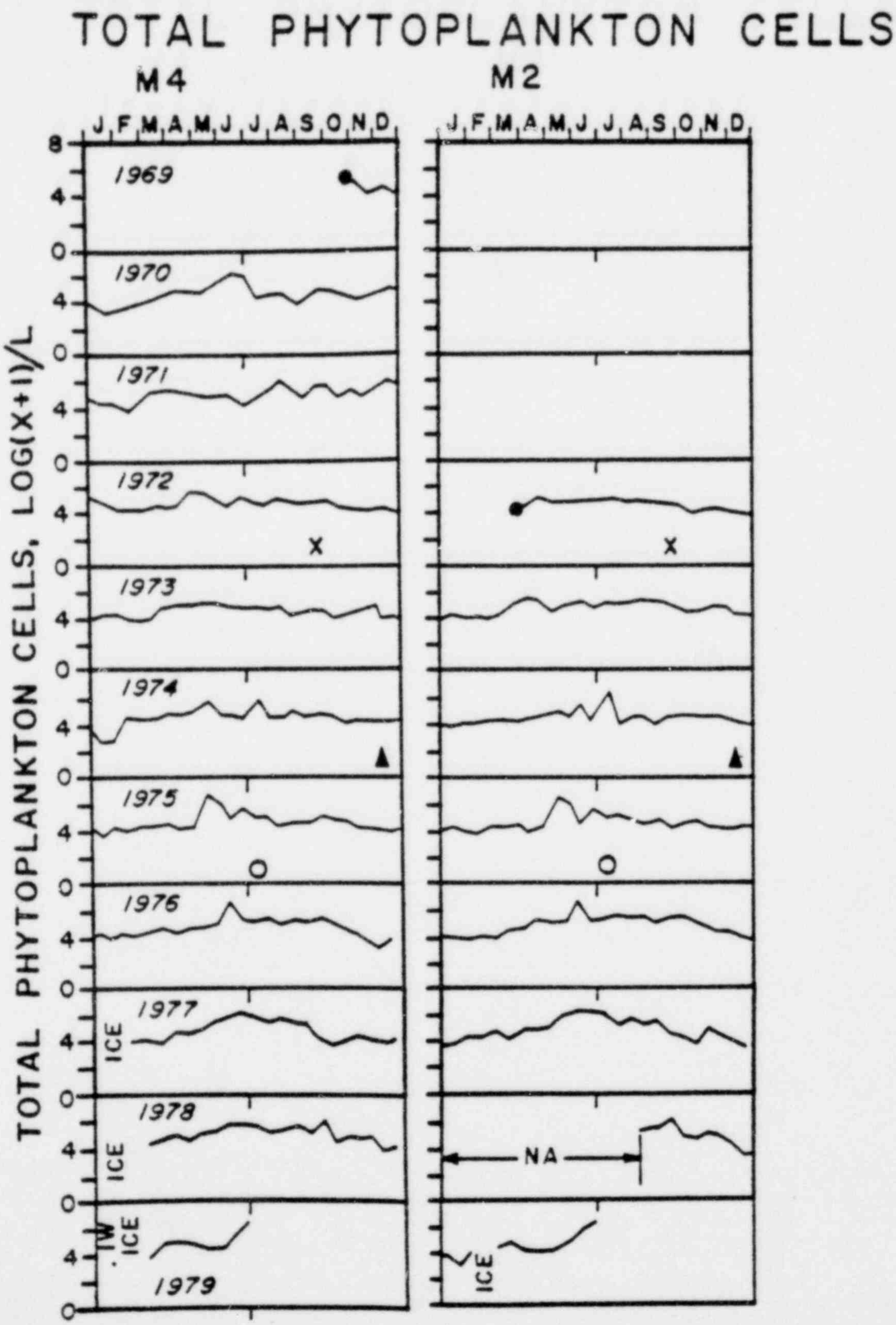
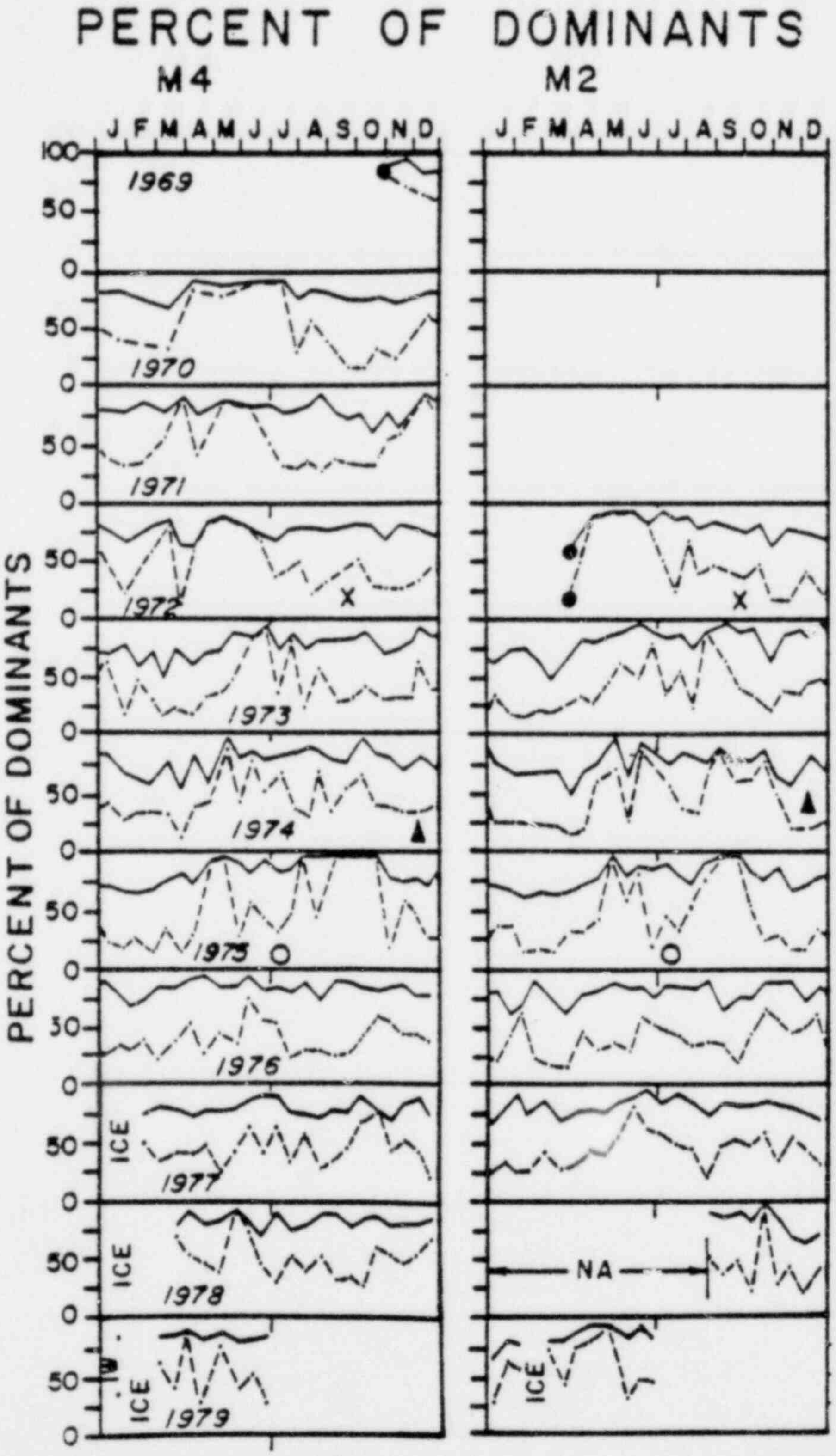

TOTAL PHYTOPLANKTON CELLS
M4
M2
J F M A M J J A S O N D
J F M A M J J A S O N D
8
4
0
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
NA
TOTAL PHYTOPLANKTON CELLS, LOG(X+1)/L

Figure 31 Percentage contributions of dominant species (>5% of total) of phytoplankton at stations M4 and M2, October 1969 to June 1979. Symbols as in Figure 30 .

———All dominant species
------Most dominant species

Figure 31



PERCENT OF DOMINANTS
M4
M2
J F M A M J J A S O N D
J F M A M J J A S O N D
100
50
0
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
NA
PERCENT OF DOMINANTS

Figures 32-37. Abundances of selected species at stations M4 and M2, October 1969 to June 1979. Symbols as in Figure 30.

———Species abundance - A
------Percentage contribution when species accounted for >5% of total population - P.

Figure 32

ASTERIONELLA FORMOSA

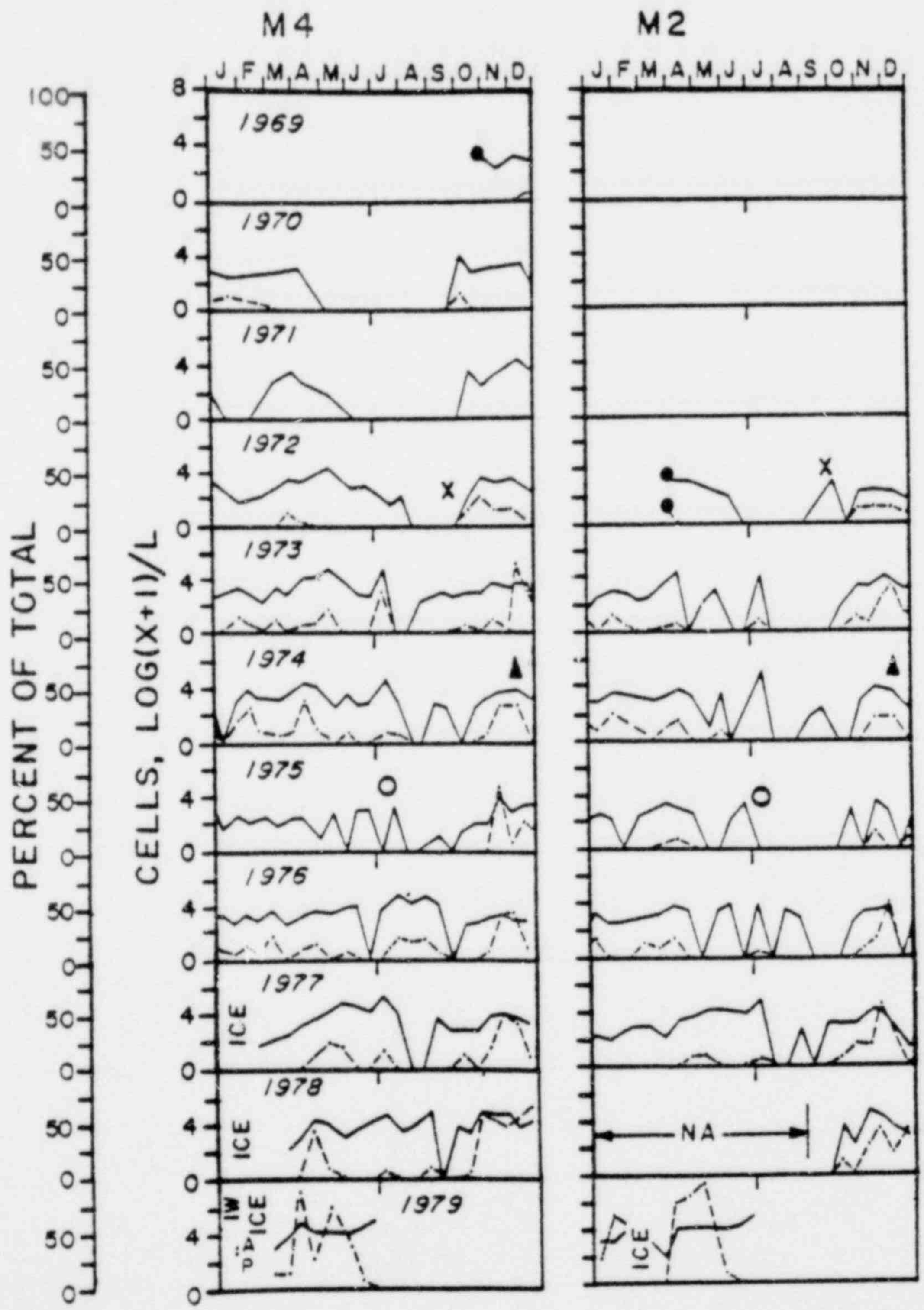


Figure 33

CHAETOCEROS DEBILE

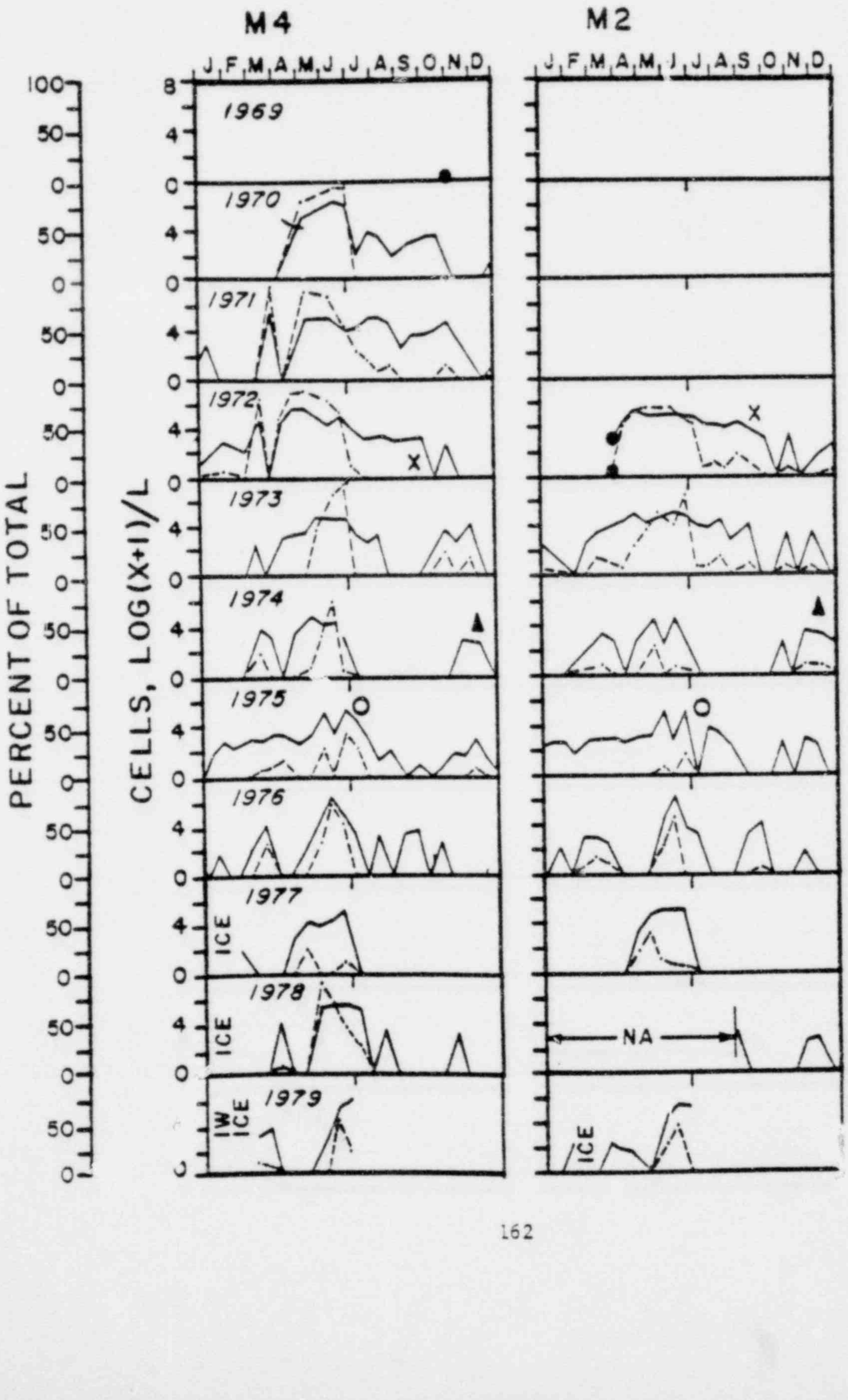


Figure 34

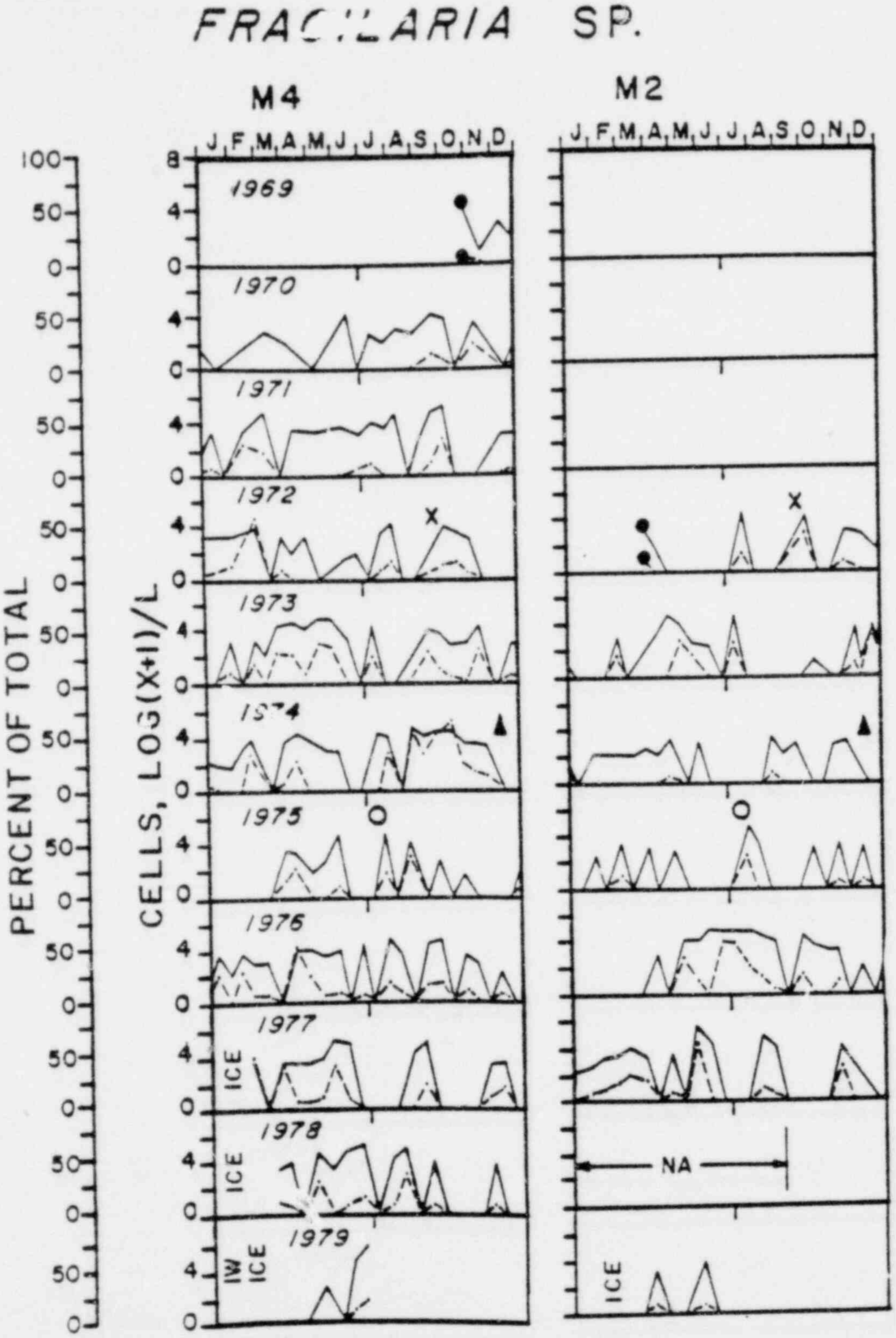
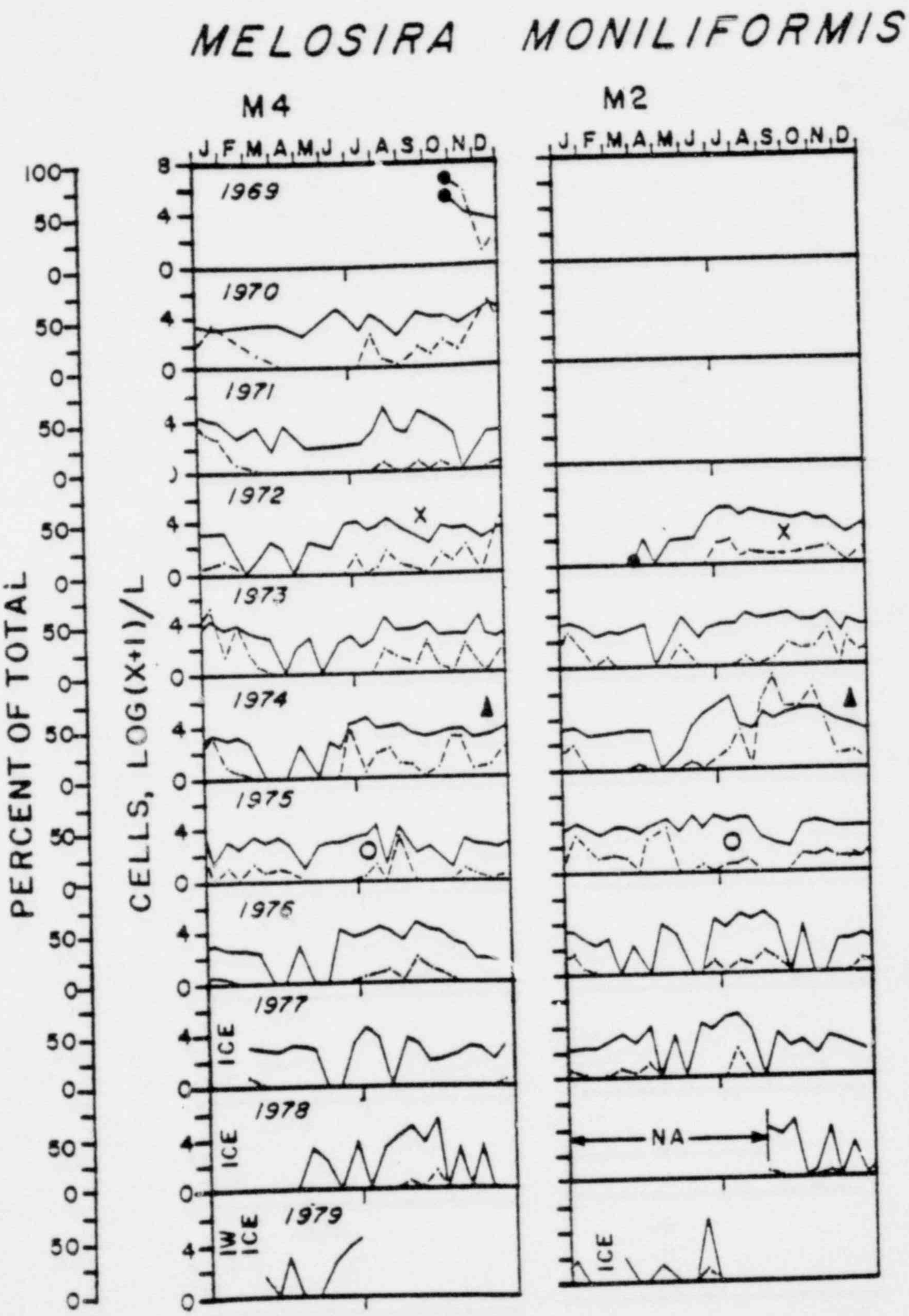

FRAGILARIA SP.
M4
M2
J F M A M J J A S O N D
PERCENT OF TOTAL
CELLS, LOG(X+1)/L
100
50
0
8
4
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
IW
NA

Figure 35



MELOSIRA MONILIFORMIS
M4
M2
J F M A M J J A S O N D
PERCENT OF TOTAL
CELLS, LOG(X+1)/L
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
IW ICE
NA

Figure 36

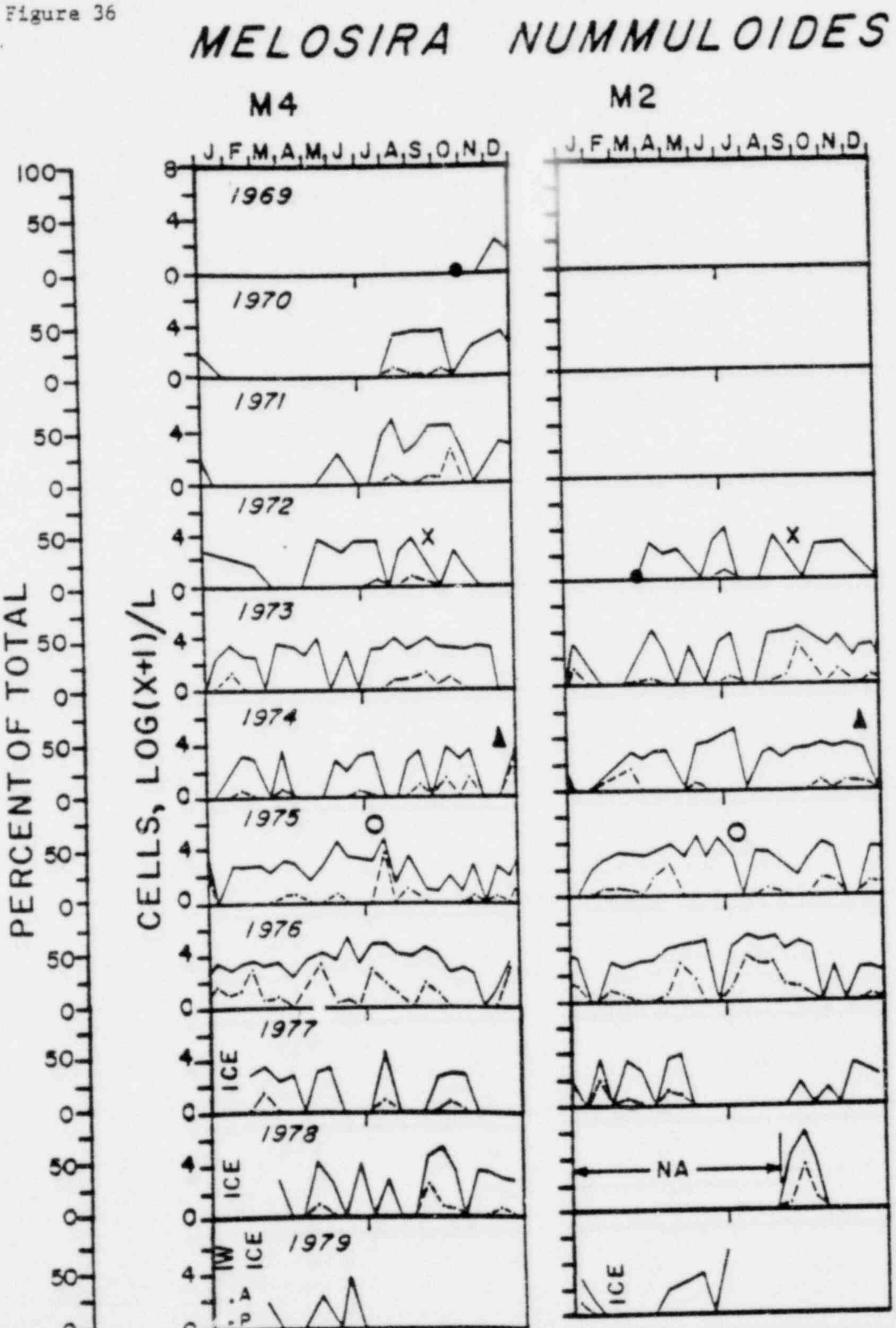
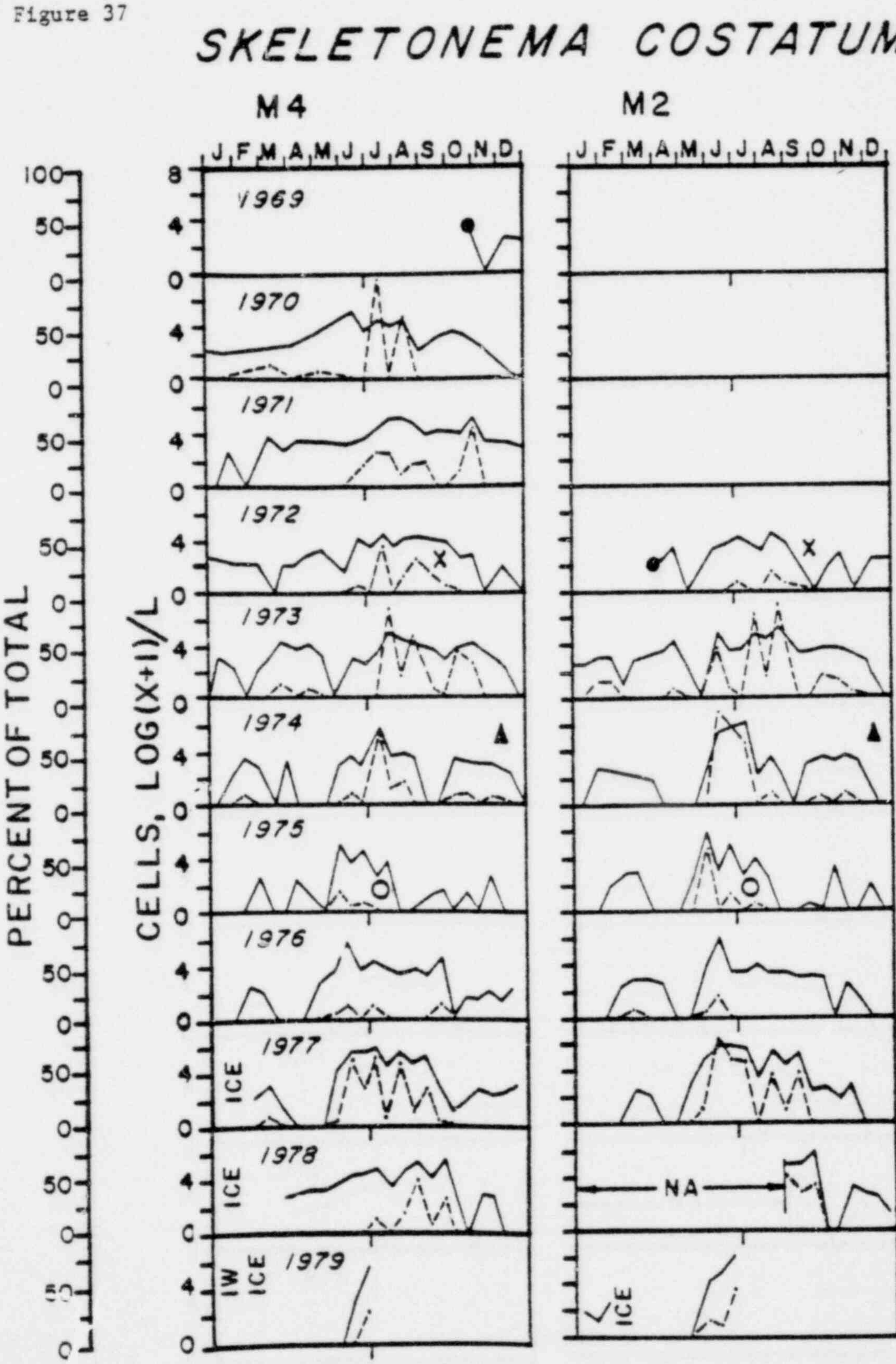

MELOSIRA NUMMULOIDES
M4
M2
J F M A M J J A S O N D
PERCENT OF TOTAL
CELLS, LOG(X+1)/L
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
NA
A
P

Figure 37


SKELETONEMA COSTATUM
M4
M2
J F M A M J J A S O N D
PERCENT OF TOTAL
CELLS, LOG(X+1)/L
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
IW
NA

ICHTHYOPLANKTON

Richard F. Shaw and Hugh H. DeWitt

Introduction

This report is the last of a comprehensive study of the marine ecology of Montsweag Bay which was initiated prior to operation of the Maine Yankee Nuclear Generating Station. The purpose of this research was to investigate and evaluate the effects of the power plant's thermal effluent or any other plant-related perturbations on the vertical, horizontal, and temporal distribution and abundance of Montsweag Bay's ichthyoplankton. Relationships between the ichthyoplankton and temperature, salinity, tidal flow, depth of capture and time have been studied in the bay and, as a control, in the Sheepscot River.

Methods

The present sampling regime began in March 1975 when the replicate buoyed and anchored plankton net stations were discontinued and additional sampling in the form of plankton tows commenced (DeWitt and Shaw, 1976).

Buoyed and anchored net sampling stations (Hauser, 1973) are designated Montsweag South and Halftide South in Montsweag Bay, and Sheepscot South and Bridge South in the Sheepscot River (Figure 38). This stationary sampling gear (Figure 39) is essentially that described by Graham and

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Ira C. Darling Center Ref. No. 79-7f

Venno (1968), modified to a three net system. Collections are made semimonthly during February, March, April, May, October and November (DeWitt and Shaw, 1976), and monthly the rest of the year. Sampling is done on nights when the fullest possible tidal cycle occurs between sunset and sunrise. Nets are set and retrieved as close to slack tide as possible and cod ends replaced between sets so that the gear fishes separately both flood and ebb tides. Collections are field fixed with 10% buffered formalin and stored in 5% buffered formalin. Standard techniques are used to pick, sort, identify and record the catch.

Temperature and salinity are measured at each net level before and after each set at each station.

All samples were taken in accordance with the NRC Technical Specification 1.7E3 for Maine Yankee's operating license with exception of those instances when ice prevented the sampling of Montsweag Station in February. No statistical analysis for 1979 was possible because of the time constraint and the normal delay in computer entry of recently generated data.

Results and Discussion

The overall larval fish abundance for the spring of 1979 appeared to be well within the ranges of those observed for Montsweag Bay and the Sheepscot River during the course of this study (Figures 40 and 41). Spring total abundance displayed the typical pattern. The three most abundant species or species groups, the rock gunnel, the sculpin group and the Atlantic herring were most responsible for the peak abundance in March. Rainbow smelt and winter flounder larval abundances generated the majority of the June total density peak.

In 1979 rock gunnel abundances (Figures 44 and 45) in the bay and river were the second highest recorded; 1978 densities were greater (Shaw and DeWitt, 1979). Larval abundances for the sculpin group, comprised of *Myoxocephalus aenaeus*, *M. octodecemspinosus*, *M. scorpius* and *Triglops murrayi*, were the highest observed in Montsweag Bay and the Sheepscot River (Figures 48 and 49). In the bay the larval abundances for the rainbow smelt (Figures 46 and 47) and the winter flounder (Figures 50 and 51) were the lowest encountered. In the river rainbow smelt abundances were also the lowest while winter flounder displayed its second lowest density; 1971 densities (Hauser, 1973) were smaller.

Smooth flounder, an arctic-boreal species, is an estuarine spring spawner (Bigelow and Schroeder, 1953). It is a year-round resident of the bay and the population is probably maintained locally since it is virtually absent in the lower Sheepscot River (McCleave and Fried, 1972). This species was identified by Shaw and DeWitt (1978) as possibly having been affected by the operation of the Maine Yankee power plant. Significant ($p < 0.05$) yearly differences in smooth flounder larval abundances were observed in the bay and not in the river (Shaw and DeWitt, 1978 - Table 8.4-5) In 1979 the bay's larval smooth flounder abundance was the lowest of all years studied (Figures 54 and 55). With the single exception of 1977, the trend after plant operation has been one of decreased larval densities since 1973, when reliable identification was first possible. Smooth flounder abundances have been fairly constant in the river, although densities have decreased since 1978.

Atlantic tomcod are year-round residents and the dominant demersal adult species in Montsweag Bay (McCleave and Fried, 1972). Targett and McCleave (1973) reported that tomcod could be excluded from a tidal cove located just east of Young's Point in Montsweag Bay during summer daylight hours if the cove were artificially warmed. Tomcod was the only species in Montsweag Bay that appeared to normally exist in waters whose temperatures approached or surpassed known thermal tolerance for its larvae, 19-20.9°C (Huntsman and Sparks, 1924), and for the adult, 23.5-30.3°C (Britton, 1924; Huntsman and Sparks, 1924). Larval tomcod, the result of local mid-winter spawning, were identified as the second species potentially affected by plant activity (Shaw and DeWitt, 1978). Its abundance (Figures 56 and 57) in the bay's 1979 buoyed and anchored catch was low (1975 was the only year lower). In the Sheepscot River, where densities in general have remained more constant, the 1979 catch was also low.

Northern pipefish larval abundance for the bay and river continued the decline which was initiated in 1977. The 1979 densities were the lowest recorded (Figures 60 and 61). No lumpfish larvae were caught in Montsweag Bay for the second time during this study (1972 was the first). In the Sheepscot River there has been a trend toward decreasing lumpfish abundances since 1975 (Figures 62 and 63). In 1979 Montsweag Bay had its highest wrymouth densities. Both areas have displayed increasing densities since 1977 (Figures 66 and 67). The remainder of the 15 most abundant larval species are presented in Figures 42 through 71. For a complete tally of the numerical catch for all species at each station and net level and the percent of the total catch by station and by species for the spring of 1979 see Table 74. For a summary of pre-operational and operational numerical ichthyoplankton catches for the buoyed and anchored sampling gear see Table 75.

In the end of March both the bay and river recorded their maximum number of species caught during a sampling period for the study, 17 and 16 species, respectively (Figures 72 and 73). The total abundance, diversity and evenness (Shannon, 1948; Pielou, 1966) all were within the ranges of those observed during the course of the study.

The bay's spring temperature range of 17.67°C, from an average net level temperature of 0.02°C in January to 17.69°C in June, was the highest recorded. This partially reflects our recent ability to measure negative temperatures with our temperature probe since this spring's upper average temperature was only the second highest observed. Both the bay and river displayed their highest salinity ranges of 19.04°/oo (from an average net level salinity of 27.72°/oo in late February to 8.68°/oo in early May) and 16.89°/oo (from 30.70°/oo in early February to 13.81°/oo in early May), respectively. Otherwise the hydrographic parameters appeared to be normal (Figures 74 to 81).

Conclusions

The 1978 and 1979 smooth flounder data strongly indicate that 1977 was the exception to a now very clear and disturbing trend of decreasing abundances in the bay since 1973. The 1978 and 1979 Atlantic tomcod abundances indicate the return of the tomcod decline initiated in 1972 and interrupted in 1976 and 1977.

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Table 74. Net distribution for the buoyed and anchored plankton nets. Total number of specimens collected. Percentage of total catch (based on total number = 15,476). Total volume of water sampled by station. 15 January to 20 June 1979 (10 sampling periods).

	STATION M			H			B			S				
	NET LEVEL													
Species	1	2	3	1	2	3	1	2	3	1	2	3	Total No. Specimens Collected	% of Total Catch
Pholis gunnellus (Rock gunnel)	215	227	222	734	400	389	1893	1072	418	535	399	422	7036	45.46
Sculpin Group													3677	23.76
Myoxocephalus aenaeus (Grubby)	52	80	77	163	142	127	667	368	168	241	126	123		
Myoxocephalus scorpius (Shorthorn sculpin)	29	16	25	65	58	43	178	102	15	84	51	34		
Myoxocephalus octodecemspinosus (Longhorn sculpin)	8	9	9	63	32	17	242	87	41	58	35	32		
Clupea harengus (Atlantic herring)	73	43	31	172	119	102	657	306	115	196	91	85	1990	12.86
Osmerus mordax (Rainbow smelt)	60	72	44	9[illegible]	125	64	118	39	2	40	80	22	759	4.90
Anguilla rostrata (American eel)	25	33	17	108	42	38	20	36	6	39	36	14	412	2.66
Pseudopleuronectes americanus (Winter flounder)	8	9	12	8	7	6	53	16	12	14	26	21	192	1.24
Ulvaria subbifurcata (Radiated shanny)	4	2	1	8	3	2	32	25	2	26	27	10	142	0.92
Liparis spp. (Seasnails)	3	6	2	12	3	7	49	22	8	14	4	7	137	0.88
Cryptacanthodes maculatus (Wrymouth)	5	3	5	11	8	7	28	20	3	10	3	9	112	0.72
Microgadus tomcod (Atlantic tomcod)	12	20	19	11	13	17	3	3		1	1	2	102	0.66
Ammodytes spp. (Sand lance)	1			1	1	1	45	12		9	5	6	81	0.52
Aspidophoroides monopterygius (Alligatorfish)			2	3	5		19	11	7	4	3	2	56	0.36
Liopsetta putnami (Smooth flounder)	1	4	4	2	11	7				2			31	0.20
Hemitripterus americanus (Sea raven)	3		1	2	1		13	3	2	2	1		28	0.18
Pollachius virens (Pollock)		1		1	1	1	4	5		2	1	2	18	0.12
Cyclopterus lumpus (Lumpfish)							4	2		2	8	1	17	0.11
Lumpenus lumpretaeformis (Snakeblenny)			1				2	2	3	1	1		10	0.06
Syngnathus fuscus (Northern pipefish)					1	2							3	0.02
Alosa pseudoharengus (Alewife)	1			1									2	0.01
Macrozoarces americanus (Ocean pout)							2						2	0.01
Hippoglossoides platessoides (American plaice)					1		1						2	0.01
Menidia menidia (Atlantic silverside)					1								1	0.01
Unidentified Gadid	4	11	3	13	9	6	39	22	10	12	9	5	144	0.93
Unidentified larvae		1											1	0.01
U.S.V. (unidentified pieces or fragments of fish)	13	16	31	51	65	84	98	72	26	26	16	23	521	3.37
Total	517	[illegible]73	506	1539	1138	920	4167	2225	839	1318	923	831	15476	99.98
Total catch by station		1576			3597			7231			3072			
% of total catch by station		10.18			23.24			46.72			19.85			99.99
Total volume sampled (m^3)		23457			45009			54545			35834		158848 m^3	
Total catch by location			5173						10303					
% of total catch by location			33.42						66.58					100.00

Table 75. Numerical rank, total numbers caught for each larval fish species, and percent species composition based on total catch for the pre-operational period from August 1970 to June 1972 (Hauser, 1973), and the operational period from January 1973 to June 1979, for the Sheepscot River - Montsweag Bay estuary. Footnotes refer to pre-operational data only.

SPECIES	Pre-operational Period: Numerical rank	Pre-operational Period: Total no. caught	Pre-operational Period: % Species composition based on total catch	Operational Period: % Species composition based on total catch	Operational Period: Total no. caught	Operational Period: Numerical rank
Pholis gunnellus (Rock gunnel)	1	18036	31.17	29.83	49583	1
Clupea harengus (Atlantic herring)	2	11950	20.65	26.85	44632	2
Osmerus mordax (Rainbow smelt)	3	11087	19.16	14.85	24693	3
Sculpin Group[1]	4	9462	16.35	12.31	20459	4
Myoxocephalus aenaeus (Grubby)	-	-	-	-	13648	-
M. scorpius (Shorthorn sculpin)	-	-	-	-	3422	-
M. octodecemspinosus (Longhorn sculpin)	-	-	-	-	3384	-
Triglops murrayi (Moustache sculpin)	-	-	-	-	5	-
Flounder Group[2]	5	3246	5.61	-	-	-
Pseudopleuronectes americanus (Winter flounder)	-	-	-	5.23	8701	5
Liopsetta putnami (Smooth flounder)	-	-	-	1.18	1967	7
Anguilla rostrata (American eel)	6	1035	1.79	2.08	3461	6
Liparis spp. (Seasnails)	7	859	1.48	.62	1034	11
Microgadus tomcod (Atlantic tomcod)	8	655	1.13	1.17	1944	8
Ulvaria subbifurcata (Radiated shanny)	9	496	.86	1.09	1816	9
Aspidophoroides monopterygius (Alligatorfish)	10	282	.49	.36	604	14
Cryptacanthodes maculatus (Wrymouth)	11	259	.45	.43	724	12
Lumpenus lumpretaeformis (Snakeblenny)	12	161	.28	.06	104	16
Syngnathus fuscus (Northern pipefish)	13	98	.17	.66	1103	10
Stickleback Group[3]	14	58	.10	.03	50	19
Cyclopterus lumpus (Lumpfish)	15	53	.09	.41	678	13
Scophthalmus aquosus (Windowpane)	16	52	.09	.16	261	15
Hemitripterus americanus (Sea raven)	17	31	.05	.05	91	17
Gadus morhua (Atlantic cod)	18	9	.02	.01	17	23
Ammodytes sp. (American sand lance)	19	6	.01	.24	404	14
Tautogolabrus adspersus (Cunner)	20	3	<.01	.03	45	21
Hippoglossoides platessoides (American plaice)	21	3	<.01	.05	79	18
Tautoga onitis? (Tautog)	22	2	<.01	-	-	-
Enchelyopus cimbrius (Fourbeard rockling)	23	1	<.01	.03	48	20
Merluccius bilinearis? (Silver hake)	24	1	<.01	-	-	-
Sebastes marinus (Redfish)	25	1	<.01	<.01	1	29
Unidentified species	-	24	.04	<.01	2	-
Pollachius virens (American pollock)				.01	18	22
Macrozoarces americanus (Ocean pout)	-	-	-	.01	12	24
Menidia menidia (Atlantic silverside)	-	-	-	<.01	9	25
Lumpenus maculatus? (Daubed shanny)	-	-	-	<.01	6	26
Alosa pseudoharengus (Alewife)	-	-	-	<.01	4	27
Brevoortia tyrannus (Atlantic menhaden)	-	-	-	<.01	2	28
Conger oceanicus[4] (Conger eel)	-	2	-	<.01	1	30
Petromyzon marinus (Sea lamprey)	-	-	-	<.01	1	31
Fundulus heteroclitus (Mummichog)	-	-	-	<.01	1	32
Unidentified flatfish	-	-	-	.11	188	-
Unidentified Gadids	-	-	-	.10	160	-
USV (unidentified pieces or fragments of fish)	-	-	-	2.00	3323	-
Total		57,870	100.01%	100.00%	166,226	

[1]May include: *Myoxocephalus aenaeus* (Grubby), *M. octodecemspinosus* (Longhorn sculpin), *M. scorpius* (Shorthorn sculpin), and *Triglops murrayi* (Moustache sculpin).

[2]May include: *Liopsetta putnami* (Smooth flounder) and *Pseudopleuronectes americanus* (Winter flounder).

[3]May include: *Apeltes quadracus* (Fourspine stickleback), *Gasterosteus aculeatus* (Threespine stickleback), *G. wheatlandi* (Blackspotted stickleback), and *Pungitius pungitius* (Ninespine stickleback).

[4]Not included in pre-operational summary, later published by Hauser (1975).

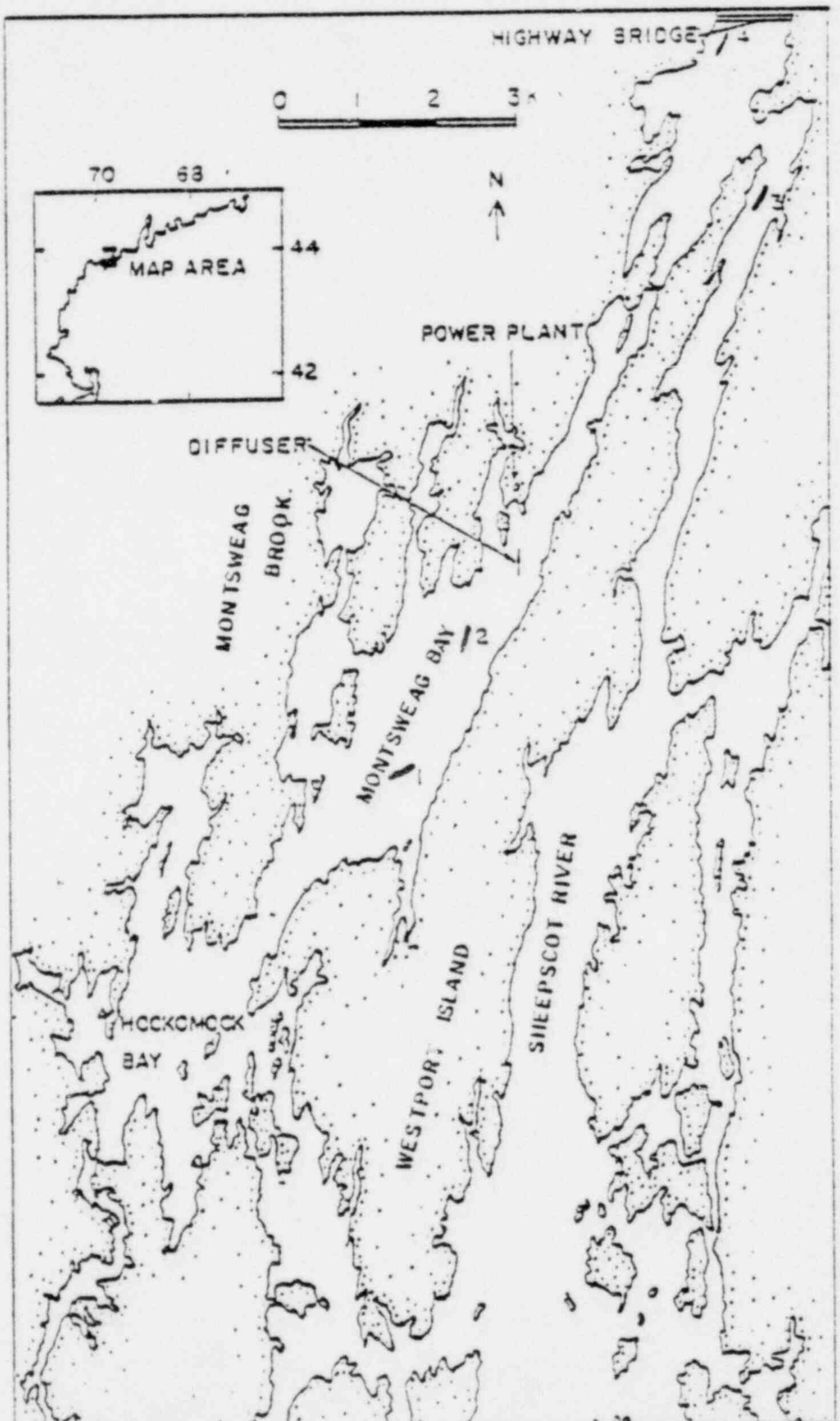


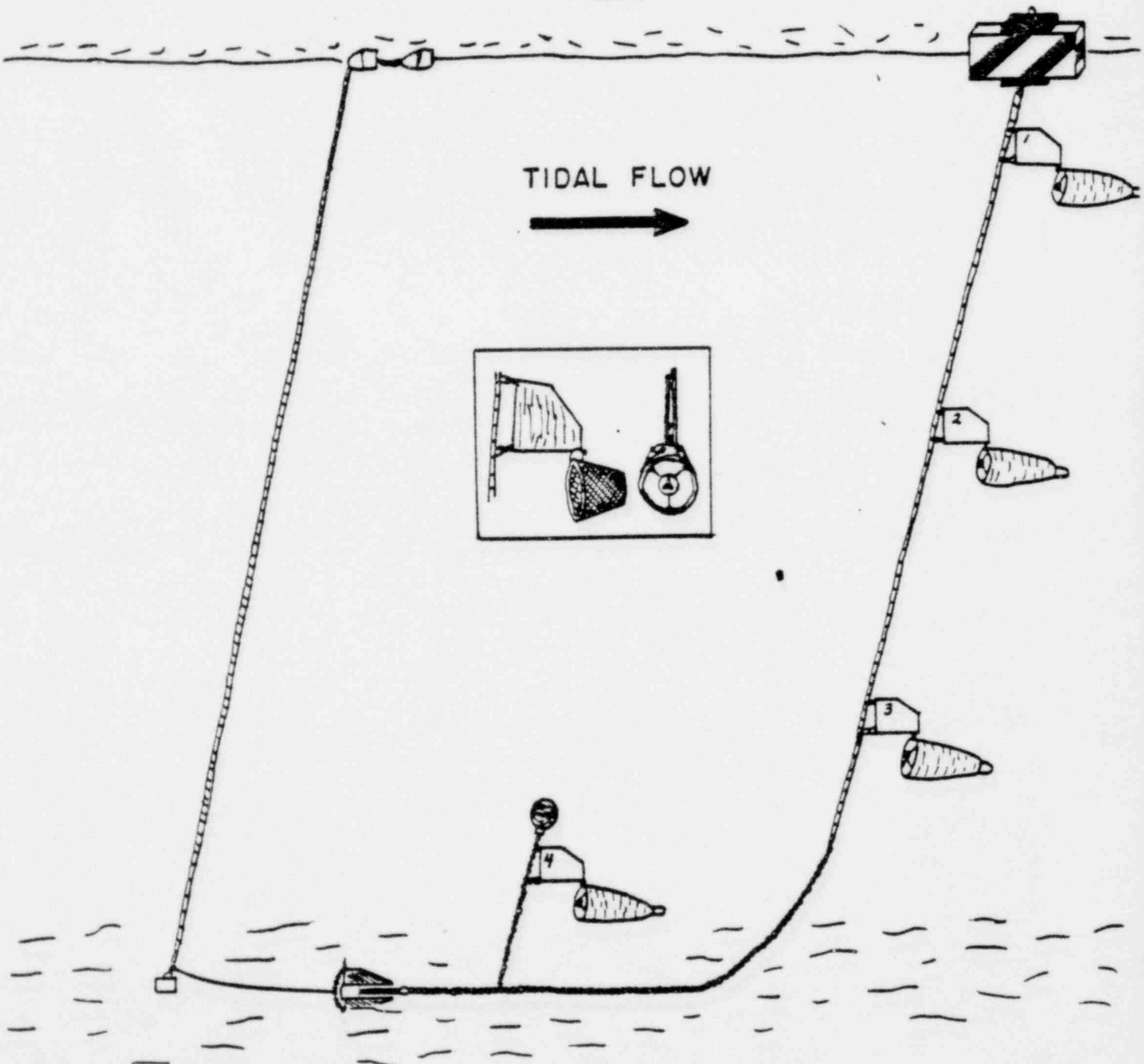
Figure 38. Sheepscot River and Montsweag Bay estuary system with sampling stations and diffuser location indicated. Inset shows locations on the Maine coast.

Stations:
1. Montsweag (MS)
2. Halftide (HS)
3. Sheepscot (SS)
4. Bridge (BS)

Figure 39. Normal fishing attitude of a single set of buoyed and anchored sets for sampling larval fishes and macrozooplankton in the water column (modified from Graham and Venno, 1968).

Insert: Arrangement of vane, net hanger and ring.

Note: A fourth net, located on the bottom chain was discontinued due to a high occurrence of grounding, makin[g] its data unreliable.



Figures 40-74 . Larval fish seasonality for the total catch and the 15 most abundant species or species groups in the Sheepscot River - Montsweag Bay estuarine system from 1 April 1971 to 20 June 1979.

Top graphs are total abundances (no. of larvae/100 m^3) caught in Montsweag Bay and the Sheepscot River. Sampling with towed nets began in April 1975.

Bottom graphs represent abundances by each station.

The species are presented in order of decreasing abundances.

NOTES:

ICE = Jan 1971. Montsweag Bay and Sheepscot River
Feb 1975. Montsweag station buoyed and anchored samples (B+A) only
Jan 1977. Montsweag Bay (B+A) only
Feb 1977. Montsweag station (B&A) only
Feb 1978. Montsweag station (B&A) only
Mar 1978. Montsweag station (B&A) only
Feb 1979. Montsweag station (B&A) only

NA = Data not available because plankton samples were not taken.

Jul to Sep 1972. Montsweag Bay and Sheepscot River
Dec 1972. Sheepscot River only
Dec 1974. Sheepscot River only

NI = Density data not included because of faulty flowmeter readings.

