Cruise Report

RV/ALBATROSS IV Cruise 9403 Part I to Georges Bank

US GLOBEC

NW ATLANTIC/GEORGES BANK STUDY

May 3 - 13, 1994

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R.V. Albatross IV Cruise 9403 Part 1
to Georges Bank

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Acknowledgements

We gratefully acknowledge the excellent support provided by the Officers and crew of the R.V. Albatross IV. Their unwavering help and positive attitude helped us to achieve all of our scientific objectives.

This cruise was sponsored by the National Science Foundation and the National Oceanic and Atmospheric Administration.

This document was edited by Erich Horgan and Larry Madin of the Woods Hole Oceanographic Institution.

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NOAA R/V ALBATROSS IV CRUISE 94-03
GLOBEC Georges Bank Predation Study

CRUISE PERIOD AND AREA

The cruise was from May 3-13, 1994. Operations were conducted on the southern flank and the central plateau of Georges Bank. Locations of the main sampling stations and Bongo grid sites are shown in Figure 1.

OBJECTIVES

The objectives were:

(1) determine the distribution and abundance of larval and pelagic juvenile cod and haddock within a standard sampling grid over the southern portion of the Bank.

(2) locate well-mixed and stratified stations based on hydrography and presence of fish larvae.

(3) sample at these station to determine the abundance, vertical and temporal distribution of fish larvae, copepods and invertebrate predators.

(4) examine gut contents and determine digestion rates of selected predators.

(5) test immunological methods for the detection and identification of copepod prey.

(6) survey hydrographic conditions at and between the two main stations.

(7) collect and process fish larvae for biochemical studies of metabolism.

METHODS

The sampling equipment used during the cruise included:

1. MARMAP standard Bongo nets with Seacat CTD. These nets were used for the initial grid survey for presence and abundance of cod and haddock larvae, and for a few other collections. CTD data were used to determine extent of stratification. The Bongo net was deployed from the boom winch.

2. MK5 CTD. This CTD was equipped with a rosette sampler and fluorometer. It was used for standard casts daily or oftener at each main station, and for a tow-yo transect between the two stations. The MK5 was deployed from the starboard hydrographic A-frame.

3. MOCNESS systems. Three MOCNESS systems were used, 1/4 m^2, 1 m^2 and 10 m^2. The two smaller nets were deployed from the boom winch, and the MOC-10 was fished from the dredge winch through the stern A-frame. The smaller systems were equipped with 9 nets each and the MOC-10 with 5 nets. All systems had CTDs mounted on them.

4. SCUBA diving. On five occasions (4 day, 1 night) SCUBA dive collections were made by groups of 4 divers. The divers made observations and video recordings of the distribution and behavior of zooplankton and collected live specimens for laboratory use.

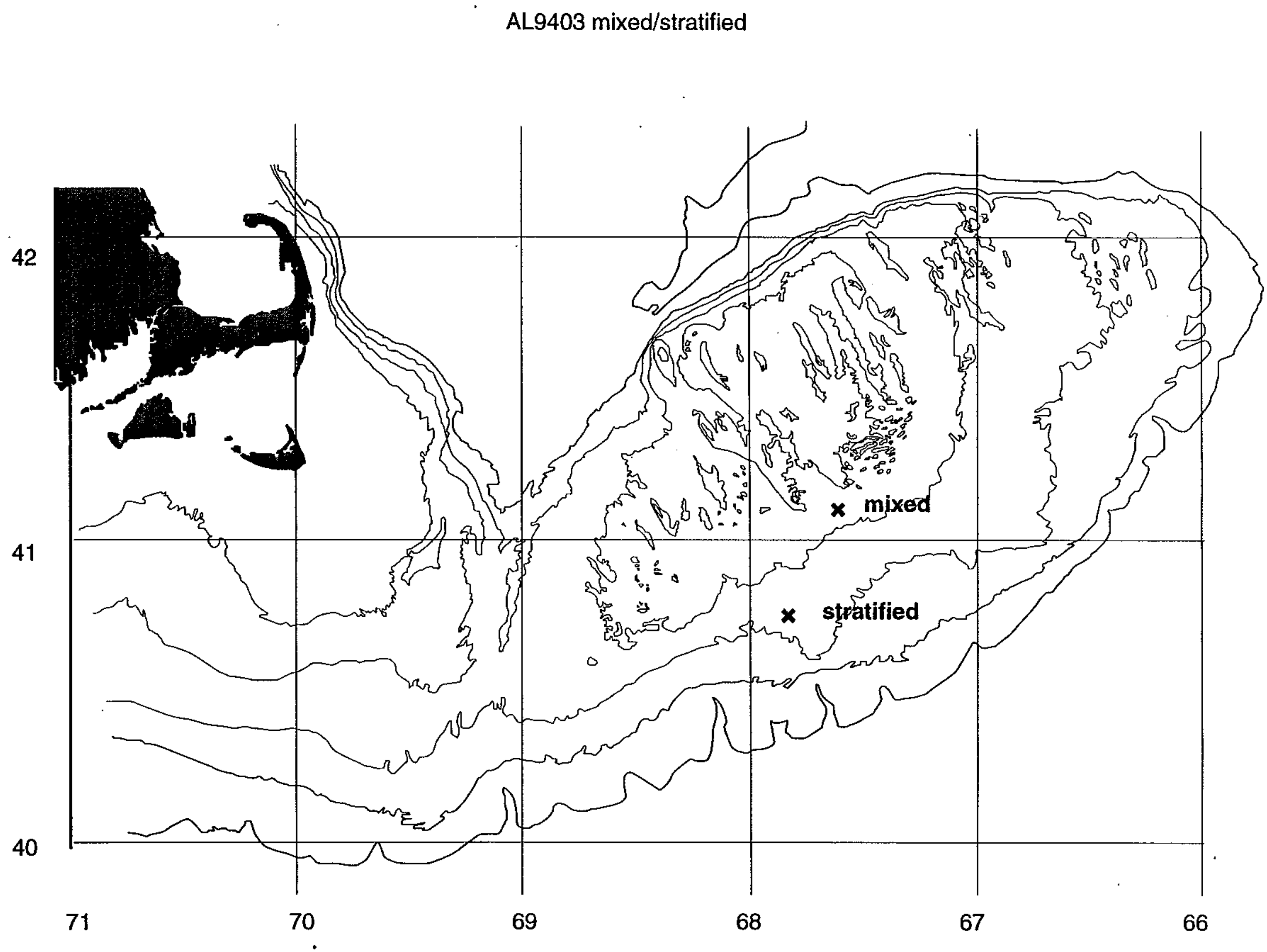


Figure 1. Map of the relative positions of the well-mixed and stratified sampling stations, R.V. Albatrtoss IV, Cruise 9403.

CRUISE NARRATIVE

The first task after leaving Woods Hole was to conduct a Bongo survey for larval cod and haddock. This was to be done in conjunction with the R/V DELAWARE. Because the sailing of the ALBATROSS was delayed a day for mechanical problems, the DELAWARE completed most of the survey. Larval fish were picked from fresh Bongo net samples (333 and 505 μm mesh), and the numbers expressed per standard 10 minute tow. The data from ALBATROSS and DELAWARE were combined and main stations selected partly on this basis. The two main stations were in the well-mixed region of the central bank (41°10'N 67°35'W) and on the stratified south flank. We found that the first stratified station chosen (40°45'N 67°47'W) was subject to intrusion of slope water during part of the tidal cycle, and so moved north to 40°47'N 67°47'W to avoid this factor.

We had planned to begin work at the stratified site, but because of a gale on 5 June, during which no work was accomplished, we decided to start work in the well-mixed region and allow a few more days for stratification to be restored on the south flank.

At the mixed site we began a diel series of collections with the MOC-1 and MOC-10 systems. Because of an electronics failure, we had only two working electronics packages for the MOCNESS systems, and therefore made only 1 collection with the 1/4 m MOCNESS at each station. Tows were made with each net system approximately every 3-4 hours, with several MK5 CTD casts during each 24 hour period. One SCUBA dive was made at the mixed station. We worked at the mixed site from May 6-8.

After leaving the mixed station, we made some additional Bongo tows to check on the distribution of fish larvae before picking the stratified site. Six additional tows were made on May 8-9, repeating some previous stations and adding some intermediate ones. On the basis of this information we picked the first stratified station and began work there on May 9. We moved to the second stratified site on May 11. The schedule was similar to the mixed station, with alternating MOC-1 and MOC-10 trawls at about 3-4 h intervals. SCUBA dives were made on May 9, 10 and 11.

Following sampling at the stratified sites, we conducted a CTD tow-yo from the stratified to the mixed and back again, towing against the tidal current. At the conclusion of this series we made one last MOC-1 cast in a mixed region before heading back to Woods Hole.

At both stations, we remained in communication with DELAWARE, which was trawling for herring and mackerel in the vicinity of our sites. While we were at the stratified site, Bill Michaels decided to move further west to try fishing there, as they weren't catching much in our area.

ALBATROSS arrived in Woods Hole at 0700 on May 13.

DISPOSITION OF DATA

The CTD data will be processed by Dave Mountain at the NEFSC in Woods Hole. Samples from the Bongo survey, the MOC-1 and MOC-1/4 tows will be stored and analyzed at the NEFSC by Greg Lough's group. Some MOC-1 samples made with 1000 µm nets will be analyzed by Barbara Sullivan and Grace Klein-MacPhee at URI. The MOC-10 samples are stored at WHOI and will be sorted under supervision of Larry Madin and Steve Bollens. Enzyme analyses of larval fish will be completed by Liz Clarke at the University of Miami.

RESULTS

After some initial problems, the sampling equipment worked well. Failure of one MOCNESS underwater unit prevented us from having three systems operable at the same time, so that we could use the MOC-1/4 only by moving the electronic unit from the MOC-1. The electrical termination for the MOC-10 had to be redone, and we ripped several of the older nets belonging to Greg Lough (NMFS), but eventually got a set that worked well.

We completed 21 Bongo net tows, the data is summarized in Table 1. The relative positions of the Bongo net tows are shown in Figure 2. The results for abundance of cod and haddock larvae at the grid stations sampled by ALBATROSS and DELAWARE are shown in Figures 3 and 4.

We made 38 stationary profiles with the MK5 CTD , and another 85 casts during the two legs of the tow-yo on May 12. The profiles indicate the mixed and stratified character of the water columns at those respective stations. Results of the tow-yo clearly show the tidal front, but did not find the high fluorescence values associated with that front that were found in May 1993.

A total of 48 MOCNESS tows were made: 24 with the MOC-1 (Fig 5), 21 with the MOC-10 (Fig 6), and 3 with the MOC-1/4 (Fig 7). Four tows were aborted or produced incomplete samples. Settled volumes for MOC-1 0.333mm and 1mm mesh nets for day/night tows at the well-mixed and stratified stations are shown in Table 2. These data are shown over depth for day/night tows at the well-mixed and stratified stations in Figure 8, and MOC-1 zooplankton > 0.333mm settled volumes over depth at the mixed site are shown in Figure 9. MOC-1 analyses of suspended hydroids for total number of hydranths, hydroid colonies, gonangia per m3, and average number of hydranths per colony over depth and day/night tows are shown in Figures 10-13. Preliminary analyses of MOC-10 day/night net tows for total number of invertebrates and abundances of various invertebrate predators over depth are shown in Figures 14-18. Total number of larval/juvenile fishes, Gadids, cod, and haddock per 1000m3 at the mixed and stratified stations and over depth are shown in Figures 19, 20, 21, and 22 respectively.

The five SCUBA dives provided information about the occurrence and distribution of organisms not well sampled by the MOCNESS (Figure 23). At the mixed site, the dives revealed the abundance of *Cyanea* and the behavior of the suspended hydroids that dominated the biomass. At the mixed site, divers observed high densities of *Bolinopsis* that were seriously undersampled by the nets; diver collected *Bolinopsis* were used for analysis of gut contents (Figure 24) and digestion times (Figure 25). Vertical stratification of the zooplankton was also apparent.

Samples of various invertebrate predators (amphipods, isopods, chaetognaths, decapods) were used in tests of immunological methods for the detection of copepod prey in the guts of other animals. This work included testing several alternative fixatives, and three different antisera.

Larval cod and haddock were used by Clarke for analysis of enzymes regulating metabolism.

ALBONGO.XLS

ALBONGO.WQ1

ALBATROSS IV 9403 BONGO DATA SUMMARY

					RAW COUNTS				AVG PER 10 MIN				
EVENT #	STA #	DEPTH	DEPTH	TOW TIME	COD	COD	HAD	HAD	COD	HAD	TEMP	SAL	COMMENTS
		NET	BOTTOM	MIN	333	505	333	505					
AL12494.002	A-1	39	38	7.1	24	25	2	1	34.5	2.1	7.50	33.20	Aequorea, chaetognaths, hydroids
AL12494.003	A-2	54	51	6.2	47	75	1	10	98.4	8.9	7.20	33.98	hydroids
AL12494.004	A-3	60	58	8.5	95	104	10	23	117.1	19.4	7.20	32.78	Pleurobrachia, most fish
AL12494.005	A-4	66	63	8.5	8		2		9.4	2.4	7.50	32.88	Bolinopsis
AL12494.006	A-5	69	66	7.3	6		16		8.2	21.9	8.00	32.50	few Staurophora, lotsa larvaceans
AL12494.007	A-6	74	72	8.9	11	7	7	18	10.1	14.0	8.40	32.90	larvaceans
AL12494.008	A-7	88	85	11.7	3	1	5	10	1.7	6.4	7.60	32.80	larvaceans
AL12494.009	AB-8	71	69	6.5	13	10	10	14	17.7	18.5			
AL12494.010	AB-9	58	56	5.7	34	32	0	1	57.9	0.9			
AL12494.011	BC-10	60	58	6.8	80	88	5	3	123.5	5.9	7.30	32.80	
AL12494.012	BC-11	76	74	10.7	62	64	15	11	58.9	12.1	7.50	32.81	
AL12494.013	12	50	49	6.2	12	11	0	2	18.5	1.6	7.31	32.82	hydroids
AL12494.014	13	49	52	6.8	18	17	0	1	25.7	0.7	7.30		
AL12494.015	14	51	54	6.7							7.70		
AL12694.001	15												qualitative tow for specimens
AL12694.002	16			11.8	11	12	5	1	9.7	2.5	6.90		
AL12894.012	17	67	69	7.6	5	6	10	6	7.2	10.5			
AL12994.001	18	64		10.8	2	16	17	23	8.3	18.5	6.10		
AL12994.002	19	71	73	9	14	5	9	10	10.6	10.6	6.10		Staurophora, larvaceans, Calanus
AL12994.003	20	80	82	8.2	6	1	6	3	4.3	5.5	8.20		Staurophora, larvaceans, Calanus
AL12994.004	21												repeat sta6

Table 1. AL9403 Bongo net data summary.

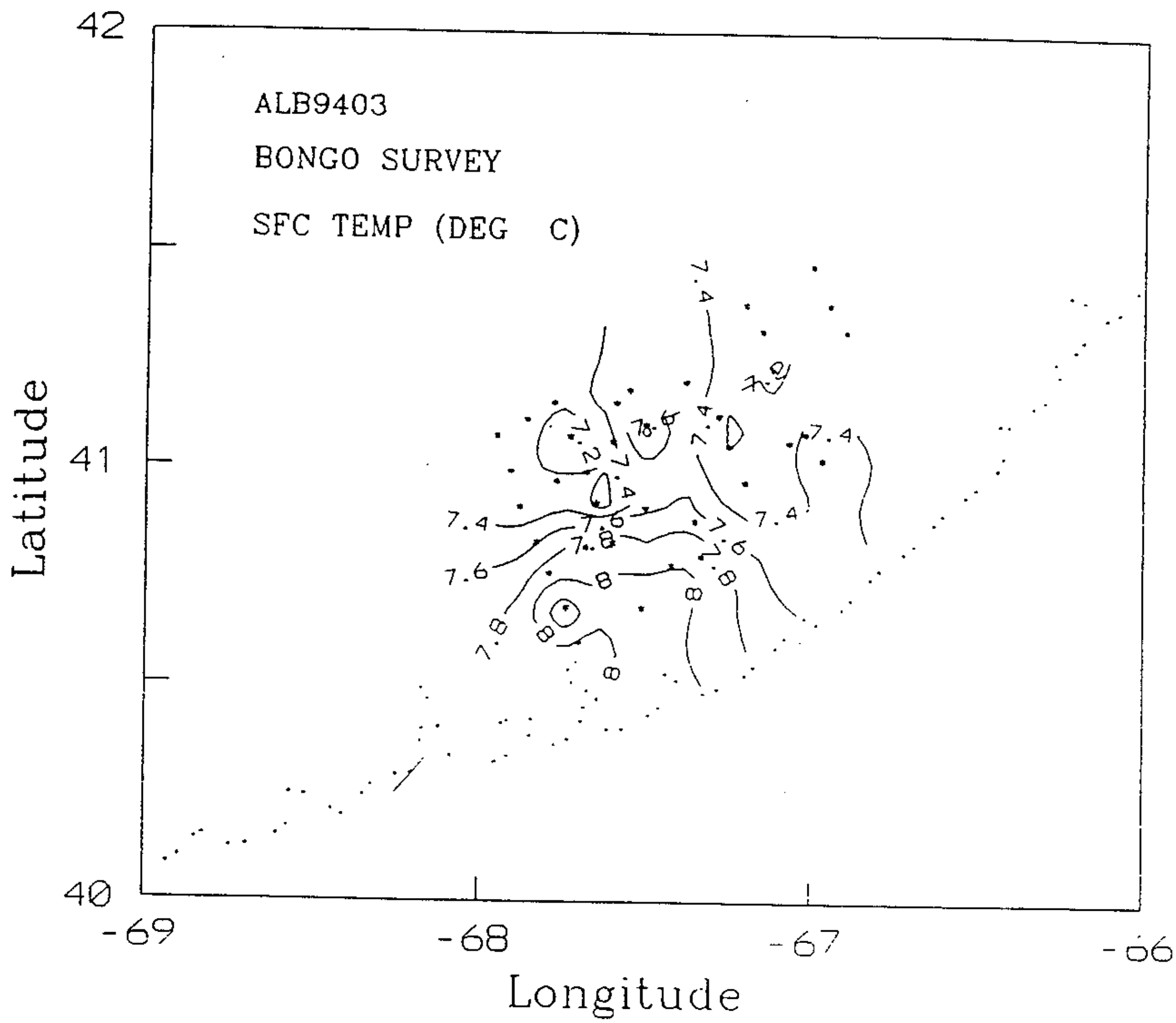


Figure 2. Surface temperature distribution from combined Bongo net survey by ALB9403 and DEL9406 cruises.

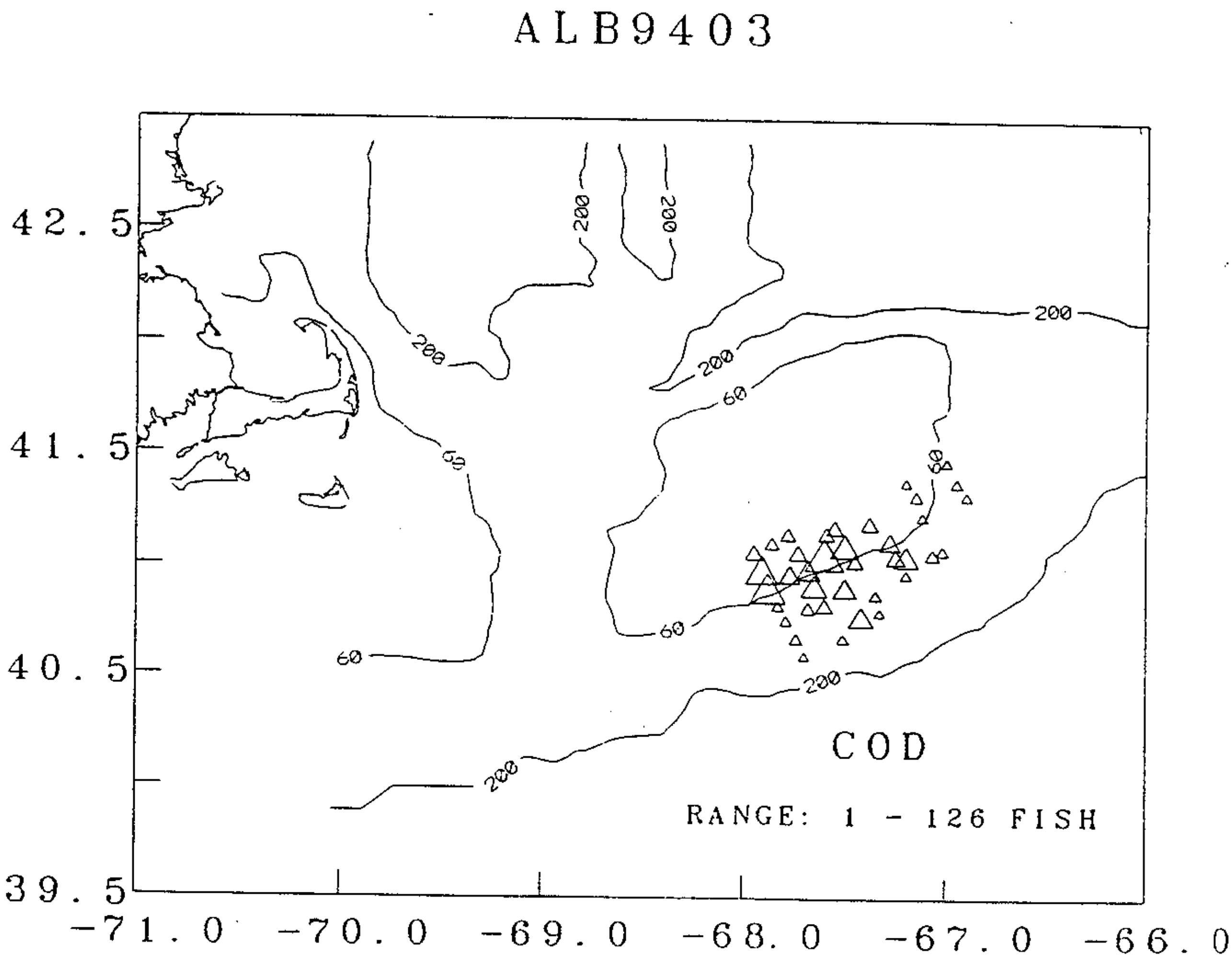


Figure 3. Abundance of cod larvae collected at Bongo grid stations.

