CRUISE REPORT

ALPHA HELIX CRUISE 200

27 August 1997 to 12 September 1997

I. **Project Title: Collaborative Research: Prolonged production and trophic transfer to predators: Processes at the Inner Front of the Southeastern Bering Sea**

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II. **Scientific Purpose:** It is hypothesized that elevated primary production at the inner front of the southeastern Bering Sea continues longer than in the upper mixed layer of non-frontal waters, and that this production provides an energy source throughout the summer for a food web that supports shearwaters, salmon, and their zooplankton prey. To test this hypothesis, we collected observations on physical and biological features in the vicinity of the inner front to determine: 1) the availability of nutrients in the euphotic zone, 2) the physical processes responsible for enhanced vertical flux of nutrients, 3) primary production, 4) the distribution, abundance and trophic ecology of near-surface swarms of euphausiids and other zooplankton, and 5) the distribution, abundance, and foraging ecology of shearwaters, and 6) by stable isotope enrichment, trophic pathways from phytoplankton to shearwaters at and away from the front. This cruise was the second of four planned for 1997 and 1998.

III. Personnel

George Hunt	Chief Sci.	UCI	USA	Ornithology
Ken O. Coyle	Co-PI	U. AK Fairbanks	USA	Zooplankton
Steve Zeeman	Co-PI	U. New England	USA	Primary Production
Dean Stockwell	Res. Assoc.	U. Texas	USA	Nutrients
Nancy Katchel	Res. Assoc.	PMEL	USA	Physical Oceanog.
Gretchen Westrick	Res. Assoc.	U. Texas	USA	Nutrients
Cheryl Baduini	Student	UCI	USA	Ornithology
Heather Revillee	Student	UCI	USA	Ornithology
David Hyrenbach	Student	Scripps Inst Ocean	USA	Ornithology
M. DesLauriers	Student	U. New England	USA	Primary Production
Milissa Jump	Technician	U. New England	USA	Primary Production
Alexey Pinchuk	Technician	U. AK Fairbanks	Russian	Zooplankton

IV. Cruise Schedule

DATE	TIME	ACTIVITY
August 27	10:00	Depart Dutch
August 28	12:00	Arrive at Nunivak Island Grid; commence CTD grid at NIA-20
August 30- September 1		Weather Days
September 2- September 5	14:00	Complete studies in Nunivak Island Grid
September 6, 7		Weather Days
September 8- September 11		Slime Bank Grid
September 12	06:00	Arrive Dutch Harbor

V. Results

Overview:

The most remarkable findings of this cruise were the documentation of a coccolithophorid bloom that extended from St Paul Island, Pribilof Islands, to Nunivak Island and south through the middle domain to the top edge of the Slime Bank Grid, a major die-off of shearwaters, and detailed documentation of the breakdown of stratification and the inner front by storms. The coccolithophorid bloom turned the water a greenish blue, and where the bloom was strongest, the water was an opaque milky-green. Visual evidence of the bloom was absent along the cruise track between the Pribilofs and the northwest corner of the Slime Bank Grid.

We documented a major die-off of short-tailed shearwaters (*Puffinnus tenuirostris*). Shearwater numbers were lower than expected, particularly in the Nunivak Island Grid, where many dead shearwaters were recorded floating in the water. Corpses were particularly conspicuous in areas of milky-green water where the dark birds could be easily seen. Both dead and living shearwaters had significantly reduced body mass when compared with birds collected during our June cruise, and diets of birds collected in September were more diverse than in June, with fish and squid occurring in a number of birds.

We were also able to document the breakdown of the summer stratification, particularly in the Nunivak Island Grid. Shortly after we completed the CTD grid, a strong storm with sustained winds of 35 knots mixed the inner domain and deepened the pycnocline by 10 to 15 m. Although we did not survey pre-storm conditions at the Slime Bank Grid, our survey there revealed that the two storms in early September had mixed the water to nearly 100 m depth, effectively destroying the inner front. Our observations show that the structure of the inner front and inner domain can be altered remarkably quickly if they are subjected to sufficiently strong wind forcing.

We interpret the presence of the coccolithophorid bloom and the die-off of shearwaters as resulting from the early and strong stratification of the middle domain and the presence of stratified water in what is normally the well-mixed inner domain. We hypothesize that the stratification resulted in the depletion of nutrients to a depth of 60 m or more, as seen in the June cruise, and the cessation of the hypothesized nutrient pump that we expected to see in the inner front. There was little or no inshore chlorophyll in June, and by September, there were few adult euphausiids in waters less than 60 m depth. In September, the scattered aggregations of euphausiids found in water less than 50 m depth consisted mostly of juveniles. We expect to find that the energy content of these juveniles is low in comparison to that of adults. Thus, we hypothesize that shearwaters were starving because there were insufficient adult euphausiids in shallow water. Additionally, foraging shearwaters appeared to avoid areas with milky-green water, in which the shearwaters may have had difficulty in detecting and capturing euphausid prey.

Physical Oceanography (Nancy Katchel)

At Nunivak Island, we occupied a grid of 55 CTD stations on five grid lines starting at 1800 GMT, August 28, and ending at 1630 GMT, August 30 (Figures 1, 2; Table 1; and Appendix A). We began our sampling of the NIA-line at NIA-24, near St. Paul Island, thereby obtaining a profile of the cold pool (Figure 3). Strong thermal stratification of 6 to 9°C was observed in the mid-shelf region where bottom depths were greater then approximately 55m (Figures 3 - 7). The thermocline was located at approximately 12 - 18 m. At bottom depths of approximately 40 - 45 m, the temperature difference had declined to 2 - 3°C. On the E-line, which was extended shoreward to 30 m depth, we found unstratified water at and inshore of the 40 m bottom contour (Figure 7).

Shortly after we finished the Nunivak Island Grid, a storm with sustained winds of 35 knots moved into the area for three days. This provided an opportunity to document the effects of a single storm event in breaking down the stratification built up during the exceptionally calm summer months of 1997. We were able to reoccupy the NIC and NIA lines on September 2 - 4, and complete an XBT survey on September 6 along the C line. A breakdown in stratification can be seen by comparison of before and after sections of temperature, salinity ,sigma-t and fluorescence across the inner front in Figures 8 - 11. These sections show only those portions of the A and C lines that were occupied during both surveys. The thermocline had deepened to 25 - 30m. The waters above it had cooled by approximately 3 °C, while there was some warming of the waters below the thermocline as isotherms appear to be pushed into deeper water. The density sections (sigma-t) reflect the change in temperature, as cooler water on top increased in density, and warming of the bottom water decreases it.

At Slime Bank, a total of twenty five CTD stations were taken on the A, C, and E lines on September 9 - 10, 1997 (Figures 12 - 15; Table 1, and Appendix B). In addition, a line of 35 XBT's were used on the C line on September 11. The storms that detained us at Nunivak Island and again at St. Paul Island had caused extensive mixing of the water column at every station. The nearshore zone was uniform. Offshore, there was a temperature gradient of 3 - 4 °C between the poorly defined surface layer and the bottom. The layer of transition extended to 75 - 90 m in the water column. Structure of this type is commonly found in the autumn after significant storm mixing has occurred. Laterally, the change in the profiles of T, S, and sigma-t was extremely gradual. No Inner front could be defined.

Nutrient and Pigment Studies (Gretchen Westrick, Dean Stockwell):

Samples were taken at 10 meter intervals and at the fluorescence maximum, if present, and were analyzed for nitrite, nitrate, ammonium, phosphate, and silicate on shipboard with an Alpkem RFA 300.

We sampled nutrients at 58 stations on the Nunivak Island Grid for a total of approximately 300 samples. Samples were taken on transects A, C, and E before the storm (Figures 16, 18), and on transects A and C after the storm (Figures 19, 20). In addition 319 water samples were filtered for chlorophyll analysis and 35 for HPLC analysis of plant pigments. Transect A before the storm showed a depletion of all nutrients in the surface layer with a small concentration below the pycnocline on the middle shelf region (Figure 15). Transect C pre-storm showed a similar trend as the A line, nutrient depletion from the surface down to about 20 meters (pycnocline) and low concentrations in the deeper waters of the middle shelf (Figure 16). In September, nitrate and phosphate were present in higher concentrations than in the spring/early summer cruise and were also found closer inshore. Our survey of the C line after the storm showed that the storm had mixed the water column and broken down the stratification of nutrients (Figure 19). Nitrate was found in higher concentrations toward the inner shelf, but overall had lower concentrations after the mixing. Ammonium was found in higher concentrations after the mixing. Transect NIE, pre-storm (Figure 17), follows the same trend as the NIA-line pre-storm (Figure 15), with depleted nutrients in the surface waters and nutrient concentrations following the physical stratification with a nutrient pool of low concentration at the bottom. The presence inshore of a small pool of water with higher nutrients than the surrounding area suggests the presence of a possible cross shelf current in the inner shelf region. The silicate data on the pre-storm stations should be disregarded due to contamination; the post-storm silicate data are reliable.

At the Slime Bank Grid, we sampled 23 stations for nutrients and obtained a total of 165 nutrient samples. An additional 113 water samples were filtered for chlorophyll analysis and 15 were filtered for HPLC examination of pigments. The nitrate, nitrite, and silicate concentrations on transects A, C, and E, were higher than any samples taken on the Nunivak Island Grid. The phosphate and ammonium had similar numbers to Nunivak Island Grid. The concentrations of the nutrients were high throughout the water column, suggesting strong wind mixing.

Productivity Sampling (Steve Zeeman, Melissa Jump, Marie DesLauriers, and Dean Stockwell).

At the Nunivak Island Grid, primary productivity experiments were conducted at nine sites. At four of these sites we conducted both *in situ* and on-deck incubator experiments. At the remainder of the sites we performed incubator experiments only. The on-deck incubations measure photosynthesis vs. irradiance curves, while the *in situ* experiments measure actual photosynthetic rates in the water column. A significant wind event intervened during the sampling which altered the water column stratification and water mass distribution. The storm also impacted the phytoplankton community, redistributing it both horizontally and vertically. At the seaward extent of the transects, this seemed to have minimal effect. Near the front, at Stations NIC-1 - NIC-3, light-saturated photosynthetic rates nearly doubled after the storm. In contrast, at the inshore end of the transects, after the storm, the light-saturated photosynthetic rates decreased by about one third.

Within the Nunivak Island Grid, a coccolithophorid bloom covered both the inshore and offshore ends of the transects, with only a small area between where the bloom was not present. There was no distinct temperature - salinity signature associated with this bloom, and it is unclear how it was maintained. Nutrients were higher in fall than they were in spring. Interestingly, on the NIE-line before the storm, nitrate was abundant both inshore and offshore, with a nitrate low between them.

In addition to the primary production experiments within the Nunivak Island Grid, we conducted three ^{15}N experiments, each of which was coupled with three nutrient limitation experiments. We also measured ^{15}N uptake while at anchor near Cape Mendenhall. Nitrate showed a decline of nearly one third the starting concentration of about 3 micro molar. The stable isotope concentrations await analysis at U. Texas.

Primary production at Slime Bank was measured at three sites SBE-2, SBA-10 and SBA-5. At each of these sites *in situ* measurements were made along with on-deck incubations of ^{14}C. We also conducted ^{15}N uptake and nutrient limitation experiments at the latter two stations.

On one transect in each of the two grids (the NIA-line at Nunivak and the SBC-line at Slime Bank), we collected water samples at several depths. These were filtered and frozen for later analysis using excitation-emission spectrofluorometry to examine dissolved organic matter.

Nunivak Island - Productivity Stations

	Offshore	Frontal Zone	Inshore
pre-storm	NIA-24 NID-09	NIC-01	NIE-X12
post-storm	NIA-13	NIC-03 NIA-05	NIC-X10 NIC-X04

Slime Bank - Productivity Stations

	Offshore	Shearwater Feeding	Inshore
	SBA-10	SBA-5	SBE-2

Zooplankton (Ken Coyle, Alexey Pinchuk):

To assess the distribution and abundance of zooplankton, in particular the distribution and abundance of the euphausiid *Thysanoessa rachii*, we used acoustic surveys to detect broad distribution patterns, and MOCNESS tows to establish the specific composition of the plankton responsible for the echo return. To sample smaller species and small life stages of *T. raschii*, we deployed CalVET nets at CTD stations along the length of the C-line in each grid. To establish trophic relations between taxa, samples of representative taxa were obtained for stable isotope and HPLC analyses.

In the Nunivak Island Grid, acoustic data were collected at 43 and 120 kHz along transects NIC and NIA. Scattering intensity appeared to be similar in both frequencies, suggesting that the majority of the scattering was due to fish. The predominant fish in the MOCNESS tows was zero class pollock. However, much of the scattering was probably from targets which were not collected by the MOCNESS. Detailed analysis of acoustic data will be done in the laboratory in conjunction with results from the net tows.

In the Nunivak Island Grid, we made nine MOCNESS and 14 CalVET tows. The CalVET tows were done along transect NIC concurrently with CTD casts at the stations listed in Table 2. MOCNESS tows 1, 2, 3 and 8 were done inside the front, tows 4, 5 and 6 were done on the stratified side of the front, and tows 7 and 9 were done in the frontal region. Euphausiids were rare or absent on the mixed side of the front, where the community was dominated by mysids and crangonid shrimp. Euphausiids were abundant on the stratified side of the front and in the frontal region. Samples collected for isotope and HPLC analysis are listed in the Table 3.

At the Slime Bank Grid, acoustic transects were run on the SBA, SBE and SBC lines. Preliminary observations indicate the presence of large targets, probably cod or pollock and gelatinous zooplankton. Scattering was observed from dense aggregates of juvenile euphausiids observed in the upper 10 m near an area of elevated fluorescence on the SBA line. When we stopped the ship to collect birds and retrieve the MOCNESS, it was possible to see from the deck a dense layer of juvenile euphausiids within a meter or two of the surface. Shearwaters and other seabird species crowded around the ship to feed on these organisms.

An the Slime Bank Grid, 11 CalVET and 7 MOCNESS tows were taken . Three MOCNESS tows were taken in water 40 to 50 m deep, 2 in shallow, well mixed water and 2 in deep, weakly stratified water. All euphausiids examined were juveniles. The dominant species was *Thysanoessa inermis*, with lesser amounts of *T. raschii* and *T. spinifera*. Young of the year Pacific cod or pollock were common. Jelly fish included *Chrysaora melanaster, Aequorea* sp., *Aurelia aurita* and *Cuspedilla mertensi*. The pteropods *Limacina helicina* and *Clione limacina* were also abundant. The MOCNESS tows on the unstratified side of the front contained almost exclusively jellyfish.

Marine Ornithology (George Hunt, Cheryl Baduini, David Hyrenbach, Heather Revillee).

Bird observations were made when the ship was underway at speeds of 5 knots or greater. All birds within an arc of 90^{o} from the bow to the side with the best visibility were counted from the bridge, and were recorded on a laptop computer for later analysis. Behaviors of all birds were recorded, with particular attention being paid to whether shearwaters were feeding at the surface by hydroplaning or diving deep.

Birds were collected in each study area, both in the early morning and later in the day. Stomach contents were removed from birds within 1 hour of collection, and stored in 80% ETOH. Additionally, samples of fat were taken from each bird for identification of the fatty acids present, and brain, pectoral muscle, liver and gut were sampled for stable isotope analysis.

Shearwaters were less common at the Nunivak Island Grid than expected. Instead of the tens to hundreds of thousands expected on the basis of historical records, numbers were in the tens to hundreds, with few observations of birds foraging (Figures 21 - 26). A first impression was that foraging activity was mostly confined to areas of water that were not milky green, that is, little foraging occurred in the areas where the coccolithophore bloom was densest. The largest aggregation of foraging shearwaters was found after the storm on the NIA-line near an area of enhanced near-surface fluorescence (Figure 26).

At the Slime Bank Grid, shearwaters were also not abundant (Figures 27-30), and most sightings of feeding flocks were of aggregations of a few hundred or less (Figure 28, 30). The largest aggregation was associated with an area of enhanced fluorescence on the SBA-line, where, when we stopped to conduct tows, birds crowded about the vessel and foraged on a near-surface aggregation of juvenile euphausiids that could be seen from the deck one or two meters below the surface.

We collected 22 shearwaters at the Nunivak Island grid and 33 at the Slime Bank Grid for analysis of diets, composition of fatty acids and stable isotope analysis. Cursory examination of stomach contents showed that the shearwaters, particularly early in the cruise at Nunivak Island, were using squid and fish in addition to the expected diet of euphausiids. Shearwaters foraging at the Nunivak Island Grid had obtained some adult euphausiids, but those at Slime Bank Grid were taking juvenile euphausiids. We hypothesize that in August and September 1997, Shearwaters were taking a broader and less energy dense diet than is usual for this species in the Bering Sea.

The condition of the shearwaters collected during the fall cruise suggested that they were severely underweight (Table 4). Shearwaters were significantly lighter than they were in Spring, 1997, and appeared lighter than the average values obtained in August, 1989, near the Pribilof Islands. Meals obtained from birds in Fall, 1997, were much lighter than those obtained in Spring, 1997, though similar to values obtained in August, 1989, near the Pribilofs. Care must be used in interpreting the values for the mass of stomach contents, as these will be very sensitive to the time of day that the birds were collected and whether they were collected from a long-active foraging flock. Nevertheless, the sum of our observations suggest that in Fall 1997, short-tailed shearwaters in the southeastern Bering Sea were near starvation. This impression was reinforced by the observation of numerous dead shearwaters floating in the ocean, which were particularly conspicuous in the areas of milky-green water. Four dead birds retrieved near the Slime Bank Grid varied in mass between 640 an 410 g (mean 535 g), with the freshest, least waterlogged specimen weighing 410 g.

We also observed an unexpected shift in the sex-ratio of shearwaters collected in Fall, 1997, compared to previous times. In both Spring, 1997 and early August, 1989, females predominated among the birds collected, whereas in Fall, 1997, males were the predominant sex (Table 4). We do not know the significance of this finding.

Table 1. Record of CTD casts made during HX200.