Aug to Dec 1973. Montsweag Bay and Sheepscot River

Figure 40

TOTAL LARVAL FISH ABUNDANCES

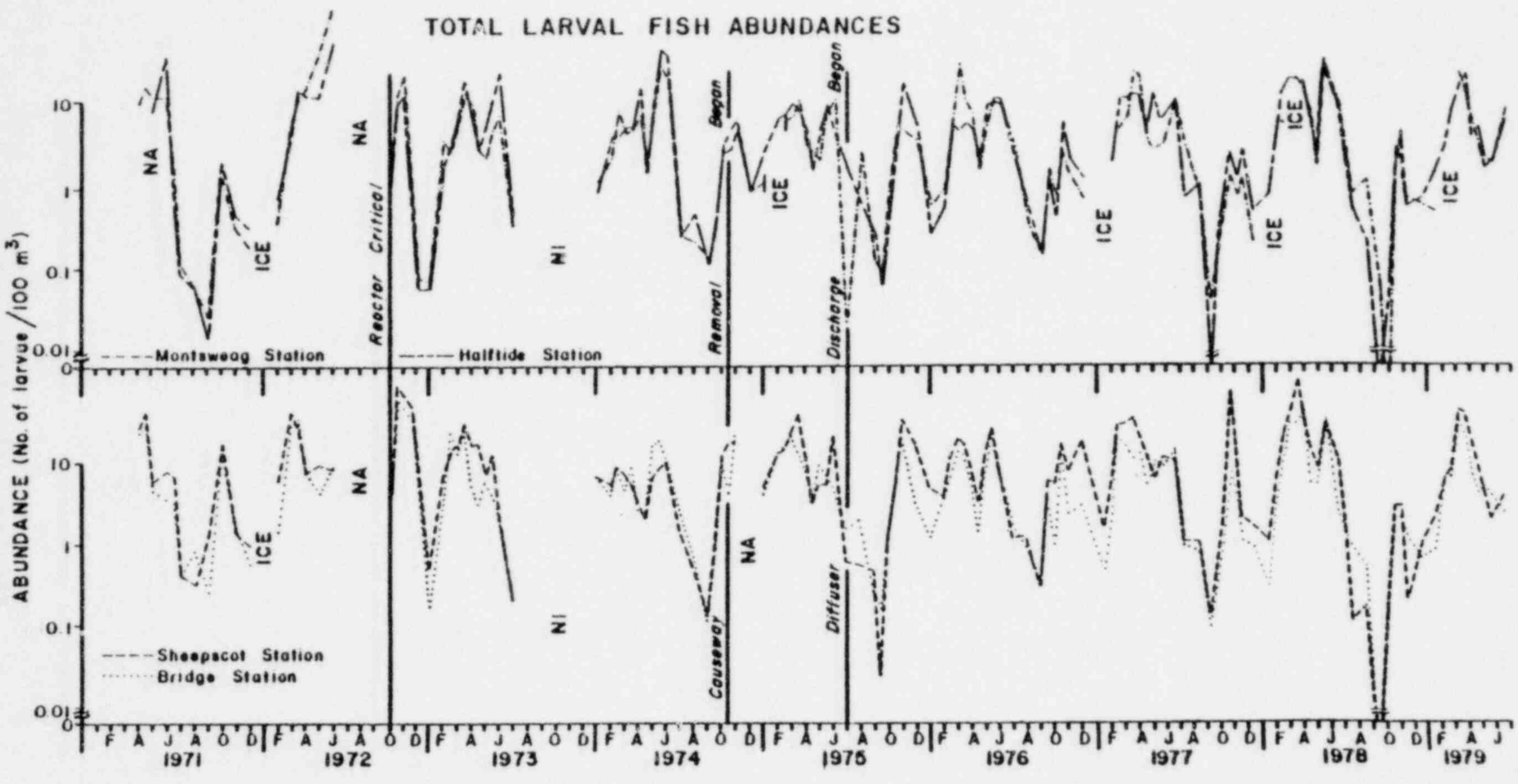


Figure 41

TOTAL LARVAL FISH ABUNDANCES

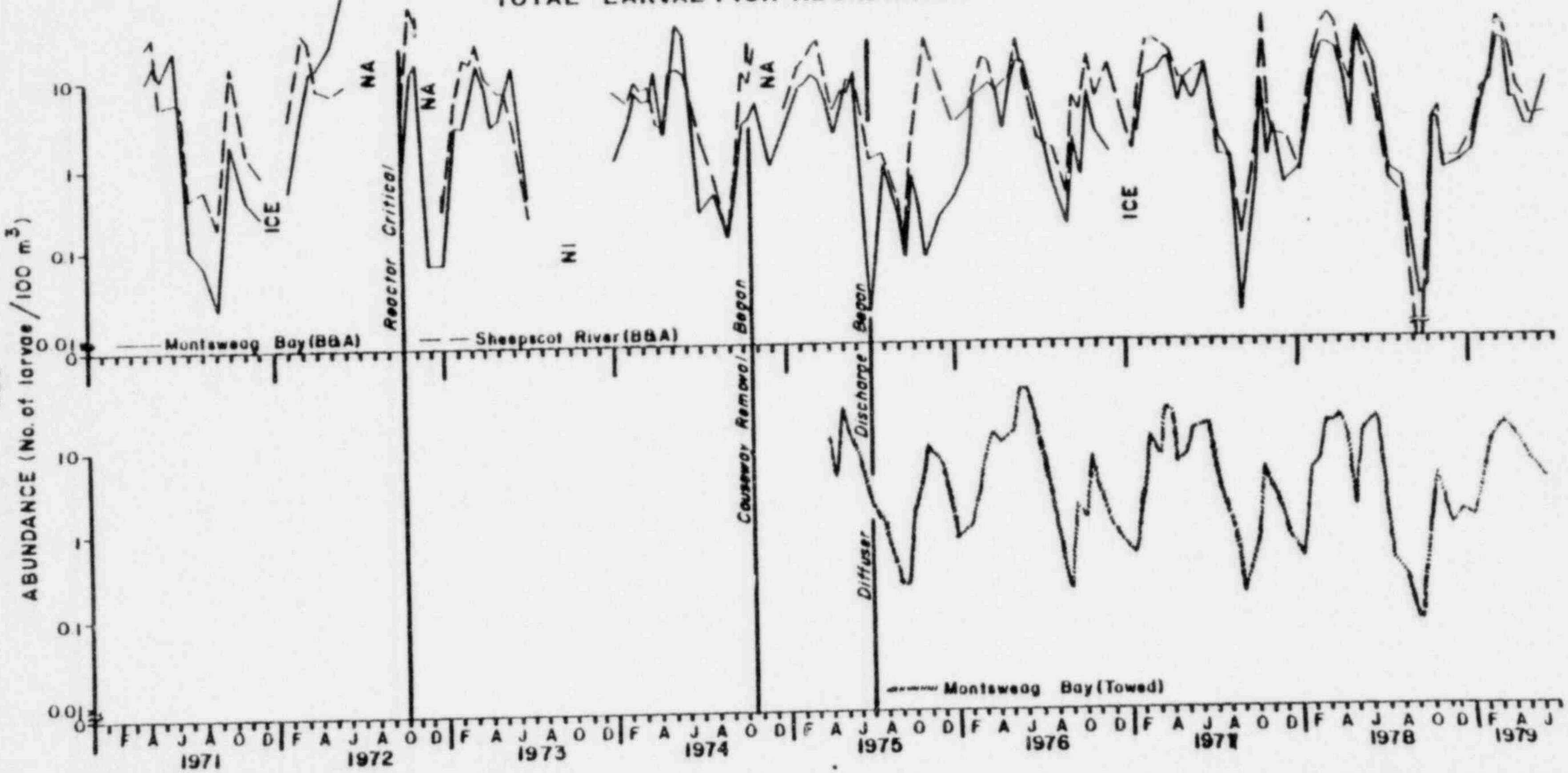


Figure 42

Clupea harengus (Atlantic herring)

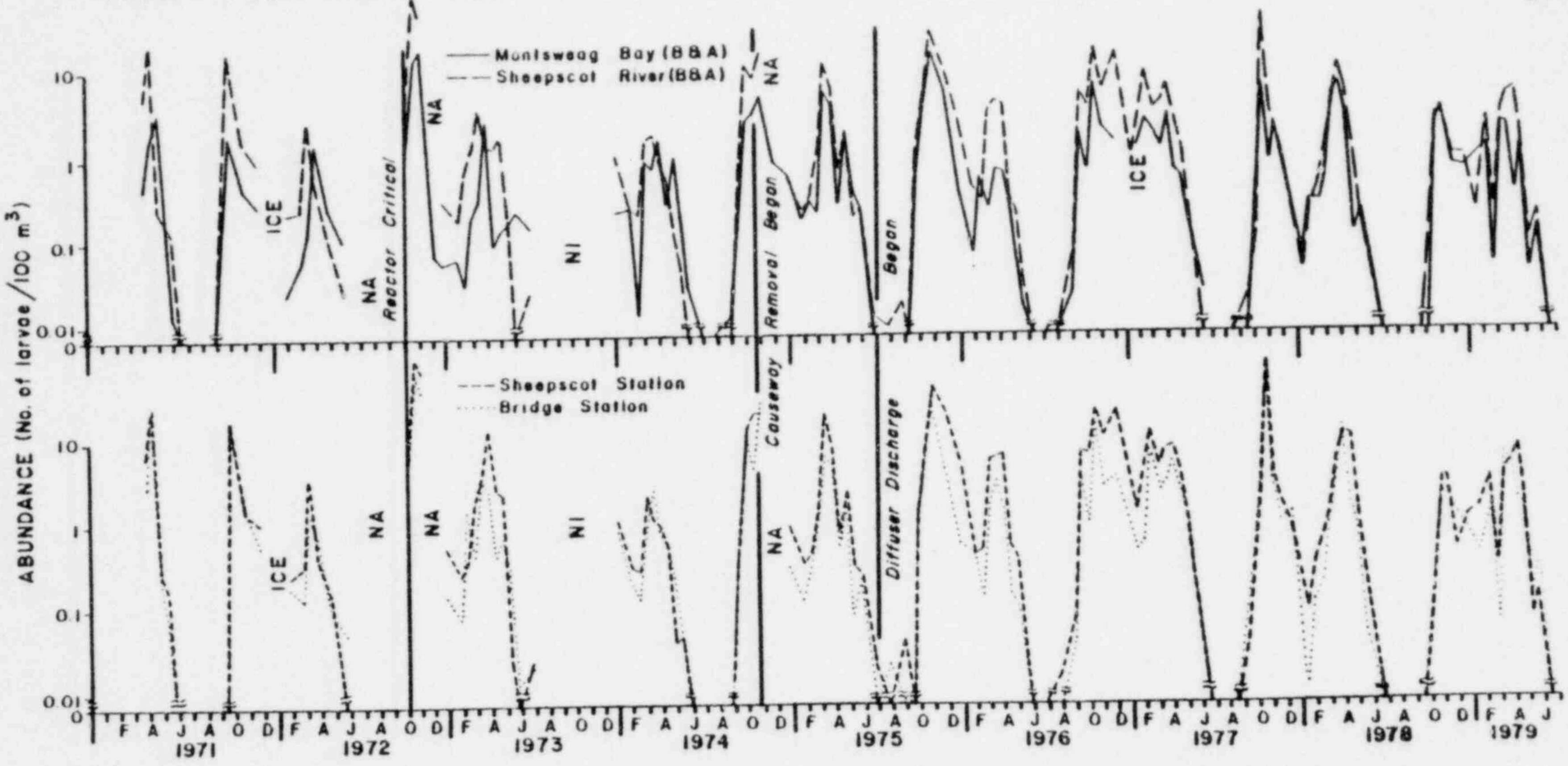
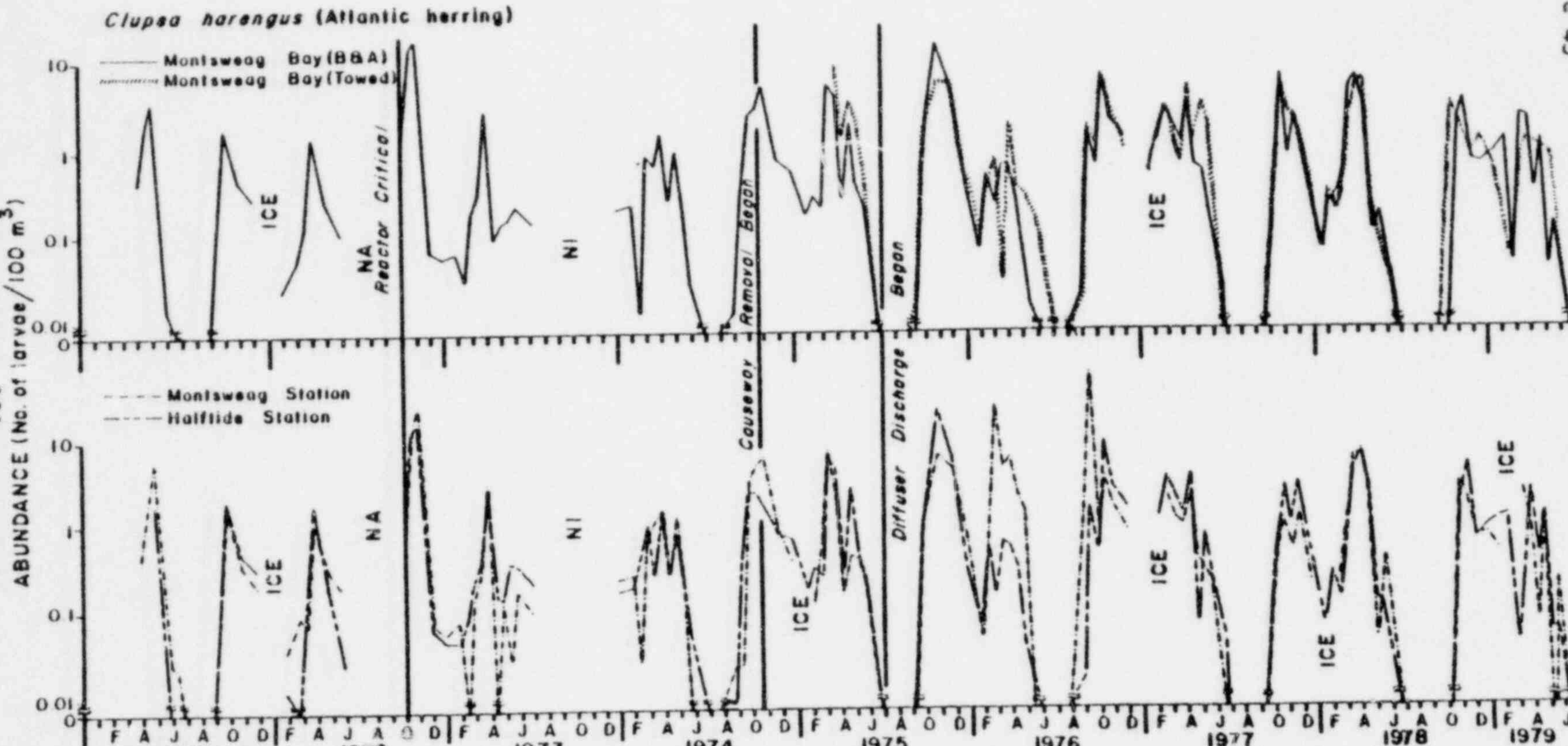


Figure 43



Clupea harengus (Atlantic herring)
Montsweag Bay (B&A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
ABUNDANCE (No. of larvae/100 m3)
10
1
0.1
0.01
0
ICE
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 44

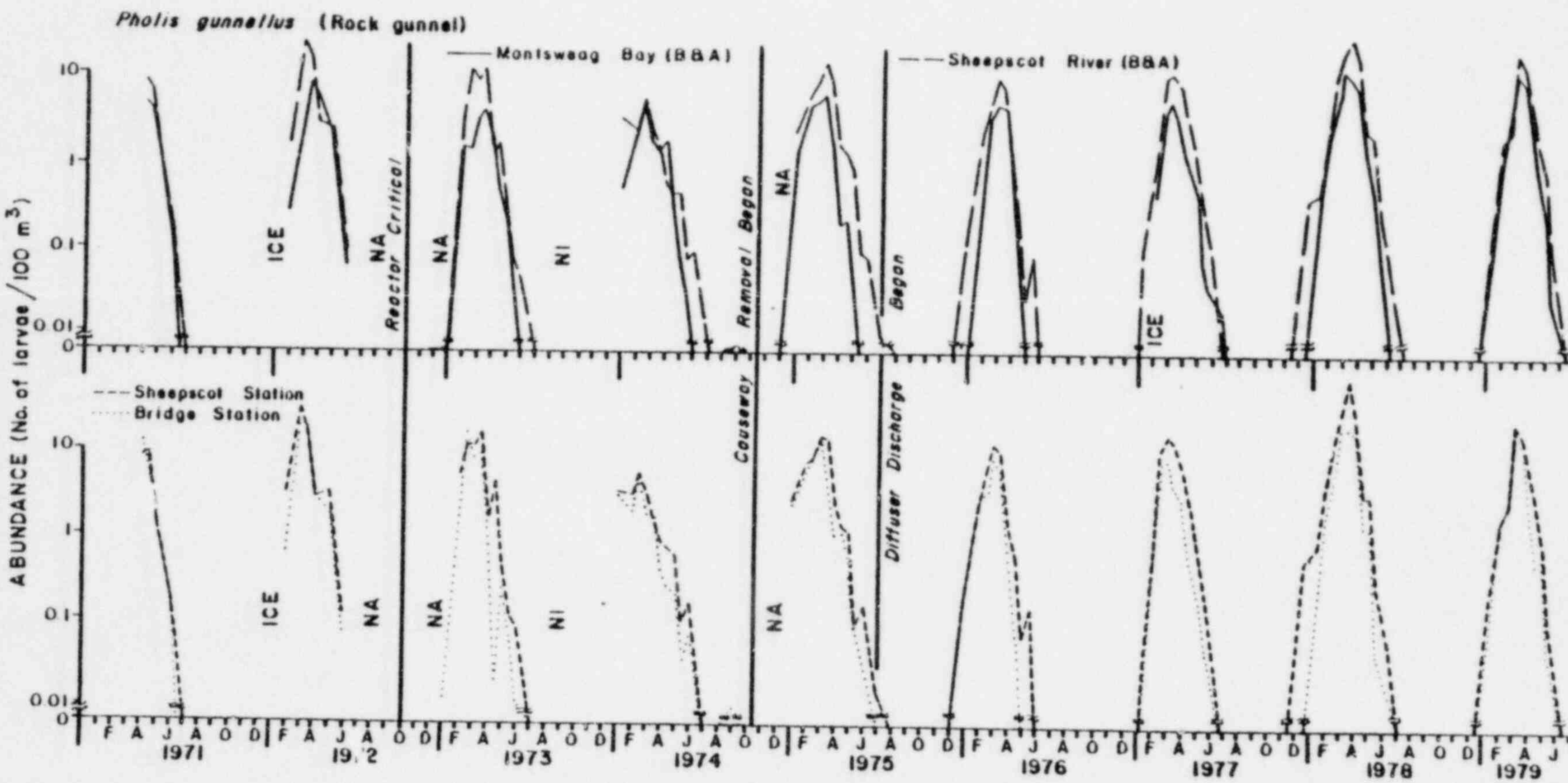
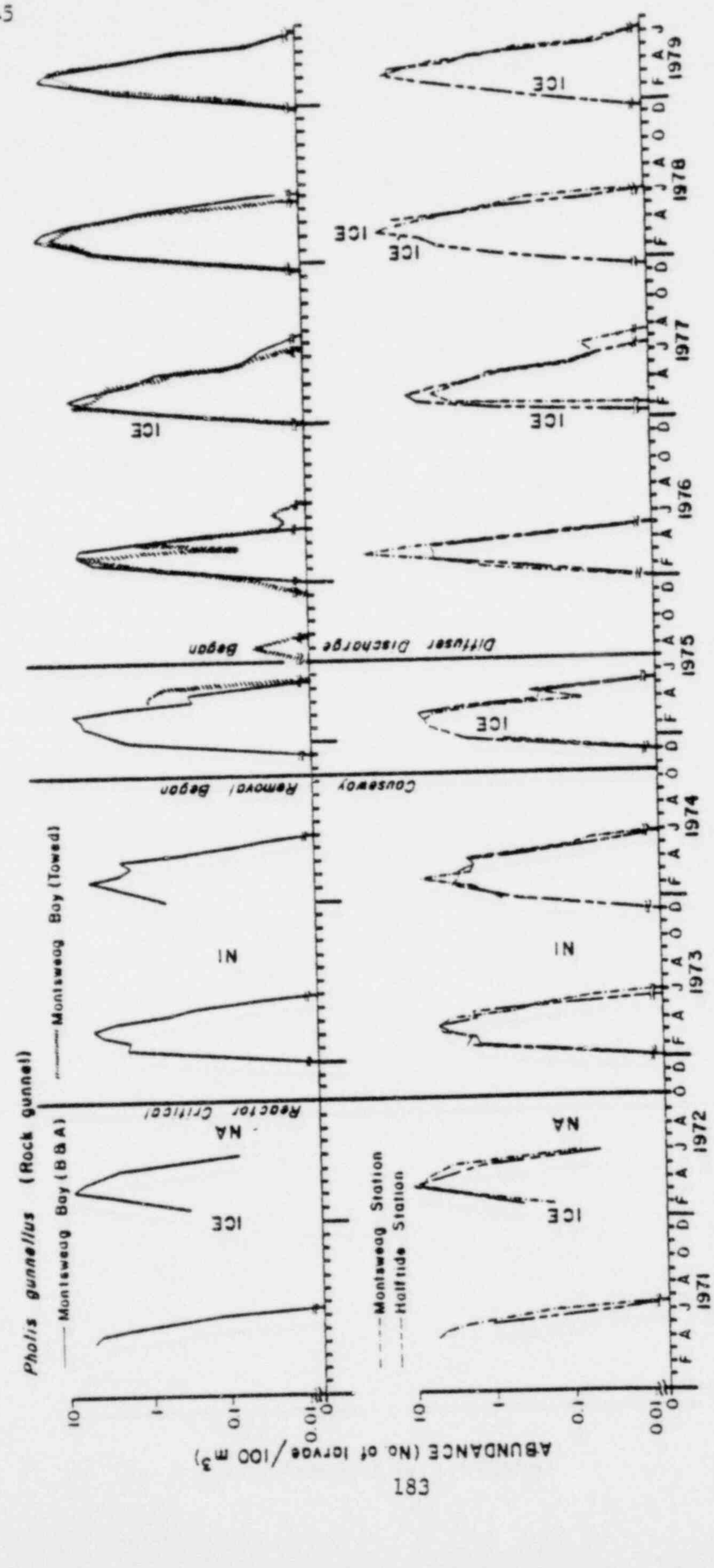

Pholis gunnellus (Rock gunnel)
Montsweag Bay (B&A)
Sheepscot River (B&A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m3)
10
1
0.1
0.01
0
ICE
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 45



Pholis gunnellus (Rock gunnel)
Montsweag Bay (BBA)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
ICE
NA
NI
1971
1972
1973
1974
1975
1976
1977
1978
1979
ABUNDANCE (No of larvae/100 m3)

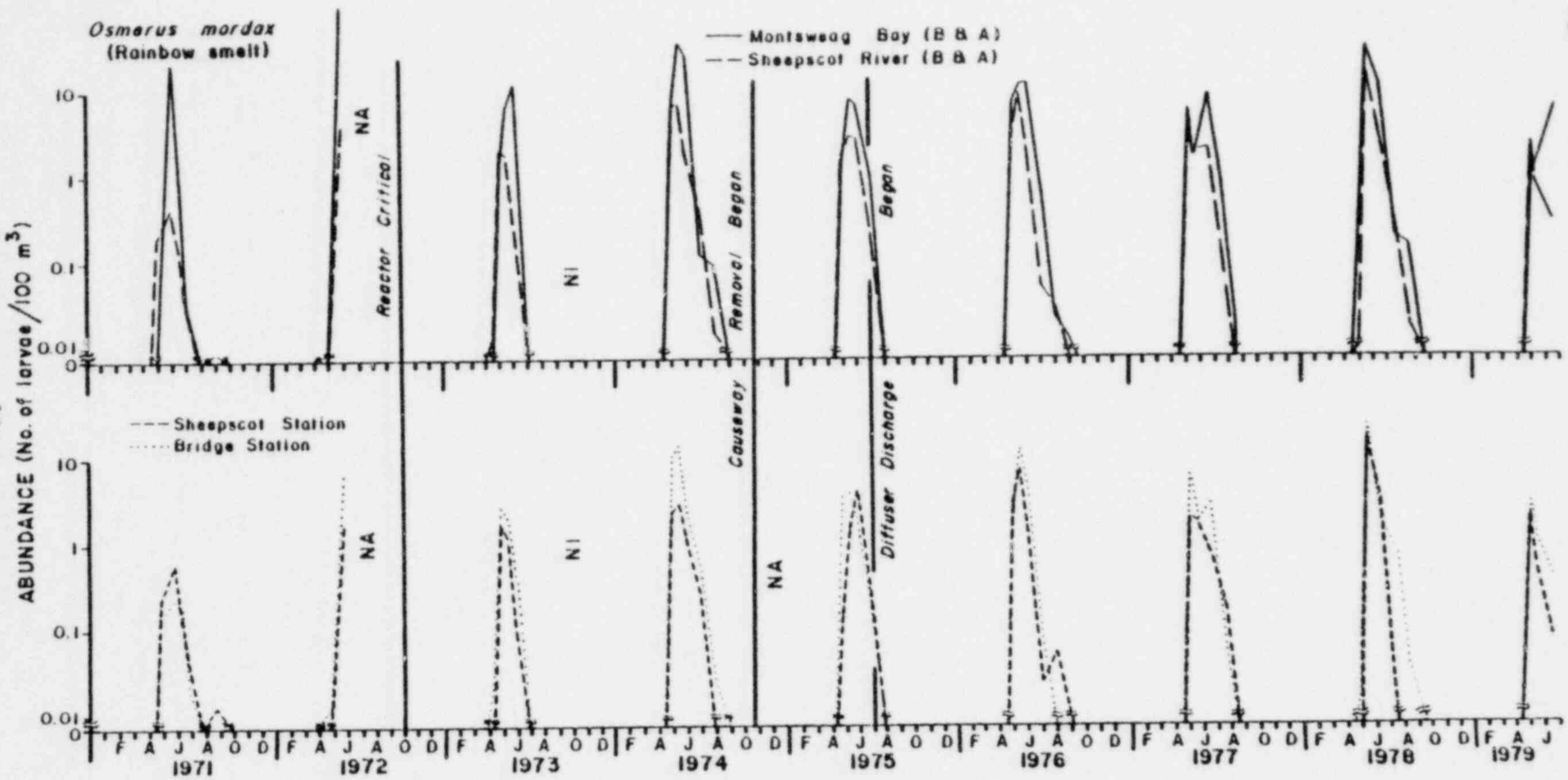
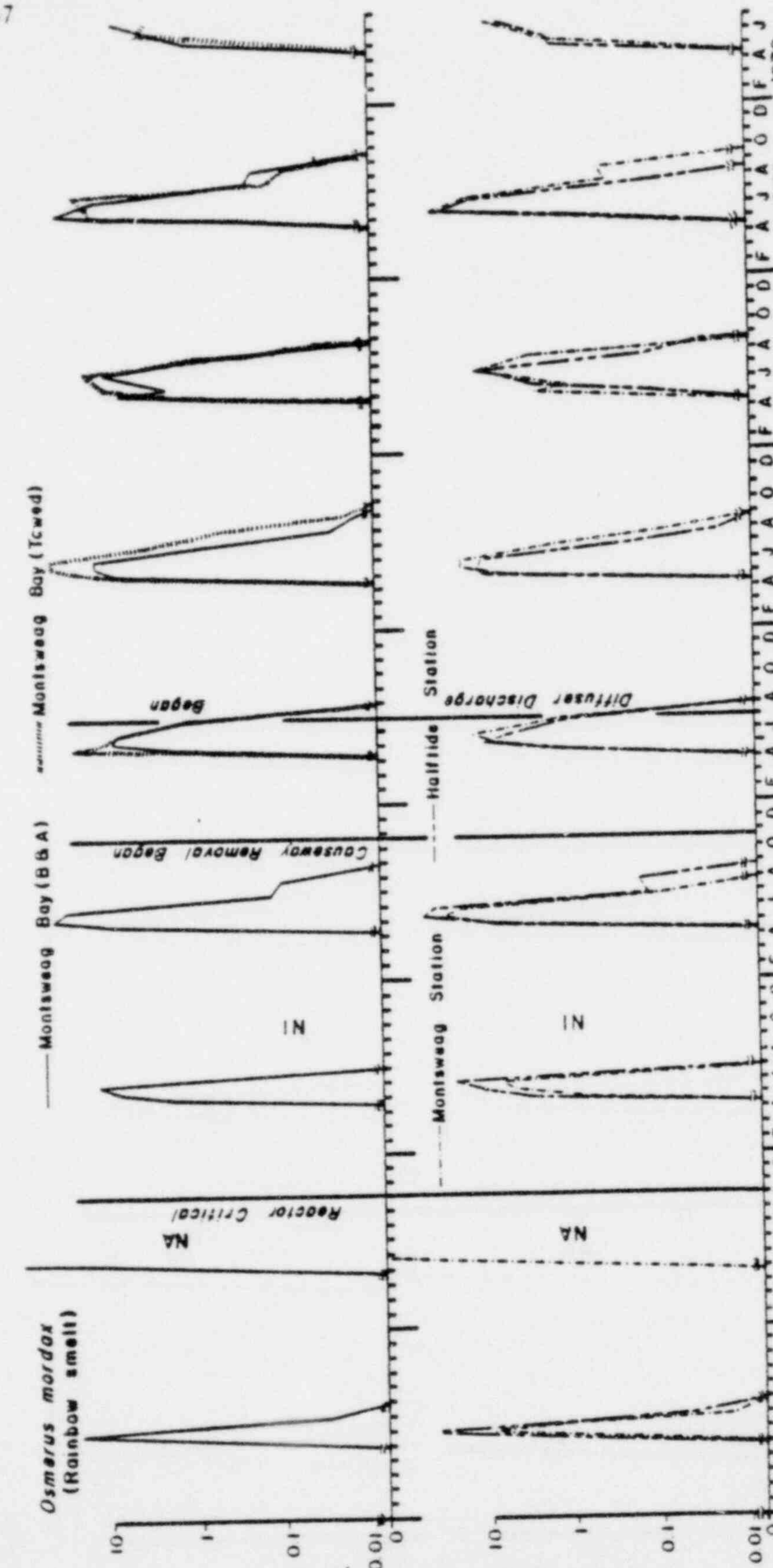
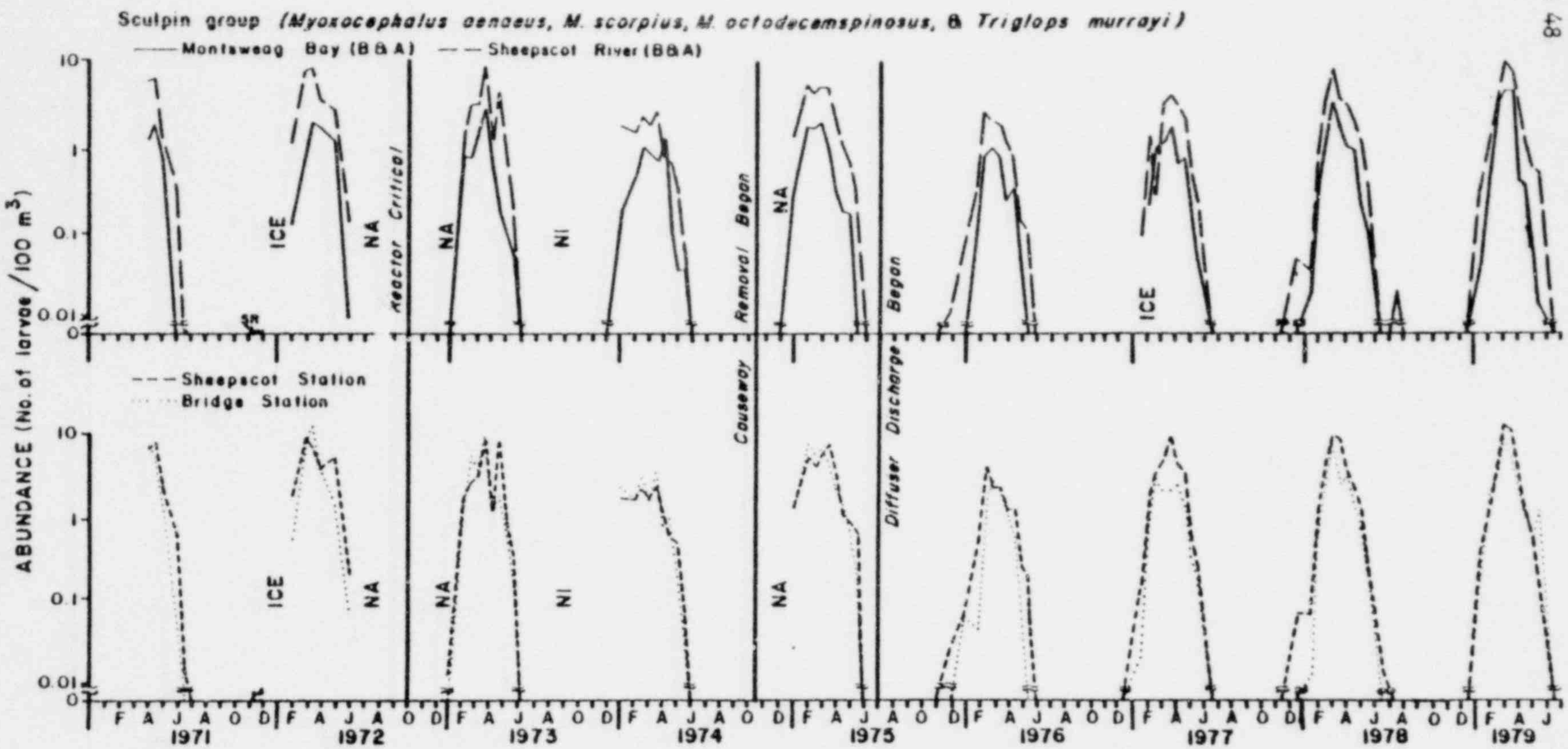

Osmerus mordax
(Rainbow smelt)
Montsweag Bay (B & A)
Sheepscot River (B & A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m^3)
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
NA
NI
10
1
0.1
0.01
0
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 46

Figure 47


Osmerus mordax
(Rainbow smelt)
Montsweag Bay (BB&A)
Montsweag Bay (Tcwed)
Montsweag Station
Halftide Station
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
NA
NI
1971
1972
1973
1974
1975
1976
1977
1978
1979
ABUNDANCE (No. of larvae/100 m³)

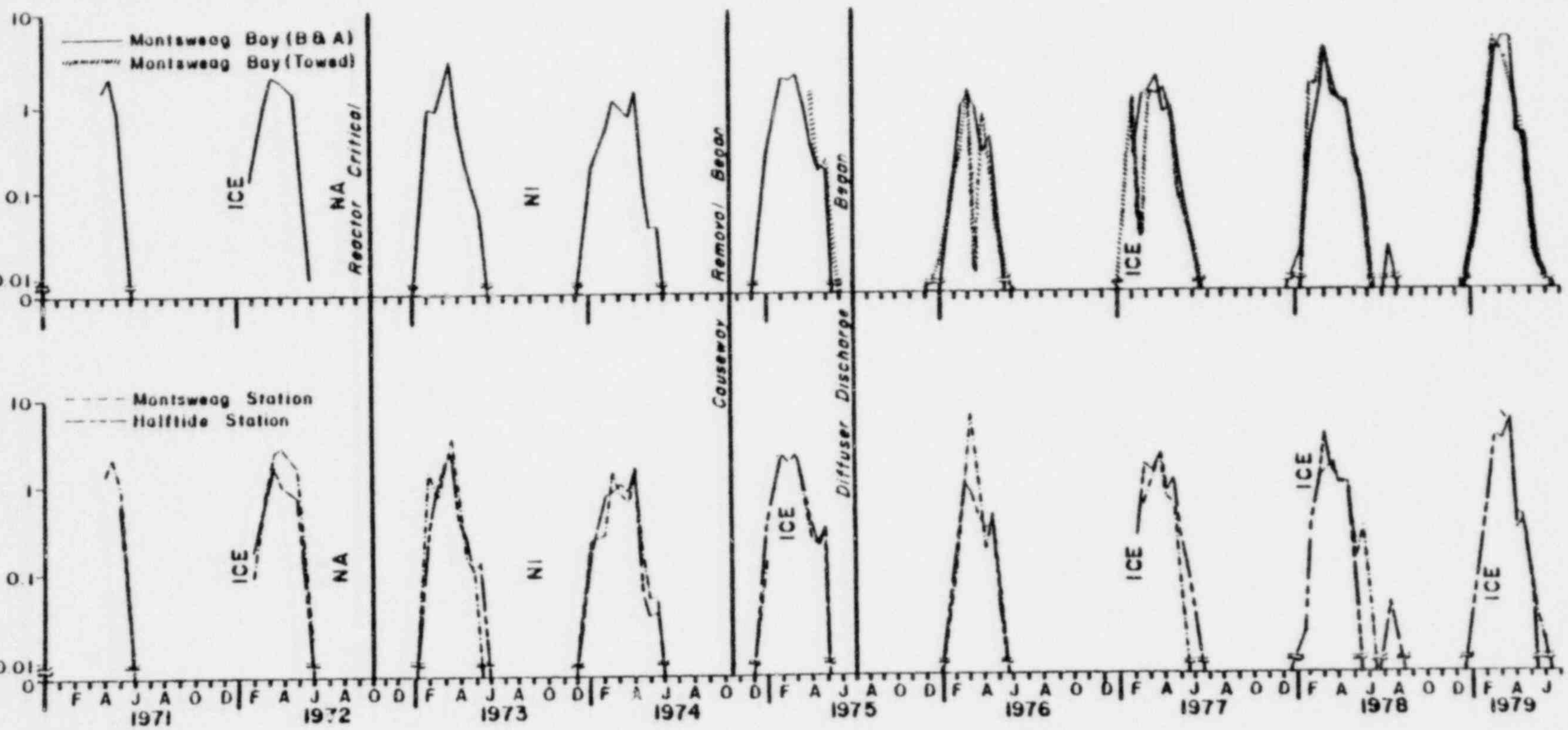


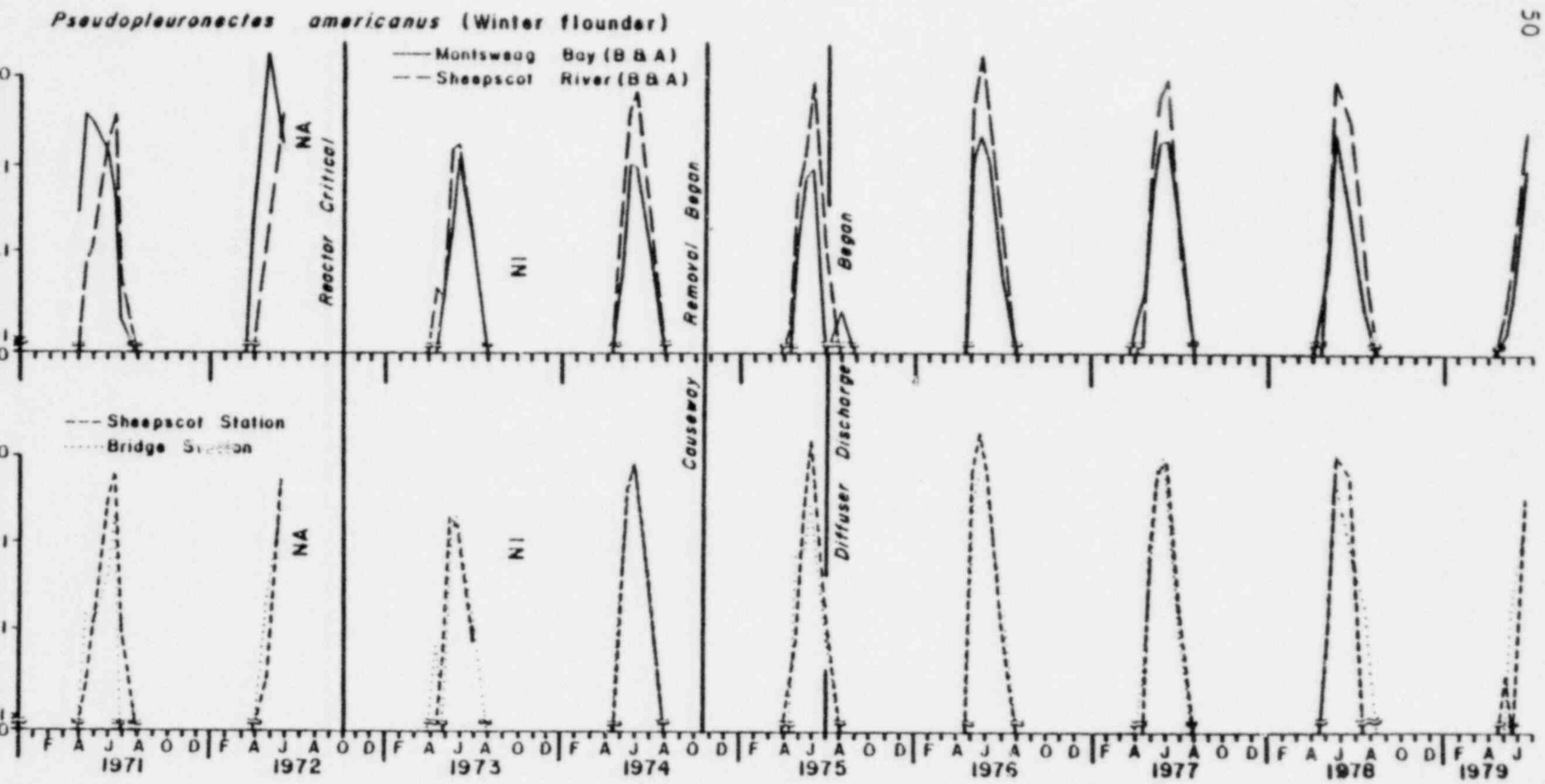
Sculpin group (Myoxocephalus aenaeus, M. scorpius, M. octodecemspinosus, & Triglops murrayi)
—— Montsweag Bay (B&A)
— — Sheepscot River (B&A)
— — Sheepscot Station
····· Bridge Station
ABUNDANCE (No. of larvae /100 m3)
10
1
0.1
0.01
0
ICE
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 48

Figure 49

Sculpin group (*Myoxocephalus aenaeus, M. scorpius, M. octodecemspinosus, & Triglops murrayi*)





Pseudopleuronectes americanus (Winter flounder)
Montsweag Bay (B & A)
Sheepscot River (B & A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m³)
10.
1
0.1
0.01
0
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 50

Figure 51

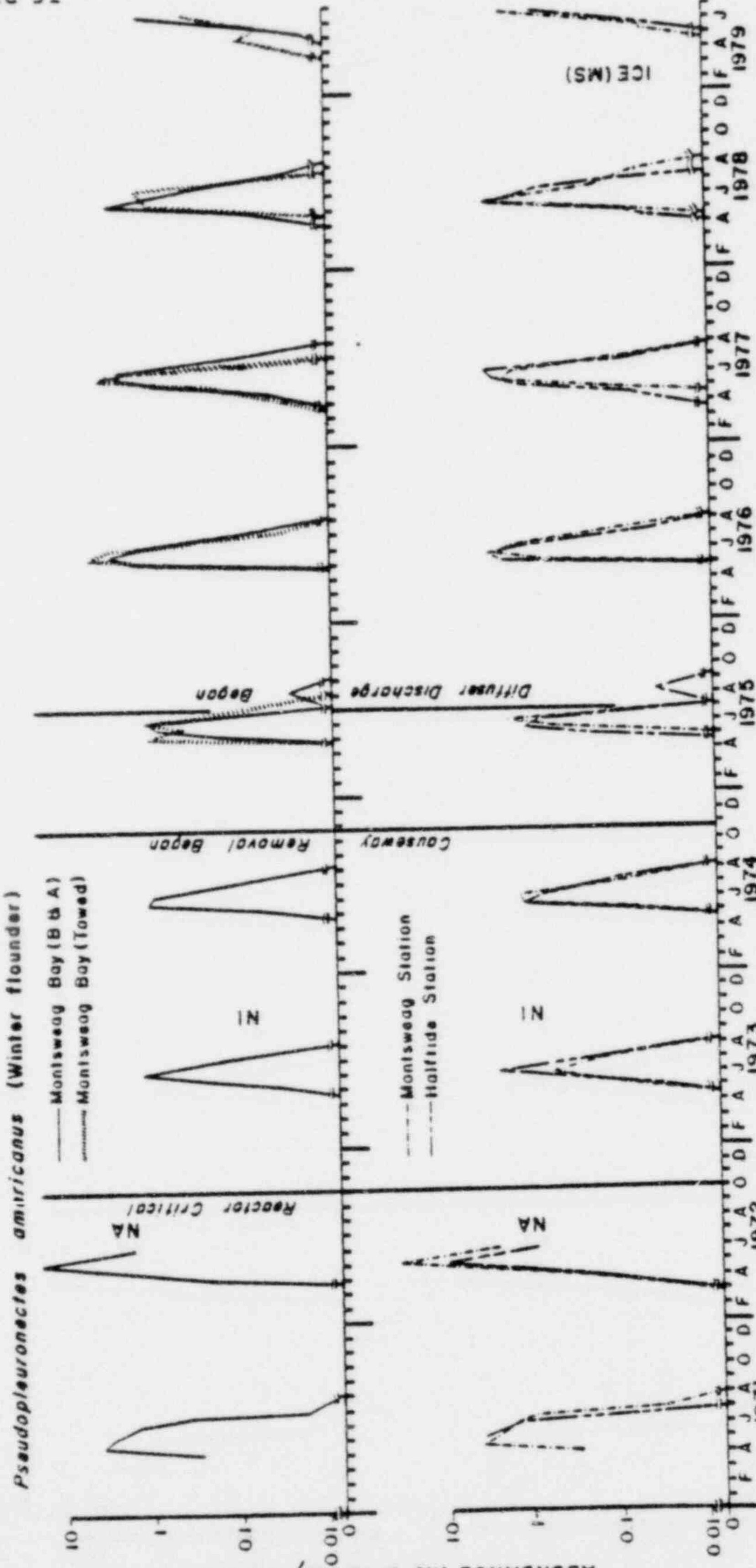
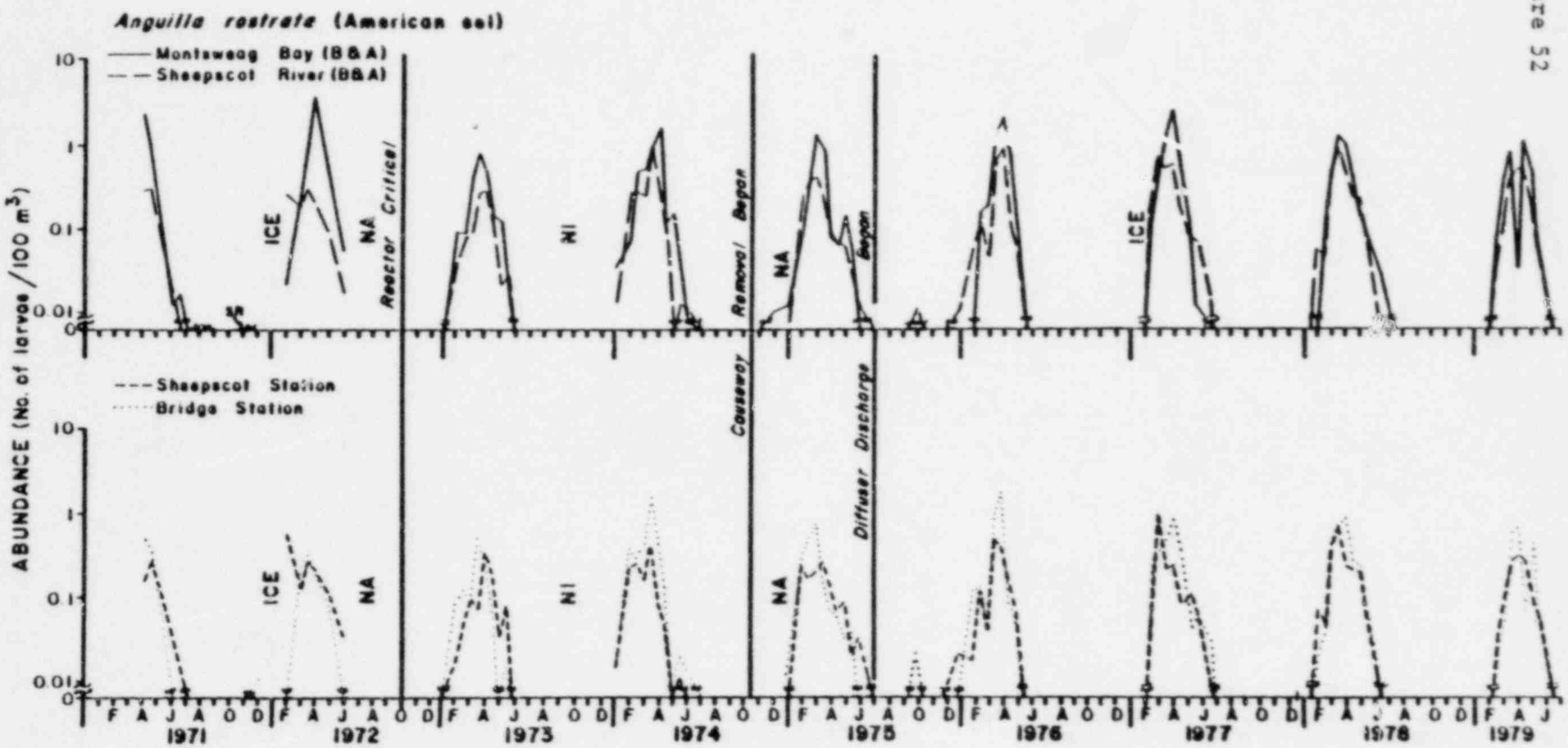
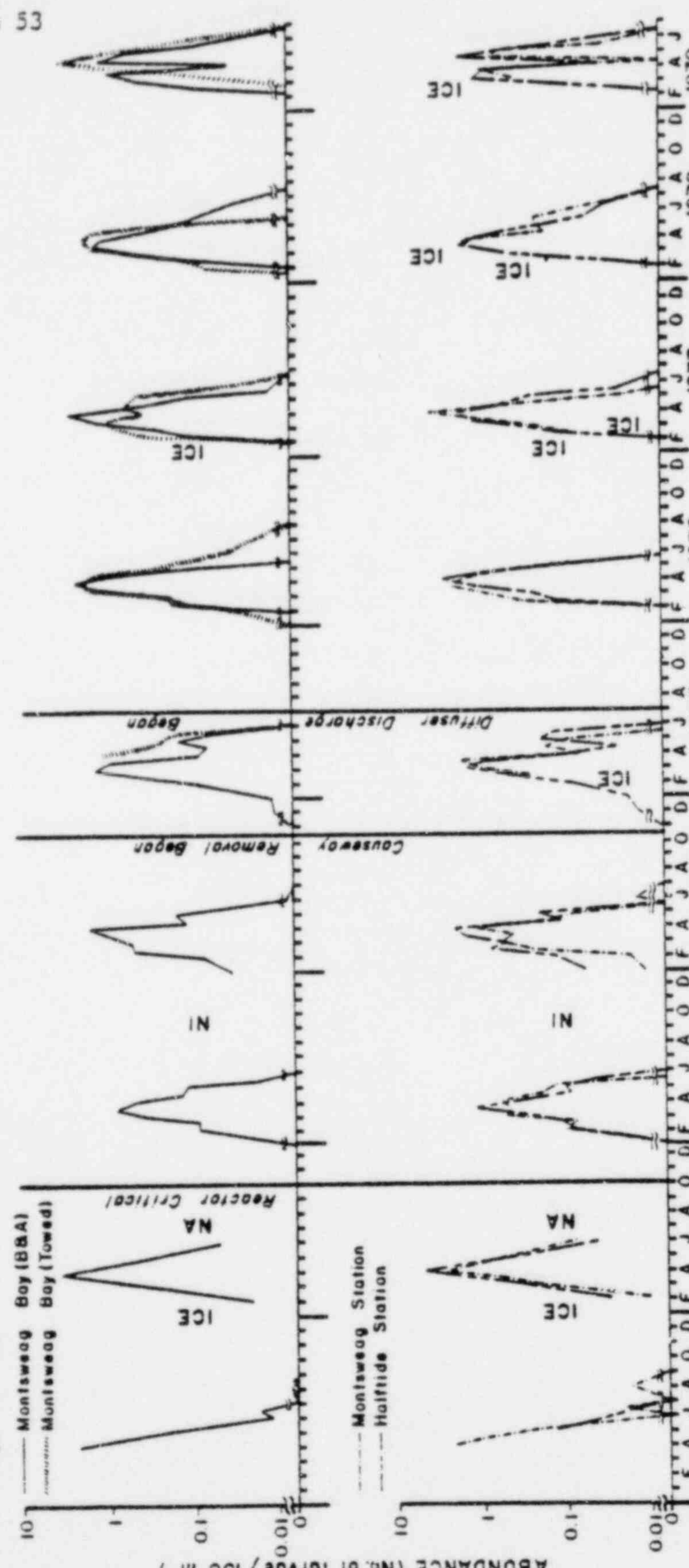

Pseudopleuronectes americanus (Winter flounder)
Montsweag Bay (B & A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
ICE (MS)
ABUNDANCE (No. of larvae/100 m³)
10
1
0.1
0.01
0
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 52

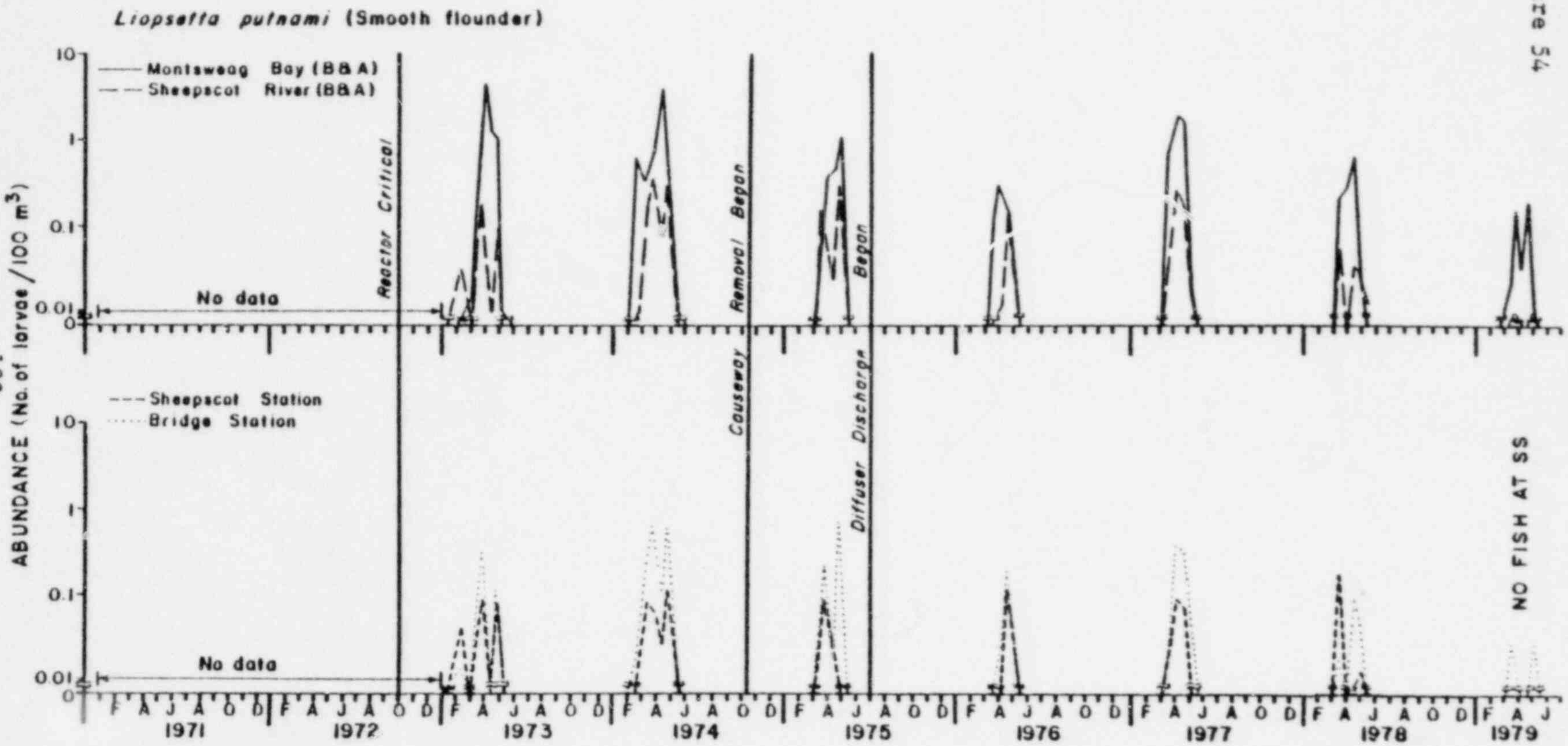


Anguilla rostrata (American eel)
Montsweag Bay (B&A)
Sheepscot River (B&A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m3)
ICE
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 53



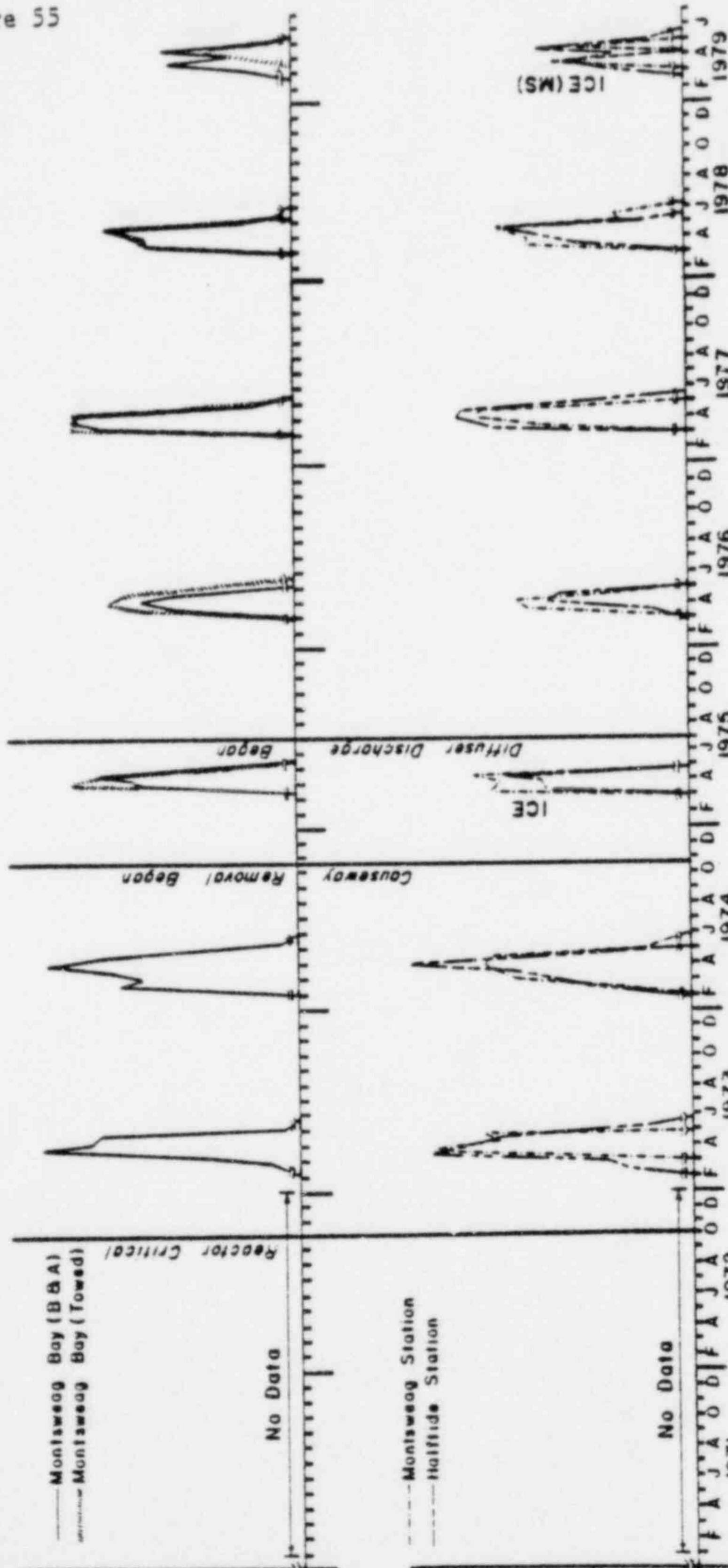
Anguilla rostrata (American eel)
Montsweag Bay (BBA)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
ABUNDANCE (No. of larvae / 100 m^3)
ICE
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
1971
1972
1973
1974
1975
1976
1977
1978
1979



Liopsetta putnami (Smooth flounder)
Montsweag Bay (B&A)
Sheepscot River (B&A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m3)
10
1
0.1
0.01
0
No data
No data
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
NO FISH AT SS
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 54

Figure 55



Liopsetta putnami (Smooth flounder)
Montsweag Bay (B&A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
No Data
No Data
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
ICE
ICE (MS)
ABUNDANCE (No. of larvae / 100 m³)
10
1
0.1
0.01
0
1971
1972
1973
1974
1975
1976
1977
1978
1979

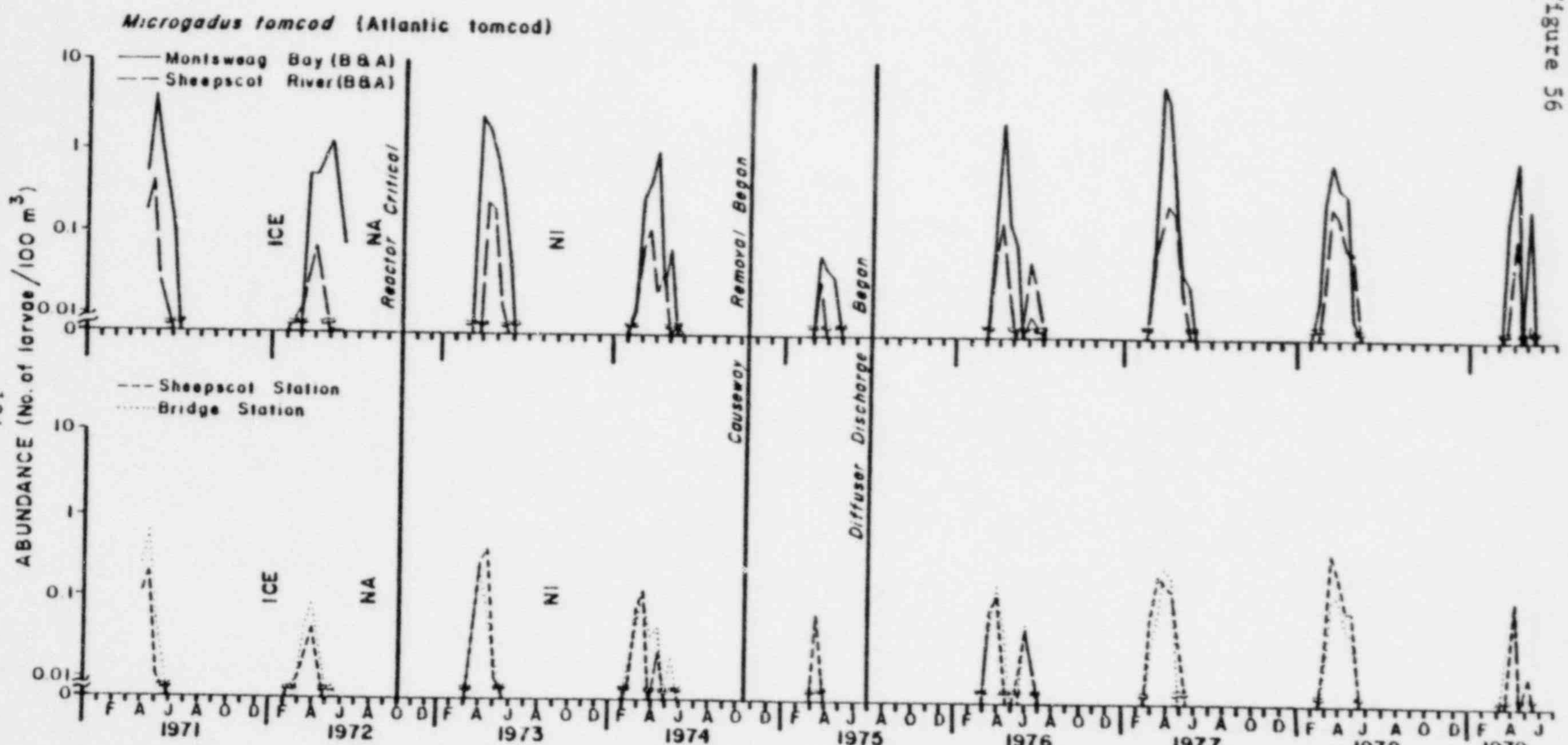
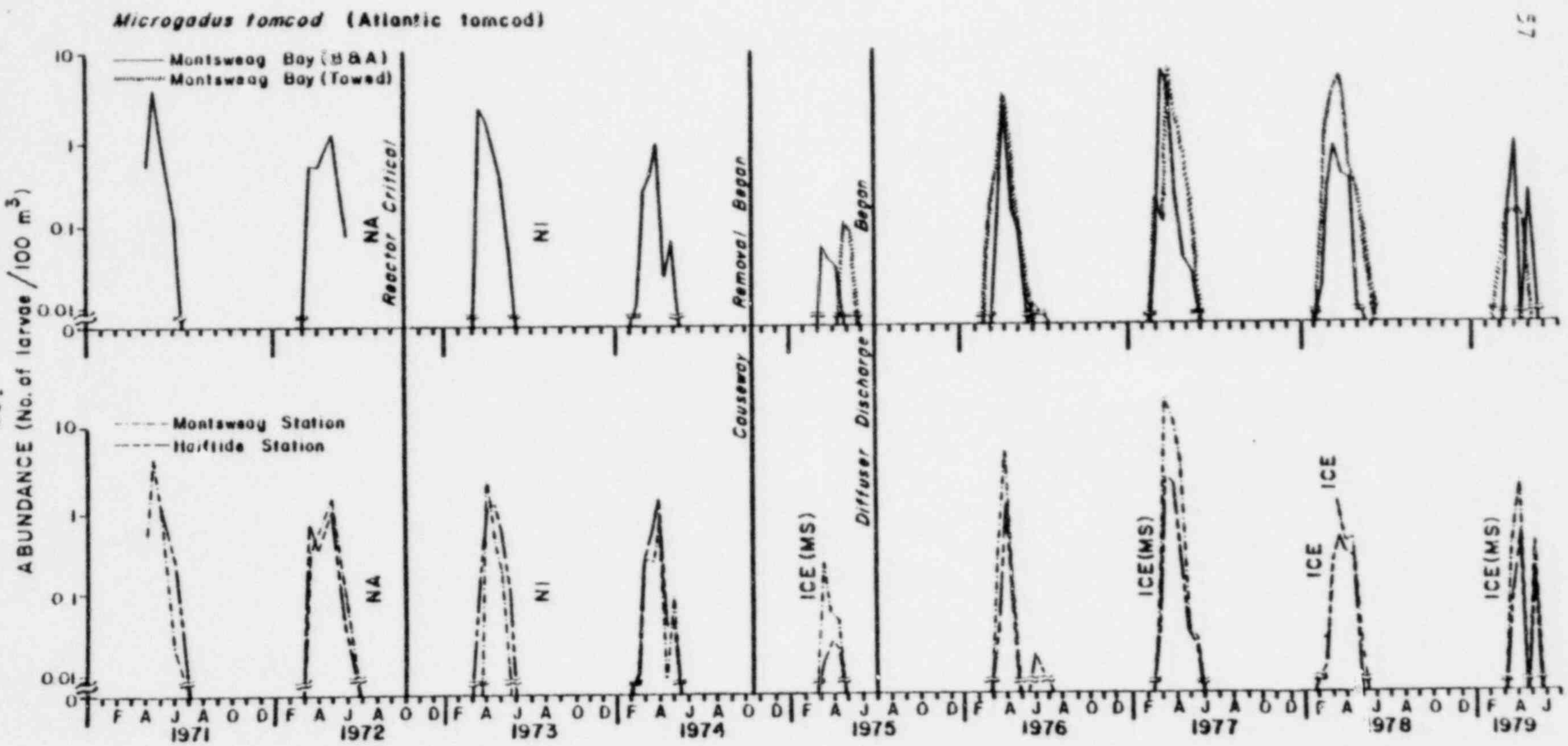

Microgadus tomcod (Atlantic tomcod)
Montsweag Bay (B&A)
Sheepscot River (B&A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m³)
10
1
0.1
0.01
0
ICE
NA
Reactor Critical
NI
Causeway Removal Began
Diffuser Discharge Began
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 56

Figure 57



Microgadus tomcod (Atlantic tomcod)
Montsweag Bay (B&A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
ABUNDANCE (No. of larvae /100 m^3)
10
1
0.1
0.01
0
NA
Reactor Critical
NI
Causeway Removal Began
Diffuser Discharge Began
ICE (MS)
ICE
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 58

Ulvaria subbifurcata (Radiated shanny)

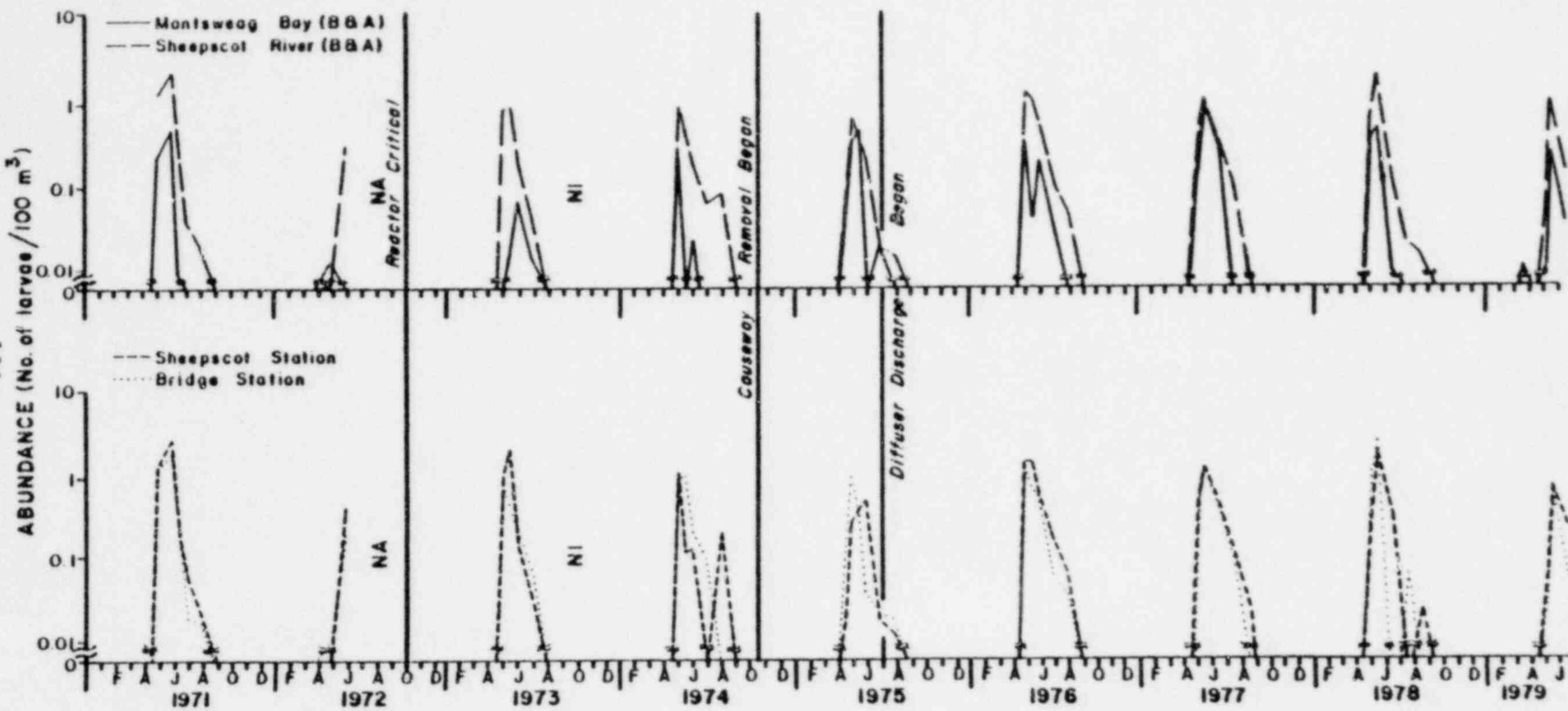
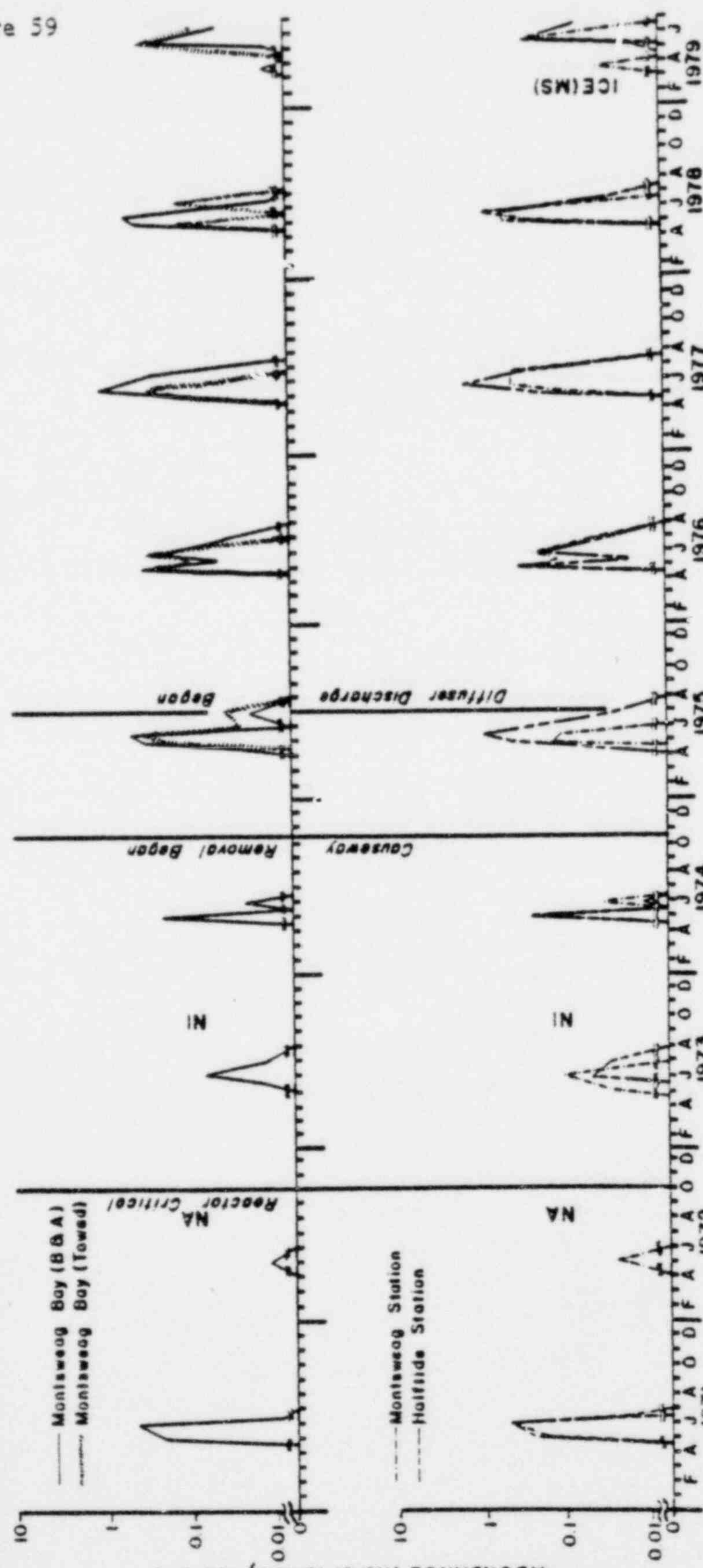