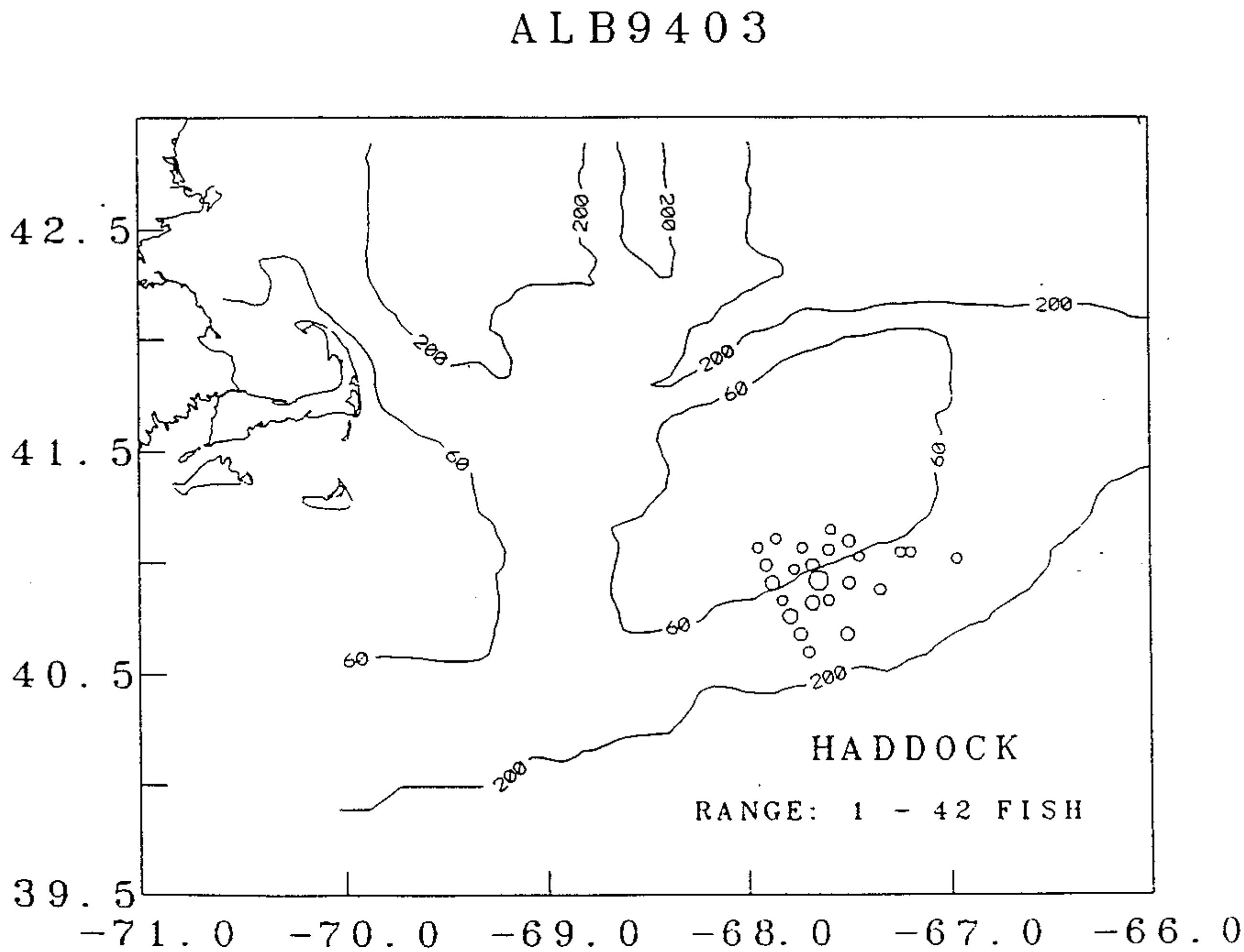


Figure 4. Abundance of haddock larvae collected at Bongo grid stations.

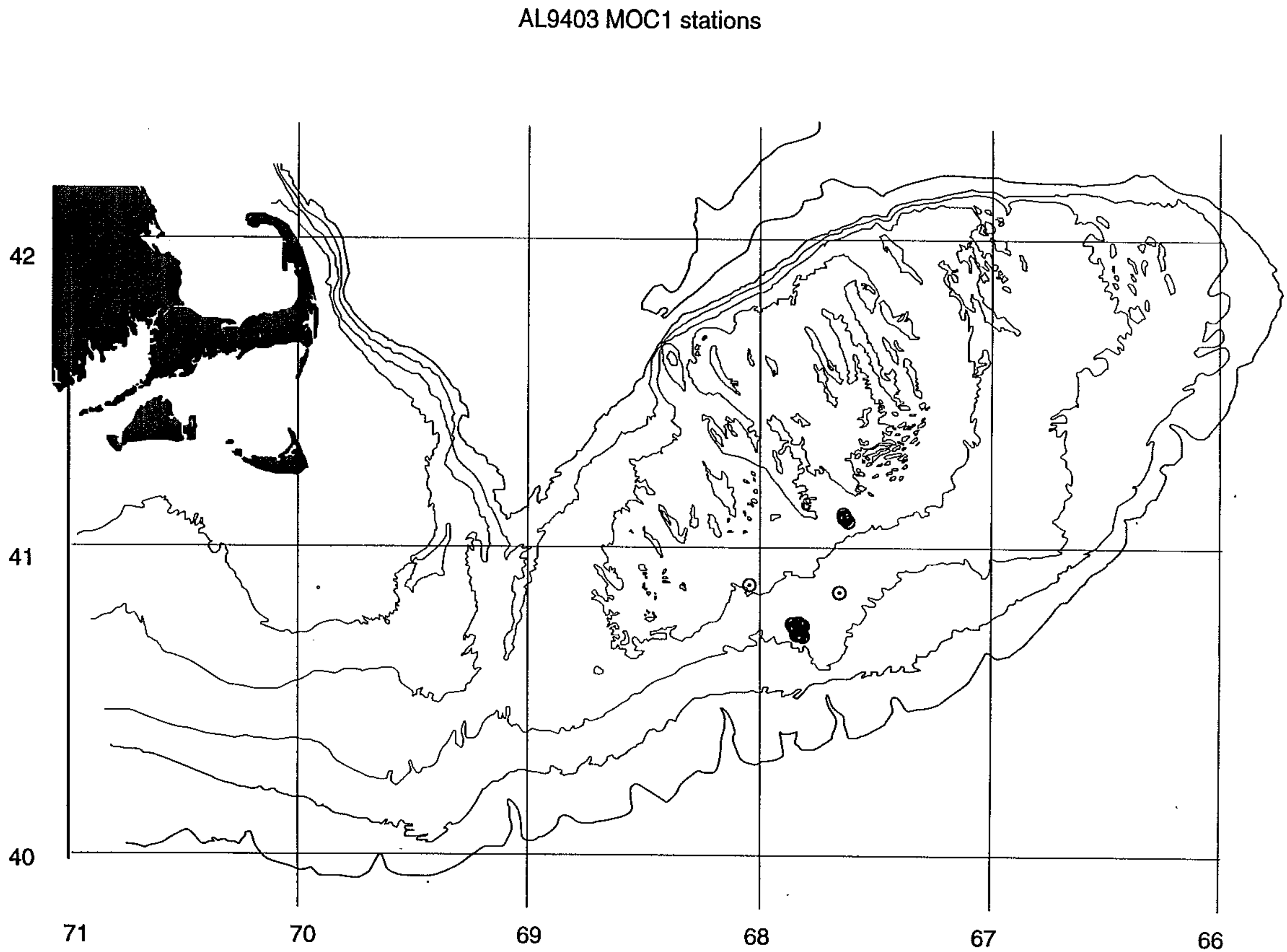


Figure 5. AL9403 MOC-1 stations.

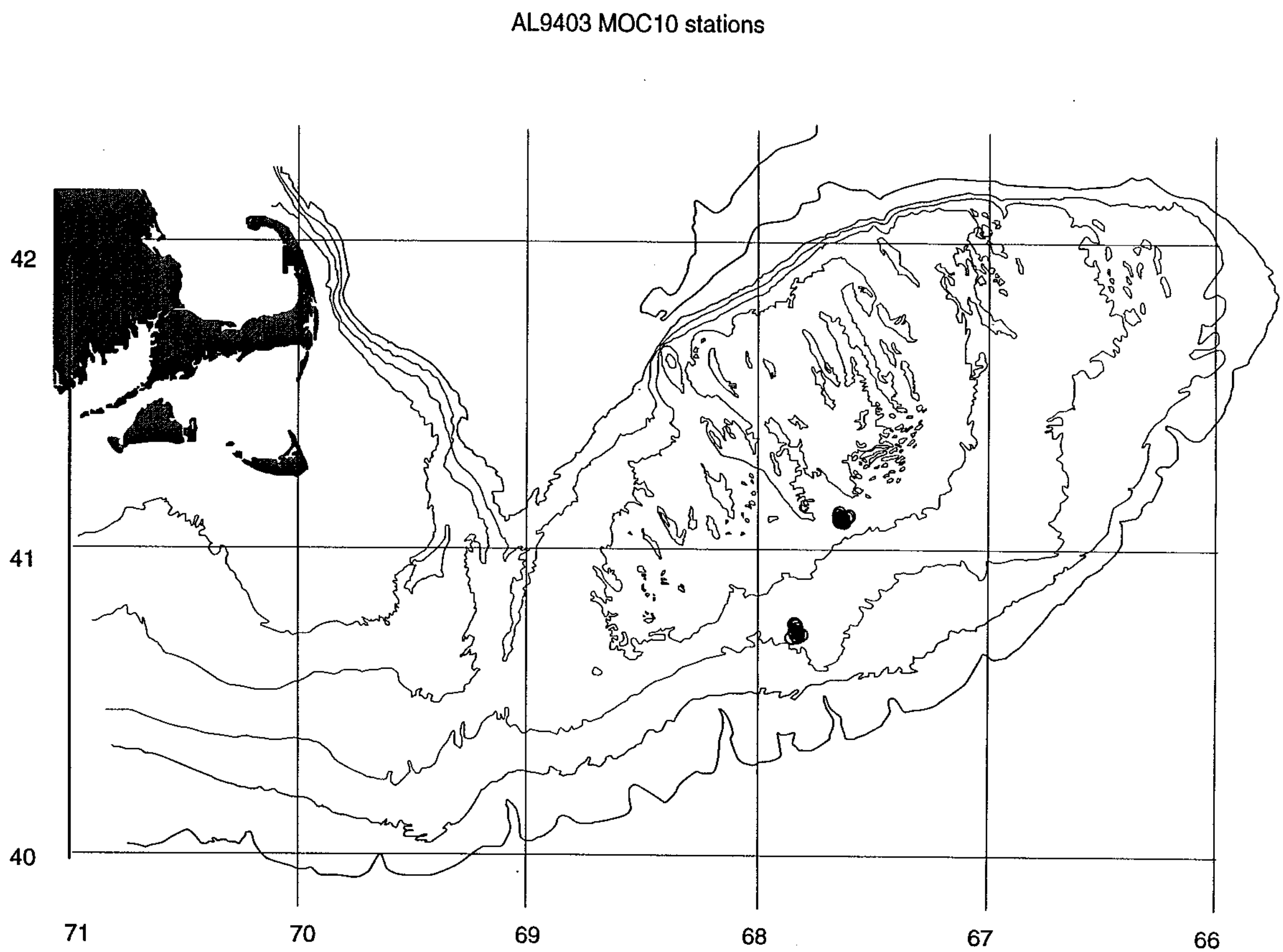


Figure 6. AL9403 MOC-10 stations.

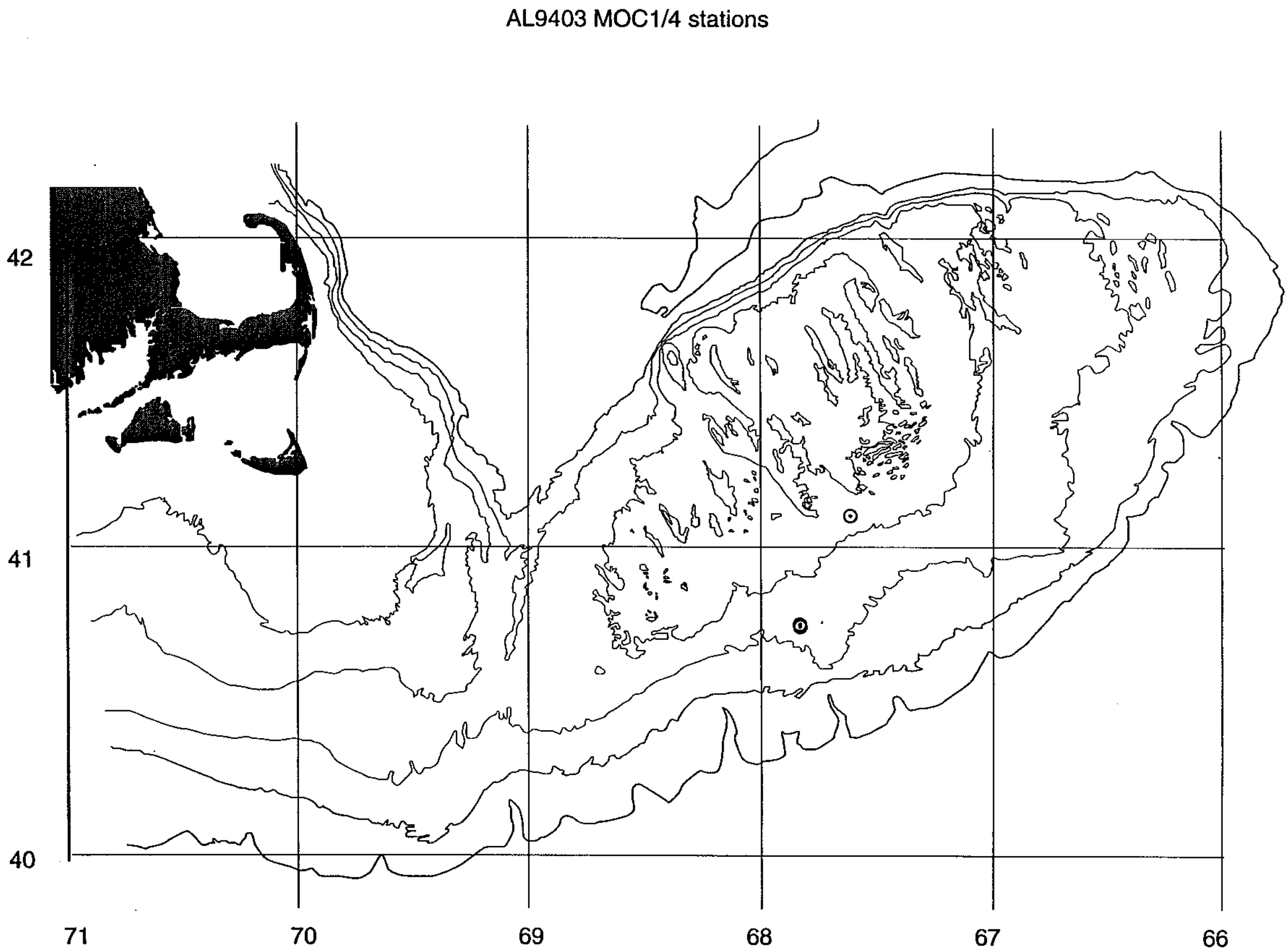
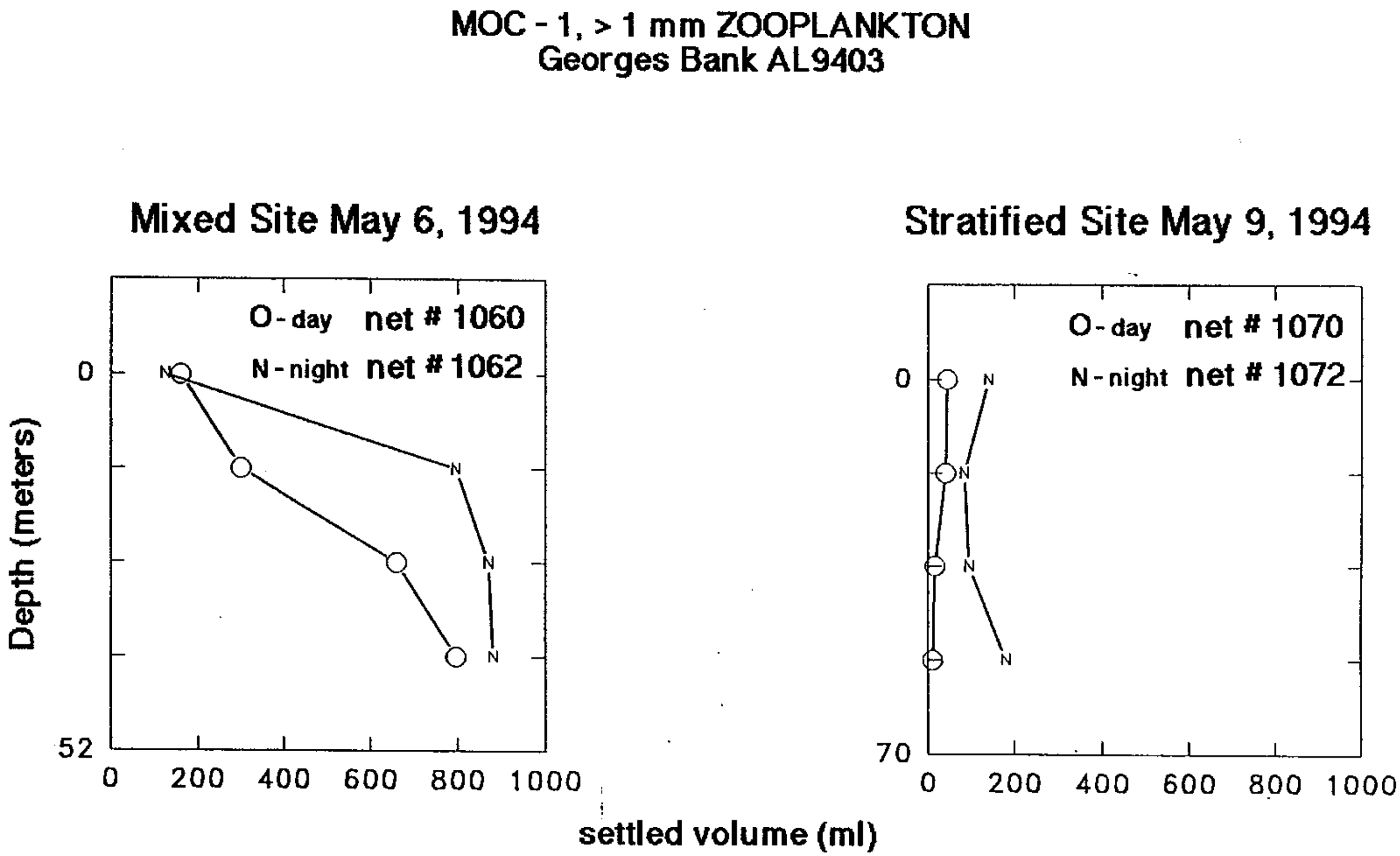


Figure 7. AL9403 MOC-1/4 stations.