Event	Date	Time (GMT)	Sta. ID	Lat (deg)	(min) North	Long (deg)	(min) West	Comments
	28-Aug-97	1807	NIA 24	57	33.33	169	47.15	cable pay out rate =15m/min
ctd002	28-Aug-97	2050	NIA 20	57	51.85	169	26.66	
ctd003	29-Aug-97	2306	NIA 16	58	10.57	169	5.83	waves getting rougher
ctd004	29-Aug-97	23	NIA 14	58	19.89	168	55.43	rain increasing
ctd005	29-Aug-97	109	NIA 13	58	20.26	168	55.23	
ctd006	29-Aug-97	146	NIA 12	58	20.33	168	44.97	
ctd007	29-Aug-97	214	NIA 11	58	31.69	168	43.44	
ctd008	29-Aug-97	251	NIA 9	58	36.33	168	37.23	
ctd009	29-Aug-97	338	NIA 7	58	40.97	168	32.1	
ctd010	29-Aug-97	405	NIA 6	58	43.28	168	29.44	
ctd011	29-Aug-97	432	NIA 5	58	45.65	168	26.86	cable pay out rate increased =30m/min
ctd012	29-Aug-97	515	NIA 3	58	50.29	168	21.72	stratification less intense, higher interface, more spread
ctd013	29-Aug-97	600	NIA 2	58	51.02	168	13.78	mixed zone wider, temp change~2.2

ctd014	29-Aug-97	628	NIB 3	58	48.64	168	10.32	ocean getting a lot rougher, rain
ctd015	29-Aug-97	715	NIB 5	58	43.95	168	21.59	
ctd016	29-Aug-97	742	NIB 6	58	41.65	168	24.04	
ctd017	29-Aug-97	808	NIB 07	58	39.39	168	26.53	
ctd018	29-Aug-97	853	NIA 09	58	34.66	168	31.8	
ctd019	29-Aug-97	940	NIB 11	58	29.89	168	36.95	
ctd020	29-Aug-97	1021	NIC 12	58	26.15	168	34.29	
ctd021	29-Aug-97	1045	NIC 11	58	28.32	168	31.75	
ctd022	29-Aug-97	1115	NIC 10	58	29.16	168	29.16	no salts taken
ctd023	29-Aug-97	1143	NIC 09	58	30.65	168	26.51	
ctd024	29-Aug-97	1212	NIC 08	58	35.39	168	24.04	seas and wind more calm
ctd025	29-Aug-97	1249	NIC 07	58	37.71	168	21.43	spike in Fluor ~27-30m on downcast, not evident on upcast
ctd026	29-Aug-97	1320	NIC 06	58	40.03	168	18.79	no salts taken
ctd027	29-Aug-97	1347	NIC 05	58	42.41	168	16.19	
ctd028	29-Aug-97	1418	NIC 04	58	44.79	168	13.59	
ctd029	29-Aug-97	1448	NIC 03	58	47.09	168	10.99	no salts taken
ctd030/prod	29-Aug-97	1516	NIC 02	58	49.39	168	8.41	

ctd031	29-Aug-97	1544	NIC 01	58	51.7	168	5.75	5 bottles prod water
ctd032	29-Aug-97	1626	NID 02	58	47.79	168	2.91	
ctd033	29-Aug-97	1655	NID 03	58	45.44	168	5.45	
ctd034	29-Aug-97	1740	NID 05	58	40.78	168	10.69	no salts taken
ctd035	29-Aug-97	1807	NID 06	58	38.42	168	13.3	
ctd036	29-Aug-97	1834	NID 07	58	36.06	168	15.9	
ctd037	29-Aug-97	1918	NID 09	58	31.41	168	21.15	6 bottles prod water; no salts taken
ctd038	29-Aug-97	2228	NID 11	58	26.78	168	26.24	water is darker color, can see green ahead
ctd039	29-Aug-97	2249	NID 11	58	27.34	168	26.68	green water, not so strong front, speculation is that color is due to coccolithophorids
ctd040	29-Aug-97	2327	NIE 11	58	25.2	168	21.08	green again, no salts taken
ctd041	30-Aug-97	8	NIE 09	58	29.79	168	15.75	light green transitional to darker water
ctd042	30-Aug-97	50	NIE 07	58	34.44	168	10.58	dark water, no salts taken
ctd043	30-Aug-97	142	NIE 06	58	36.82	168	7.97	
ctd044	30-Aug-97	513	NIE 05	58	39.4	168	5.19	

ctd045	30-Aug-97	219	NIE 03	58	43.85	168	0.16	thermocline shallower, less change in temp profile from top to bottom
ctd046	30-Aug-97	243	NIE 02	58	46.22	167	57.54	no salts taken
ctd047	30-Aug-97	308	NIE 01	58	48.45	167	54.92	
ctd048	30-Aug-97	349	NIE X02	58	53.2	167	49.71	
ctd049	30-Aug-97	428	NIE X04	58	57.87	167	44.59	no thermocline
ctd050	30-Aug-97	512	NIE X06	59	2.5	167	39.37	inside front
ctd051	30-Aug-97	534	NIE X08	59	7.18	167	34.11	
ctd052	30-Aug-97	636	NIE X10	59	11.84	167	29.02	no salts taken
ctd053	30-Aug-97	754	NIE X12	59	21.12	167	18.81	high chlorophyll
ctd054	30-Aug-97	1608	NIE X12	58	21.07	167	18.68	
ctd055	30-Aug-97	1634	NIE X12	58	21.13	167	18.68	n-15 water, productivity cast, no salts taken
ctd056	31-Aug-97	2035	CAP EM	59	48.57	166	4.59	Single cast at Cape Mendenhall
ctd057	9/2/97	1553	NIC X12	59	24.44	167	29.44	first cast after gale, green
ctd058	9/2/97	1732	NIC X10	59	14.99	167	39.81	green

ctd059	9/2/97	1826	NIC X08	59	10.31	167	44.98	
ctd060	9/2/97	1917	NIC X06	59	5.68	167	50.12	
ctd061	9/2/97	2006	NIC X04	59	1.01	167	55.42	
ctde062	9/2/97	2055	NIC X02	58	56.36	168	0.59	
ctd063	9/2/97	2142	NIC 01	58	51.7	168	5.72	
ctd064	9/2/97	2214	NIC 02	58	49.37	168	8.34	no salts taken
ctd065	9/2/97	2241	NIC 03	58	47.05	168	10.98	
ctd066	9/2/97	2311	NIC 03	58	47.04	168	11.05	
ctd067	9/3/97	104	NIC 04	58	44.71	168	13.57	no salts taken
ctd068	9/3/97	130	NIC 05	58	42.37	168	16.15	
ctd069	9/3/97	204	NIC 06	58	40.05	168	18.7	transition btw black & green
ctd070	9/3/97	232	NIC 07	58	37.76	168	21.32	dark green not murky
ctd071	9/3/97	306	NIC 08	58	35.48	168	23.87	spikes due to rolling, no salts taken
ctd072	9/3/97	334	NIC 09	58	33.07	168	26.51	dark green
ctd073	9/3/97	411	NIC 10	58	30.75	168	29.06	murky light green, no salts
ctd074	9/3/97	438	NIC 11	58	28.37	168	31.65	murky light green

ctd075	9/3/97	516	NIC 12	58	26.06	168	34.22	murky green, no salts taken
ctd076	9/3/97	600	NIC 13	58	21.4	168	39.41	murky green, bottom temp <20, rocking ship
ctd077	9/3/97	1802	NIA 13	58	24.6	168	50.11	in situ prod, slightly murky green, no salts
ctd078	9/3/97	1838	NIA 13	58	24.6	168	50.1	N-15 water, slightly murky green, no salts
ctd079	9/4/97	2009	NIC X04	59	1.1	167	55.2	
c td080	9/4/97	2042	NIC X04	59	1.2	167	55.71	
ctd081	9/4/97	2308	NIA X04	59	4.22	168	6.18	barometer dropping again, begin re-survey NIA line comparison after previous storm
ctd082	9/4/97	2357	NIA X02	58	59.67	168	11.6	getting rough, well mixed
ctd083	9/4/97	52	NIA 01	58	54.98	168	17.01	
ctd084	9/5/97	130	NIA 02	58	52.69	168	19.28	no salts taken
ctd085	9/5/97	212	NIA 03	58	50.3	168	21.87	
ctd086/ prod	9/5/97	256	NIA 04	58	47.91	168	24.47	no salts taken
ctd087	9/5/97	334	NIA 05	58	45.61	168	27.16	green water
ctd088	9/5/97	416	NIA 06	58	43.18	168	29.69	green water, no salts taken

ctd089	9/5/97	450	NIA 07	58	40.97	168	32.2	beginning transition zone to dark green
ctd090	9/5/97	548	NIA 09	58	36.26	168	37.33	transition from dark green to slightly murky green
ctd091	9/5/97	637	NIA 11	58	31.65	168	42.52	murky green
ctd092	9/6/97	465	NIC 13	58	21.41	168	39.6	end of xbt/acoustic line, begin transit from Nunivak to Slime Bank
ctd093	9/6/97	742	MD 01	58	4.09	168	12.43	light green, rough water, no salts
ctd094	9/6/97	1037	MD 02	57	46.61	167	45.88	murky green, seas rougher
ctd095	9/6/97	1414	MD 03	57	29.23	167	18.83	murky green, no salts, high seas, terminating ctd's line MD
ctd096	9/9/97	1752	SBE 02	55	5.46	164	3.69	begin Slime Bank, black water, prod water, no salts
ctd097	9/9/97	1955	SBE 02	55	5.46	164	3.56	
ctd098	9/9/97	2050	SBE 04	55	10.29	164	7.41	appears jelly entered cond. #1 probe on upcast, no salts
ctd099	9/9/97	2128	SBE 05	55	12.79	164	9.63	jellyfish parts removed from pump c1-t1 side after cast, no salts

ctd100	9/9/97	2219	SBE 06	55	15.24	164	11.63	.06 diff btw c1&c2, maybe d/t cleaning duct of jellyfish, no salts taken
ctd101	9/9/97	2328	SBE 08	55	20.03	164	15.62	c1-c2 appears to be normal now, no salts
ctd102	9/10/97	37	SBE 10	55	24.93	164	19.61	no salts taken
ctd103	9/10/97	218	SBC 12	55	35.10 1	164	15.45	salinity near bottom may be to variable for good calib.
ctd104	9/10/97	314	SBC 11	55	30.23	164	11.45	
ctd105	9/10/97	354	SBC 10	55	27.78	164	9.46	black water, one bottle tripped extra-probably surface trip during retrieval, rough water
ctd106	9/10/97	432	SBC 09	55	25.3	164	7.34	jellyfish on upcast @15m
ctd107	9/10/97	507	SBC 08	55	22.93	164	5.41	no salts taken
ctd108	9/10/97	543	SBC 07	55	20.44	164	3.4	black water very clear, strong Fluor peak 20-25m, n 15-60m
ctd109	9/10/97	617	SBC 06	55	17.99	164	1.41	black water very clear
ctd110	9/10/97	650	SBC 05	55	15.58	164	59.41	no salts taken
ctd111	9/10/97	721	SBC 04	55	13.15	163	57.32	

ctd112	9/10/97	753	SBC 03	55	10.68	163	55.35	
ctd113	9/10/97	827	SBC 02	55	8.25	163	55.42	
ctd114	9/10/97	901	SBC 01	55	5.75	163	51.35	no salts taken
ctd115	9/10/97	957	SBA 00	55	6.1	163	39.14	no salts taken
ctd116	9/10/97	1026	SBA 1	55	8.45	163	41.15	
ctd117	9/10/97	1130	SBA 04	55	15.76	163	47.13	no salts taken
ctd118	9/10/97	1200	SBA 05	55	18.2	163	49.25	high fluor near surface
ctd119	9/10/97	1231	SBA 06	55	20.6	163	51.14	
ctd120	9/10/97	1320	SBA 08	55	25.54	163	55.2	
ctd121	9/10/97	1410	SBA 10	55	30.4	163	59.3	suspect salinity 15-30m
ctd122	9/10/97	1804	SBA 10	55	30.48	163	59.17	prod water, dark black clear water
ctd123	9/10/97	1844	SBA 10	55	30.46	163	59.17	n-15 water
ctd124	9/11/97	510	SBA 5	55	16.76	163	49.98	shearwater foraging area, very high fluor 2.3 @0-5m

Table 2. List of Zooplankton Net Tows and Acoustic surveys.

Event	Date	Time (GMT)	Sta.ID	Lat (deg)	(min) North	Long (deg)	(min) West
CalVet#1/ctd 057	2-Sep	753.00	NICX12	59	24.44	167	29.44
CalVet#2/ctd 058	2-Sep	932.00	NICX10	59	14.99	167	39.81
CalVet#3/ctd 059	2-Sep	1026.00	NICX08	59	10.31	167	44.98
CalVet#4/ctd 060	2-Sep	1117.00	NICX06	59	5.68	167	50.12
CalVet#5/ctd 061	2-Sep	1206.00	NICX04	59	1.01	167	55.42
CalVet#6/ctd 062	2-Sep	1255.00	NICX02	58	56.36	168	0.59
CalVet#7/ctd 063	2-Sep	1342.00	NIC01	58	51.7	168	5.72
CalVet#8/ctd 065	2-Sep	1441.00	NIC03	58	47.05	168	10.98
CalVet#9/ctd 068	3-Sep	1730.00	NIC05	58	42.37	168	16.15
CalVet#10/ctd 070	3-Sep	1832.00	NIC07	58	37.76	168	21.32
CalVet#11/ctd 072	3-Sep	1934.00	NIC09	58	33.07	168	26.51
CalVet#12/ctd 074	3-Sep	2038.00	NIC11	58	28.37	168	31.65
CalVet#13/ctd 076	3-Sep	2200.00	NIC13	58	21.4	168	39.41
CalVet#14/ctd 103	9-Sep	1822.00	SBC12	55	35.02	164	15.46
CalVet#15/ctd 104	9-Sep	1915.00	SBC11	55	30.23	164	11.45

CalVet#16/ctd 105	9-Sep	1955.00	SBC10	55	27.77	164	9.44
CalVet#17/ctd 106	9-Sep	2030.00	SBC9	55	25.3	164	7.34
CalVet#18/ctd 107	9-Sep	2107.00	SBC8	55	22.93	164	5.44
CalVet#19/ctd 108	9-Sep	2144.00	SBC7	55	20.45	164	3.42
CalVet#20/ctd 109	9-Sep	2217.00	SBC6	55	17.99	164	1.43
CalVet#21/ctd 110	9-Sep	2251.00	SBC5	55	15.58	163	59.41
CalVet#22/ctd 111	9-Sep	2321.00	SBC4	55	13.15	163	57.33
CalVet#23/ctd 112	9-Sep	2353.00	SBC3	55	10.69	163	55.36
CalVet#24/ctd 113	9-Sep	28.00	SBC2	55	8.25	163	53.42
CalVet#25/ctd 114	9-Sep	101.00	SBC1	55	5.75	163	51.36
MOCNESS#1	30-Aug	0117-0152	NIEX12	59	23.85	167	20.52
MOCNESS#2	30-Aug	0405-0439	NIEX12	59	27.07	167	31.22
MOCNESS#3	2-Sep	0350-0428	NICX06	59	4.85	167	45.77
MOCNESS#4	2-3 Sep	2357-0036	NIC13	58	21.41	168	39.22
MOCNESS#5	3-Sep	0122-0137	NIC13	58	21.58	168	43.68
MOCNESS#6	3-Sep	0249-0331	NIA12	58	28.33	168	43.7
MOCNESS#7	3-Sep	1639-1719	NIA11	58	31.86	168	42.25
MOCNESS#8	4-Sep	0040-0156	NIA08	59	39.88	168	33.99

MOCNESS#9	4-Sep	0312-0345	NIA05	58	45.64	168	27.75
MOCNESS#10	8-9 Sep	2353-0031	SBE6	55	14.46	164	11.1
MOCNESS#11	9-Sep	0259-0332	SBE5	55	14.15	164	11.17
MOCNESS#12	9-Sep	0510-0535	SBE2	55	4.95	164	3.82
MOCNESS#13	9-Sep	0709-0728	SBC2	55	8.16	163	53.74
MOCNESS#14	10-Sep	0637-0708	SBA10	55	29.77	163	59.38
MOCNESS#15	10-Sep	1843-1916		55	17.6	163	48.92
MOCNESS#16	11-Sep	0010-1246		55	34.89	164	15.76
MOCNESS#17	11-Sep	0320-0352		55	17.41	164	1.3
Acoustic Transect							
NIA Line	3-Sep	1237-2337	NIA13-X2				
NIC Line	5-Sep	0841-2031	NICX12-13				
SBE Line	8-Sep	1757-2203	SBE10-1				
SBA Line	10-Sep	1236-1623	SBA10-1				
foraging flock	10-Sep	2032-2102					
SBC Line	11-Sep	1249-1811	SBC1-C12				

Table 3. List of zooplankton taken for chemistry samples during HX200.

No	Gear	Species	Location
1	MOCNESS 1	Pandalus goniurnus	inside
2	MOCNESS 1	Neomysis rayi	inside
3	MOCNESS 1	Neomysis rayi	inside
4	MOCNESS 1	Acanthomysis alaskensis	inside
5	MOCNESS 1	Crangon sp.	inside
6	MOCNESS 1	Crangon sp.	inside
7	MOCNESS 1	Crangon sp.	inside
8	MOCNESS 1	Crangon sp.	inside
9	MOCNESS 1	Crangon sp.	inside
10	MOCNESS 1	Thysanoessa raschii	inside
11	MOCNESS 2	Flatfish	inside
12	MOCNESS 2	Thysanoessa raschii	inside
13	MOCNESS 2	Crab megalopa (small)	inside
14	MOCNESS 2	Crab megalopa (large)	inside
15	MOCNESS 2	Fish juvenile	inside
16	MOCNESS 2	Crangon sp.	inside
17	MOCNESS 2	Priapulida sp.	inside
18	MOCNESS 1	Priapulida sp.	inside
19	MOCNESS 3	Thysanoessa raschii	inside
20	MOCNESS 3	Calanus marshallae	inside
21	MOCNESS 3	Neomysis rayi	inside
22	MOCNESS 3	Acanthomysis dybowski	inside
23	MOCNESS 3	Crangon sp.	inside
24	MOCNESS 4a	Thysanoessa raschii	outside
25	MOCNESS 4a	Thysanoessa raschii	outside
26	MOCNESS 4a	Thysanoessa raschii	outside (HPLC)
27	MOCNESS 4a	Thysanoessa raschii	outside
28	MOCNESS 4a	Thysanoessa raschii	outside
29	MOCNESS 6	Thysanoessa inermis	outside
30	MOCNESS 6	Thysanoessa inermis	outside
31	MOCNESS 6	Thysanoessa raschii	outside

32	MOCNESS 6	Parathemisto libellula	outside
33	MOCNESS 6	Calanus marshallae	outside
34	MOCNESS 8	Crangon sp.	inside
35	MOCNESS 8	Acanthomysis dybowski	inside
36	MOCNESS 8	Neomysis rayii	inside (HPLC)
37	MOCNESS 9	Thysanoessa raschii	front (HPLC)
38	MOCNESS 10	Clione limicina	front
39	MOCNESS 10	Pacific cod	front
40	MOCNESS 11	Pacific cod	front
41	MOCNESS 11	Pacific cod	front
42	MOCNESS 14	Clione limacina	outside
43	MOCNESS 14	Thysanoessa raschii	outside
44	MOCNESS 14	Thysanoessa spinifera	outside
45	MOCNESS 14	Limacina helicina	outside
46	MOCNESS 14	Pandalas goniurus	outside
47	MOCNESS 16	Pacific cod	outside
48	MOCNESS 16	Branchirynchus (crab megal)	outside
49	MOCNESS 16	Clione limacina	outside
50	MOCNESS 17	Pacific cod	front
51	MOCNESS 17	Pacific cod	front
52	MOCNESS 17	Clione limacina	front
53	MOCNESS 17	Thysanoessa inermis	front
54	MOCNESS 17	Thysanoessa spinifera	front

Table 4. Gross mass, mass of gut contents, net mass, and sex ratios of short-tailed shearwaters collected in the southeastern Bering Sea.