Figure 59



Ulvaria subbifurcata (Radiated shanny)
Montsweag Bay (B&A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
ABUNDANCE (No. of larvae/100 m3)
NA
Reactor Critical
NI
Causeway Removal Began
Diffuser Discharge Began
ICE(MS)
1971
1972
1973
1974
1975
1976
1977
1978
1979

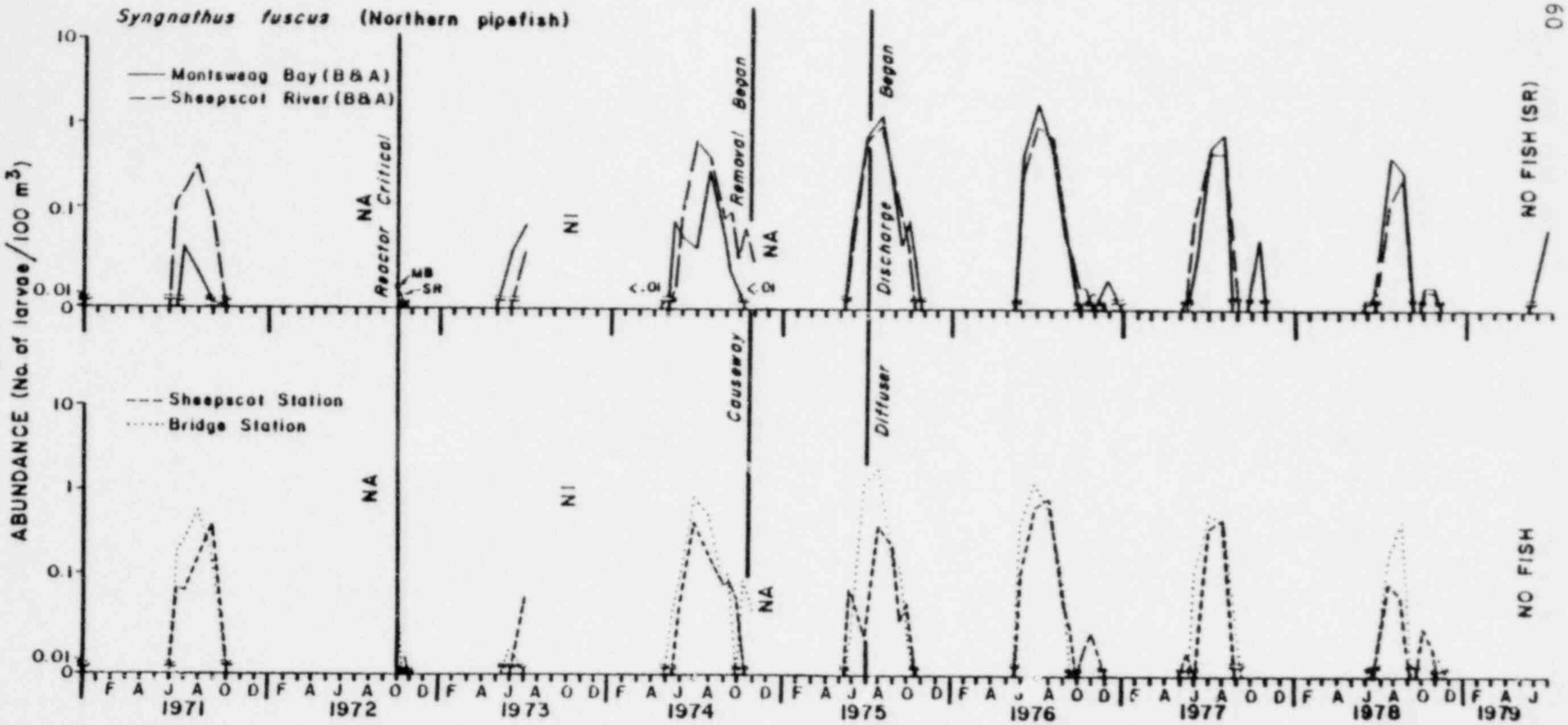

Syngnathus fuscus (Northern pipefish)
Montsweag Bay (B&A)
Sheepscot River (B&A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m³)
10
1
0.1
0.01
0
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
MB
SR
<.01
NO FISH (SR)
NO FISH
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 60

Figure 61

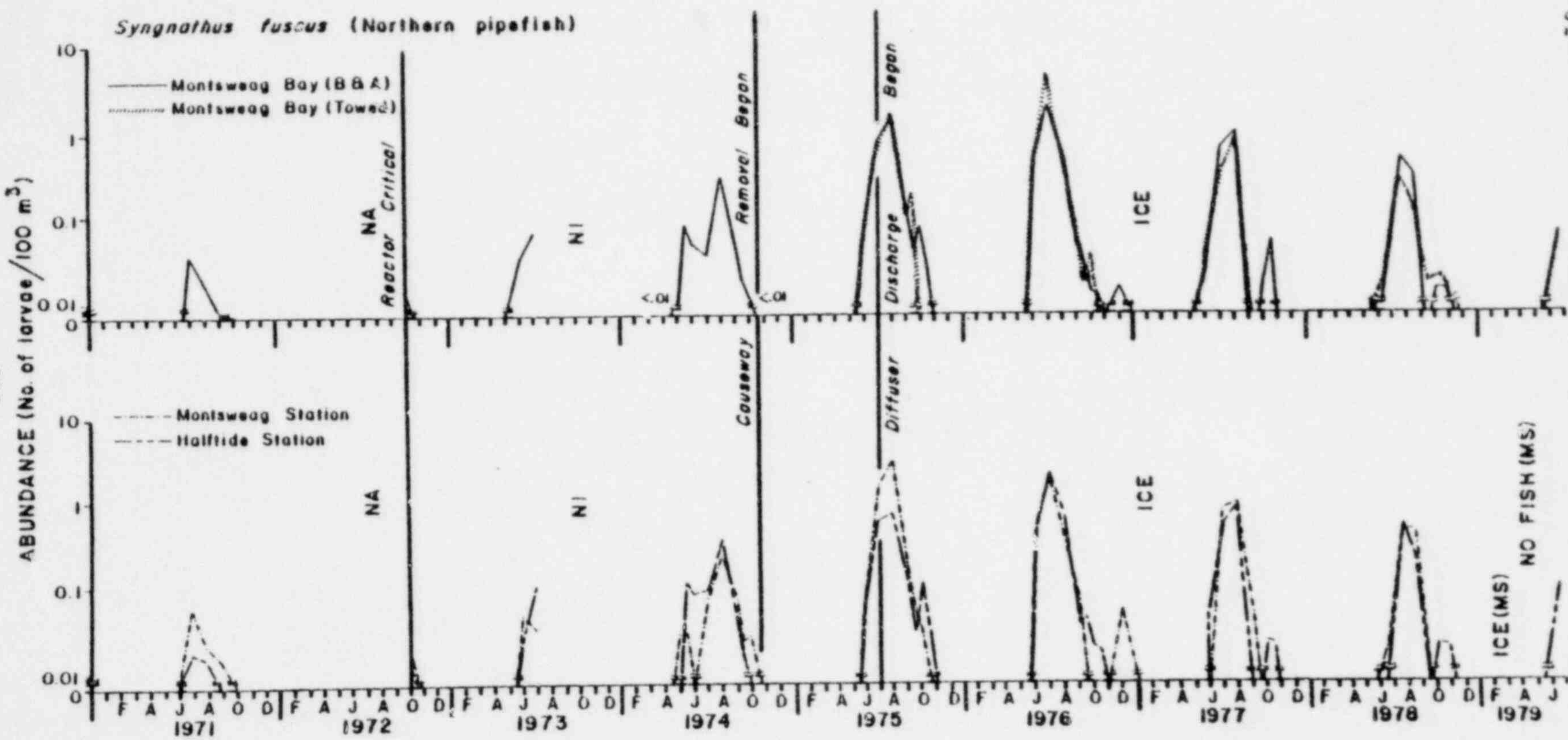
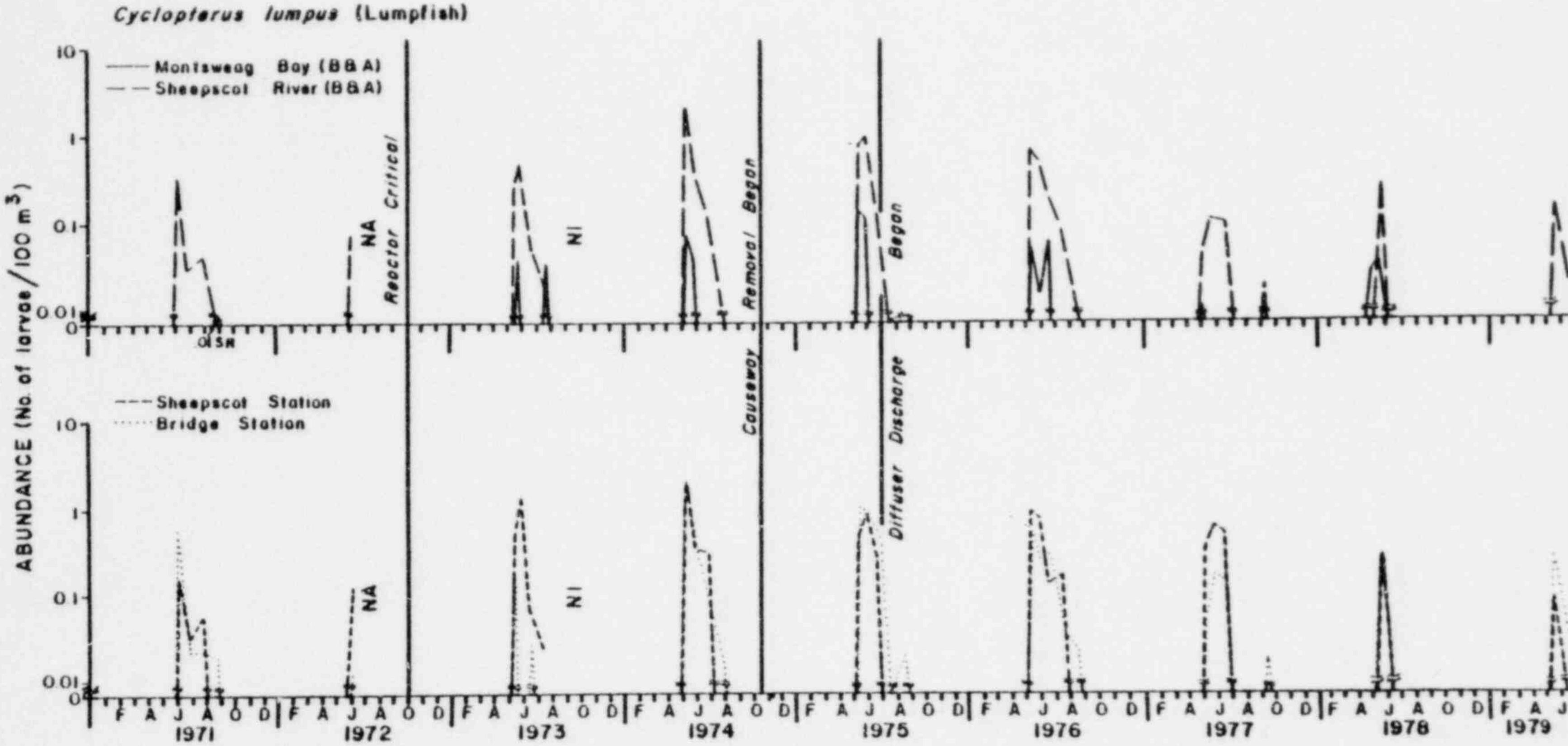

Syngnathus fuscus (Northern pipefish)
Montsweag Bay (B & A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
ABUNDANCE (No. of larvae/100 m³)
10
1
0.1
0.01
0
NA
Reactor Critical
NI
Causeway Removal Began
Diffuser Discharge Began
ICE
ICE (MS)
NO FISH (MS)
<.01
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 62


Cyclopterus lumpus (Lumpfish)
Montsweag Bay (B&A)
Sheepscot River (B&A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m3)
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
10
1
0.1
0.01
0
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

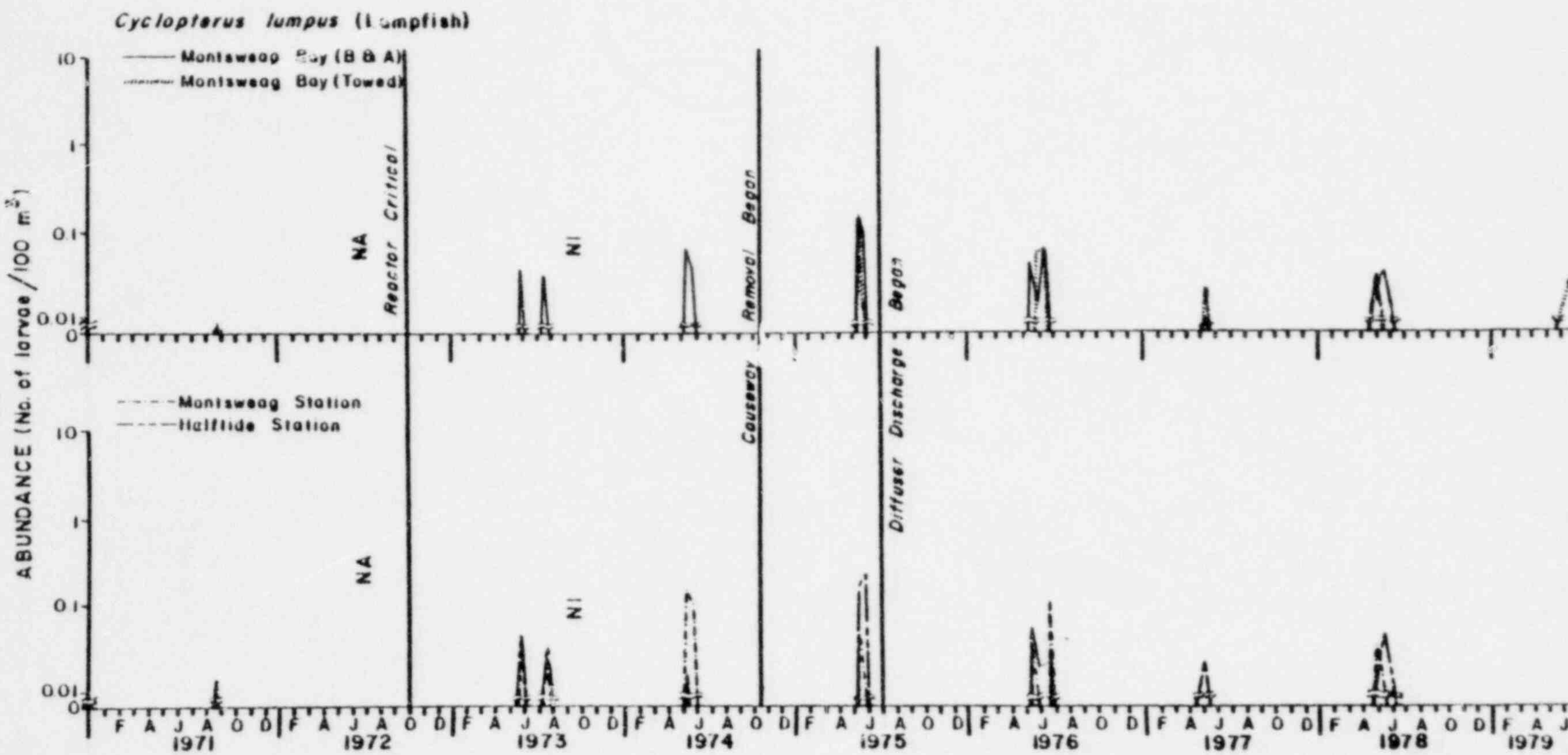
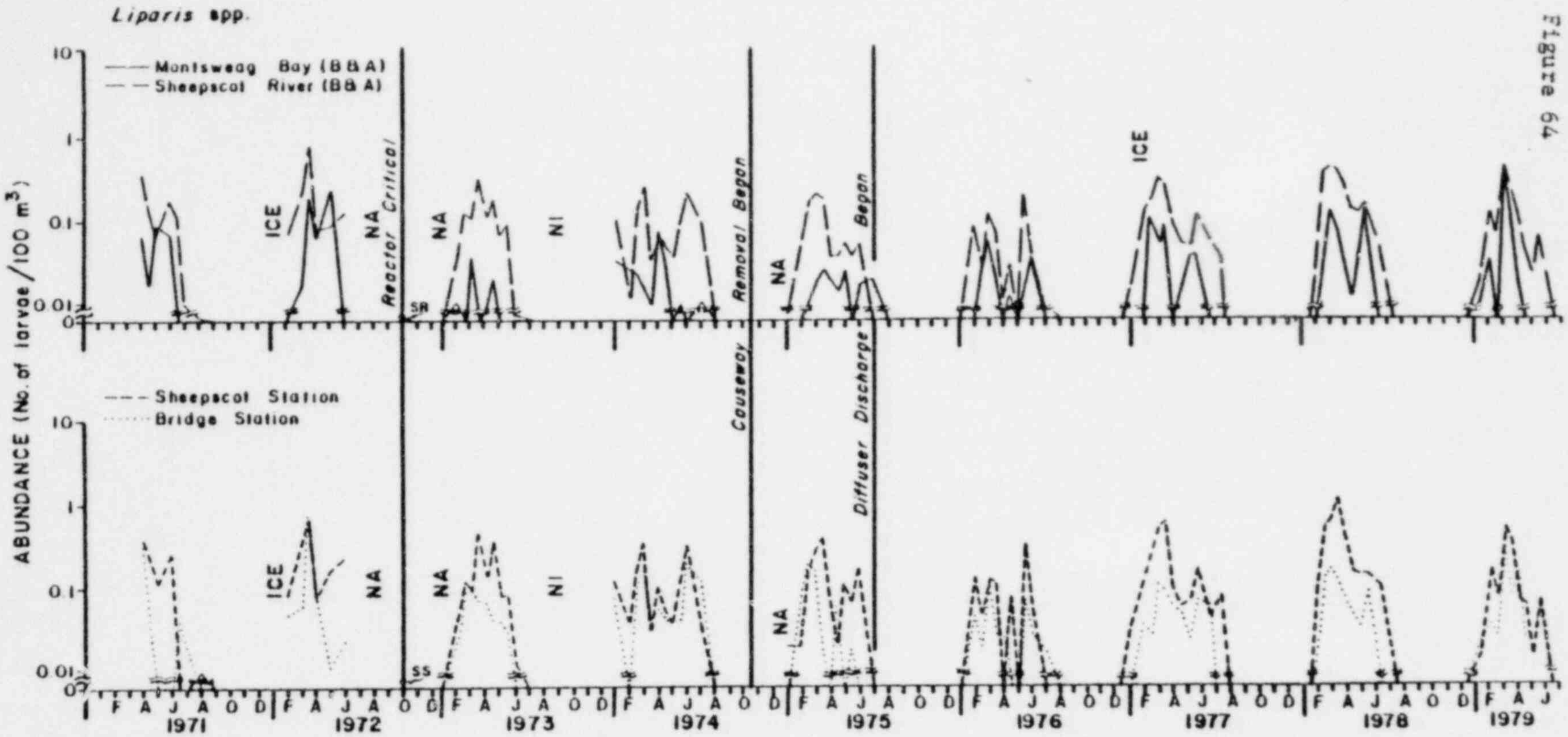

Cyclopterus lumpus (Lumpfish)
Montsweag Bay (B & A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
ABUNDANCE (No. of larvae/100 m³)
10
1
0.1
0.01
0
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 63



Liparis spp.
Montsweag Bay (BB A)
Sheepscot River (BB A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m3)
10
1
0.1
0.01
0
ICE
NA
NI
SR
SS
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 64

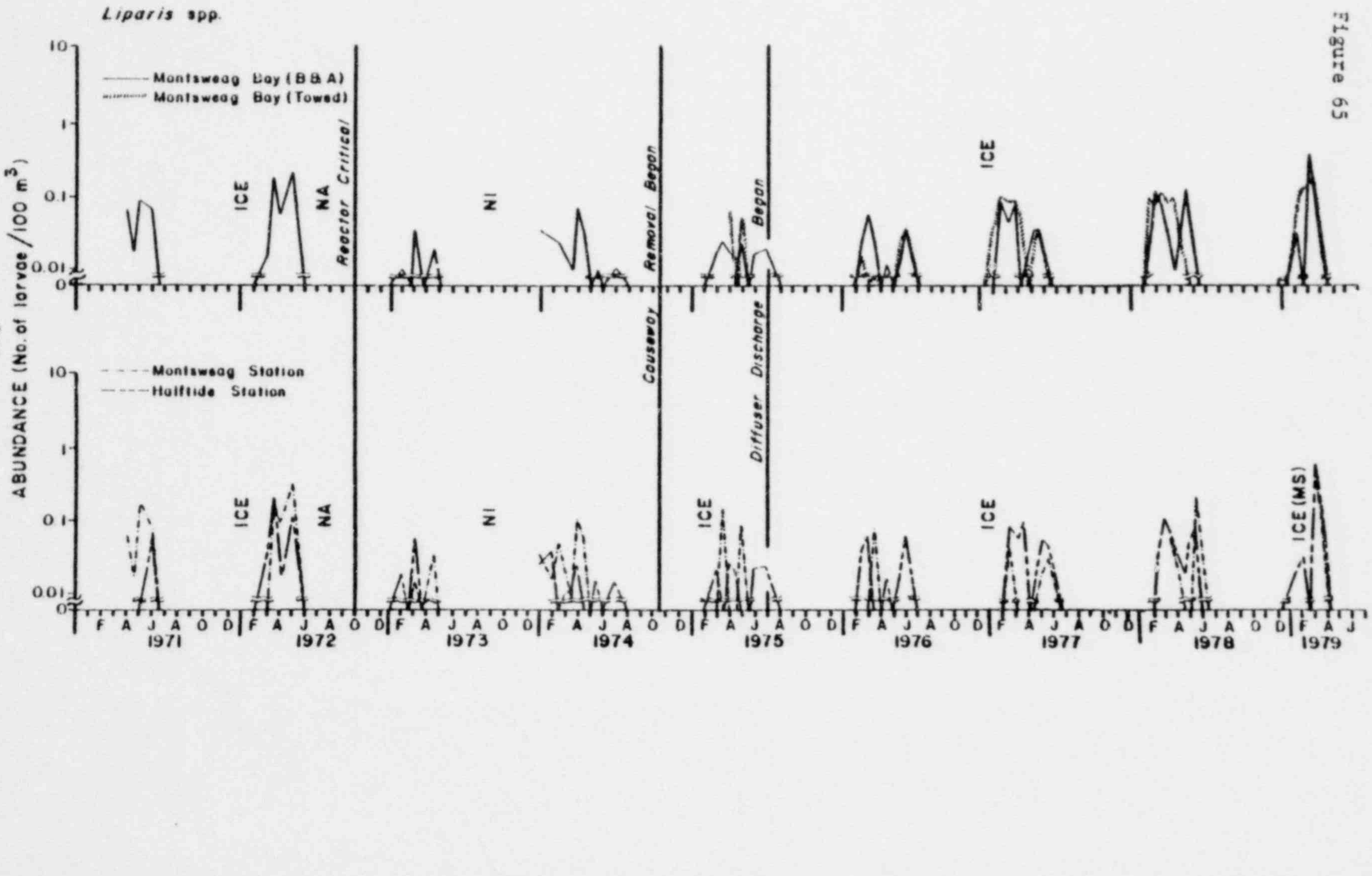

Liparis spp.
ABUNDANCE (No. of larvae/100 m3)
Montsweag Bay (B&A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
ICE
NA
NI
ICE (MS)
10
1
0.1
0.01
0
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 65

Figure 66

Cryptacanthodes maculatus (Wrymouth)

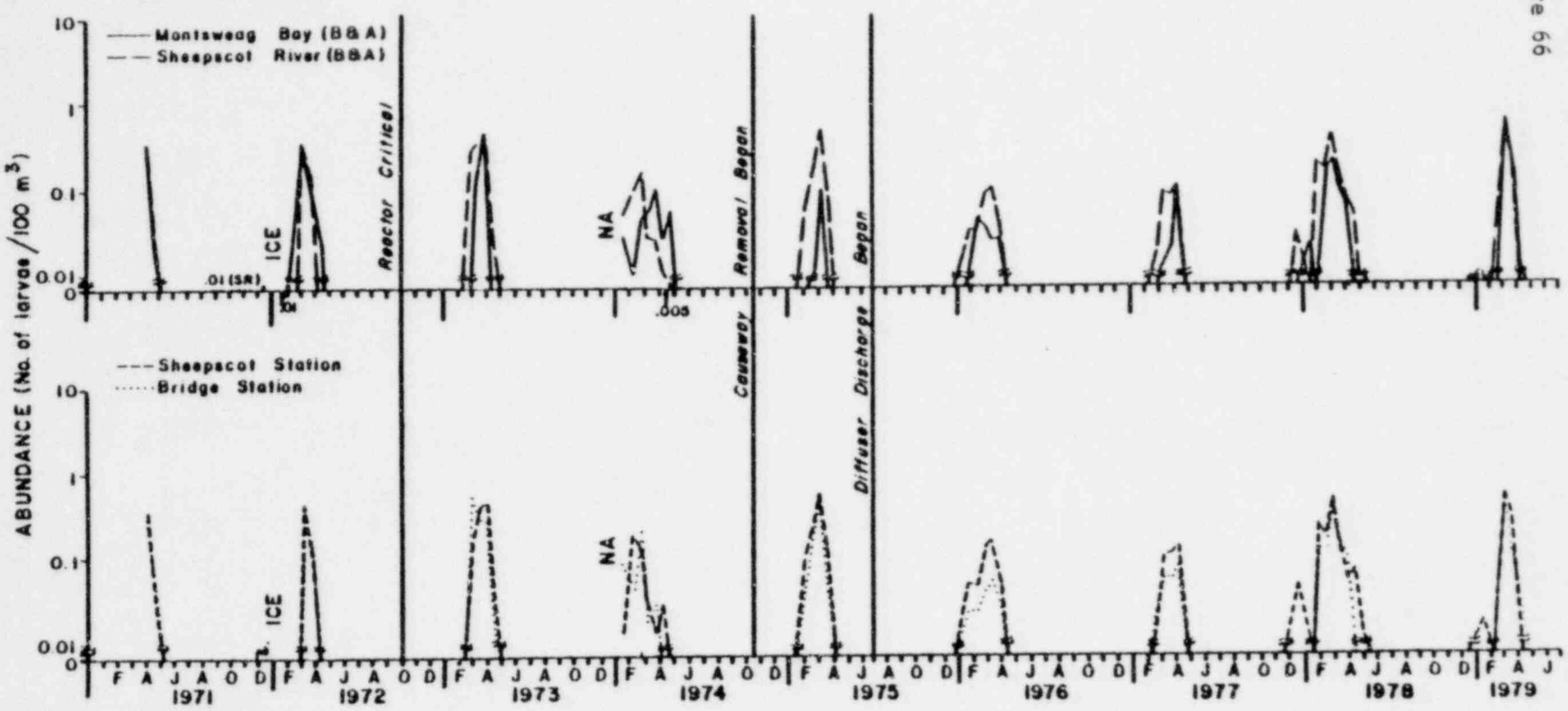
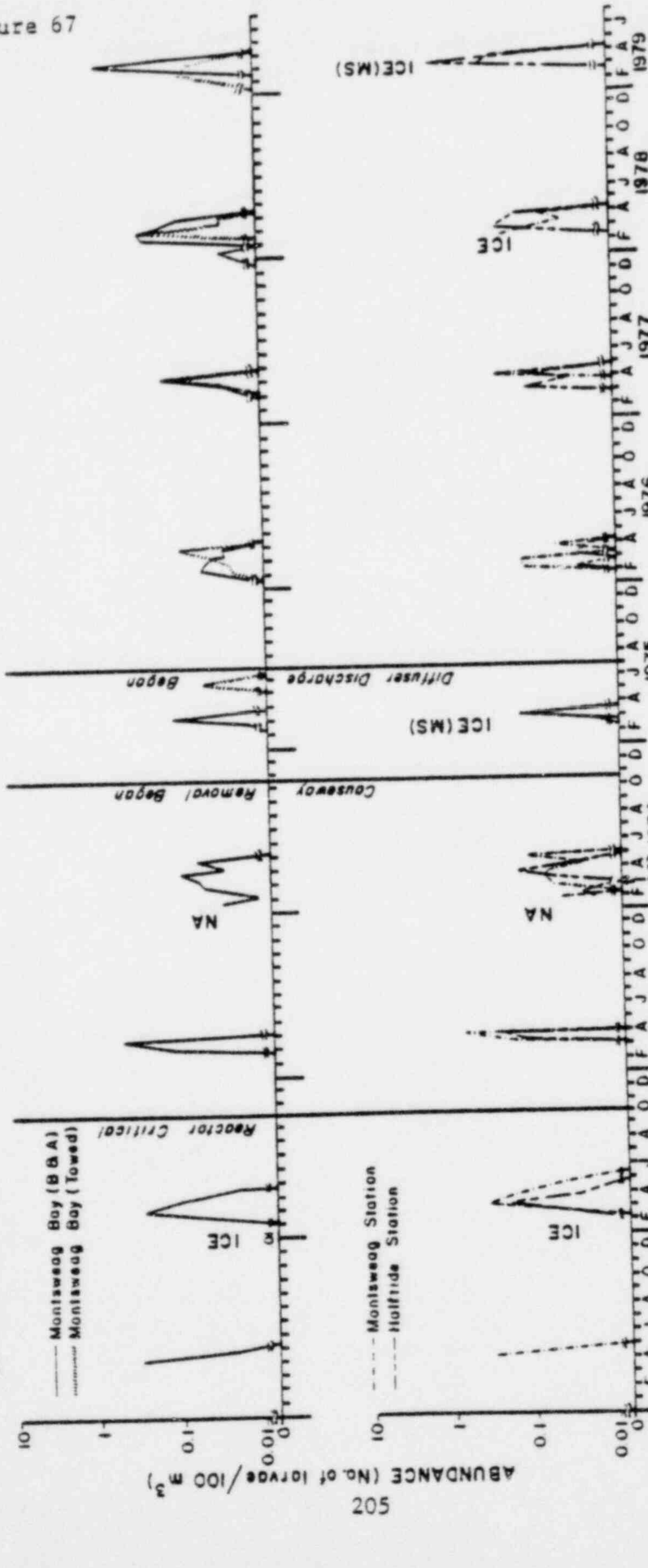


Figure 67


Cryptacanthodes maculatus (Wrymouth)
Montsweag Bay (B&A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
ICE
NA
ICE(MS)
ABUNDANCE (No. of larvae/100 m³)
1971
1972
1973
1974
1975
1976
1977
1978
1979

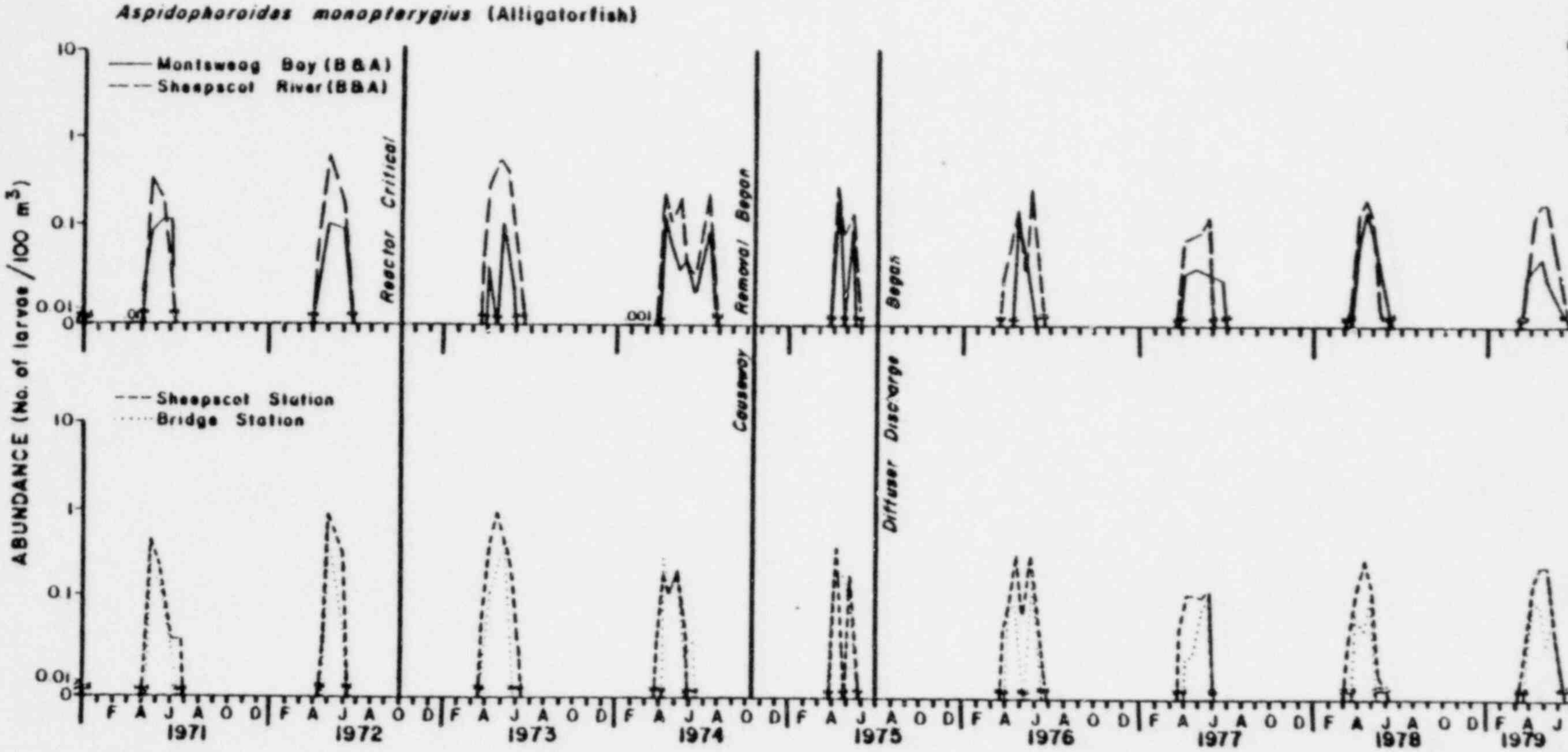
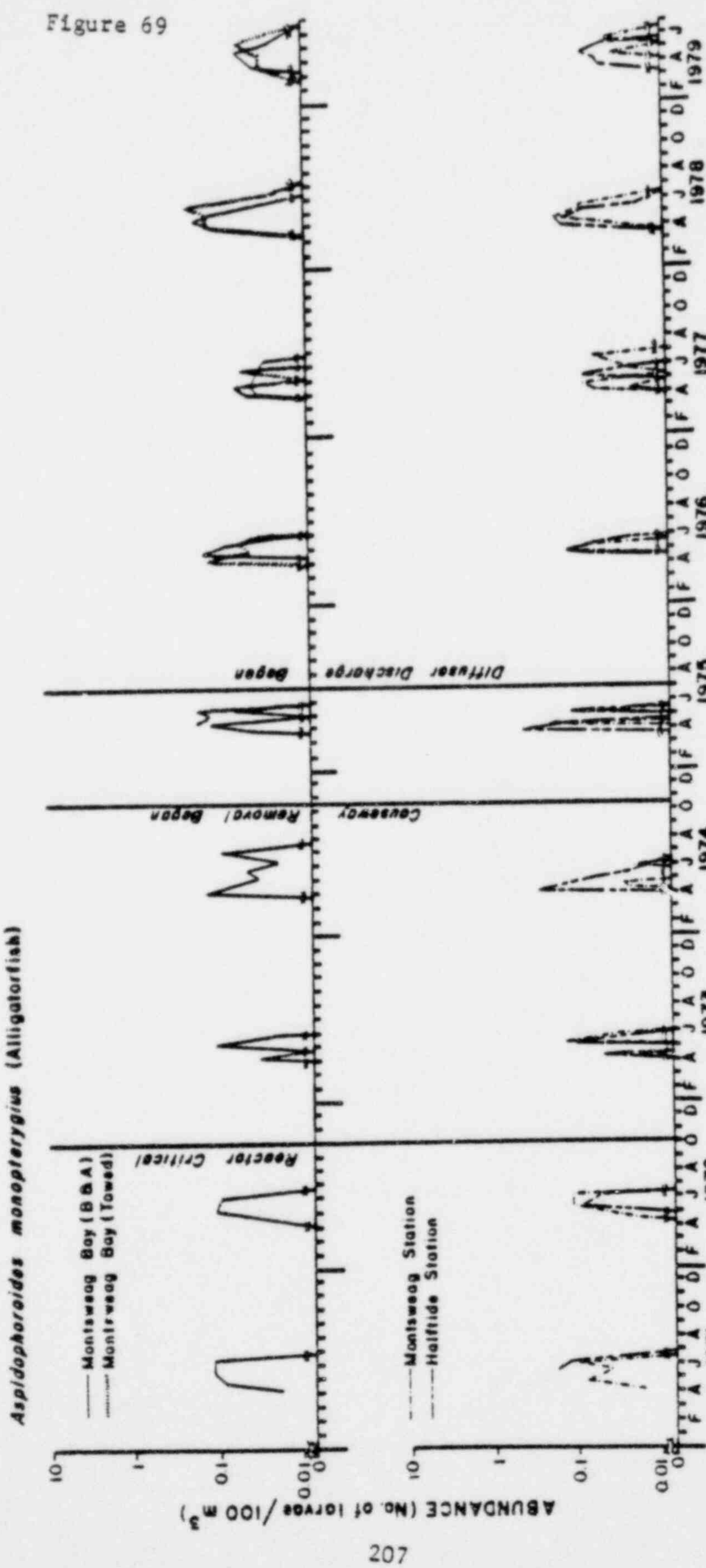

Aspidophoroides monopterygius (Alligatorfish)
Montsweag Bay (B&A)
Sheepscot River (B&A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m^3)
10
1
0.1
0.01
0
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 68

Figure 69



Aspidophoroides monopterygius (Alligatorfish)
Montsweag Bay (B&A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
ABUNDANCE (No. of larvae /100 m3)
10
1
0.1
0.01
0
1971
1972
1973
1974
1975
1976
1977
1978
1979

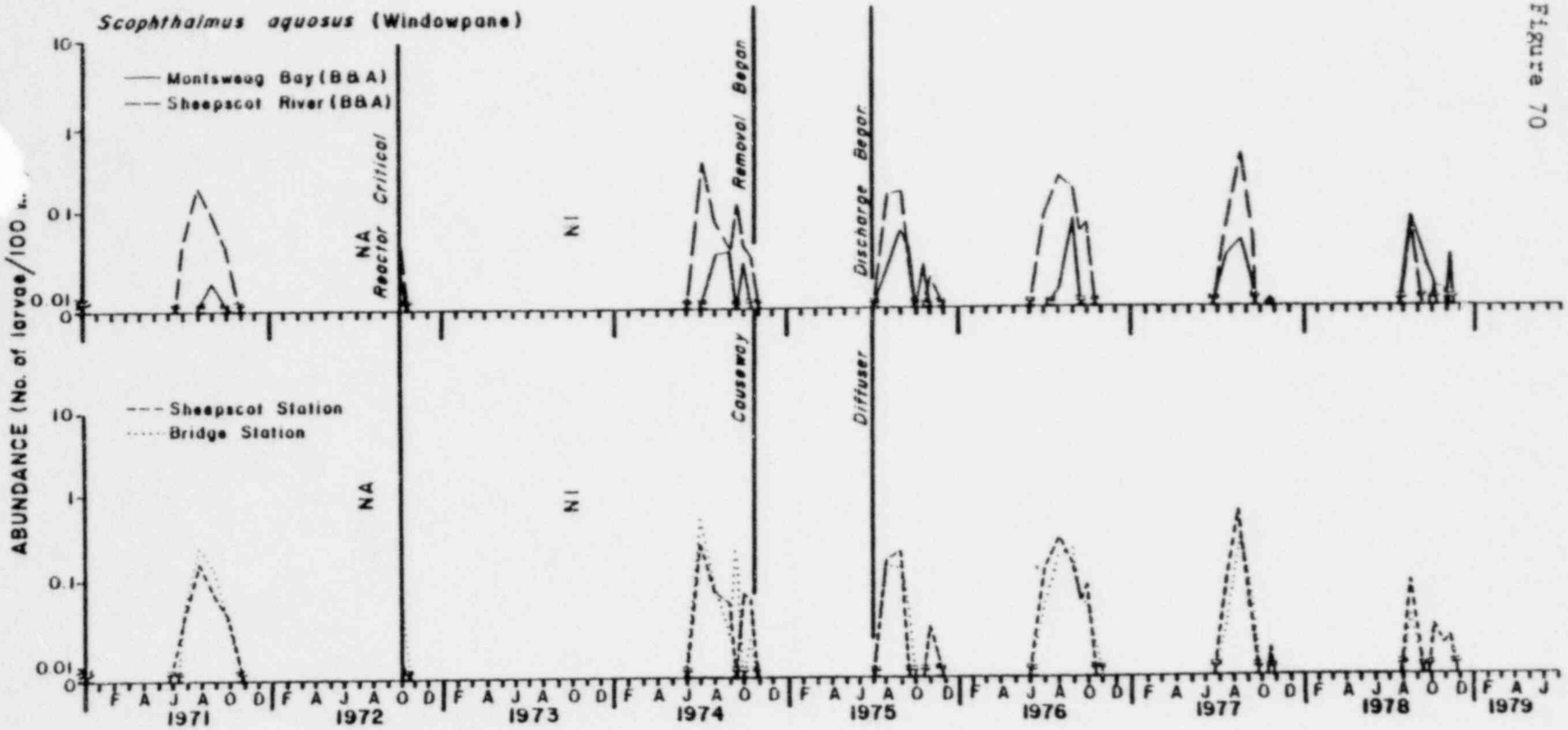

Scophthalmus aquosus (Windowpane)
Montsweag Bay (B&A)
Sheepscot River (B&A)
Sheepscot Station
Bridge Station
ABUNDANCE (No. of larvae/100 m³)
10
1
0.1
0.01
0
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
F A J A O D
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 71

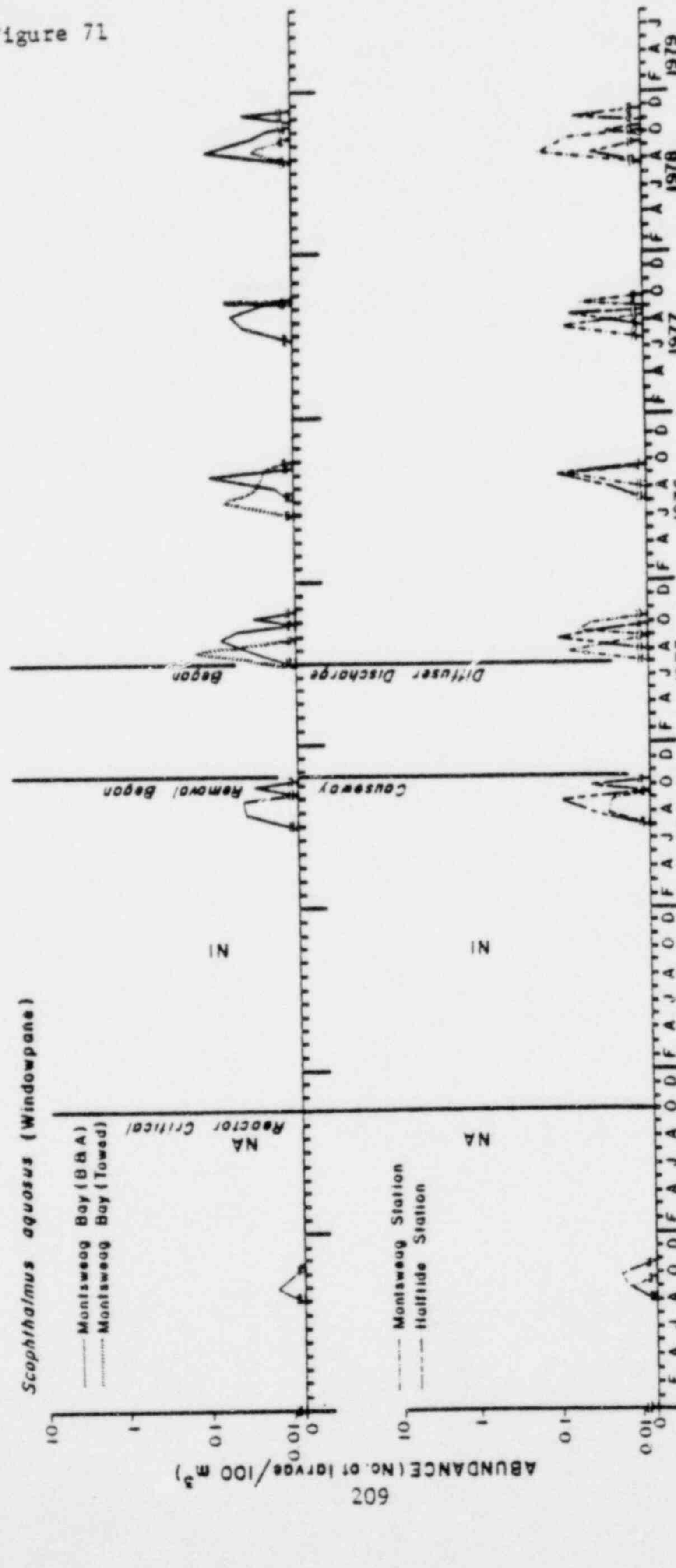

Scophthalmus aquosus (Windowpane)
Montsweag Bay (B & A)
Montsweag Bay (Towed)
Montsweag Station
Halftide Station
NA
NI
Reactor Critical
Causeway Removal Begun
Diffuser Discharge Begun
ABUNDANCE (No. of larvae/100 m³)
10
1
0.1
0.01
0
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 72 Montsweag Bay, 13 May 1971 to 20 June 1979.
Buoyed and anchored larval fish data showing by sampling period:

A Total number of species of larval fish caught (S)
B Total abundance (no. of fish/100 m^3) of larvae
C Shannon's Information Theory Diversity Index (H')
D Pielou's Diversity Evenness Index (J')

NOTE: *____* Designates periods when Hauser's grouping (used until June 1972) of four species of Cottids (*Myoxocephalus aenaeus*, *M. octodecemspinosus*, *M. scorpius*, and *Triglops murrayi*) and four species of sticklebacks (*Gasterosteus aculeatus*, *G. wheatlandi*, *Apeltes quadracus*, and *Pungitius pungitius*) into just two species groups, "sculpins" and "sticklebacks", respectively, affected the "S" (number of species) factor in the calculation of diversity and evenness indices.

——————— Hauser's grouping
- - - - - - - - - Groups broken down into six species ($\overline{X}$ = three species per each group)

NI - Data not included in these graphs
NA - Data not available

Figure 72

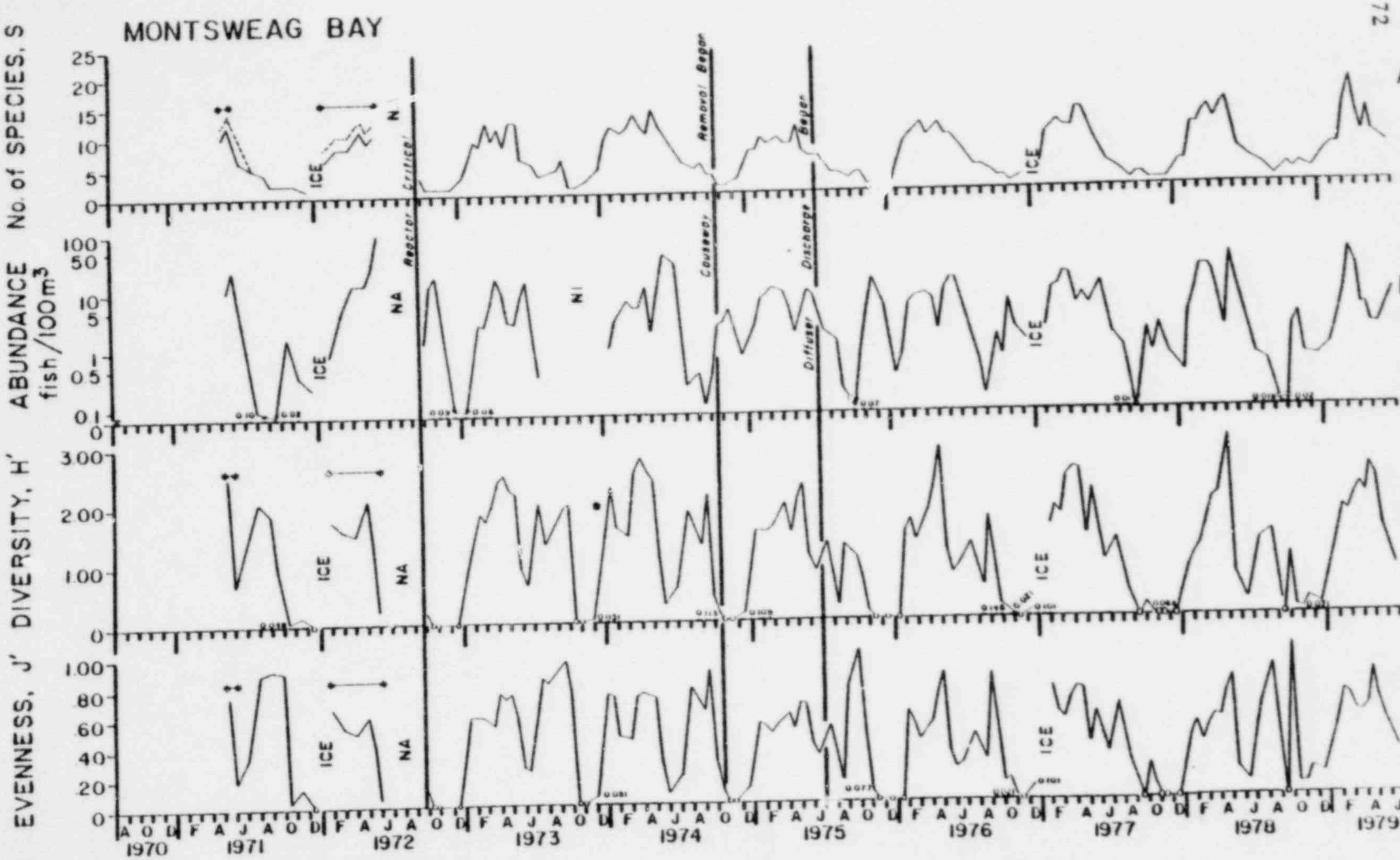

MONTSWEAG BAY
No. of SPECIES, S
ABUNDANCE fish/100m³
DIVERSITY, H'
EVENNESS, J'
A
B
C
D
ICE
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

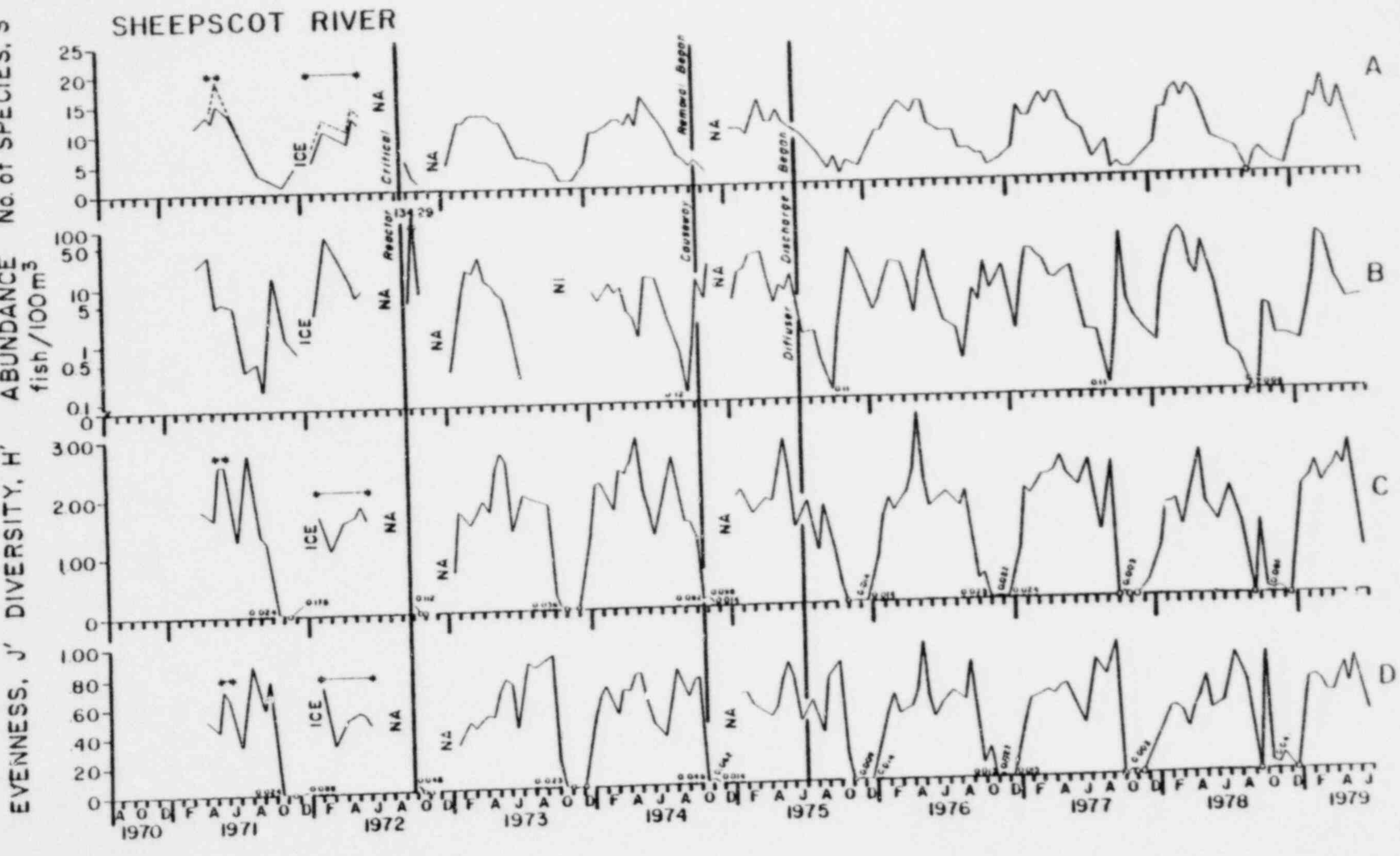
Figure 73 Sheepscot River, 13 May 1971 to 20 June 1979. Buoyed and anchored larval fish data showing by sampling period:

A Total number of species of larval fish caught (S)
B Total abundance (no. of fish/100 m^3) of larvae
C Shannon's Information Theory Diversity Index (H')
D Pielou's Diversity Evenness Index (J')

NOTE: *____* Designates periods when Hauser's grouping (used until June 1972) of four species of Cottids (*Myoxocephalus aenaeus*, *M. octodecemspinosus*, *M. scorpius*, and *Triglops murrayi*) and four species of sticklebacks (*Gasterosteus aculeatus*, *G. wheatlandi*, *Apeltes quadracus*, and *Pungitius pungitius*) into just two species groups, "sculpins" and "sticklebacks", respectively, affected the "S" (number of species) factor in the calculation of diversity and evenness indices.

——— ———Hauser's groupings
-----------Groups broken down into six species ($\overline{x}$ = three species per each group)
NI - Data not included in these graphs
NA - Data not available

Figure 73


SHEEPSCOT RIVER
A
B
C
D
No. of SPECIES, S
ABUNDANCE fish/100m^3
DIVERSITY, H'
EVENNESS, J'
ICE
NA
NI
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figures 74 to 77. Average water temperatures at Montsweag, Halftide, Sheepscot, and Bridge stations for each net level. For the Montsweag and Sheepscot stations data were taken from 11 August 1970 to 20 June 1979. For the Halftide stations data collection commenced on 13 May 1971 while the Bridge station data collection began on 1 April 1971. Average readings were obtained from measurements made at each net level before, during, and after each sampling period.

Figures 78 to 81. Average water salinities at Montsweag, Halftide, Sheepscot, and Bridge stations for each net level. Data collection dates and the method for arriving at average readings were the same as above.

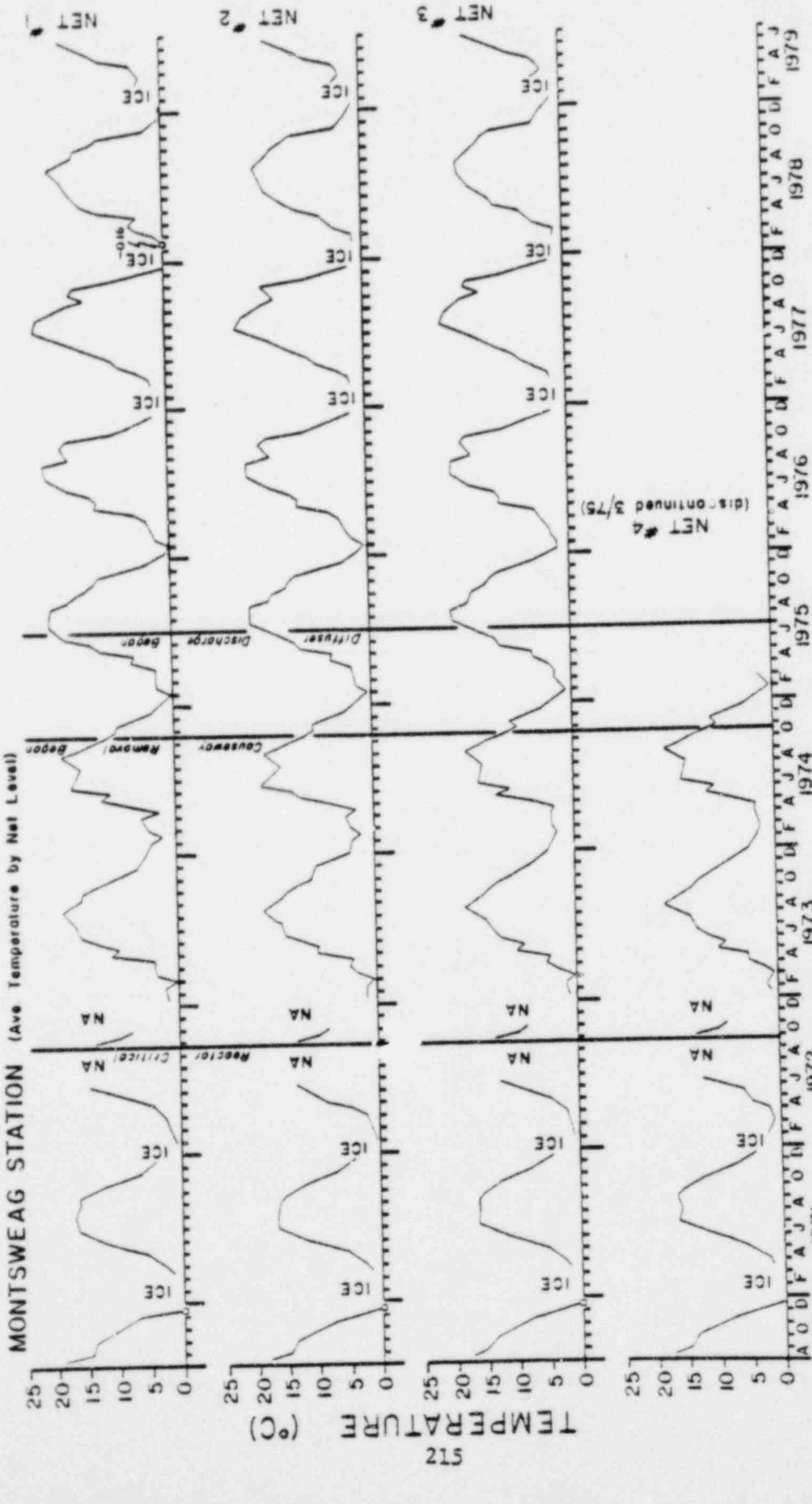
NOTE: Data collection before 8 June 1972 was made by Hauser (see Hauser, 1973).

NOTE: The fourth net was discontinued for all stations in March 1975.

NOTE: As of August 1977 the salinomiter-temperature probe was modified to read temperatures as low as -2.00°C.