Settled Volumes 0f MOC -1 Tows
AL9403 May 3-13, 1994

SYSTEM	MESH SIZE	TOW # - location	NET #	SETTLED VOLUME (ml)	COMMENTS
MOC - 1	.333 mm	#1054 - mixed site	1	800	includes all >0.333 mm zooplankton
		day	2	750	
			3	520	
			4	510	
			5	240	
			6	250	
			7	120	
			8	150	
MOC - 1	1mm	#1060 - mixed site	2	795	excludes copepods
		day	4	660	primarily hydroids, chaetognaths, Cyanea
			6	300	
			8	160	
		#1062 - mixed site	2	880	similar to #1060 except shrimp present
		night	4	870	
			6	795	
			8	125	
		#1070 - stratified site	2	10	
		day	4	15	
			6	40	
			8	44	
		#1072 - stratified site	2	180	
		night	4	95	
			6	84	
			8	140	

Table 2. Settled volumes of MOC - 1 tows AL9403.



- depths are approximate
- Zooplankton at the mixed site were primarily hydroids, chaetognaths, the scyphomedusae Cyanea sp., and at night , shrimp
- Zooplankton at the stratified site were hydromedusae, shrimp, amphipods, isopods, and chaetognaths

Figure 8. Settled volumes of day/night MOC - 1 tows for >1 mm zooplankton at the mixed and stratified sites, May 6, 1994 and May 9, 1994, respectively, AL9403.

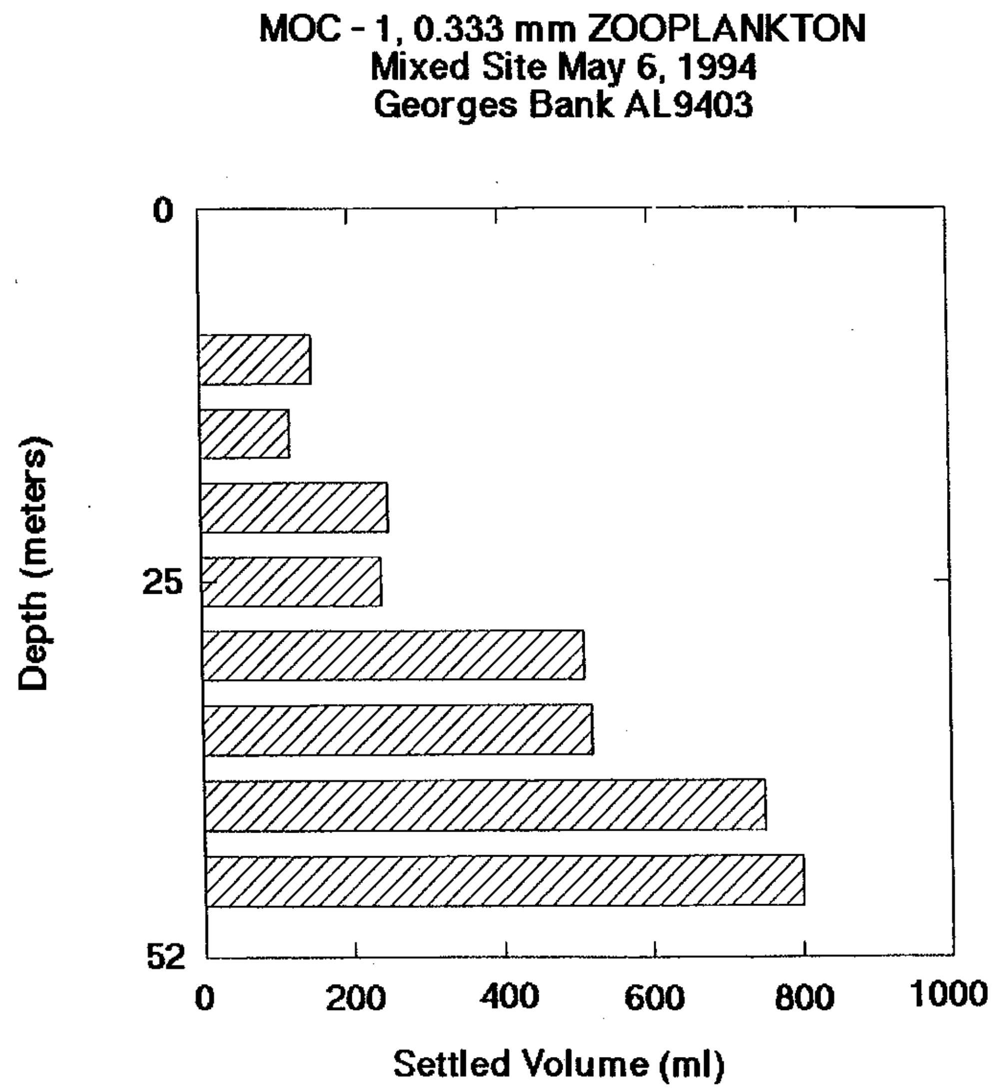


Figure 9. Settled volumes of MOC - 1 tows for <.333 mm zooplankton at the mixed site May 6, 1994, AL9403.

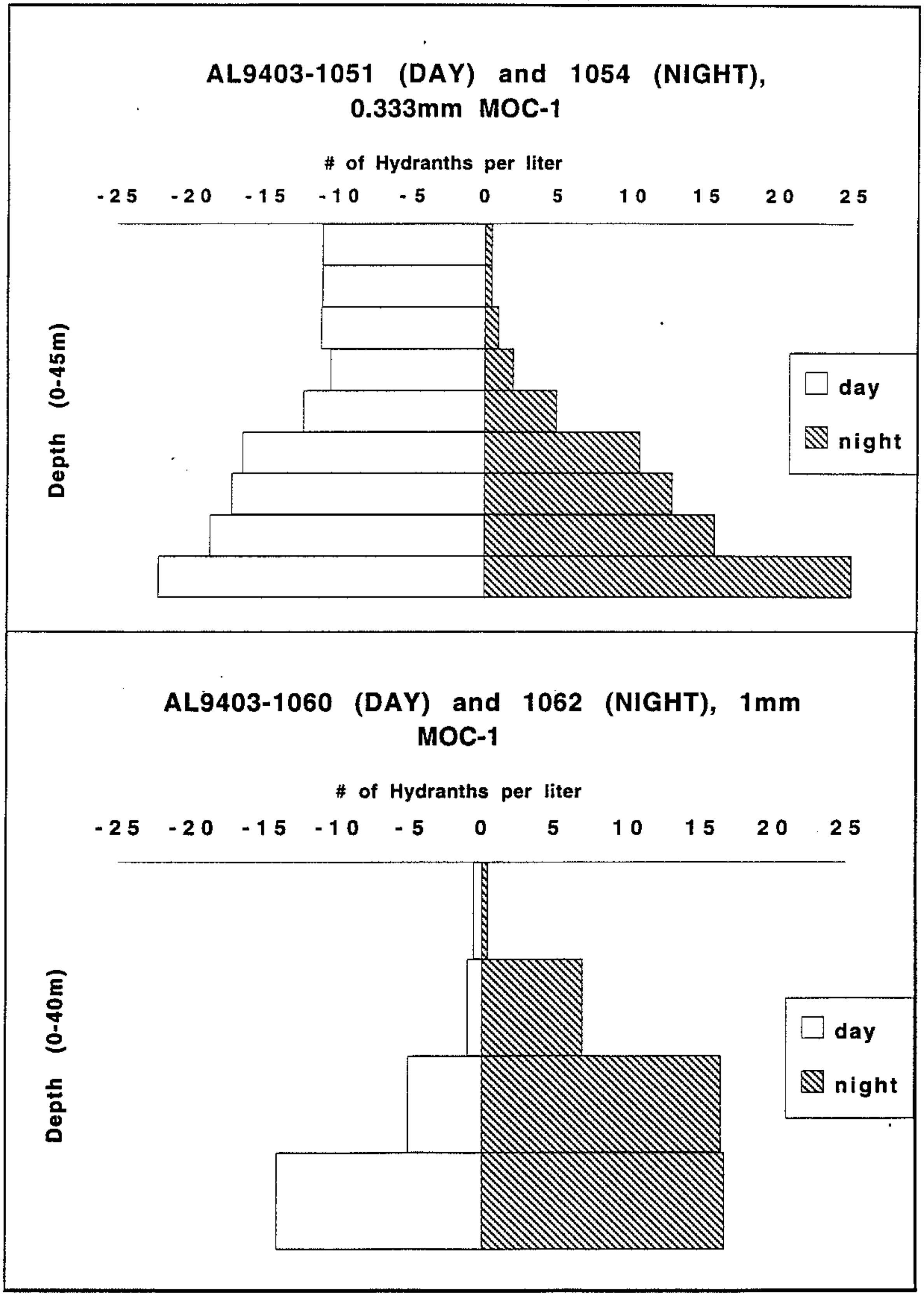


Figure 10. Total number of hydranths per liter over depth during day/night collected with 0.333mm and 1mm MOC - 1 nets.

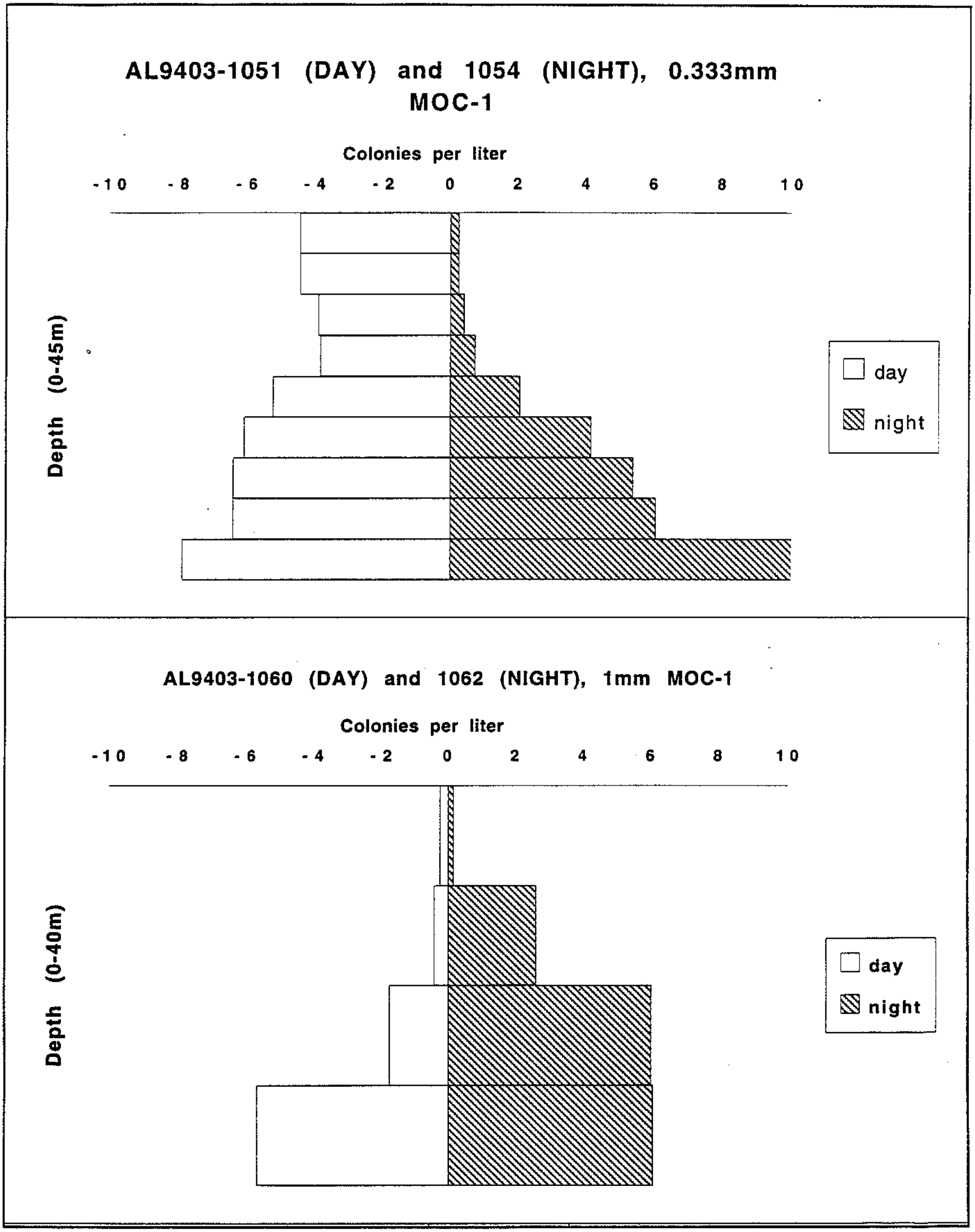


Figure 11. Total number of hydroid colonies per liter over depth during day/night collected with 0.333mm and 1mm MOC - 1 nets.

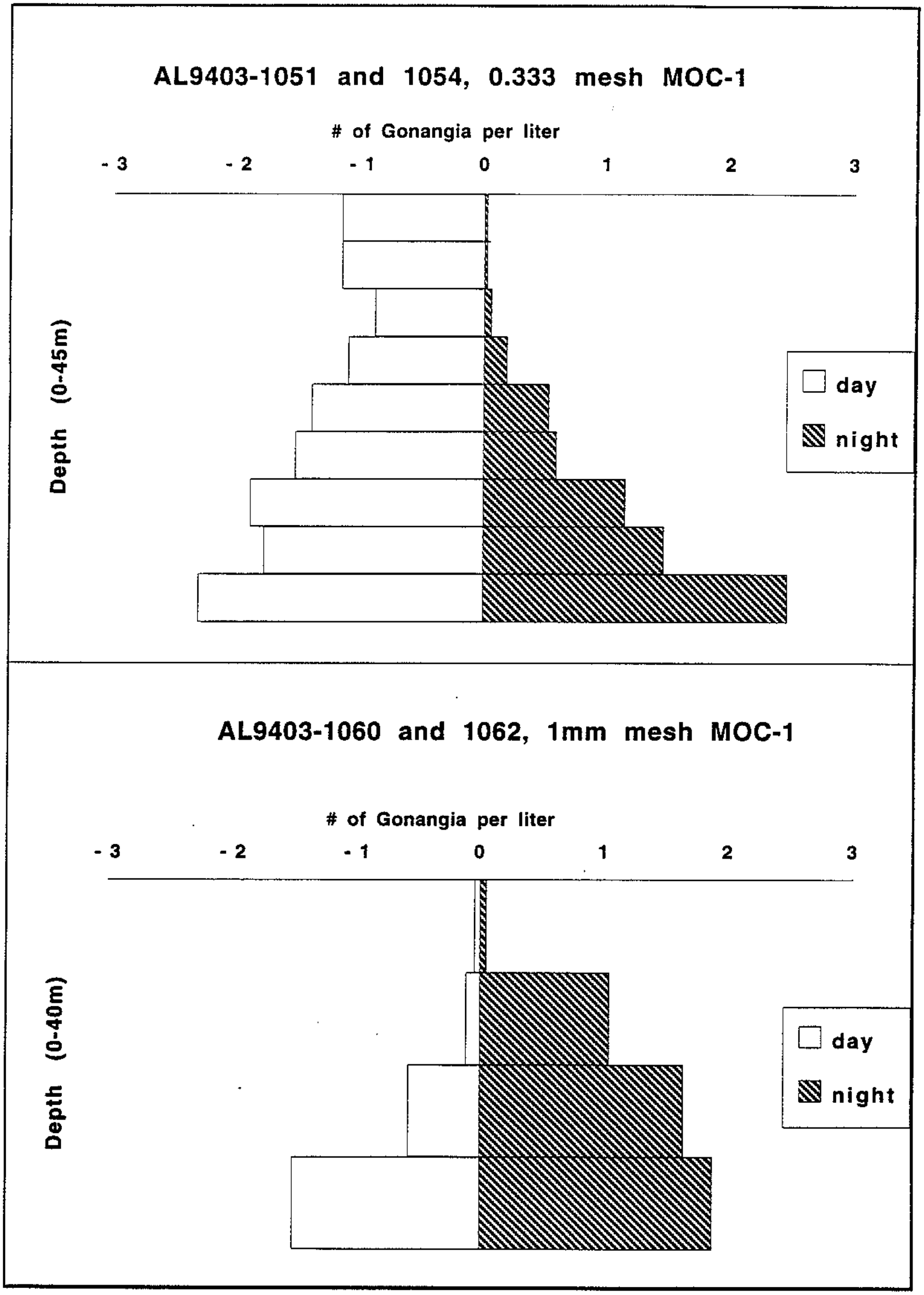


Figure 12. Total number of hydroid gonangia per liter over depth during day/night collected with 0.333mm and 1mm MOC - 1 nets.

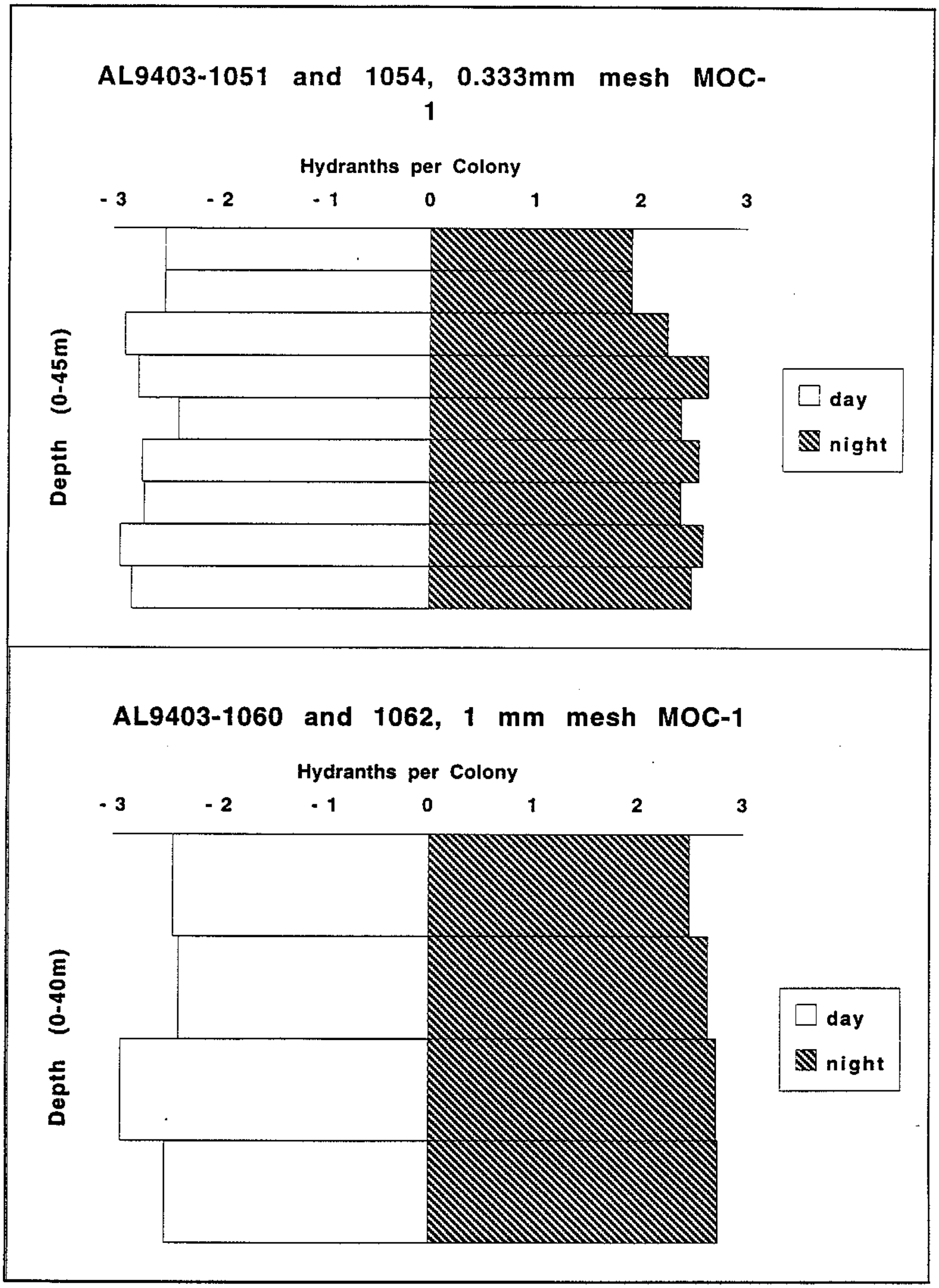


Figure 13. Average number of hydranths per colony over depth during day/night collected with 0.333mm and 1mm MOC - 1 nets.