Date	sample size	mean gross mass g	mean mass of gut contents g	mean net mass g	% birds < 500 g net mass	M/F ratio
June 1997	39	656	57.5	598	00	10/25
Sept. 1997	55	535	18.9	517	42	36/17
Aug. 1989	26	572	14.4	559	??	7/17

APPENDIX A

Nunivak Island Grid Positions

station name	Lat.	Long.	Lat.	Long.
A-Line				
NIA-24	57.5546	169.7850	57 33.28	169 47.10
NIA-23	57.6324	169.6988	57 37.95	169 41.93
NIA-22	57.7102	169.6126	57 42.61	169 36.76
NIA-21	57.7880	169.5264	57 47.28	169 31.59
NIA-20	57.8658	169.4402	57 51.95	169 26.41
NIA-19	57.9436	169.3541	57 56.62	169 21.24
NIA-18	58.0214	169.2679	58 01.29	169 16.07
NIA-17	58.0992	169.1817	58 05.95	169 10.90
NIA-16	58.1770	169.0955	58 10.62	169 05.73
NIA-15	58.2548	169.0093	58 15.29	169 00.56
NIA-14	58.3326	168.9232	58 19.96	168 55.39
NIA-13	58.4104	168.8370	58 24.62	168 50.22
NIA-12	58.4882	168.7508	58 29.292	168 45.049
NIA-11	58.5271	168.7077	58 31.626	168 42.460
NIA-10	58.5660	168.6645	58 33.960	168 39.871
NIA-09	58.6049	168.6214	58 36.294	168 37.283
NIA-08	58.6438	168.5782	58 38.628	168 34.695
NIA-07	58.6827	168.5351	58 40.962	168 32.106
NIA-06	58.7216	168.4919	58 43.296	168 29.514
NIA-05	58.7605	168.4488	58 45.630	168 26.928
NIA-04	58.7994	168.4057	58 47.964	168 24.340
NIA-03	58.8383	168.3625	58 50.298	168 21.751
NIA-02	58.8772	168.3194	58 52.632	168 19.162
NIA-01	58.9161	168.2762	58 54.966	168 16.574
NIA-X2	58.9939	168.1900	58 59.63	168 11.40
NIA-X4	59.0717	168.1038	59 04.30	168 06.23
NIA-X6	59.1495	168.0177	59 08.97	168 01.06
NIA-X8	59.2273	167.9315	59 13.64	167 55.89

NIA-X10	59.3051	167.8453	59	18.31	167	50.72
NIA-X11	59.3829	167.7591	59	22.97	167	45.55
NIA-X12	59.4607	167.6729	59	27.64	167	40.38
NIA-X13	59.5385	167.5867	59	32.31	167	35.20
NIA-X14	59.6163	167.5006	59	36.98	167	30.03
NIA-X15	59.6941	167.4144	59	41.64	167	24.86
NIA-X16	59.7719	167.3282	59	46.31	167	19.69
NIA-X17	59.8497	167.2420	59	50.98	167	14.52

<u>B-Line</u>

NIB-12	58.4613	168.6612	58	27.678	168	39.670
NIB-11	58.5002	168.6180	58	30.012	168	37.081
NIB-10	58.5391	168.5749	58	32.346	168	34.492
NIB-09	58.5780	168.5317	58	34.680	168	31.902
NIB-08	58.6169	168.4886	58	37.014	168	29.313
NIB-07	58.6558	168.4454	58	39.348	168	26.724
NIB-06	58.6947	168.4022	58	41.682	168	24.132
NIB-05	58.7336	168.3591	58	44.016	168	21.546
NIB-04	58.7725	168.3159	58	46.350	168	18.957
NIB-03	58.8114	168.2728	58	48.684	168	16.368
NIB-02	58.8503	168.2296	58	51.018	168	13.779
NIB-01	58.8892	168.1865	58	53.352	168	11.190

<u>C-Line</u>

NIC-24	57.5010	169.6082	57	30.06	169	36.49
NIC-23	57.5788	169.5219	57	34.73	169	31.31
NIC-22	57.6566	169.4355	57	39.40	169	26.13
NIC-21	57.7344	169.3491	57	44.07	169	20.94
NIC-20	57.8122	169.2627	57	48.73	169	15.76
NIC-19	57.8900	169.1763	57	53.40	169	10.58
NIC-18	57.9678	169.0899	57	58.07	169	05.39
NIC-17	58.0456	169.0035	58	02.74	169	00.21
NIC-16	58.1234	168.9171	58	07.40	168	55.03
NIC-15	58.2012	168.8307	58	12.07	168	49.84

NIC-14	58.2790	168.7443	58	16.74	168	44.66
NIC-13	58.3568	168.6579	58	21.41	168	39.47
NIC-12	58.4346	168.5715	58	26.079	168	34.287
NIC-11	58.4735	168.5283	58	28.410	168	31.698
NIC-10	58.5123	168.4852	58	30.741	168	29.109
NIC-09	58.5512	168.4420	58	33.072	168	26.520
NIC-08	58.5900	168.3988	58	35.403	168	23.931
NIC-07	58.6289	168.3557	58	37.734	168	21.342
NIC-06	58.6678	168.3125	58	40.068	168	18.750
NIC-05	58.7066	168.2694	58	42.396	168	16.164
NIC-04	58.7455	168.2262	58	44.727	168	13.575
NIC-03	58.7843	168.1831	58	47.058	168	10.985
NIC-02	58.8232	168.1399	58	49.389	168	08.396
NIC-01	58.8620	168.0968	58	51.720	168	05.807
NIC-X2	58.9398	168.0104	58	56.39	168	00.62
NIC-X4	59.0176	167.9240	59	01.06	167	55.44
NIC-X6	59.0954	167.8376	59	05.72	167	50.26
NIC-X8	59.1732	167.7512	59	10.39	167	45.07
NIC-X10	59.2510	167.6648	59	15.06	167	39.89
NIC-X11	59.3288	167.5784	59	19.73	167	34.71
NIC-X12	59.4066	167.4920	59	24.39	167	29.52
NIC-X13	59.4844	167.4056	59	29.06	167	24.34
NIC-X14	59.5622	167.3192	59	33.73	167	19.15
NIC-X15	59.6400	167.2328	59	38.40	167	13.97
NIC-X16	59.7178	167.1465	59	43.07	167	08.79
NIC-X17	59.7956	167.0601	59	47.73	167	03.60

D-Line

NID-12	58.4078	168.4818	58	24.465	168	28.906
NID-11	58.4466	168.4386	58	26.796	168	26.317
NID-10	58.4855	168.3955	58	29.127	168	23.728
NID-09	58.5243	168.3523	58	31.458	168	21.139
NID-08	58.5632	168.3092	58	33.789	168	18.549
NID-07	58.6020	168.2660	58	36.120	168	15.960
NID-06	58.6408	168.2228	58	38.448	168	13.368

NID-05	58.6797	168.1797	58	40.782	168	10.782
NID-04	58.7185	168.1366	58	43.113	168	08.193
NID-03	58.7574	168.0934	58	45.444	168	05.604
NID-02	58.7962	168.0502	58	47.775	168	03.015
NID-01	58.8351	168.0071	58	50.106	168	00.426

E-line

NIE-24	57.4469	169.4288	57	26.82	169	25.73
NIE-23	57.5247	169.3425	57	31.48	169	20.55
NIE-22	57.6025	169.2561	57	36.15	169	15.36
NIE-21	57.6803	169.1697	57	40.82	169	10.18
NIE-20	57.7581	169.0833	57	45.49	169	05.00
NIE-19	57.8359	168.9969	57	50.16	168	59.81
NIE-18	57.9137	168.9105	57	54.82	168	54.63
NIE-17	57.9915	168.8241	57	59.49	168	49.44
NIE-16	58.0693	168.7377	58	04.16	168	44.26
NIE-15	58.1471	168.6513	58	08.83	168	39.08
NIE-14	58.2249	168.5649	58	13.49	168	33.89
NIE-13	58.3027	168.4785	58	18.16	168	28.71
NIE-12	58.3805	168.3921	58	22.830	168	23.524
NIE-11	58.4194	168.3489	58	25.164	168	20.934
NIE-10	58.4583	168.3058	58	27.498	168	18.345
NIE-09	58.4972	168.2626	58	29.832	168	15.756
NIE-08	58.5361	168.2195	58	32.166	168	13.167
NIE-07	58.5750	168.1763	58	34.500	168	10.578
NIE-06	58.6139	168.1331	58	36.834	168	07.986
NIE-05	58.6528	168.0900	58	39.168	168	05.400
NIE-04	58.6917	168.0468	58	41.502	168	02.811
NIE-03	58.7306	168.0037	58	43.836	168	00.222
NIE-02	58.7695	167.9605	58	46.170	167	57.632
NIE-01	58.8084	167.9174	58	48.504	167	55.043
NIE-X2	58.8862	167.8310	58	53.17	167	49.86
NIE-X4	58.9640	167.7446	58	57.84	167	44.68
NIE-X6	59.0418	167.6582	59	02.51	167	39.49
NIE-X8	59.1196	167.5718	59	07.18	167	34.31

NIE-X10	59.1974	167.4854	59	11.84	167	29.13
NIE-X11	59.2752	167.3990	59	16.51	167	23.94
NIE-X12	59.3530	167.3126	59	21.18	167	18.76
NIE-X13	59.4308	167.2262	59	25.85	167	13.57
NIE-X14	59.5086	167.1398	59	30.51	167	08.39
NIE-X15	59.5864	167.0535	59	35.18	167	03.21
NIE-X16	59.6642	166.9671	59	39.85	166	58.02
NIE-X17	59.7420	166.8807	59	44.52	166	52.84

APPENDIX B

Slime Bank Station Positions

Station Name	Lat	Long	Lat		Long		Comment
SBC-0							
SBC-1	55.0965	163.8570	55	5.79	163	51.42	
SBC-2	55.1371	163.8903	55	8.23	163	53.42	
SBC-3	55.1777	163.9236	55	10.66	163	55.42	
SBC-4	55.2184	163.9568	55	13.10	163	57.41	
SBC-5	55.2591	163.9901	55	15.55	163	59.41	
SBC-6	55.2998	164.0234	55	17.99	164	01.40	
SBC-7	55.3405	164.0567	55	20.43	164	03.40	
SBC-8	55.3811	164.0900	55	22.87	164	05.40	
SBC-9	55.4218	164.1233	55	25.31	164	07.40	
SBC-10	55.4625	164.1566	55	27.75	164	09.40	
SBC-11	55.5032	164.1899	55	30.19	164	11.39	
SBC-12	55.5844	164.2565	55	35.06	164	15.39	
SBC-13	55.6656	164.3231	55	39.94	164	19.38	
SBC-14	55.7468	164.3897	55	44.81	164	23.38	
SBC-15	55.8280	164.4563	55	49.68	164	27.38	
SBC-16	55.9092	164.5228	55	54.55	164	31.37	
SBC-17	55.9904	164.5894	55	59.42	164	35.37	
SBC-18	56.0716	164.6560	56	04.30	164	39.36	
SBC-19	56.1528	164.7226	56	09.17	164	43.36	
SBE-10	55.4170	164.3279	55	25.02	164	19.67	
SBE-8	55.3356	164.2613	55	20.14	164	15.68	
SBE-6	55.2543	164.1947	55	15.26	164	11.68	
SBE-5	55.2136	164.1615	55	12.81	164	09.69	
SBE-4	55.1729	164.1282	55	10.37	164	07.69	
SBE-2	55.0915	164.0616	55	05.49	164	03.70	
SBE-1	55.0508	164.0283	55	03.05	164	01.70	

SBD-1	55.0736	163.9426	55	04.42	163	56.56
SBD-2	55.1143	163.9759	55	06.86	163	58.56
SBD-4	55.1957	164.0425	55	11.74	164	02.55
SBD-5	55.2363	164.0758	55	14.18	164	04.55
SBD-6	55.2770	164.1091	55	16.62	164	06.55
SBD-7			55	19.06	164	08.54
SBD-8	55.3584	164.1757	55	21.50	164	10.54
SBD-10	55.4397	164.2422	55	26.38	164	14.53
SBB-10	55.4853	164.0709	55	29.12	164	04.26
SBB-8	55.4039	164.0043	55	24.23	164	00.26
SBB-7			55.	.21.92	163	58.38
SBB-6	55.3225	163.9378	55	19.35	163	56.27
SBB-5	55.2819	163.9045	55	16.91	163	54.27
SBB-4	55.2412	163.8712	55	14.47	163	52.27
SBB-3			55	12.03	163	50.28
SBB-2	55.1598	163.8046	55	09.59	163	48.28
SBB-1	55.1191	163.7713	55	07.15	163	46.28
SBA-0			55	06.13	163	39.10
SBA-1	55.1419	163.6856	55	08.51	163	41.14
SBA-2	55.1826	163.7189	55	10.96	163	43.14
SBA-4	55.2640	163.7855	55	15.84	163	47.13
SBA-5	55.3046	163.8188	55	18.28	163	49.13
SBA-6	55.3453	163.8521	55	20.72	163	51.13
SBA-8	55.4267	163.9187	55	25.60	163	55.12
SBA-10	55.5080	163.9853	55	30.48	163	59.12