NA - Data not available

Figure 74



MONTSWEAG STATION (Ave Temperature by Net Level)
TEMPERATURE (°C)
NET #1
NET #2
NET #3
NET #4 (discontinued 3/75)
ICE
NA
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 75

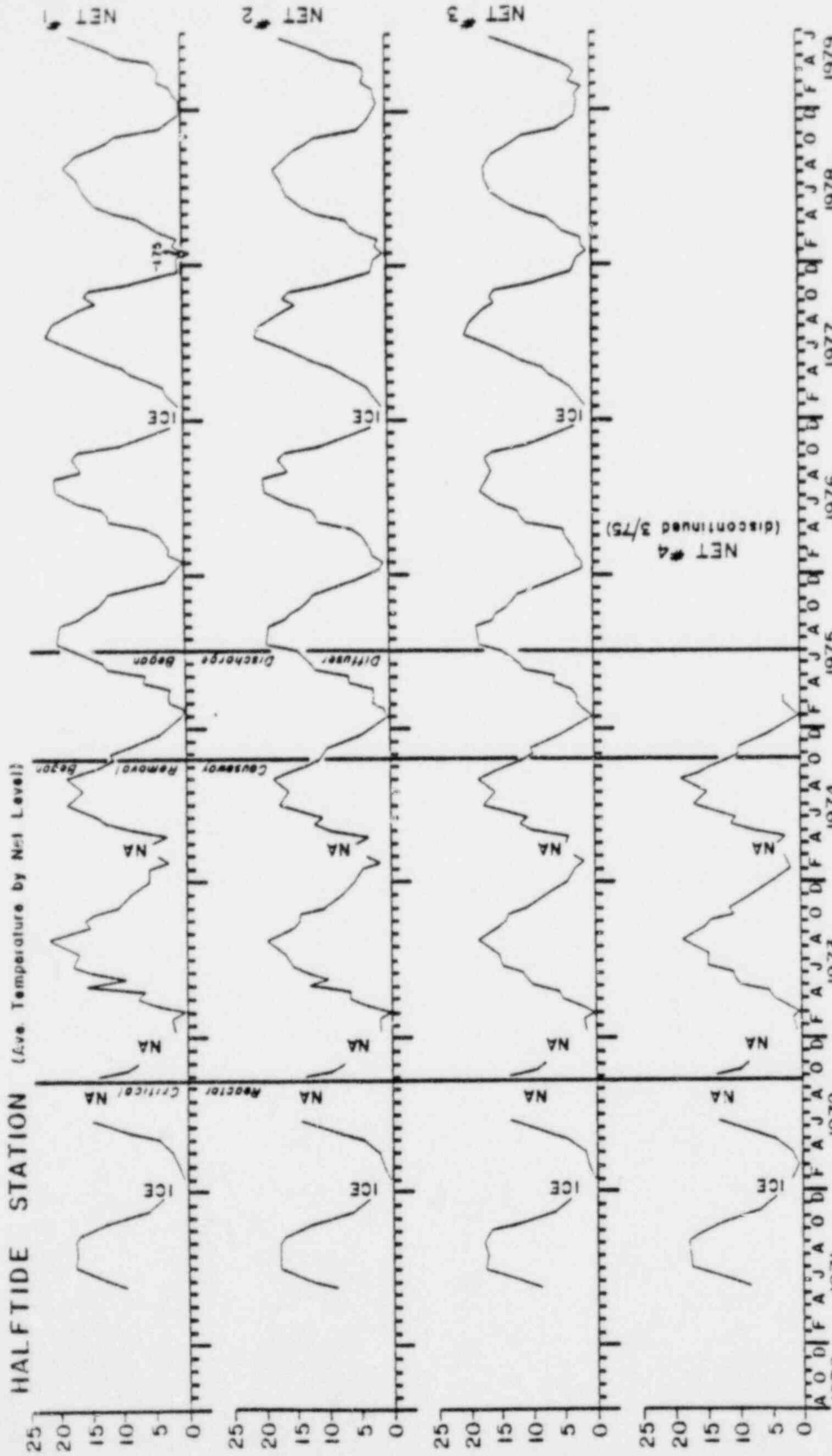
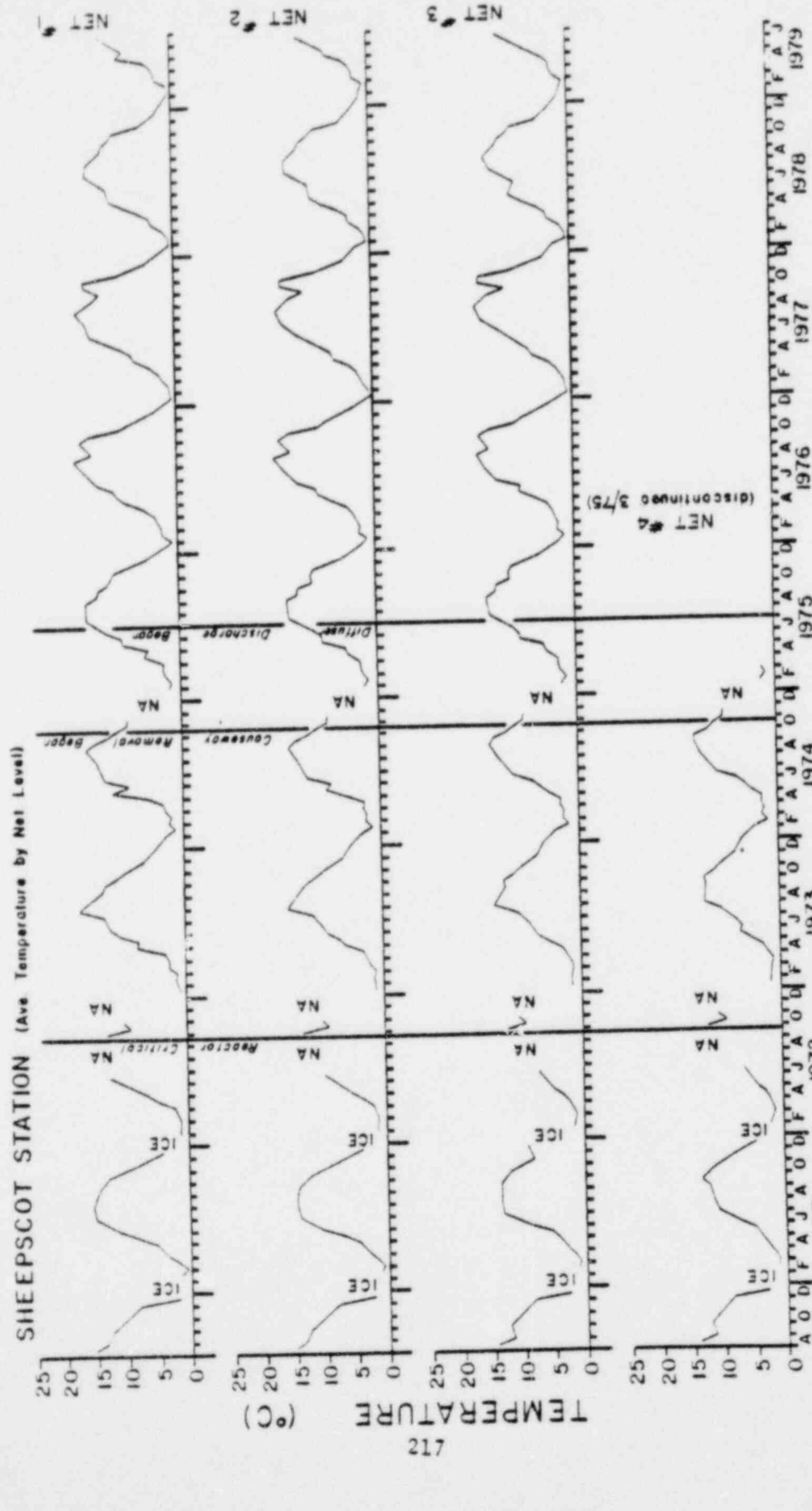

HALFTIDE STATION (Ave. Temperature by Net Level)
NET #1
NET #2
NET #3
NET #4 (discontinued 3/75)
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
ICE
NA
TEMPERATURE (°C)
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 76



SHEEPSCOT STATION (Ave Temperature by Net Level)
NET #1
NET #2
NET #3
NET #4 (discontinued 3/75)
TEMPERATURE (°C)
ICE
NA
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
0
5
10
15
20
25
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

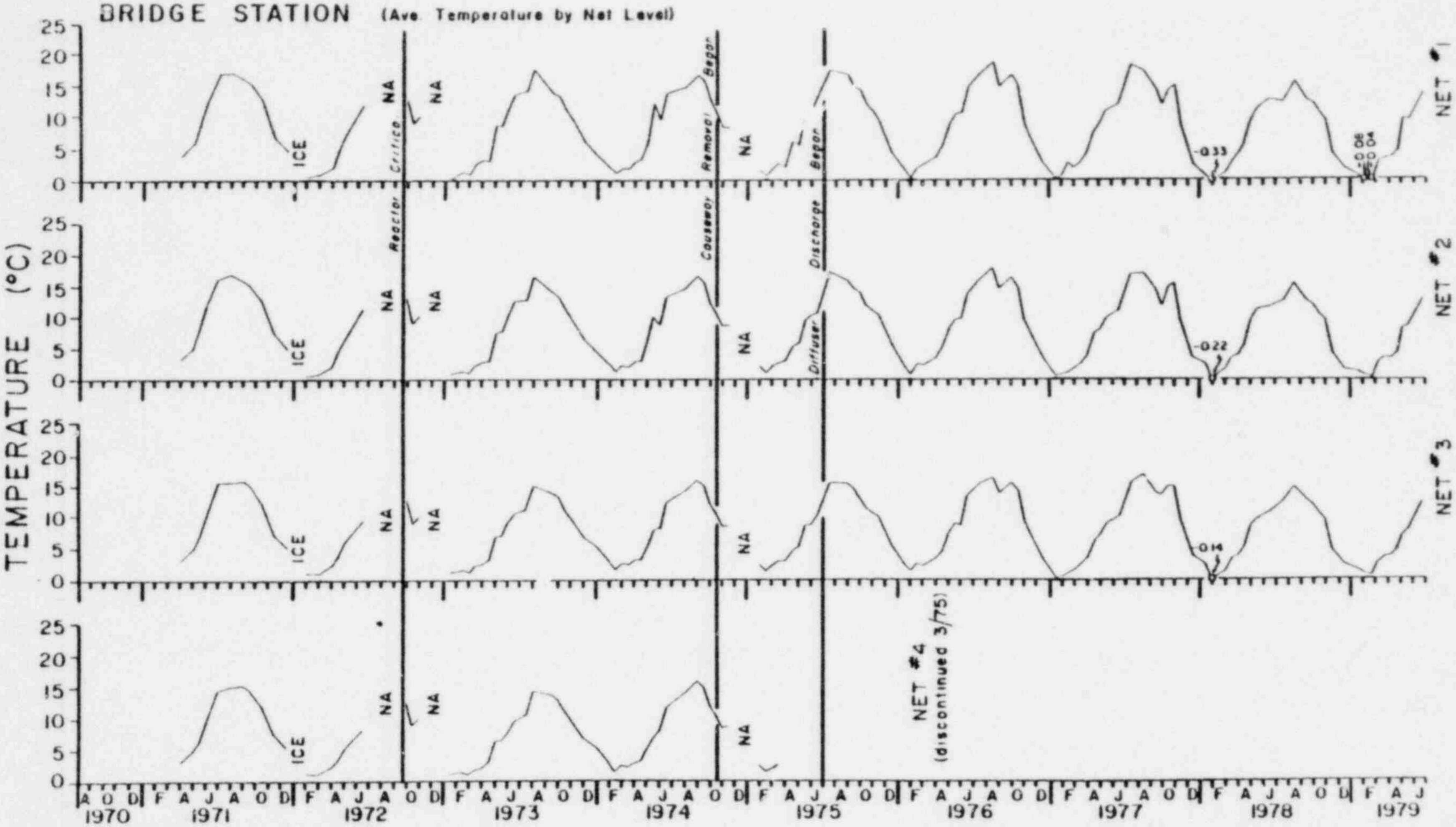

BRIDGE STATION (Ave. Temperature by Net Level)
TEMPERATURE (°C)
NET #1
NET #2
NET #3
NET #4 (discontinued 3/75)
Reactor Critical
Causeway Removal Began
Discharge Diffuser Began
NA
ICE
-0.33
-0.06
-0.04
-0.22
-0.14
A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D F A J
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 77

Figure 78

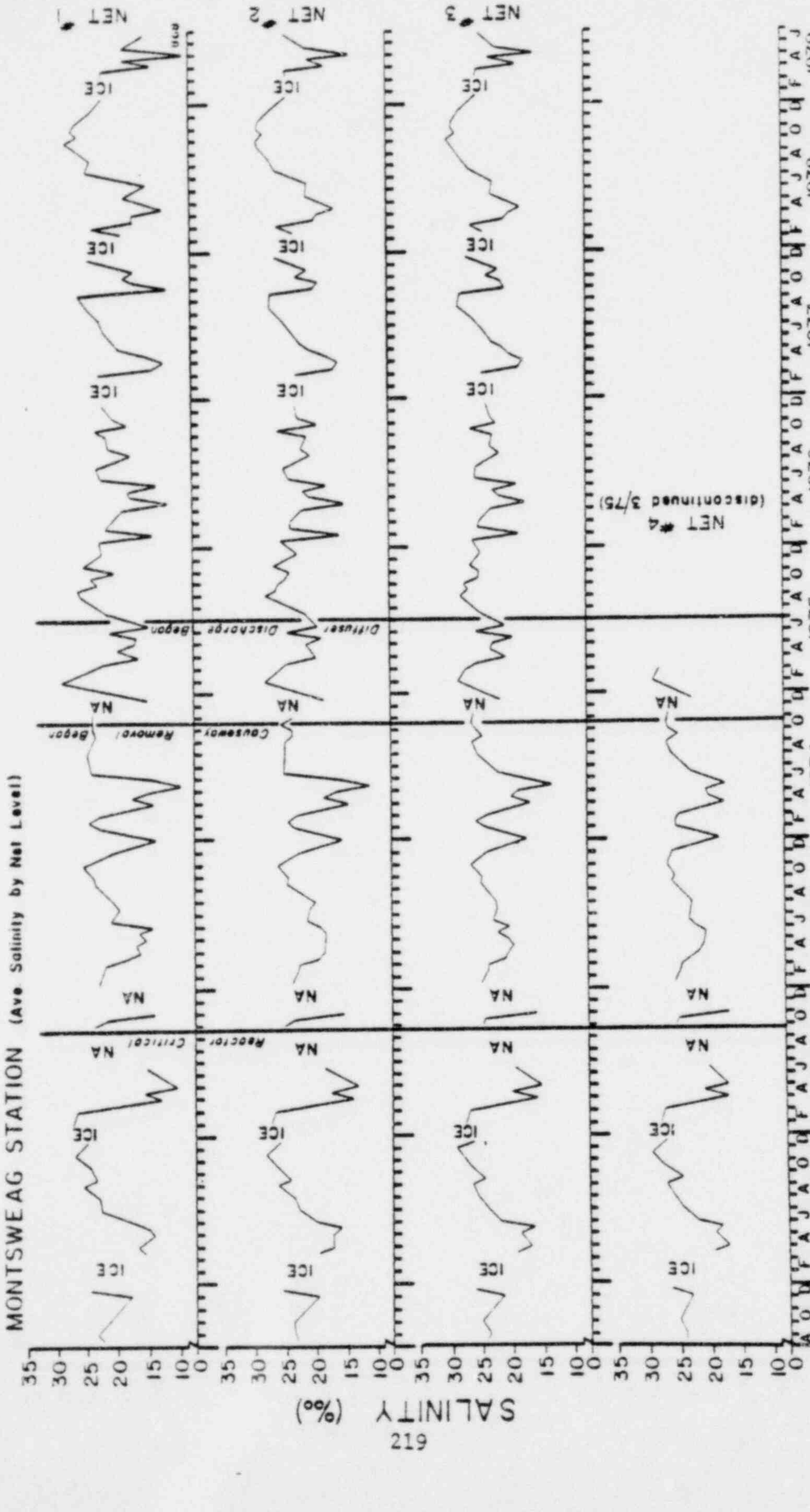

MONTSWEAG STATION (Ave Salinity by Net Level)
SALINITY (‰)
NET #1
NET #2
NET #3
NET #4
(discontinued 3/75)
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
ICE
NA
35
30
25
20
15
10
0
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 79

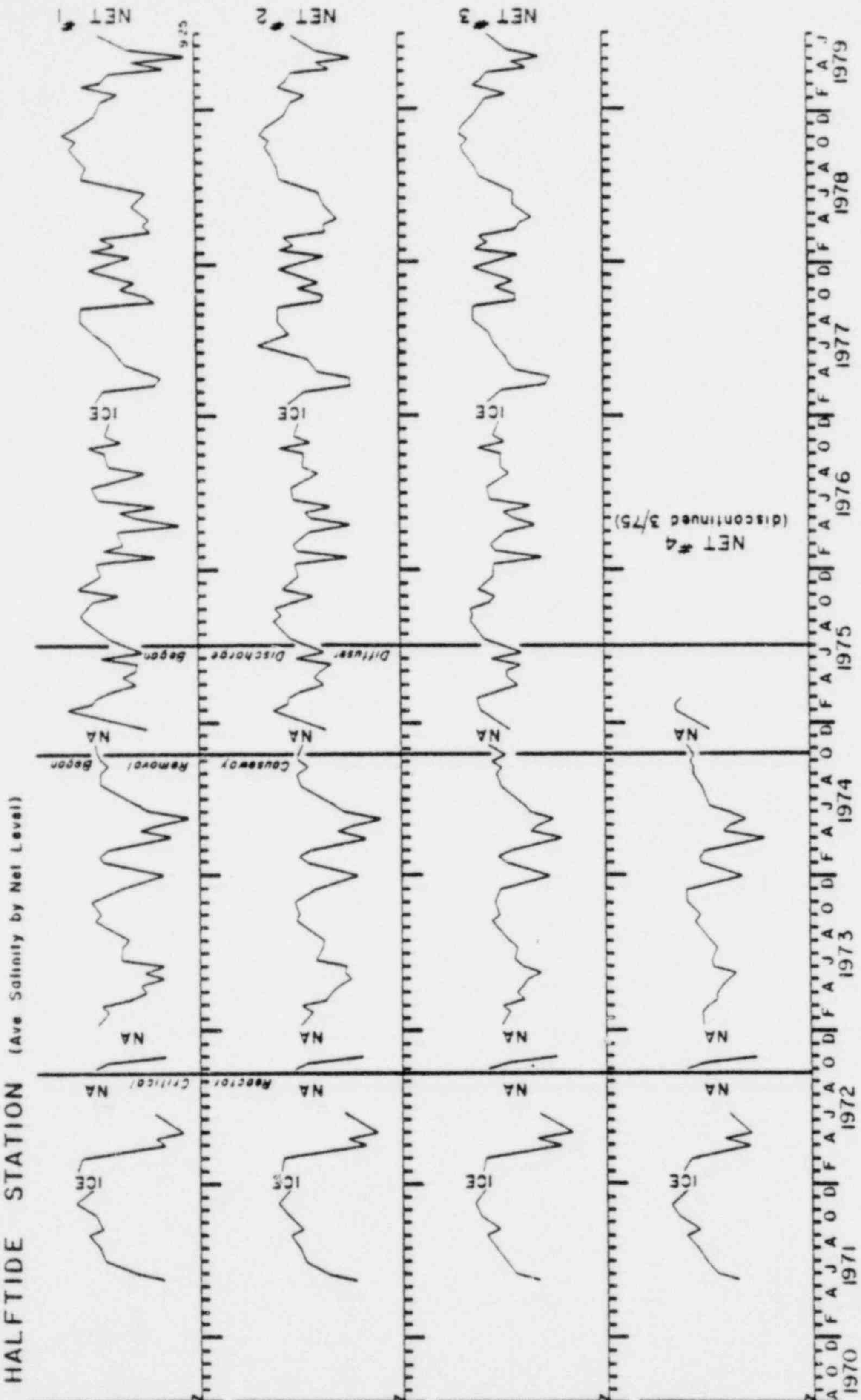

HALFTIDE STATION (Ave Salinity by Net Level)
NET #1
NET #2
NET #3
NET #4 (discontinued 3/75)
ICE
NA
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
SALINITY (‰)
35 30 25 20 15 10 0
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979

Figure 80

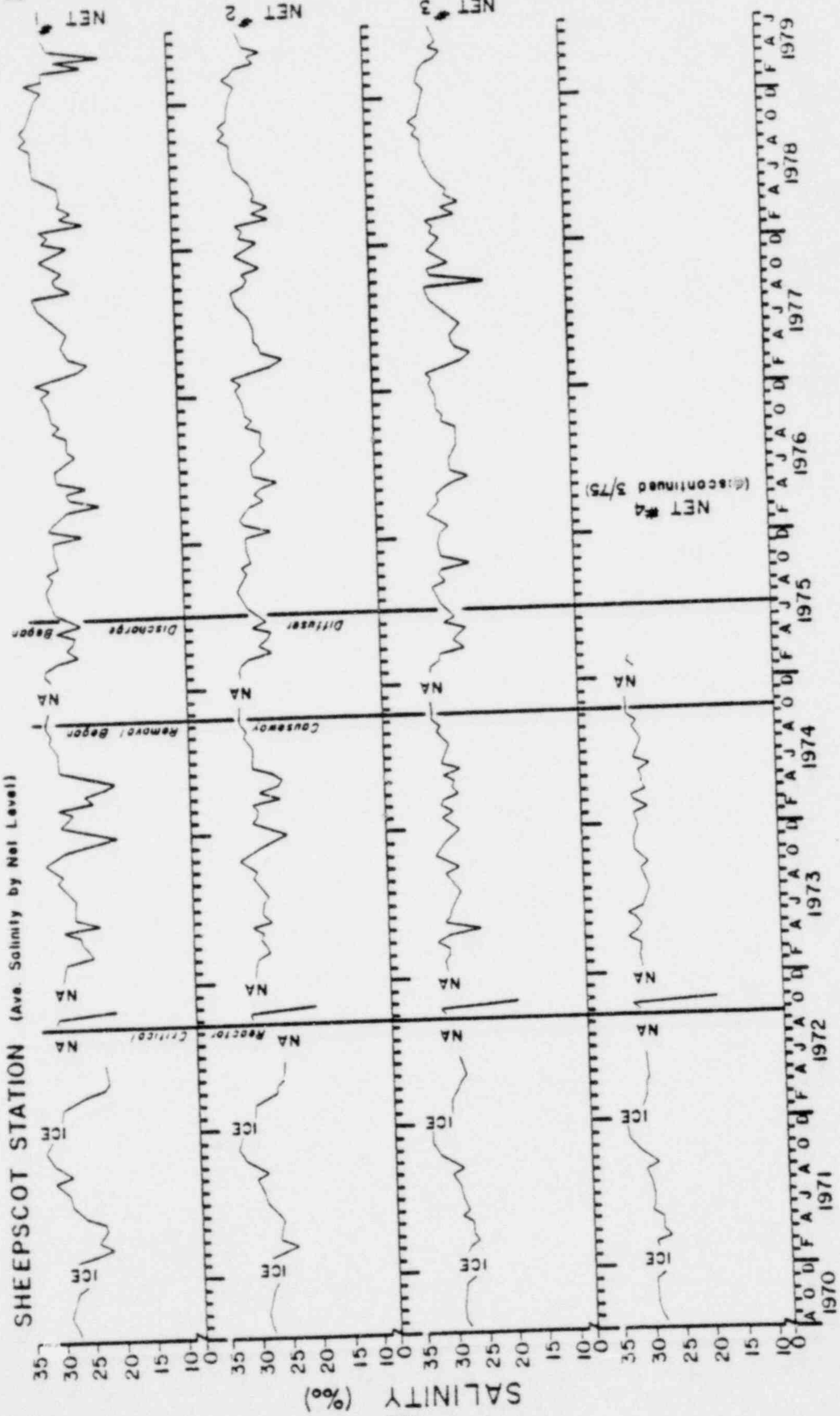
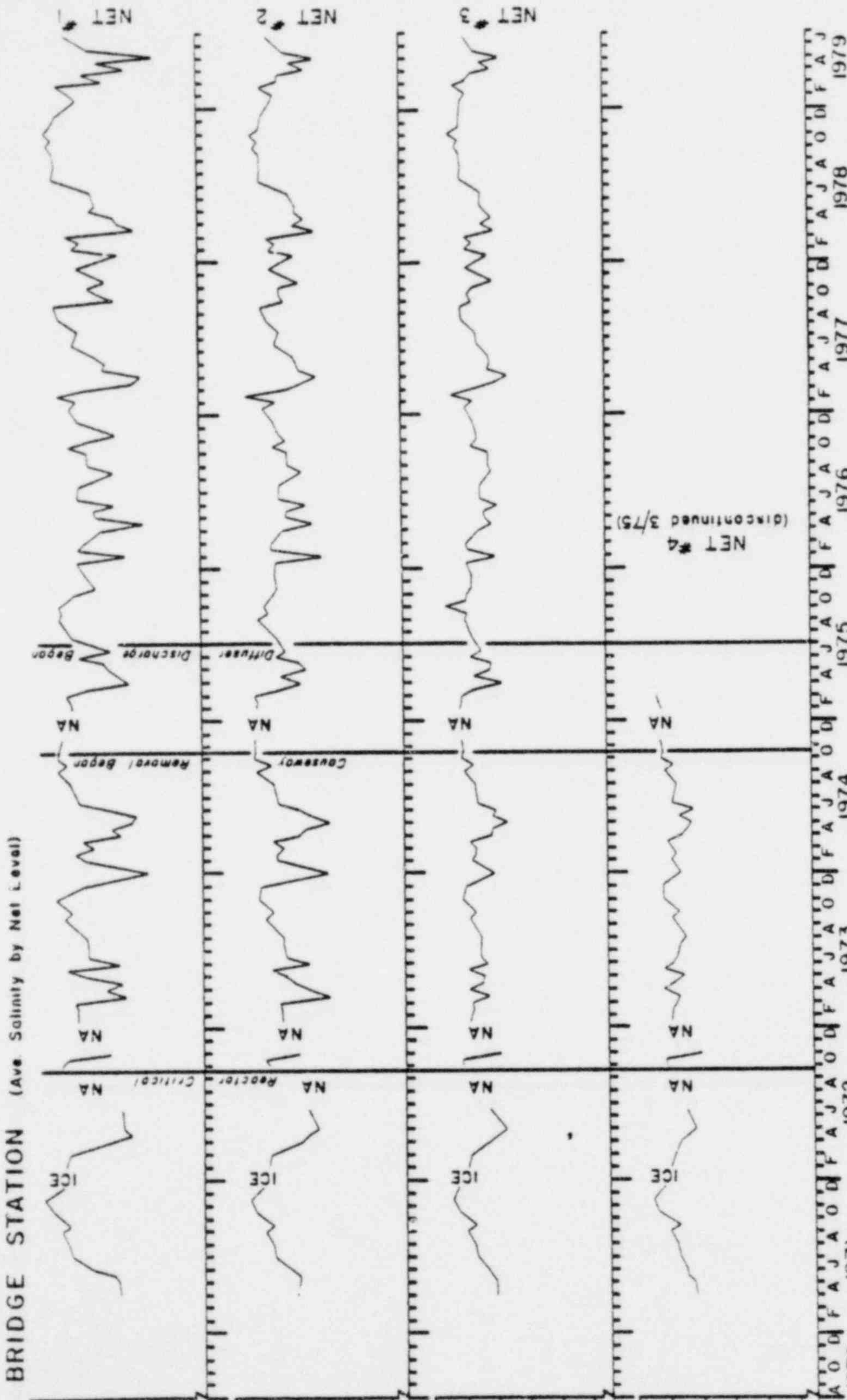

SHEEPSCOT STATION (Ave. Salinity by Net Level)
SALINITY (‰)
NET #1
NET #2
NET #3
NET #4
(discontinued 3/75)
ICE
NA
Reactor Critical
Causeway Removal Begun
Diffuser Discharge Begun
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

Figure 81


BRIDGE STATION (Ave. Salinity by Net Level)
NET #1
NET #2
NET #3
NET #4
(discontinued 3/75)
Reactor Critical
Causeway Removal Began
Diffuser Discharge Began
ICE
NA
SALINITY (‰)
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979

BENTHOS

David Dean and Terry Cucci

Introduction

Benthic communities are good indicators of environmental stress conditions because of their fluctuations in abundance in relation to these stresses. This particular study involves the monitoring of the benthos at nine selected sites; six experimental stations in Montsweag Bay - Back River area (MB-BR) and three control stations in nearby waters. Figure 82 shows the nine areas currently being investigated. The objective of this continuing study is to reveal any effects the warmed water discharge from the Maine Yankee Nuclear Generating Station has on the benthic communities in the local area of Montsweag Bay.

Methods

Benthic samples were obtained using a Ponar grab which removes a volume of sediment from an area of 0.05 m^2 down to a maximum depth of 13.5 cm. At each station, three grabs are taken and treated separately. A sediment sample is taken from the third grab to be processed in the laboratory. All grabs are washed through a 500u sieve to remove excess sediment and preserved with 10% buffered formalin. Rose Bengal was added to the formalin which stains the organisms and facilitates the sorting

Ira C. Darling Center Ref. No. 79-7g

of the animals from the remaining sediment and detritus. All organisms are identified and counted for each separate grab at all stations. They are then packed in 70% isopropyl alcohol and stored in labeled vials.

Sediment analysis involves the modified ASTM standard 0422-51 method. The silt-clay fractions (<63μ) are analyzed with a hydrometer utilizing 100 grams of sediment dispersed with 10 ml (5%) sodium metaphosphate. The sandy fractions (>63μ) are analyzed by washing the sample through a 63μ sieve, oven dried, and shaken through a series of screens (2000, 1000, 500, 250, 125, and 63 microns) for 15 minutes. All sediments retained on each sieve are weighed to obtain the size distribution greater than 63μ. Sediment classifications were described according to Shepard (1954) (Figure 83).

Results will be discussed in two sections; intertidal stations which consist of 4 experimental stations (B1-I, B2-I, B3-I, B8-I) and 3 control stations (B5-I, B6-I, B7-I), and subtidal stations consisting of 2 stations (B2-S, B4-S).

Results

Intertidal stations

Declines in total numbers of individuals were observed from March 1979 (8,442 individuals) to June 1979 (6,596 individuals). A similar trend has been observed in the last several years with peak abundances in late summer (September) followed by a gradual decline from December to June (Dean and Cucci, 1978, 1979). Several new species were recorded during sampling periods 39 and 40 (March 1979 and June 1979) and can be found on Table 76.

Sediment characteristics for 6 intertidal stations remain consistent with previous years (Figure 84). The only exception was at Bailey Cove (B2-I) where a combined sand-silt-clay characteristic was observed.

Previous data characterized this station as predominantly a silty sediment. Two control stations outside Montsweag Bay, Rum Cove (B6-I) and Wentworth Point (B7-I), possess sediment characteristics more towards the sandy fractions.

Table 77 lists the most abundant species at all intertidal stations for each of the four experimental and three control stations. Although *Aglaophamus* sp. was the most abundant species in both sampling periods (39 and 40), it appeared in 5 of 7 stations in March 1979 and 4 of 7 stations in June 1979. Approximately 60% and 78% of the total number of *Aglaophamus* sp. were encountered at B6-I (Rum Cove) for March 1979 and June 1979, respectively. The only other station with relatively high densities of *Aglaophamus* sp. was at B1-I (Berry Flats) where 25% and 20% of the total number of individuals were found during March 1979 and June 1979, respectively.

Tharyx acutus is another such species which ranks among the most abundant species, yet it is predominantly found at B5-I (Bareneck Island Cove). Approximately 92% and 91% of the total number of individuals were found at B5-I during March 1979 and June 1979, respectively. *Clymenella torquata*, which ranked among the ten most abundant species in June 1979 was found only at B7-I (Wentworth Point).

Those species whose distribution is widespread and of similar densities among the intertidal stations are *Heteromastus filiformis*, *Scoloplos* sp., *Streblospio benedicti*, and *Macoma balthica*.

Figures 85-94 illustrate mean annual densities (no. individuals/m^2) of some of the more dominant species found at all intertidal stations. It must be noted that the results for 1979 are based only on the first two quarterly sampling periods (39, March 1979, and 40, June 1979).

Previous data characterized this station as predominantly a silty sediment. Two control stations outside Montsweag Bay, Rum Cove (B6-I) and Wentworth Point (B7-I), possess sediment characteristics more towards the sandy fractions.

Table 77 lists the most abundant species at all intertidal stations for each of the four experimental and three control stations. Although *Aglaophamus* sp. was the most abundant species in both sampling periods (39 and 40), it appeared in 5 of 7 stations in March 1979 and 4 of 7 stations in June 1979. Approximately 60% and 78% of the total number of *Aglaophamus* sp. were encountered at B6-I (Rum Cove) for March 1979 and June 1979, respectively. The only other station with relatively high densities of *Aglaophamus* sp. was at B1-I (Berry Flats) where 25% and 20% of the total number of individuals were found during March 1979 and June 1979, respectively.

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Those species whose distribution is widespread and of similar densities among the intertidal stations are *Heteromastus filiformis*, *Scoloplos* sp., *Streblospio benedicti*, and *Macoma balthica*.

Figures 35 illustrates mean annual densities (no. individuals/m^2) of some of the more dominant species found at all intertidal stations. It must be noted that the results for 1979 are based only on the first two quarterly sampling periods (39, March 1979, and 40, June 1979).

Aglaophamus sp. was the only species that had substantial increases at the two st..ions where approximately 85% of the total number were found. A 110% increase in mean annual density was observed at B1-I (Berry Flats) and a 112% increase at B6-I (Rum Cove). The only major decrease was seen at B7-I (Wentworth Point) which can possibly be explained by a shift in sediment characteristics from a silty sand in previous years and in March 1979 to a pure sand substrate in June 1979 in which no *Aglaophamus* were observed.

Perhaps the most interesting finding in sampling periods 39 and 40 (March 1979 and June 1979) was the sharp decline in *Streblospio benedicti*. The previous 2 years saw large increases in abundance at all stations (Dean and Cucci, 1978; 1979); however, indications of a rapid decline in *S. benedicti* abundance have been observed at all stations for these two sampling quarters in 1979. In Figure 93 similar declines were observed in 1974 and 1975 at stations where, previously, its densities were extremely high. These results seem to indicate cyclic occurrences of *Streblospio benedicti* in benthic communities.

Mean annual densities for *Heteromastus filiformis* in the first half of 1979 show declines at all stations except at B8-I (Long Ledge) where a 65% increase in density occurred. Reasons for this increase at B8-I cannot be explained at this time.

Scoloplos sp. densities increased at all stations except at B7-I (Wentworth Point) where a slight decline occurred (Figure 92). These results support past conclusions that *Scoloplos* sp. is a dominant species in the benthic communities in and around Montsweag Bay - Back River.

Small declines in mean annual densities were observed for *Macoma balthica* and *Polydora* sp. while fluctuations in densities were found with *Hydrobia totteni*, *Tharyx acutus*, and Oligochaeta (Figures 88-91 and 94).

During sampling periods 39 and 40 (March 1979 and June 1979), several new species were identified not previously seen in past benthic samples. A list of these species can be found in Table 76.

Subtidal stations

In March 1979 a total of 904 individuals were found at both B2-S and B4-S and 640 individuals from these two stations in June 1979. These totals show an increase in numbers from totals obtained in March 1978 (727 individuals) and June 1978 (524 individuals) A total of 130 and 78 individuals were found at B2-S during March 1979 and June 1979, respectively, compared to 774 and 562 individuals at B4-S during March 1979 and June 1979. Sediment characteristics remained consistent with previous results at both stations (Figure 85).

Species diversity was much greater at subtidal stations than at intertidal stations having a mean number of species of 33 in March and 30 in June at B2-S and B4-S compared to a mean of 20 and 17.5 for March and June, respectively, at the intertidal stations.

Table 78 lists the ten most abundant species at B2-S (Bailey Point) and B4-S (Phipps Point) for March and June 1979. Perhaps, this list reflects the abundance at B4-S (Phipps Point) since 99% of the total number of *Prionospio steenstrupi* and *Aricidea jeffreysi*, and 93% of the total number of *Scoloplos* sp. were found at B4-S. The most dominant species at B2-S appears to be (in order of total number of individuals) *Polydora ligni* (26), *Scoloplos* sp. (25), *Unciola irrorata* (21), and *Aglaophamus* sp. (18). It is difficult to determine any dominant species at B2-S with such small numbers of individuals.

At B4-S (Phipps Point), *Prionospio steenstrupi*, *Scoloplos* sp., and *Aricidea jeffreysi* were the three most dominant species which agrees with previous reports (Dean and Cucci, 1978; 1979).

Mean annual densities for *Scoloplos* sp. can be found in Figure 92. A gradual decline at B2-S (Bailey Point) occurred over the past 4 years. Conversely at B4-S (Phipps Point) a continuing increase in densities of *Scoloplos* sp. has been observed over the past 5 years. Decreasing densities of *Polydora* sp. at B2-S (Bailey Point) with slightly increasing densities at B4-S (Phipps Point) can be seen in Figure 91. Reasons for these results are difficult to assess.

Declines in *Streblospio benedicti* densities at both stations can possibly be correlated with their declines at intertidal stations which seems to be related to cyclic abundance patterns of this species.

Conclusions

Results from sampling periods 39 (March 1979) and 40 (June 1979) suggest that the previously described community structure of *Heteromastus*, *Scoloplos*, and *Macoma* still exists at the intertidal stations. Unlike the past two reports (Dean and Cucci, 1978; 1979), *Streblospio benedicti* has shown a complete reversal in abundance at all stations which seems to indicate cyclic abundances associated with this species.

Subtidal stations remain consistent in species makeup, however, it was found that low numbers of total individuals at B2-S (Bailey Point) made it difficult to assess dominant forms at that station. *Prionospio steenstrupi*, *Scoloplos* sp., and *Aricidea jeffreysi* were the dominant forms at B4-S.

Sediment characteristics remained similar to previous years for all stations except at B2-I where a shift to a sand-silt-clay characterization occurred.

Literature Cited

Dean, D. and T. Cucci. 1978. Benthos. *In*: Environ. Surveillance Rep. #11. Maine Yankee Atomic Power Co., Augusta, Maine.

Dean, D. and T. Cucci. 1979. Benthos. *In*: Environ. Surveillance Rep. #12. Maine Yankee Atomic Power Co., Augusta, Maine (in press).

Shepard, F.P. 1954. Nomenclature based on sand-silt-clay ratios. J. Sed. Petrol. 24: 151-158.

Table 76. Addition to species list, March and June 1979.

PHYLUM Annelida
  Class Polychaeta
    Family Sternaspidae
      Sternaspis scutata

PHYLUM Arthropoda
  Class Crustacea
    Family Gammaridae
      Marinogammarus finmarchicus
      Marinogammarus stoerensis

Table 77. Lists of the ten most abundant species for March 1979 (period 39) and June 1979 (period 40). Only the seven intertidal stations are included in these lists. Means for the number of individuals per station is indicated.

March 1979 (Period 39)

	Species	$\bar{X}$ (# individuals/station)
1.	*Aglaophamus* sp.	289.7
2.	*Scoloplos* sp.	200.3
3.	*Streblospio benedicti*	139.6
4.	*Heteromastus filiformis*	127.9
5.	*Tharyx acutus*	108.3
6.	Oligochaeta	88.3
7.	*Eteone* sp.	36.4
8.	*Hydrobia totteni*	35.1
9.	*Macoma balthica*	23.6
10.	*Nereis virens*	21.4

June 1979 (Period 40)

	Species	$\bar{X}$ (# individuals/station)
1.	*Aglaophamus* sp.	245.6
2.	*Heteromastus filiformis*	194.1
3.	*Scoloplos* sp.	140.9
4.	*Streblospio benedicti*	73.9
5.	Oligochaeta	59.7
6.	*Tharyx acutus*	55.4
7.	*Nereis virens*	23.0
8.	*Macoma balthica*	21.9
9.	*Cyathura polita*	20.6
10.	*Clymenella torquata*	17.6

Table 78. List of the ten most abundant species for the two subtidal stations (B2-S, B4-S) during sampling periods 39 (March 1979) and 40 (June 1979). This list represents a combined total of the two sampling periods.

	Species	$\bar{X}$ (# individuals/station/period)
1.	*Prionospio steenstrupi*	137.0
2.	*Scoloplos* sp.	89.8
3.	*Aricidea jeffreysi*	44.8
4.	*Aglaophamus* sp.	11.5
5.	*Orchomenella minuta*	11.5
6.	*Polydora ligni*	7.5
7.	Oligochaeta	7.0
8.	*Photis* sp.	7.0
9.	*Edotea montosa*	7.0
10.	*Unciola irrorata*	5.5

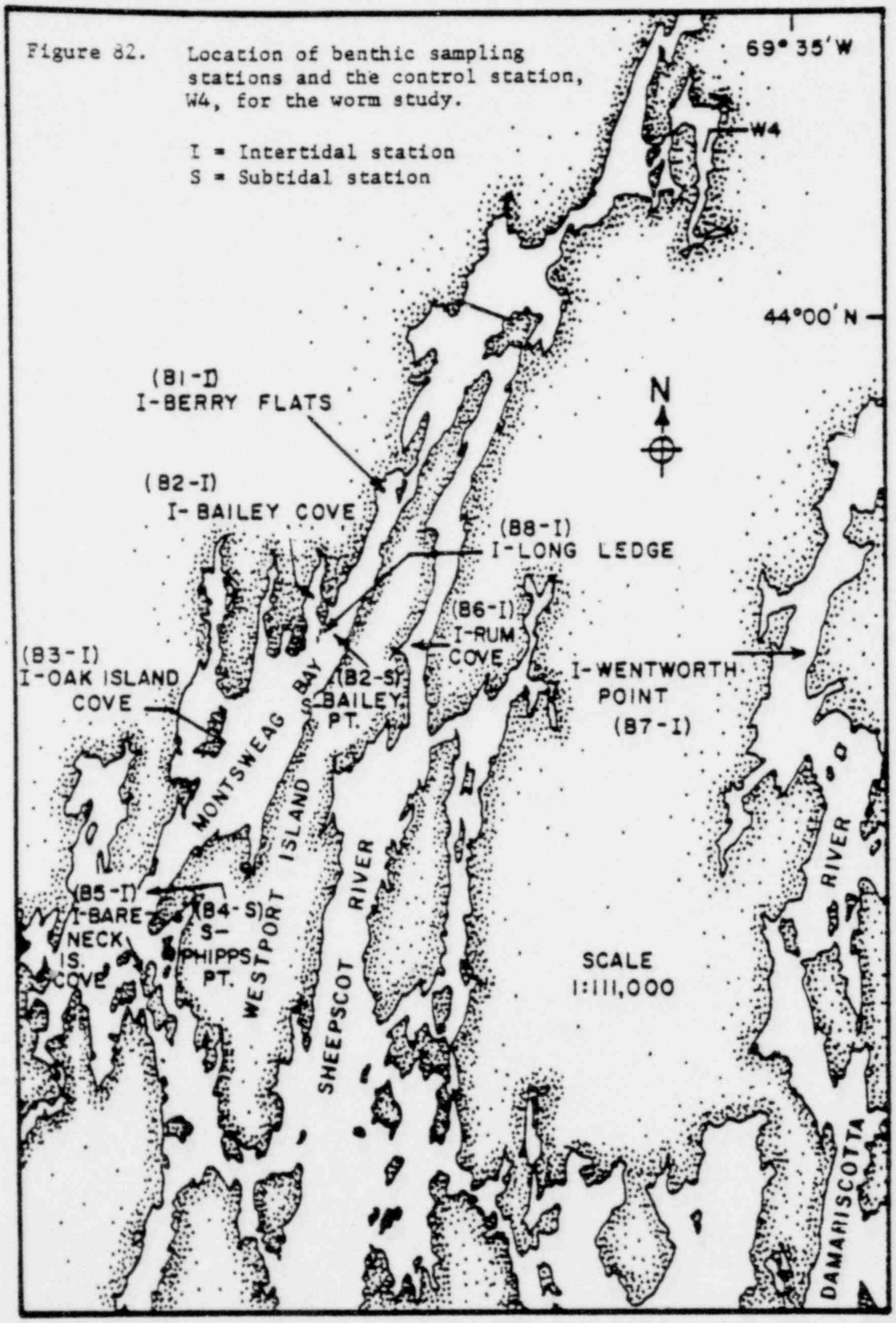


Figure 82. Location of benthic sampling stations and the control station, W4, for the worm study.

I = Intertidal station
S = Subtidal station

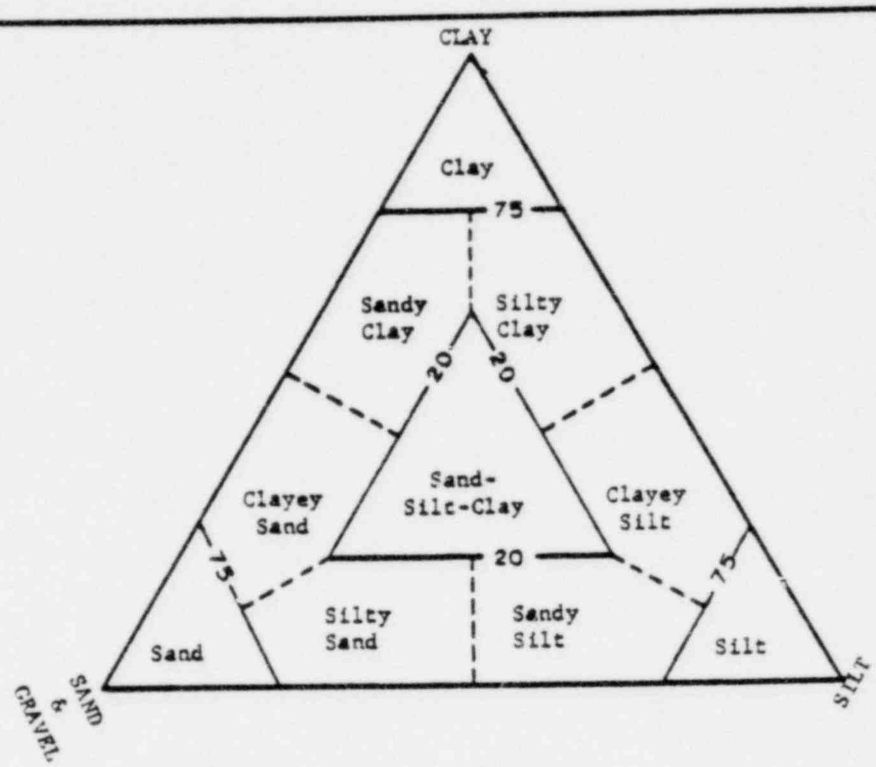


Figure 83. Method for classifying sediments found during the study.

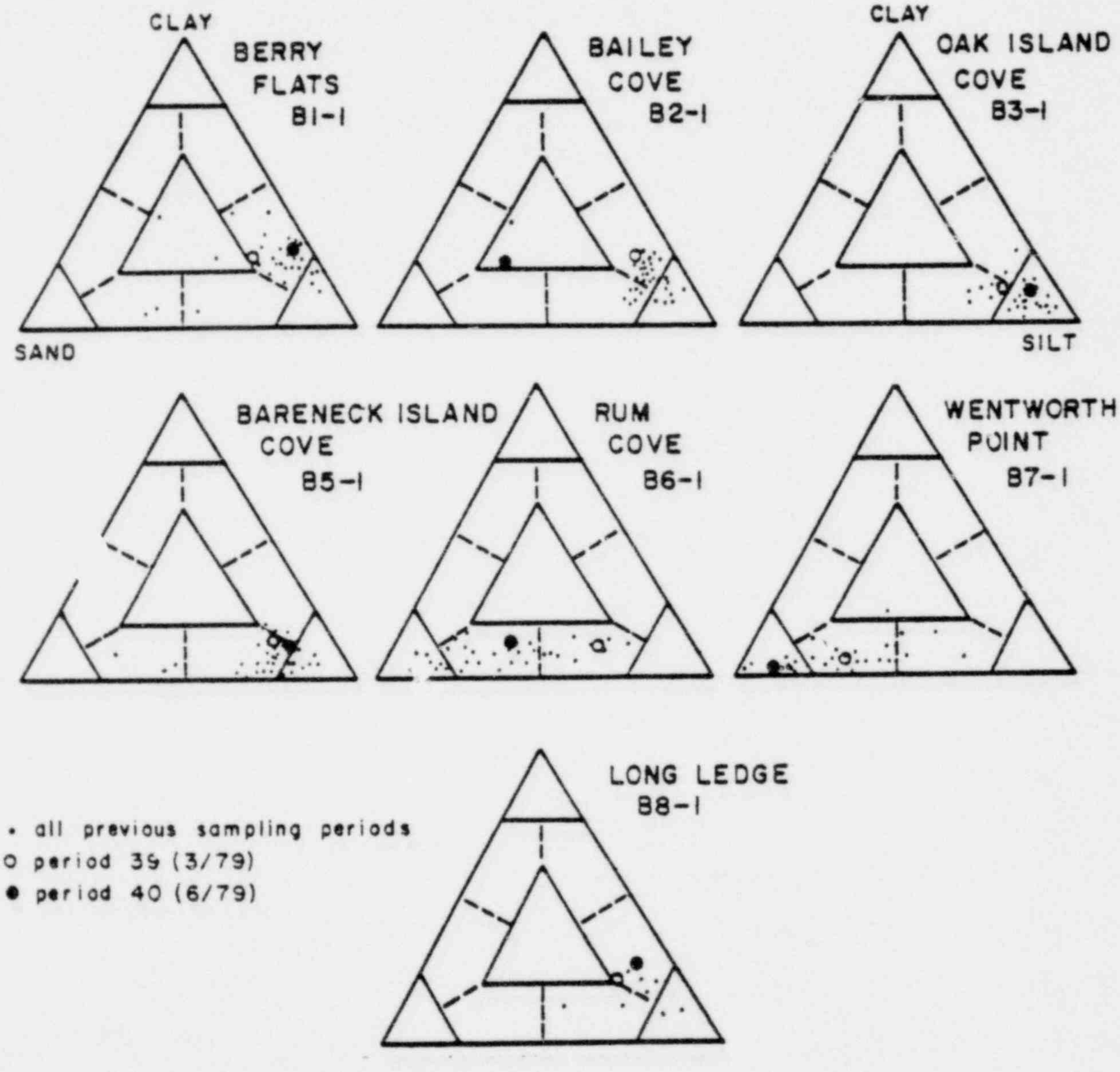


Figure 84. Classification of sediments found at seven intertidal benthic stations.

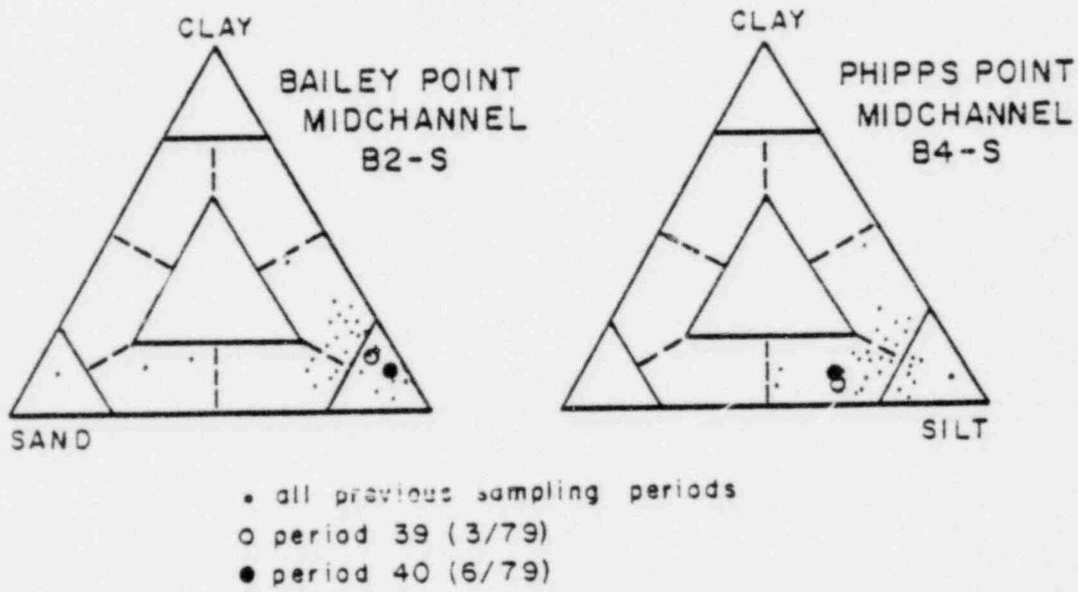
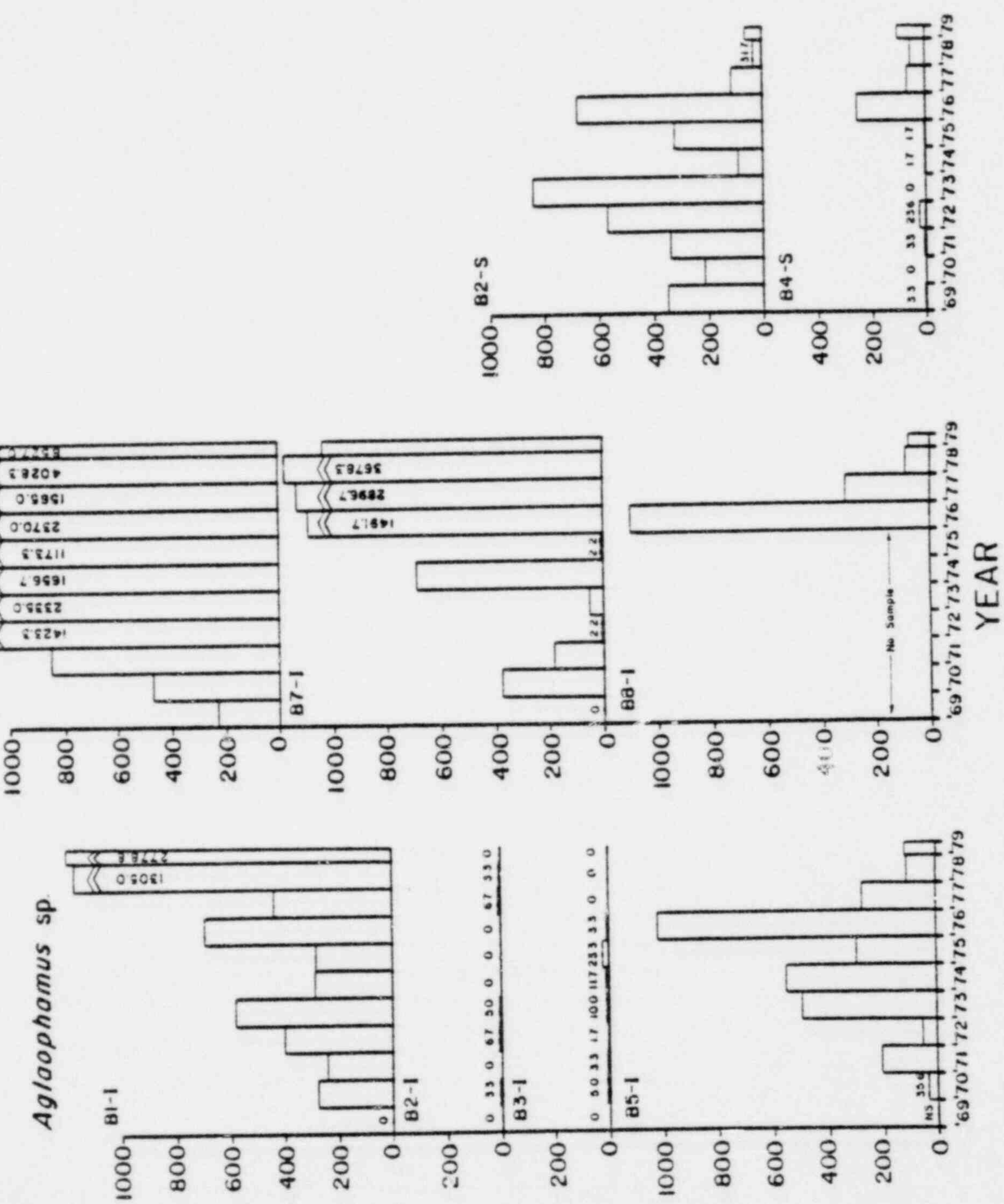


Figure 85. Classification of sediments at two subtidal benthic stations.

Figures 86-94. Mean annual density (no. individuals/m^2) of *Hydrobia totteni*, *Streblospio benedicti*, *Macoma balthica*, *Scoloplos* sp., *Heteromastus filiformis*, *Aglaophamus* sp., *Polydora* sp., *Thoryx acutus*, and Oligochaeta found at all intertidal and subtidal stations during the period from 1969 to 1979.

Figure 86



Aglaophamus sp.
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
No Sample
MEAN ANNUAL DENSITY
YEAR
'69'70'71'72'73'74'75'76'77'78'79

Figure 87

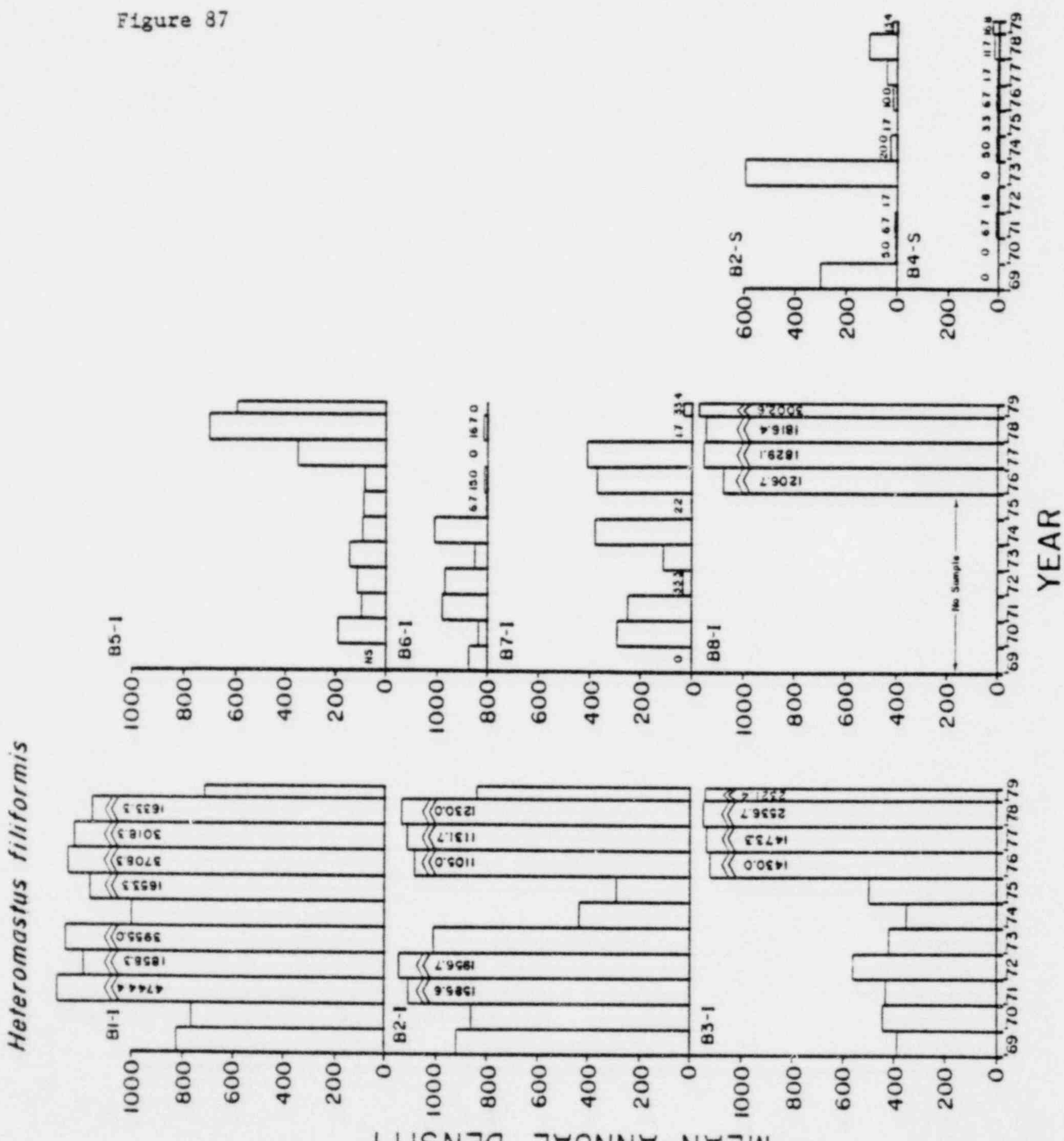

Heteromastus filiformis
MEAN ANNUAL DENSITY
YEAR
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
No Sample

Figure 88

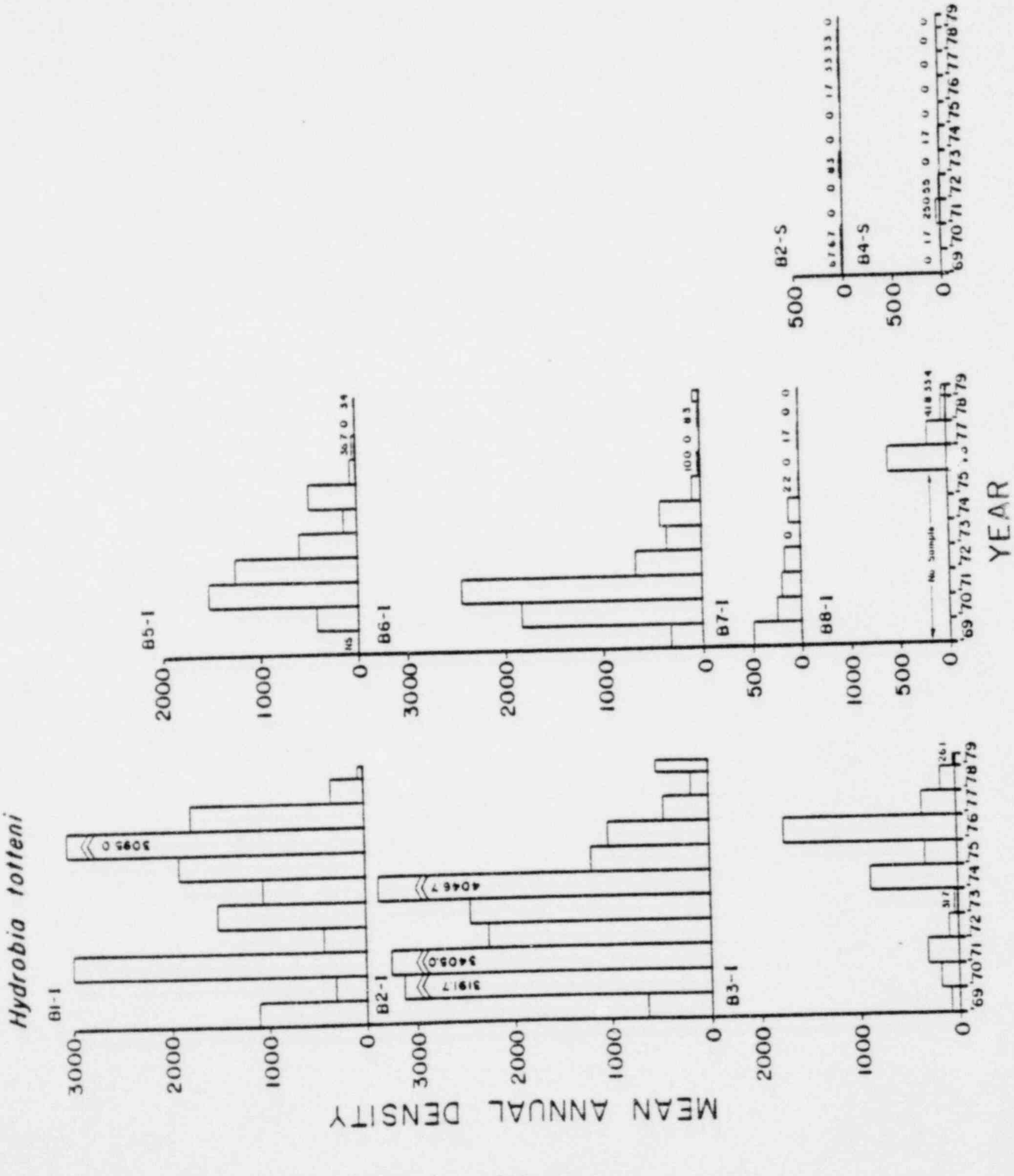
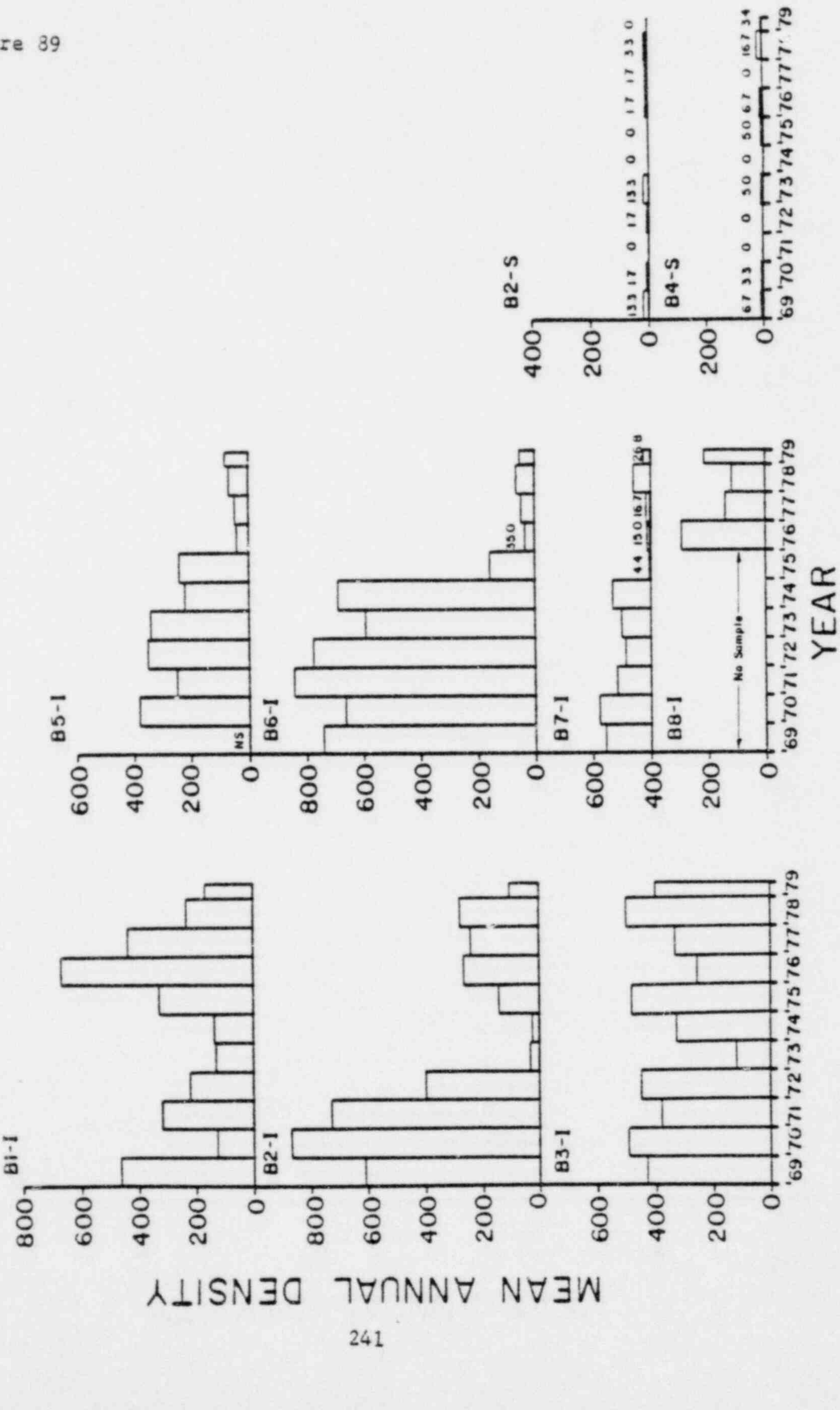
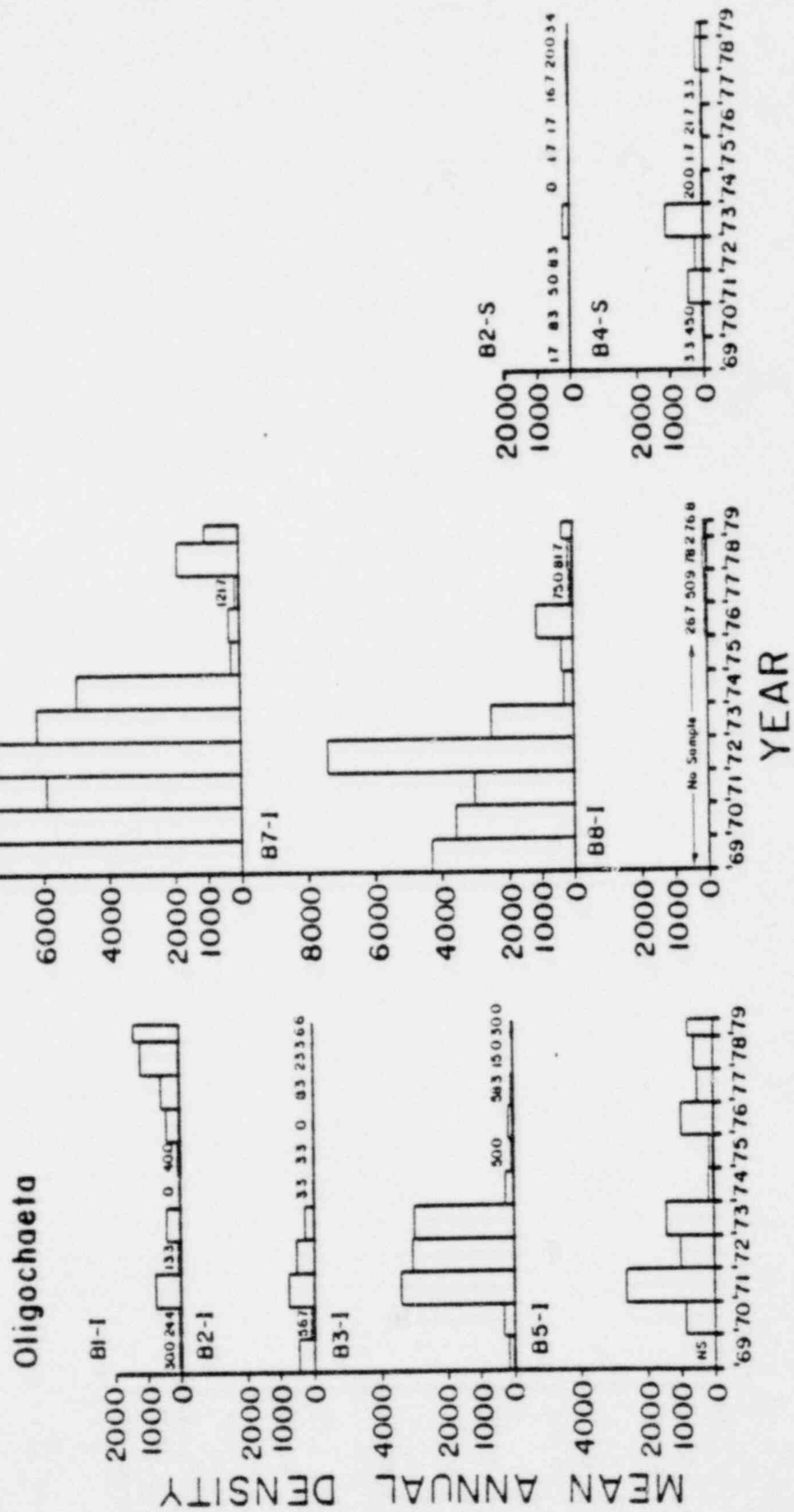