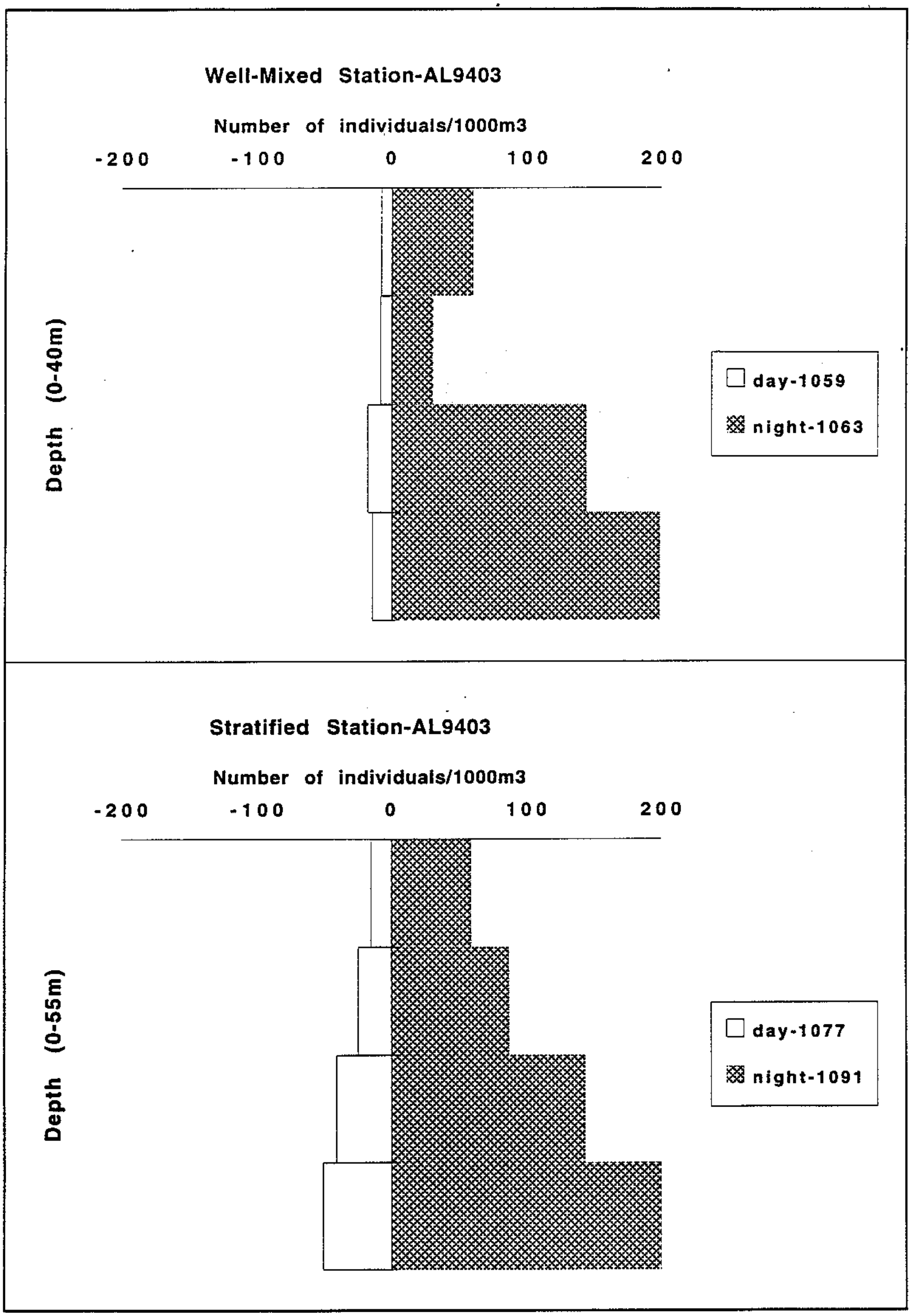


Figure 14. Total number of individual zooplankters per m3 at the mixed and stratified station, day and night MOC10 tows.

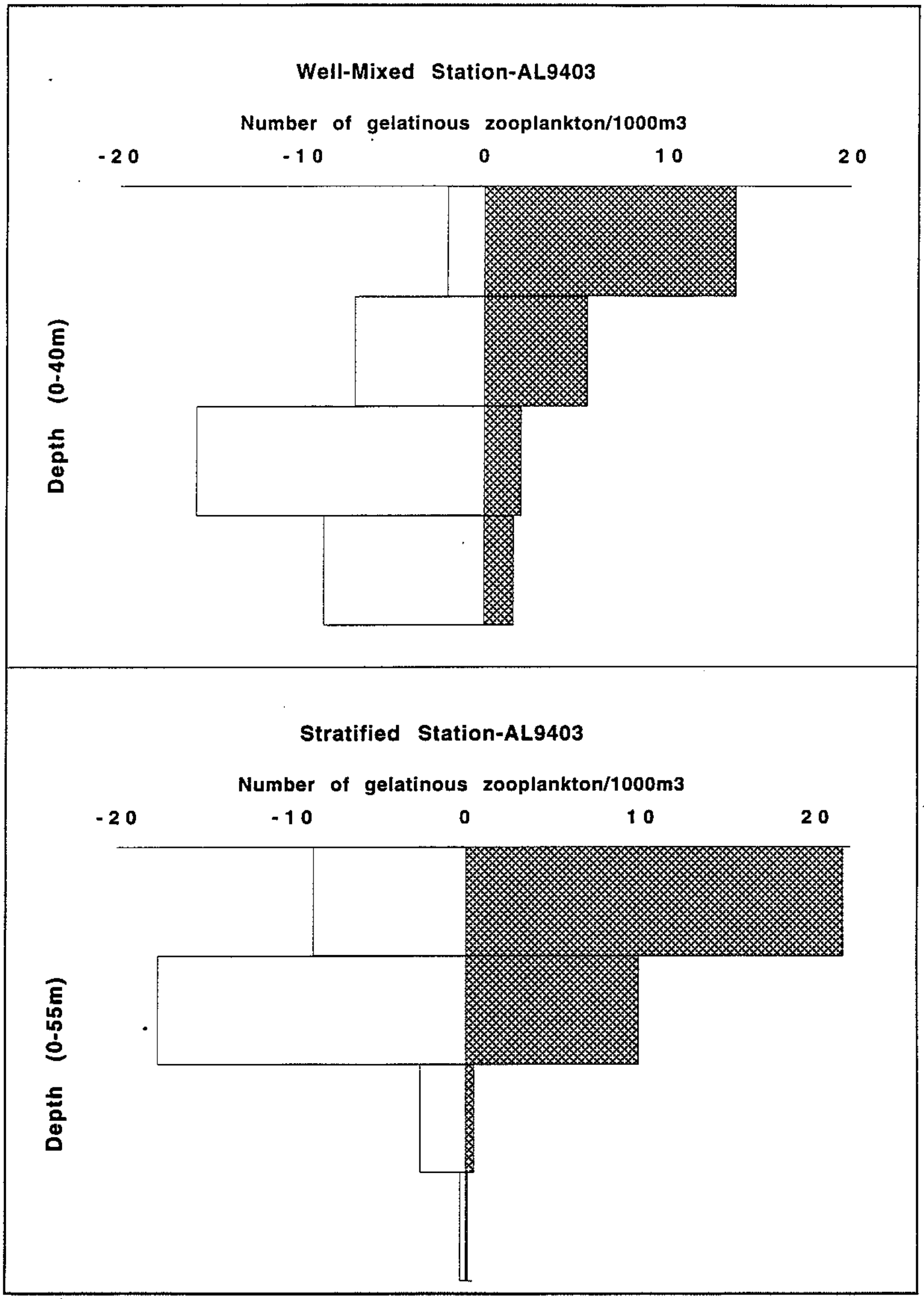


Figure 15. Total number of gelatinous zooplankters per m3 at the mixed and stratified station, day and night MOC10 tows.

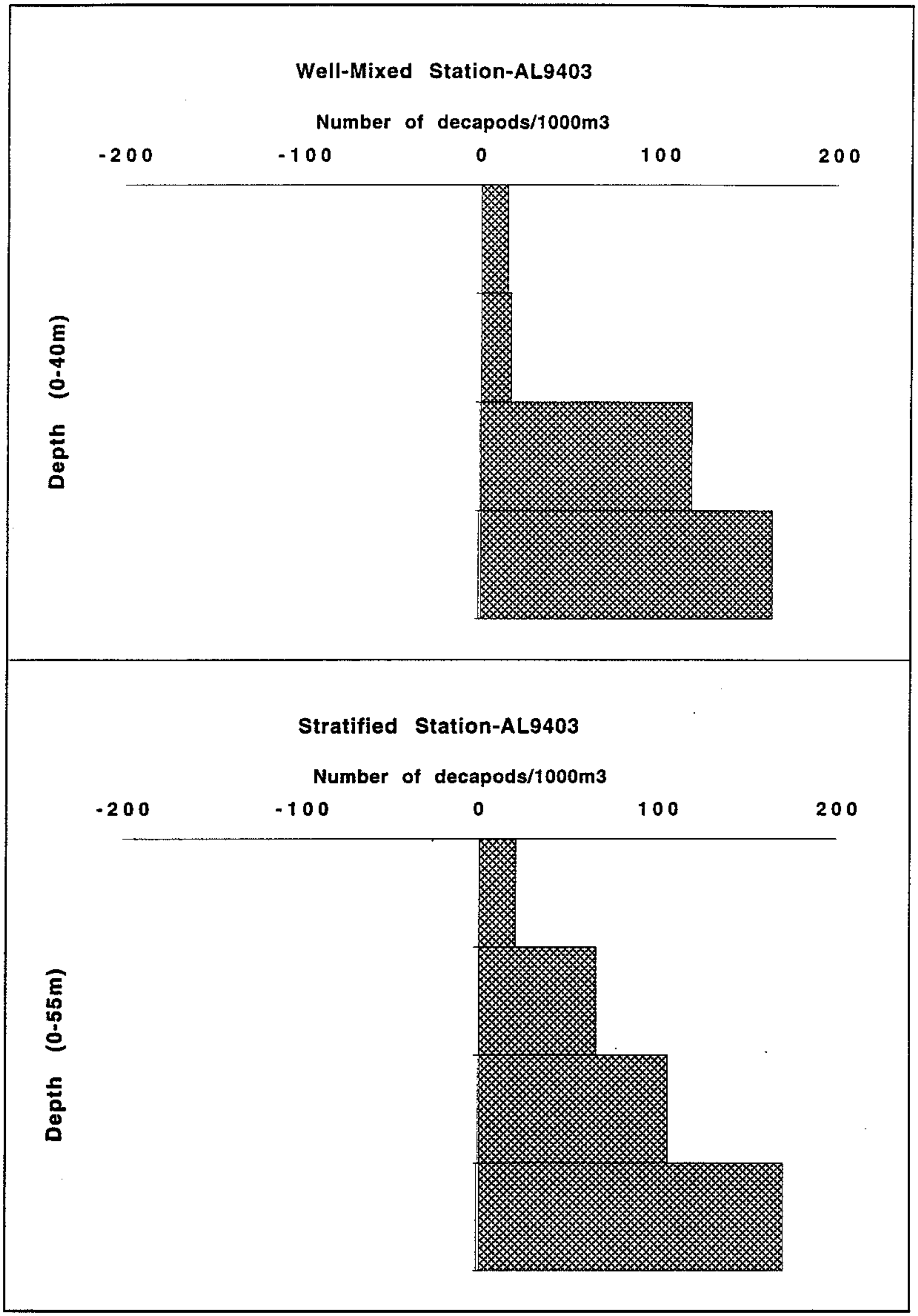


Figure 16. Total number of decapod larvae per m3 at the mixed and stratified station, day and night MOC10 tows.

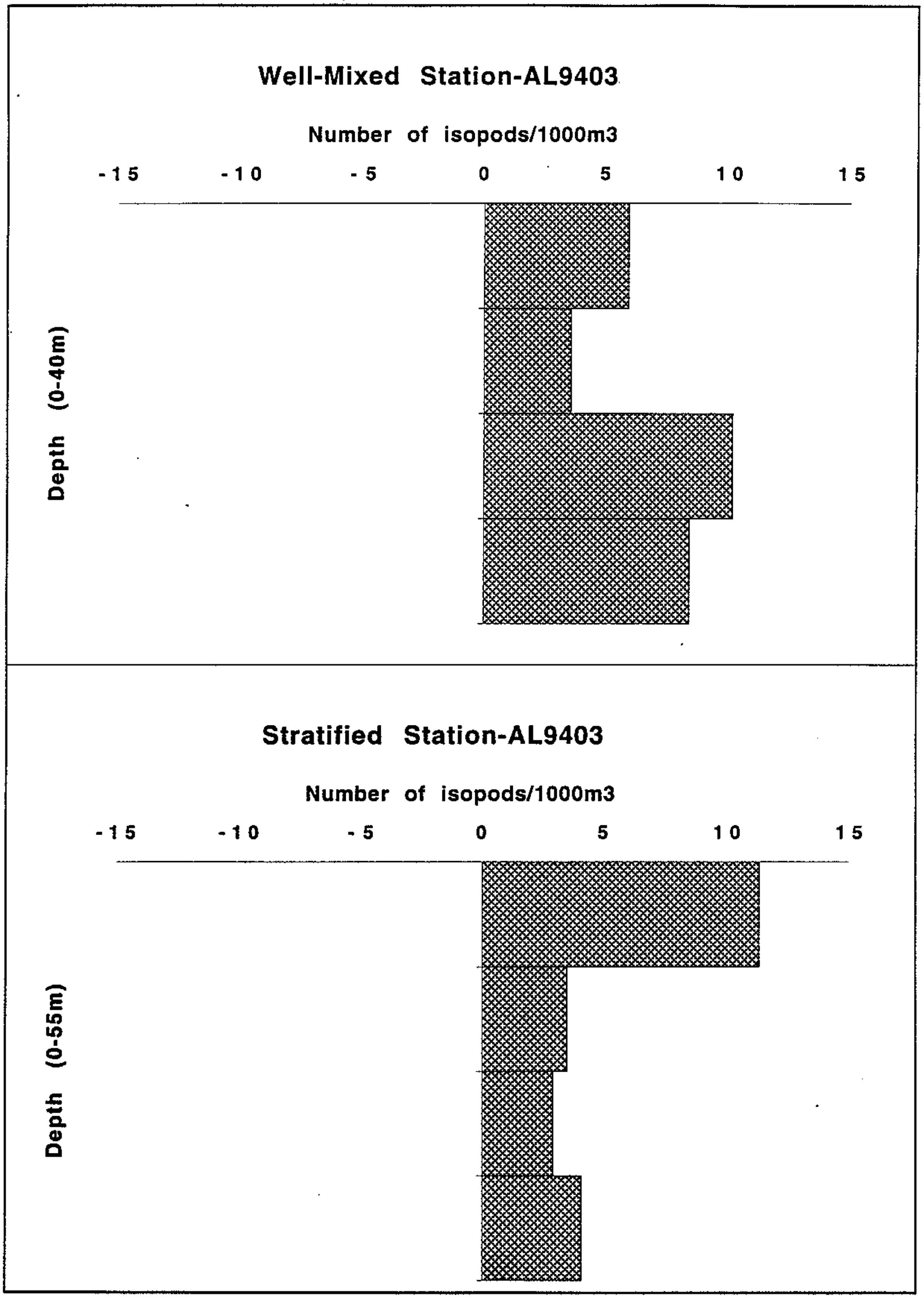


Figure 17. Total number of isopods per m3 at the mixed and stratified station, day and night MOC10 tows.

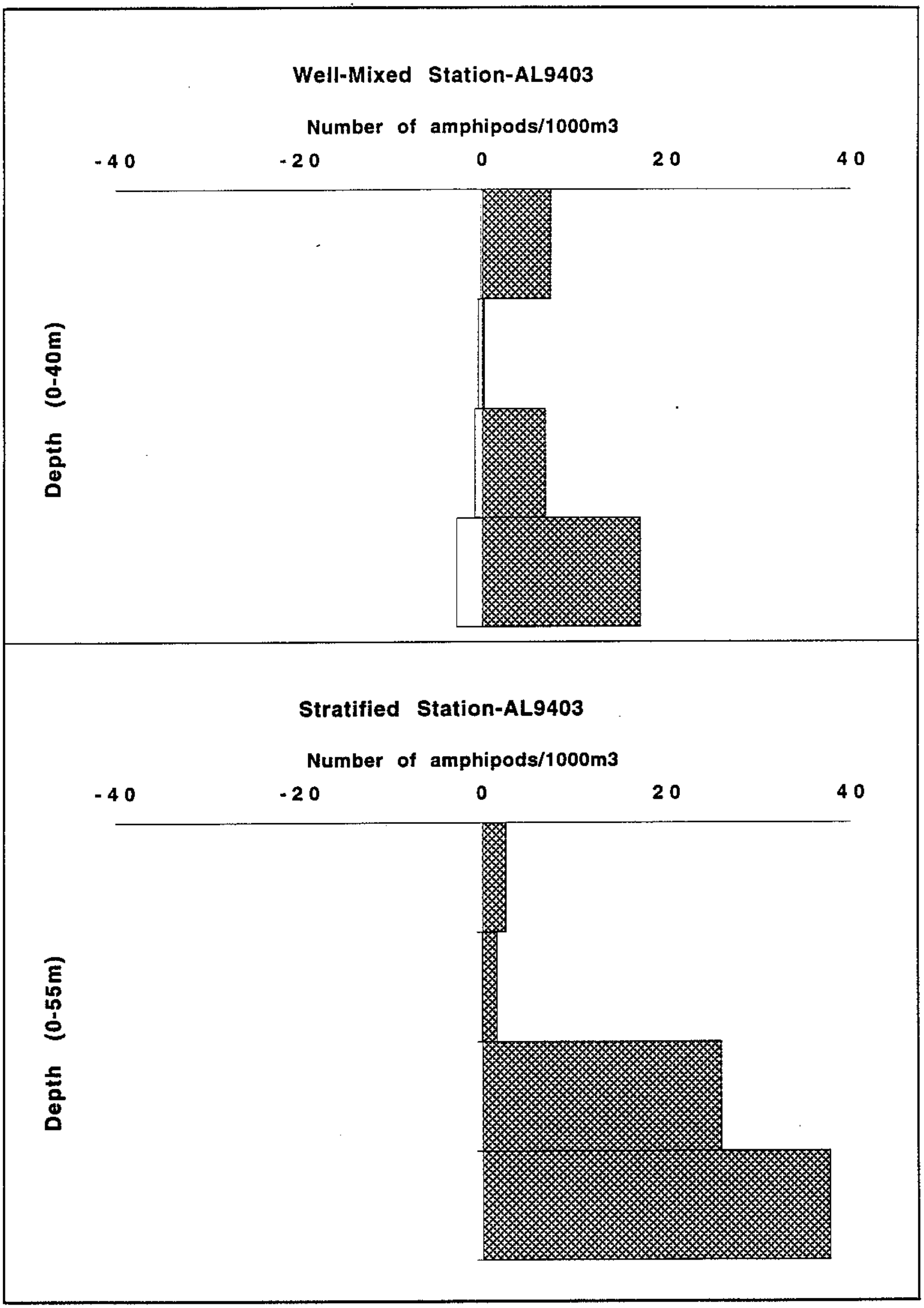


Figure 18. Total number of amphipods per m3 at the mixed and stratified station, day and night MOC10 tows.