09/08/97 SeaPlot - (untitled) 14:50:27

Scale: 200NM 1:1426000 Chart: NOAA/513A

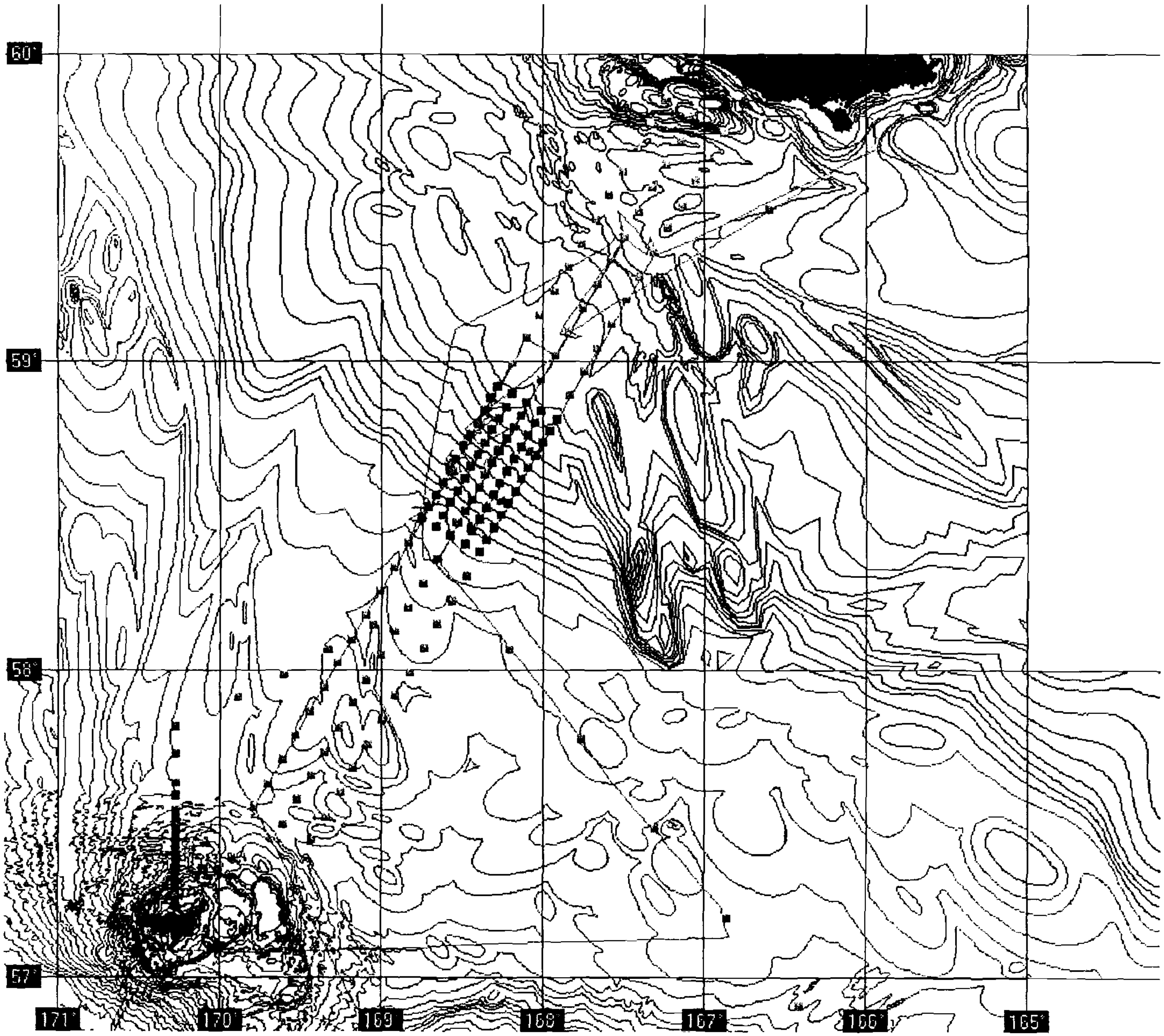


Figure 1

09/08/97 SeaPlot - (untitled) 14:57:42

Scale: 48.6NM 1:347000 Chart: NOAA/513A

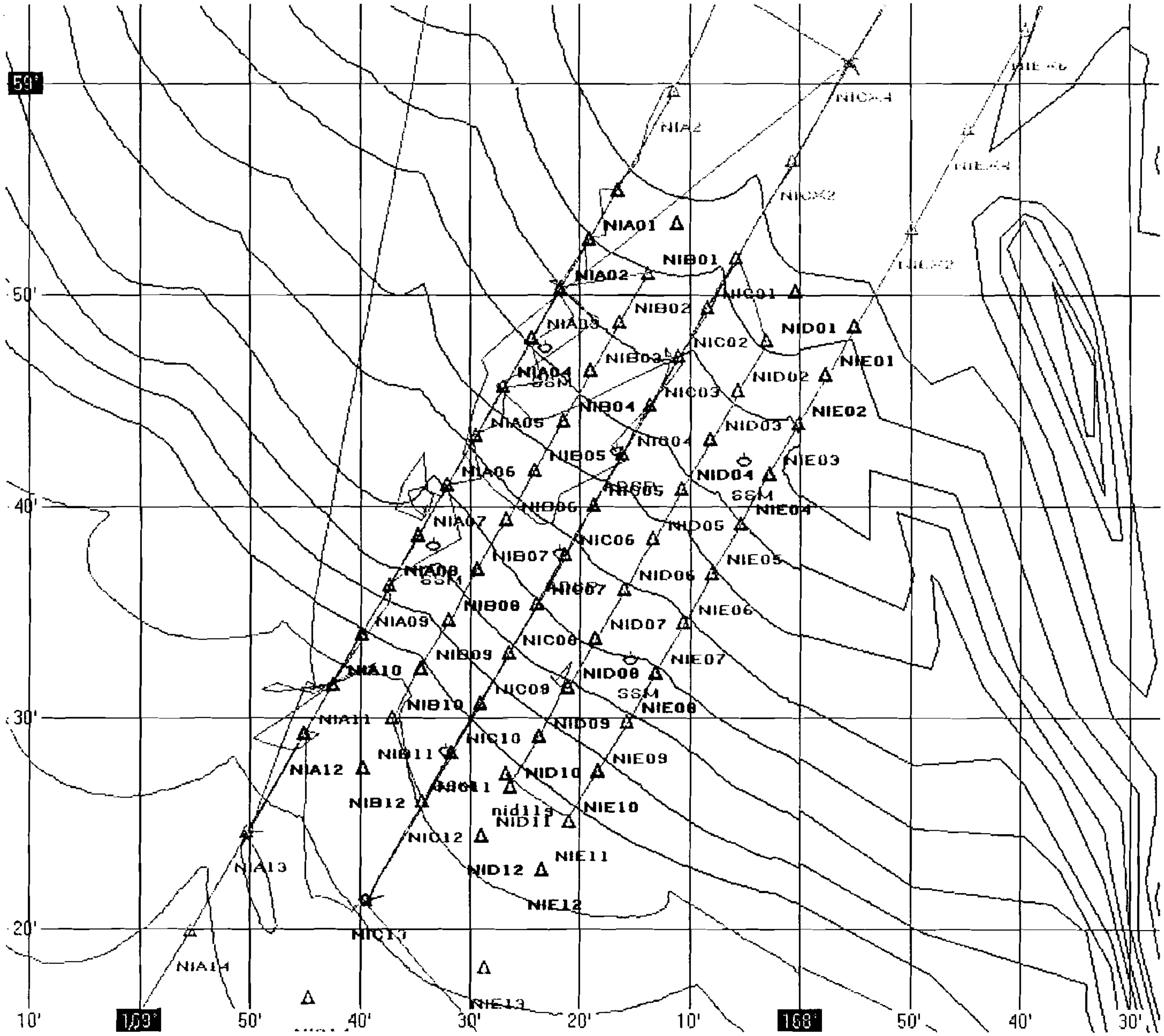
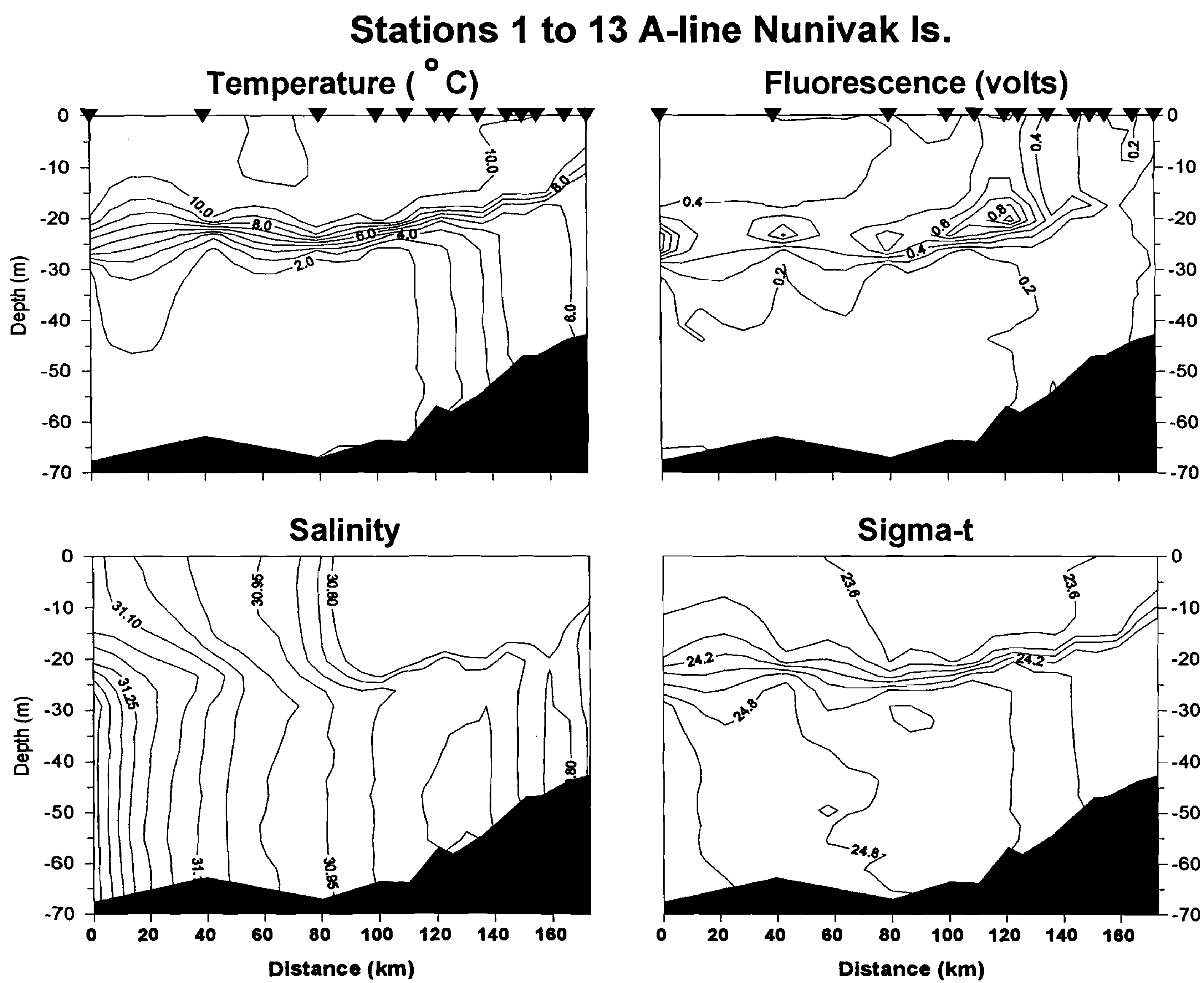


Figure 2



Stations 1 to 13 A-line Nunivak Is.
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)
10.0
8.0
6.0
4.0
2.0
0.4
0.6
0.8
0.2
31.10
31.25
30.95
30.80
23.6
24.2
24.8

Figure 3

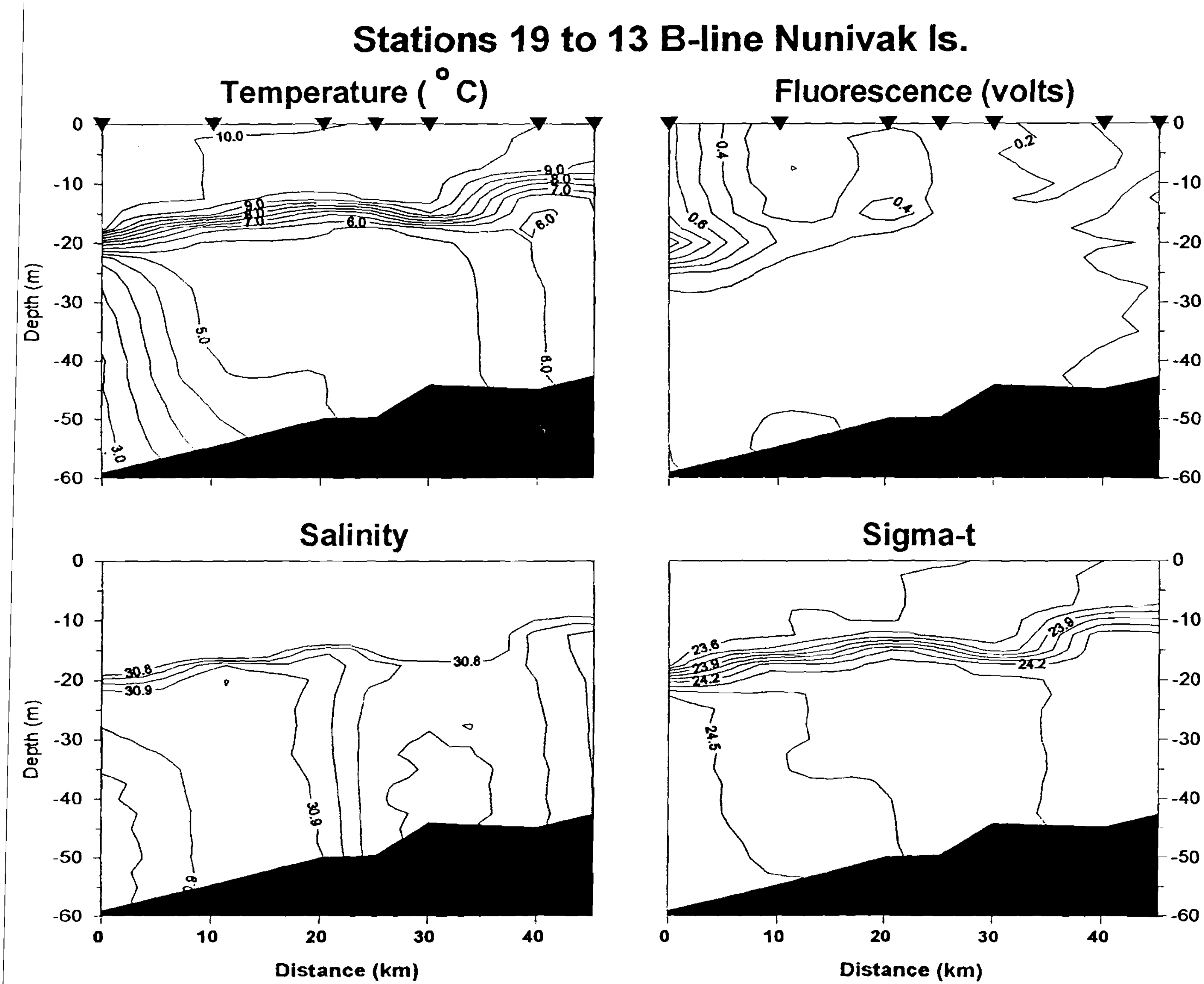

Stations 19 to 13 B-line Nunivak Is.
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)
10.0
9.0
8.0
7.0
6.0
5.0
3.0
0.2
0.4
0.6
30.8
30.9
23.6
23.9
24.2
24.5

Figure 4

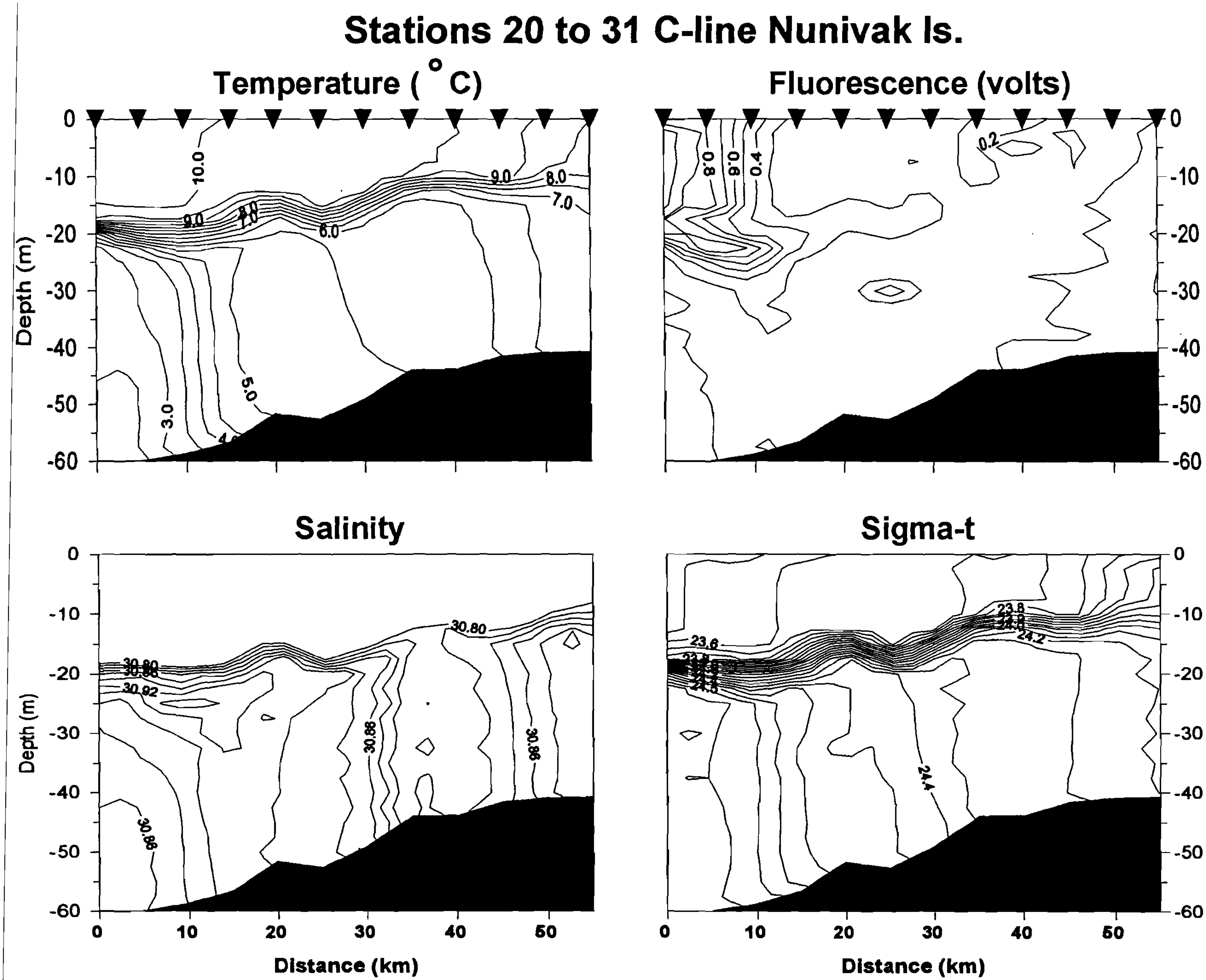

Stations 20 to 31 C-line Nunivak Is.
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)
10.0
9.0
8.0
7.0
6.0
5.0
3.0
0.2
0.4
0.6
0.8
30.80
30.86
30.92
23.6
23.8
24.2
24.4

Figure 5

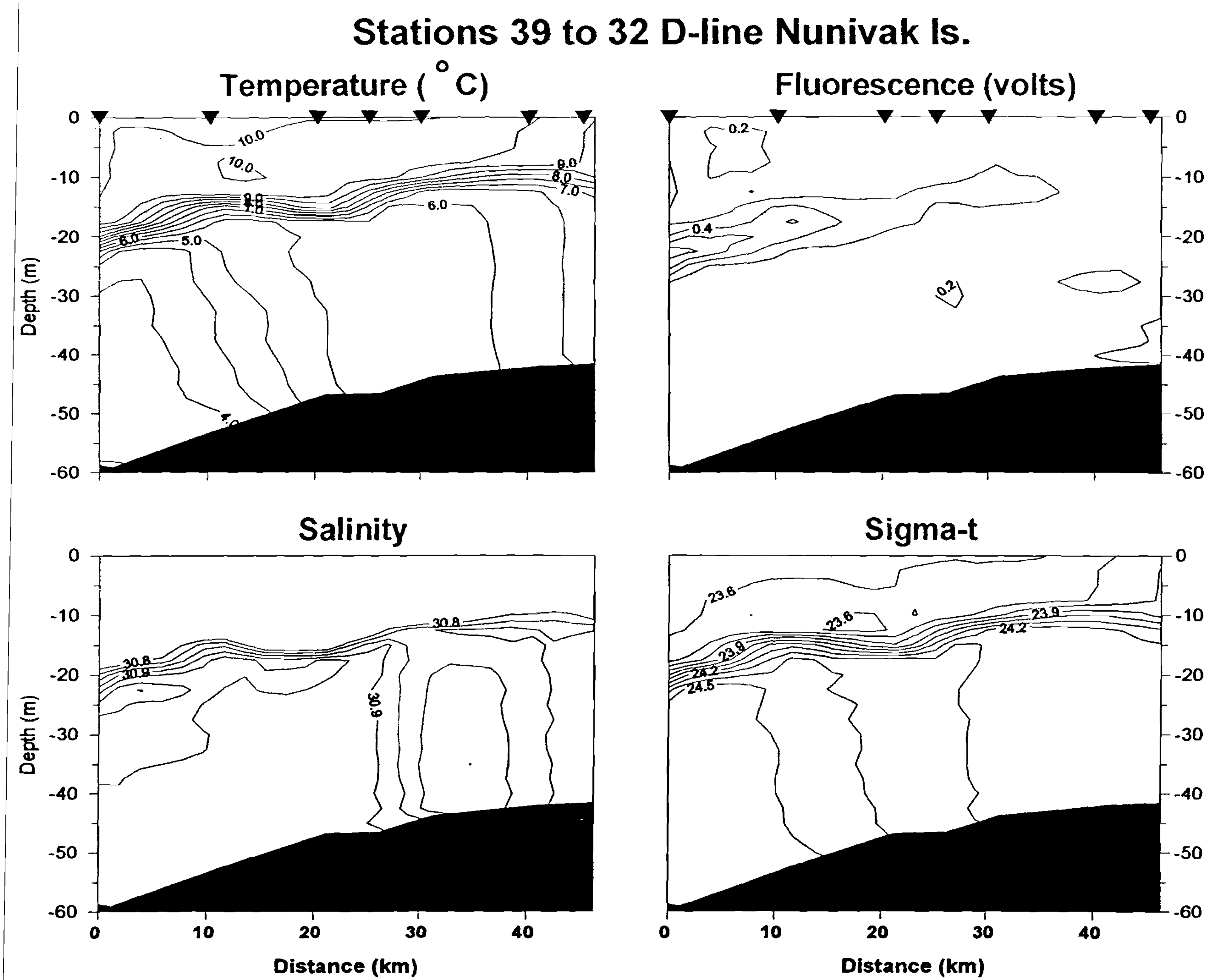

Stations 39 to 32 D-line Nunivak Is.
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)
10.0
9.0
8.0
7.0
6.0
5.0
0.2
0.4
30.8
30.9
23.6
23.9
24.2
24.5