Hydrobia totteni
MEAN ANNUAL DENSITY
YEAR
B1-1
B2-1
B3-1
B5-1
B6-1
B7-1
B8-1
B2-S
B4-S
No Sample

Figure 89



Macoma baltica
MEAN ANNUAL DENSITY
YEAR
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
NS
No Sample
'69 '70 '71 '72 '73 '74 '75 '76 '77 '78 '79

Figure 90



Oligochaeta
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
MEAN ANNUAL DENSITY
YEAR
No Sample

Figure 91

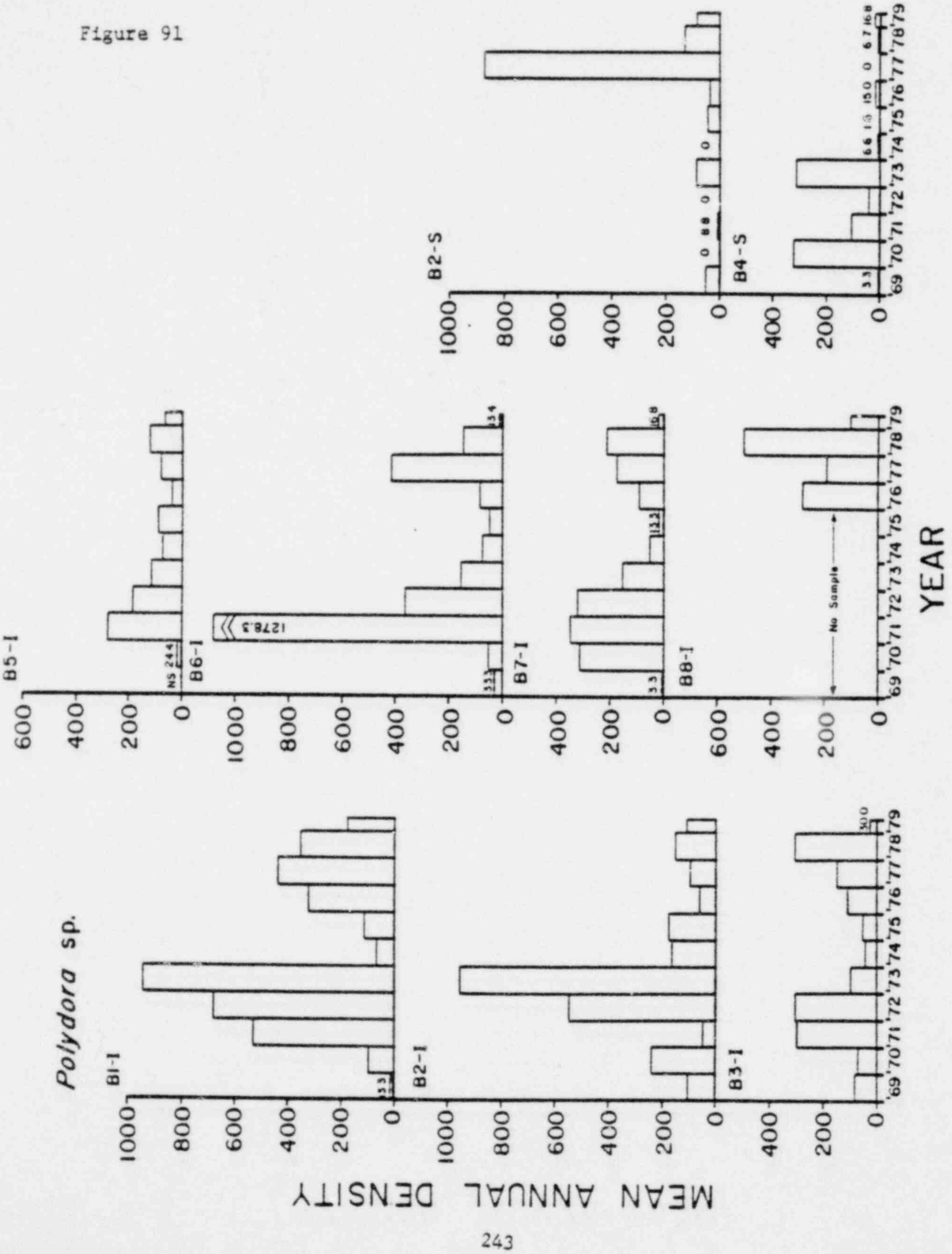
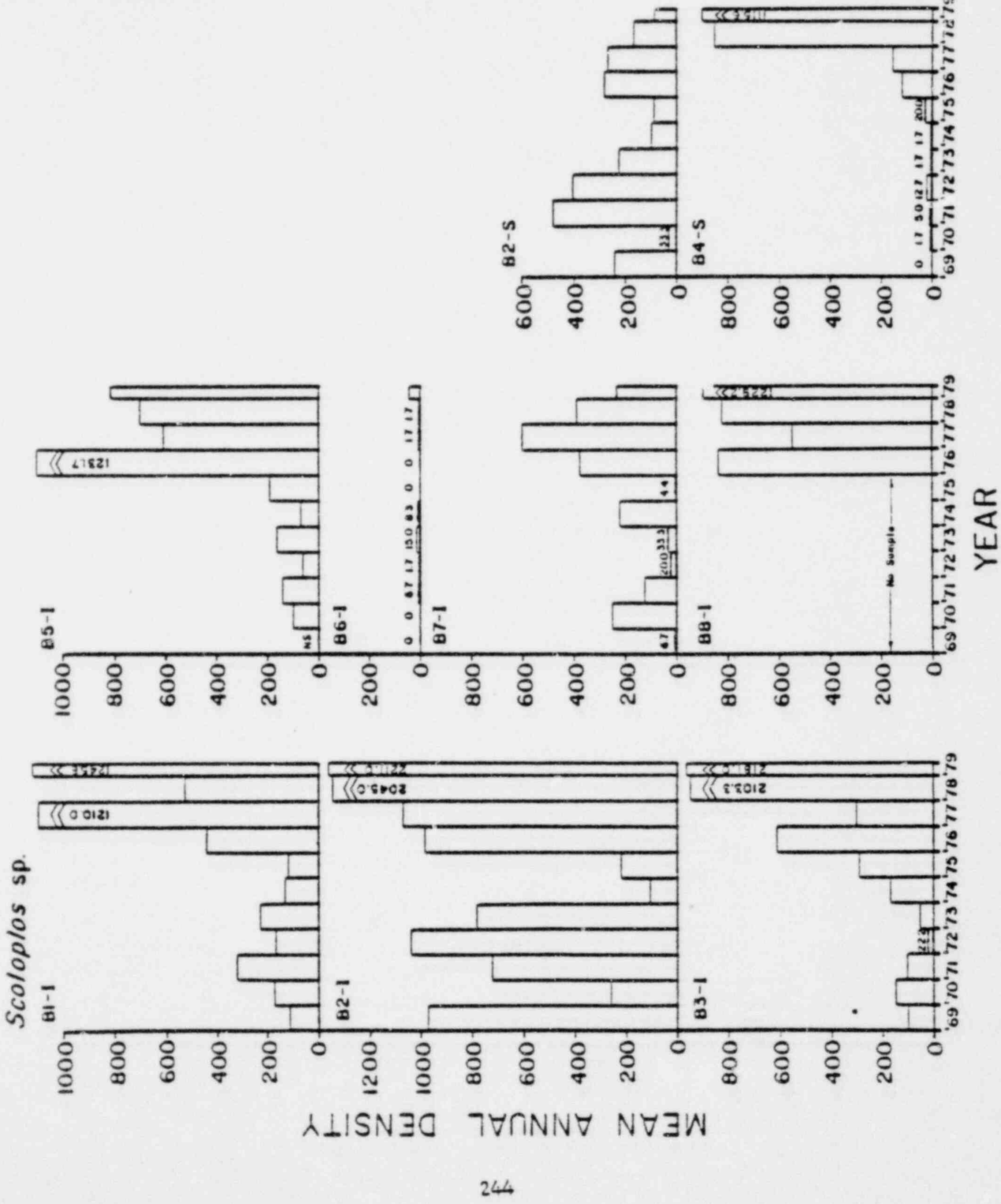

Polydora sp.
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
1278.3
No Sample
YEAR
MEAN ANNUAL DENSITY

Figure 92



Scoloplos sp.
MEAN ANNUAL DENSITY
YEAR
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
No Sample

Figure 93

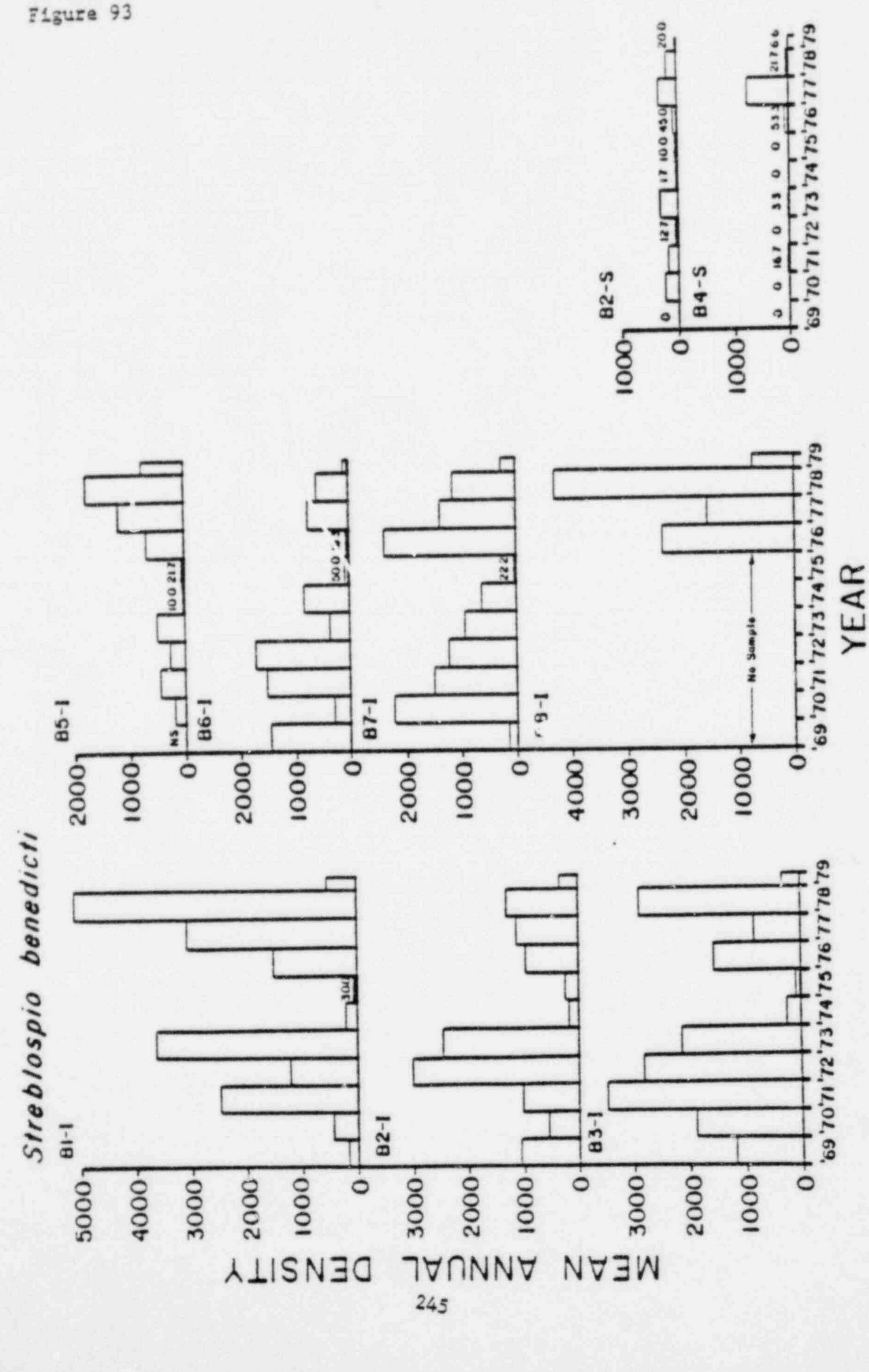
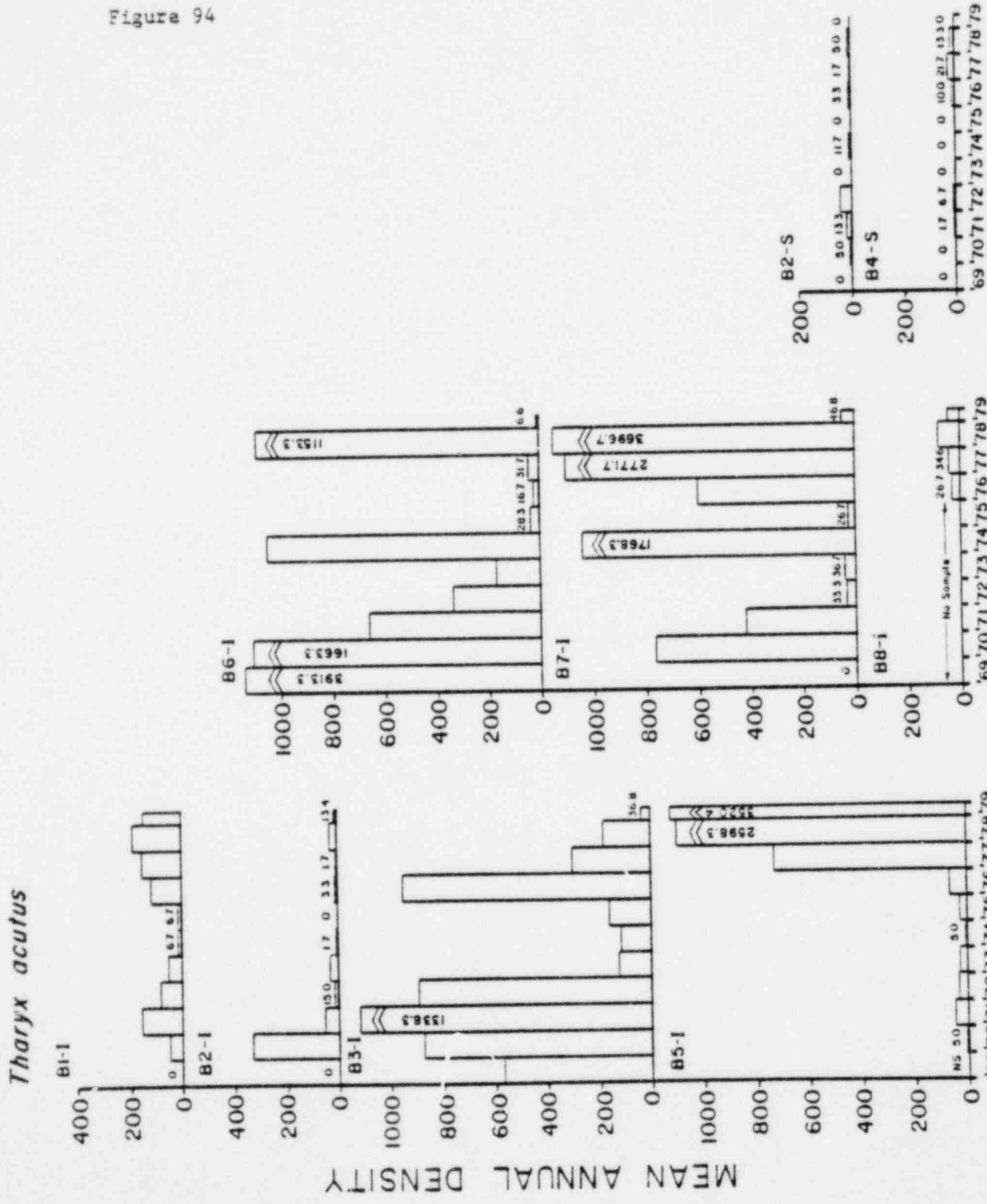

Streblospio benedicti
MEAN ANNUAL DENSITY
YEAR
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B9-I
B2-S
B4-S
No Sample
NS
'69 '70 '71 '72 '73 '74 '75 '76 '77 '78 '79

Figure 94


Tharyx acutus
MEAN ANNUAL DENSITY
YEAR
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
No Sample

PART II

ENTRAINMENT MONITORING

Andrew K. Towt

Introduction

The objective of this study is to identify and enumerate meroplankton (including ichthyoplankton) entrained by the condenser cooling water system at the Maine Yankee Nuclear Generating Station. Entrainment monitoring began in 1972. Starting July 1979, discharge sampling and mortality assessment were discontinued. Data presented in this report are from 1 July through 31 December 1979. Sampling was not conducted during the September shutdown.

Materials and Methods

Ichthyoplankton and zooplankton samples were taken from the intake waters between the trash racks and the traveling screens. Zooplankton samples were collected semimonthly (monthly during December) by suspending a weighted 30 cm, 76μm mesh net in the intake waters for 15 minutes. Ichthyoplankton samples were collected semimonthly from October through November and monthly from July through September and December. For ichthyoplankton, a weighted 50 cm, 363μ mesh net was suspended in the intake for 60 minutes. On 24 October an experimental 120 minute ichthyoplankton sample was taken to note any variability resulting from a lengthened sampling period. General Oceanic digital flowmeters were mounted in the mouth of each net. Upon completion of each tow, the samples were washed from the net into containers of 5% buffered formalin.

During each sampling period temperature and salinity were measured with a Beckman RS-5 field salinometer. Also, a water sample collected at the sampling site was analyzed for dissolved oxygen using the Azide Modification of the Iodemetric Method (Standard Methods for Examination of Water and Wastewater, 1965).

Samples were analyzed by Marine Research, Inc., Falmouth, Massachusetts. Each sample was reduced in volume to 50-100 mls by allowing the sample to settle. Samples were then vigorously shaken to insure that all solid material was randomly dispersed. Three 1 ml subsamples were taken from each aliquot and analyzed on a Sedgewick-Rafter cell.

Because of the taxonomic difficulty with bivalve larvae these data are presented according to generic groups.

Results

Physical Data

Salinity, water temperature and dissolved oxygen measurements varied throughout the reporting period (Table 1). Salinity was highest on 9 August (25.8 $^{o}/oo$) and lowest on 29 November (19.6 $^{o}/oo$). Water temperature ranged from 21.1°C in July to 1.7°C in December. Dissolved oxygen peaked at 8.1 ppm in December and reached a low of 5.5 ppm during July.

Zooplankton

From 12 July 1979 through 20 December 1979, 16 meroplankton taxa representing seven phyla were collected. Table 2 lists individual and total catch densities.

Total catch densities varied throughout the sampling period from a peak of 8370.8 larvae/m^3 on 9 August to a low of 169.3 larvae/m^3 on 29 November. The greatest sampling period densities occurred in August (8370.8 larvae/m^3 and 6492.3 larvae/m^3) as a result of large polychaete larvae catches. Throughout the summer months polychaete larvae represented greater than 80% of the total catch except on 12 July when they constituted 65.1% of the total (Table 3).

Total catch densities decreased during fall sampling. Harpacticoids were the dominant fall taxon. Polychaete larvae accounted for less than 11% of any sampling period catch during the fall, except for 20 October (26.4%). Polychaete larvae, harpacticoids and bivalve larvae, were the only taxa to constitute more than 20% of the total sample catch in the summer and fall collecting periods.

Species abundance and diversity varied throughout the sampling period. A peak of 10 taxa were represented in the 12 July sample. A low of six taxa were found in the 29 November and 20 December catches. Species composition per sample varied from polychaete, gastropod, and bivalve larvae being present in every sample to mysid and crab zoea being present in only one sample.

Bivalve larvae taxa composition per sample is presented in Table 4. Entrained bivalve larvae were keyed into one of four genus groups, or listed as unknowns if taxonomic identification was not possible. The most abundant bivalve group was the *Laevicardium - Spisula - Mya - Hiatella - Ensis - Anomia - Mulina* group, representing 36.7% of the bivalve larvae captured during this reporting period. Except for 29 November, this bivalve group was present in every sample.

The *Modiolus - Mytilus - Mercinaria* group was the second most abundant bivalve group representing 35.6% of all bivalve larvae captured. This bivalve group was present in all samples through October, but absent in the November and December samples.

Both the *Anadara - Argopectin - Pitar* and the *Petricola - Spisula - Pitar* groups were present in only one sampling period (12 July and 9 August, respectively). Both groups accounted for less than 10% of the total bivalve larvae captured during the reporting period.

Entrained eggs reached a peak density of 5045.1 eggs/m^3 on 23 August. Eggs were not present in any post August sample. *Littorina* sp. was the only egg taxa identified.

Ichthyoplankton

Entrained ichthyoplankton larvae species composition and abundance is presented in Table 5. Included in this table are species that were not present during this reporting period, but were present in the first half of 1979. From 12 July 1979 through 20 December 1979, 25 fish larvae from one species (*Clupea harengus*) were collected in seven samples.

Clupea larvae did not appear until the October sample and then steadily increased in abundance through every subsequent sampling. *Clupea harengus* peak abundance occurred in December (3.8 larvae/100m^3). Fish eggs were only present in the August sample (16.7 eggs/100m^3).

Table 1. Water temperature, salinity, and DO measurements, July through December 1979.

1979 Sampling Dates	Salinity °/oo	Temperature °C	Dissolved O_2 P.P.M.
12 July	25.2	18.8	7.6
26 July	25.2	21.1	5.5
9 August	25.8	20.8	8.0
23 August	24.7	19.3	7.3
2 October	25.6	14.4	7.8
24 October	23.1	14.0	7.3
13 November	20.7	11.9	7.1
29 November	19.6	9.7	7.6
20 December	25.4	1.7	8.1

Table 2. Entrainment densities July 1979 through December 1979, number of zooplankton per cubic meter.

	7 Jul	26 Jul	9 Aug	23 Aug	2 Oct	24 Oct	13 Nov	29 Nov	20 Dec
Phylum Annelida									
Polychaete larvae	643.7	436.1	6838.5	5909.0	110.7	93.4	19.5	1.4	8.7
Phylum Arthropoda									
Class Crustacea									
Subclass Copepoda									
Harpacticoids	142.4	67.1	784.8	0	182.1	1511.9	107.3	129.9	1356.8
Subclass Cirripedia									
Barnacle nauplii	147.0	22.4	0	0	0	4.9	0	0	0
Barnacle Cyprid	0	2.2	12.5	11.8	0	0	0	0	0
Subclass Malacostraca									
Superorder Peracardia									
Unidentified gammarid	0	0	12.5	5.9	2.4	2.5	0	5.6	0
Unidentified mysid	0	0	12.5	0	0	0	0	0	0
Superorder Eucarida									
Decopoda larvae	5.7	2.2	0	0	0	0	0	0	0
Crab Zoea	2.3	0	0	0	0	0	0	0	0
Phylum Bryozoa									
Cyphonaute larvae	1.1	0	0	0	3.1	29.5	18.8	29.6	34.9
Phylum Chordata									
Chordata larvae	5.7	0	0	11.8	0.8	0	7.5	0	0
Phylum Coelenterata									
Unidentified medusa	0	1.1	0	0	0	2.5	0	0	0
Phylum Mollusca									
Bivalve larvae	23.9	6.7	685.1	536.1	110.7	93.4	19.5	0	8.7
Gastropod larvae	12.5	2.2	24.9	11.8	1.6	27.0	3.0	1.4	109.1
Phylum Platyhelminthes									
Unidentified Turbellarian	4.6	3.4	0	5.9	7.1	0	5.6	0	4.4
Total Larval Density (m^3)	988.9	543.4	8370.8	6492.3	418.5	1765.1	181.2	167.9	1522.6
Eggs									
Littorina sp. eggs	33.0	3.4	12.5	11.8	0	0	0	0	0
Unidentified eggs	84.3	21.2	5032.6	2904.4	0	0	0	0	0
Total egg density	117.3	24.6	5045.1	2916.2	0	0	0	0	0

Table 3. Zooplankton larvae % composition by sample 12 July 1979 to 20 December 1979.

	12 Jul	26 Jul	9 Aug	23 Aug	2 Oct	24 Oct	13 Nov	29 Nov	20 Dec
Polychaete larvae	65.1	80.2	81.7	91.0	26.4	5.3	10.8	0.8	0.6
Harpacticoids	14.4	12.4	9.3		43.5	85.7	59.2	77.4	89.1
Barnacle nauplii	14.9	4.1				0.3			
Barnacle cyprid		0.4	0.2	0.2					
Unidentified gammarid			0.2	0.1	0.6	0.1		3.4	
Unidentified mysid			0.2						
Decopoda larvae	0.6	0.4							
Crab zoea	0.2								
Cyphonate larvae	0.1				0.7	1.7	10.4	17.6	2.3
Chordata larvae	0.6			0.2	0.2		4.1		
Unidentified medusa		0.2				0.1			
Bivalve larvae	2.4	1.2	8.2	8.3	26.4	5.3	10.8		0.6
Gastropod larvae	1.3	0.4		0.1	0.4	1.5	1.6	0.8	7.2
Unidentified Turbellarian	0.4	0.7	0.2	0.1	1.8		3.1		0.2

Table 4. Bivalve larvae % composition by sample 12 July 1979 to 20 December 1979.

	12 Jul	26 Jul	9 Aug	23 Aug	2 Oct	24 Oct	13 Nov	29 Nov	20 Dec	Total
Anadara-Argopecten-Pitar	30.0	0	0	0	0	0	0	0	0	5.9
Laevicardium-Spisula-Mya-Hiatella-Ensis-Anomia-Mulina	15.0	33.3	25.0	30.0	40.0	16.7	75.0	0	75.0	36.7
Petricola-Spisula-Pitar	0	0	35.0	0	0	0	0	0	0	6.9
Modiolus-Mytilus-Mercinaria	30.0	50.0	30.0	60.0	20.0	66.6	20.0	0	0	35.6
Unknown bivalve larvae	25.0	16.7	10.0	10.0	40.0	16.7	5.0	0	25.0	14.9

Table 5. Species densities of larval fish collected at intake, 12 July 1979 to 20 December 1979.

	12 Jul	9 Aug	2 Oct	24 Oct	13 Nov	29 Nov	20 Dec	Total
Volume Filtered (m^3)	50	334	414	531	202	268	286	2,085
Total # of Juveniles	0	0	0	1	0	0	1	2
Total # of Larvae	0	0	0	3	5	6	11	25
Total Larval Density (larvae/100m^3)	0	0	0	0.56	2.48	2.24	3.85	1.20
Egg Density (eggs/100m^3)	0	16.8	0	0	0	0	0	2.68
Clupea harengus				3	5	6	11	25
Pholis gunnellus								
Myoxocephalus octodecemspinosus								
M. scorpius								
M. aenaeus								
Gasterosteus wheatlandi								
Pollachius virens								
Cryptacanthodes maculatus								
Osmerus mordax							1*	
Alosa pseudoharengus				1*				
Fish eggs	0	56	0	0	0	0	0	56

* Juvenile fish (not included in density calculation)

MEROPLANKTON

Glenn E. Nutting

Introduction

Plankton populations in the Montsweag Bay - Back River area have been sampled since 1969. Beginning July 1979 the scope of the plankton monitoring program shifted from holozooplankton studies to meroplankton studies. The objective of the sampling program is to assess the effects of Maine Yankee operations on the composition, abundance, and seasonality of local meroplankton populations. Results of the Montsweag Bay studies are compared with similar data collected from the Sheepscot River. Reported herein are data collected from 1 July through 31 December 1979.

Materials and Methods

Plankton were sampled at stations S2, M2, M3 and M4 (Figure 2). Samples were collected semimonthly, except for December (monthly). All stations were sampled on the same day, during daylight hours at various tidal stages. Three to five minute oblique tows were made with a 75 μm mesh net of 0.5 m mouth diameter (mouth area = 0.196 m^2) equipped with a centrally mounted flowmeter. Boat speed during tows was 1 to 2 m/sec.

If sample density required it, samples were split with a laboratory splitter designed by Marine Research Inc., Falmouth, Massachusetts. The samples were reduced in volume to approximately 50-100 ml by allowing the sample to settle and siphoning off the animal-free preserving solution. Subsamples were analyzed from this volume. In mixing samples for subsampling two 100 ml beakers were used. The sample was poured vigorously from one beaker to the other twenty times to insure that all the material in the sample was resuspended and randomly dispersed throughout the volume of the sample. Three 1 ml samples were analyzed on a Sedgwick-Rafter cell to count and identify the meroplankton. Species numbers were recorded on multiple tally counters and then transferred to data cards, together with other salient data such as final volume and splitting factors. Total numbers of the various organisms per sample were calculated.

Results and Discussion

Meroplankton data for stations S2, M2, M3 and M4 are shown in Tables 6 and 7, and Figures 3 through 6. Identification of those taxa shown in Figure 6 began in July 1979 when program emphasis shifted from holozooplankton studies to meroplankton studies.

During the present reporting period bivalve larvae, polychaete larvae, and cirripeds decreased in abundance as compared to previous years (Figure 3 through 5). On a per station basis the greatest monthly density was recorded at M4 during August. Peak abundance at M2 and M3 was during September, after which time polychaete abundance continually declined at all stations through December.

Cirriped larvae abundance peaked in July at S2 and M4 and in August at M2 and M3. At all stations cirriped abundance sharply declined from August through December. In prior years several secondary peaks were observed during this period, although during most years (including 1979) no larvae were collected in December.

Bivalve larvae density was greatest during October although historically peak abundance has occurred during the summer. At all stations larval densities fluctuated throughout the reporting period with no distinguishing trends. Bivalve larvae were absent at M2 and M3 during September and December, respectively.

Percent composition of selected bivalve taxa collected in the Montsweag Bay - Back River area are shown in Table 7 . Five genera were collectively grouped in the table (*Mya* group) because their early larval stages were indistinguishable. *Mya arenaria* and *Mytilus edulis* are two commercially important bivalves found in the area. *M. edulis* was found from July through October, primarily at S2. At the other stations *M. edulis* larvae appeared in the collections on two or fewer occassions (absent at M2). Individuals of the *Mya* group were only found during August at M4.

Anomia simplex larvae were most common at all stations from September through November. Periodic dominance was observed at S2 and M4 in September, S2 and M3 in October and S2, M2 and M4 in November.

Modiolus demiscus were found at all stations from September through November and on a limited basis during the remainder of the reporting period. At S2, M3 and M4 *M. demiscus* dominated the collections on four of the eleven sampling dates while at M2 *M. demiscus* accounted for the highest relative abundance on seven occassions. The average monthly abundance of *M. demiscus* exceeded that of all other species during October and November at all stations.

Abundance of several taxa collected during the reporting period are shown in Figure 6. Harpacticoid density peaked in late summer and early fall. Abundance remained relatively high through December. Cyphonaute larvae abundance also peaked during the fall. Crab zoea were most common at M2 during August. Zoea abundance sharply declined during September after which time no crab zoea were found. Decapod larvae showed a temporal and spatial distribution similar to crab zoea. Gastropod larvae were common from July through December with several periods of peak abundance at each station. *Littorina* sp. eggs were present from July through September, with a peak abundance occurring in August.

Table 6. Meroplankton densities (individuals/m^3) at each of four stations in the Montsweag Bay - Sheepscot River area from July to December 1979.

MAINE YANKEE MEROPLANKTON SUMMARY DATE 071279

DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

SPECIES	STATION INTAKE	M2	M3	M6	S2
UNIDENTIFIED MEDUSAE	0.	0.	1.8	0.	3.2
UNIDENTIFIED TURBELLARIAN	4.6	0.	1.8	0.	3.2
GASTROPOD LARVAE	12.5	0.	6.2	10.5	7.3
LITTORINA SP. EGGS	33.0	37.4	42.4	6.0	50.1
BIVALVE LARVAE	23.9	22.5	9.7	9.0	38.0
POLYCHAETE LARVAE	643.7	15.0	101.7	173.3	64.6
HARPACTICOIDS	122.4	82.4	99.9	19.4	82.4
BARNACLE NAUPLII	147.0	15.0	43.3	1.5	91.3
BARNACLE CYPRID	0.	0.	1.8	1.5	4.8
UNIDENTIFIED GAMMARID	0.	0.	0.9	0.	0.
DECOPOD LARVAE	8.2	0.	4.4	9.5	1.6
CRAB ZOEA	2.3	0.	1.8	0.	4.0
CYPHONAUTE LARVAE	1.1	0.	1.8	0.	0.8
CHORDATA LARVAE	1.1	0.	0.	0.	0.
UNIDENTIFIED EGGS	87.3	1615.1	170.2	1582.2	61.6

Table 6. (continued)

MAINE YANKEE

MEROPLANKTON SUMMARY

DATE 372679

DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

SPECIES	STATION INTAKE	S2	M2	M3	M4
UNIDENTIFIED MEDUSAE	1.1	3.4	8.0	12.4	0.5
UNIDENTIFIED TURBELLARIAN	3.4	3.4	2.0	0.	0.
GASTROPOD LARVAE	2.2	6.8	4.0	24.7	1.1
LITTORINA SP. EGGS	3.4	6.8	29.2	54.7	0.5
BIVALVE LARVAE	6.7	23.9	19.1	24.7	2.1
POLYCHAETE LARVAE	436.1	300.0	890.1	730.1	201.0
HARPACTICOIDS	67.1	180.7	369.1	24.7	320.4
BARNACLE NAUPLII	22.4	6.8	33.2	12.4	204.7
BARNACLE CYPRID	2.2	10.2	6.0	24.7	0.
UNIDENTIFIED GAMMARID	0.	0.	3.0	0.	0.
DECOPOD LARVAE	2.2	6.8	9.1	0.	1.6
PAGURID LARVAE	0.	6.8	0.	0.	0.
CRAB ZOEA	0.	0.	13.1	0.	1.1
CHORDATA LARVAE	0.	3.4	8.0	0.	0.
UNIDENTIFIED EGGS	21.2	1227.4	126.7	3316.4	12.3

Table 6. (continued)

MAINE YANKEE MEROPLANKTON SUMMARY DATE 380979

DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

SPECIES	INTAKE	S2	H2	H3	H6
			STATION		
UNIDENTIFIED MEDUSAE	0.	19.3	28.2	0.	7.4
UNIDENTIFIED TURBELLARIAN	0.	4.8	2.8	8.8	26.0
GASTROPOD LARVAE	24.9	9.6	28.2	53.0	52.0
LITTORINA SP. EGGS	12.5	96.3	50.7	26.5	18.6
BIVALVE LARVAE	685.1	17.6	11.3	35.3	96.6
POLYCHAETE LARVAE	4838.8	256.7	901.3	821.0	2358.6
HARPACTICOIDS	784.8	152.4	1509.6	1297.8	2525.7
BARNACLE NAUPLII	0.	11.2	25.3	8.8	111.5
BARNACLE CYPRID	12.5	11.3	19.7	17.7	11.1
UNIDENTIFIED GAMMARID	12.5	57.3	0.	0.	0.
UNIDENTIFIED CAPRELLID	0.	11.2	0.	0.	0.
UNIDENTIFIED MYSID	12.5	0.	0.	0.	0.
DECOPOD LARVAE	0.	9.6	28.2	0.	0.
CRAB ZOEA	0.	6.4	22.5	0.	3.7
CYPHONAUTE LARVAE	0.	0.	0.	0.	3.7
CHORDATA LARVAE	0.	0.	5.6	0.	22.3
UNIDENTIFIED EGGS	5032.6	367.4	245.0	3884.4	1099.4

Table 6. (continued)

MAINE YANKEE MEROPLANKTON SUMMARY DATE 382379

DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

SPECIES	STATION INTAKE	S2	M2	M3	M4
UNIDENTIFIED MEDUSAE	0.	0.	17.8	3.3	0.
UNIDENTIFIED TURBELLARIAN	5.9	0.	8.9	3.3	0.
GASTROPOD LARVAE	11.8	37.0	48.9	32.5	9.3
LITTORINA SP. EGGS	11.8	6.2	22.2	0.	0.
BIVALVE LARVAE	536.1	123.2	71.1	29.3	28.0
POLYCHAETE LARVAE	5909.0	600.5	488.8	227.6	8769.6
HARPACTICOIDS	0.	431.3	919.8	2324.5	831.2
BARNACLE NAUPLII	0.	6.2	26.7	123.5	0.
BARNACLE CYPRID	11.8	6.2	8.9	3.3	0.
UNIDENTIFIED GAMMARID	5.9	0.	13.3	0.	0.
DECOPOD LARVAE	0.	12.3	26.7	0.	9.3
CRAB ZOEA	0.	18.5	57.8	0.	0.
CYPHONAUTE LARVAE	0.	0.	0.	3.3	0.
CHORDATA LARVAE	11.8	0.	0.	6.5	0.
UNIDENTIFIED EGGS	2904.4	4449.0	973.1	809.5	1036.7

Table 6. (continued)

MAINE YANKEE MEROPLANKTON SUMMARY DATE 091079

DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

SPECIES	STATION E2	M2	M3	M4
UNIDENTIFIED MEDUSAE	0.	0.	7.3	1.7
GASTROPOD LARVAE	8.8	7.9	3.6	0.9
LITTORINA SP. EGGS	8.8	55.3	7.3	0.
BIVALVE LARVAE	43.8	0.	5.5	2.6
POLYCHAETE LARVAE	131.4	102.7	263.5	135.1
HARPACTICOIDS	0.	229.0	2086.4	1892.1
BARNACLE NAUPLII	0.	0.	3.6	2.3
UNIDENTIFIED GAMMARID	0.	0.	1.8	0.
DECOPOD LARVAE	0.	0.	1.8	3.5
CYPHONAUTE LARVAE	0.	0.	0.	2.6
CHORDATA LARVAE	8.8	0.	5.5	0.
UNIDENTIFIED EGGS	2829.5	1508.5	289.0	126.5

Table 6. (continued)

DATE 092679

MAINE YANKEE MEROPLANKTON SUMMARY

DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

SPECIES	STATION S2	M2	M3	M6
UNIDENTIFIED MEDUSAE	0.	1.8	0.	0.
UNIDENTIFIED TURBELLARIAN	1.1	10.5	6.9	3.1
GASTROPOD LARVAE	2.4	0.6	0.	3.1
LITTORINA SP. EGGS	12.1	0.6	0.	3.1
BIVALVE LARVAE	5.2	2.1	1.1	16.1
POLYCHAETE LARVAE	85.5	1593.1	2386.1	522.7
HARPACTICOIDS	405.6	195.3	215.8	539.6
BARNACLE NAUPLII	2.7	3.5	3.4	1.5
BARNACLE CYPRID	1.1	0.	0.	0.
DECOPOD LARVAE	1.1	0.6	0.	0.4
CRAB ZOEA	0.5	0.	0.	0.
CYPHONAUTE LARVAE	1.1	0.	0.	0.8
UNIDENTIFIED EGGS	47.7	8.2	4.6	32.3

Table 6. (continued)

EENMER

MEROPLANKTON STUDY

RUN ON 03/13/80

DATE 100279

MAINE YANKEE

MEROPLANKTON SUMMARY

DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

SPECIES	INTAKE	S2	M2	M3	M4
			STATION		
UNIDENTIFIED MEDUSAE	0.	4.9	0.	1.7	0.7
UNIDENTIFIED TURBELLARIAN	7.1	4.9	0.	6.7	2.0
GASTROPOD LARVAE	1.6	59.2	43.7	0.	0.7
BIVALVE LARVAE	3.9	148.1	21.9	33.3	1.4
POLYCHAETE LARVAE	110.7	320.8	137.5	38.3	14.2
HARPACTICOIDS	182.1	5399.7	6079.4	1513.3	360.7
BARNACLE NAUPLII	0.	0.	4.4	5.0	0.
UNIDENTIFIED GAMMARID	2.4	0.	0.	0.	0.7
CRAB ZOEA	0.	9.9	0.	0.	0.
CYPHONAUTE LARVAE	3.1	0.	4.4	5.0	0.7
CHORDATA LARVAE	0.8	0.	0.	0.	0.

Table 6. (continued)

EENNER MEROPLANKTON STUDY RUN ON 03/13/80

MAINE YANKEE MEROPLANKTON SUMMARY DATE 102479

DENSITIES IN NUMBER : PLANKTON PER CUBIC METER

SPECIES	INTAKE	S2	M2	M3	M4
			STATION		
UNIDENTIFIED MEDUSAE	2.5	0.	0.	0.	0.5
UNIDENTIFIED TURBELLARIAN	0.	14.9	2.8	3.5	0.
GASTROPOD LARVAE	27.0	127.0	35.8	24.5	4.2
BIVALVE LARVAE	14.7	276.4	100.5	45.6	31.8
POLYCHAETE LARVAE	93.4	205.4	63.3	59.6	72.4
HARPACTICOIDS	1511.9	3133.6	896.1	1065.9	838.9
BARNACLE NAUPLII	4.9	0.	0.	3.5	0.
BARNACLE CYPRID	0.	0.	1.4	0.	0.
UNIDENTIFIED GAMMARID	2.5	0.	1.4	0.	0.
CRAB ZOEA	0.	0.	1.4	0.	1.0
CYPHONAUTE LARVAE	29.5	29.9	27.5	14.0	4.7

Table 6. (continued)

KENNER — MEROPLANKTON STUDY — RUN ON 03/13/80

MAINE YANKEE — MEROPLANKTON SUMMARY — DATE 111379

DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

		STATION			
SPECIES	INTAKE	S2	M2	M3	M6
UNIDENTIFIED MEDUSAE	0.	0.	2.5	0.4	0.
UNIDENTIFIED TURBELLARIAN	5.6	0.	2.5	0.4	1.3
GASTROPOD LARVAE	3.0	3.9	19.7	16.3	37.1
BIVALVE LARVAE	9.4	62.5	54.1	19.7	11.9
POLYCHAETE LARVAE	19.5	27.3	14.7	10.0	10.1
HARPACTICOIDS	107.3	1824.2	1599.5	524.7	358.1
BARNACLE NAUPLII	0.	0.	0.	1.3	0.
BARNACLE CYPRID	0.	3.9	0.	0.	0.
UNIDENTIFIED CAPRELLID	0.	0.	0.	0.4	0.
CYPHONAUTE LARVAE	0.				
CHORDATA LARVAE	18.8	35.2	54.1	42.2	20.1
	7.5	0.	0.	0.	0.

Table 6. (continued)

EENMER — MEROPLANKTON STUDY — RUN ON 03/13/80

MAINE YANKEE — MEROPLANKTON SUMMARY — DATE 112979

DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

SPECIES	INTAKE	S2	M2	M3	M4
	STATION				
UNIDENTIFIED TURBELLARIAN	4.2	34.8	19.0	1.4	0.
GASTROPOD LARVAE	1.4	29.4	12.2	16.7	15.3
BIVALVE LARVAE	0.	10.7	6.8	1.9	6.5
POLYCHAETE LARVAE	1.4	2.7	4.1	3.7	21.8
HARPACTICOIDS	129.9	1349.3	583.1	398.3	449.3
BARNACLE NAUPLII	0.	0.	1.4	0.	0.
UNIDENTIFIED GAMMARID	5.6	0.	0.	0.	0.
CYPHONAUTE LARVAE	29.6	40.2	46.2	19.0	6.5

Table 6. (continued)

EENMER

MEROPLANKTON STUDY

RUN ON 03/13/80

DATE 122079

MAINE YANKEE

MEROPLANKTON SUMMARY

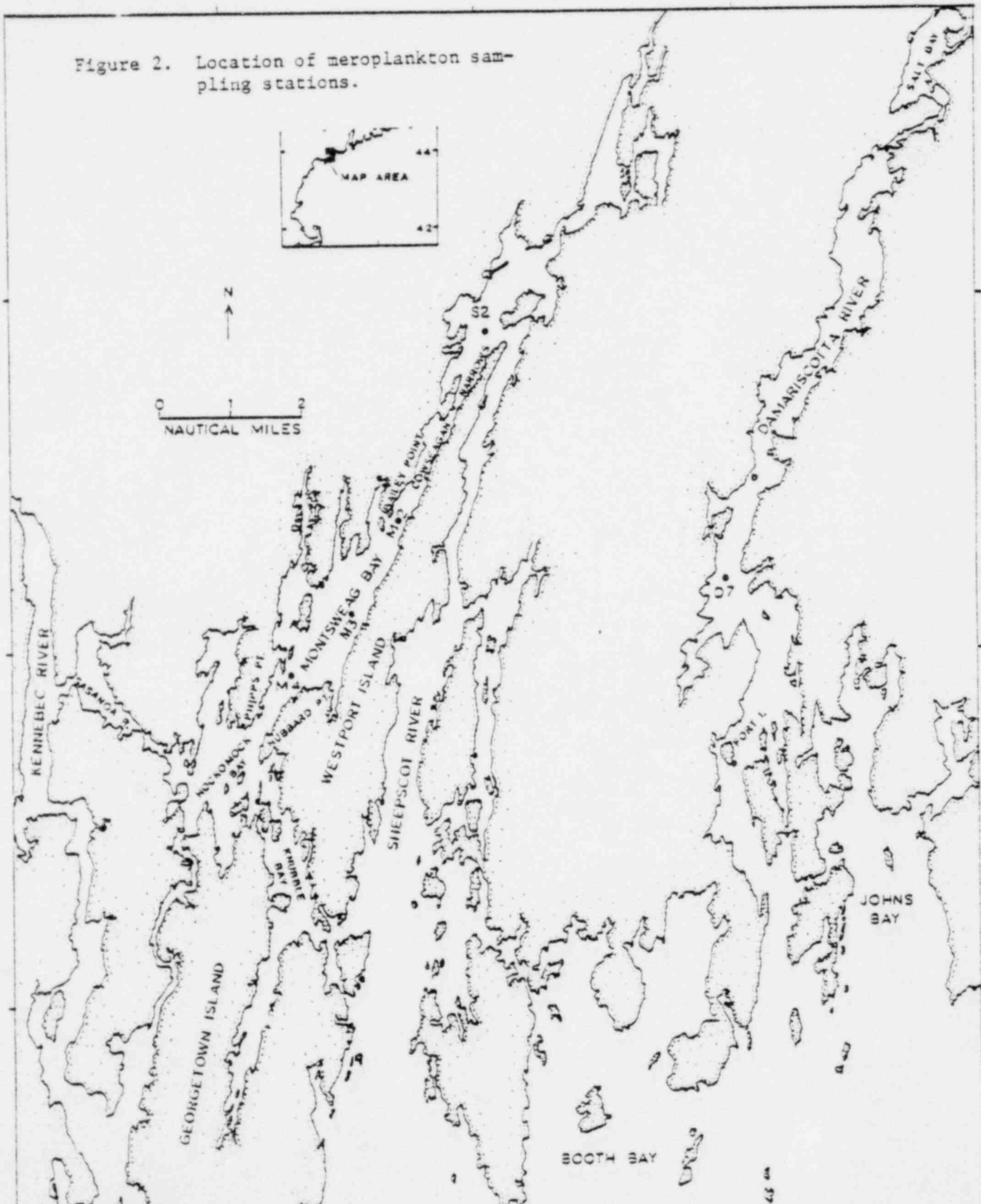
DENSITIES IN NUMBER OF PLANKTON PER CUBIC METER

SPECIES	STATION INTAKE	S2	M2	M3	M4
UNIDENTIFIED TURBELLARIAN	4.4	15.2	13.9	7.3	0.9
GASTROPOD LARVAE	109.1	76.0	87.1	12.7	31.6
BIVALVE LARVAE	17.5	60.8	10.5	0.	20.7
POLYCHAETE LARVAE	8.7	5.1	13.9	1.8	7.2
HARPACTICOIDS	1356.8	1282.0	986.0	636.9	1763.2
UNIDENTIFIED GAMMARID	0.	0.	3.5	0.	0.
CYPHONAUTE LARVAE	34.9	50.7	38.3	7.3	5.4

Table 7. Percent composition for selected bivalve larvae collected in the Montsweag Bay - Sheepscot River area, July - December 1979. *Mya* group comprised of individuals from the following genera: *Laevicardium*, *Spisula*, *Mulinia*, *Ensis*, *Mya* and *Hyatella*.

	12 July	26 July	9 Aug	23 Aug	10 Sept	26 Sept	2 Oct	24 Oct	13 Nov	29 Nov	20 Dec
S2											
Mytilus edulis	0	14	0	25	100	0	0	0	0	0	0
Anomia simplex	0	0	30	0	0	75	30	25	44	25	0
Modiolus demiscus	100	0	0	0	0	25	25	75	31	75	100
Mya group	0	0	0	0	0	0	0	0	0	0	0
M2											
Mytilus edulis	0	0	0	0	0	0	0	0	0	0	0
Anomia simplex	0	0	25	0	0	43	0	5	40	60	50
Modiolus demiscus	33	60	25	6	0	14	20	85	60	40	67
Mya group	0	0	0	0	0	0	0	0	0	0	0
M3											
Mytilus edulis	0	0	25	0	0	0	0	8	0	0	0
Anomia simplex	0	0	0	0	33	0	50	15	25	25	0
Modiolus demiscus	0	0	0	11	0	100	15	54	15	75	0
Mya group	0	0	0	0	0	0	0	0	0	0	0
M4											
Mytilus edulis	50	0	0	0	0	0	0	0	0	0	0
Anomia simplex	0	0	5	0	67	50	50	10	21	100	20
Modiolus demiscus	17	50	0	0	33	10	50	85	37	0	80
Mya group	0	0	5	67	0	0	0	0	0	0	0

Figure 2. Location of meroplankton sampling stations.



Figures 3 through 6. Population abundance of selected species at four stations, October 1969 through December 1979.

Figure 3.

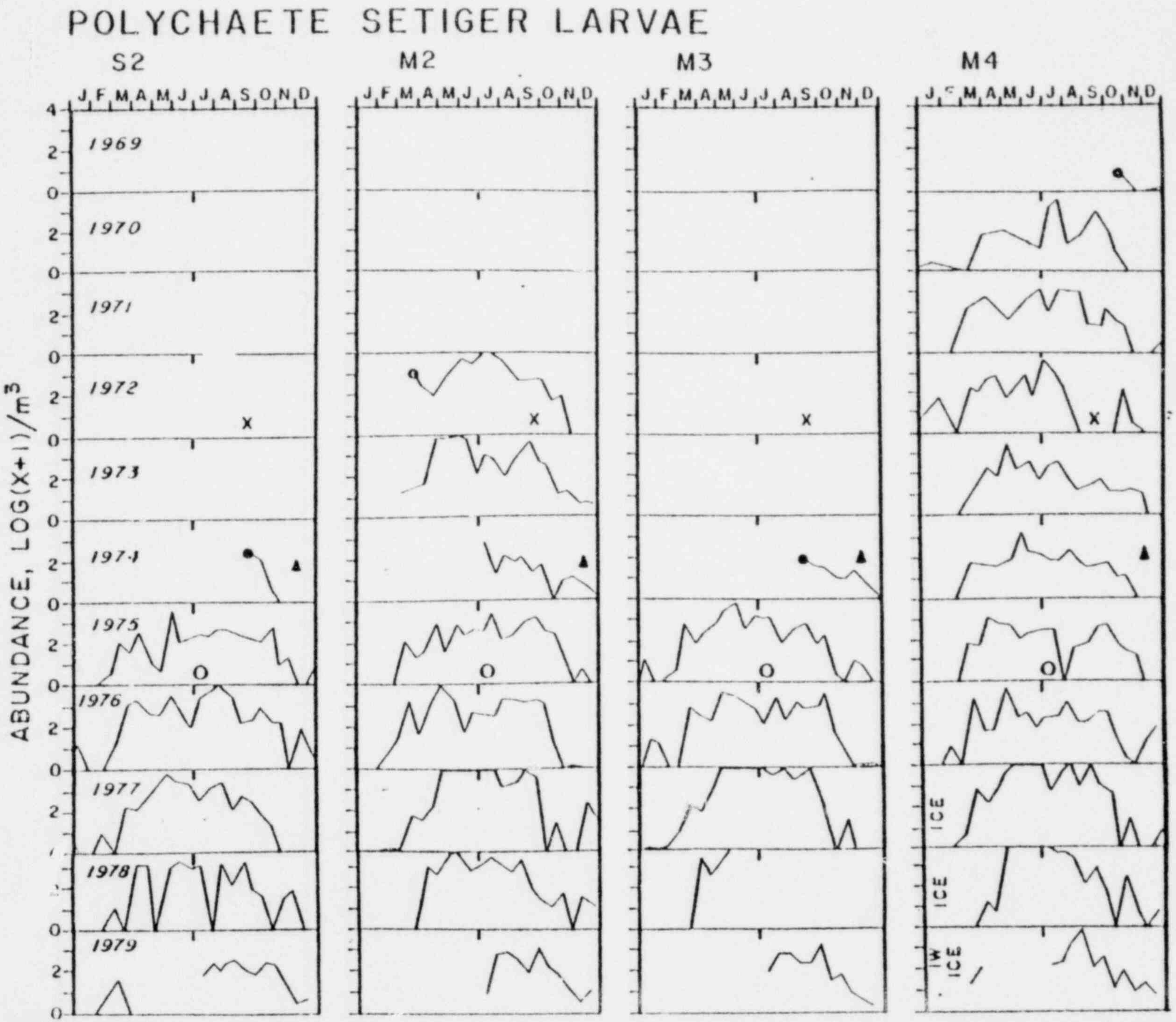
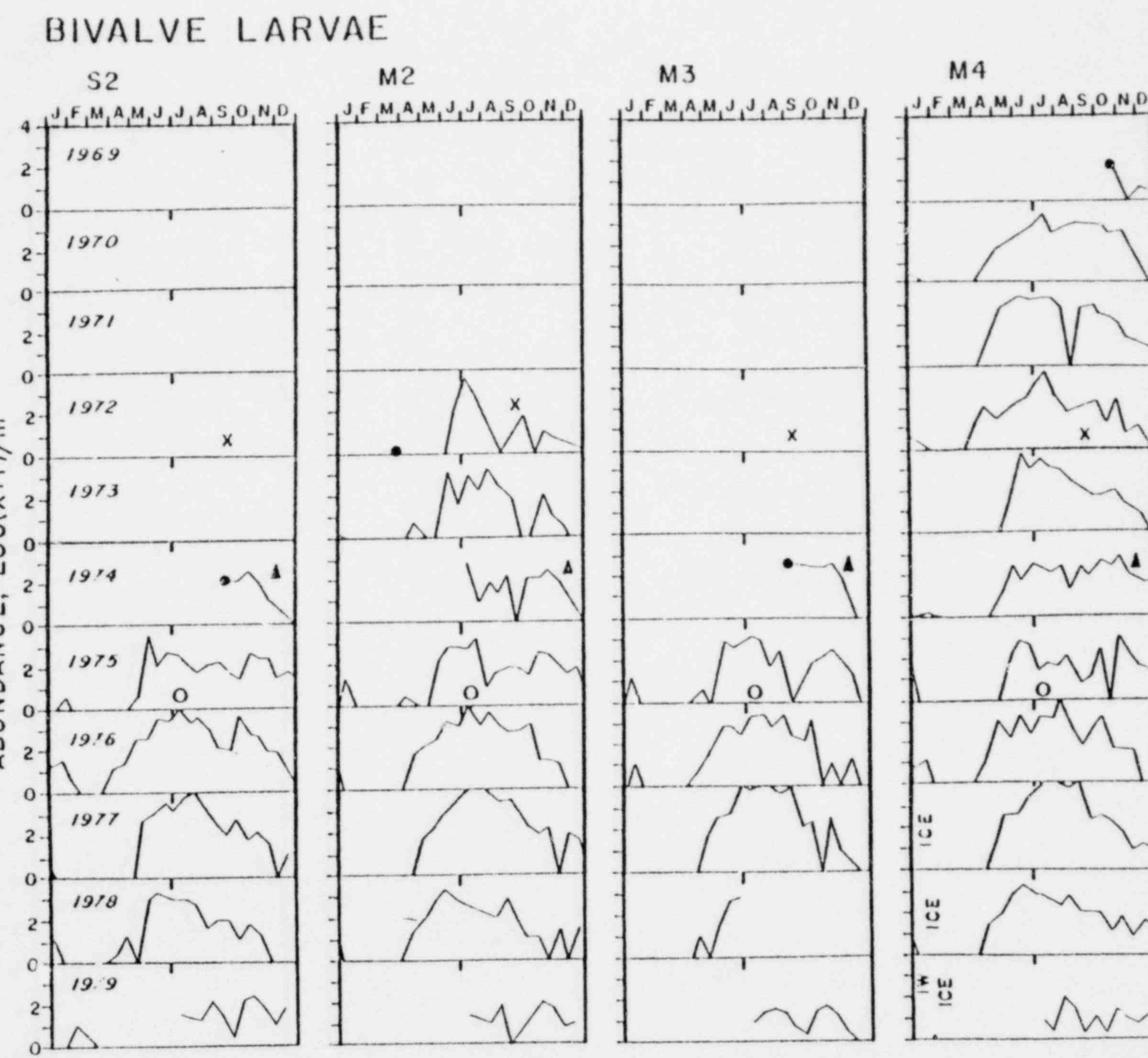

POLYCHAETE SETIGER LARVAE
S2
M2
M3
M4
J F M A M J J A S O N D
ABUNDANCE, LOG(X+1)/m³
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
IW

Figure 4.



BIVALVE LARVAE
S2
M2
M3
M4
J F M A M J J A S O N D
ABUNDANCE, LOG(X+1)/m³
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE

Figure 5.