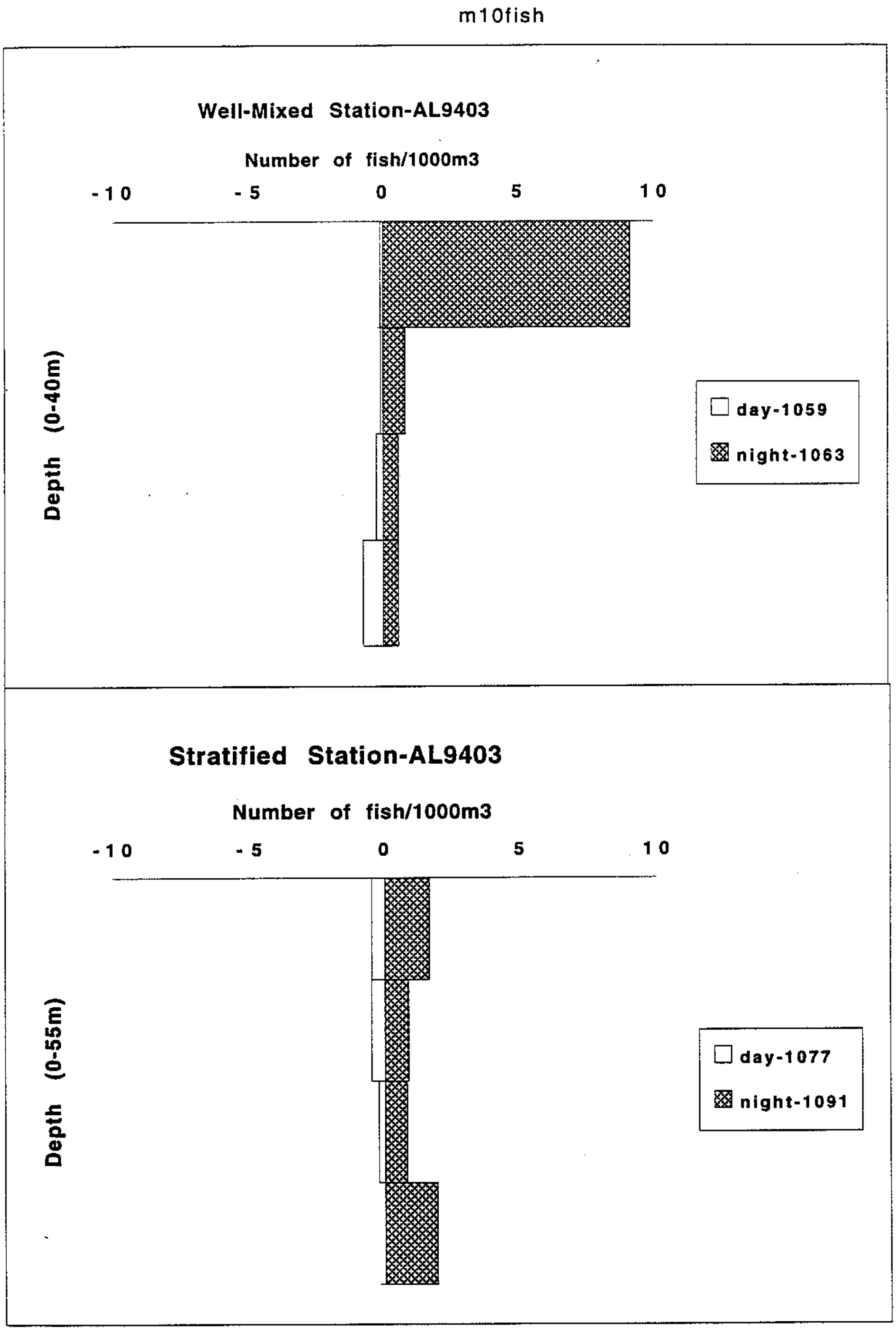
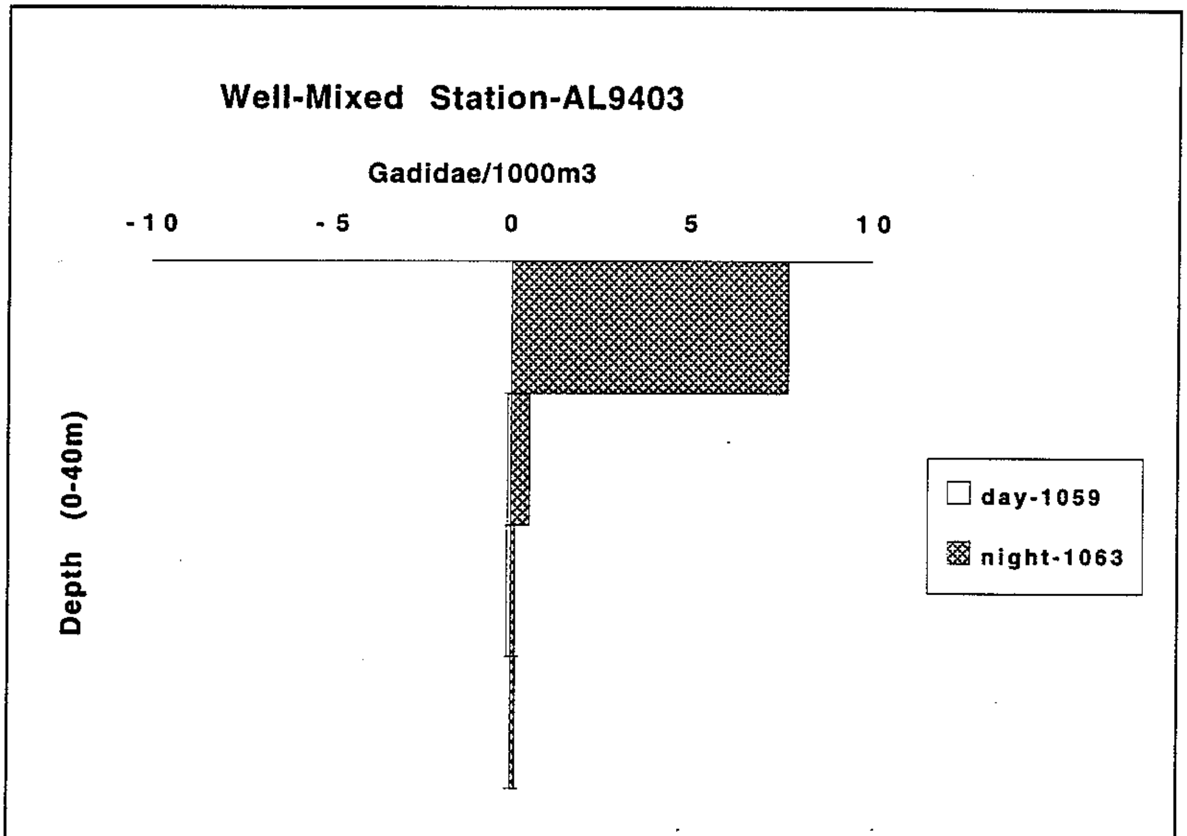


Figure 19. Total number of larval/juvenile fishes per m3 at the mixed and stratified station, day and night MOC10 tows.

moc10gad



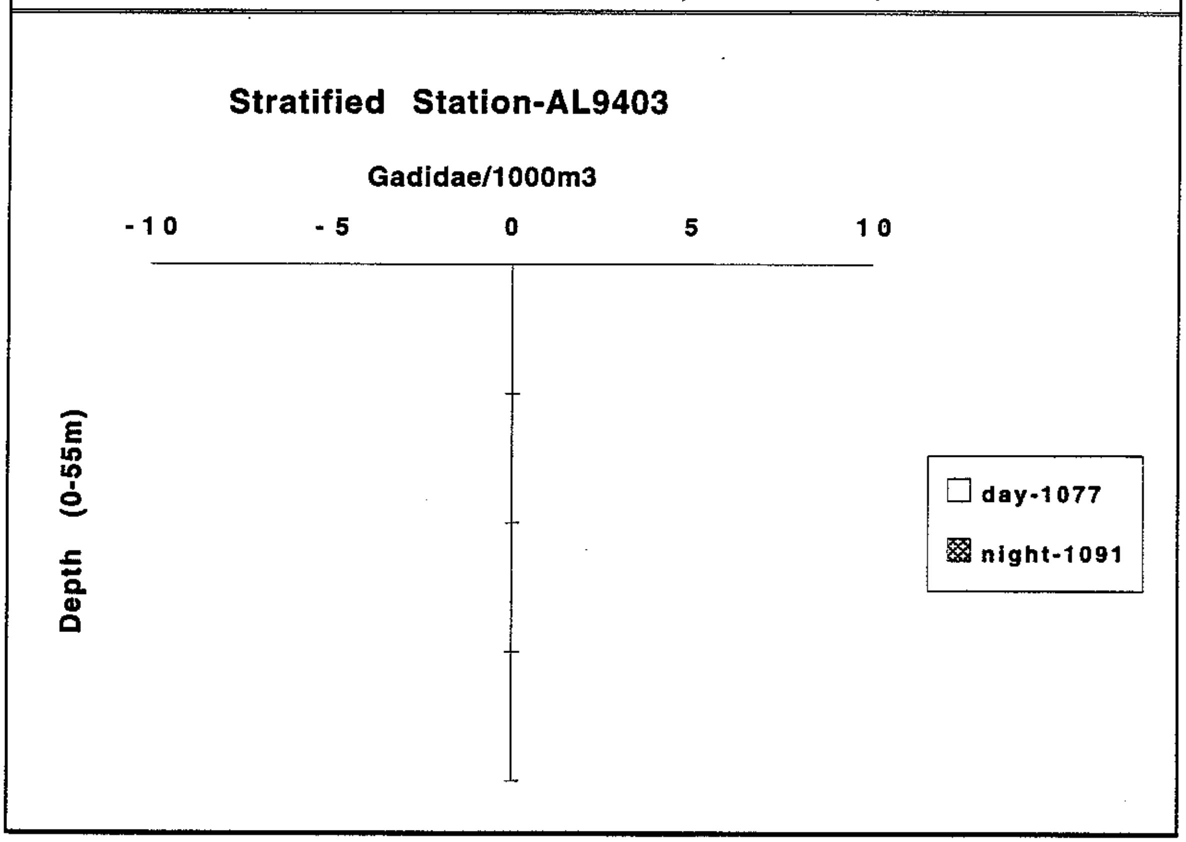


Figure 20. Total number of larval/juvenile Gadids per m3 at the mixed and stratified station, day and night MOC10 tows.

m10cod

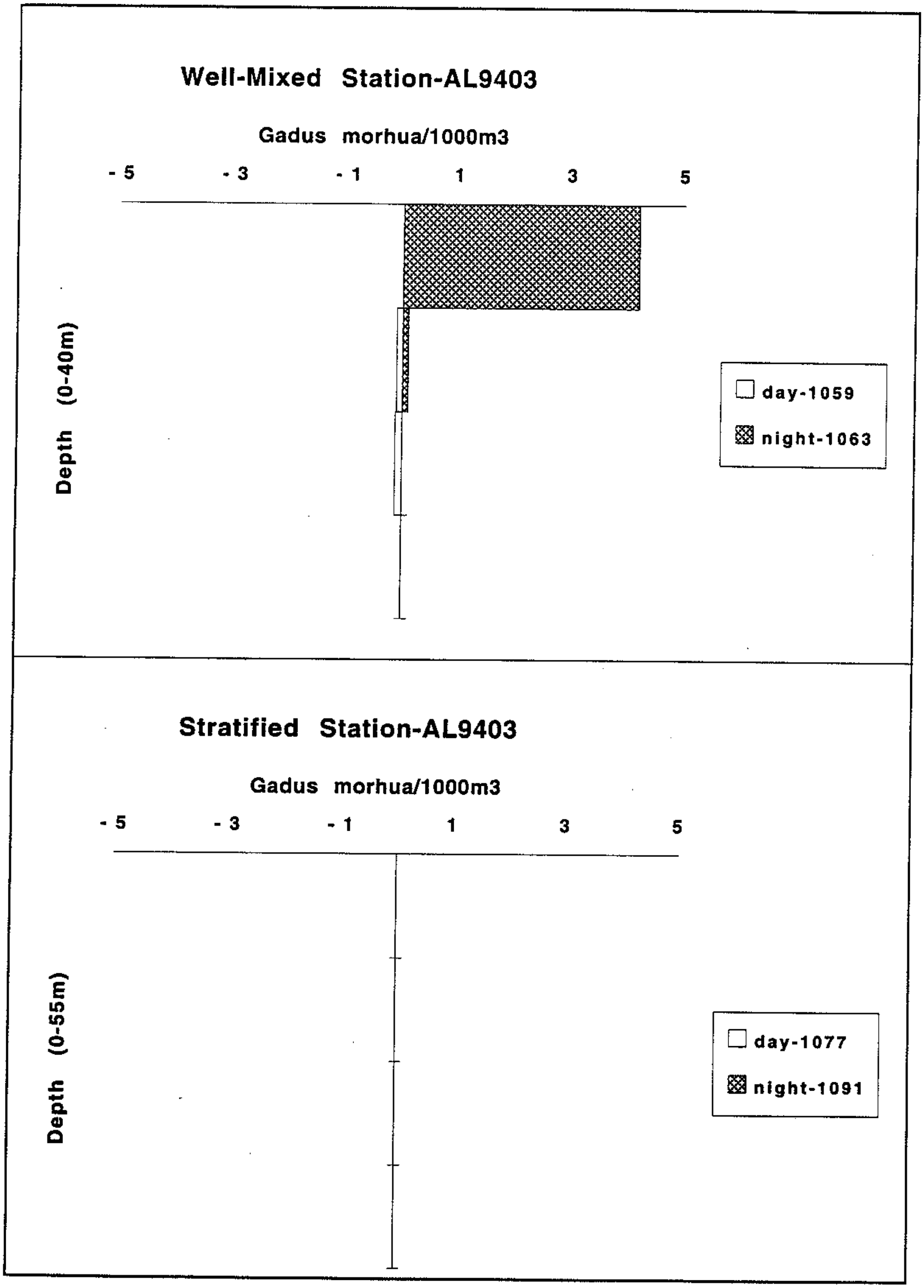


Figure 21. Total number of larval/juvenile COD per m3 at the mixed and stratified station, day and night MOC10 tows.

moc10had

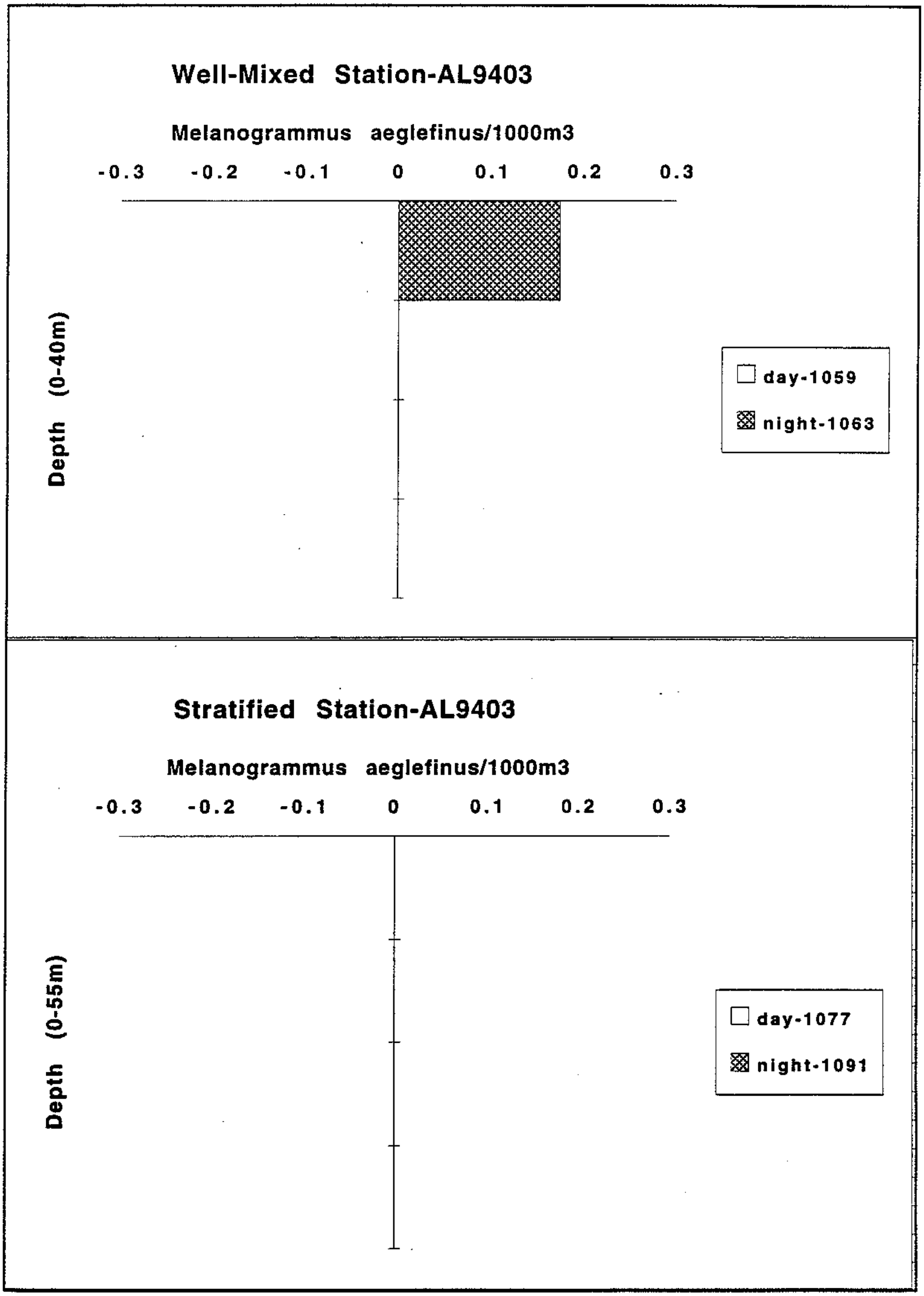


Figure 22. Total number of larval/juvenile HADDOCK per m3 at the mixed and stratified station, day and night MOC10 tows.

AL9403 bluewater dive stations

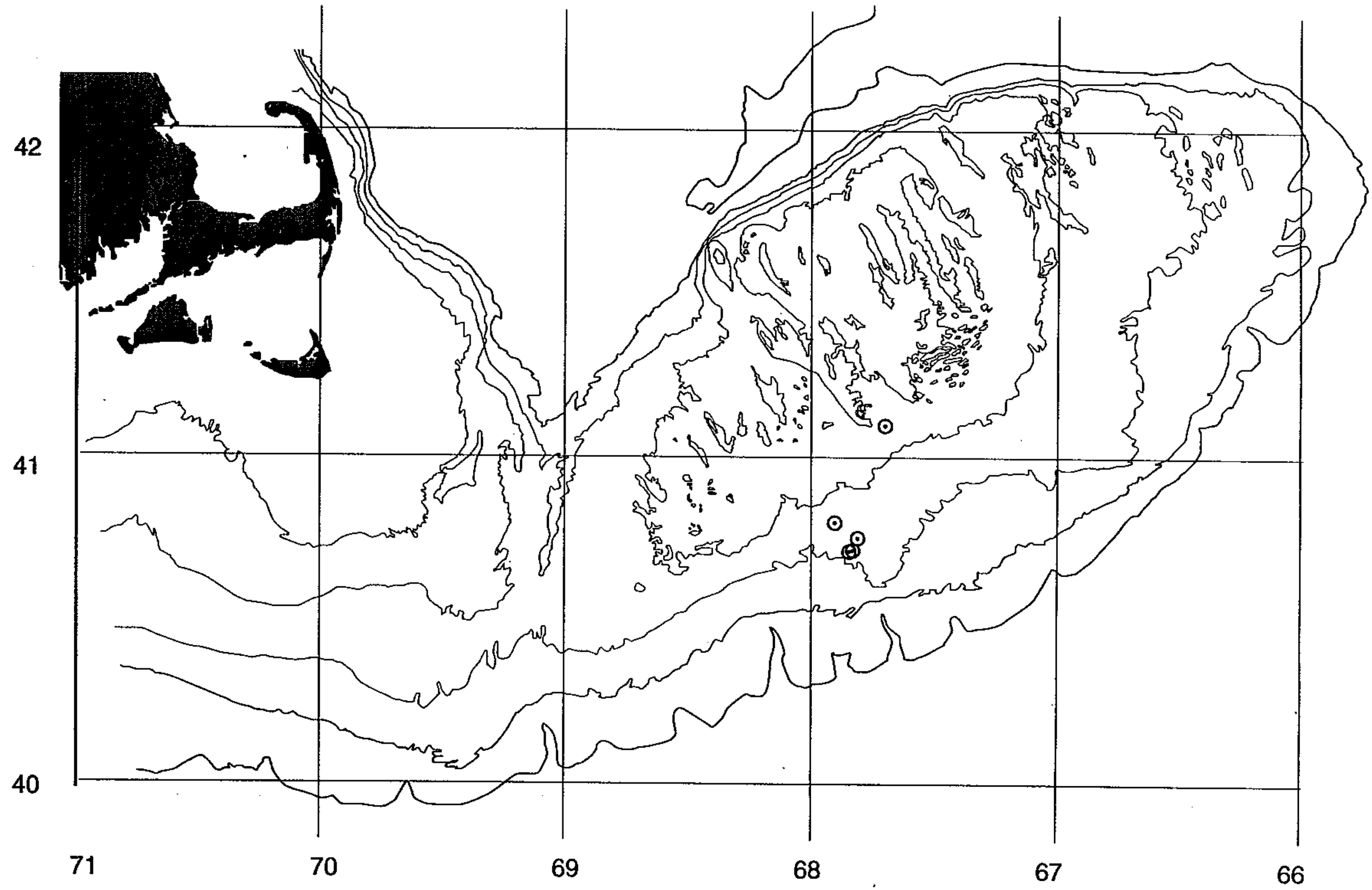


Figure 23. AL9403 bluewater dive stations.