Figure 6

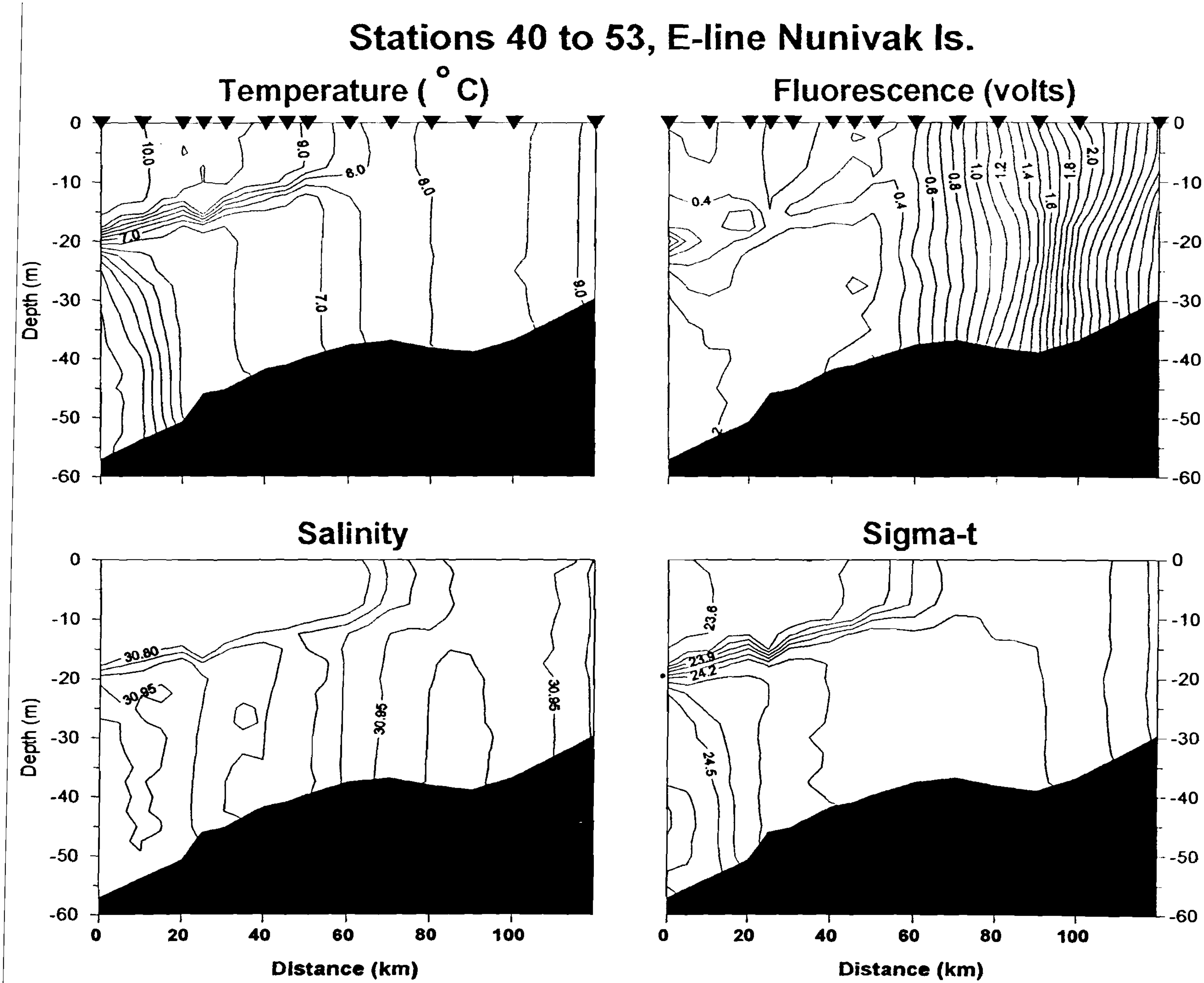

Stations 40 to 53, E-line Nunivak Is.
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)
10.0
9.0
8.0
7.0
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
30.80
30.95
23.6
23.9
24.2
24.5

Figure 7

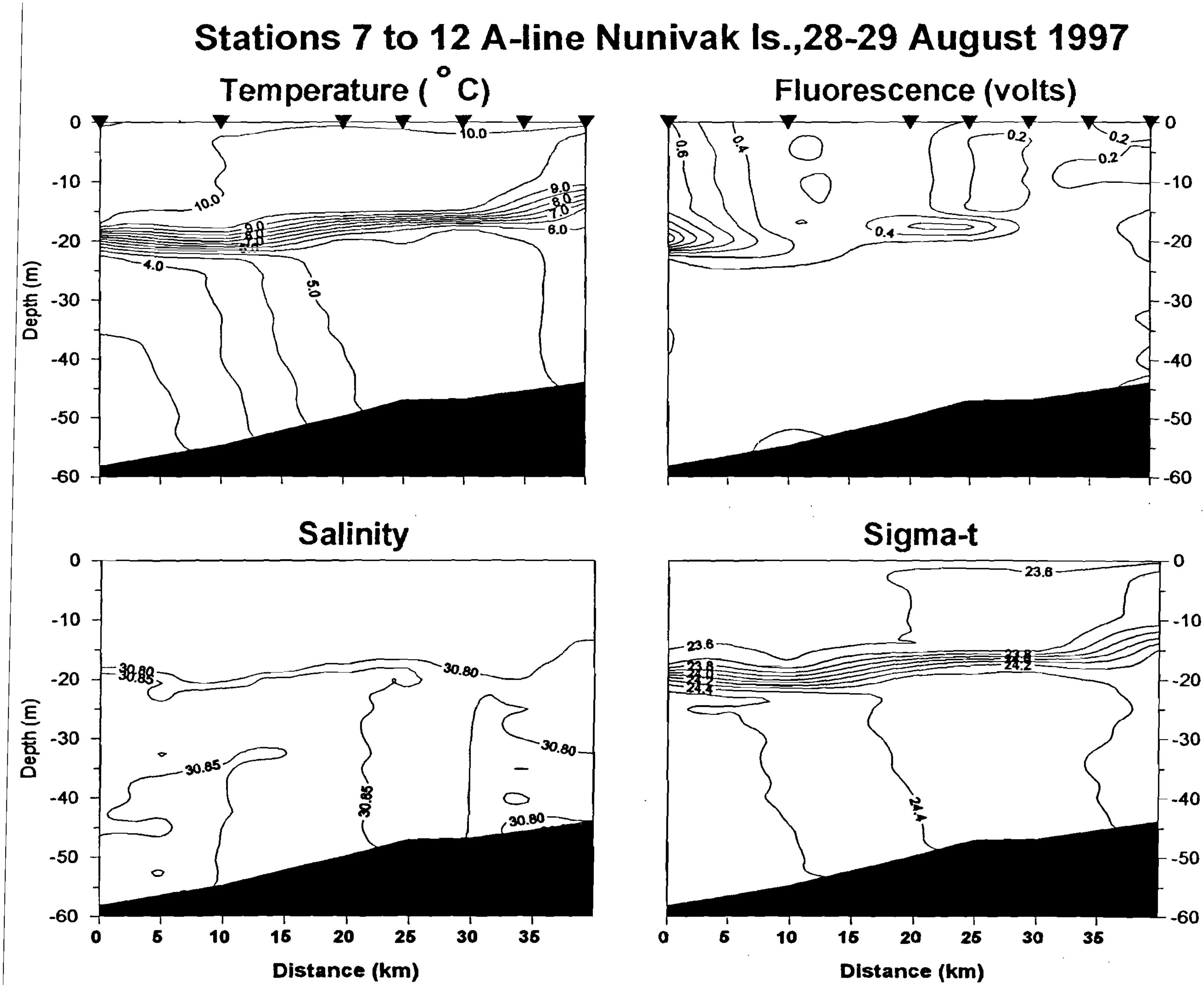

Stations 7 to 12 A-line Nunivak Is.,28-29 August 1997
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
0.6
0.4
0.2
30.80
30.85
23.6
24.2
24.4

Figure 8

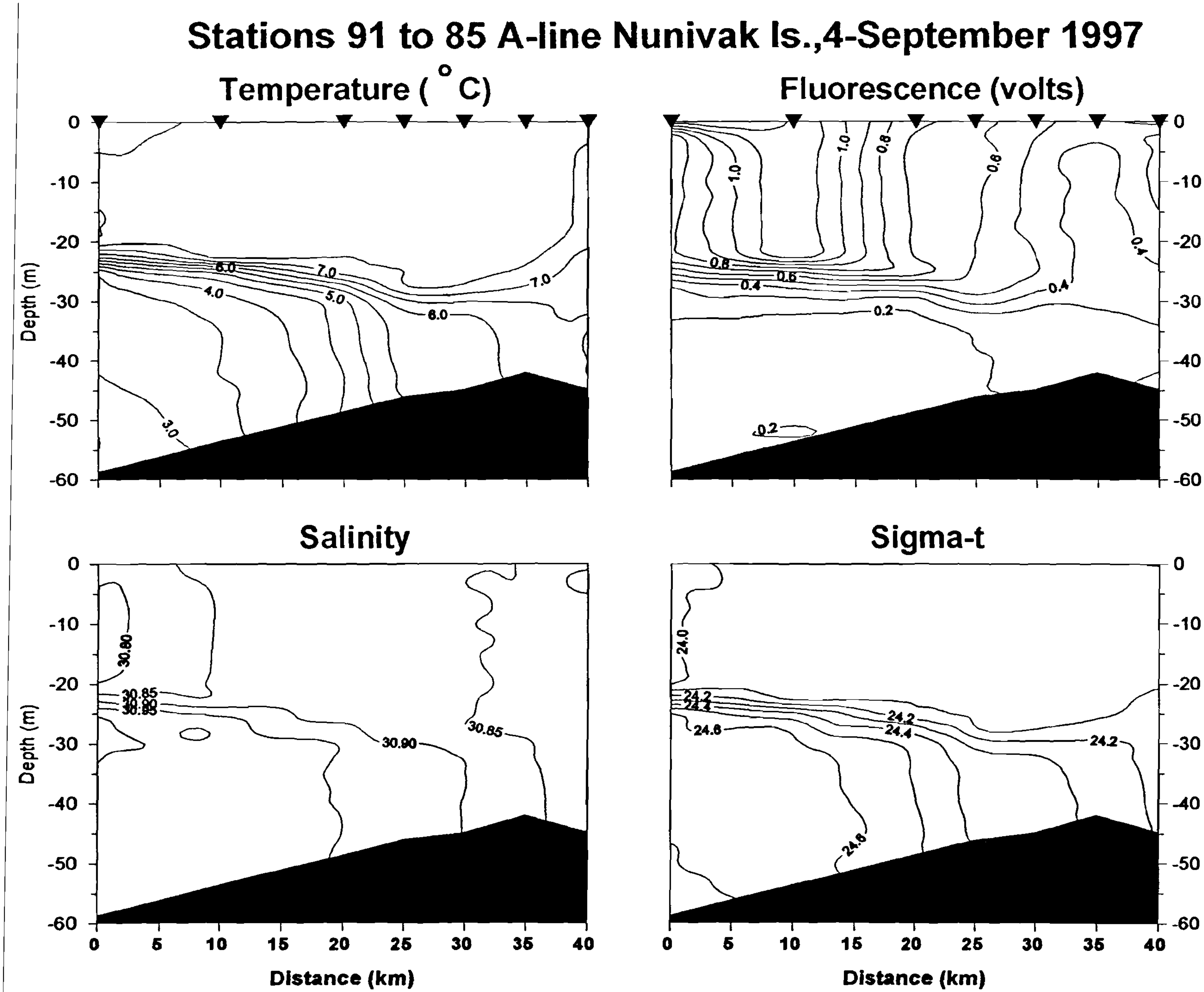

Stations 91 to 85 A-line Nunivak Is.,4-September 1997
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)
0
-10
-20
-30
-40
-50
-60
0
5
10
15
20
25
30
35
40
8.0
7.0
6.0
5.0
4.0
3.0
1.0
0.8
0.6
0.4
0.2
30.80
30.85
30.90
24.0
24.2
24.4
24.6

Figure 9

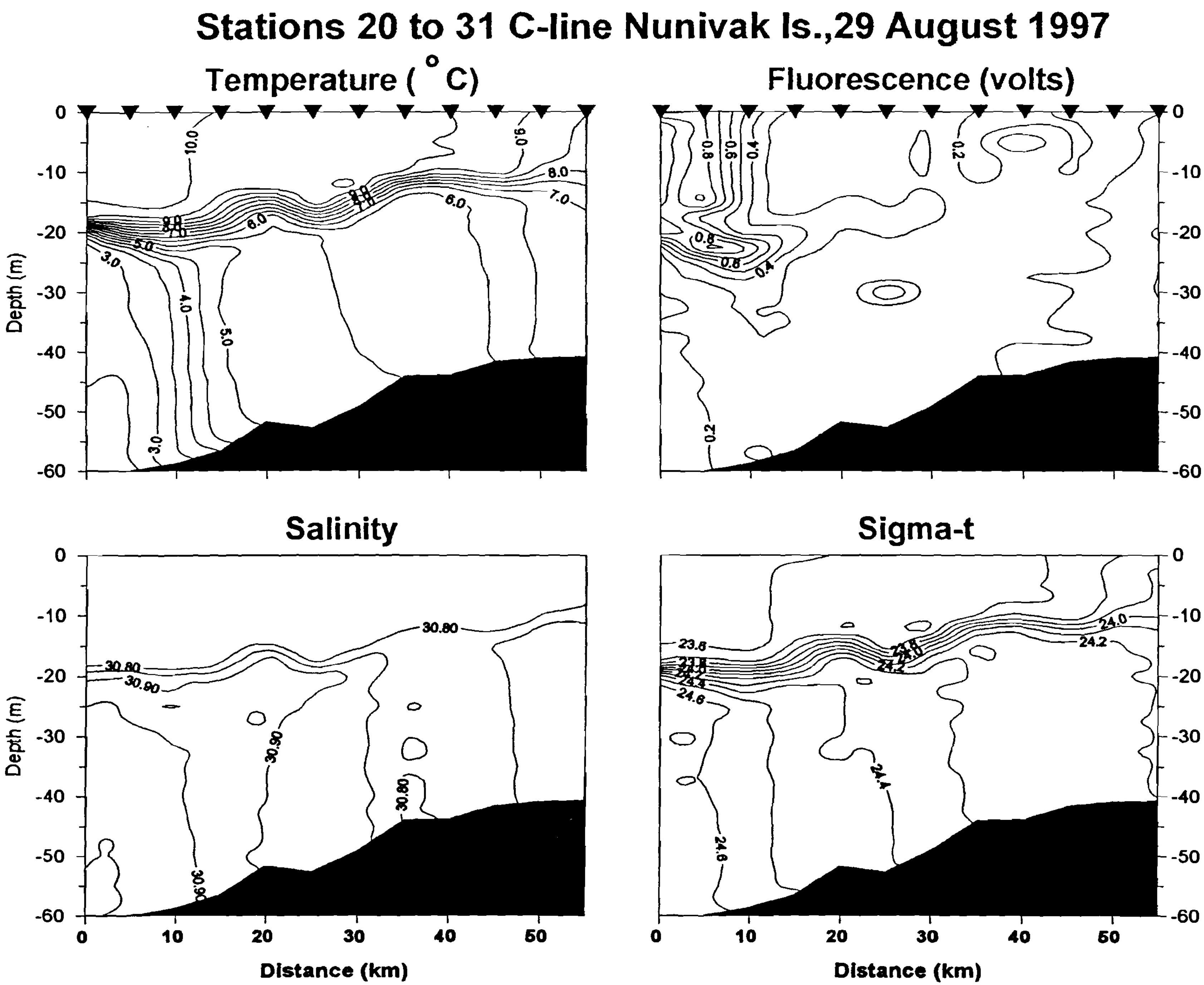

Stations 20 to 31 C-line Nunivak Is.,29 August 1997
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)