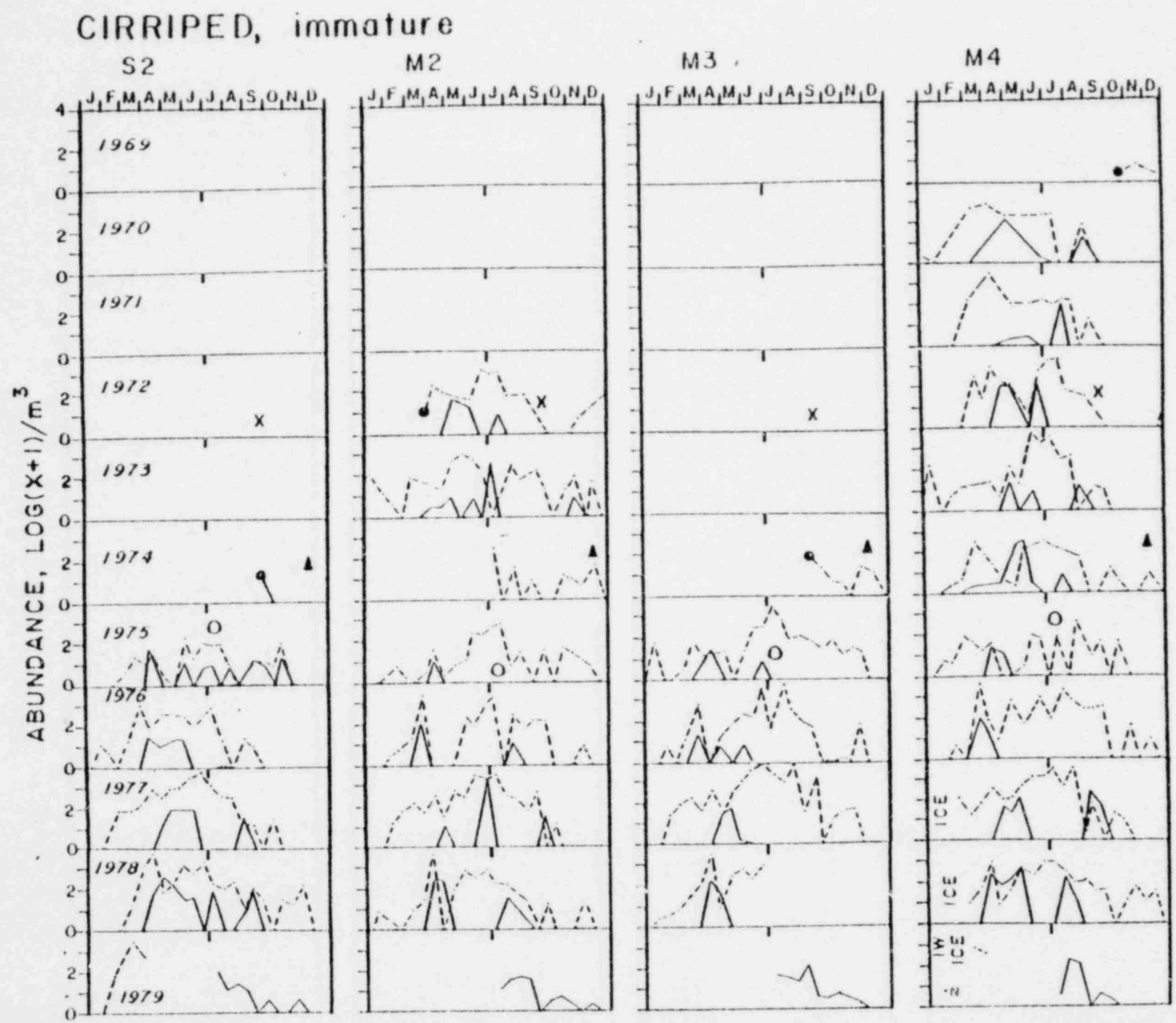
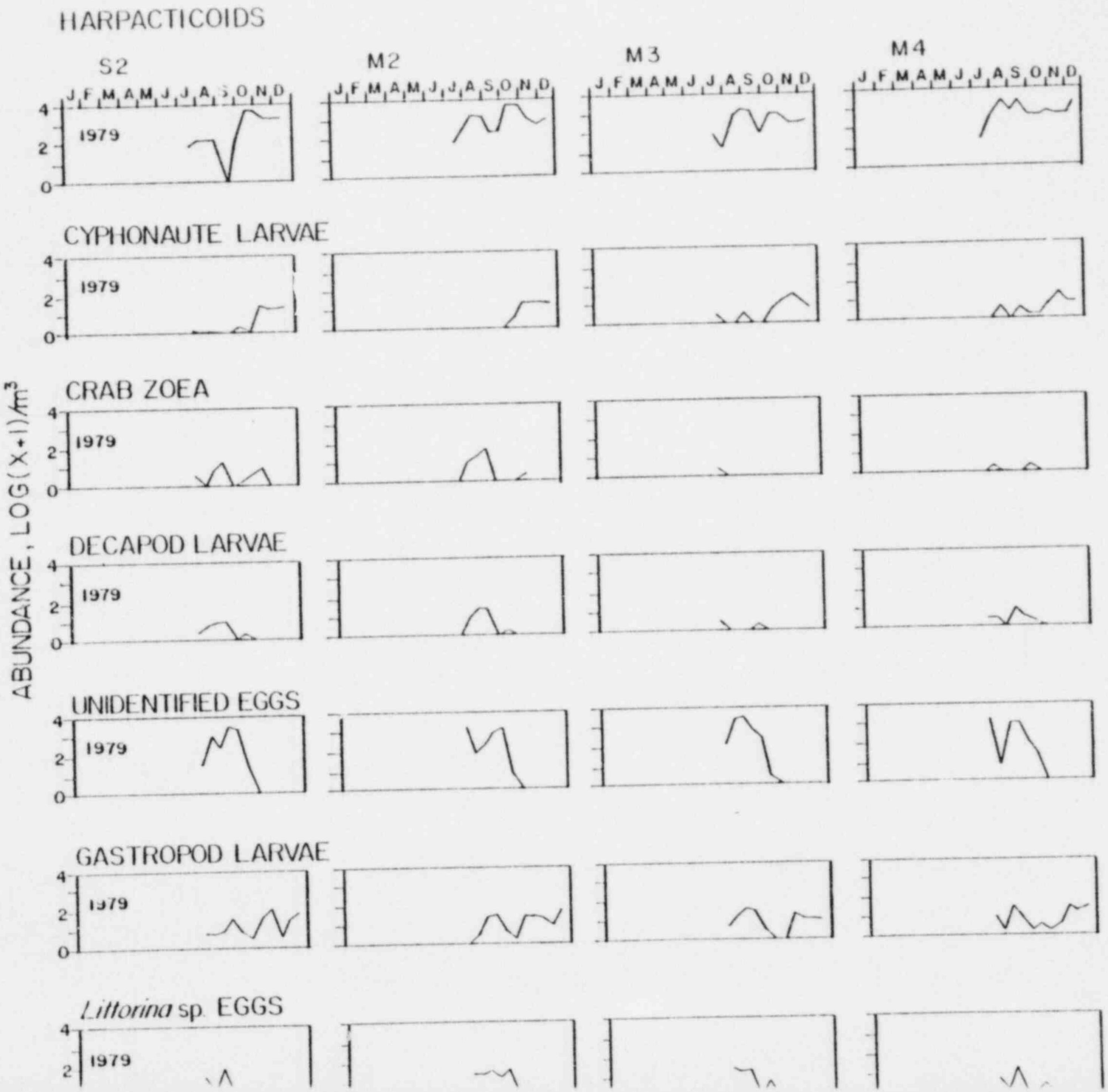

CIRRIPED, immature
S2
M2
M3
M4
J F M A M J J A S O N D
ABUNDANCE, LOG(X+1)/m3
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
ICE
ICE
IW
ICE

Figure 6.


HARPACTICOIDS
S2
M2
M3
M4
J F M A M J J A S O N D
1979
4
2
0
CYPHONAUTE LARVAE
CRAB ZOEA
DECAPOD LARVAE
UNIDENTIFIED EGGS
GASTROPOD LARVAE
Littorina sp. EGGS
ABUNDANCE, LOG(X+1)/m3

BENTHOS

Glenn E. Nutting

Introduction

The objective of this report is to summarize benthic grab data collected during 1979 and to compare these data with data of prior years to evaluate Maine Yankee's impact on the sedentary benthic fauna. During the March and June 1979 sampling periods the benthic invertebrate community was monitored at six experimental stations in the Montsweag Bay - Back River area and at three control stations in nearby waters (Figure 7). Starting in September 1979 B6-I was the only control station sampled. The other two control stations were discontinued.

Materials and Methods

Benthic samples were collected using a Ponar grab which removes a volume of sediment from an area of .05 m^2 down to a maximum depth of 13.5 cm. At each station, three grabs were taken and segregated for analysis. All grabs were washed through a 505μ sieve to remove excess sediment and preserved with 10% buffered formalin. Organisms were identified and enumerated at the lowest practical taxonomic level.

Results are discussed below in two sections; (1) intertidal stations which include four experimental stations (B1-I, B2-I, B3-I, B8-I) and three control stations (B5-I, B6-I, B7-I) and (2) subtidal stations (B2-S, B4-S).

Results and Discussion

Intertidal stations. The total number of individuals declined from March 1979 (8442) to June 1979 (6596), although collections during both periods were higher than recorded for corresponding periods in 1978 (March, 5849; June 4267). In September 1979 a total of 31,104 individuals were collected, the highest total ever recorded during the September sampling period. Following the September peak a decline in total abundance was observed in December 1979 (21,961) which was, however, more than a two fold increase over the total number in December 1978 (9186). Relative abundance during 1979 follows a similar trend observed during the last several years with peak abundance in late summer (September) followed by a gradual decline from December to June. During 1979 several new species were collected (Table 8).

Table 9 lists the most abundant taxa by density (no. organisms/m^2) for each sampling period. *Aglaophamus* sp. dominated the catch during each sampling period with over 82% of the individuals collected at B6-I (Rum Cove). Station B1-I (Berry Flats) was the only other station where *Aglaophamus* sp. was commonly found (17% of total *Aglaophamus* catch). The genus *Aglaophamus* includes a new species *A. neotenus* described by G. S. Noyes in Biological Bulletin 158(1):103-177, February 1980.

Tharyx acutus and *Clymenella torquata* were two commonly collected species which also had a limited spatial distribution. *T. acutus* was predominantly found at B5-I (Bareneck Island). At this station over 90% of the catch was *T. acutus* during both March and June 1979. *Clymenella torquata*, common during June 1979 was found only at B7-I (Wentworth Point).

Heteromastus filiformis, *Scoloplos* sp., *Streblospio benedicti* and *Macoma balthica* were characterized by their widespread distribution and similar densities among the intertidal stations with exception to B6-I where abundance of these species was low. *Polydora* sp. had similar densities among all intertidal stations.

Figure 8 illustrates mean annual densities (no. individuals/m^2) of the dominant species found at all intertidal stations. Data from stations B5-I and B7-I for 1979 are from the first two quarterly sampling periods (39, March 1979, and 40, June 1979). These stations were deleted following June.

Aglaophamus sp. density at B1-I and B6-I increased four and seven fold respectively compared to densities for the same stations in 1978. The only substantial decrease in abundance was at B7 where no *Aglaophamus* were found. This may have resulted from a shift in sediment characteristics, from a silty sand in previous years to a pure sand substrate in June 1979.

Mean annual densities for *Heteromastus filiformis* show two-fold increases at B2-I, B3-I, B8-I compared to 1978 data at these stations. Density at B1-I (14.98.3/m^2) was slightly less than the density in 1978 (1633.3/m^2). A downward trend in abundance is evident from 1976 to present.

A sharp decline in density of *Streblospio benedicti* occurred at B1-I, as compared to the previous three years. *S. benedicti* abundance at B8-I increased more than two-fold over the previous year. Abundance at B3-I increased from approximately 3000/m^2 to 4953/m^2. As shown in Figure 8 declines were observed in 1974 and 1975 at stations where previous densities were extremely high.

Scoloplos sp. densities increased one and one half to two-fold at all stations (Figure 8), supporting past conclusions that *Scoloplos* sp. is a dominant species in the benthic communities of Montsweag Bay - Back River. Small declines in mean annual densities were observed for *Macoma balthica* (except at B1-I), and *Polydora* sp., while fluctuations in densities were found for *Hydrobia totteni* and *Tharyx acutus*. Substantial increases in densities were observed for Oligochaeta, with the exception of B1-I.

<u>Subtidal stations</u>. Total numbers of individuals found in 1979 at both B2-S and B4-S were 904 (March), 640 (June), 3470 (September), 4409 (December). These totals show an increase in numbers as compared to 1978.

Species diversity was greater at subtidal stations than at intertidal stations. Total species abundance at the subtidal stations (33 species) was 50% greater than found at the intertidal stations (22 species).

Table 10 lists the ten most abundant species at B2-S (Bailey Point) and B4-S (Phipps Point) for March through December 1979. At station B2-S 99% of all *Prionospio steenstrupi* and *Aricidea jeffreysi* were found, while 93% of all *Scoloplos* sp. were found at B4-S during the March and

June sampling periods. *Prionospio steenstrupi* was not found at either subtidal station in September or December. Ninety-seven percent (97%) of all *Ampelisca abdita* were collected in September. *A. abdita* abundance increased substantially over 1978 levels.

Mean annual densities for nine species are found in Figure 8. *Scoloplos* sp. density at B2-S ($301.7/m^2$) increased to 1976 and 1977 levels following a decline since 1976. Conversely, at B4-S (Phipps Point) a continuing increase in densities of *Scoloplos* sp. has been observed for the past six years.

Increases in Oligochaeta, *Heteromastus filiformis*, *Aglaophamus* sp., and *Streblospio benedicti* densities at both subtidal stations corresponded to increased abundance of these taxa at several intertidal stations. Conversely, decreases in *Polydora* sp. at B2-S were similar to this taxa's abundance at all intertidal stations.

Table 8. Addition to species list, sampling periods (39-42) of 1979.

PHYLUM Annelida

Class Polychaeta

Order Spionida

Family Paraonidae
Aricidea catharinae

Family Spionidae
Prionospio cristata
Spio setosa

Order Sternaspida

Family Sternaspidae
Sternaspis scutata

Order Cirratulida

Family Cirratulidae
Chaetozone sp.

Order Sabellidae

Family Sabellidae
Laonome sp.

Order Capitellidae

Family Capitellidae
Mediomastus ambiseta

Family Opheliidae
Ophelina acuminata

Order Phyllodocida

Family Phyllodocidae
Phyllodoce arenae

Family Sphaerodoridae
Sphaerodoropsis sp.

Family Nephtyidae
Aglaophamus neotenus

PHYLUM Arthropoda

Class Crustacea

Order Amphipoda

Family Corophiidae
Corophium crassicorne

Family Ischyroceridae
Jassa falcata

Family Photidae
Photis macrocoxae

Family Gammaridae
Marinogammarus finmarchicus
Marinogammarus stoerensis

Table 9. List of ten most abundant taxa for March, June, September, December 1979. March and June include seven intertidal stations; September and December include five intertidal stations.

March 1979 (Period 39)	Density (No. organisms/m^2)
1. *Aglaophamus* sp.	13519.3
2. *Scoloplos* sp.	9347.3
3. *Streblospio benedicti*	6514.7
4. *Heteromastus filiformis*	5968.7
5. *Tharyx acutus*	5054.0
6. Oligochaeta	4120.7
7. *Eteone* sp.	1698.7
8. *Hydrobia totteni*	1638.0
9. *Macoma balthica*	1101.3
10. *Nereis virens*	998.7
June 1979 (Period 40)	
1. *Aglaophamus* sp.	11461.3
2. *Heteromastus filiformis*	9058.0
3. *Scoloplos* sp.	6575.3
4. *Streblospio benedicti*	3448.7
5. Oligochaeta	2786.0
6. *Tharyx acutus*	2585.3
7. *Nereis virens*	1073.3
8. *Macoma balthica*	1022.0
9. *Cyathura polita*	961.3
10. *Clymenella torquata*	821.3
September 1979 (Period 41)	
1. *Aglaophamus* sp.	71916.7
2. *Streblospio benedicti*	46603.3
3. *Ampelisca abdita*	22080.0
4. *Heteromastus filiformis*	19173.3
5. *Scoloplos* sp.	16550.0
6. Oligochaeta	13286.7
7. Nematoda	10566.7
8. *Eteone* sp.	3366.7
9. *Odostomia* sp.	3090.0
10. *Cyathura polita*	3020.0
December 1979 (period 42)	
1. *Aglaophamus* sp.	44733.3
2. *Odostomia* sp.	22046.7
3. *Heteromastus filiformis*	19246.7
4. *Streblospio benedicti*	14480.0
5. *Gemma gemma*	14206.7
6. *Scoloplos* sp.	11580.0
7. Oligochaeta	3726.7
8. *Eteone* sp.	2706.7
9. *Cyathura polita*	2373.3
10. Nematoda	1906.7

Table 10. List of the ten most abundant taxa for the two subtidal stations (B2-S, B4-S) during 1979. The upper list represents a combined total of the sampling periods 39 (March 1979) and 40 (June 1979); the lower list represents a combined total of the sampling periods 41 (September 1979) and 42 (December 1979).

March and June 1979	Density (No. organisms/m^2)
1. *Prionospio steenstrupi*	3653.3
2. *Scoloplos* sp.	2394.7
3. *Aricidea* sp.	1194.7
4. *Aglaophamus* sp.	306.7
5. *Orchomenella minuta*	306.7
6. *Polydora ligni*	200.0
7. Oligochaeta	186.7
8. *Photis* sp.	186.7
9. *Edotea montosa*	186.7
10. *Unciola irrorata*	146.7

September and December 1979	
1. *Ampelisca abdita*	11533.3
2. *Aricidea* sp.	10080.0
3. *Streblospio benedicti*	6293.3
4. *Aglaophamus* sp.	6266.7
5. *Scoloplos* sp.	4573.3
6. Nematoda	2913.3
7. Oligochaeta	2393.3
8. *Heteromastus filiformis*	940.0
9. *Unciola irrorata*	580.0
10. *Asabellides oculata*	506.7

Figure 7. Location of benthic sampling stations and the control station, W4, for the worm study.

I = Intertidal station
S = Subtidal station

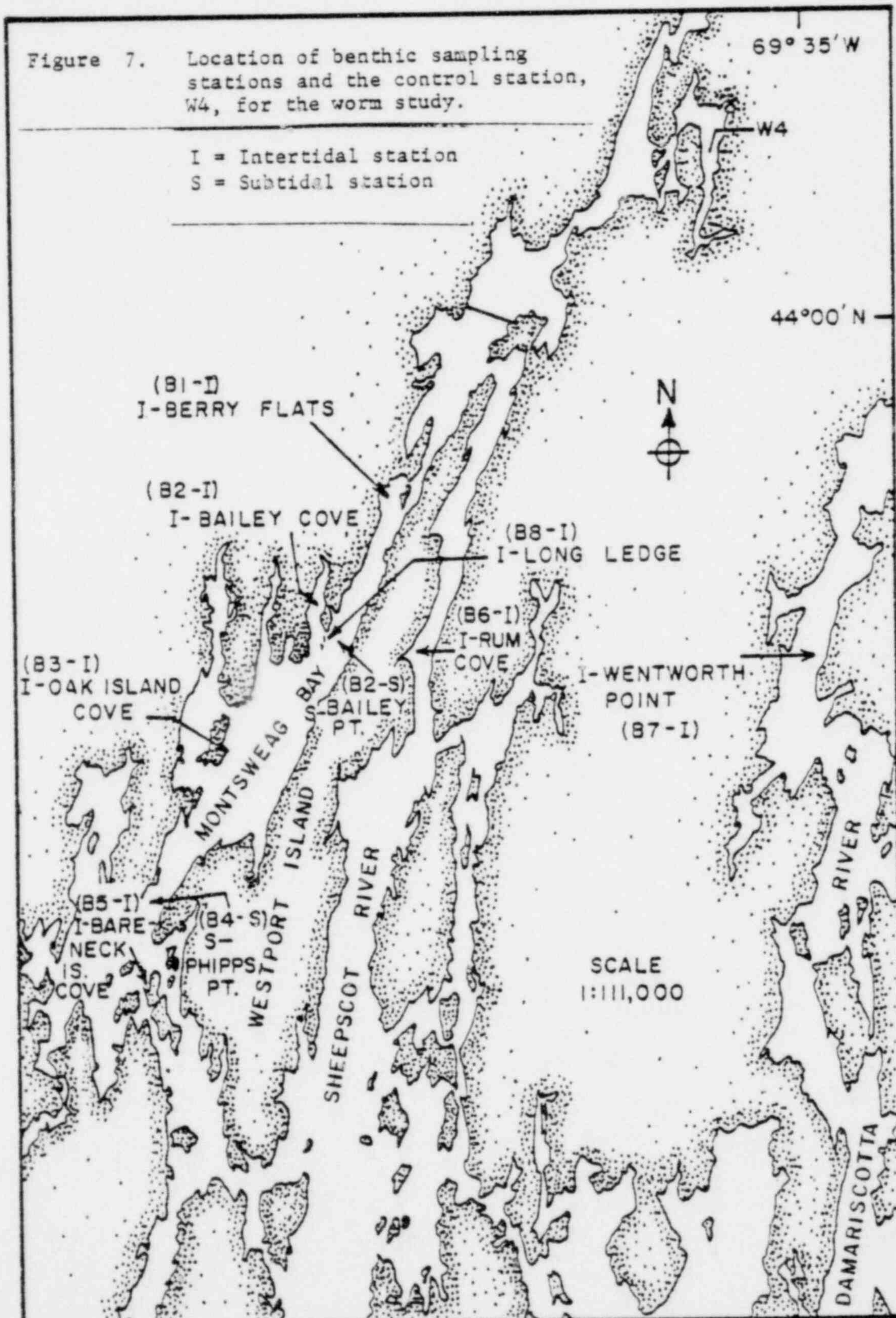
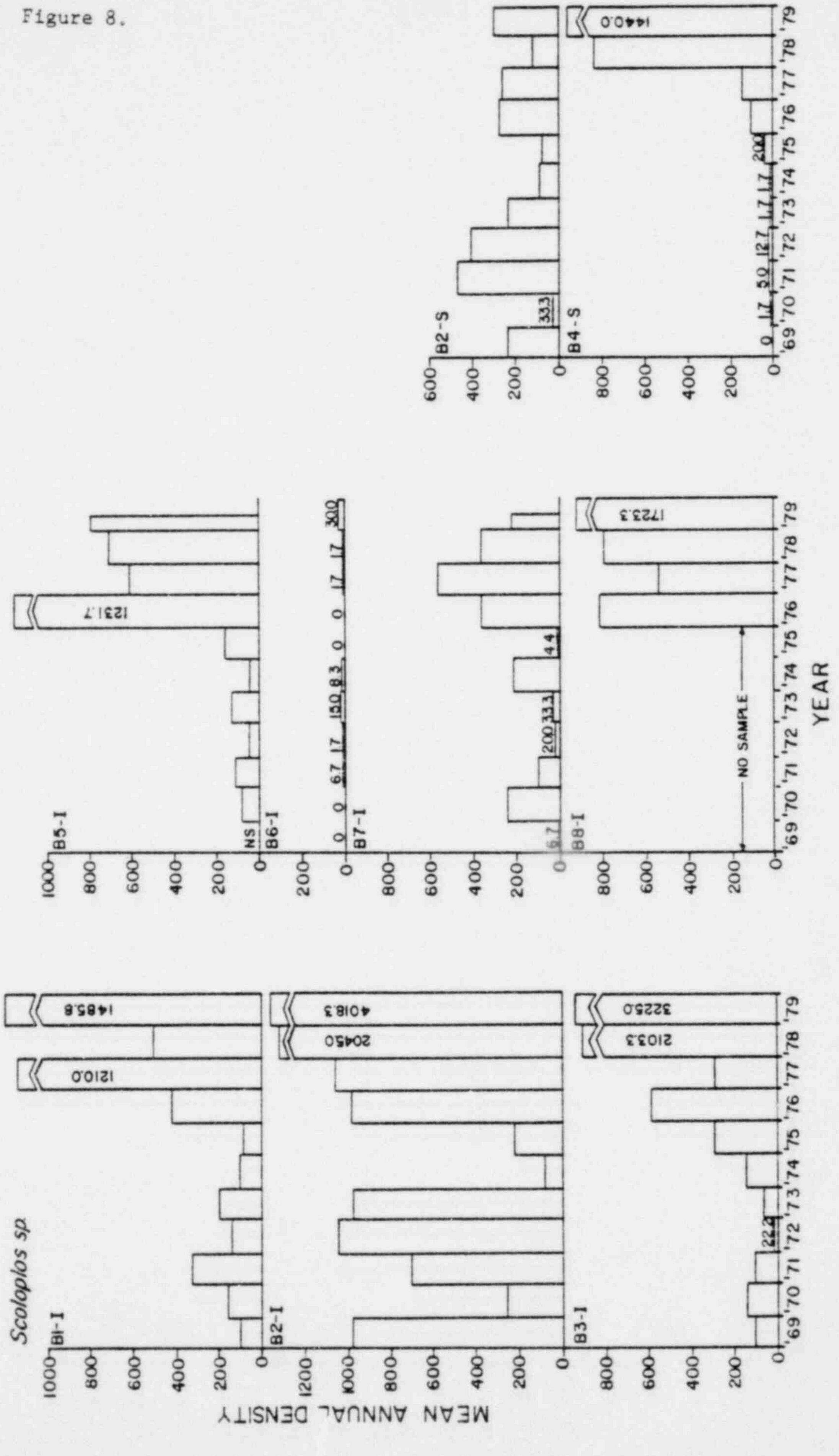


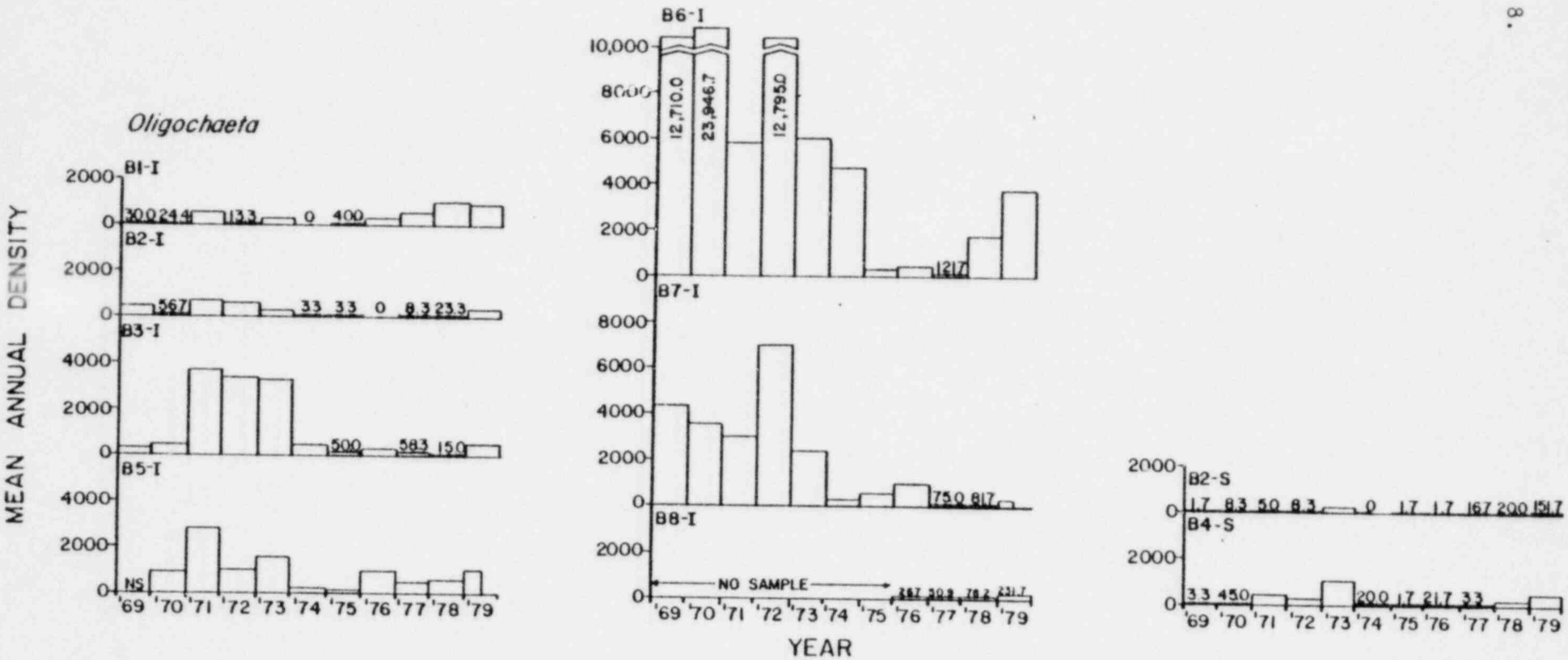
Figure 8. Mean annual density (no. individuals/m^2) of *Hydrobia totteni*, *Streblospio benedicti*, *Macoma balthica*, *Scoloplos* sp., *Heteromastus filiformis*, *Aglaophamus* sp., *Polydora* sp., *Tharyx acutus* and Oligochaeta found at all intertidal and subtidal stations during the period from 1969 to 1979.

Figure 8.



Scolopios sp
MEAN ANNUAL DENSITY
YEAR
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
1485.8
1210.0
4018.3
2045.0
3225.0
2103.3
1231.7
1723.3
1440.0
22.2
NS
NO SAMPLE
'69 '70 '71 '72 '73 '74 '75 '76 '77 '78 '79

Figure 8.


Oligochaeta
MEAN ANNUAL DENSITY
B1-I
2000
0
30.0 24.4
13.3
0
40.0
B2-I
2000
0
56.7
3.3
3.3
0
8.3 23.3
B3-I
4000
2000
0
50.0
58.3
15.0
B5-I
4000
2000
0
NS
'69 '70 '71 '72 '73 '74 '75 '76 '77 '78 '79
B6-I
10,000
8000
6000
4000
2000
0
12,710.0
23,946.7
12,795.0
121.7
B7-I
8000
6000
4000
2000
0
75.0 81.7
B8-I
2000
0
NO SAMPLE
'69 '70 '71 '72 '73 '74 '75 '76 '77 '78 '79
YEAR
2000
B2-S
0
1.7 8.3 5.0 8.3
0
1.7 1.7 16.7 20.0 151.7
B4-S
2000
0
3.3 45.0
20.0 1.7 21.7 3.3
'69 '70 '71 '72 '73 '74 '75 '76 '77 '78 '79

Streblospio benedicti

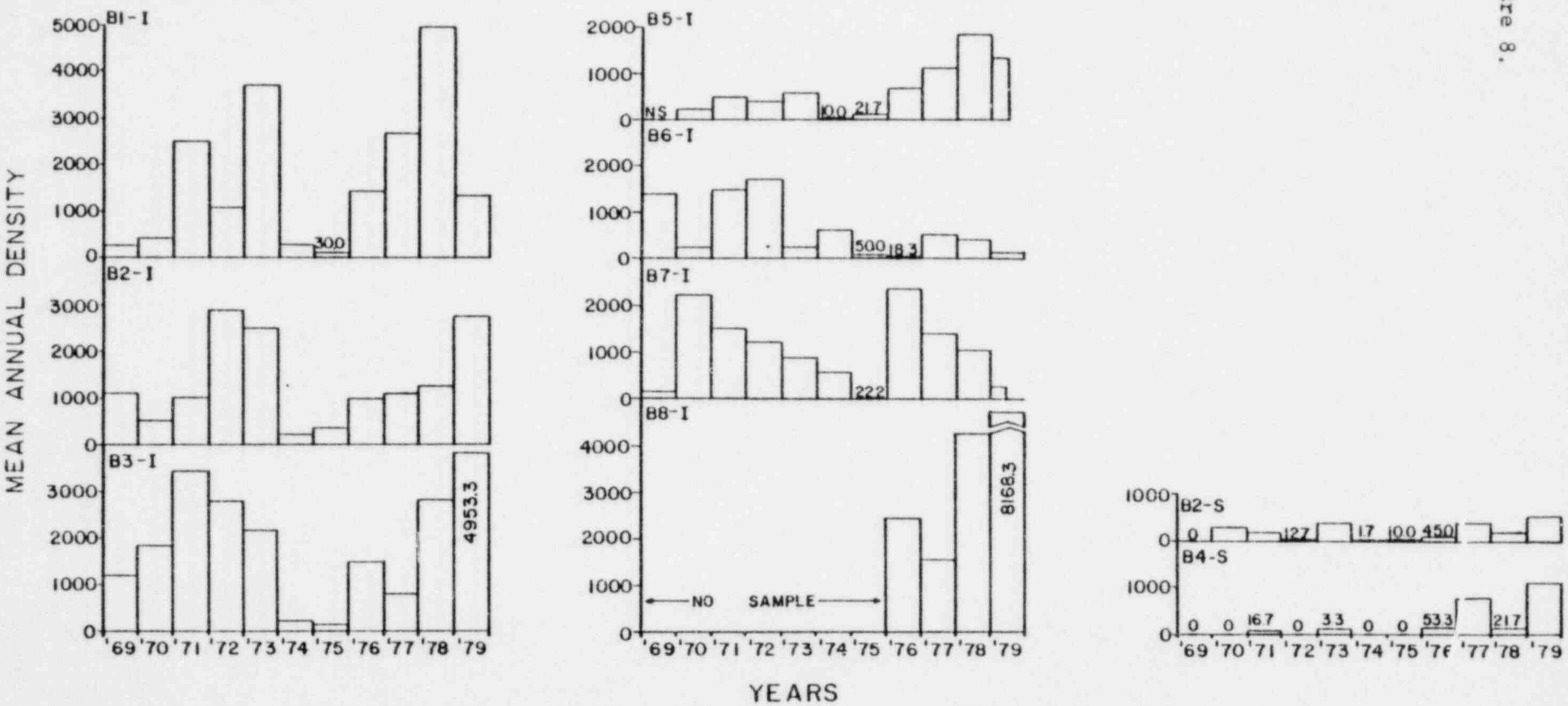


Figure 8.

Figure 8.

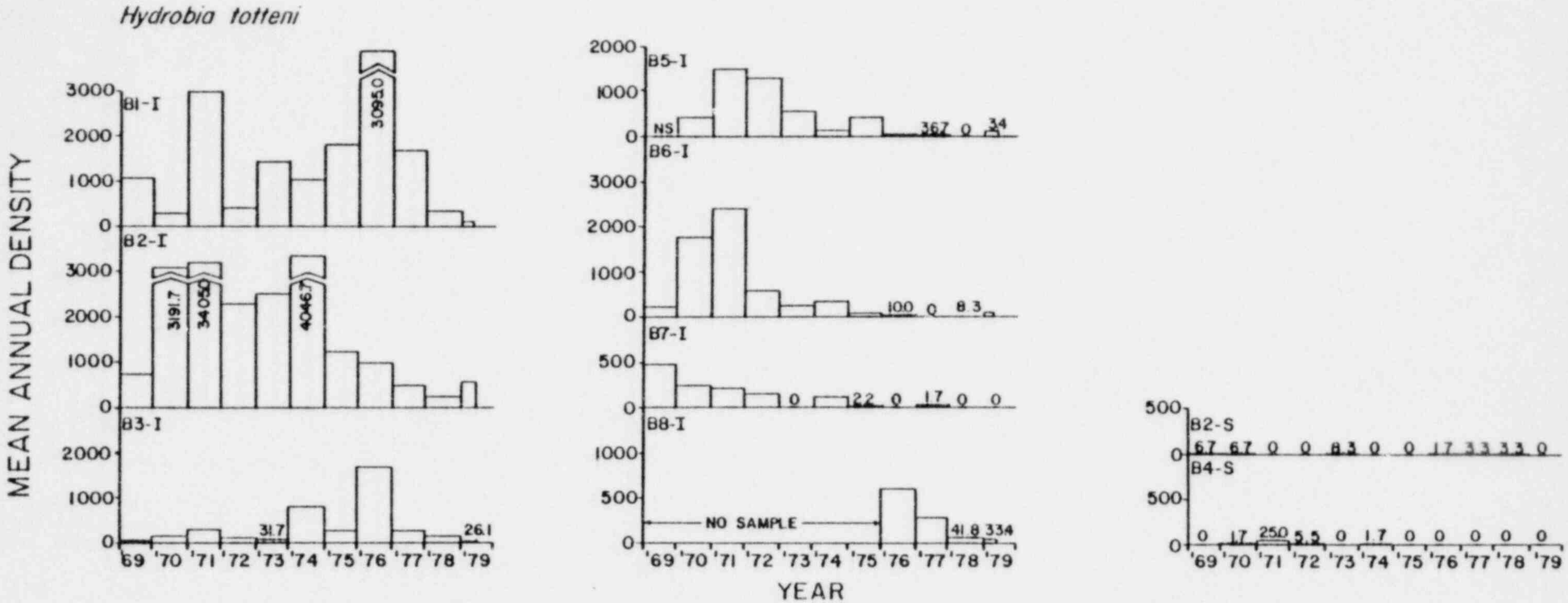

Hydrobia totteni
MEAN ANNUAL DENSITY
YEAR
B1-I
3095.0
B2-I
3191.7
3405.0
4046.7
B3-I
31.7
26.1
B5-I
NS
36.7
0
3.4
B6-I
10.0
0
8.3
B7-I
0
2.2
0
1.7
0
0
B8-I
NO SAMPLE
41.8
33.4
B2-S
6.7
6.7
0
0
8.3
0
0
1.7
3.3
3.3
0
B4-S
0
1.7
25.0
5.5
0
1.7
0
0
0
0
0
'69 '70 '71 '72 '73 '74 '75 '76 '77 '78 '79

Figure 8.

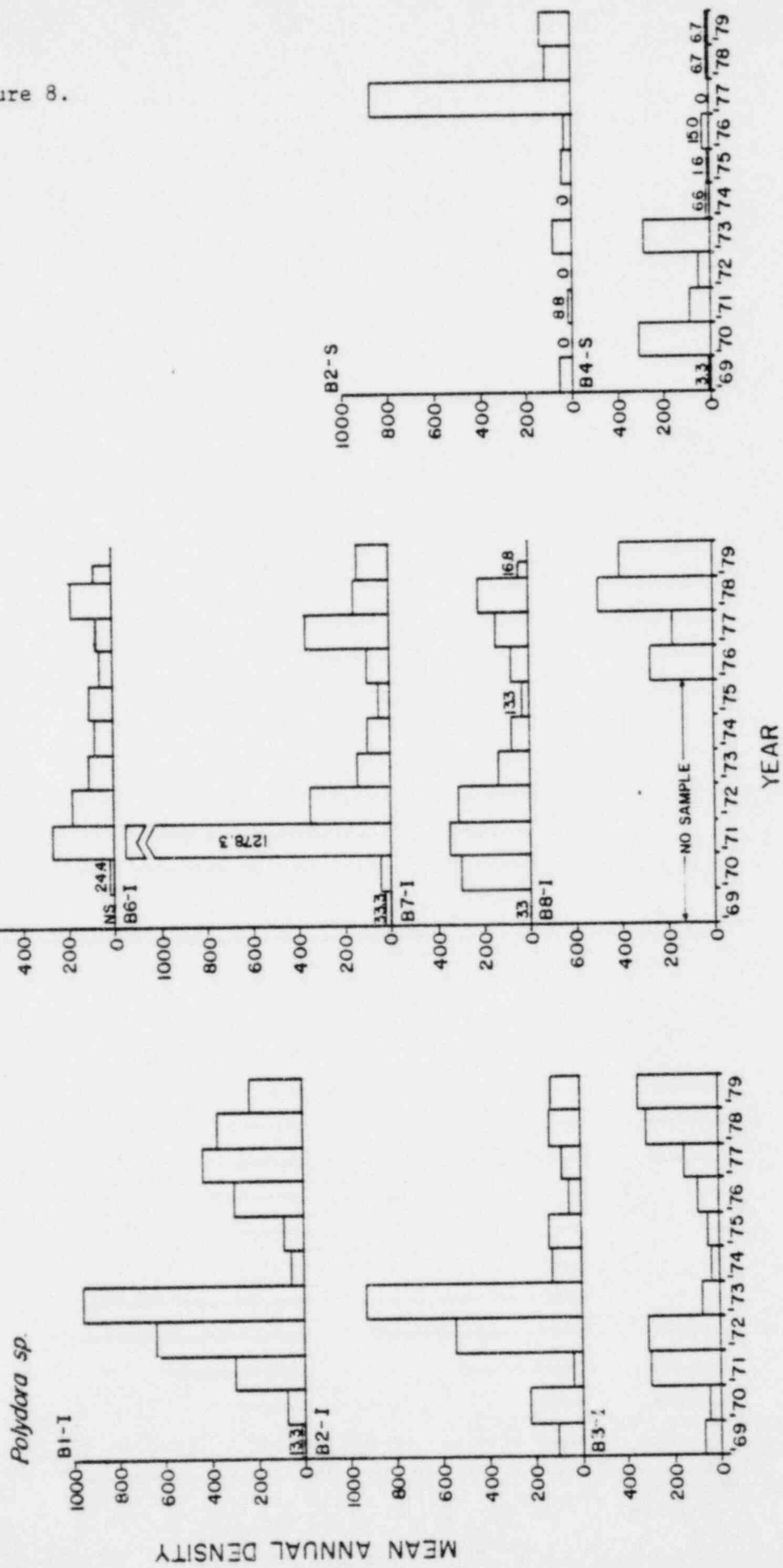

Polydora sp.
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
1278.3
NO SAMPLE
MEAN ANNUAL DENSITY
YEAR

Figure 8.

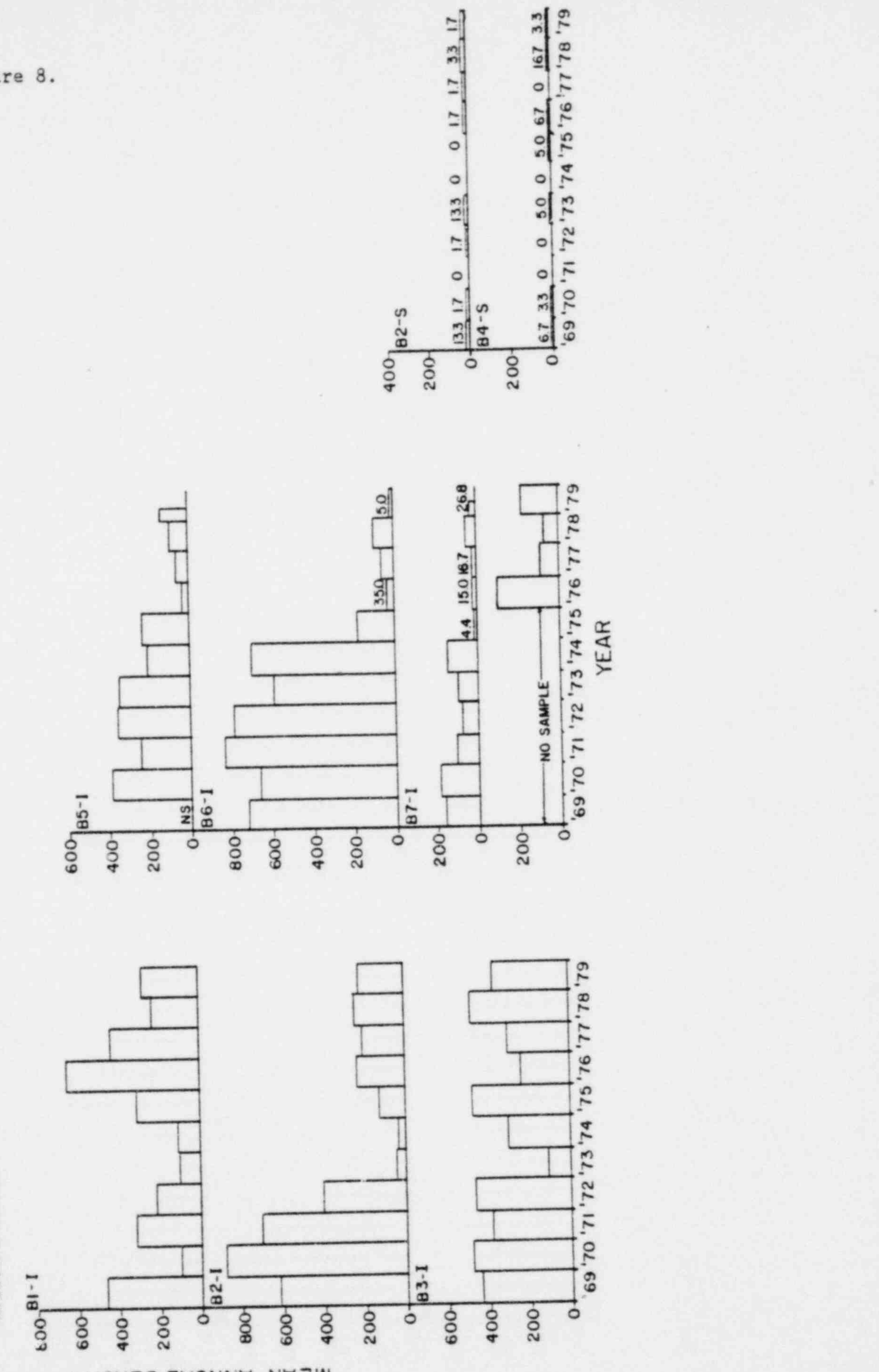
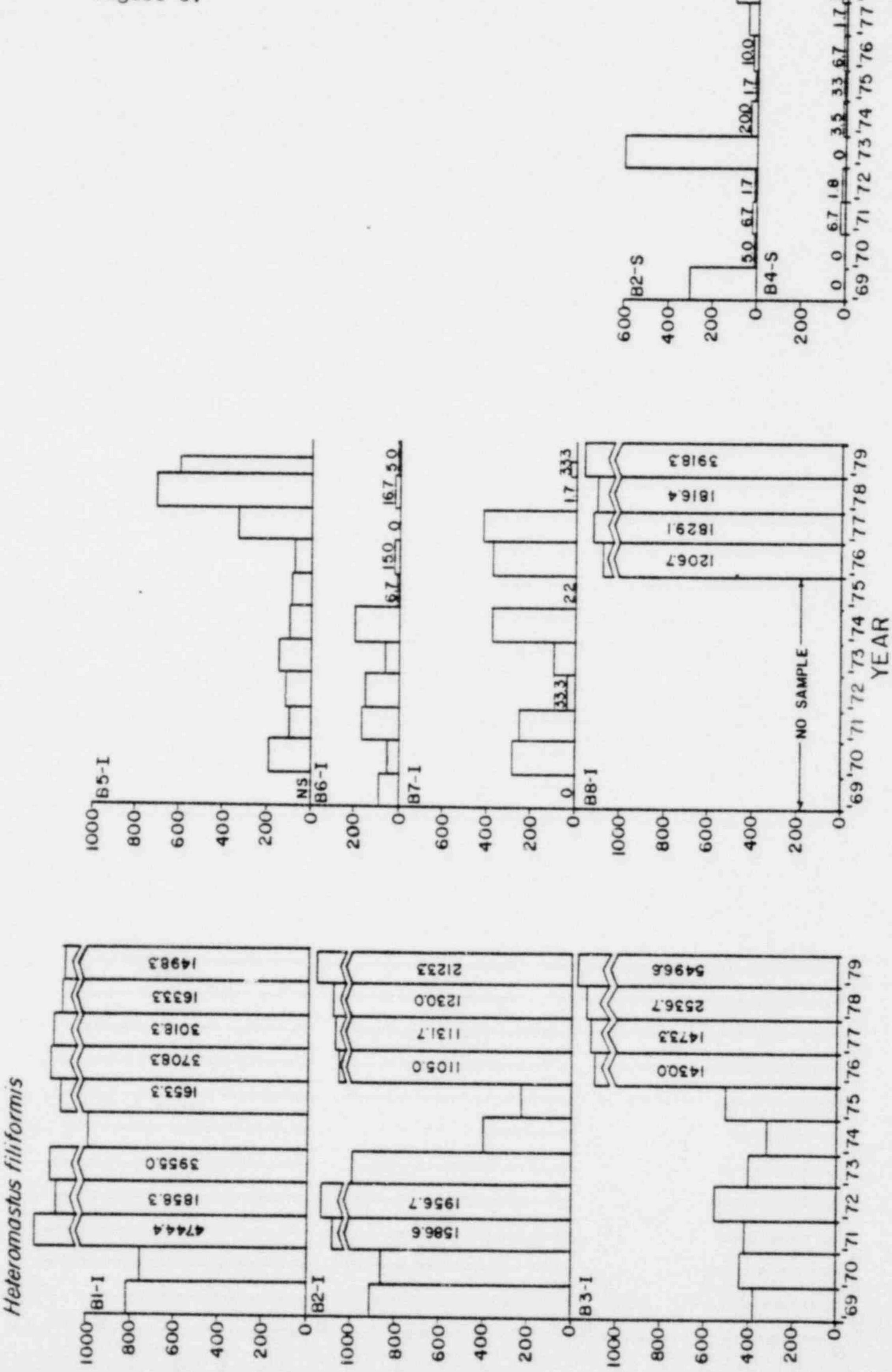
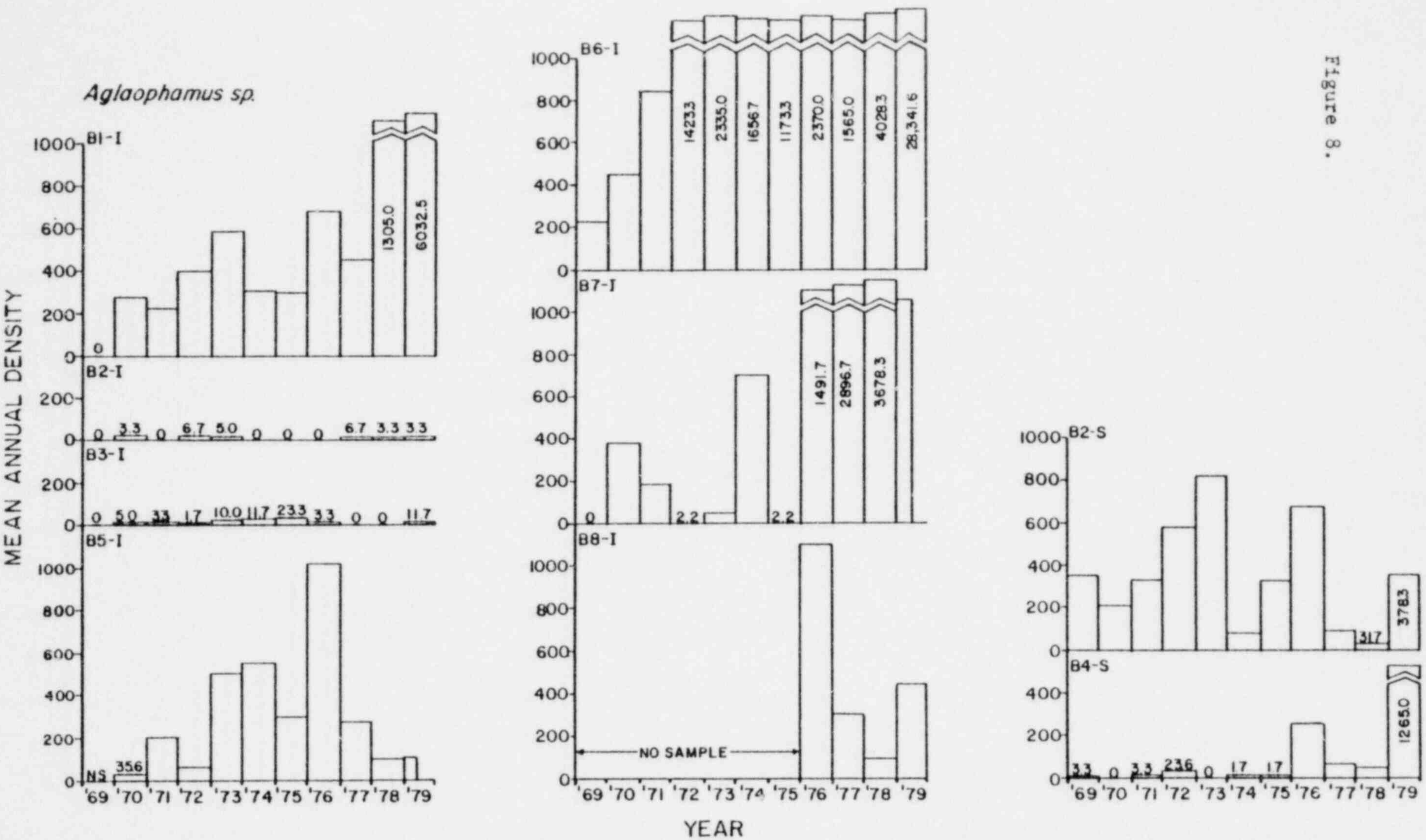

Macoma balthica
MEAN ANNUAL DENSITY
YEAR
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
NS
NO SAMPLE
B2-S
B4-S

Figure 8.



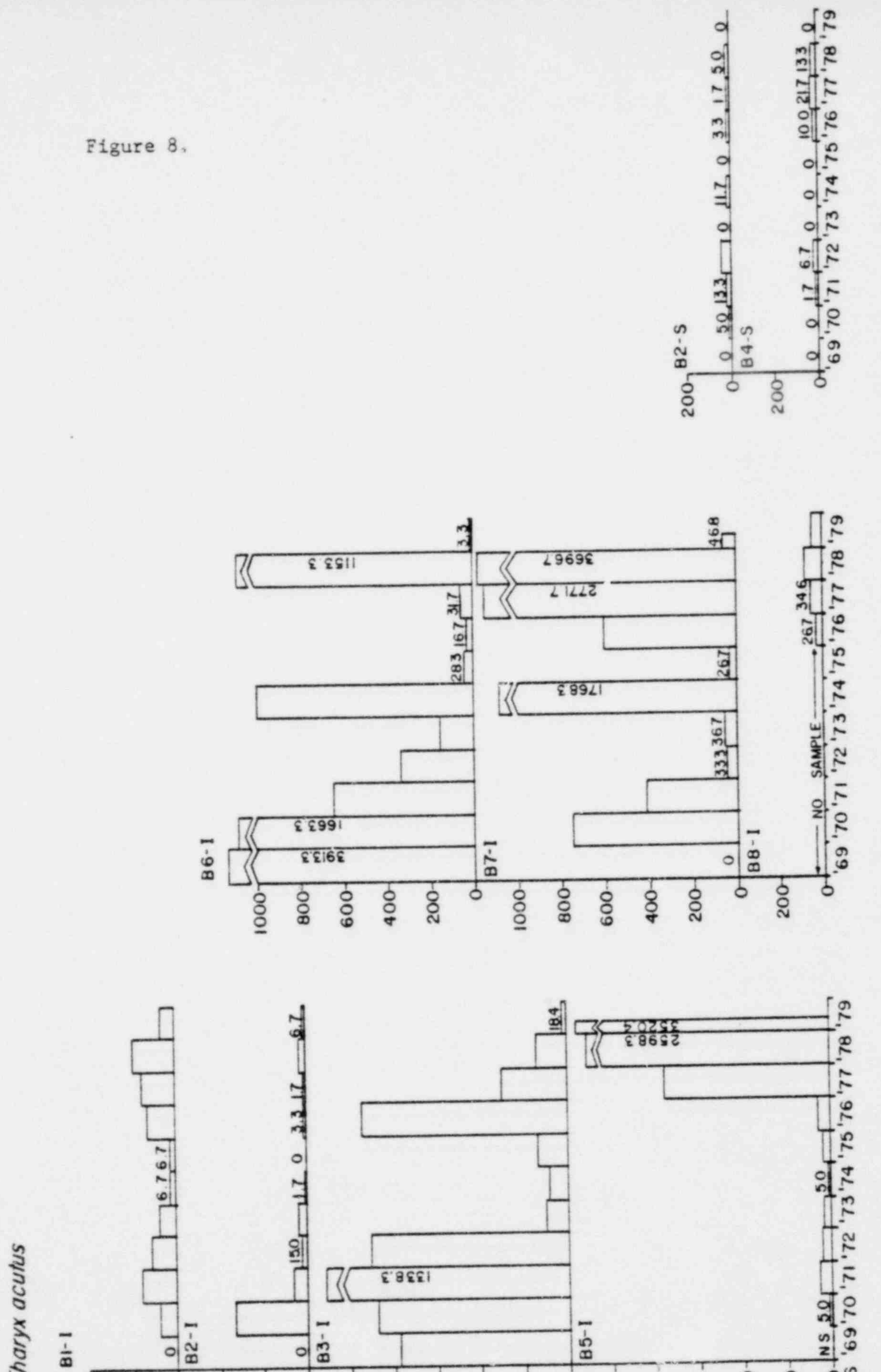
Heteromastus filiformis
MEAN ANNUAL DENSITY
YEAR
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
NS
NO SAMPLE
'69 '70 '71 '72 '73 '74 '75 '76 '77 '78 '79



Aglaophamus sp.
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
MEAN ANNUAL DENSITY
YEAR
NO SAMPLE
NS
1305.0
6032.5
1423.3
2335.0
1656.7
1173.3
2370.0
1565.0
4028.3
28,341.6
1491.7
2896.7
3678.3
378.3
1265.0
'69 '70 '71 '72 '73 '74 '75 '76 '77 '78 '79

Figure 8.

Figure 8.



Tharyx acutus
MEAN ANNUAL DENSITY
YEARS
B1-I
B2-I
B3-I
B5-I
B6-I
B7-I
B8-I
B2-S
B4-S
NO SAMPLE
NS

COMMERCIALLY IMPORTANT INVERTEBRATES

Glenn E. Nutting

Introduction

The objective of this study is to monitor local populations of several commercially important invertebrates in the Maine Yankee area. Species involved in this study include blue mussel *(Mytilus edulis)*, bloodworm *(Glycera dibranchiata)*, sandworm *(Nereis virens)*, American lobster *(Homarus americanus)*, and rock crab *(Cancer irroratus)*. This report covers sampling periods from March 1979 through November 1979.

Materials and Methods

Blue Mussel

Blue mussel were removed once annually (November) from two nearly vertical, rocky intertidal areas (Stations M1 and M2, Figure 9). Five 0.1 m^2 quadrats were randomly placed approximately 1.5 m below MHW at each location. All mussels found within the quadrats were returned to the laboratory for shell length measurements.

Prior to November 1974, four stations were sampled three times a year. Due to the unnatural depletion of the local mussel populations, believed to be caused in part by the sampling method used, stations M1 and M2 were sampled once annually with M1 serving as the Montsweag Bay control station.

Bloodworm and Sandworm

A commercial worm digger collected samples during spring, summer and fall on tidal flats at four locations in Montsweag Bay and one control location in Cushman Cove (Figure 10). Worms were dug with a standard bait-diggers fork at three 10 m long x 1.25 m wide intertidal levels (low, middle, high) along a transect established at each station. All exposed bloodworm and sandworms including fragments were collected and separated into labeled containers. In the laboratory worms were relaxed in a 0.15% propylene phenoxytol seawater solution. Worms were identified to species, counted, and measured to the nearest centimeter while immersed in the relaxant fluid. Worms that were severed were counted but not measured. Sediment temperature was recorded 15 cm below the mud surface in each middle intertidal level.

American Lobster and Rock Crab

Crabs and lobsters were sampled quarterly using two trawls fished in four areas (Figure 9). Each trawl contained five wire lobster traps (Friendship Trap Co., Friendship, Maine) separated from each other by 16 m of line. Bait was homogenized dehydrated herring with modified fish oil. Trawls were hauled for seven consecutive days, except on Sundays during the summer when state law prohibits lobster and crab fishing. Carapace width of crabs, and carapace length of lobsters were measured to the nearest 0.1 mm. The sex of each was recorded. To reduce the probability of recapture, all organisms were released some distance from the trawl site.

Results and Discussion

Blue Mussel

No mussels were found in any of the 0.1 m^2 plots sampled at stations M1 (Back River) and M2 (Bailey Cove). These results are consistent with previous years' data which show a sharp decline in *Mytilus edulis* populations (Figure 11) through 1975 and a complete absence of mussels since 1976. The decline in numbers of mussels found at M1 has been dramatic since the removal of the Westport causeway.

Bloodworms and Sandworms

During 1979 the bloodworm densities (worms/m^2) ranged from 0.1/m^2 to 1.0/m^2 (Table 11). Lowest density was at Z-1 (Cushman Cove) in November and the highest at Z-5 (Oak [illegible] May. These data were within the range of densities recorded during the previous two years with the exception of densities at Z-5. During 1978 the highest density was in November (1.2/m^2) and the lowest was in May (0.4/m^2). During 1979 the highest density was in May (1.0/m^2) and the lowest density was in November (0.3/m^2). Length data of bloodworms at all stations show no increase in the smaller size classes from May through November, indicating virtually no juvenile growth or new recruitment.

During 1979 sandworm densities were greatest at Z-5 (Oak Island) in August (1.5/m^2) and November (1.8/m^2). In May the densities at Z-1 ($0.1/m^2$), Z-4 ($0.4/m^2$), and Z-5 ($0.3/m^2$) were considerably lower than the corresponding densities during May 1978 (Z-1, $8.8/m^2$; Z-4, $2.1/m^2$; Z-5, $3.9/m^2$). At station Z-1 only one sandworm was collected during August and November as compared to 89 worms (15 in August, 74 in November) during the corresponding period in 1978.

Length data for sandworms at Z-3 show an increase in the intermediate and smaller size classes from May through November indicating juvenile growth and new recruitment, and decreases in the large size classes.

American Lobster and Rock Crab

Data obtained during the 1979 sampling periods are summarized in Tables 12-16, and Figure 12. The total lobster catch for June (37), September (30), and December (5) approximated that reported during these periods last year. Only one lobster was collected in the first quarter (March) samples. Generally, catch per station during each sampling period was similar to last year except during September 1979 when the Phipps Point (L6) catch decreased 6 fold (12, 1978; 2, 1979) and Greenleaf Ledge (L7) abundance increased from 4 (1978) to 12 lobsters. Approximately 74% of all lobsters captured were male.

The number of crabs captured during March (713), June (704) and September (539) was two to four times lower than reported in 1978. The December 1979 catch (738) compared favorably with December 1978 data (767). The sex ratio (male:female = 2.5:1) for 1979 was consistent with 1978 except in December at Little Oak Island (L3) where males dominated this year contrary to last year.

Table 11. Total numbers, mean length, and densities of sandworms *(Nereis virens)* and bloodworms *(Glycera dibranchiata)* dug at each of the five sampling stations in Montsweag Bay during the period from June 1976 to November 1979. Total area dug was 37.5^2 at each station unless otherwise noted. Sediment temperatures have also been recorded.

* - total area dug = 75 m^2 ** - total area dug = 50 m^2

Station Z-1: Cushman Cove

	Jun 1976*	Aug 1976	Nov 1976	May 1977	Aug 1977	Nov 1977	May 1978	Aug 1978	Nov 1978	May 1979	Aug 1979	Nov 1979
Sediment temperature (°C)	15°	18°	9.5°	10°	18°	11°	12°	16.1°	4.4°	11.1°	16.7°	10.0°
Nereis virens												
# worms in sample	150	306	293	477	161	221	329	74	15	4	1	-
maximum length (cm)	38	35	42	40	24	32	43	33	17	20	25	-
minimum length (cm)	7	7	3	6	6	5	7	4	7	9	25	-
$\bar{x}$ length (cm)	20.5	21.0	16.6	16.8	14.6	16.7	21.6	19.0	13.2	14.8	-	-
density (worms/m^2)	2.0	8.2	7.8	12.7	4.3	5.9	8.8	2.0	0.4	0.1	0.0	-
Glycera dibranchiata												
# worms in sample	10	10	49	14	12	14	9	9	14	6	8	5
maximum length (cm)	30	37	33	40	37	47	49	46	31	37	22	33
minimum length (cm)	15	16	7	17	15	12	13	18	7	14	12	13
$\bar{x}$ length (cm)	18.7	23.5	14.7	29.1	24.3	18.7	26.9	30.5	17.9	27.5	16.5	22.4
density (worms/m^2)	0.1	0.3	1.3	0.4	0.3	0.4	0.2	0.2	0.4	0.2	0.2	0.1

Table II. *(continued)*

Station Z-4: Young Point

	Jun 1976*	Aug 1976	Nov 1976	May 1977	Aug 1977	Nov 1977	May 1978	Aug 1978	Nov 1978	May 1979	Aug 1979	Nov 1979
Sediment temperature (°C)	15°	18°	9.75°	10°	21°	9°	12°	16.4°	4.2°	13.9°	18.9°	11.7°
Nereis virens												
# worms in sample	23	12	28	33	36	-	86	13	38	15	9	19
maximum length (cm)	34	40	37	43	41	-	49	30	33	37	20	24
minimum length (cm)	9	18	2	10	9	-	12	9	7	12	5	6
$\bar{x}$ length (cm)	18.2	30.3	25.7	19.9	25.4	-	29.2	15.8	16.5	24.4	11.7	13.9
density (worms/m²)	0.3	0.3	0.8	0.9	1.0	-	2.1	0.3	1.0	0.4	0.2	0.5
Glycera dibranchiata												
# worms in sample	44	17	19	14	27	27	12	14	27	24	11	20
maximum length (cm)	30	40	40	40	42	46	46	27	23	37	40	35
minimum length (cm)	16	17	15	17	11	19	10	15	7	6	6	16
$\bar{x}$ length (cm)	20.3	31.1	26.2	29.1	25.4	29.2	26.9	22.1	14.6	22.5	22.8	25.4
density (worms/m²)	0.6	0.5	0.5	0.7	0.8	0.8	0.3	0.4	0.7	0.6	0.3	0.5

Station Z-5: Oak Island

	Jun 1976*	Aug 1976	Nov 1976	May 1977	Aug 1977	Nov 1977	May 1978	Aug 1978	Nov 1978	May 1979	Aug 1979	Nov 1979
Sediment temperature (°C)	15°	18°	9.5°	10°	21°	8°	12°	16.1°	4.4°	12.5°	19.7°	10.8°
Nereis virens												
# worms in sample	163	140	61	135	67	115	145	51	48	12	58	68
maximum length (cm)	43	43	40	43	32	38	43	40	33	37	35	37
minimum length (cm)	9	7	9	9	6	9	7	5	8	11	4	6
$\bar{x}$ length (cm)	27.3	27.0	27.0	26.3	16.6	24.9	22.2	18.3	19.2	19.0	17.0	21.6
density (worms/m²)	2.2	3.7	1.6	3.6	1.8	3.1	3.9	1.4	1.3	0.3	1.5	1.8
Glycera dibranchiata												
# worms in sample	17	21	42	12	20	37	16	40	46	39	15	13
maximum length (cm)	39	49	45	32	37	36	51	47	33	35	30	29
minimum length (cm)	11	14	6	14	15	7	16	9	8	7	6	11
$\bar{x}$ length (cm)	23.6	30.0	21.5	21.6	19.9	20.0	27.8	24.7	19.2	19.5	20.3	19.5
density (worms/m²)	0.2	0.6	1.1	0.3	0.5	1.0	0.4	1.1	1.2	1.0	0.4	0.3

Table 11. *(continued)*

Station Z-2: Foxbird Island

	Jun 1976*	Aug 1976	Nov 1976	May 1977	Aug 1977	Nov 1977	May 1978	Aug 1978	Nov 1978	May 1979	Aug 1979	Nov 1979
Sediment temperature (°C)	15°	18°	9.5°	10°	20°	11°	12°	16.7°	5.0°	11.4°	18.3°	10.0°
Nereis virens												
# worms in sample	90	71	35	20	11	16	36	26	16	27	27	41
maximum length (cm)	46	45	24	51	20	32	50	40	45	35	35	34
minimum length (cm)	7	11	5	10	9	6	22	5	10	11	6	6
$\bar{x}$ length (cm)	19.7	20.8	16.2	25.6	14.0	19.0	40.6	17.6	24.2	19.8	13.7	20.0
density (worms/m²)	1.8	1.9	0.9	0.5	0.5	0.4	0.8	0.7	0.4	0.7	0.7	1.1
Glycera dibranchiata												
# worms in sample	32	26	35	18	18	35	22	22	21	30	6	20
maximum length (cm)	32	53	41	40	40	31	44	33	38	34	30	35
minimum length (cm)	18	16	15	17	10	8	14	9	10	9	10	11
$\bar{x}$ length (cm)	25.8	30.4	28.9	22.5	22.4	16.3	27.1	23.1	20.4	23.1	23.7	22.3
density (worms/m²)	0.7	0.7	0.9	0.5	0.5	0.9	0.6	0.6	0.6	0.8	0.2	0.5

Station Z-3: Long Ledge

	Jun 1976*	Aug 1976	Nov 1976	May 1977	Aug 1977	Nov 1977	May 1978	Aug 1978	Nov 1978	May 1979	Aug 1979	Nov 1979
Sediment temperature (°C)	15°	18°	9.5°	10°	21°	11°	12°	16.1°	5.6°	11.9°	19.4°	10.6°
Nereis virens												
# worms in sample	33	19	21	34	109	20	21	50	31	16	25	21
maximum length (cm)	43	27	31	53	43	35	45	29	35	26	40	25
minimum length (cm)	8	9	5	9	8	7	7	4	12	16	6	7
$\bar{x}$ length (cm)	19.7	15.4	18.1	30.5	23.6	19.5	20.1	15.2	21.6	20.5	15.8	14.4
density (worms/m²)	0.4	0.5	0.6	0.9	2.9	1.9	0.3	1.3	0.8	0.4	0.7	0.6
Glycera dibranchiata												
# worms in sample	55	31	32	28	34	27	18	31	24	25	16	19
maximum length (cm)	40	43	50	43	45	29	50	42	30	34	40	35
minimum length (cm)	12	11	13	12	8	8	19	10	12	9	7	7
$\bar{x}$ length (cm)	22.3	25.1	28.3	26.3	25.4	29.2	33.3	27.8	19.7	20.8	22.0	23.4
density (worms/m²)	0.7	0.8	0.9	0.8	0.9	0.7	0.5	0.8	0.6	0.7	0.4	0.5

Table 12. Size and sex of crabs, *Cancer irroratus*, caught during the sampling periods #38-41 (March, June, September, and December 1979).