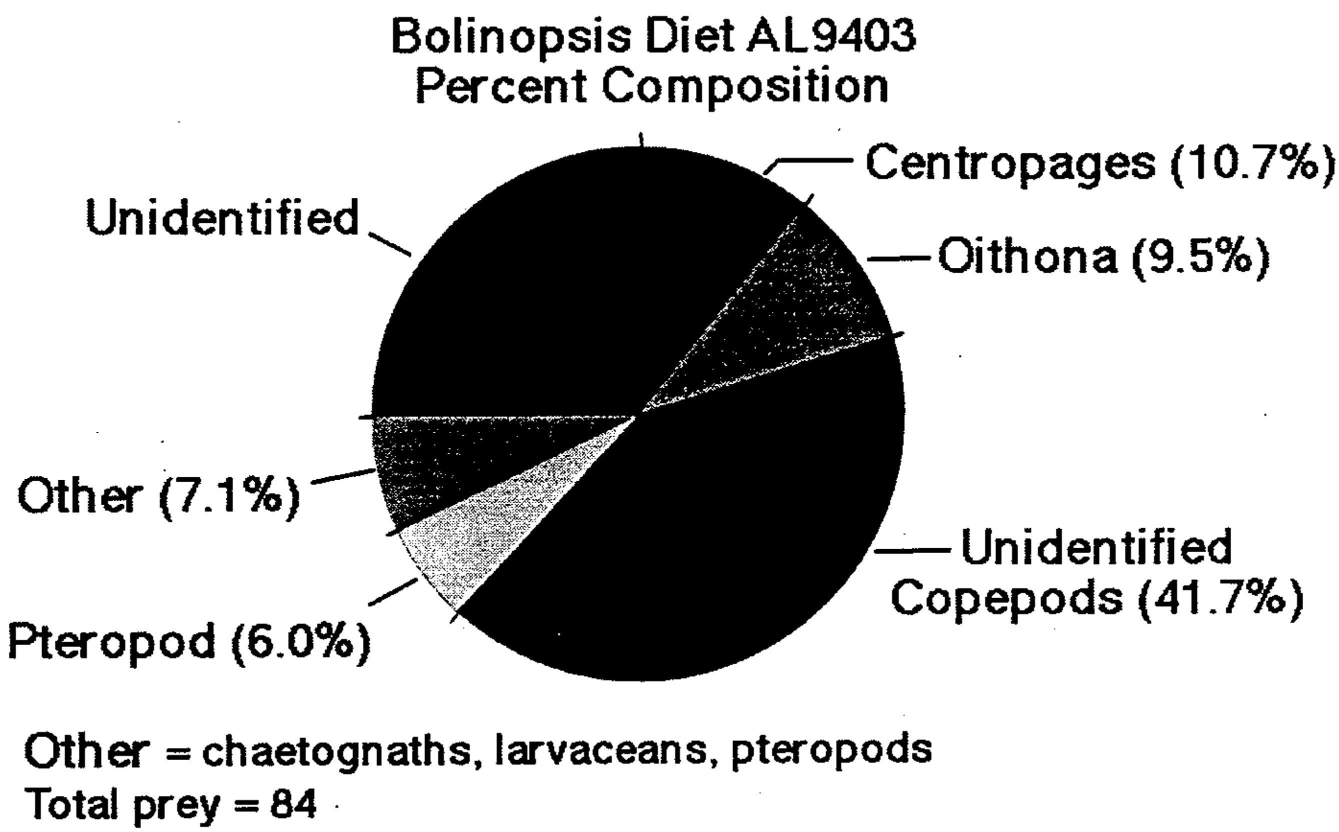


Figure 24. Gut content analysis for Bolinopsis collected by diving, AL9403.

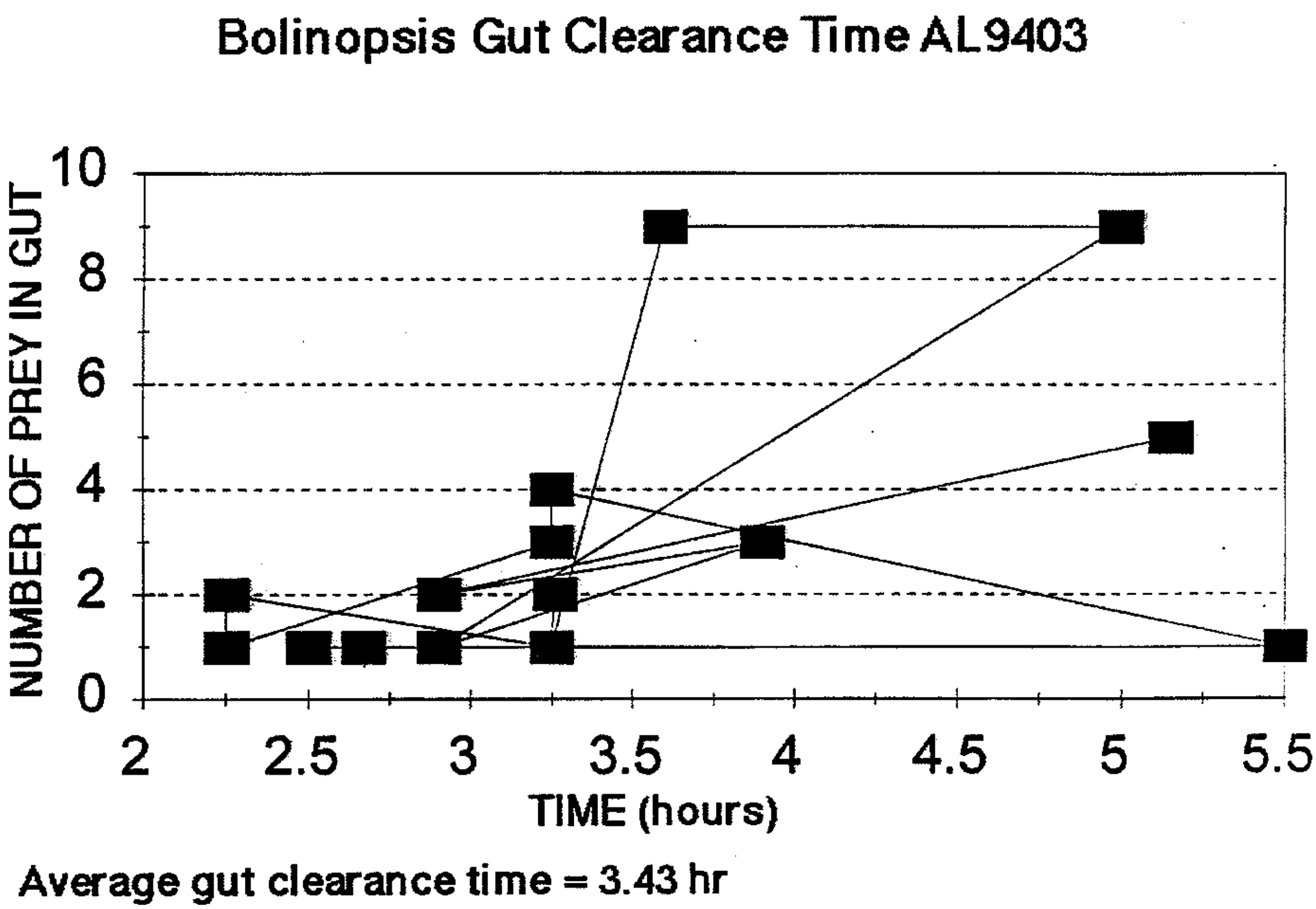


Figure 25. Gut clearance times for Bolinopsis collected by diving, AL9403.

Hydrography

The hydrographic sampling was done using a SEABIRD SBE19 Seacat CTD instrument on the initial bongo survey and with a MKV CTD unit with rosette sampler during the rest of the cruise (Figure 26). The MKV instrument includes a fluorometer. The primary objective of the hydrography was to document the vertical structure of the water column at the two primary sampling sites (well-mixed and stratified).

Water samples were taken with the rosette sampler (Figure 27) to provide calibration of the CTD salinity and for determining the amount of chlorophyll in the water to calibrate the fluorometer. The determination was done by filtering the water samples from three depths to collect the phytoplankton on filters, for later analysis of the chlorophyll content on shore. The filtering was done for total chlorophyll and for two size fractions, >20 um and < 20 um.

The data collected on the initial bongo survey (Figure 2) showed the surface temperature to be approximately 1 °c warmer than normal and the density stratification over the upper 30 m of the column to be about 0.3 - 0.5 sigma-t units greater than normal (with normal conditions determined by the NMFS MARMAP 10 year hydrographic data set).

The CTD data collected at the well-mixed site indicated the temperature and salinity were nearly uniform from top to bottom, although some subtle thermal stratification was evident in some casts. The fluorescence data showed considerably variability over the water column. At the first choice of the stratified site, sampling over a day period indicated an oscillation in temperature and salinity below 50 m depth. This change in deeper water properties was due to the site being sufficiently close to the shelf/slope front so that frontal water was advected to the site during the onbank tidal excursion. The frontal water was indicated by increasing temperature and salinity (figure 28). The site was originally selected because historic data suggested it would be stratified and sufficiently distant from the front not to be influence by the front. A review of satellite data for the cruise period indicates that the front appeared to be located over the southern edge of the Bank - north of its expected location - which would explain the frontal water observed at the first stratified site. Because of these hydrographic conditions, a second stratified site was chosen about 4 km north of the first.

Near the end of the cruise, a CTD tow-yo was conducted from the second stratified site to well-mixed water to the north, to measure the structure of the tidally mixed frontal region. While the vessel steamed at about 3 knots, the CTD was profiled up and down every six minutes. The tow-yo was timed such that the tidal ellipse would be at its off-bank extreme during the sampling. After reaching well-mixed water, a southward tow-yo was conducted and timed such that the tidal ellipse would be at its on-bank extreme. The results (figure 29 and 30) show the front steepening and moving northward with the on-bank tide. The fluorescence has a maximum in the pycnocline region on the southern (stratified) side of the front.

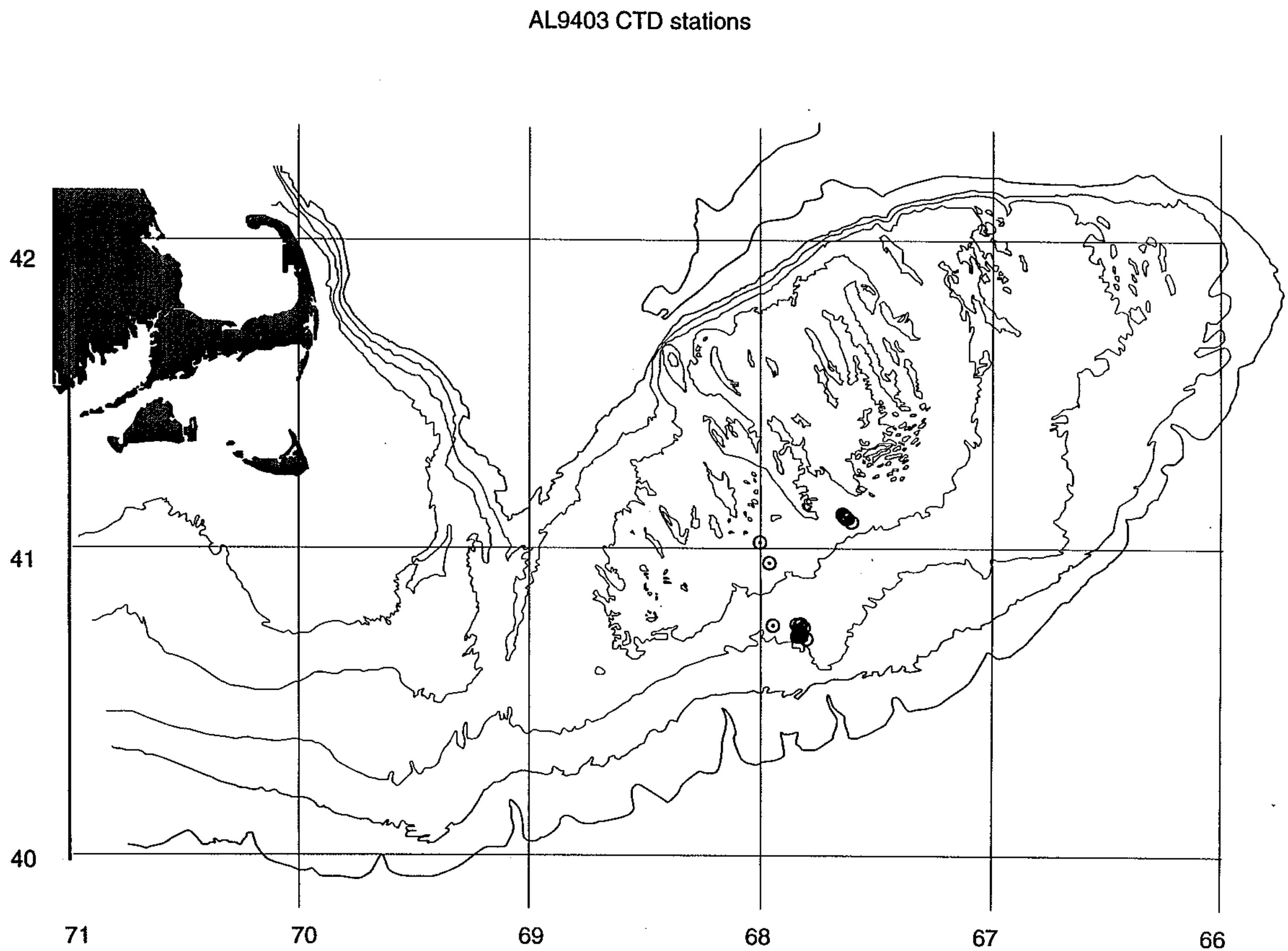


Figure 26. AL9403 CTD stations.

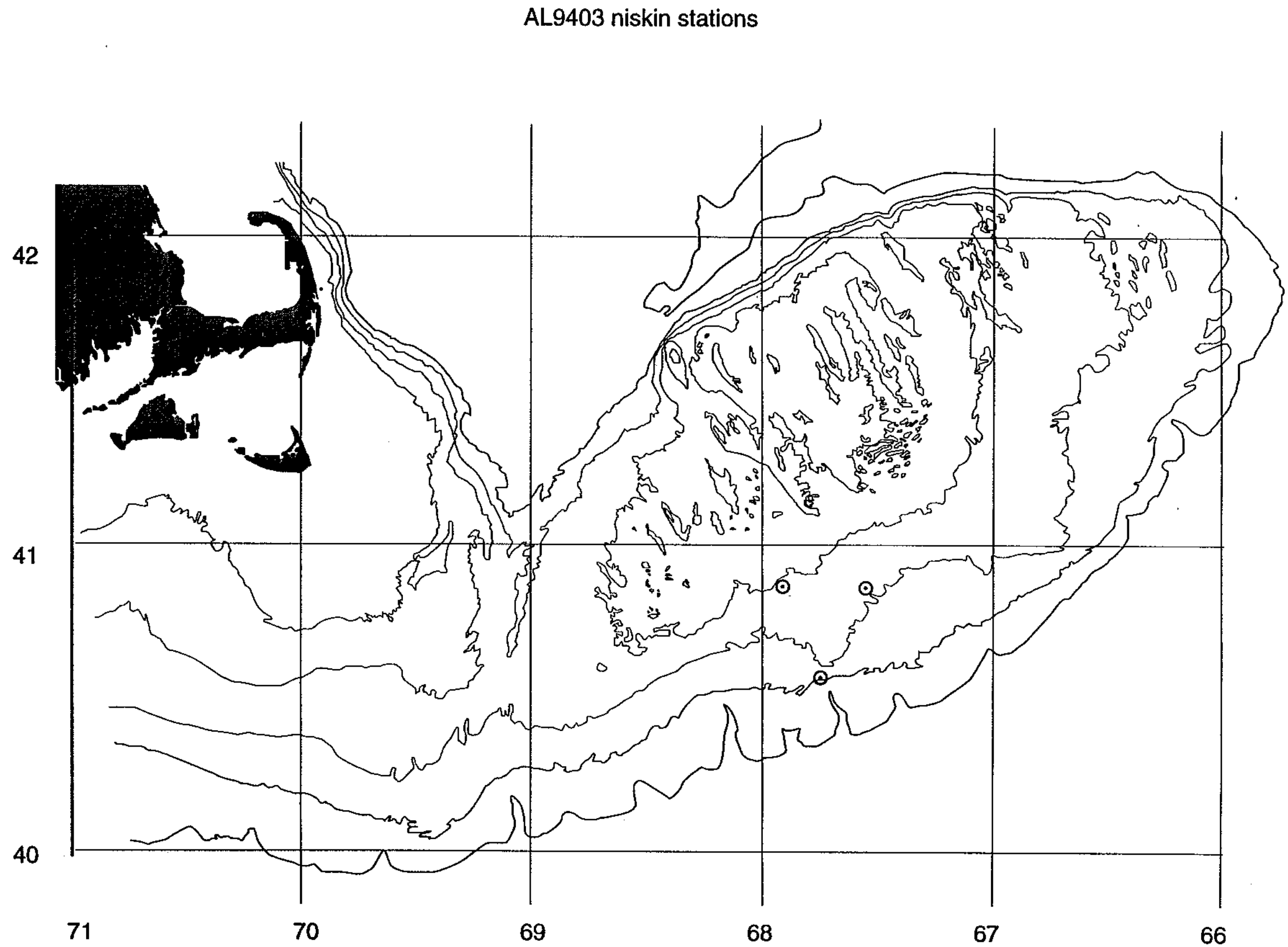


Figure 27. AL9403 Niskin bottle stations.