Figure 10

Stations 76 to 63 C-line Nunivak Is.,3 September 1997

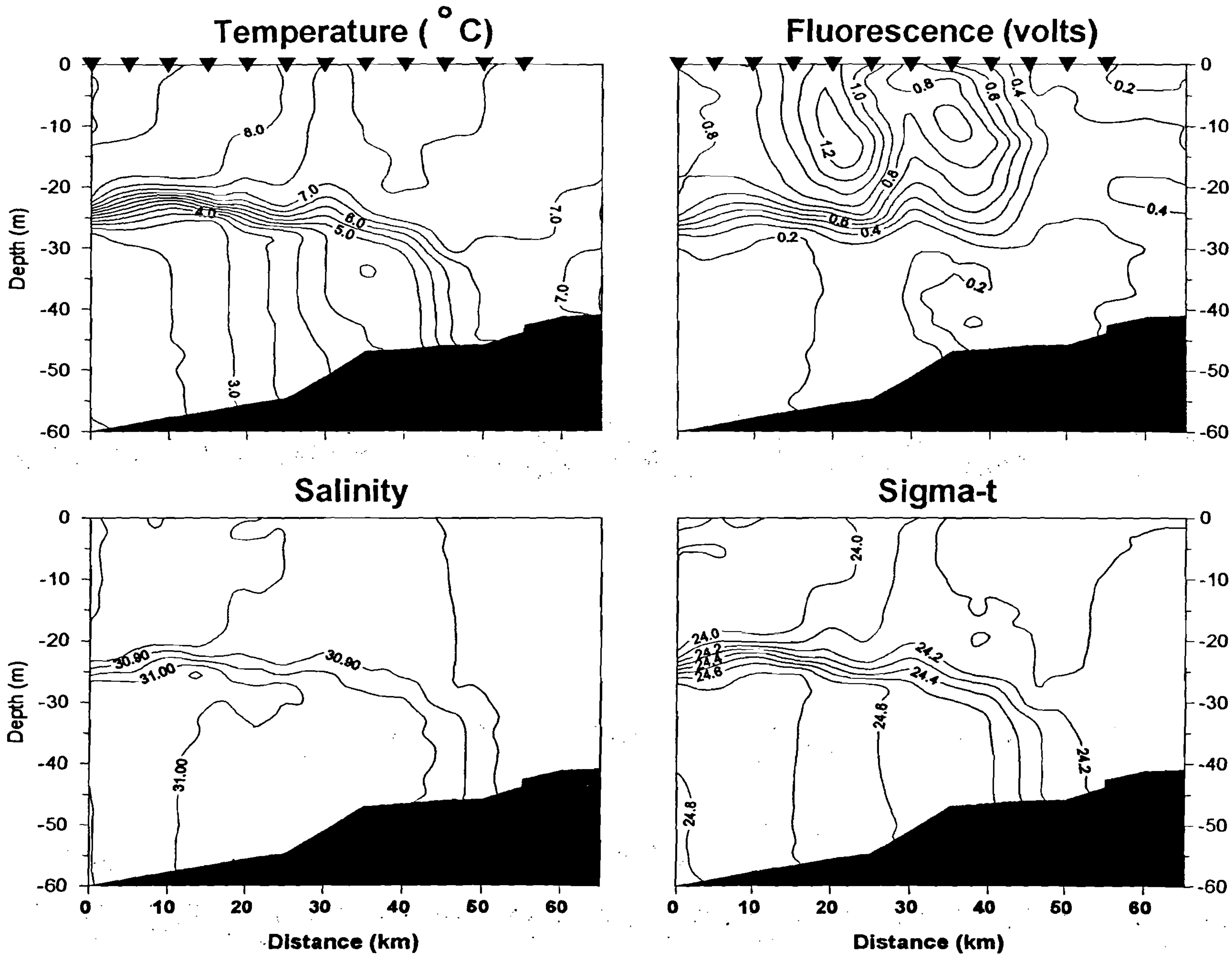


Figure 11

09/11/97 SeaPlot - (untitled) 18:41:56

Scale: 68.0km 1:262000 Chart: NOAA/16520A

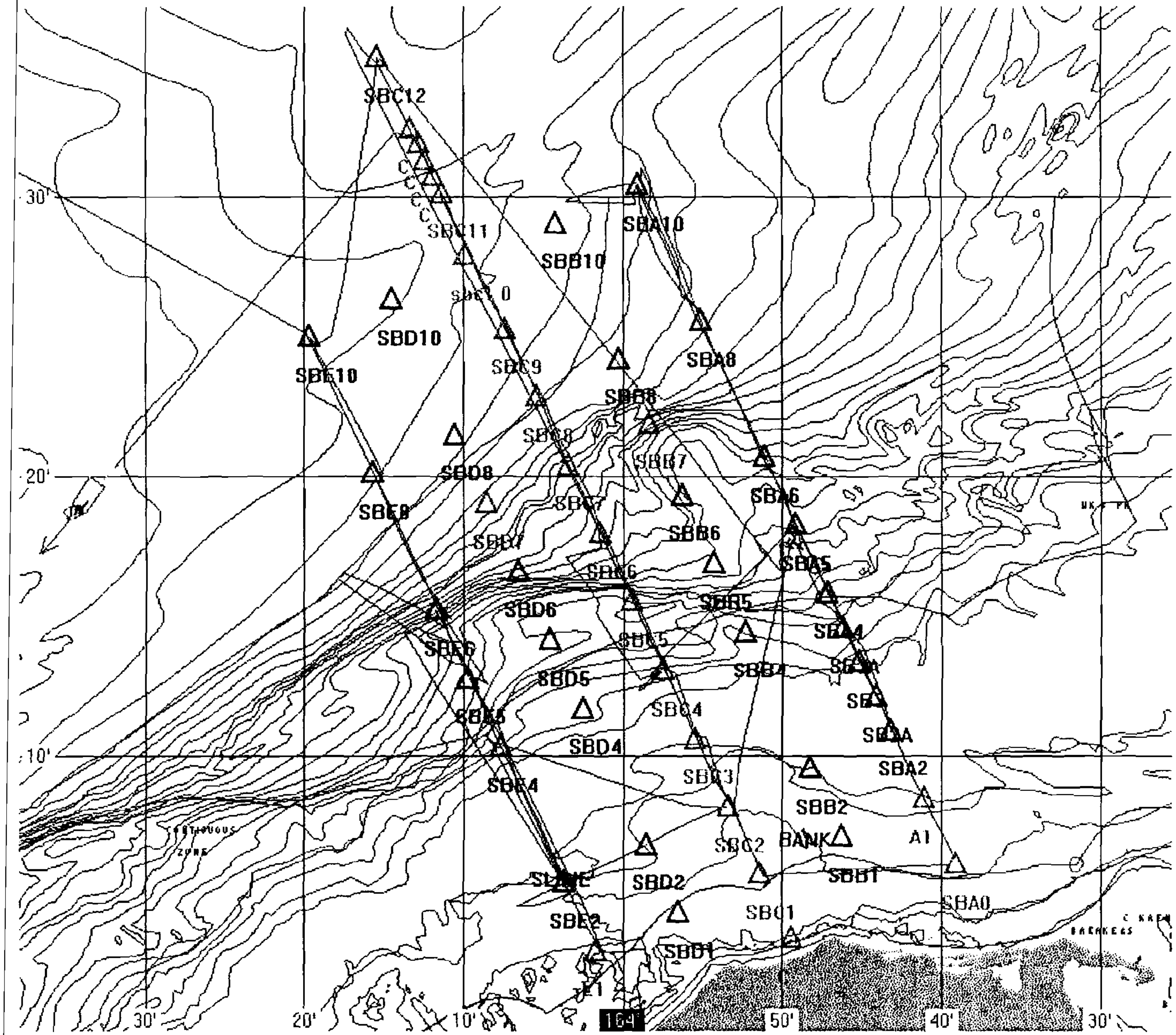


Figure 12

Stations 115 to 123 A-line Slime Bank,10-SEPTEMBER 1997

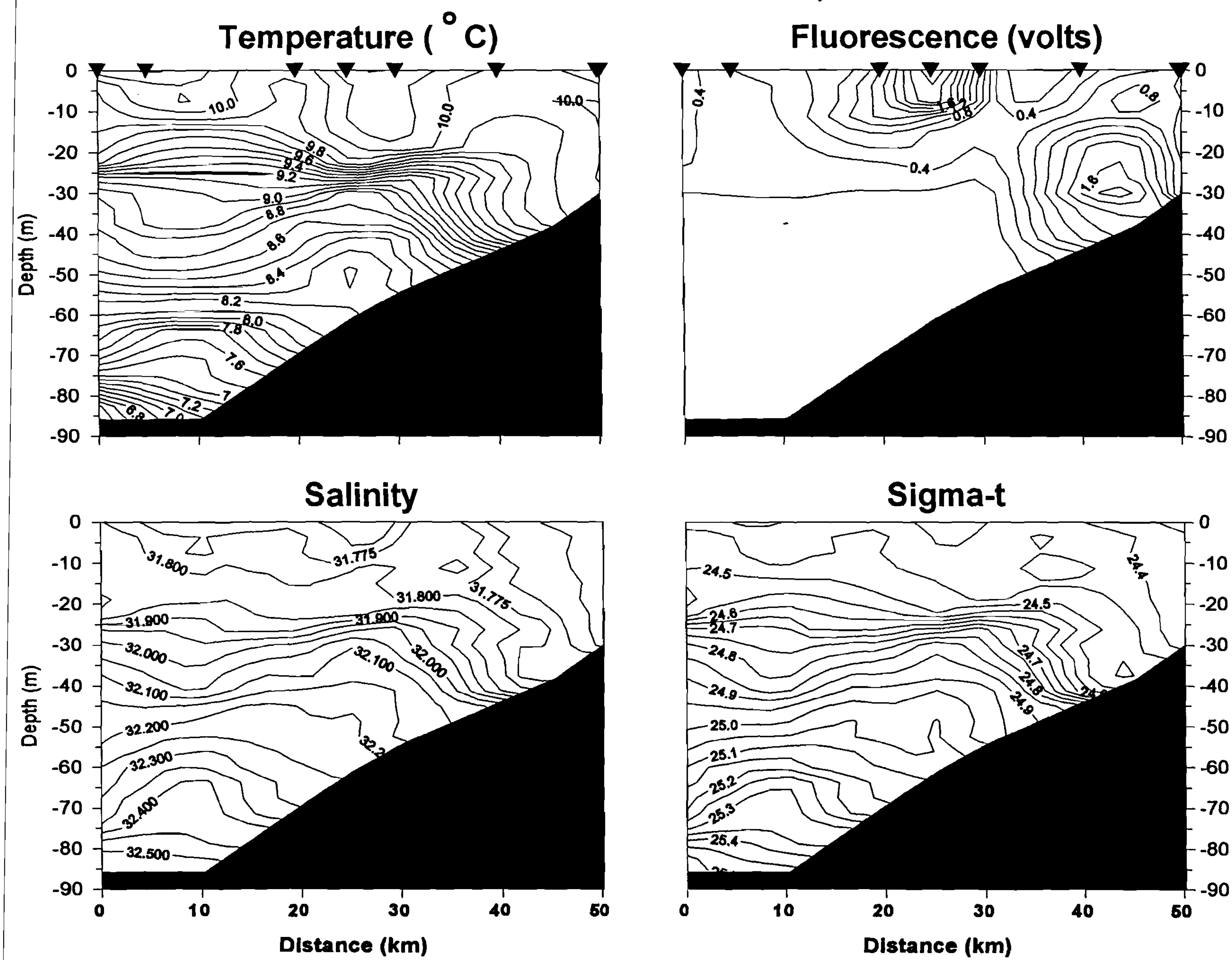
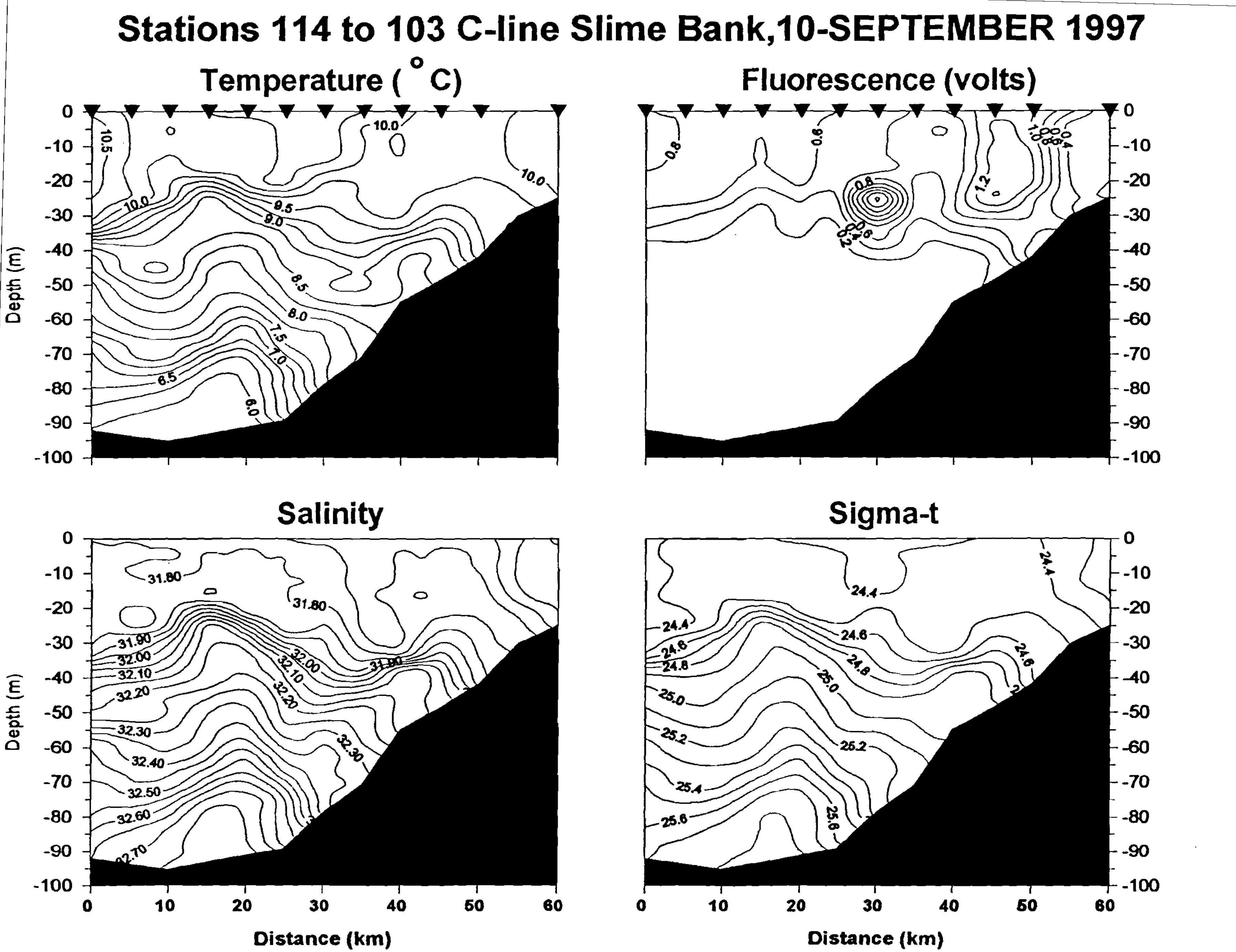


Figure 13



Stations 114 to 103 C-line Slime Bank,10-SEPTEMBER 1997
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)

Figure 14

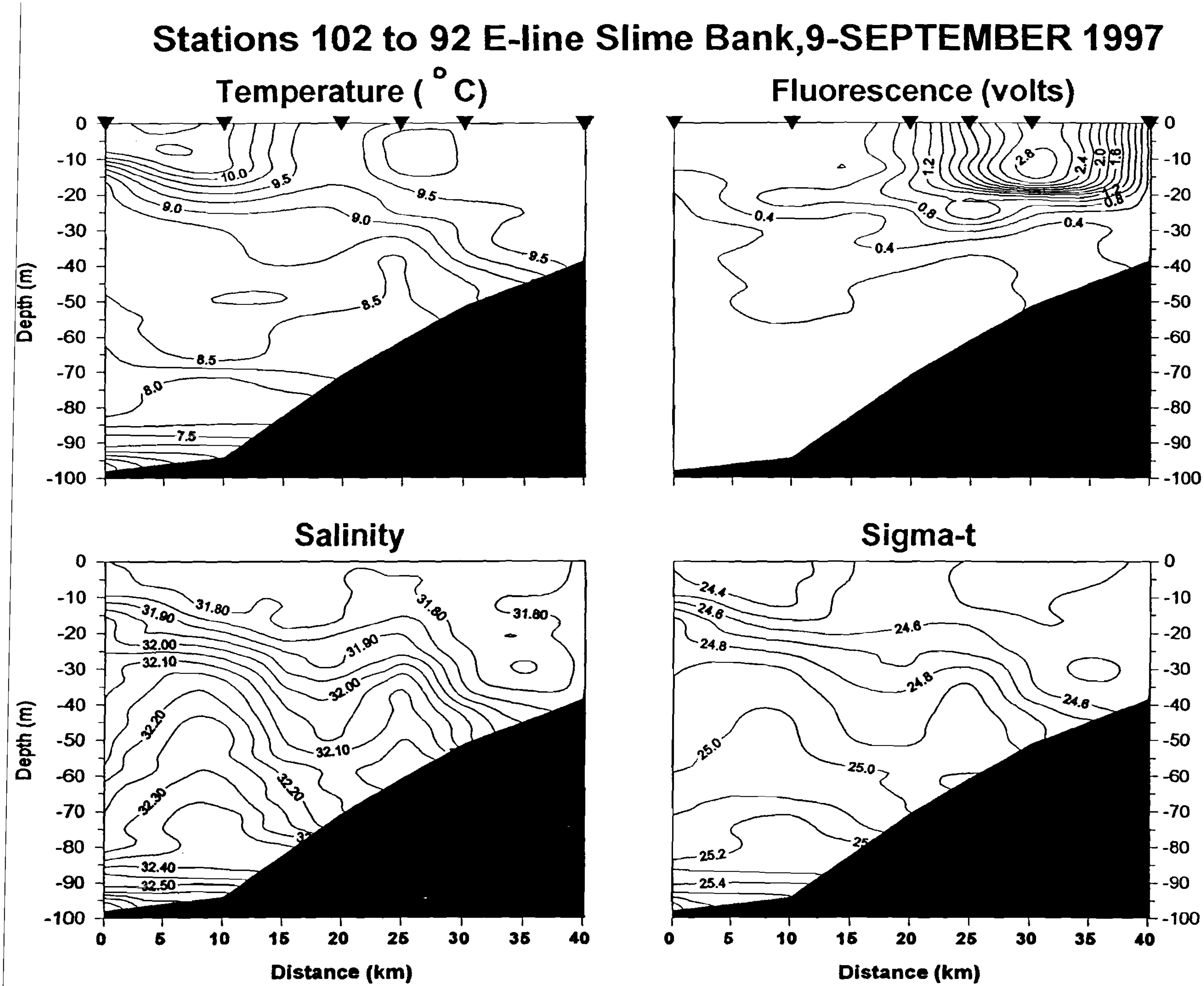

Stations 102 to 92 E-line Slime Bank,9-SEPTEMBER 1997
Temperature (°C)
Fluorescence (volts)
Salinity
Sigma-t
Depth (m)
Distance (km)

Figure 15

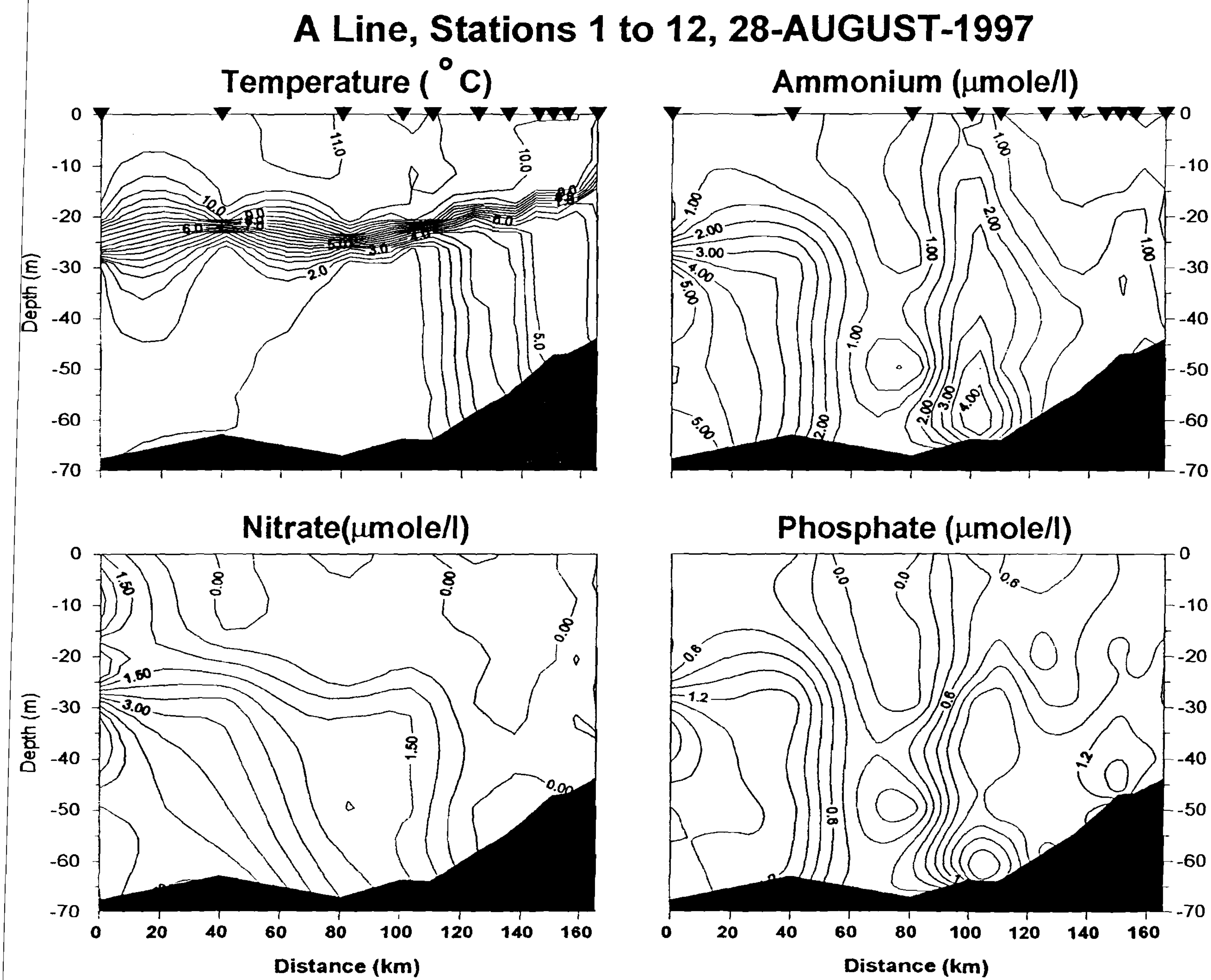

A Line, Stations 1 to 12, 28-AUGUST-1997
Temperature (°C)
Ammonium (μmole/l)
Nitrate(μmole/l)
Phosphate (μmole/l)
Depth (m)
Distance (km)
0
-10
-20
-30
-40
-50
-60
-70
0
20
40
60
80
100
120
140
160
11.0
10.0
6.0
2.0
5.0
1.00
2.00
3.00
4.00
5.00
1.50
3.00
0.00
0.6
0.8
1.2
0.0