# Trap Days	Station	Dates	Number Caught M/F	Ratio M/F	Males (mm) Max	Males (mm) Min	Males (mm) Avg	Females (mm) Max	Females (mm) Min	Females (mm) Avg	No. caught per trap days hauled M	No. caught per trap days hauled F
35	38-L1	Mar 10-16	29/8	3.62	109.6	70.9	86.7	80.0	69.7	74.0	0.82	0.23
35	38-L2	↓	76/18	4.22	109.6	65.8	86.4	81.9	61.5	73.8	2.17	0.51
35	38-L3		62/12	5.16	111.3	61.9	88.2	90.2	66.5	78.0	1.77	0.34
35	38-L4		221/7	31.57	120.0	78.2	102.6	87.4	73.5	80.5	6.31	0.20
35	38-L5		1/0	-	108.2	108.2	-	-	-	-	0.03	-
35	38-L6		4/0	-	111.7	104.4	107.2	-	-	-	0.11	-
35	38-L7		182/56	3.25	127.0	71.1	107.9	95.4	70.5	81.7	5.20	1.60
35	38-L8		17/10	1.70	123.4	91.0	104.6	92.3	74.4	84.9	0.48	0.28
35	39-L1	June 8-14	86/7	12.28	108.5	69.1	88.4	92.3	69.0	74.8	2.46	0.20
35	39-L2	↓	103/16	6.44	110.5	68.3	94.8	92.5	63.9	75.0	2.94	0.46
35	39-L3		101/48	2.10	115.9	56.0	90.2	89.8	68.9	77.2	2.88	1.37
35	39-L4		106/41	2.58	110.5	65.5	89.0	89.4	69.2	78.8	3.03	1.17
35	39-L5		11/4	2.75	93.5	48.5	84.9	86.9	68.4	75.8	0.31	0.11
35	39-L6		59/17	3.47	110.2	71.6	90.6	90.7	67.5	80.4	1.68	0.48
35	39-L7		35/10	3.50	125.0	82.2	101.4	92.3	76.4	83.0	1.00	0.28
35	39-L8		57/3	19.0	120.1	81.4	103.6	96.1	78.6	86.9	1.63	0.08
35	40-L1	Sept 14-20	45/15	3.00	104.0	65.1	90.2	86.6	56.2	72.5	1.28	0.43
35	40-L2	↓	33/6	5.50	106.8	75.5	94.1	91.8	66.8	77.3	0.94	0.17
35	40-L3		30/22	1.36	101.5	76.4	87.6	90.2	65.9	79.8	0.86	0.63
35	40-L4		62/70	0.88	103.8	67.2	80.3	93.5	67.0	80.0	1.77	2.00
35	40-L5		20/18	1.11	107.6	71.2	85.8	93.5	61.3	80.5	0.57	0.51
35	40-L6		38/18	2.11	101.6	55.3	87.0	100.8	71.8	81.8	1.08	0.51
35	40-L7		29/60	0.48	118.5	87.5	95.8	96.7	68.6	82.9	0.83	1.71
35	40-L8		21/52	0.40	111.6	86.1	98.4	97.7	72.9	83.2	0.60	1.48
35	41-L1	Dec 7-13	39/9	4.33	102.9	70.0	89.1	82.8	69.4	75.8	1.11	0.26
35	41-L2	↓	58/61	0.95	109.0	70.3	95.6	94.4	64.5	75.6	1.66	1.74
35	41-L3		27/18	1.50	114.9	78.6	95.2	88.7	66.3	79.5	0.77	0.51
35	41-L4		114/16	7.12	118.1	72.9	97.4	90.3	73.1	81.4	3.26	0.46
35	41-L5		64/15	4.27	124.6	71.4	105.4	84.5	69.9	77.4	1.[illegible]	0.4[illegible]
35	41-L6		107/34	3.15	125.6	75.5	103.1	93.6	63.4	82.6	3.06	0.9[illegible]
35	41-L7		51/68	0.75	114.5	72.5	97.0	98.6	73.6	84.8	1.46	1.9[illegible]
35	41-L8		26/31	0.84	117.0	74.1	99.6	93.4	72.4	84.6	0.74	0.8[illegible]

Table 13. Size (mm) and sex of lobsters *(Homarus americanus)* caught during sampling period #38 (10-16 March 1979).

M = Male F = Female * = Legal sized lobster

Trawl No.	Mar 10	Mar 11	Mar 12	Mar 13	Mar 14	Mar 15	Mar 16	Total
L1							88.4M*	1
L2								
L3								
L4								
L5								
L6								
L7								
L8								
Total							1	1

Table 14. Size (mm) and sex of lobsters *(Homarus americanus)* caught during sampling period #39 (8-14 June 1979).

M = Male F = Female * = Legal sized lobster

Trawl No.	June 8	June 9	June 10	June 11	June 12	June 13	June 14	Total
L1	86.0 F*		Sunday - Could not haul	95.3 M*		78.8 M		3
L2								
L3								
L4				88.1 M*				1
L5								
L6							77.8 M	1
L7	79.5 M 78.1 M	74.2 M 70.1 F		73.6 M 73.8 M 79.5 M 78.0 F	79.5 M 71.7 M 79.6 F	77.1 M 78.4 M	83.8 M* 69.0 M 80.9 M*	16
L8	76.4 M			80.3 M 71.5 M	76.6 M 76.1 M 79.9 M 71.2 F	77.0 M 74.6 F 72.4 F 80.7 F 83.8 F*	78.0 M 76.9 M 68.7 M 77.3 M	16
Total	4	2		8	7	8	8	37

Table 15. Size (mm) and sex of lobsters *(Homarus americanus)* caught during sampling period #40 (14-20 September 1979).

M = Male F = Female * = Legal sized lobster

Trawl No.	Sept 14	Sept 15	Sept 16	Sept 17	Sept 18	Sept 19	Sept 20	Total
L1		75.6 M	84.3 M* 78.9 M		89.7 M*		80.7 M	5
L2		77.9 M					79.8 M	2
L3	71.2 M							1
L4						92.7 F*	80.1 M	2
L5				87.0 M*		81.4 F*		2
L6			77.2 M		76.7 M			2
L7	74.4 M 79.5 F	78.6 M 77.4 M 76.7 F	84.8 M*	74.9 M 75.1 F 76.7 M 78.3 F 81.1 M*	81.2 M* 77.6 M 89.6 F* 67.7 F			15
L8			73.5 M					1
Total	3	5	5	6	6	2	3	30

Table 16. Size (mm) and sex of lobsters *(Homarus americanus)* caught during sampling period # 41 (7-13 December 1979).

M = Male   F = Female   * = Legal sized lobster

Trawl No.	Dec 7	Dec 8	Dec 9	Dec 10	Dec 11	Dec 12	Dec 13	Total
L1			93.7 F*					1
L2								
L3								
L4	76.7 M							1
L5								
L6								
L7			70.3 F		77.5 M 80.2 F			3
L8								
Total	1		2		2			5

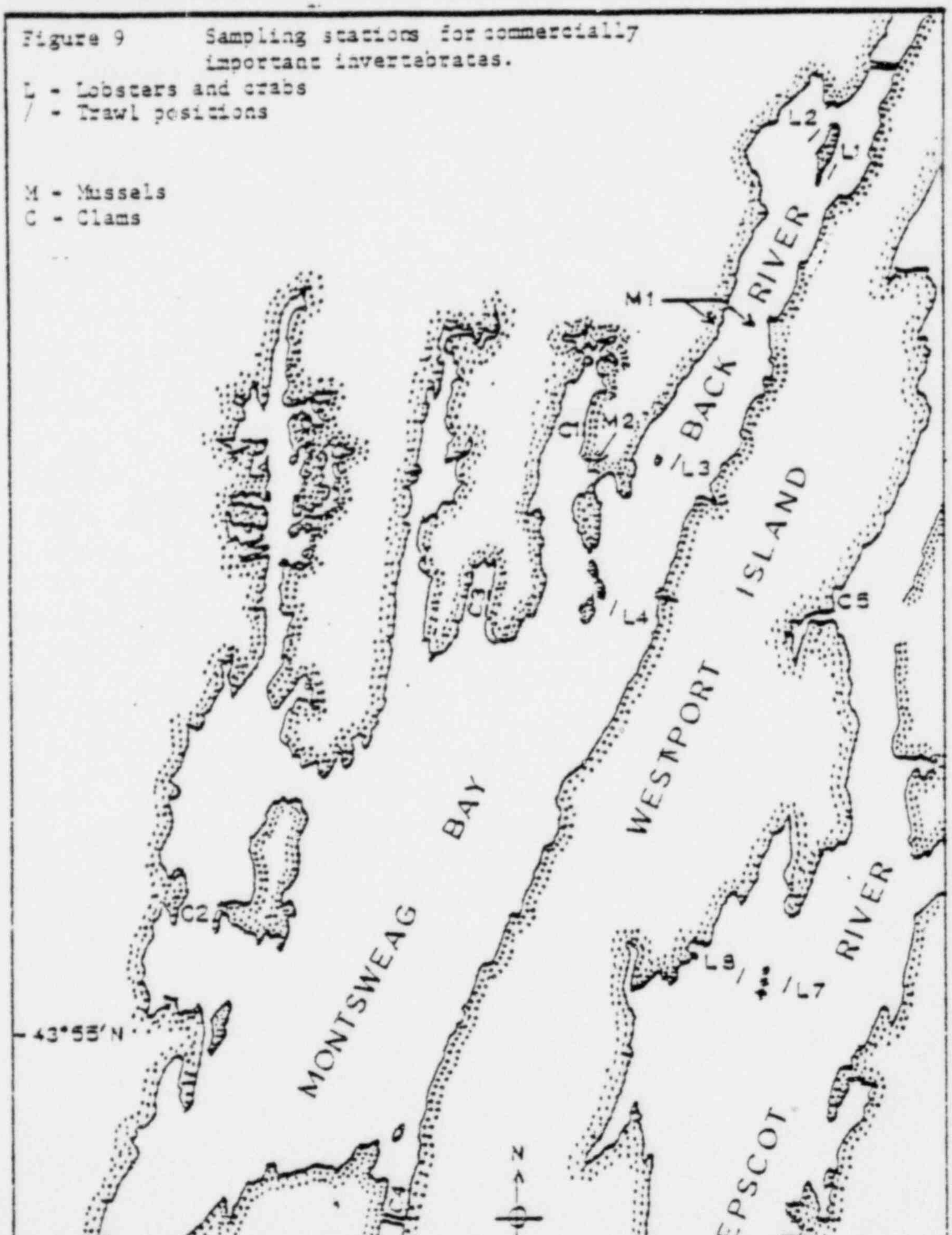


Figure 9 Sampling stations for commercially important invertebrates.

L - Lobsters and crabs
/ - Trawl positions

M - Mussels
C - Clams

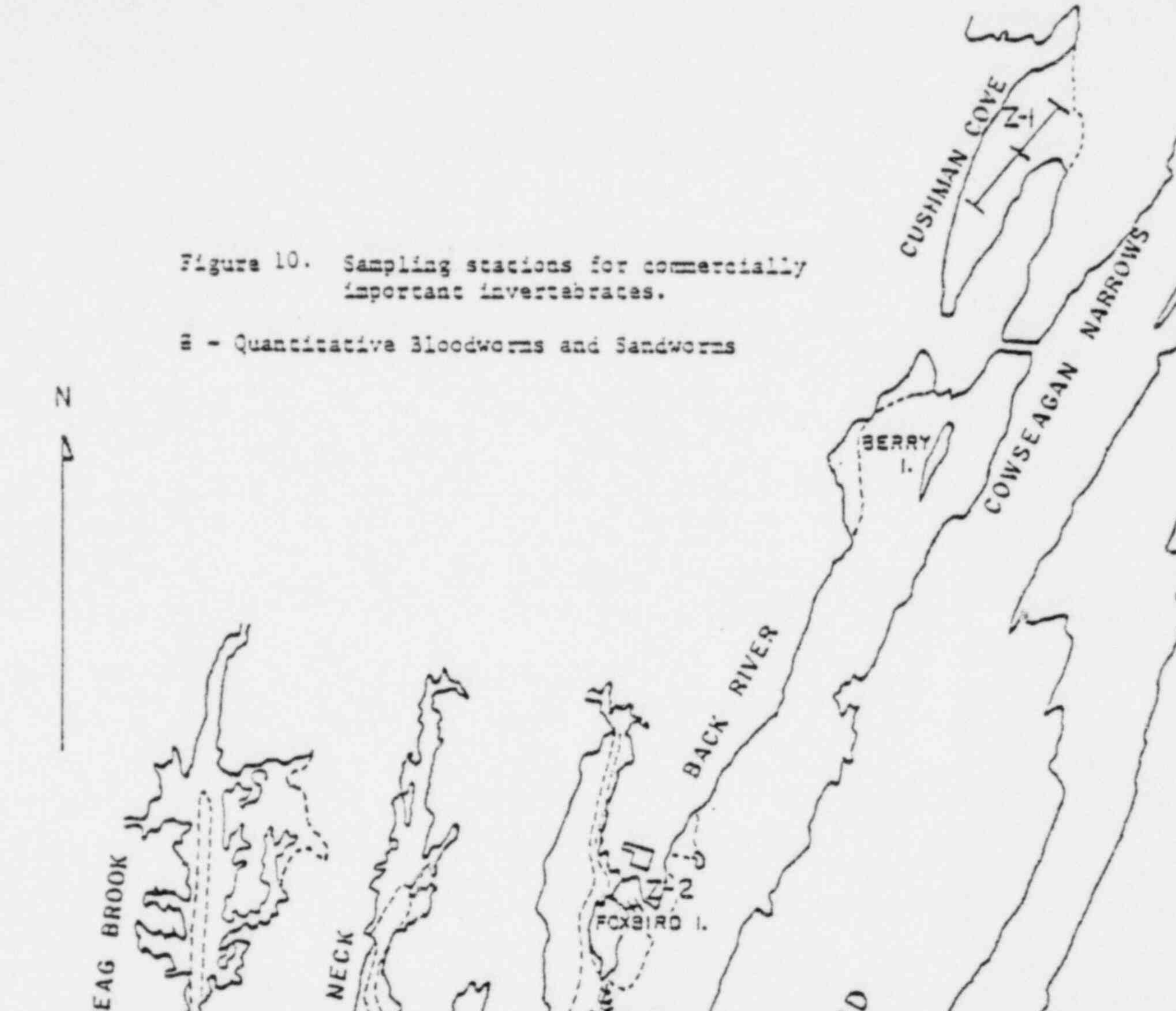


Figure 10. Sampling stations for commercially important invertebrates.

Z - Quantitative Bloodworms and Sandworms

Figure 11. Number of blue mussels *(Mytilus edulis)* found at two historical sampling stations, 1970 - 1979.

* = inaccessible due to ice

\- = not sampled

NMF = no mussels found

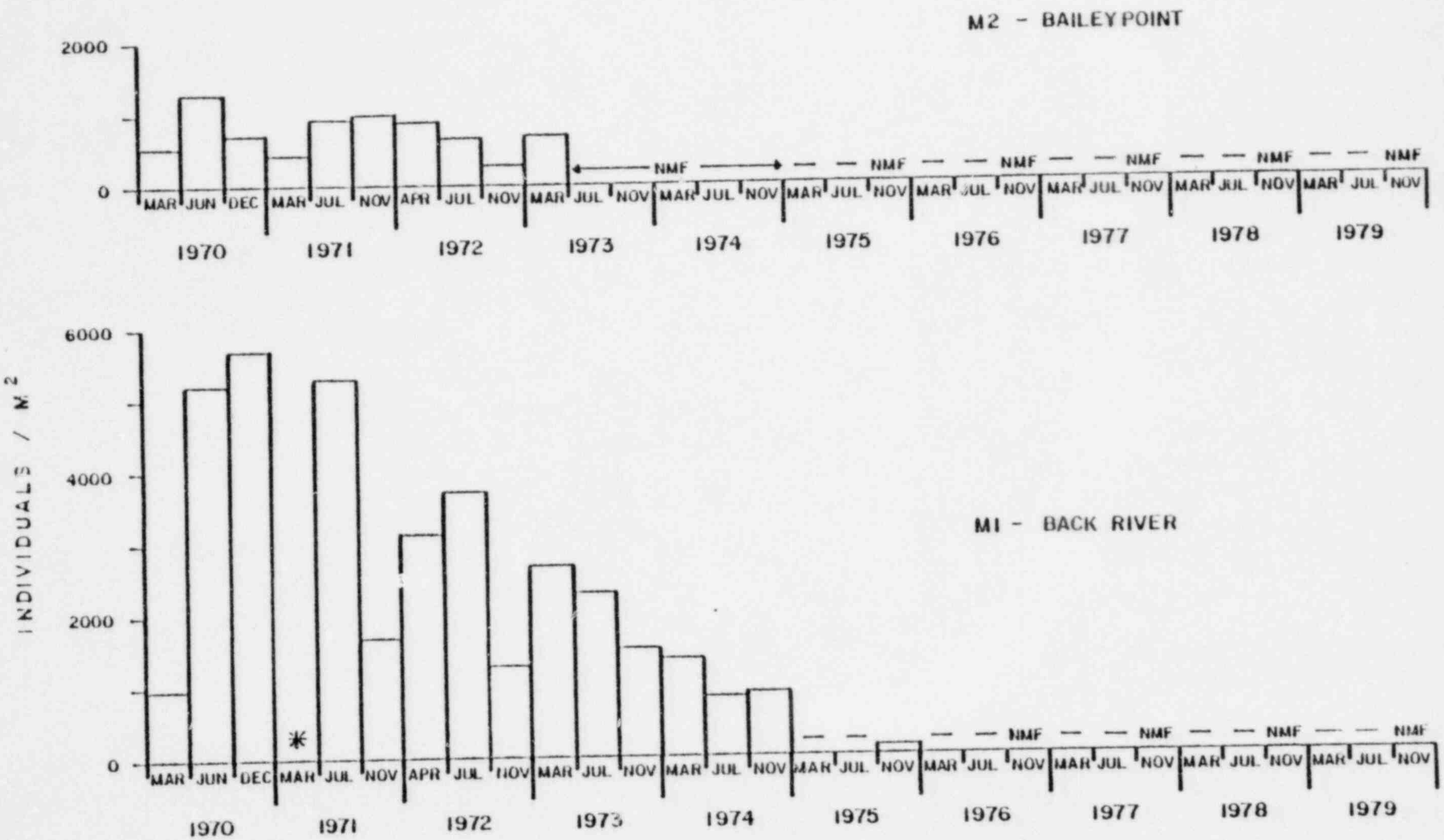

M2 - BAILEYPOINT
2000
0
MAR JUN DEC MAR JUL NOV APR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979
NMF
INDIVIDUALS / M²
6000
4000
2000
0
MI - BACK RIVER
*
MAR JUN DEC MAR JUL NOV APR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV MAR JUL NOV
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979
NMF

Figure 12. Number of crabs caught per trap day at Stations L1 - L8 from December 1969 to December 1979.

Figure 12.

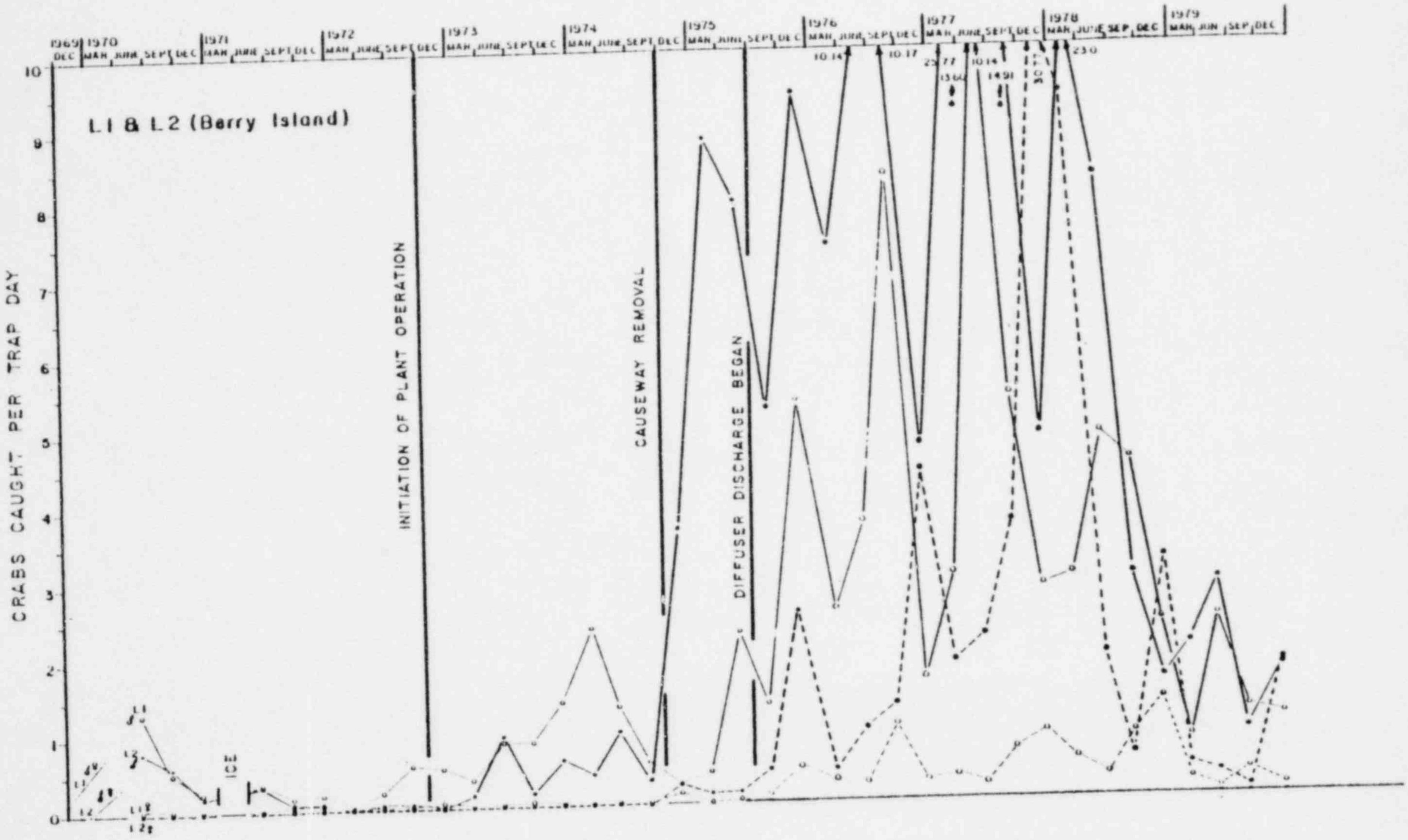

L1 & L2 (Berry Island)
CRABS CAUGHT PER TRAP DAY
INITIATION OF PLANT OPERATION
CAUSEWAY REMOVAL
DIFFUSER DISCHARGE BEGAN
ICE
1969 DEC
1970 MAR JUNE SEPT DEC
1971 MAR JUNE SEPT DEC
1972 MAR JUNE SEPT DEC
1973 MAR JUNE SEPT DEC
1974 MAR JUNE SEPT DEC
1975 MAR JUNE SEPT DEC
1976 MAR JUNE SEPT DEC
1977 MAR JUNE SEPT DEC
1978 MAR JUNE SEP DEC
1979 MAR JUN SEP DEC
0 1 2 3 4 5 6 7 8 9 10
10.14
10.17
25.77
13.62
10.14
14.91
23.0

Figure 12.

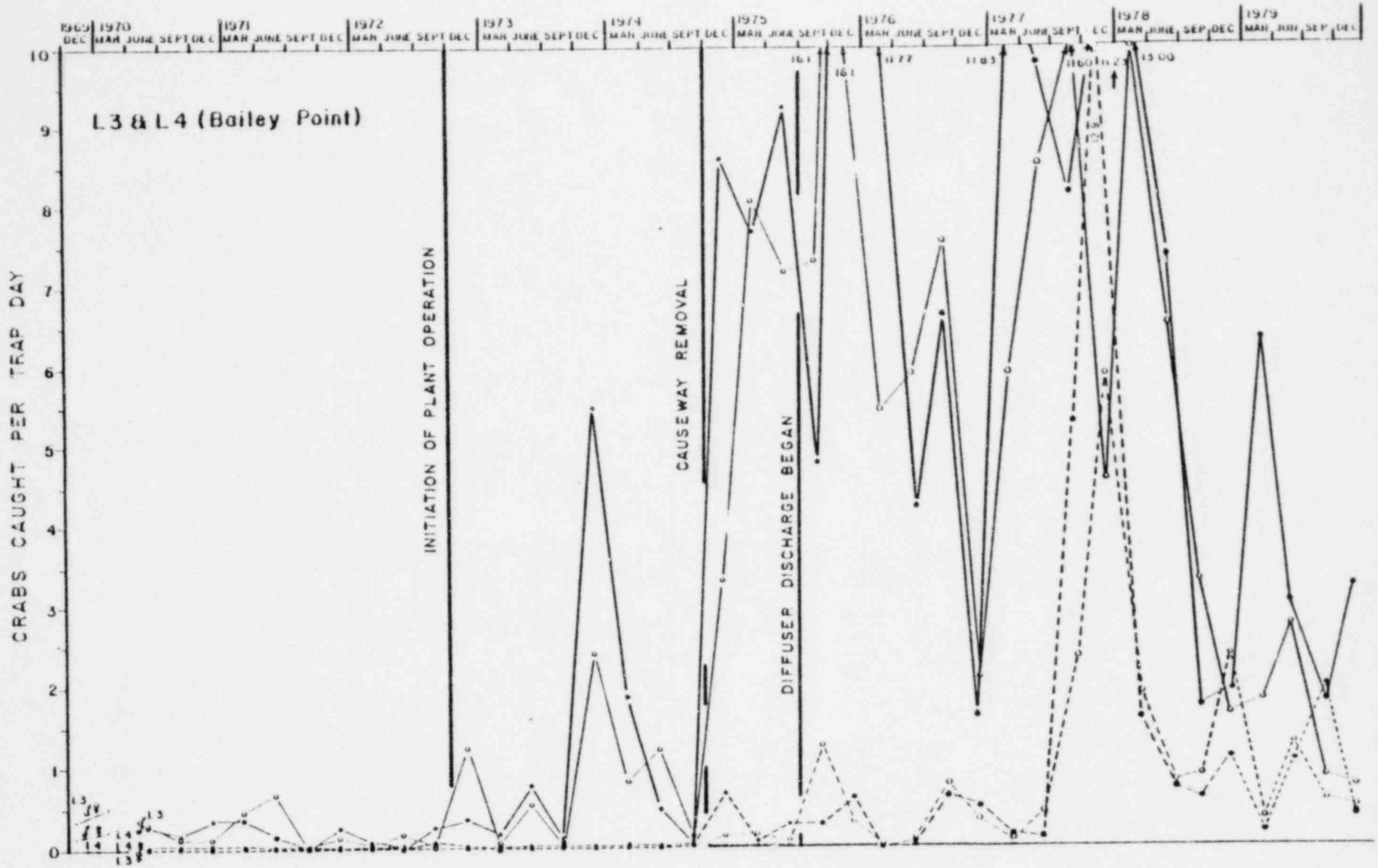
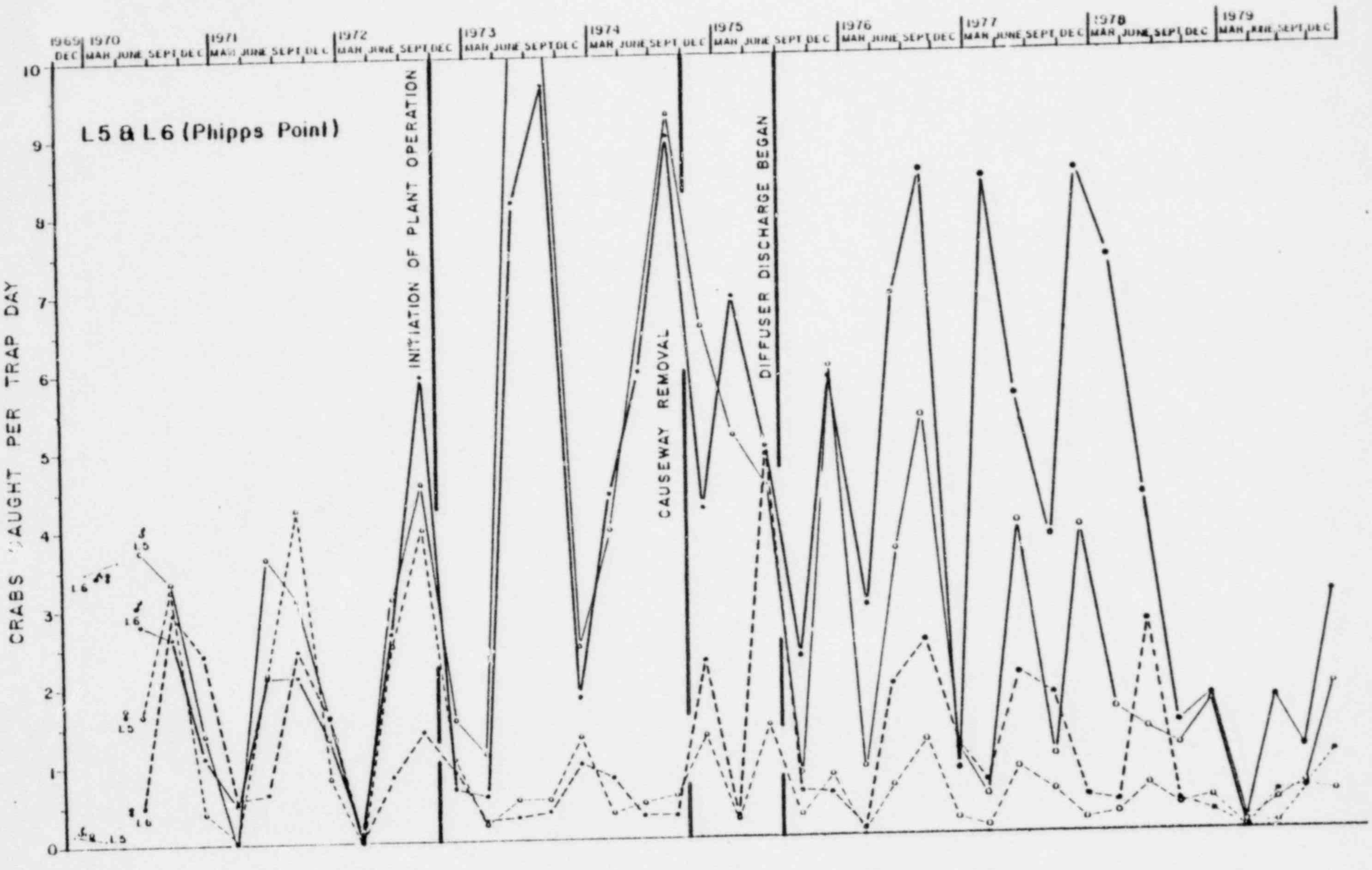

L3 & L4 (Bailey Point)
CRABS CAUGHT PER TRAP DAY
INITIATION OF PLANT OPERATION
CAUSEWAY REMOVAL
DIFFUSER DISCHARGE BEGAN
1969 DEC
1970 MAR JUNE SEPT DEC
1971 MAR JUNE SEPT DEC
1972 MAR JUNE SEPT DEC
1973 MAR JUNE SEPT DEC
1974 MAR JUNE SEPT DEC
1975 MAR JUNE SEPT DEC
1976 MAR JUNE SEPT DEC
1977 MAR JUNE SEPT DEC
1978 MAR JUNE SEPT DEC
1979 MAR JUN SEP DEC
0
1
2
3
4
5
6
7
8
9
10
L3
L4
16.1
11.77
11.83
11.60
13.00

Figure 12.


L5 & L6 (Phipps Point)
CRABS CAUGHT PER TRAP DAY
INITIATION OF PLANT OPERATION
CAUSEWAY REMOVAL
DIFFUSER DISCHARGE BEGAN
1969 DEC
1970 MAR JUNE SEPT DEC
1971 MAR JUNE SEPT DEC
1972 MAR JUNE SEPT DEC
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1974 MAR JUNE SEPT DEC
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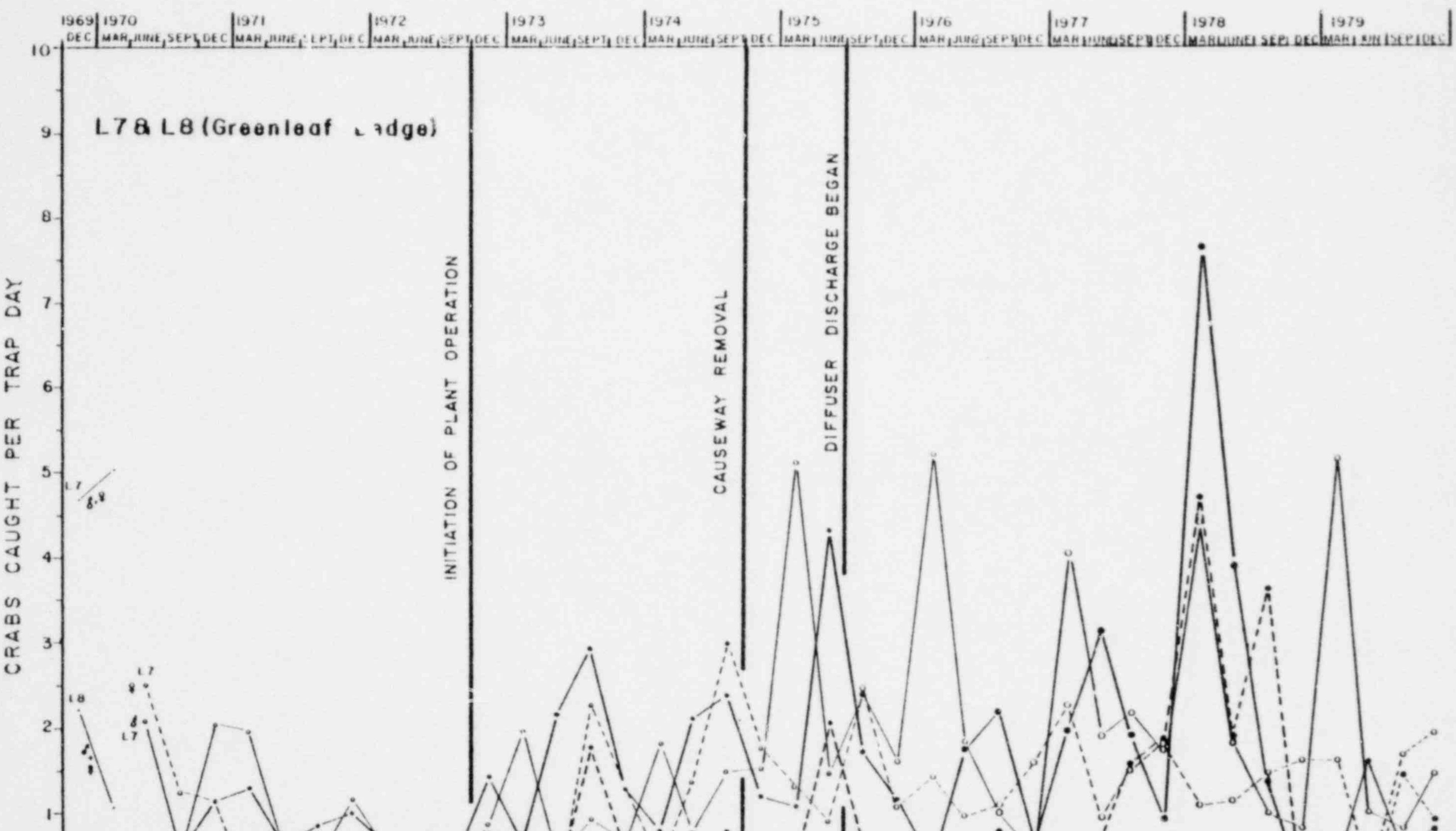
1976 MAR JUNE SEPT DEC
1977 MAR JUNE SEPT DEC
1978 MAR JUNE SEPT DEC
1979 MAR JUNE SEPT DEC
0 1 2 3 4 5 6 7 8 9 10

Figure 12.


L7 & L8 (Greenleaf Ledge)
CRABS CAUGHT PER TRAP DAY
INITIATION OF PLANT OPERATION
CAUSEWAY REMOVAL
DIFFUSER DISCHARGE BEGAN
1969 DEC
1970 MAR JUNE SEPT DEC
1971 MAR JUNE SEPT DEC
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1979 MAR JUN SEPT DEC
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L7
L8

IMPINGEMENT STUDIES

Stephen D. Evans

Introduction

The objective of this continuing study is to determine the numbers of fishes and macroinvertebrates impinged on Maine Yankee's circulatin water system traveling screens in order to assess impingement effects on the aquatic populations of Montsweag Bay. This study began in November 1972.

Cooling water for the plant is drawn from Back River at 27m^3/sec through an intake structure parallel to the shoreline. A U-shaped (cross-section) channel, 30-70 m wide, extends 180 m from the intake structure to the main channel of Montsweag Bay. The nearshore zone contiguous to the channel is extremely shallow at low tide. Intake velocities range from 0.2 to 0.8 m/s, depending on tidal stage, and are typically ≥ 0.6 m/s near the bottom.

Each of the four 1-cm mesh traveling screens are rotated vertically past a jet water spray (ca. 90 psi) which dislodges debris and impinged organisms into a sluiceway. A prewash system was installed in June 1977 to reduce the stress associated with the screenwash spray. Six nozzles per traveling screen emit a wide-pattern spray (ca. 38 psi) that removes fishes from the screens before they are exposed to screenwash jets. The screenwash water containing debris and organisms empties into a shallow tank (3.6 x 1.2 x 0.7 m), where samples are collected. All animals, except for those collected during sampling, are returned to the bay via a sluiceway. Under normal operating conditions the traveling screens are washed usually at two-hour intervals to minimize the duration of impingement or whenever a head across the screens exceeds two inches of water. The screens are washed continuously when large amounts of debris accumulate. Massive amounts of flotsam frequently occur in the bay during the fall under conditions of extreme high tides and strong winds.

Materials and Methods

Impingement samples were collected weekly over a 24-hour period to minimize the effects of light and tide. All four traveling screens were rotated and cleaned to establish a starting time for the sampling period, which usually began at 0800 EST. The screenwash was sieved through a 0.6 cm woven mesh bag. All fish and macroinvertebrates collected at the end of the 24-hour period were identified, measured and the total weight of each taxa recorded. A random subsample was taken when necessary to expedite processing. The number of operating circulating water pumps and their valve positions were recorded for each sample.

Results and Discussion

Two Maine Yankee shutdowns during 1979 prevented impingment sampling. Once from 15 March to 5 June, in compliance with an NRC show-cause order requiring seismic reanalysis of some piping systems, and again during September for transformer replacement and planned maintenance activities. Also, no impingement collections were made during mid-November and late December when heavy trash loading on the traveling screens required continuous screen wash and rotation.

The numbers of principal fishes, two macroinvertebrates, and all fish species combined that were impinged per 24-hour period are shown in Table 17. In thirty-three, 24-hour impingement samples, 3396 fish (total weight 64 kg (142 lb)) from 17 species or species groups were impinged during 1979. Seven species or species groups -- sticklebacks (48%), alewife (18%), winter flounder (8%), smooth flounder (7%), sculpins (6%), tomcod (5%), and rainbow smelt (3%) -- collectively make up 94% of the total catch and about 72% of the biomass impinged during 1979. Species totals for 1979 and previous years are shown in Table 18.

Total fish impingement rates were highest during January due to the abundance of sticklebacks, smooth flounder and rainbow smelt (Tables 17,19). Table 1ᴗ is included primarily to show the variability of the monthly sample means.

For all fish species combined, monthly mean impingement rates ranged from 14.4 fish per hour in January to 1.3 fish per hour in August (Table 20). Monthly mean impingement rates of principal fishes were generally less than one fish per hour throughout 1979 except for the stickleback group in January ($\bar{x}$ = 11 fish/hour). Length-frequency distributions of fishes remained unchanged from previous years' data.

Impingement of rock crabs *(Cancer irroratus)* and green crabs *(Carcinus maenas)* was lowest during February when none were caught and highest in June (Table 20). The green crab comprised 86% of the total crab catch (297) in the 24-hour samples.

The 1979 impingement rates were similar to last year, which were the lowest rates measured since the program's inception in late 1972. These data generally reflect the relatively low abundance of fish populations in the estuary. Crab catches have also continued their decline in abundance following the 1976 impingement peak for both species.

Table 17. Impingement (number of individuals/24 hours) of all fishes, principal fish species, and crabs at Maine Yankee, January - December 1979.

EENFI

MAINE YANKEE FISH IMPINGEMENT

DATE	TOTAL FISH	STICKLEBACK	SMOOTH FLOUNDER	WINTER FLOUNDER	SMELT	ALEWIFE	GREEN CRAB	ROCK CRAB
1/ 3/1979	432.	385.	24.	4.	0.	0.	0.	0.
1/10/1979	428.	315.	72.	2.	9.	0.	0.	0.
1/17/1979	730.	585.	49.	0.	26.	0.	8.	2.
1/24/1979	116.	0.	6.	4.	26.	0.	0.	0.
1/31/1979	27.	0.	5.	2.	8.	0.	0.	3.
2/ 7/1979	11.	4.	1.	0.	1.	0.	0.	0.
2/14/1979	53.	26.	9.	3.	0.	0.	0.	0.
2/21/1979	26.	12.	0.	2.	7.	0.	0.	0.
2/28/1979	42.	18.	5.	3.	0.	0.	0.	0.
3/ 7/1979	64.	0.	0.	10.	5.	33.	0.	0.
3/14/1979	46.	23.	15.	1.	0.	0.	0.	6.
6/13/1979	56.	0.	8.	25.	0.	8.	19.	3.
6/20/1979	75.	5.	2.	20.	0.	32.	52.	6.
6/27/1979	58.	11.	6.	16.	0.	9.	15.	5.
7/ 2/1979	41.	10.	0.	7.	0.	13.	4.	5.
7/11/1979	17.	3.	0.	3.	0.	4.	15.	2.
7/18/1979	91.	9.	0.	6.	0.	67.	25.	0.
7/25/1979	126.	23.	0.	15.	0.	44.	38.	2.
8/ 1/1979	20.	7.	0.	3.	0.	7.	25.	0.
8/ 8/1979	30.	0.	0.	1.	5.	21.	12.	1.
8/15/1979	33.	0.	0.	10.	0.	14.	0.	0.
8/22/1979	15.	0.	0.	3.	1.	7.	7.	0.
8/29/1979	56.	0.	0.	15.	0.	19.	0.	0.
10/ 2/1979	211.	22.	3.	7.	0.	156.	12.	1.
10/10/1979	158.	20.	2.	37.	0.	78.	0.	0.
10/18/1979	34.	4.	0.	1.	0.	19.	0.	0.
10/24/1979	92.	49.	0.	28.	0.	9.	7.	0.
11/ 1/1979	89.	20.	2.	16.	0.	41.	0.	2.
11/ 7/1979	NO COLLECTION POSSIBLE							
11/14/1979	NO COLLECTION POSSIBLE							
11/20/1979	32.	3.	0.	16.	0.	8.	6.	0.
11/28/1979	38.	26.	1.	7.	0.	0.	0.	2.
12/ 5/1979	37.	3.	6.	9.	0.	0.	7.	0.
12/12/1979	89.	38.	12.	0.	4.	11.	3.	7.
12/19/1979	23.	8.	0.	7.	0.	2.	0.	0.
12/27/1979	NO COLLECTION POSSIBLE							

Table 18. Total numbers of fishes collected in the impingement samples at Maine Yankee, by year.

Species	1972	1973	1974	1975	1976	1977	1978	1979
Sticklebacks	56064	17139	18897	13925	7821	4312	349	1629
Smooth flounder	10433	19364	9321	3193	1974	704	616	228
Winter flounder	388	2671	1974	2478	3868	1005	451	283
White perch	1367	4350	2867	679	169	39	27	0
Rainbow smelt	3858	7584	6056	4505	7706	2932	1019	92
Alewife	296	1463	3409	3612	13993	21417	540	602
Sculpins	694	2282	876	322	609	183	220	202
Atlantic silverside	30	417	1042	1875	825	148	33	51
Atlantic menhaden	0	1879	13948	3263	11	25	11	0
Atlantic tomcod	67	686	101	473	577	504	176	173
American eel	40	141	156	118	134	47	33	13
Atlantic herring	36	58	109	65	121	151	50	60
Northern pipefish	1	338	91	91	120	34	4	0
Wrymouth	9	58	43	20	61	4	9	0
White hake	20	447	484	227	419	269	36	20
Red hake	0	11	8	0	0	0	0	0
Cunner	6	11	11	10	43	15	6	5
Lumpfish	14	35	63	73	8	5	5	3
Atlantic cod	0	9	14	0	1	0	0	0
Mummichog	1	257	28	115	161	11	20	0
Radiated shanny	0	0	2	0	0	0	0	0
Windowpane	6	146	215	243	153	27	6	6
Seasnail	3	0	0	0	0	0	0	0
Silver hake	5	30	43	133	158	75	7	23
Blueback herring	71	186	1192	54	0	32	0	0
Sea raven	3	26	7	12	7	1	0	0
Little skate	1	29	13	8	12	9	4	5
Pollock	5	8	4	4	34	12	0	0
Snake blenny	0	2	0	0	0	0	0	0
Rock gunnel	1	6	2	9	7	1	1	0
American plaice	0	3	0	4	1	0	0	0
Atlantic mackerel	0	3	0	4	2	0	0	0
Butterfish	0	1	2	0	2	2	0	1
Striped bass	0	1	0	0	0	0	0	0
Atlantic sturgeon	0	2	1	3	0	0	0	0
Sea lamprey	1	0	1	1	0	0	0	0
Spiny dogfish	0	0	2	0	0	0	0	0
Striped anchovy	0	0	115	0	0	0	0	0
Scup	0	0	62	0	0	0	0	0
Bluefish	0	0	0	3	1	0	0	0
Coho salmon	0	0	0	2	4	0	0	0
Fourspot flounder	0	0	0	0	1	0	0	0
Yellow perch	0	0	0	0	0	1	0	0
TOTAL	73420	59643	61139	35524	39003	31955	3623	3396
Total weight (kg)	-	754	951	435	546	361	127	64
Number of species	26	33	34	31	31	27	22	17
No. of 24-hr samples	8	47	36	44	48	37	41	3[illegible]

Table 19. Basic statistics for impingement (number of individuals/24 hours) of all fishes, principal fish species, and crabs, by month, January - December 1979.

EENFI

MAINE YANKEE FISH IMPINGEMENT

DATE	TOTAL FISH	STICKLE BACK	SMOOTH FLOUNDER	WINTER FLOUNDER	SMELT	ALEWIFE	GREEN CRAB	ROCK CRAB
SUMMARY FOR	1, 1979	BASED ON	5 SAMPLES					
SUM	1733.	1285.	156.	12.	69.	0.	8.	5.
MEAN	346.6	257.0	31.2	2.4	13.8	0.	1.6	1.0
S.D.	281.2	254.7	29.0	1.7	11.7	0.	3.6	1.4
SUMMARY FOR	2, 1979	BASED ON	4 SAMPLES					
SUM	132.	60.	15.	8.	8.	0.	0.	0.
MEAN	33.0	15.0	3.8	2.0	2.0	0.	0.	0.
S.D.	18.4	9.3	4.1	1.4	3.4	0.	0.	0.
SUMMARY FOR	3, 1979	BASED ON	2 SAMPLES					
SUM	110.	23.	15.	11.	5.	33.	0.	6.
MEAN	55.0	11.5	7.5	5.5	2.5	16.5	0.	3.0
S.D.	12.7	16.3	10.6	6.4	3.5	23.3	0.	4.2
SUMMARY FOR	6, 1979	BASED ON	3 SAMPLES					
SUM	189.	16.	16.	61.	0.	49.	86.	14.
MEAN	63.0	5.3	5.3	20.3	0.	16.3	28.7	4.7
S.D.	10.4	5.5	3.1	4.5	0.	13.6	20.3	1.5
SUMMARY FOR	7, 1979	BASED ON	4 SAMPLES					
SUM	275.	45.	0.	31.	0.	128.	82.	9.
MEAN	68.8	11.3	0.	7.8	0.	32.0	20.5	2.3
S.D.	49.1	8.4	0.	5.1	0.	28.9	14.5	2.1
SUMMARY FOR	8, 1979	BASED ON	5 SAMPLES					
SUM	154.	7.	0.	32.	6.	68.	44.	1.
MEAN	30.8	1.4	0.	6.4	1.2	13.6	8.8	0.2
S.D.	15.9	3.1	0.	5.9	2.2	6.5	10.4	0.4
SUMMARY FOR	10, 1979	BASED ON	4 SAMPLES					
SUM	495.	95.	5.	73.	0.	262.	19.	1.
MEAN	123.8	23.8	1.3	18.3	0.	65.5	4.8	0.3
S.D.	77.1	18.7	1.5	17.0	0.	67.6	5.9	0.5
SUMMARY FOR	11, 1979	BASED ON	3 SAMPLES					
SUM	159.	49.	3.	39.	0.	49.	6.	4.
MEAN	53.0	16.3	1.0	13.0	0.	16.3	2.0	1.3
S.D.	31.3	11.9	1.0	5.2	0.	21.7	3.5	1.2
SUMMARY FOR	12, 1979	BASED ON	3 SAMPLES					
SUM	149.	49.	18.	16.	4.	13.	10.	7.
MEAN	49.7	16.3	6.0	5.3	1.3	4.3	3.3	2.3
S.D.	34.8	18.9	6.0	4.7	2.3	5.9	3.5	4.0

Table 20. Mean impingement rates (number of fish/hour) of the principal fishes encountered at Maine Yankee and all fishes combined.

		Month											
	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total fish	1977	26.0	30.0	18.4	*	*	1.4	1.9	18.1	203.6	18.7	4.9	6.3
	1978	13.9	1.2	1.4	1.6	2.7	1.1	0.7	*	3.9	4.1	3.8	5.5
	1979	14.4	1.4	2.3	*	*	2.6	2.9	1.3	*	5.2	2.2	2.1
Sticklebacks	1977	18.6	16.7	7.0	*	*	0	0.2	0.2	0.2	0.7	0.7	0.4
	1978	0.3	0.3	0.3	0.4	0.4	0.3	0.2	*	0	0.4	0.5	0.6
	1979	10.7	0.6	0.5	*	*	0.2	0.5	0.1	*	1.0	0.7	0.7
Smooth flounder	1977	1.0	0.4	0.6	*	*	0	0.1	0.3	1.7	1.7	0.1	1.4
	1978	3.8	0.1	0.1	0.2	0.1	0	0	*	0.5	0.5	0	1.1
	1979	1.3	0	0.3	*	*	0.2	0	0	*	0.1	0	0.2
Winter flounder	1977	0.6	0.3	1.3	*	*	0.3	0.2	0.6	1.8	3.4	0.2	0.5
	1978	0.9	0.1	0.1	0.1	1.3	0.2	0	*	0.4	0.8	0.2	0.4
	1979	0.1	0.1	0.2	*	*	0.8	0.3	0.3	*	0.8	0.5	0.2
Rainbow smelt	1977	5.2	11.6	7.4	*	*	0	0	0.1	1.3	2.7	1.1	1.4
	1978	7.4	0.4	0.6	0.1	0.2	0	0	*	0	0.6	0.4	0.8
	1979	0.6	0.1	1.0	*	*	0	0	0.1	*	0	0	0
Alewife	1977	0	0	0.1	*	*	0.1	0.6	15.1	194.8	7.2	1.6	0.7
	1978	0	0	0	0.6	0.1	0.1	0.2	*	2.6	1.1	1.9	0.8
	1979	0	0	0.7	*	*	0.7	1.3	0.6	*	0.2	0.1	0.2

* = Shutdown

ICHTHYOPLANKTON (BONGO NET COLLECTIONS)

Nancy J. Shaboski

Introduction

This report is part of an ongoing program to assess the ichthyoplankton ecology of the Montsweag Bay - Sheepscot River estuary. Fish larvae have been collected in the area using various sampling techniques since 1970. The present methodology has been employed since late March 1976. This monitoring program is conducted in accordance with the requirements of the NPDES Permit No. ME0002569 and the Maine Waste Discharge License No. 746 for the Maine Yankee Nuclear Generating Station.

The purpose of this program is to monitor the temporal and spatial abundance and distribution of fish larvae and eggs in the bay-river system to provide input to assess the effects of power plant operation. This report covers the fourth year of ichthyoplankton data collection, from March 1979 to February 1980.

Methods

Plankton samples were collected at five stations in the Montsweag Bay - Sheepscot River estuary (Figure 13).

Samples were collected approximately every two weeks from February through May, October and November, and monthly the remainder of the year. This sampling schedule was established because ichthyoplankton were known to be more abundant in the spring and late autumn.

The sampling gear and methods closely followed those that were established by the National Marine Fisheries Service for their Marine Resources Monitoring, Assessment and Prediction (MAPMAP) Program ichthyoplankton survey.

Samples were collected with a 0.6 m diameter Bongo net equipped with a 505 µm mesh net. Digital flowmeters (General Oceanics Model 2030) were located off-center of the net mouths.

Double oblique collections (surface to bottom and back to the surface) were made at all stations with the Bongo net at a tow speed of approximately 2 knots. Towing time was usually between 5 and 6 minutes. All tows were taken during daylight hours against the current. Montsweag Bay was sampled during high water because of its shallowness. Tow wire angle was measured during setting and retrieval of the gear to ensure the bongo net fished the entire water column. Water temperature and salinity were recorded at each station; depths occupied were 0.6 m, 1.5 m, thence in 1.5 m intervals to the bottom.

Once on board, the nets were washed down from the outside with saltwater. Samples were fixed in 5% buffered formalin and stored in 1.1 liter glass jars. In the laboratory, all fish eggs and larvae were removed from the sample, counted, and larvae identified to species if possible. Beginning June 1979 fish eggs were identified when possible to the lowest practical taxon by Marine Research, Inc.

Results

Hydrography

Water temperature in the Sheepscot River ranged from 0.0°C in February 1980 to 15.3°C in July 1979. In Montsweag Bay, temperatures ranged from 0.0°C in February 1980 to 22.4°C in July 1979. Water temperature was higher in Montsweag Bay (as compared to the Sheepscot River) from March 1979 through October 1979, similar to the Sheepscot River in early November 1979, and lower in late November and December 1979 and January 1980 (Figure 14).

Throughout the sampling period salinity in the Sheepscot River was higher than in Montsweag Bay (Fig 15). In Montsweag Bay, surface salinity ranged from 8.3 to 30.3 °/oo and the bottom salinity ranged from 16.5 to 30.5 °/oo. Surface salinity in the Sheepscot River ranged from 20.6 to 32.9 °/oo while bottom salinity was from 22.9 to 32.4 °/oo. For both areas, salinity was highest during the winter months and lowest in the spring.

Larval species composition

From 2 March 1979 through 22 February 1980 a total of 2312 fish larvae representing 21 fish species were collected in 88 bongo net tows. Atlantic herring, rock gunnel, and rainbow smelt were the dominant species, comprising 78% of the total larvae collected (Table 21). The average fish larval density for all stations and sampling dates combined was $10.39/100m^3$.

Larval spatial distribution and abundance

Average fish larval density was $9.98/100\ m^3$ in the Sheepscot River (stations 1, 2) and $10.75/100\ m^3$ in the Montsweag Bay (stations 3, 4, 5).

Mean larval densities for each species by station are shown in Table 22. Station 5 accounted for the highest total abundance of any sampling location (14.27/100 m^3). Atlantic herring, the most abundant species overall, accounted for the largest individual species density per station (5.03/100 m^3 at station 1). The greatest number of species (16) was found at stations 3 and 4.

Species abundance was greater in Montsweag Bay (19 species) than in the Sheepscot River (17). Grubby, winter flounder, and Atlantic herring were most common in the Sheepscot River. Rainbow smelt were primarily found in the bay, with the majority of the catch collected at station 4. American plaice, windowpane, and American sand lance were found in the Sheepscot River only while radiated shanny, sea raven, snakeblenny, and Atlantic cod were exclusive to Montsweag Bay.

Larval temporal variation

Total fish larvae density was lowest from June through October. Larval densities peaked in late February, March and early November. In Montsweag Bay larval abundance was greatest in mid-May (Table 23), when the highest per station density was recorded at station 4 (44.16/100 m^3).

Table 24 shows the temporal abundance of individual species of larval fish. Rock gunnel and Atlantic herring dominated the catch in March and April. Rainbow smelt were the most abundant larvae in early May. Atlantic herring was the most commonly collected species during November, December and January. In February, rock gunnel and longhorn sculpin were the dominant species. From June through October, low larval densities prevailed and few species were present.

Egg species composition

A total of 2812 fish eggs representing 10 family species groupings were collected during the reporting period (Table 25). The dominant egg groups, Labridae - *Limanda, Scopthalmus aquosus*, and *Enchelyopus - Urophycis*, comprised 90% of the total catch.

The average fish egg density for all stations and sampling dates combined was 12.63/100 m^3.

Egg spatial distribution and abundance

The average egg density in the Sheepscot River was 13.78/100 m^3. In Montsweag Bay the average density was 11.83/100 m^3. All ten egg groups were found in the Sheepscot River while eight were found in Montsweag Bay (Table 26).

The highest total egg density occurred at station 2 (15.58/100 m^3) and the lowest at station 5 (8.06/100 m^3). *Gadus morhua, Enghelyopus - Urophycis*, and *Enchelyopus cimbrius* were most abundant at the river stations (1, 2). *Scopthalmus aquosus* was most common at stations 1, 2 and 3. At each station Labridae - *Limanda* was the most abundant egg group with the greatest collections found at station 3 (731 individuals).

Egg temporal variation

Fish egg abundance was highest in the summer with peak densities in July ranging from 43 to 173 eggs/100 m^3 (Table 27). From late October through early March no eggs appeared in the sample collections.

Egg group identification began in June and continued through January. Labridae - *Limanda, Scopthalmus aquosus*, and *Enchelyopus - Urophycis* dominated the June - September catches. The largest individual catch was of Labridae - *Limanda* during July (90.97/100 m^3).

Discussion and Conclusions

Fish larvae and egg abundance in the Montsweag Bay - Sheepscot River estuary decreased as compared to last year (78-79 larvae 14.60/100 m^3, eggs 20.21/100 m^3) but increased from the 1977-78 reporting period (77-78 larvae 7.89/100 m^3, eggs 16.38/100 m^3, 79-80 larvae 9.46/100 m^3, eggs 12.63/100 m^3). Larval fish abundance peaked in late winter and spring, with greatest numbers occurring in late February. The most abundant larvae during this period was the rock gunnel, which peaked in February (17.15/100 m^3). This was a substantial decrease from the previous year's peak of (71.61/100 m^3) and a slight increase over the 1977-78 peak (15.73/100 m^3). Rock gunnel peaked a month earlier this year than in the two previous years. Also contributing to the high seasonal density was longhorn sculpin and shortnose sculpin abundance. As in previous years, fish egg abundance was highest during the summer months, peaking in late July.

Rainbow smelt larvae abundance declined during this sampling period as compared to last year's. During both years, peak smelt abundance occurred in May (1978-79 42.53/100 m^3, 1979-80 19.27/100 m^3).

Atlantic herring, the most abundant species during the present reporting period, ranked third last year. Peak density of herring occurred in November, one month later than in prior years. A secondary peak in March followed trends historically observed, although in previous years the peak often extended through April and May.

Smooth flounder larval abundance has continued to decline throughout the study. Highest smooth flounder density during the reporting period was 0.99/100 m^3 at station 3, the lowest on record.

Table 21. Relative abundance of larval fishes collected in the Montsweag Bay - Sheepscot River estuary, 2 March 1979 - 22 February 1980.

Taxa	Number	Percent of Total
Clupea harengus, Atlantic herring	910	39.4
Pholis gunnellus, rock gunnel	636	27.5
Osmerus mordax, rainbow smelt	257	11.1
Myoxocephalus aenaeus, grubby	117	5.1
Myoxocephalus octodecemspinosus, longhorn sculpin	115	5.0
Myoxocephalus scorpius, shorthorn sculpin	92	4.0
Pseudopleuronectes americanus, winter flounder	56	2.4
Cryptacanthodes maculatus, wrymouth	28	1.2
Ulvaria subbifurcata, radiated shanny	26	1.1
Syngnathus fuscus, northern pipefish	23	1.0
Liparis coheni, seasnail	15	.6
Microgadus tomcod, Atlantic tomcod	7	.3
Liparis atlanticus, seasnail	6	.3
Liopsetta putnami, smooth flounder	6	.3
Aspidophoroides monopterygius, alligatorfish	4	.2
Ammodytes americanus, American sandlance	3	.1
Hemitripterus americanus, sea raven	3	.1
Gadus morhua, Atlantic cod	2	.1
Lumpenus lumpretaeformis, snakeblenny	2	.1
Scopthalmus aquosus, windowpane	2	.1
Hippoglossoides platessoides, American plaice	1	<.1
Unidentified larvae	1	<.1
TOTAL	2312	100.0

Table 22. Mean density (number per $100m^3$) of fish larvae in the Montsweag Bay (Stations 3-5) - Sheepscot River (Station 1,2) estuary, March 1979 - February 1980.

Taxa	Station 1	2	3	4	5
Clupea harengus	5.03	3.80	2.68	2.38	3.53
Pholis gunnellus	3.08	3.00	3.19	1.47	3.62
Osmerus mordax	.23	0	1.24	2.75	1.61
Myoxocephalus aenaeus	.62	.75	.30	.37	.46
Pseudopleuronectes americanus	.25	.48	.16	.13	.19
Myoxocephalus scorpius	.33	.37	.48	.13	.60
Myoxocephalus octodecemspinosus	.33	.48	.44	.62	.70
Liparis coheni	.04	.11	.07	.07	.05
Syngnathus fuscus	.02	.07	.14	.20	.17
Microgadus tomcod	.06	0	0	.09	0
Cryptacanthodes maculatus	.12	.05	.18	.09	.17
Liparis atlanticus	.04	.05	.02	.02	0
Ammodytes americanus	0	.02	0	0	0
Liopsetta putnami	.02	0	.05	.02	.05
Ulvaria subbifurcata	0	0	.09	0	.02
Aspidophoroides monopterygius	.02	.05	0	.02	0
Hemitripterus americanus	0	0	.05	0	.02
Lumpenus lumpretaeformis	0	0	.02	0	.02
Scopthalmus aquosus	0	.05	0	0	0
G dus morhua	0	0	.02	.02	0
ippoglossoides platessoides	.02	0	0	0	0
Unidentified larvae	0	0	0	.02	0
Number of species	15	13	16	16	14
Total larvae	495	422	400	400	595
Volume sampled (m^3)	4808	4372	4361	4546	4169
Total larval density (per $100m^3$)	10.30	9.65	9.17	8.80	14.27

Table 23. Abundance (numbers/100m^3) of fish larvae and eggs of all species, 2 March 1979 - 22 February 1980. NS = not sampled.