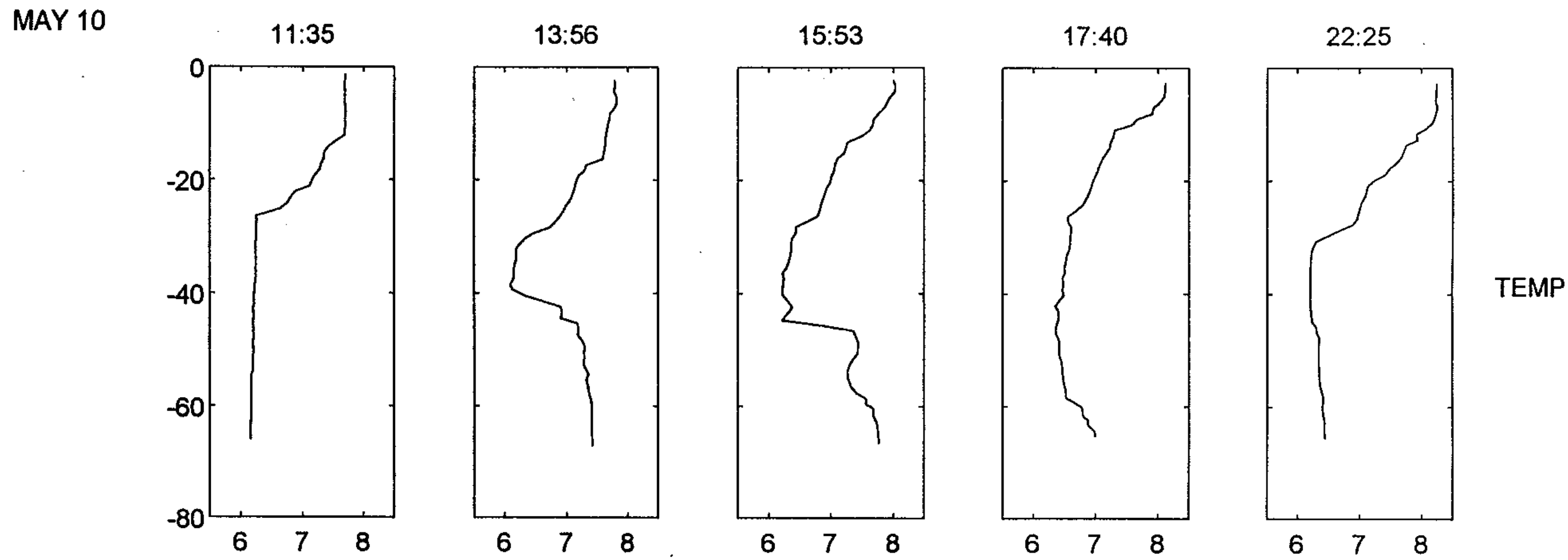
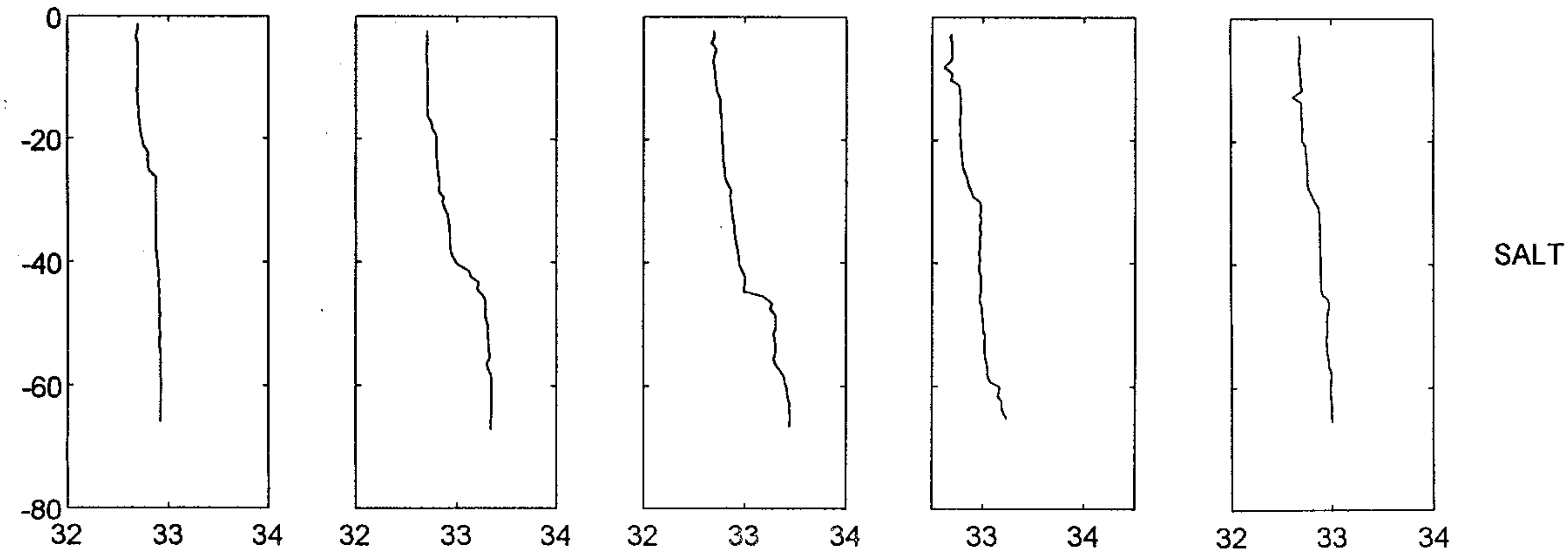


Figure 28. Series of temperature (top) and salinity (bottom) profiles over a tidal cycle at the well-mixed study site. The times of the profiles, indicated above each set of profiles, is in GMT on May 10, 1994.



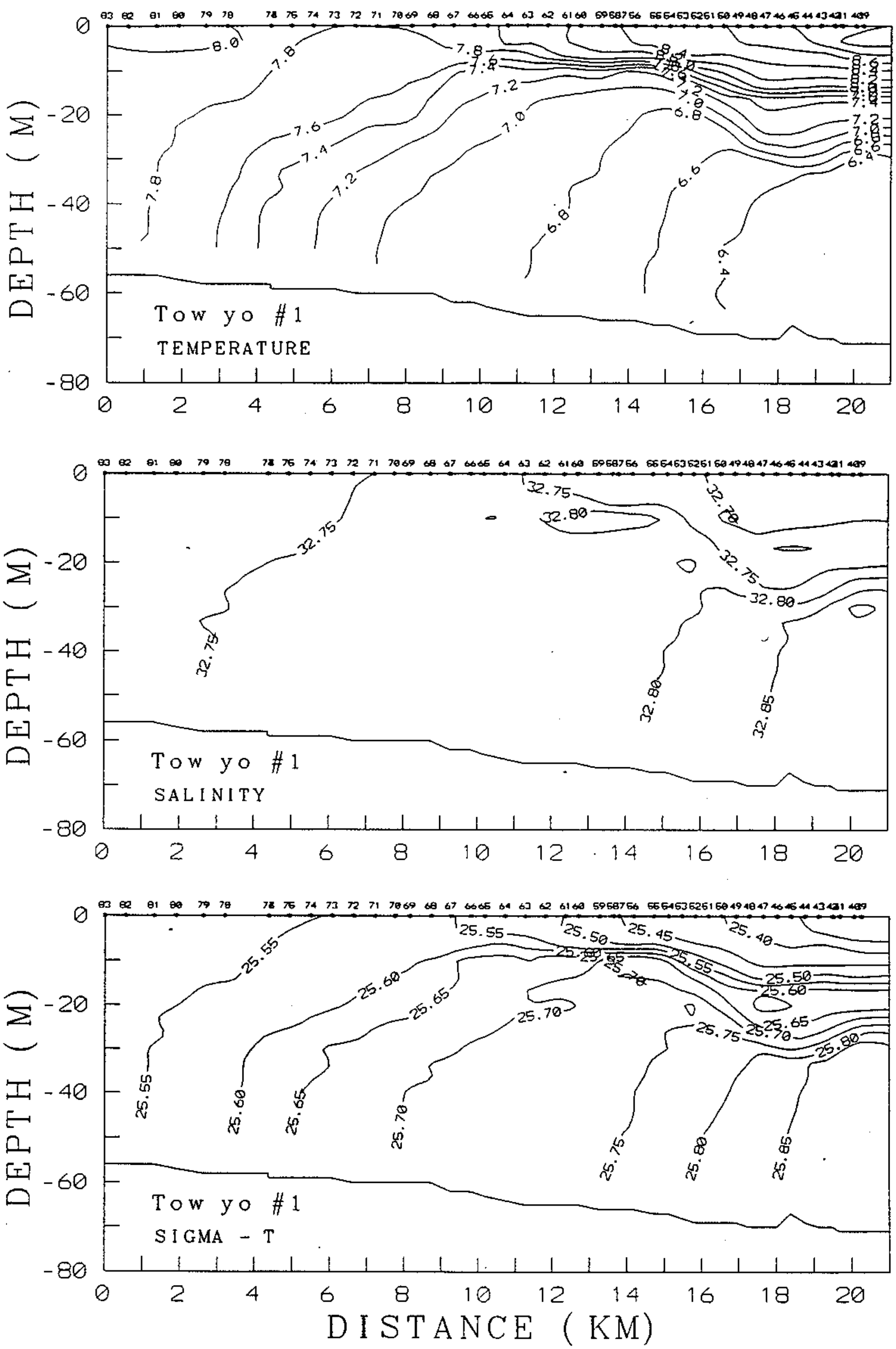


Figure 29. Temperature, salinity, density (sigma-t) and flourescence cross sections from first tow-yo, when the tidal ellipse was at its off-bank extreme.

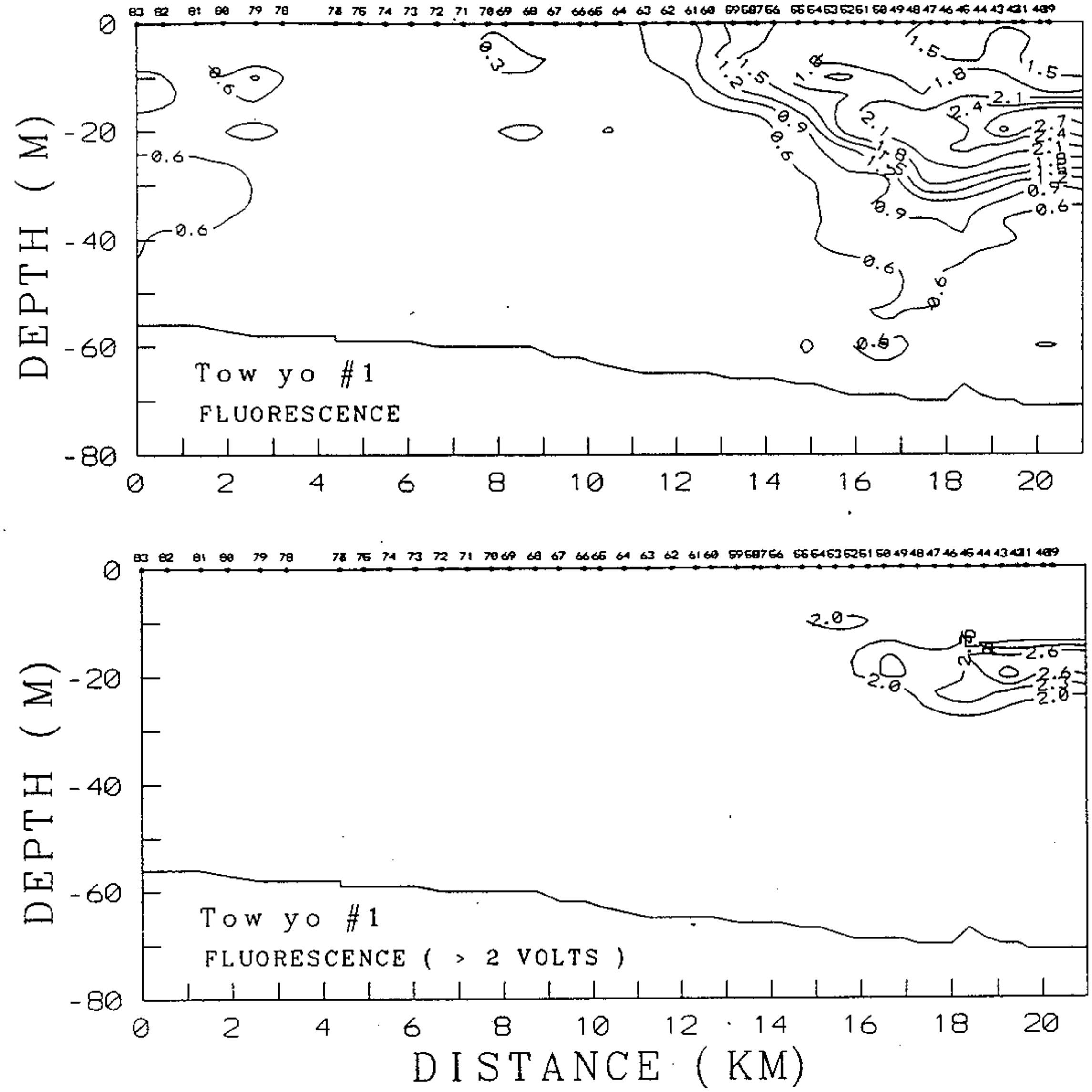


Figure 29 (continued). Temperature, salinity, density (sigma-t) and flourescence cross sections from first tow-yo, when the tidal ellipse was at its off-bank extreme.

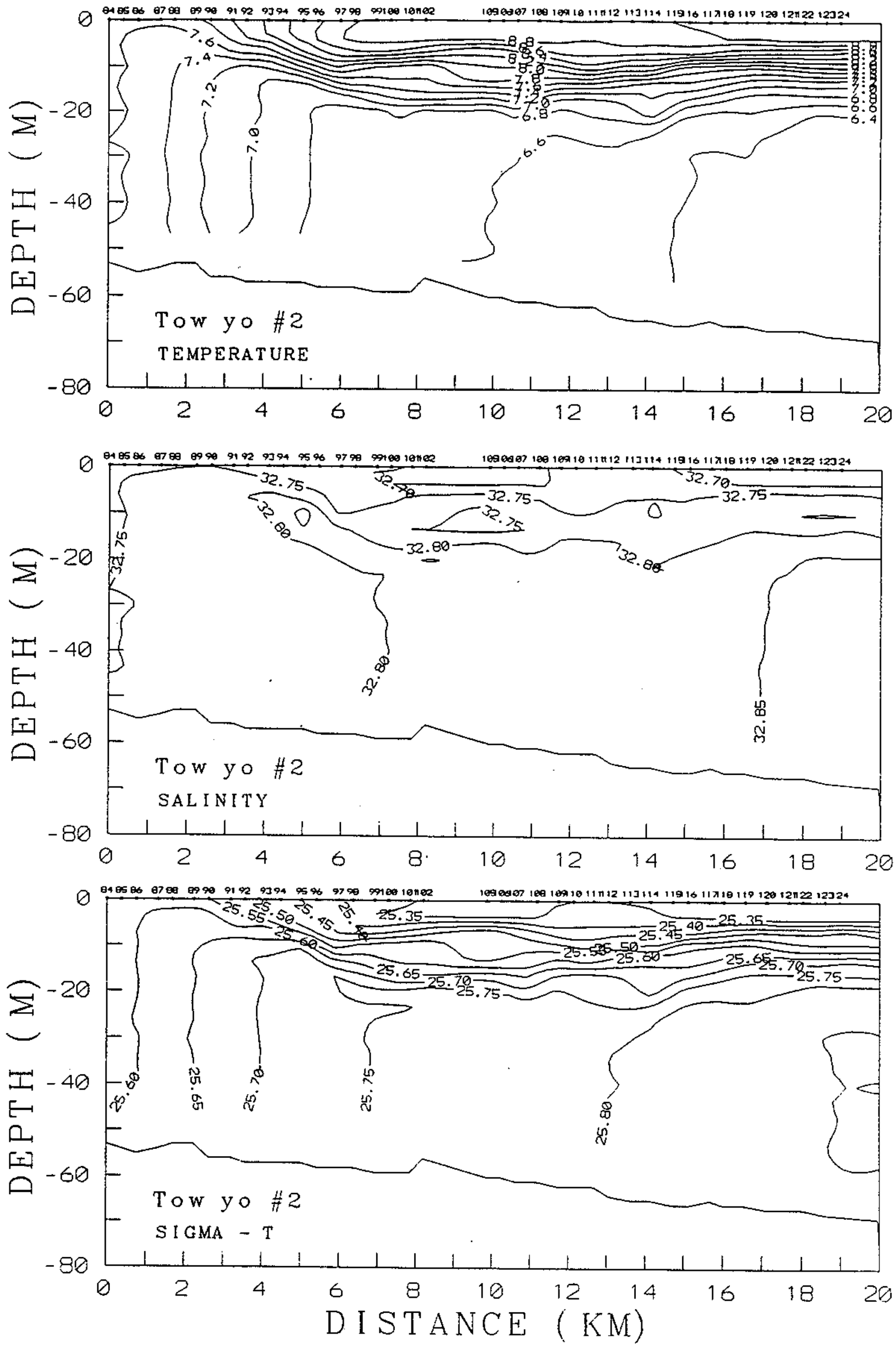


Figure 30. Temperature, salinity, density (sigma-t) and flourescence cross sections from second tow-yo, when the tidal ellipse was at its on-bank extreme.

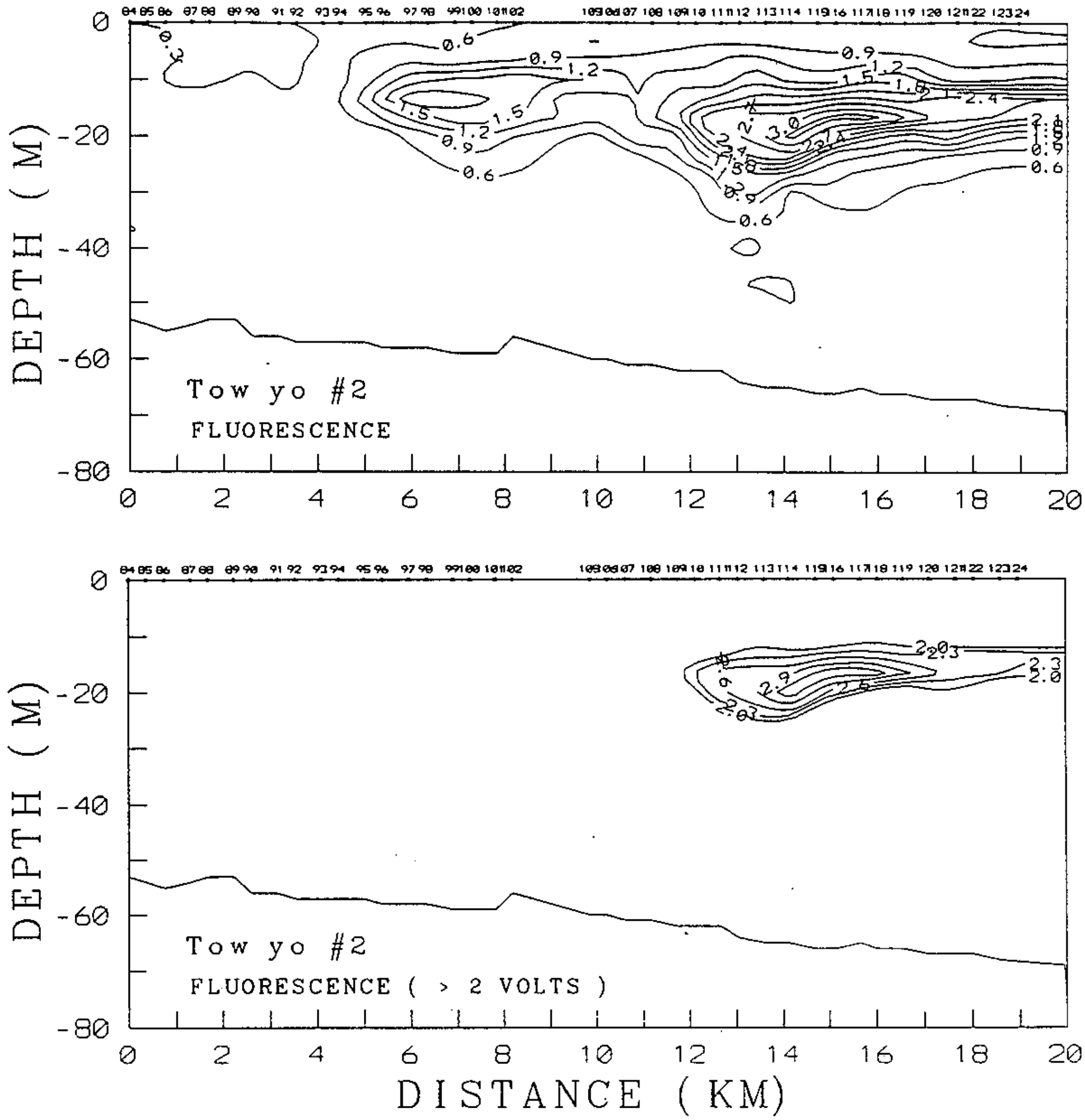


Figure 30 (continued). Temperature, salinity, density (sigma-t) and flourescence cross sections from second tow-yo, when the tidal ellipse was at its on-bank extreme.

Enzyme Analysis of Zooplankton and Ichthyoplankton

The objective of this project is to determine the condition of zooplankton on Georges Bank by determining their enzyme activities. On cruise AL9403 our specific objectives were to obtain samples for the determination of the temporal and spatial variability in the condition of zooplankton on the Bank and to test the feasibility of conducting enzyme analysis on board ship.

Samples were obtained from both Bongo net tows and 1 m2 MOCNESS tows. Samples were sorted from 25 tows. A total of 839 individuals were sorted and rinsed in a sucrose solution (Table 3). The tails of all larval fish and whole copepods collected were frozen in liquid nitrogen. The heads and guts of some larval fish were preserved in ethanol and given to NMFS. All individuals were recorded on video tape. Video recordings will be used to verify specific identifications and to subsequently determine sizes of all individuals. Standard lengths of all fish larvae will be provided to NMFS.

An adequate number of samples of cod and Calanus were obtained during MOCNESS hauls to enable an eventual analysis of condition from most depth strata at both the mixed and stratified stations. Haddock were only found in high numbers at the stratified station. Determinations of the enzyme activities of 350 individuals were performed on board ship. While the biochemical analysis proved to be no problem, it was soon apparent that one more individual would be needed in our group to allow for the analysis of the data on board ship. Our preliminary analysis indicated that interspecific differences were similar to those found in samples collected in 1993. However, the condition of Calanus throughout the Bank seemed lower than in 1993.

Table 3. Samples taken for enzyme analysis on AL9403.