Figure 16

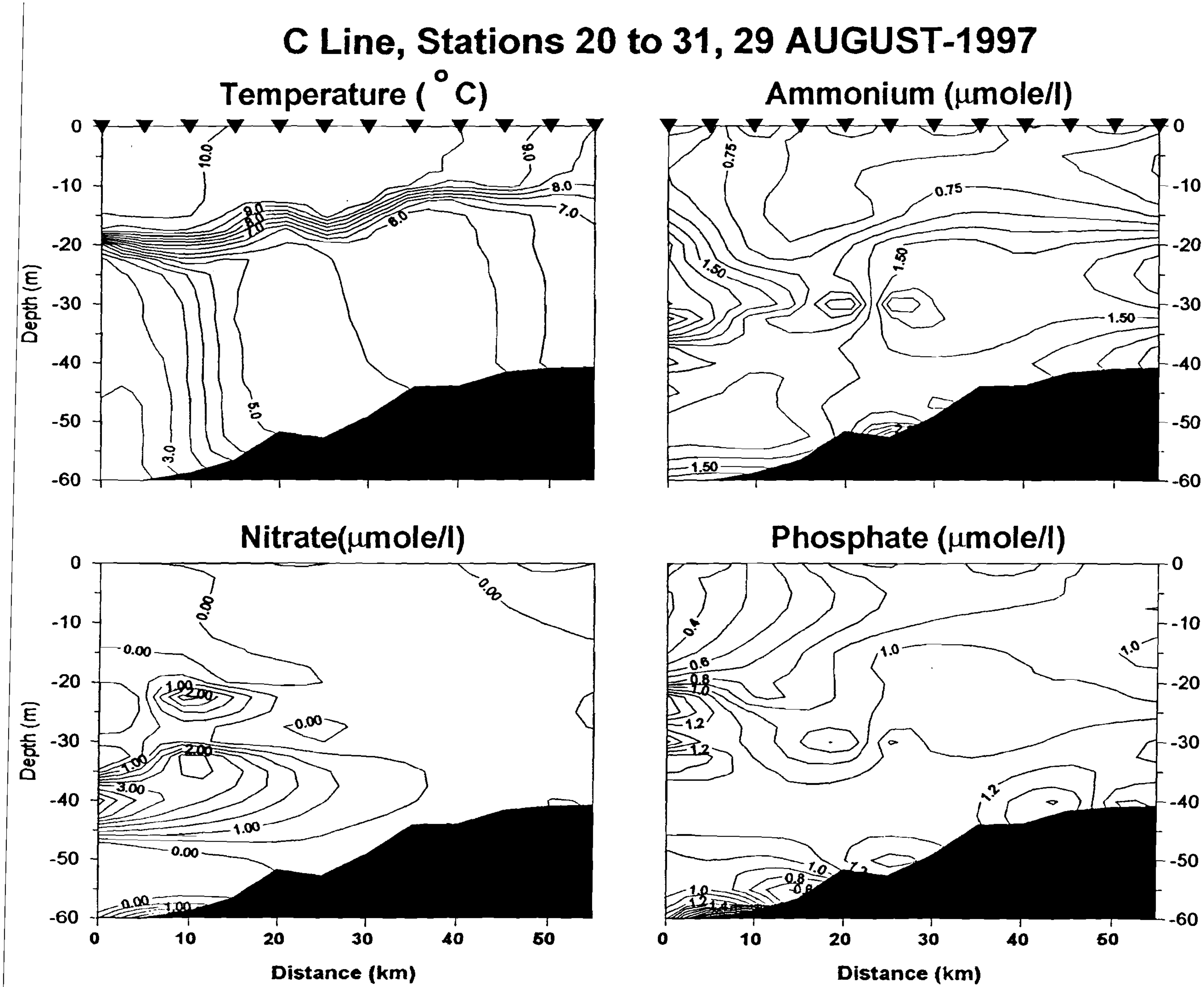

C Line, Stations 20 to 31, 29 AUGUST-1997
Temperature (°C)
Ammonium (μmole/l)
Nitrate(μmole/l)
Phosphate (μmole/l)
Depth (m)
Distance (km)
10.0
9.0
8.0
7.0
6.0
5.0
3.0
0.75
1.50
0.00
1.00
2.00
3.00
0.4
0.6
0.8
1.0
1.2

Figure 17

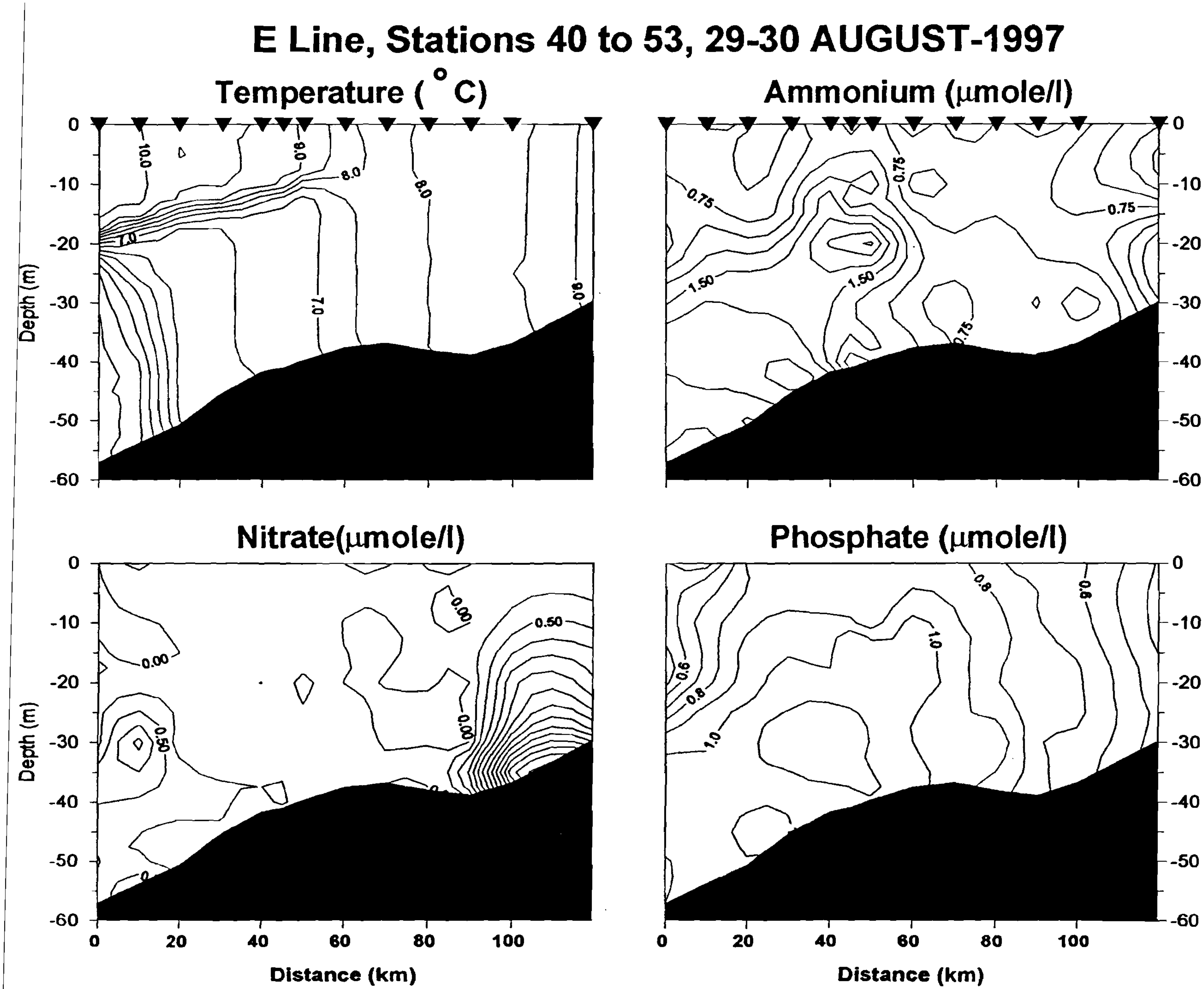
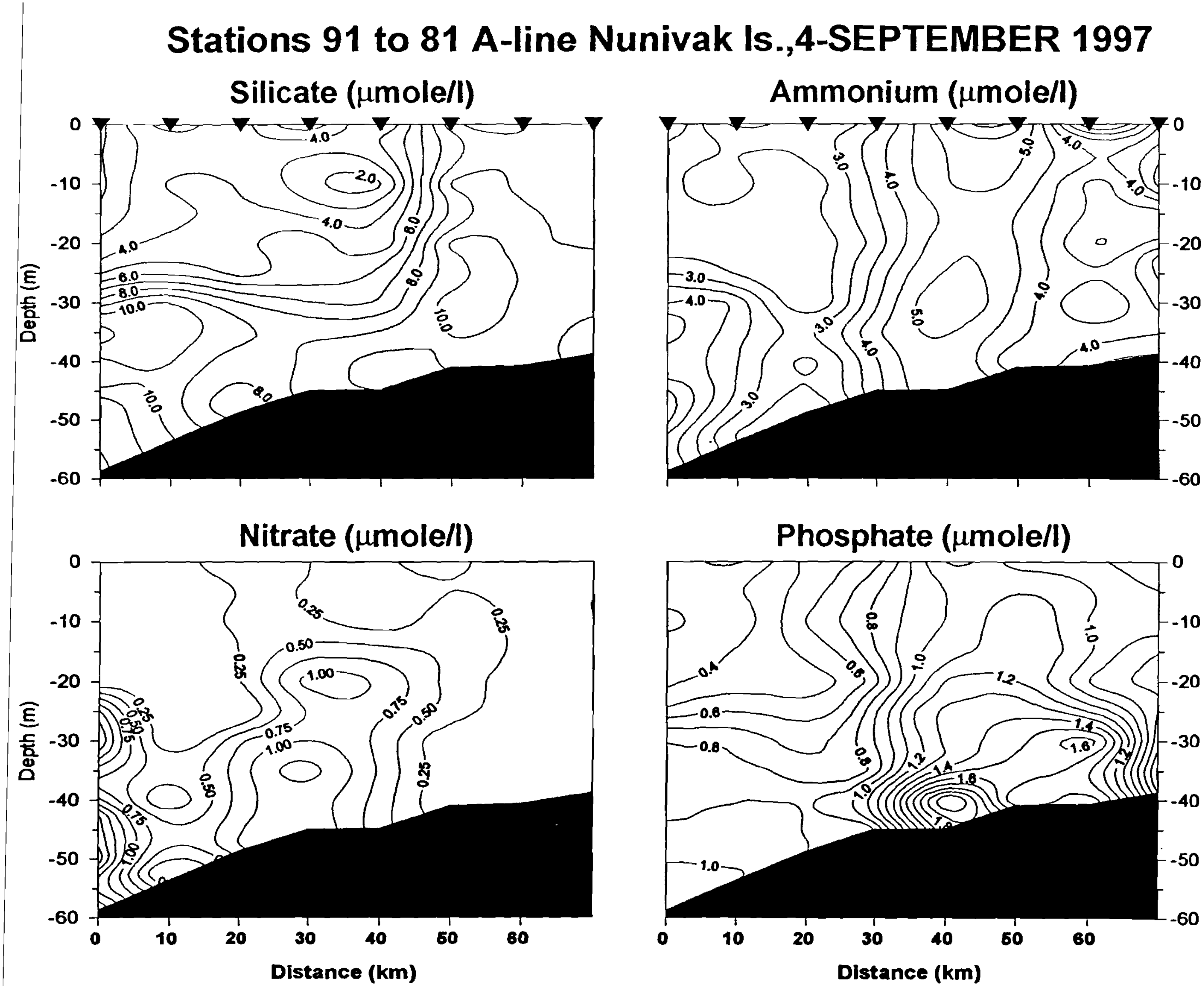

E Line, Stations 40 to 53, 29-30 AUGUST-1997
Temperature (°C)
Ammonium (μmole/l)
Nitrate(μmole/l)
Phosphate (μmole/l)
Depth (m)
Distance (km)
10.0
9.0
8.0
7.0
0.75
1.50
0.00
0.50
0.6
0.8
1.0

Figure 18

7.



Stations 91 to 81 A-line Nunivak Is.,4-SEPTEMBER 1997
Silicate (μmole/l)
Ammonium (μmole/l)
Nitrate (μmole/l)
Phosphate (μmole/l)
Depth (m)
Distance (km)

Figure 19

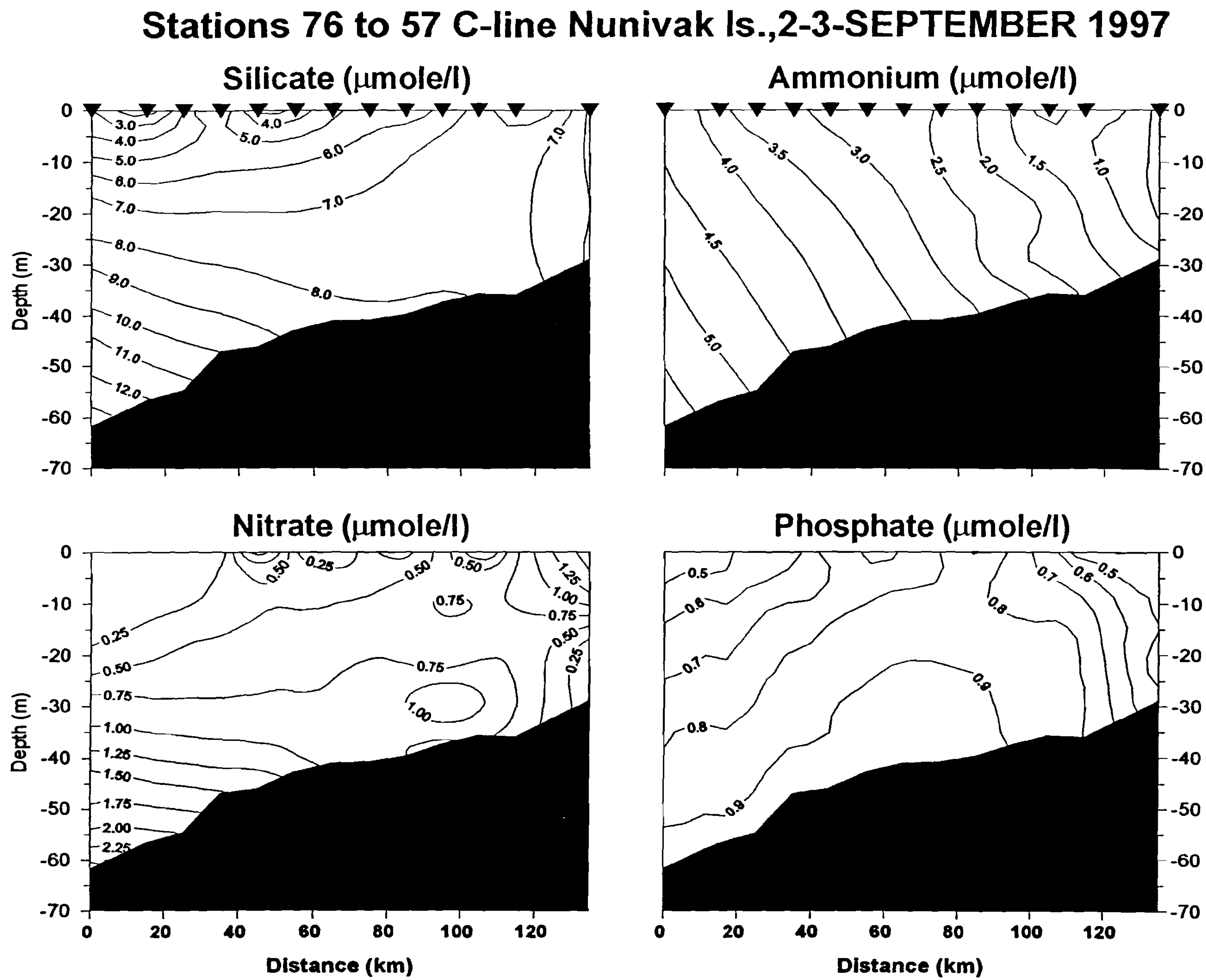

Stations 76 to 57 C-line Nunivak Is.,2-3-SEPTEMBER 1997
Silicate (μmole/l)
Ammonium (μmole/l)
Nitrate (μmole/l)
Phosphate (μmole/l)
Depth (m)
Distance (km)
0
-10
-20
-30
-40
-50
-60
-70
0
20
40
60
80
100
120