FISH LARVAE

Station	2 Mar	27 Mar	12 Apr	26 Apr	11 May	25 May	25 Jun	24 Jul	28 Aug	12 Sep	12 Oct	29 Oct	6 Nov	19 Nov	19 Dec	19 Jan	8 Feb	22 Feb
1	16.98	15.69	21.82	6.30	9.27	3.52	NS	0.35	0	0	1.61	2.86	31.09	23.79	.08	.08	5.41	31.32
2	23.35	30.86	9.75	3.64	3.69	10.81	1.69	1.13	.42	.41	1.67	1.63	18.06	22.52	.06	.13	4.30	20.61
3	17.26	34.48	6.87	3.49	23.60	2.59	2.14	1.18	.41	0	1.22	1.65	11.07	.05	.05	.13	11.55	29.37
4	13.66	20.98	7.03	5.78	44.16	4.39	1.65	1.53	.38	0	1.20	4.03	14.07	.07	.04	.08	4.42	15.35
5	28.71	20.00	9.52	0.80	27.48	1.81	0.84	0.77	0	0	0.44	1.63	20.41	13.68	.06	.20	NS	41.60

FISH EGGS

Station	2 Mar	27 Mar	12 Apr	26 Apr	11 May	25 May	25 Jun	24 Jul	28 Aug	12 Sep	12 Oct	29 Oct	6 Nov	19 Nov	19 Dec	19 Jan	8 Feb	22 Feb
1	0	1.47	15.91	14.70	23.39	57.27	NS	155.59	27.48	20.72	.40	0	0	0	0	0	0	1.13
2	0	0	9.75	5.00	6.56	54.50	101.27	134.34	24.69	16.60	.42	0	<.01	<.01	0	0	0	0
3	0	.49	3.00	9.17	10.73	24.14	70.71	172.55	18.85	3.10	0	0	0	0	0	0	0	0
4	0	0	1.17	7.02	12.04	10.96	80.58	130.53	14.12	2.22	0	0	0	0	0	0	0	0
5	0	0	.79	0	0.38	4.52	54.39	42.91	1.75	1.06	0	0	0	0	0	0	NS	0

Table 24. Temporal abundance (number/100m³) of larval fishes in the Montsweag Bay - Sheepscot River estuary, March 1979 - February 1980. All 5 stations combined.

Taxa	2 Mar	27 Mar	12 Apr	26 Apr	11 May	25 May	25 Jun	24 Jul	28 Aug	12 Sep	12 Oct	29 Oct	6 Nov	19 Nov	19 Dec	16 Jan	8 Feb	22 Feb
Clupea harengus	1.87	5.89	2.17	.17	.08						1.16	2.37	19.37	15.44	6.00	7.48	.09	.23
Pholis gunnellus	9.24	13.22	6.60	.51	.24	.09										2.37	4.28	17.15
Osmerus mordax					19.27	1.07	.25											
Myoxocephalus aenaeus	2.05	3.62	1.34	2.04	.16											.30	.09	.61
Pseudopleuronectes americanus			.25	.85	1.59	1.60	.51	.08										
Myoxocephalus octodecemspinosus	1.87	.36														1.71	1.62	3.89
Myoxocephalus scorpius	3.73	.27															.09	3.66
Ulvaria subbifurcata					.63	1.69	.38											
Syngnathus fuscus							.88	.91	.23									
Liparis coheni	.93			.08														.08
Liparis atlanticus	.09		.08	.08	.16	.09										.15		
Liopsetta putnami		.36	.08	.08														
Microgadus tomcod		.27	.08	.08													.09	
Aspidophoroides monopterygius			.17		.08	.36												
Cryptacanthodes americanus	.09	.18														.08	.09	1.75
Scopthalmus aquosus										.08	.09							.08
Gadus morhua		.09																
Hemitripterus americanus																		
Hippoglossoides platessoides		.09																
Lumpenus lumpretaeformis				.08												.08		.08
Unidentified larvae																		
Total larvae	19.96	24.46	10.78	3.99	22.20	4.61	2.01	.98	.23	.08	1.24	2.37	19.37	15.44	6.00	12.14	6.37	27.74

Table 25. Temporal abundance of fish eggs for all stations combined in the Montsweag Bay - Sheepscot River estuary, 25 June 1979 - 22 February 1980.

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Labridae - *Limanda I, II*	555	1208	102	36	0	0	0	0	0	1901
Labridae *III*	4	82	6	1	0	0	0	0	0	93
Scopthalmus aquosus	68	228	49	20	0	0	0	0	0	365
Gadidae - *Glyptocephalus I, II*	39	16	1	0	0	3	0	0	0	59
Gadus morhua III	13	13	2	0	0	1	0	0	0	29
Encheluopus cimbrius III	5	46	15	15	0	0	0	0	0	81
Enchelyopus - Urophycis I, II	58	95	51	45	4	0	0	0	0	253
Hippoglossoides platessoides	4	6	1	0	0	0	0	0	0	11
Urophycis spp. *III*	0	6	1	1	0	0	0	0	0	8
Merluccius bilinearis	0	7	1	0	0	0	0	0	0	8
Unidentified	0	0	0	1	0	0	0	0	3	4
TOTAL	746	1707	229	119	4	4	0	0	3	

Table 26. Mean density (number per $100m^3$) of fish eggs in the Montsweag Bay (Stations 3-5) - Sheepscot River (Stations 1, 2) estuary, June 1979 - February 1980.

	Station				
	1	2	3	4	5
Labridae - *Limanda I, II*	6.20	7.09	11.10	10.12	7.51
Labridae *III*	.56	.57	.37	.26	.34
Scopthalmus aquosus	1.58	3.34	2.18	1.83	.19
Gadidae - *Glyptocephalus I, II*	.25	1.05	.05	0	0
Gadus morhua III	.19	.43	.02	0	0
Enchelyopus - Urophycis I, II	2.33	1.99	.62	.51	.02
Enchelyopus cimbrius III	.75	.82	.07	.11	0
Hippoglossoides platessoides	.06	.11	0	0	0
Urophycis spp. *III*	.08	.07	0	0	0
Merluccius bilinearis	.08	.07	.02	0	0
Unidentified	.06	.02	0	0	0
Number of species	11	11	8	5	4
Total fish eggs	584	681	629	582	336
Volume sampled (m^3)	4808	4372	4361	4546	4169
Total egg density (per $100m^3$)	12.15	15.58	14.42	12.80	8.06

Table 27. Temporal abundance (number/100m³) of fish eggs in the Montsweag Bay - Sheepscot River estuary, June 1979 - February 1980. All 5 stations combined.

Taxa	25 Jun	24 Jul	28 Aug	12 Sep	12 Oct	29 Oct	6 Nov	19 Nov	19 Dec	16 Jan	8 Feb	22 Feb
Labridae - *Limanda I, II*	55.67	90.97	8.27	2.65	0	0	0	0	0	0	0	0
Labridae *III*	.60	6.17	.52	.07	0	0	0	0	0	0	0	0
Scopthalmus aquosus	6.82	17.16	4.02	1.47	0	0	0	0	0	0	0	0
Gadidae - *Glyptocephalus I, II*	3.91	1.20	.07	0	0	0	.24	0	0	0	0	0
Gadus morhua III	1.30	.98	.15	.15	0	0	0	.08	0	0	0	0
Enchelyopus cimbrius III	.50	3.46	1.19	1.10	0	0	0	0	0	0	0	0
Enchelyopus - Urophycis I, II	5.82	7.15	5.21	3.25	.33	0	0	0	0	0	0	0
Hippoglossoides platessoides	.30	.38	0	0	0	0	0	0	0	0	0	0
Urophycis spp. *III*	0	.45	.07	.07	0	0	0	0	0	0	0	0
Merluccius bilinearis	0	.53	.07	0	0	0	0	[illegible]	0	0	0	0
Unidentified	0	0	0	1	0	0	0	0	0	0	0	3
Total fish eggs	746	1707	229	.19	4	0	3	1	0	0	0	3
Total fish egg density	80.44	112.87	22.49	8.41	.33	0	.24	.08	0	0	0	.23

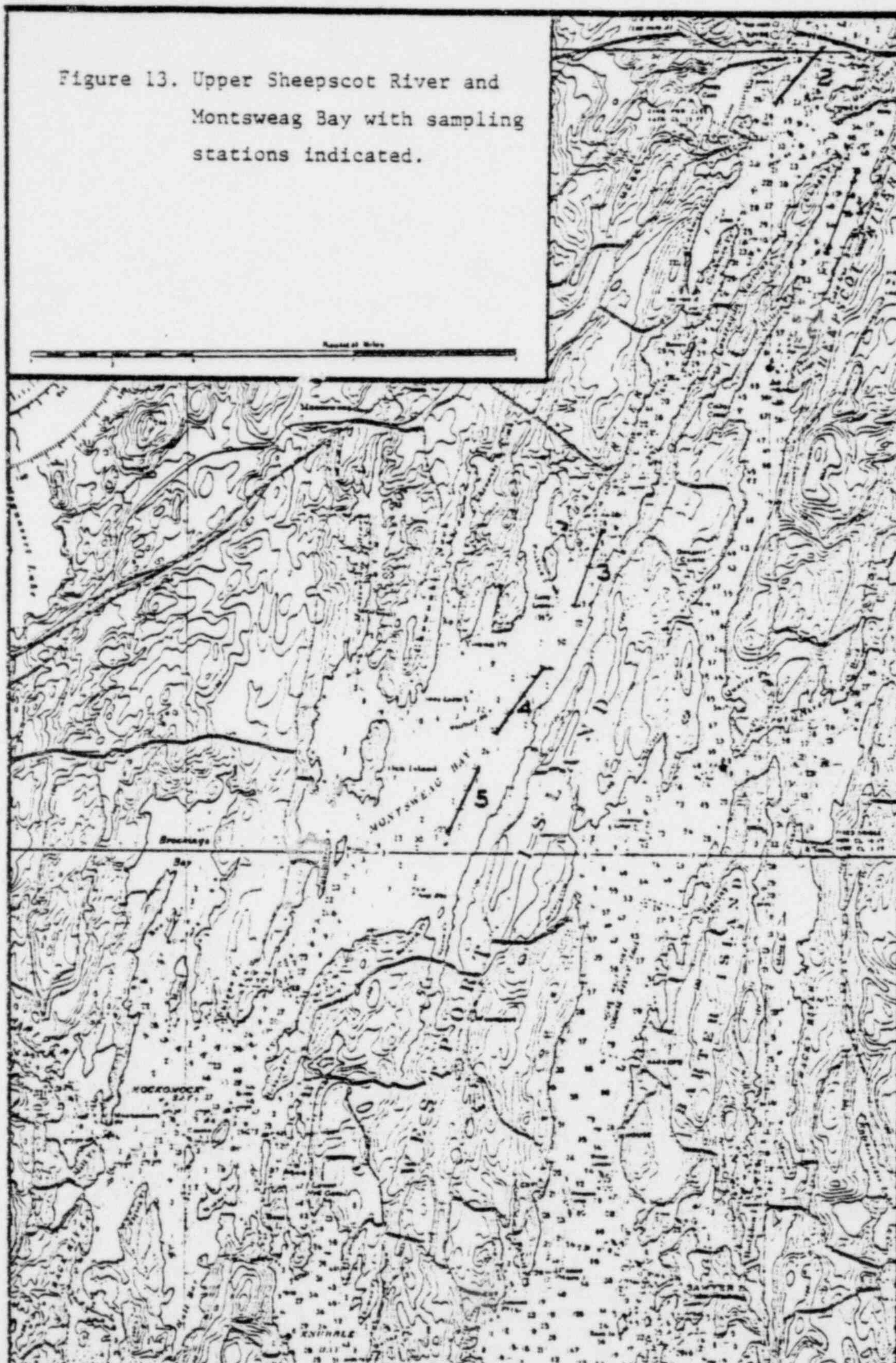
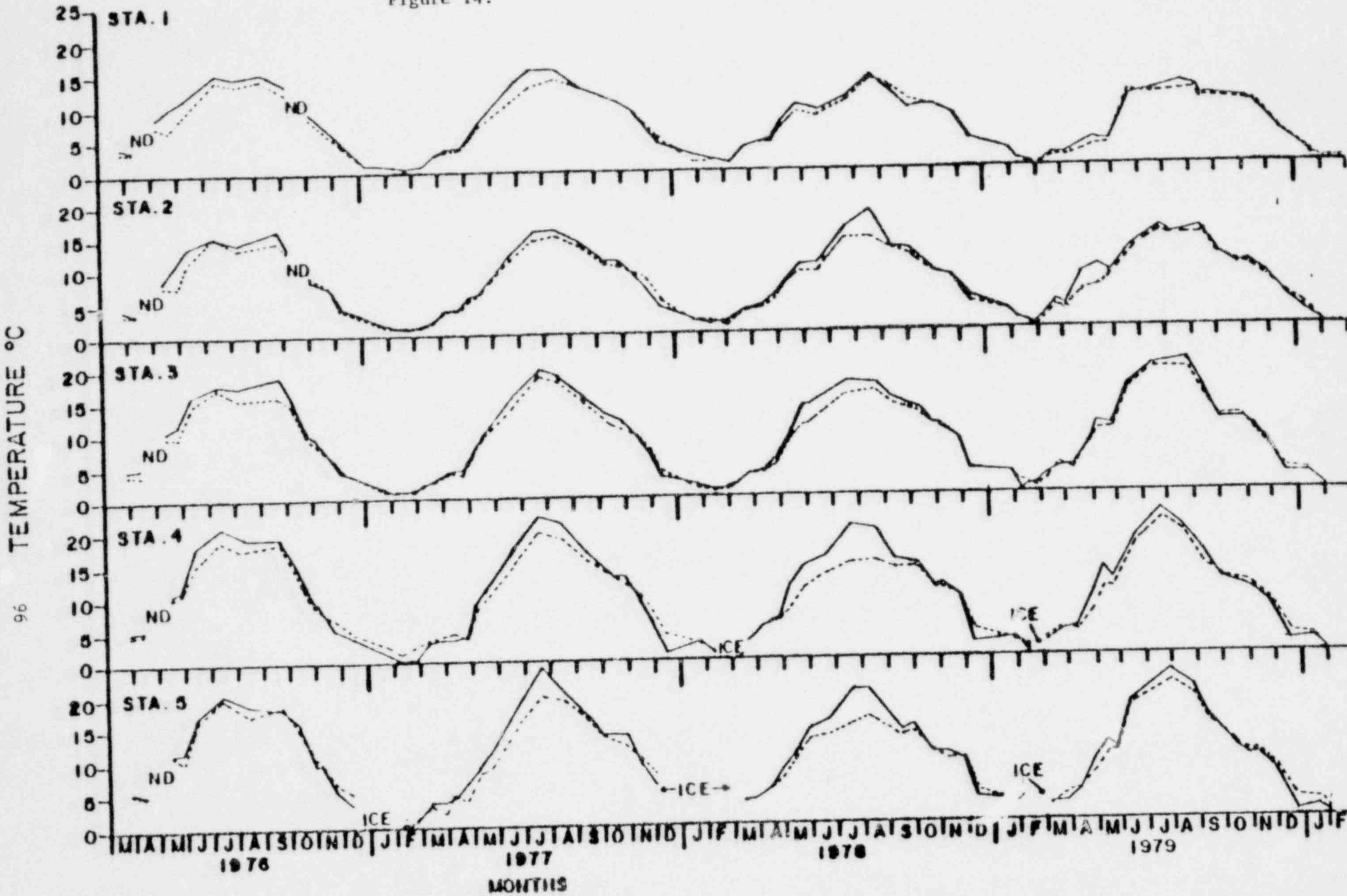


Figure 13. Upper Sheepscot River and Montsweag Bay with sampling stations indicated.

Figure 14. Surface (solid line) and bottom (broken line) water temperatures at two stations in the Sheepscot River (1 and 2) and three stations in Montsweag Bay (3, 4 and 5), March 1976 to March 1980. ND = no data (equipment failure).

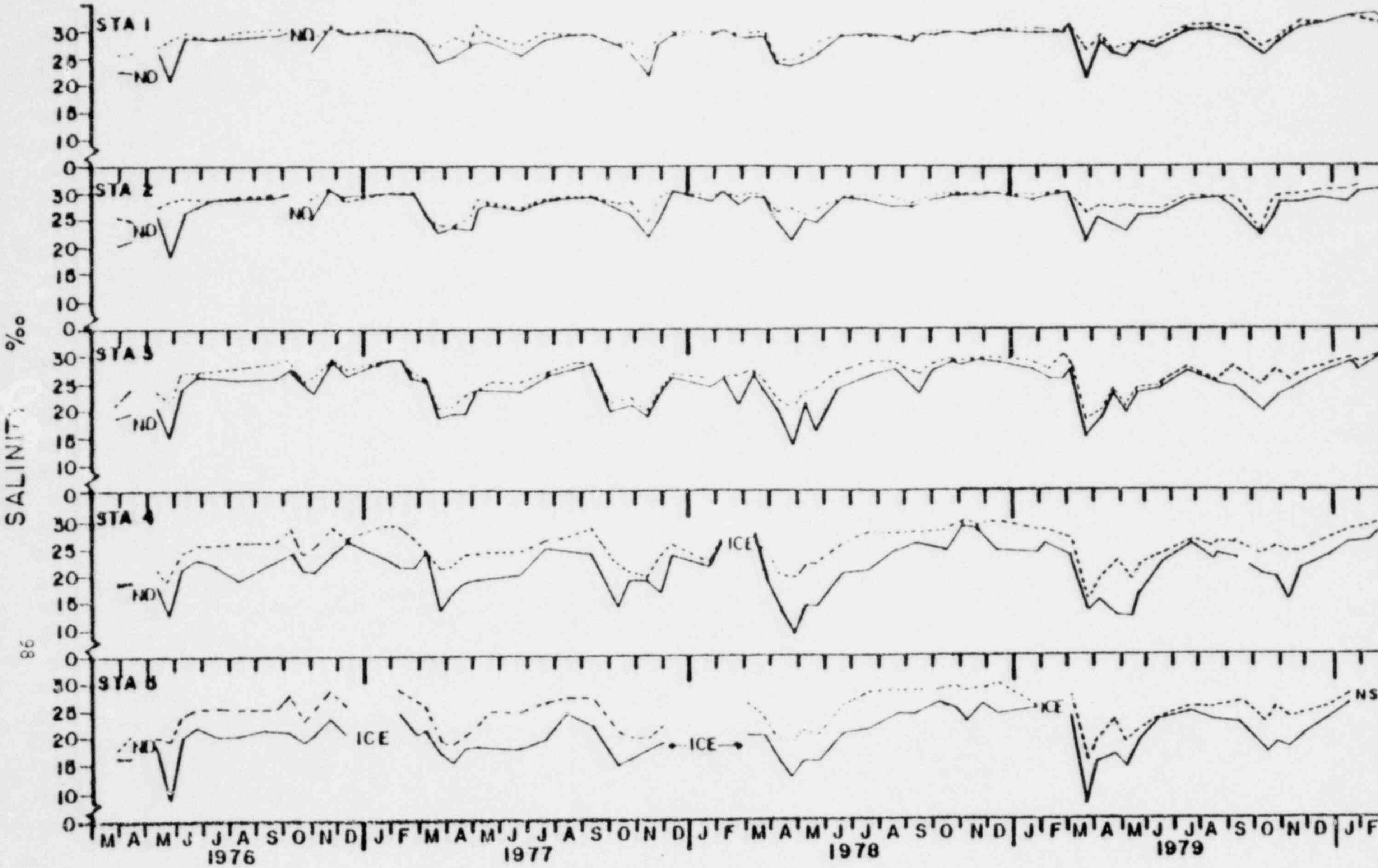
Figure 14.



STA. 1
STA. 2
STA. 3
STA. 4
STA. 5
ND
ICE
TEMPERATURE °C
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F
1976
1977
1978
1979
MONTHS

Figure 15. Surface (solid line) and bottom (broken line) water salinities at two stations in the Sheepscot River (1 and 2) and three stations (3, 4, and 5) in Montsweag Bay, March 1976 to March 1980. ND = no data (equipment failure).

Figure [illegible].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1979

PELAGIC AND DEMERSAL FISHES

Andrew K. Towt

Introduction

Demersal and pelagic fish sampling of the Montsweag Bay - Sheepscot River estuarine system entered its tenth year in 1979. The objective of this continuing study is to monitor distribution and seasonal changes in relative abundance of fishes indigenous to the region. This report contains the results of data collected during 1979.

Materials and Methods

Pelagic Fishes

Methods were established by McCleave (1972). Pelagic fishes were sampled at six stations (Figure 16). Station G1 is in the Back River; G2 and G3 are in the main channel of Montsweag Bay; G4, about 1500 m north of the Westport Island Bridge, and G5 in Wiscasset Harbor are in the upper Sheepscot River estuary; G6 is in Cross River. The latter three stations serve as locations unaffected by plant operation. All station locations have remained unchanged since June 1970 when sampling began with two exceptions: G5 was moved about 1000 m south to its present location in October 1974, and G1 was moved about 860 m south to its present location in April 1977 because strong currents at the former Berry Island location reduced the net's efficiency.

Three-panel, monofilament gill nets (45.6 m long x 2.4 m deep with mesh sizes of 12.7 mm, 25.4 mm, and 50.8 mm square measure) were fished with the top of the net 1.8 m below the surface. Nets were set and retrieved from specially designed gillnet rollers mounted on the bow of a 5.5 m outboard motorboat. Nets were set to fish across the tidal current. Sets were made in late afternoon, fished through the night, and picked up in the early morning. Nets were fished monthly, ice conditions permitting, during neap tide periods to avoid the largest tidal currents. Increased tidal currents in Montsweag Bay and especially Back River as a result of causeway removal at Cowseagan Narrows (in late 1974) have reduced gillnetting efficiency.

Continuous temperature recordings were made at a depth of 1.8 m during each net set. Prior to September 1974, a water sample was taken at 1.8 m at the beginning and end of each set, the two mixed, and the salinity determined by hydrometer. Thereafter, salinity was measured at the same depth with a Beckman RS5-3 field salinometer and averaged.

Collections were either preserved in formalin or examined fresh. Collections were sorted, identified, and numbers and total weights of each species recorded.

Demersal fishes

Demersal fishes were sampled at five stations in the main channels of the areas that McCleave (1972) studied until 1974 (Figure 16). Three stations are in Montsweag Bay: T3 is near the plant intake, T4 just below the discharge and T5 in the bay proper. Stations T1 and T2 are in the Sheepscot River estuary and serve as locations unaffected by plant operation.

Sampling began in March 1971. Fishes were sampled with a 9 m otter trawl (25.4 mm square mesh in the wings and body, and 13.1 mm square mesh in the codend) approximately monthly during daylight, ice conditions permitting. Three different vessels were used during the first six months of 1974. A 13 m commercial side trawler has been used since September 1974. At each station two 7 minute tows at a speed of 2-3 knots were taken in opposite directions to minimize wind and current effects. Bottom water temperature and salinity measurements were taken at each station.

If time did not permit fresh examination, collections were frozen and later thawed, sorted, identified and numbers and total weight of each species recorded.

Results and Discussion

Pelagic fishes

A total of 650 fishes representing seven species were collected in 72 gill net sets during 1979 (Table 28). Rainbow smelt dominated the catch, comprising 48% of the annual total. Other species commonly collected were: Alewife (24% of total catch), Atlantic herring (16%), and Atlantic menhaden (6%).

During 1979 gill net collections accounted for 33.4% of the number of fish captured in 1978 (Table 29). This reduction was attributed to an eight fold decrease in alewife collections, which were atypically low during this year's summer months. Atlantic menhaden and Atlantic mackerel abundance also decreased from last year's levels.

Numerical abundance of remaining species approximated that reported for 1978.

Individual station catches for the year are shown in Table 30. The largest number of fishes was captured at Long Ledge (G2) and the smallest number at Mason Station (G4). Species abundance was greatest (9 species) at the Back River (G1) and Long Ledge (G2) stations.

Over 68% of all fish were collected from May through July although historically the annual peak abundance is from June - September. Rainbow smelt during May and Atlantic herring during June 1979 accounted for the largest monthly catches by species. Gill net catches during the remaining months (August through April) averaged fewer than four fish per net.

Demersal fishes

Otter trawl sampling during 1979 captured 10,845 fishes representing 21 species (Table 31). Eight of these species comprised approximately 98% of the total annual catch. The three most abundant species were: Atlantic tomcod (57%), winter flounder (27%) and smooth flounder (5%). These three species were also most common during 1978, although this year Atlantic tomcod abundance increased 16% while the winter flounder and smooth flounder catch decreased 6%. Other species commonly collected in 1979 were: longhorn sculpin (3%), white hake (2%), grubby (2%), silver hake (1%) and little skate (1%). Trawl catches by station during 1979 are shown in Table 32.

The 1979 total catch increased 69% as compared to last year's catch. The magnitude of this increase in abundance is similar to one reported in 1975 (Table 33). Accounting for this year's increased catch was an increased abundance of Atlantic tomcod (2,618, 1978 vs 6,135, 1979) reported at stations T4 and T5. Winter flounder catches noted as being low last year (Evans 1979) also increased in 1979, (2,123, 1978 vs 2,980, 1979) as a result of large catches at stations T4 and T5. Smooth flounder abundance decreased during 1979 although the relative catch per station paralleled that reported in 1978. An 80% increase in longhorn sculpin abundance resulted from increased sculpin catches at T1 and T2 during 1979. White hake collections were similar to 1978, increasing at station T1 and correspondingly decreasing at station T5.

Conclusions

Pelagic and demersal fish data generally support previously observed trends in the relative abundance, species composition and distribution of the various species collected. The decline in this year's total pelagic catch is primarily attributable to a substantial decrease in alewife abundance. Conversely, the 1979 demersal fish catch increased over 1978 levels as a result of greater Atlantic tomcod abundance.

LITERATURE CITED

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McCleave, J. D. 1972. Finfish. Pages 181-249 *in* Survey of Hydrography, Sediments, Plankton, Benthos and Commercially Important Plants and Animals including Finfish, in the Montsweag Bay - Back River area. Third annual report from the University of Maine, Orono, Maine and the Ira C. Darling Center for Research, Teaching and Service, Walpole, Maine to Maine Yankee Atomic Power Company. Ira C. Darling Center. Ref. No. 72-12. 310 p.

Table 28. Seasonal occurrence and abundance of fishes collected by gillnet in Montsweag Bay - Sheepscot River Estuary 1979.

Species	January	February	March	April	May	June	July	August	September	October	November	December	All Months
Rainbow smelt	68	2	32	13	171	2	14	5			4	3	314
Alewife				3	76	29	20	5	4	13	6	2	158
Atlantic herring	2				1	81	13			2	1	1	101
Atlantic menhaden						1	23	2	13	2			41
Atlantic tomcod	1				3		4		4	1		5	18
Silver hake							3			3			6
Blueback herring						4							4
White hake					1				3				4
Atlantic mackerel							1			1			2
White perch				1	1								2
TOTAL	71	2	32	17	253	117	78	12	24	22	11	11	650
No. of Sets	6	6	6	6	6	6	6	6	6	6	6	6	72

Table 29. Total abundance of some dominant fishes collected by gill net in Montsweag Bay - Sheepscot River Estuary, 1970-1979.

SPECIES	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Alewife	1820	2059	1913	1235	1075	368	578	318	1256	158
Rainbow smelt	232	229	271	1164	806	153	389	532	295	314
Atlantic menhaden	157	182	408	1084	968	158	75	153	132	41
Atlantic herring	931	1123	100	556	236	50	394	147	80	101
Atlantic mackerel	96	73	25	36	14	1	19	8	42	2
TOTAL ALL SPECIES	4253	5205	3838	5351	4027	1143	1686	1561	1842	650

Table 30. Gill net catches by station for 1979.

Station G1

(Back River)

Date	Temp °C	Sal °/oo	Alewife	Atlantic Herring	Atlantic menhaden	Rainbow smelt	Atlantic tomcod	White hake	Atlantic mackerel	White perch	Silver hake	TOTAL
1/03/79	4.1	27.3	0	2	0	6	0	0	0	0	0	8
2/13/79	0.0	28.7	0	0	0	0	0	0	0	0	0	0
3/06/79	3.9	22.6	0	0	0	2	0	0	0	0	0	2
4/03/79	3.5	19.8	0	0	0	0	0	0	0	1	0	1
5/02/79	7.8	12.0	24	0	0	22	1	0	0	1	0	48
6/06/79	12.3	15.2	6	14	0	0	0	0	0	0	0	20
7/10/79	16.4	26.0	6	0	2	0	4	0	1	0	0	13
8/09/79	18.0	27.5	0	0	0	0	0	0	0	0	0	0
9/05/79	16.2	26.2	0	0	1	0	0	1	0	0	0	2
10/12/79	11.0	24.8	3	0	1	0	0	0	1	0	1	6
11/08/79	9.5	21.4	4	1	0	0	0	0	0	0	0	5
12/14/79	5.9	24.6	0	0	0	0	0	0	0	0	0	0
TOTAL			43	17	4	30	5	1	2	2	1	105

IMAGE EVALUATION
TEST TARGET (MT-3)

6″

MICROCOPY RESOLUTION TEST CHART

Table 30 *(continued)*

Station G2
(Long Ledge)

Date	Temp °C	Sal °/oo	Alewife	Atlantic herring	Atlantic menhaden	Rainbow smelt	Atlantic tomcod	White hake	Atlantic mackerel	Blue back	Silver hake	TOTAL
1/03/79	4.5	26.0	0	0	0	10	0	0	0	0	0	10
2/13/79	5.6	27.7	0	0	0	0	0	0	0	0	0	0
3/06/79	6.6	21.8	0	0	0	16	0	0	0	0	0	16
4/03/79	6.0	17.1	3	0	0	6	0	0	0	0	0	9
5/02/79	10.2	9.9	10	0	0	84	0	0	0	0	0	94
6/06/79	15.0	14.2	22	26	1	2	0	0	0	4	0	55
7/10/79	19.1	25.5	6	0	12	0	0	0	0	0	0	18
8/09/79	20.2	27.2	3	0	2	0	0	0	0	0	0	5
9/05/79	18.2	26.1	2	0	4	0	4	0	0	0	0	10
10/12/79	12.1	26.4	5	0	0	0	1	0	0	0	2	8
11/08/79	8.6	20.7	0	0	0	0	0	0	0	0	0	0
12/04/79	6.0	23.2	0	0	0	1	0	0	0	0	0	1
TOTAL			51	26	19	119	5	0	0	4	2	226

Table 30. *(continued)*

Station G3

(Half Tide Rock)

Date	Temp °C	Sal °/oo	Alewife	Atlantic herring	Atlantic menhaden	Rainbow smelt	Atlantic tomcod	White hake	Atlantic mackerel	TOTAL
1/03/79	3.8	25.2	0	0	0	47	1	0	0	48
2/13/79	-0.5	26.3	0	0	0	2	0	0	0	2
3/06/79	4.2	17.6	0	0	0	13	0	0	0	13
4/03/79	3.0	18.5	0	0	0	5	0	0	0	5
5/03/79	9.0	11.5	35	0	0	60	1	0	0	96
6/06/79	14.5	15.0	0	0	0	0	0	0	0	0
7/10/79	18.1	25.2	2	0	8	0	0	0	0	10
8/09/79	19.8	26.4	0	0	0	0	0	0	0	0
9/05/79	17.5	25.5	0	0	2	0	0	1	0	3
10/10/79	10.9	23.7	0	0	0	0	0	0	0	0
11/08/79	9.3	20.2	0	0	0	3	0	0	0	3
12/04/79	5.3	21.7	0	0	0	0	2	0	0	2
TOTAL			37	0	10	130	4	1	0	182

Table 30 *(continued)*

Station G4

(Mason Station)

Date	Temp °C	Sal ‰	Alewife	Atlantic herring	Atlantic menhaden	Rainbow smelt	Atlantic tomcod	White hake	Atlantic mackerel	TOTAL
1/04/79	2.6	27.4	0	0	0	0	0	0	0	0
2/12/79	0.5	29.3	0	0	0	0	0	0	0	0
3/05/79	2.5	25.7	0	0	0	1	0	0	0	1
4/02/79	3.3	22.4	0	0	0	1	0	0	0	1
5/01/79	8.2	16.4	0	0	0	0	0	0	0	0
6/05/79	10.4	18.6	0	0	0	0	0	0	0	0
7/09/79	14.2	26.3	1	1	0	0	0	0	0	2
8/08/79	16.7	28.1	0	0	0	0	0	0	0	0
9/04/79	14.3	27.9	0	0	0	0	0	0	0	0
10/09/79	11.0	26.6	1	0	0	0	0	0	0	1
11/07/79	10.1	23.4	0	0	0	0	0	0	0	0
12/03/79	6.0	25.8	1	1	0	1	1	0	0	4
TOTAL			3	2	0	3	1	0	0	9

Table 30 *(continued)*

Station G5
(Wiscasset)

Date	Temp °C	Sal °/oo	Alewife	Atlantic herring	Atlantic menhaden	Rainbow smelt	Atlantic tomcod	White hake	Atlantic mackerel	TOTAL
1/04/79	2.6	27.4	0	0	0	0	0	0	0	0
2/12/79	5.7	30.2	0	0	0	0	0	0	0	0
3/05/79	4.0	25.0	0	0	0	0	0	0	0	0
4/02/79	5.4	21.5	0	0	0	1	0	0	0	1
5/01/79	9.7	18.4	0	0	0	5	0	0	0	5
6/05/79	12.6	18.7	1	41	0	0	0	0	0	42
7/09/79	15.9	27.1	0	0	1	0	0	0	0	1
8/08/79	18.3	28.0	2	0	0	0	0	0	0	2
9/04/79	16.2	28.4	2	0	6	0	0	1	0	9
10/09/79	11.7	26.2	4	2	1	0	0	0	0	7
11/07/79	10.3	21.1	0	0	0	0	0	0	0	0
12/03/79	6.4	25.1	1	0	0	0	2	0	0	3
TOTAL			10	43	8	6	2	1	0	70

Table 30. *(continued)*

Station G6

(Cross River)

Date	Temp °C	Sal °/oo	Alewife	Atlantic herring	Atlantic menhaden	Rainbow smelt	Atlantic tomcod	White hake	Atlantic mackerel	Silver hake	TOTAL
1/05/79	2.3	29.1	0	0	0	5	0	0	0	0	5
2/12/79	-0.1	31.9	0	0	0	0	0	0	0	0	0
3/05/79	1.6	29.4	0	0	0	0	0	0	0	0	0
4/02/79	3.5	27.8	0	0	0	0	0	0	0	0	0
5/01/79	6.1	25.6	7	1	0	0	1	1	0	0	10
6/05/79	8.8	25.3	0	0	0	0	0	0	0	0	0
7/09/79	11.7	29.0	5	12	0	14	0	0	0	3	34
8/08/79	13.6	27.1	0	0	0	5	0	0	0	0	5
9/04/79	12.6	30.1	0	0	0	0	0	0	0	0	0
10/09/79	9.7	31.8	0	0	0	0	0	0	0	0	0
11/07/79	9.2	28.9	2	0	0	1	0	0	0	0	3
12/03/79	5.9	25.6	0	0	0	1	0	0	0	0	1
TOTAL			14	13	0	26	1	1	0	3	58

Table 31. Seasonal occurrence and abundance of fishes by otter trawl in Montsweag Bay - Sheepscot River estuary, 1979.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All Months
Atlantic tomcod	19	1	22	102	1438	713	343	95	1475	1105	794	28	6135
Winter flounder		1	25	306	320	422	523	329	516	427	83	28	2980
Smooth flounder			1	60	124	85	101	39	82	30		2	524
Longhorn sculpin	3	5	13	5	81	37	68	10	18	36	31	18	325
White hake				1	7	4	21	7	46	124	8	1	[illegible]
Grubby	9	14	41	54	9	9		1	3	6	10	11	167
Silver hake					2	1	10	15	70	29	4	1	132
Little skate				3	2	12	5	3	14	27	26	5	97
Alewife					6	2	3	3	12	25	4		55
Sea raven	1	1	4	4	6	11	4	2	1	7	3	9	53
Rainbow smelt	5		31	6	1	1						6	50
Windowpane		1			4	10	15	2	1	1			34
Ocean pout			4	4	9	3	5		2	2			29
Atlantic cod			3	1	9	4	1		1	1	2	2	24
Shorthorn sculpin	1	1	2	3	1						1	1	10
Cunner					2	1	2						5
Pollock												2	2
White perch	1												1
American eel									1				1
Atlantic herring										1			1
American plaice							1						1
TOTAL	39	24	146	549	2021	1315	1102	506	2242	1821	966	114	10845
No. of Trawls													

Table 12 Trawl catches by station for 1979.

Station T1

(Measured Mile)

Date	Temp °C	Sal ‰	Rep	Little skate	Thorny skate	Alewife	Rainbow smelt	Silver hake	Atlantic tomcod	Red hake	White hake	Ocean pout	Sea raven	Grubby	Longhorn sculpin	Window-pane	Smooth flounder	Winter flounder	Atlantic cod	Plaice	TOTAL
1/22/79	2.2	31.8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/20/79	0.7	30.8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/20/79	2.1	29.9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
			2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/24/79	3.5	31.0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
			2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	6	0	0	7
5/22/79	5.3	28.6	1	0	0	0	0	0	7	0	0	0	0	0	28	0	0	26	0	0	61
			2	0	0	0	0	2	6	0	1	2	0	0	46	0	0	37	0	0	94
6/19/79	17.0	29.2	1	1	0	0	0	0	1	0	0	1	0	0	27	0	0	9	0	0	39
			2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
7/17/79	10.9	29.8	1	0	0	0	0	0	0	0	1	0	0	0	32	0	0	31	0	0	64
			2	0	0	0	0	0	0	0	2	4	2	0	25	1	0	21	1	1	57
8/24/79	11.0	30.8	1	0	0	0	0	3	0	0	0	0	0	0	5	0	0	18	0	0	26
			2	0	0	0	0	0	0	0	2	0	0	0	3	0	0	30	0	0	35
9/11/79	11.8	30.2	1	0	0	0	0	5	0	0	21	1	0	0	3	0	0	23	0	0	53
			2	0	0	0	0	4	0	0	3	0	0	0	0	1	0	7	0	0	15
10/23/79	10.0	32.4	1	3	0	0	0	16	0	0	52	0	0	0	10	0	0	50	1	0	132
			2	2	0	0	0	7	0	0	32	0	0	0	4	1	0	25	0	0	71
11/20/79	9.1	31.4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2	6	0	0	0	1	0	0	1	0	0	0	5	0	0	0	12	0	25
12/18/79	6.8	32.5	1	1	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	4
			2	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	4
TOTAL				13	0	0	0	39	14	0	116	9	2	0	195	3	0	287	14	1	693

Table 32. (continued)

Station T2

(Sheepscot River)

Date	Temp °C	Sal °/oo	Rep	Little skate	Thorny skate	Alewife	Rainbow smelt	Silver hake	Atlantic tomcod	Red hake	White hake	Ocean pout	Sea raven	Grubby	Longhorn sculpin	Window-pane	Smooth flounder	Winter flounder	Atlantic cod	Shorthorn sculpin	Cunner	Pollock	TOTAL
1/22/79	1.4	28.4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
2/20/79	0.1	[illegible]	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2	0	0	0	0	0	0	0	0	0	1	5	0	[illegible]	0	0	0	0	0	0	6
3/20/79	1.9	25.9	1	0	0	0	5	0	1	0	0	2	4	13	6	0	0	14	3	0	0	0	48
			2	0	0	0	7	0	0	0	0	2	0	4	1	0	0	3	0	1	0	0	18
4/24/79	4.9	28.1	1	0	0	0	0	0	2	0	0	2	0	1	2	0	0	32	1	0	0	0	40
			2	1	0	0	1	0	0	0	1	1	2	0	2	0	0	25	0	0	0	0	33
5/22/79	8.0	26.0	1	0	0	0	0	0	0	0	3	6	3	0	1	1	0	1	7	0	0	0	22
			2	0	0	0	0	0	4	0	1	1	0	0	0	0	0	3	2	0	1	0	12
6/19/79	11.4	26.6	1	2	0	0	0	0	3	0	0	2	3	0	2	4	0	6	2	0	0	0	26
			2	1	0	0	0	0	10	0	0	0	4	0	4	0	0	3	2	0	0	0	24
7/17/79	14.9	28.7	1	0	0	0	0	5	3	0	2	0	0	0	5	5	0	11	0	0	0	0	31
			2	0	0	0	0	[illegible]	6	0	2	1	2	0	6	1	0	21	0	0	0	0	39
8/24/79	12.3	30.6	1	0	0	0	0	0	0	0	5	0	0	0	0	1	0	6	0	0	0	0	12
			2	0	0	0	0	10	0	0	0	2	0	0	2	0	0	2	0	0	0	0	16
9/11/79	13.9	28.7	1	0	0	0	0	1	6	0	9	0	0	0	4	0	0	2	0	0	0	0	22
			2	0	0	0	0	2	1	0	1	1	1	0	11	0	0	11	1	0	0	0	29
10/23/79	10.5	31.0	1	0	0	0	0	1	4	0	15	0	1	0	6	0	0	9	0	0	0	0	36
			2	3	0	0	0	0	2	0	12	2	3	0	15	0	0	32	0	0	0	0	69
11/20/79	9.5	32.0	1	0	0	0	0	0	8	0	3	0	1	0	11	0	0	3	2	0	0	0	28
			2	2	0	0	0	0	1	0	1	0	2	0	12	0	0	16	0	0	0	0	34
12/19/79	5.5	30.4	1	0	0	0	1	0	0	0	0	0	2	0	12	0	0	0	6	1	0	1	23
			2	0	0	0	0	0	2	0	0	0	5	1	1	0	0	0	4	1	0	0	14
TOTAL				9	0	0	14	19	53	0	55	22	34	24	103	12	0	200	30	3	1	1	560

Table 32. (continued)

Station T3

(Back River)

Date	Temp °C	Sal ‰	Rep	Little skate	Thorny skate	Alewife	Rainbow smelt	Silver hake	Atlantic tomcod	Red hake	White hake	Ocean pout	Sea raven	Grubby	Longhorn sculpin	Window-pane	Smooth flounder	Winter flounder	Shorthorn sculpin	Cunner	American eel	Pollock	TOTAL
1/22/79	2.3	28.0	1	0	0	0	3	0	18	0	0	0	1	6	2	0	0	0	0	0	0	0	30
			2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2/20/79	1.3	28.4	1	0	0	0	0	0	0	0	0	0	0	7	4	0	0	1	0	0	0	0	12
			2	0	0	0	0	0	1	0	0	0	0	2	1	0	0	0	0	0	0	0	4
3/20/79	1.8	25.4	1	0	0	0	16	0	16	0	0	0	0	10	0	0	0	2	1	0	0	0	45
			2	0	0	0	0	0	0	0	0	0	0	6	1	0	0	2	0	0	0	0	9
4/24/79	6.0	25.4	1	0	0	0	0	0	1	0	0	0	0	5	0	0	0	19	0	0	0	0	25
			2	1	0	0	1	0	3	0	0	0	0	8	1	0	1	10	1	0	0	0	26
5/22/79	8.6	24.0	1	0	0	0	0	0	3	0	0	0	2	4	4	0	0	53	1	1	0	0	68
			2	0	0	0	0	0	13	0	1	0	1	0	0	0	0	17	0	0	0	0	32
6/19/79	15.1	24.6	1	0	0	0	0	0	15	0	0	0	4	0	0	0	1	9	0	0	0	0	29
			2	1	0	2	0	0	37	0	1	0	0	7	0	0	0	11	0	0	0	0	59
7/17/79	18.0	27.3	1	1	0	0	0	4	40	0	0	0	0	0	0	0	0	87	0	1	0	0	133
			2	0	0	2	0	0	90	0	5	0	0	0	0	0	0	108	0	1	0	0	206
8/24/79	15.9	28.8	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	53	0	0	0	0	56
			2	1	0	0	0	0	1	0	0	0	0	1	0	0	0	47	0	0	0	0	50
9/11/79	15.2	28.0	1	1	0	0	0	17	73	0	6	0	0	1	0	0	0	32	0	0	0	0	130
			2	1	0	0	0	0	5	0	1	0	0	0	0	0	0	0	0	0	1	0	8
10/23/79	12.4	25.9	1	1	0	0	0	2	48	0	5	0	1	6	1	0	0	13	0	0	0	0	77
			2	1	0	0	0	0	86	0	1	0	0	0	0	0	0	11	0	0	0	0	99
11/20/79	10.2	27.5	1	2	0	0	0	2	21	0	0	0	0	3	1	0	0	7	1	0	0	0	37
			2	4	0	0	0	1	61	0	1	0	0	5	2	0	0	12	0	0	0	0	86
12/19/79	4.3	28.1	1	0	0	0	2	0	8	0	0	0	1	7	0	0	0	0	1	0	0	1	22
			2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	5
TOTAL				16	0	4	23	27	541	0	21	0	10	78	17	0	2	494	11	3	1	1	1249

Table 32. *(continued)*

Station T4

(Long Ledge)

Date	Temp °C	Sal °/oo	Rep	Little skate	Thorny skate	Alewife	Rainbow smelt	Silver hake	Atlantic tomcod	Red hake	White hake	Ocean pout	Sea raven	Grubby	Longhorn sculpin	Window-pane	Smooth flounder	Winter flounder	White perch	Shorthorn sculpin	Atlantic herring	TOTAL
1/22/79	1.9	27.5	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	4
			2	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1	0	4
2/20/79	1.9	27.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
3/20/79	1.9	22.4	1	0	0	0	3	0	1	0	0	0	0	1	0	0	0	1	0	0	0	6
			2	0	0	0	0	0	1	0	0	0	0	0	5	0	1	0	0	0	0	7
4/24/79	7.6	20.3	1	0	0	0	0	0	32	0	0	0	0	8	0	0	3	45	0	0	0	88
			2	1	0	0	4	0	35	0	0	0	0	10	0	0	8	60	0	0	0	118
5/22/79	11.2	19.7	1	1	0	3	1	0	162	0	0	0	0	2	2	3	19	24	0	0	0	217
			2	1	0	3	0	0	887	0	0	0	0	0	0	0	25	63	0	0	0	979
6/19/79	10.5	22.6	1	1	0	0	0	0	12	0	0	0	0	1	0	1	11	30	0	0	0	56
			2	2	0	0	1	0	407	0	1	0	0	0	2	1	13	116	0	0	0	543
7/17/79	17.9	26.9	1	0	0	0	0	0	1	0	1	0	0	0	0	1	34	44	0	0	0	82
			2	2	0	0	0	1	26	0	0	0	0	0	0	2	2	62	0	0	0	94
8/24/79	15.9	28.8	1	0	0	0	0	0	36	0	0	0	0	0	0	0	9	52	0	0	0	97
			2	0	0	1	0	1	22	0	0	0	0	0	0	0	12	47	0	0	0	83
9/11/79	15.2	26.9	1	1	0	0	0	11	659	0	5	0	0	0	0	0	37	270	0	0	0	983
			2	10	0	4	0	4	347	0	0	0	0	0	0	0	20	45	0	0	0	430
10/23/79	13.0	25.7	1	1	0	17	0	2	237	0	1	0	0	0	0	0	19	151	0	0	1	429
			2	2	0	7	0	0	20	0	0	0	0	0	0	0	1	32	0	0	0	62
11/20/79	10.4	28.3	1	1	0	0	0	0	381	0	0	0	0	1	0	0	0	16	0	0	0	399
			2	0	0	2	0	0	29	0	0	0	0	0	0	0	0	6	0	0	0	37
12/18/79	4.5	27.3	1	2	0	0	0	0	12	0	0	0	0	0	0	0	0	1	0	0	0	15
			2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL				25	0	37	10	19	3308	0	8	0	0	26	10	9	214	1065	1	2	1	4735

Table 32. (continued)

Station T5

(Montsweag Bay)

Date	Temp °C	Sal °/oo	Rep	Little skate	Thorny skate	Alewife	Rainbow smelt	Silver hake	Atlantic tomcod	Red hake	White hake	Ocean pout	Sea raven	Grubby	Longhorn sculpin	Window-pane	Smooth flounder	Winter flounder	Shorthorn sculpin	Cunner	Σ
1/22/79			1	NOT SAMPLED - ICE OBSTRUCTION																	0
			2																		0
2/20/79			1	NOT SAMPLED - ICE OBSTRUCTION																	0
			2																		0
3/20/79	2.5	20.6	1	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	0	0	4
			2	0	0	0	0	0	2	0	0	0	0	5	0	0	0	1	0	0	8
4/24/79	6.3	23.5	1	0	0	0	0	0	3	0	0	0	2	14	0	0	28	66	0	0	113
			2	0	0	0	0	0	26	0	0	0	0	8	0	0	20	40	2	0	96
5/22/79	12.5	18.8	1	0	0	0	0	0	253	0	[illegible]	0	0	3	0	0	52	61	0	0	370
			2	0	0	0	0	0	103	0	0	0	0	0	0	0	28	35	0	0	166
6/19/79	19.9	21.6	1	2	0	0	0	1	225	0	2	0	0	0	0	1	36	141	0	0	408
			2	2	0	0	0	0	3	0	0	0	0	1	0	3	24	97	1	0	131
7/17/79	17.5	27.2	1	2	0	0	0	0	62	0	8	0	0	0	0	3	53	101	0	0	229
			2	0	0	1	0	0	115	0	0	0	0	0	0	2	12	37	0	0	167
8/24/79	17.8	26.2	1	0	0	2	0	0	23	0	0	0	0	0	0	0	3	48	0	0	76
			2	0	0	0	0	0	13	0	0	0	0	0	0	1	15	26	0	0	55
9/11/79	15.0	27.0	1	1	0	3	0	1	216	0	0	0	0	1	0	0	10	85	0	0	317
			2	0	0	5	0	25	168	0	0	0	0	1	0	0	15	41	0	0	255
10/23/79	12.7	25.4	1	0	0	0	0	0	36	0	1	0	0	0	0	0	0	3	0	0	40
			2	14	0	1	0	1	672	0	5	0	2	0	0	0	10	101	0	0	806
11/20/79	10.5	28.2	1	9	0	0	0	0	115	0	1	0	0	1	0	0	0	8	0	0	134
			2	2	0	2	0	0	178	0	1	0	0	0	0	0	0	3	0	0	186
12/18/79	4.8	24.6	1	1	0	0	0	0	0	0	0	0	1	3	0	0	0	1	6	0	12
			2	1	0	0	3	0	5	0	0	0	0	0	0	0	0	1	4	1	15
TOTAL				34	0	14	3	28	2219	0	19	0	5	39	0	10	306	897	13	1	3588

Table 33. Total abundance of all fish species collected by otter trawl at each station and sampling year, Montsweag Bay and Sheepscot River, 1971-1979. Number of collections (trawls) in parenthesis.

Station	1971	1972	1973	1974	1975	1976	1977	1978	1979
T1	1157 (20)	930 (22)	710 (24)	941 (24)	997 (24)	1186 (24)	1580 (24)	398 (24)	693 (24)
T2	2072 (20)	2115 (22)	1863 (24)	1344 (24)	1142 (24)	685 (24)	442 (24)	317 (24)	580 (24)
T3	2282 (18)	2266 (20)	2150 (24)	941 (22)	1908 (24)	3148 (24)	3178 (21)	1653 (24)	1249 (24)
T4	2954 (20)	4325 (22)	2295 (24)	1584 (24)	3496 (24)	6156 (22)	5892 (22)	2034 (22)	4735 (24)
T5	7475 (20)	4551 (22)	1921 (24)	873 (24)	1561 (23)	3238 (18)	5006 (21)	2025 (20)	3588 (20)
All stations	15940	14187	8939	5683	9104	14413	16098	6427	10845
No. of trawls	98	108	120	118	119	112	112	114	116
Catch per trawl	163	131	74	48	76	129	144	56	93

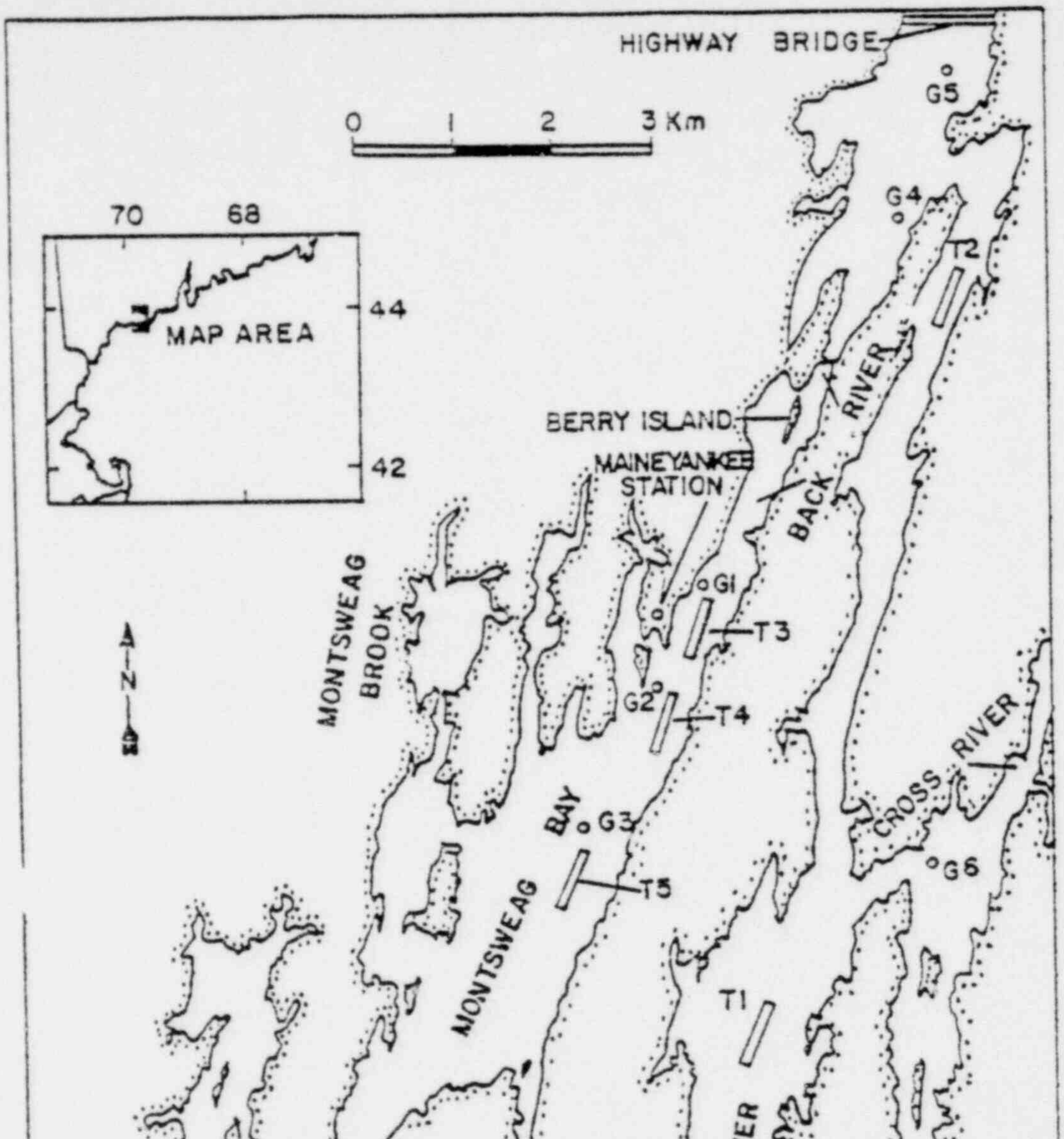

Figure 16. Montsweag Bay and Sheepscot River showing gill net (G) and otter trawl (T) sampling stations.

MARINE ALGAE

Daniel M. Greenstein

Introduction

Abundance, distribution, and growth of intertidal marine algae indigenous to Montsweag Bay has been monitored for the past nine years. During 1979 changes in marine algae community structure were assessed using percent cover estimates at seven historic monitoring locations (Figure 17). Presented herein are the results from data collected during June and November 1979.

Materials and Methods

The percent cover of algae, marsh grasses, attached invertebrates and substrate types was measured seasonally since 1971. During June and November 1979 percent cover was measured at each station in three permanent vertical belt transects 0.25 m wide and of variable length, depending on intertidal slope. Transects were from the litus line to mean low water on the mudflats subtending the ledge at each site. Transect data was taken in 1.0 m segments and analyzed according to tide height.

Results and Discussion

The coverage of intertidal substrates by benthic algae and other organisms is shown in Table 34. Data comparisons are for the November sampling period unless otherwise noted.

As in previous years, *Ascophyllum nodosum* continued to dominate substrate coverage, accounting for 76% and 84% of the intertidal composition during June and November, respectively. *A. nodosum* coverage characteristically increased from June through November in both the upper (zone 1) and lower (zone 2) intertidal zones. In zone 2, where *A. nodosum* is most prevalent, an 11% increase in cover was seen from late June through November (81%, June; 92%, November) while a 5% increase was reported for zone 1 (71%, June; 76%, November). During the growth season increases in *A. nodosum* cover were generally offset by corresponding decreases in exposed substrate or *Fucus* spp. cover. Intertidal substrate exposure averaged 10% during the reporting period while *Fucus* spp. cover was variable among locations.

At the experimental stations (Bailey Point, Foxbird Island, Young Point), intertidal algal standing stocks were representative of those attached algae found at the control stations. Average *A. nodosum* coverage at the experimental stations was slightly higher (experimental coverage = 86%; all stations combined = 80%) than that recorded for all stations combined. Correspondingly, substrate exposure was lower at the experimental stations. At only one experimental zone (zone 1, Bailey Point) did the exposed substrate exceed the combined average (10%) for all stations. However, as compared to 1978, substrate exposure at this site and Foxbird Island decreased substantially.

Percent cover composition at all stations (excluding Restaurant Site) approximated that coverage reported during 1978. At Dewick's Area, Ferry Site, and Foxbird Island, substrate colonization and growth of previously established plants resulted in increased *A. nodosum* dominance. The overall decrease in *A. nodosum* cover seen at Restaurant Site was partially compensated by increased *Fucus* spp. cover, thereby limiting the quantity of exposed substrate. At only one other station (Young Point) was a net increase in substrate exposure (7% increase during 1979) observed during November.

Conclusions

Data from the intertidal profiles observed during 1979 continue to substantiate the existance of a stabilized intertidal attached algae community in the Montsweag Bay area. Although natural variations in substrate coverage are seen seasonally as well as annually, algal cover is generally within 10% of the established average reported for the diffuser discharge phase of plant operations.

Table 34. Percent cover of intertidal substrates at each of seven stations during June and November 1979. Z = zone.

Station (#)		Jun 1979			Nov 1979		
		Z1	Z2	Z3	Z1	Z2	Z3
Ferry Site (3)	*Ascophyllum nodosum*	86	86	88	74	80	95
	Fucus spp.	10	9	11	25	7	2
	Other plants	0	0	0	0	0	0
	Animals	0	0	0	0	0	0
	Rock & Mud	4	5	1	1	13	3
Bailey Point (4)	*Ascophyllum nodosum*	59	97		79	95	
	Fucus spp.	32	0		9	4	
	Other plants	0	0		0	0	
	Animals	1	0		0	0	
	Rock & Mud	8	3		12	1	
Restaurant Site (5)	*Ascophyllum nodosum*	60	73		72	91	
	Fucus spp.	15	11		22	1	
	Other plants	1	0		1	1	
	Animals	0	1		0	0	
	Rock & Mud	24	15		5	[illegible]	
Foxbird Island (2)	*Ascophyllum nodosum*	87	87		94	89	
	Fucus spp.	9	1		3	4	
	Other plants	0	0		0	0	
	Animals	1	1		0	0	
	Rock & Mud	3	11		3	7	
Young Point (6)	*Ascophyllum nodosum*	88	93		76	97	
	Fucus spp.	0	0		10	1	
	Other plants	7	0		6	1	
	Animals	0	1		0	0	
	Rock & Mud	5	6		8	1	
Dewick's Area (9)	*Ascophyllum nodosum*	58	46		77	93	
	Fucus spp.	6	25		8	6	
	Other plants	0	0		0	0	
	Animals	0	1		0	0	
	Rock & Mud	36	28		15	1	
Clough Point (1)	*Ascophyllum nodosum*	57	83		57	99	
	Fucus spp.	22	2		19	0	
	Other plants	0	0		0	0	
	Animals	1	3		1	0	
	Rock & Mud	22	12		23	1	

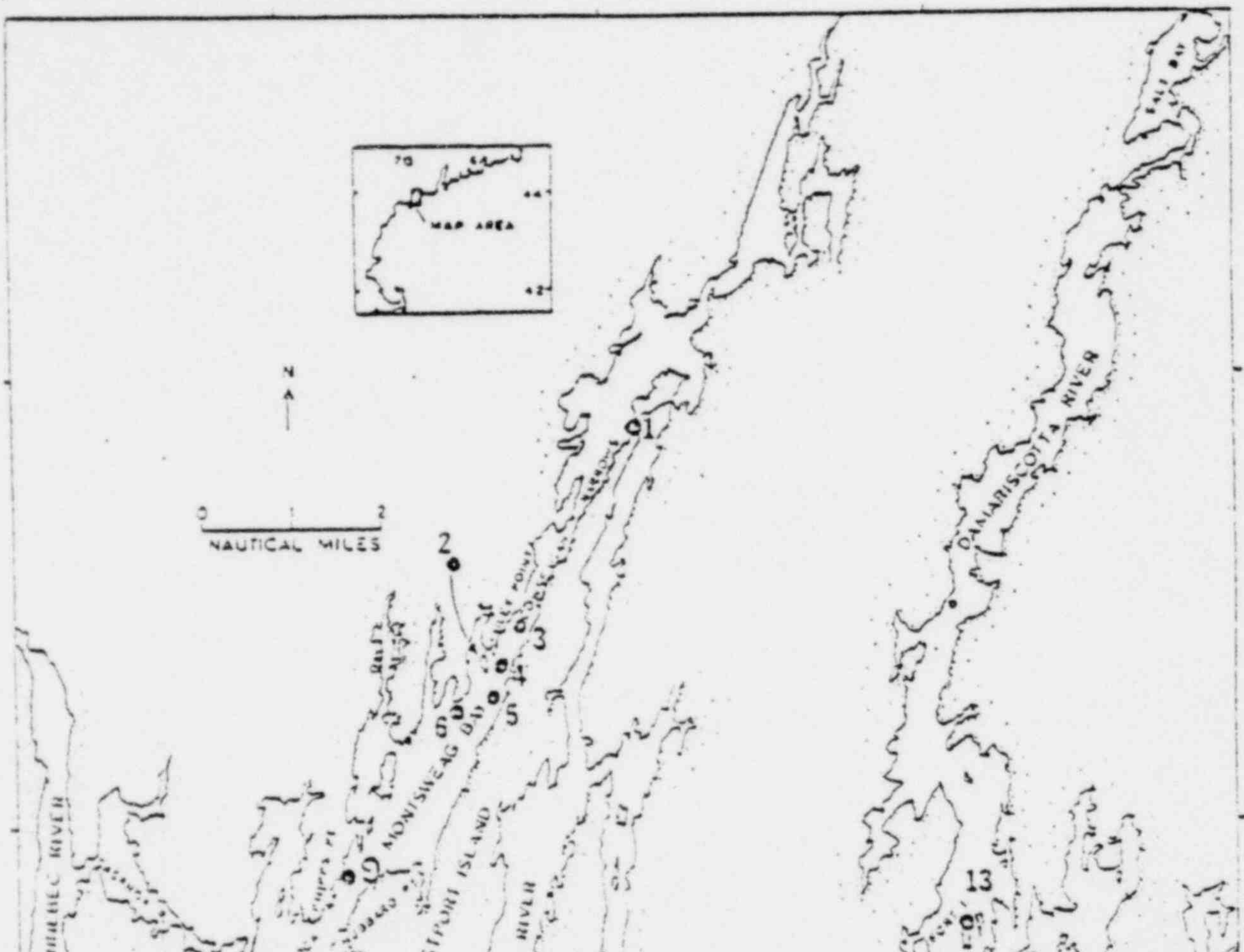

Figure 17. Benthic Marine Algae
Study Sites.