Event	Station	Gear	Region	Cod	Haddock	Calanus	Pseudocalanus
AL12494.002	AL9403A.001	Bongo net	Bongo grid	10	0	0	0
AL12494.003	AL9403A.002	Bongo net	Bongo grid	6	0	0	0
AL12494.004	AL9403A.003	Bongo net	Bongo grid	12	1	0	0
AL12494.008	AL9403A.006	Bongo net	Bongo grid	10	8	0	0
AL12494.011	AL9403A.008	Bongo net	Bongo grid	11	11	0	0
AL12494.012	AL9403A.009	Bongo net	Bongo grid	15	0	0	0
AL12494.013	AL9403A.010	Bongo net	Bongo grid	17	0	0	0
AL12494.014	AL9403A.011	Bongo net	Bongo grid	13	15	0	0
AL12494.016	AL9403A.016	1 m. MOCNESS	Bongo grid	11	3	0	0
AL12694.001	AL9403A.012	Bongo net	Bongo grid	15	0	0	0

Event	Station	Gear	Region	Cod	Haddock	Calanus	Pseudocalanus
AL12694.002	AL9403A.013	Bongo net	Bongo grid	15	0	0	0
AL12694.004	AL9403A.013	1 m. MOCNESS	Mixed	70	0	0	0
AL12794.003	AL9403A.013	1 m. MOCNESS	Mixed	84	0	0	0
AL12794.007	AL9403A.013	1 m. MOCNESS	Mixed	0	0	25	13
AL12894.010	AL9403A.013	1 m. MOCNESS	Mixed	0	0	1	45
AL12894.013	AL9403A.014	Bongo net	Bongo grid	0	0	0	10
AL12994.001	AL9403A.016	Bongo net	Bongo grid	6	0	0	0
AL12994.002	AL9403A.017	Bongo net	Bongo grid	6	6	0	0
AL12994.003	AL9403A.018	Bongo net	Bongo grid	11	11	0	0
AL12994.007	AL9403A.018	1 m. MOCNESS	Stratified	0	0	19	0
AL13094.002	AL9403A.018	1 m. MOCNESS	Stratified	0	0	49	12
AL13094.011	AL9403A.018	1 m. MOCNESS	Stratified	31	37	0	0
AL13194.012	AL9403A.022	1 m. MOCNESS	Stratified	21	55	6	0
AL13194.018	AL9403A.022	1 m. MOCNESS	Stratified	1	11	95	0
AL13294.001	AL9403A.025	1 m. MOCNESS	Mixed	0	0	37	2

Table 3. Samples taken for enzyme analysis on AL9403.

Immunological Studies

Shipboard immunological studies were conducted by L. Madin, S. Bollens, E. Horgan, and M. Butler, in association with Hydros. Inc. This work was supported by the US GLOBEC program and the NOAA Coastal Ocean Program. The need for accurate identification of species in the field now looks to molecular methodologies to identify species-specific proteins, or epitopes. Currently, antibodies developed for animals found in the plankton of Georges Bank are cross-reactive. Also, methods for preservation which do not denature the delicate structure of epitopes need illumination. Several experimental objectives were carried out during the cruise:

- to determine and compare the best modes of preservation
- to establish background cross-reactivity for immuno reagents

Preservation

Calanus, Pseudocalanus, cod, haddock, flatfish, amphipods, isopods, shrimp, and euphausids were sorted from bongo net tows and preserved in each of the 5 preservatives taken along. These vials were grouped according to preservation media and labeled for analysis at Hydros. In addition to these sorted samples, we elected to preserve an unsorted sample using each of the 5 media.

Cross-reactivity

Three antibodies were taken to sea, none of which are optimized for specific epitopes. Our job was to test the same organisms, which we had preserved for qualitative differences, in response to these antibodies. We used only 2 of the 5 preservation media for our tests, along with "live" organisms. Samples were refrigerated and returned to Hydros for laboratory analysis.

We devised a convenient method for labeling descriptors. The first character describes the preservation technique: L=live, F=formalin, and G=glycerol-azide. The second character describes the antiserum(a) used for the prep: A=antiserum A, B=antiserum B, and C=antisera C&D. The third character, if present, denotes whether or not the specimens were kept whole (W), or were ground (G) for analysis. Table 4 shows which preps were done for each of the three cross-reactivity tests:

Table 4.

	Calanus	Euphausid	shrimp	hyperid amphipod	Isopod (Cirolina)	flatfish
ANTISERUM A	FAW	LA	GA	FA	FA	LA
	FAG	FA	FA	GAW	GA	GA
	GAW	GA	LA	LA	LA	FA
	GAG	LAG	LA			
	LAW	GAG	FA			
	LAG	FAG	GA			
ANTISERUM B						
	FBG	FBG	LB	FB	FB	FB
	FBW	LB	FB	GBW	GB	GB
	GBG	FB	GB	LB	LB	LB
	LBG	GB	LB			
	GBW	LBG	FB			
	LBW	GBG	GB			
ANTISERA C&D						
	GCG	GC	GC	GCW	GC	GC
	FCG	FC	FC	FC	FC	FC
	LCG	LC	LC	LC	LC	LC
	LCW	LCG				
	FCW	FCG				
	GCW	GCG				

Table 4. Samples taken for immunological studies on AL9403.

Personnel List
Cruise AL9403
May 03 - 13, 1994

Name	Title	Organization
Scientific Personnel:		
1. Laurence Madin	Chief Scientist	WHOI, Woods Hole, MA
2. Stephen Bollens	Scientist	WHOI, Woods Hole
3. Erich Horgan	Technician	WHOI, Woods Hole
4. Terry Rioux	Diving Safety Officer	WHOI, Woods Hole
5. Dan Almgren	Volunteer	
6. Mari Butler	Technician	WHOI, Woods Hole
7. Barbara Sullivan	Scientist	URI/GSO, Narragansett
8. Grace Klein-MacPhee	Scientist	UIR/GSO, Narragansett
9. David Mountain	Scientist	NMFS/NEFSC, Woods Hole
10. Maureen Taylor	Hydrogr. Tech.	NMFS/NEFSC, Woods Hole
11. Betsy Broughton	Technician	NMFS/NEFSC, Woods Hole
12. Liz Clarke	Scientist	RSMAS, Miami
13. John Paupe	Technician	RSMAS, Miami
14. Nir Hus	Student	RSMAS, Miami
NOAA Officers and Crew:		
15. Cdr Gary Bulmer	Commanding Officer	
16. Lt Cdr Peter Celone	Executive Officer	
17. Lt James Meigs	Operations Officer	
18. Ens Christopher Koch	Navigation Officer	
19. Kevin Cruse	Chief Mechanical Engineer	
20. John Hurder	1st Asst. Eng.	
22. Aurthur Butterworth	3rd Asst. Eng.	
23. John Enright	Engineer	
24. Manuel Botelho	Chief Bosun	
25. Kenneth Rondeau	Lead Fisherman	
26. John Cravo	Skilled Fisherman	
27. Francisco Ferriera	Skilled Fisherman	
28. Antonio Alvarez	Skilled Fisherman	
29. William Amaro	Skilled Fisherman	
30. Brian Cardoza	Fisherman	
31. Harold Bowen	Ordinary Fisherman	
32. John Braxton	Chief Steward	
33. Jerome Nelson	2nd Cook	
34. Don Byrd	Rotating Electronics Technician	
35. Bruce Stone	Rotating Electronics Technician	

Appendix 1.

Event Log
R.V. Albatross Cruise 9403

Appendix 1.

AL9403 Event Log

LOG # XX	EVENT# vvdddyy.eee	STATION# vvccccl.sss	Instrument iiiiii	Tow/ Cast #	Loctime HHMMSS: hhmmss	Locdate YYMMDD: yymmdd	Latitude DDMM.FFF: ddmm.fff	Longitude DDMM.FFF: ddmm.fff	WatDep DDDD: dddd	InsDep dddd: DDDD	GMTdate YYMMDD: yymmdd	GMTtime HHMMSS: hhmmss	PI "NNNN"	Region "RRR PPP"
1	AL12494.001	AL9403A.001	ctdmk5	1	0202	940504	4103.99	6757.71	45	40				Bongo grid
2	AL12494.002	AL9403A.001	bongsb	1	0224	940504	4103.77	6757.28	42	39				Bongo grid
3	AL12494.003	AL9403A.002	bongsb	2	0408	940504	4059.36	6754.56	54	51				Bongo grid
4	AL12494.004	AL9403A.003	nisksb	3	0458	940504	4054.39	6752.09	60	54				Bongo grid
5	AL12494.005	AL9403A.003	bongsb	4	0539	940504	4054.41	6752.38	60	57				Bongo grid
6	AL12494.006	AL9403A.004	bongsb	5	0628	940504	4050.00	6749.50	66	63				Bongo grid
7	AL12494.007	AL9403A.005	bongsb	6	0734	940504	4054.40	6749.10	69	66				Bongo grid
8	AL12494.008	AL9403A.006	bongsb	7	0831	940504	4040.70	6744.50	74	72				Bongo grid
9	AL12494.009	AL9403A.007	nisksb	8	0924	940504	4036.10	6742.10	87	50				Bongo grid
10	AL12494.010	AL9403.007	bongsb	9	0934	940504	4035.10	6742.20	88	85				Bongo grid
11	AL12494.011	AL9403.008	bongsb	10	1207	940504	4048.56	6740.85	71	69				Bongo grid
12	AL12494.012	AL9403.009	bongsb	11	1325	940504	4057.24	6746.79	58	56				Bongo grid
13	AL12494.013	AL9403.010	bongsb	12	1440	940504	4103.56	6735.78						Bongo grid
14	AL12494.014	AL9403.011	bongsb	13	1551	940504	4054.10	6730.12						Bongo grid
15	AL12494.015	AL9403A.011	nisksb	14	1615	940504	4054.10	6730.12						Bongo grid
16	AL12494.016	AL9403A.011	moc1xx	1050	2200	940504	4053.83	6736.51	0069	0065				Bongo grid
17	AL12694.001	AL9403A.012	bongsb	15	0415	940506	4106.82	6751.55	52	49				Bongo grid
18	AL12694.002	AL9403A.013	bongsb	16	0627	940506	4109.10	6735.30	52	49				mixed 1
19	AL12694.003	AL9403A.013	ctdmk5	4		940506	4108.90	6734.80	59	54				mixed 1
20	AL12694.004	AL9403A.013	moc1xx	1051	0854	940506	4109.55	6735.41	0050	0045				mixed 1
21	AL12694.005	AL9403A.013	moc10x	1052	1322	940506	4108.98	6735.15	52	45				mixed 1
22	AL12694.006	AL9403A.013	moc10x	1053	1456	940506	4109.33	6735.15	52	45				mixed 1
23	AL12694.007	AL9403A.013	moc1xx	1054	1733	940506	4108.77	6735.25	52	45				mixed 1
24	AL12694.008	AL9403A.013	moc10x	1055	2200	940506	4109.59	6733.37	52	45				mixed 1
25	AL12794.001	AL9403A.013	ctdmk5	5	0024	940507	4108.80	6734.90	52					mixed 1
26	AL12794.002	AL9403A.013	moc1xx	1056	0057	940507	4108.04	6734.23						mixed 1
27	AL12794.003	AL9403A.013	ctdmk5	6	0257	940507	4109.00	6735.00	58	53				mixed 1
28	AL12794.004	AL9403A.013	moc10x	1057	0348	940507	4108.39	6734.71						mixed 1
29	AL12794.005	AL9403A.013	moc10x	1058	0516	940507	4108.71	6734.92		40				mixed 1
30	AL12794.006	AL9403A.013	moc10x	1059	1109	940507	4109.22	6733.88		40				mixed 1
31	AL12794.007	AL9403A.013	ctdmk5	7	1324	940507	4108.83	6734.52						mixed 1
32	AL12794.008	AL9403A.013	moc1xx	1060	1403	940507	4108.57	6734.83						mixed 1
33	AL12794.009	AL9403A.013	bwdive	AL1	1615	940507	4108.80	6739.10	54	28				mixed 1
34	AL12794.010	AL9403A.013	ctdmk5	8		940507	4109.69	6735.94						mixed 1
35	AL12794.011	AL9403A.013	moc10x	1061	1908	940507	4109.69	6735.94						mixed 1
36	AL12794.012	AL9403A.013	moc1xx	1062	2130	940507	4108.98	6735.24						mixed 1
37	AL12794.013	AL9403A.013	moc10x	1063	2320	940507	4108.58	6735.73						mixed 1
38	AL12794.008	AL9403A.013	ctdmk5	9	2112	940507	4109.10	6735.30						mixed 1

Appendix 1.

AL9403 Event Log

39	AL12894.001	AL9403A.013	moc10x	1064	0226	940508	4108.31	6734.59						mixed 1
40	AL12894.002	AL9403A.013	ctdmk5	10-16	0123	940508	4109.10	6734.90						mixed 1
40.5	AL12894.003	AL9403A.013	ctdmk5	17	0507	940508	4109.10	6735.10						mixed 1
41	AL12894.004	AL9403A.013	moc10x	1065	0532	940508	4109.23	6735.65						mixed 1
42	AL12894.005	AL9403A.013	ctdmk5	18	0800	940508	4109.40	6735.60						mixed 1
43	AL12894.006	AL9403A.013	moc10x	1066	0825	940508	4109.81	6735.49						mixed 1
44	AL12894.007	AL9403A.013	moc1/4	1067	1040	940508	4109.02	6733.96						mixed 1
45	AL12894.008	AL9403A.013	ctdmk5	19	1110	940508	4108.10	6733.50						mixed 1
46	AL12894.009	AL9403A.013	ctdmk5	20	1158	940508	1409.10	6735.10						mixed 1
47	AL12894.010	AL9403A.013	moc1xx	1068	1339	940508	4109.07	6735.08						mixed 1
48	AL12894.011	AL9403A.013	moc10x	1069	1506	940508	4110.21	6735.77						mixed 1
49	AL12894.012	AL9403A.014	bongsb	17	1730	940508	4109.20	6736.80	54	51				Bongo grid
50	AL12894.013	AL9403A.015	bongox		2100	940508	4104.00	6738.80	65					Bongo grid
51	AL12994.001	AL9403A.016	bongsb	18	0112	940509	4050.80	6735.30	75	71				Bongo grid
52	AL12994.002	AL9403A.017	bongsb	19	0344	940509	4047.90	6740.20	69					Bongo grid
53	AL12994.003	AL9403A.018	bongsb	20	0424	940509	4045.40	6740.00	71	64				Bongo grid
54	AL12994.004	AL9403A.019	bongsb	21	1200	940509	4054.40	6749.10						Bongo grid
56	AL12994.006	AL9403A.020	ctdmk5	21	1333	940509	4045.10	6746.70	75	70				Bongo grid
57	AL12994.007	AL9403A.018	moc1	1070	1355	940509	4045.31	6746.76	74	60				stratified 1
58	AL12994.008	AL9403A.018	bwdive	AL2	1700	940509	4045.00	6748.00	70	27				stratified 1
59	AL12994.009	AL9403A.018	ctdmk5	22	1934	940509	4045.50	6746.90	72	67				stratified 1
60	AL12994.010	AL9403A.018	moc10x	1071	2022	940509	4046.18	6747.58	68	55				stratified 1
62	AL12994.011	AL9403A.018	ctdmk5	23	2215	940509	4044.50	6745.40	68	64				stratified 1
63	AL12994.012	AL9403A.018	moc1xx	1072	2306	940509	4045.06	6746.08	72	60				stratified 1
64	AL13094.001	AL9403A.018	ctdmk5	24	52	940510	4045.30	6746.80	75	70				stratified 1
65	AL13094.002	AL9403A.018	moc1xx	1073	140	940510	4045.06	6746.08	72	60				stratified 1
66	AL13094.003	AL9403A.018	moc10x	1074	228	940510	4045.03	6748.45	72	60				stratified 1
67	AL13094.004	AL9403A.018	ctdmk5	25	500	940510	4045.40	6747.00	75	70				stratified 1
68	AL13094.005	AL9403A.018	moc10x	1075	534	940510	4046.15	6746.71	74	60				stratified 1
69	AL13094.006	AL9403A.018	ctdmk5	26	735	940510	4045.30	6747.00	75	70				stratified 1
70	AL13094.007	AL9403A.018	moc1xx	1076	803	940510	4045.38	6747.73	73	60				stratified 1
71	AL13094.008	AL9403A.018	ctdmk5	27	956	940510	4045.90	6746.80	75	70				stratified 1
72	AL13094.009	AL9403A.018	moc10x	1077	1008	940510	4045.93	6746.69	73	55				stratified 1
73	AL13094.010	AL9403A.018	ctdmk5	28	1153	940510	4045.50	6747.30	75	70				stratified 1
74	AL13094.011	AL9403A.018	moc1xx	1078	1241	940510	4045.31	6747.30	73	60				stratified 1
75	AL13094.012	AL9403A.018	ctdmk5	29	1349	940510	4045.10	6747.80	75	70				stratified 1
76	AL13094.013	AL9403A.018	moc10x	1079	1448	940510	4045.22	6746.87	73	55				stratified 1
77	AL13094.014	AL9403A.018	bwdive	AL3	1630	940510	4045.20	6747.10	73					stratified 1
78	AL13094.015	AL9403A.018	ctdmk5	30	1825	940510	4045.20	6747.10	75	70				stratified 1
79	AL13094.016	AL9403A.018	moc10x	1080	1940	940510	4045.63	6745.86	66	55				stratified 1
80	AL13094.017	AL9403A.018	moc1xx	1081	2156	940510	4045.58	6746.60	67	60				stratified 1
81	AL13194.001	AL9403A.018	bwdive	AL4	30	940511	4050.40	6751.60	67	24				stratified 1

Appendix 1. AL9403 Event Log

82	AL13194.001	AL9403A.018	ctdmk5	31	156	940511	4045.20	6747.10	75	70				stratified 1
83	AL13194.002	AL9403A.022	ctdmk5	32	223	940511	4047.50	6746.90	71	66				stratified 2
84	AL13194.003	AL9403A.022	moc10x	1082	237	940511	4047.41	6747.25	63	55				stratified 2
85	AL13194.004	AL9403A.022	moc1xx	1083	449	940511	4047.37	6748.80	64	55				stratified 2
86	AL13194.005	AL9403A.022	ctdmk5	33	612	940511	4047.40	6747.90	71	66				stratified 2
87	AL13194.006	AL9403A.022	moc1xx	1084	650	940511	4047.43	6747.22	64	55				stratified 2
88	AL13194.007	AL9403A.022	ctdmk	34	820	940511	4047.20	6747.10	72	67				stratified 2
89	AL13194.008	AL9403A.022	mocqxx	1085	1019	940511	4047.34	6747.25	63	55				stratified 2
90	AL13194.009	AL9403A.022	mocqxx	1086	1124	940511	4046.88	6747.14	63	55				stratified 2
91	AL13194.010	AL9403A.022	ctdmk5	35	1234	940511	4047.40	6746.80	72	67				stratified 2
92	AL13194.011	AL9403A.022	moc1xx	1087	1334	940511	4047.15	6746.08	63	55				stratified 2
93	AL13194.012	AL9403A.022	moc1xx	1088	1521	940511	4046.69	6747.77	62	55				stratified 2
94	AL13194.013	AL9403A.022	bwdive	al5	1645	940511	4047.50	6745.90		30				stratified 2
95	AL13194.014	AL9403A.022	ctdmk5	36	1803	940511	4046.80	6746.10	72	67				stratified 2
96	AL13194.015	AL9403A.022	moc10x	1089	1928	940511	4047.78	5747.74	63	55				stratified 2
97	AL13194.016	AL9403A.022	ctdmk5	37	2130	940511	4047.30	6746.90	72	67				stratified 2
98	AL13194.017	AL9403A.022	moc1xx	1090	2203	940511	4047.70	6747.18	66	55				stratified 2
99	AL13194.018	AL9403A.022	moc10x	1091	2345	940511	4047.39	6747.37	66	55				stratified 2
100	AL13294.001	AL9403A.022	moc1xx	1092	128	940512	4047.55	6748.94	66	55				stratified 2
101	AL13294.002	AL9403A.022	ctdmk5	38	255	940512	4047.20	6747.20	66	66				stratified 2
102	AL13294.003	AL9403A.022	moc1xx	1093	308	940512	4046.92	6747.89	66	10				stratified 2
103	AL13294.004	AL9403A.022	moc1xx	1094	324	940512	4046.91	6748.43	66	5				stratified 2
104	AL13294.005	AL9403A.023	ctdmk5	39-83	0405-0828	940512	4047.20	6754.24						towyo north
105	AL13294.006	AL9403A.024	ctdmk5	84-124		940512	4059.80	6755.22						towyo south
106	AL13294.007	AL9403A.022	moc1xx	1095	1457	940512	4046.91	6746.70	66	10				stratified 2
107	AL13294.008	AL9403A.022	moc1xx	1096	1514	940512	4046.91	6746.67	66	5				stratified 2
108	AL13294.009	AL9403A.022	moc10x	1097	1542	940512	4046.83	6747.16	66	55				stratified 2
109	AL13294.010	AL9403A.025	moc1xx	1098	1822	940512	4055.27	6800.28	45	40				mixed 2

Appendix 2.

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