Figure 20

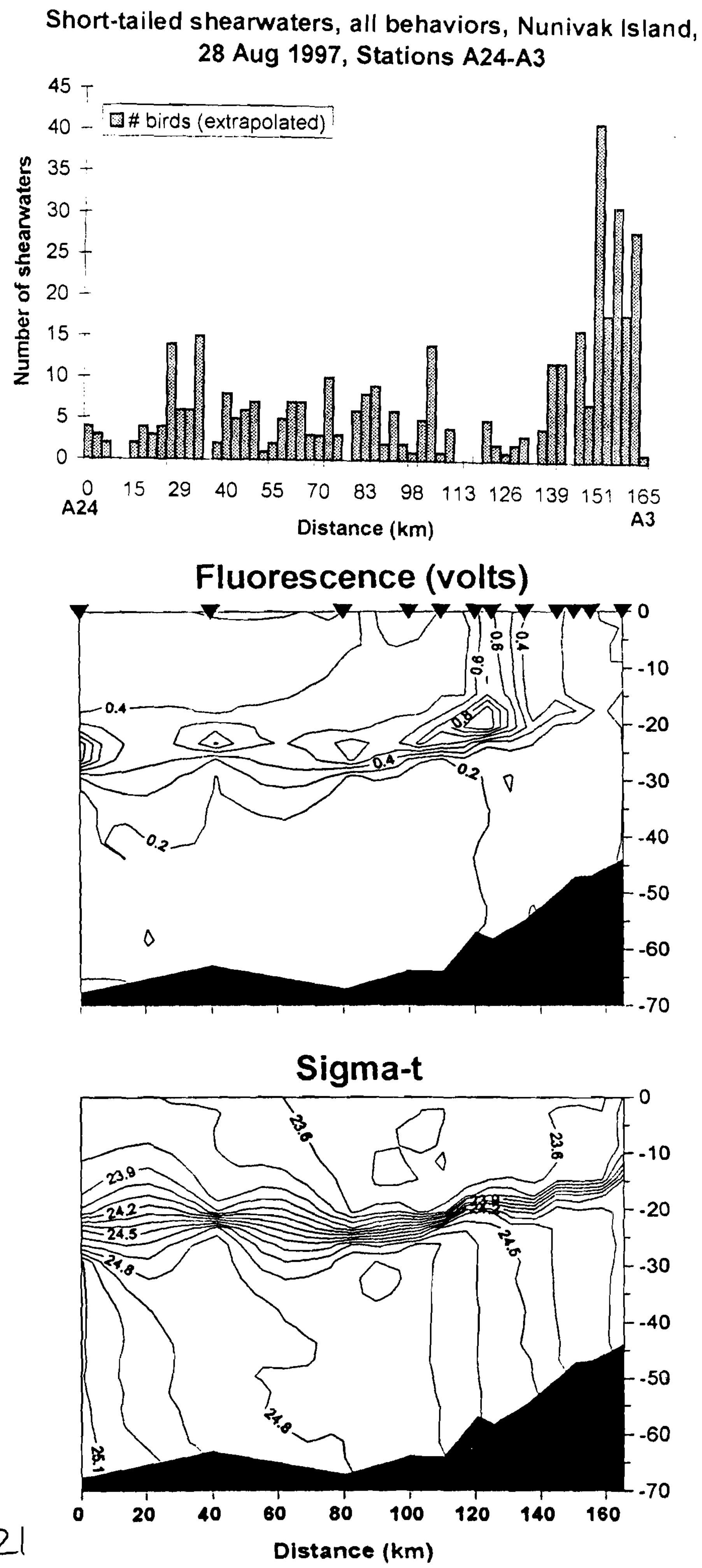

Short-tailed shearwaters, all behaviors, Nunivak Island, 28 Aug 1997, Stations A24-A3
birds (extrapolated)
Number of shearwaters
0 15 29 40 55 70 83 98 113 126 139 151 165
A24
A3
Distance (km)
Fluorescence (volts)
Sigma-t
Distance (km)

Figure 21

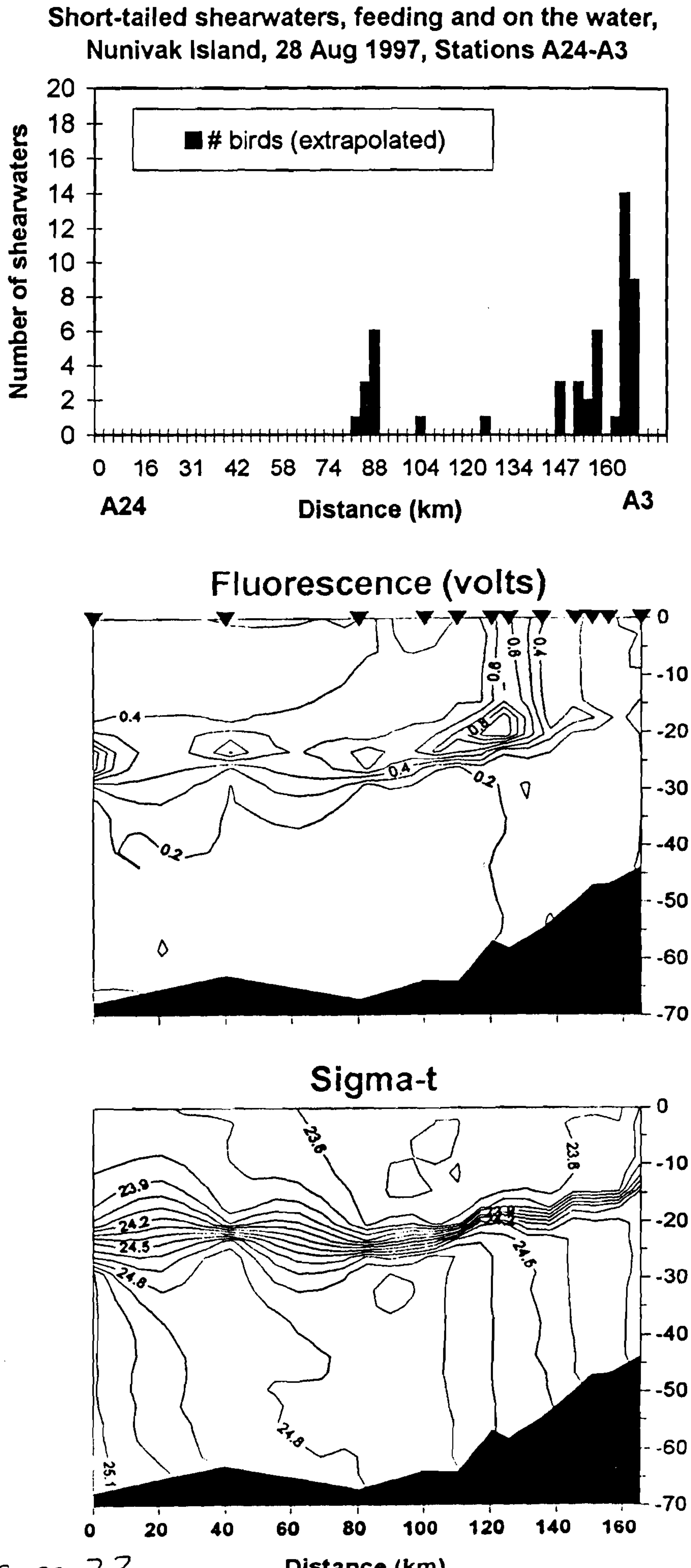
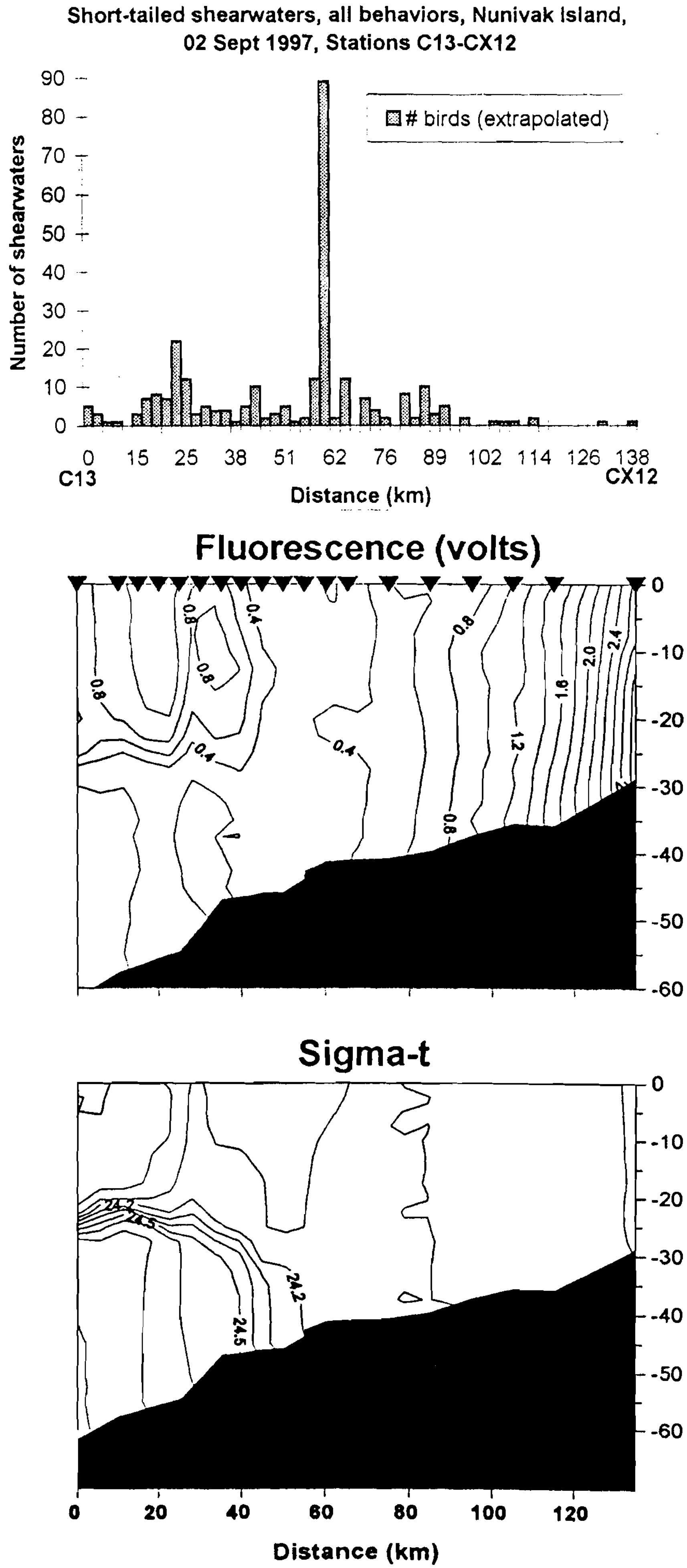

Short-tailed shearwaters, feeding and on the water,
Nunivak Island, 28 Aug 1997, Stations A24-A3
Number of shearwaters
birds (extrapolated)
0 2 4 6 8 10 12 14 16 18 20
0 16 31 42 58 74 88 104 120 134 147 160
A24
Distance (km)
A3
Fluorescence (volts)
0.4
0.2
0.6
0.8
0 -10 -20 -30 -40 -50 -60 -70
Sigma-t
23.6
23.9
24.2
24.5
24.8
25.1
0 20 40 60 80 100 120 140 160
Distance (km)

Figure 22



Short-tailed shearwaters, all behaviors, Nunivak Island,
02 Sept 1997, Stations C13-CX12
Number of shearwaters
birds (extrapolated)
0 10 20 30 40 50 60 70 80 90
0 15 25 38 51 62 76 89 102 114 126 138
C13
CX12
Distance (km)
Fluorescence (volts)
0.8
0.4
1.2
1.6
2.0
2.4
0 -10 -20 -30 -40 -50 -60
Sigma-t
24.2
24.5
0 -10 -20 -30 -40 -50 -60
0 20 40 60 80 100 120
Distance (km)

Figure 23

Short-tailed shearwaters, feeding and on the water, Nunivak Island, 02 Sept 1997, Stations C13-CX12

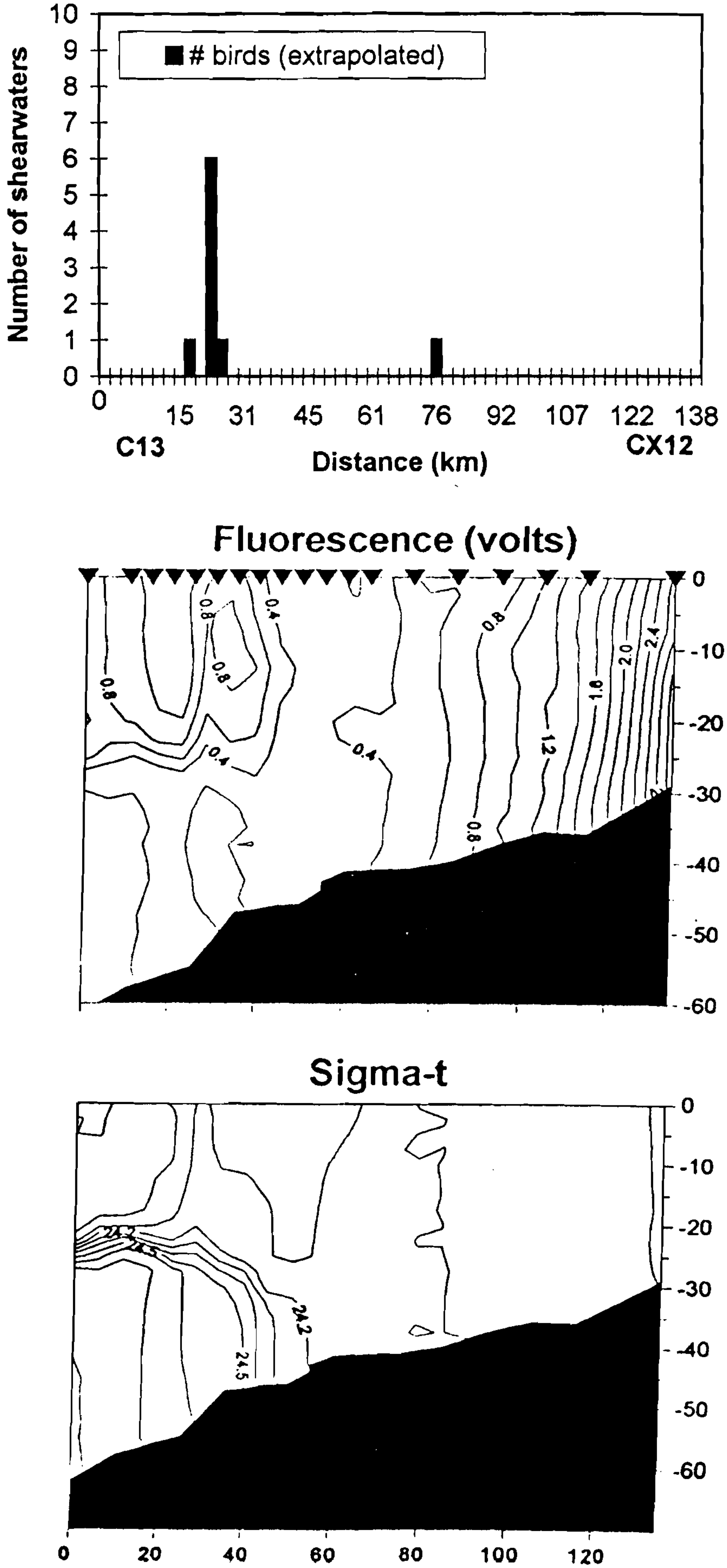


Figure 24

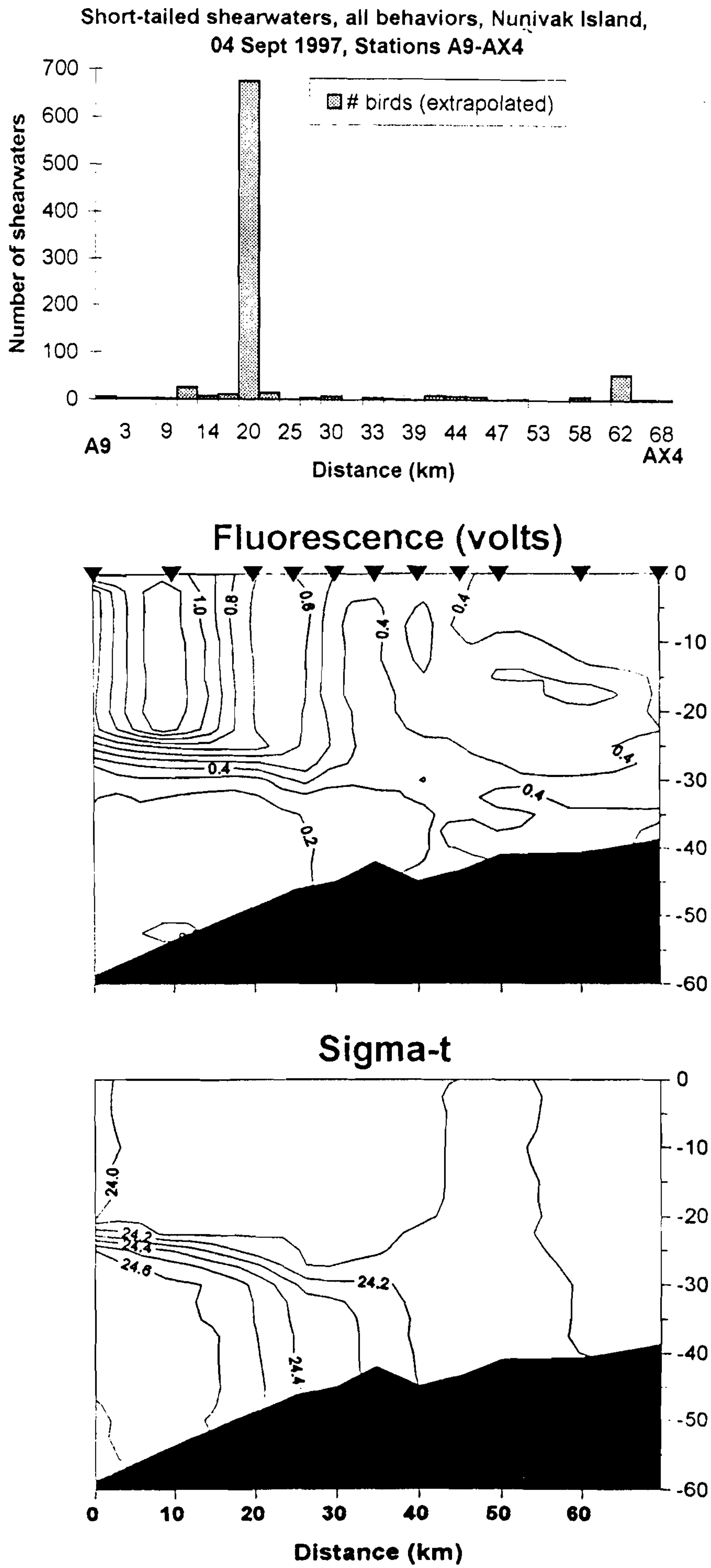

Short-tailed shearwaters, all behaviors, Nunivak Island,
04 Sept 1997, Stations A9-AX4
Number of shearwaters
700
600
500
400
300
200
100
0
birds (extrapolated)
A9
3
9
14
20
25
30
33
39
44
47
53
58
62
68
AX4
Distance (km)
Fluorescence (volts)
1.0
0.8
0.6
0.4
0.2
0
-10
-20
-30
-40
-50
-60
Sigma-t
24.0
24.2
24.4
24.6
0
10
20
30
40
50
60
Distance (km)

Figure 25

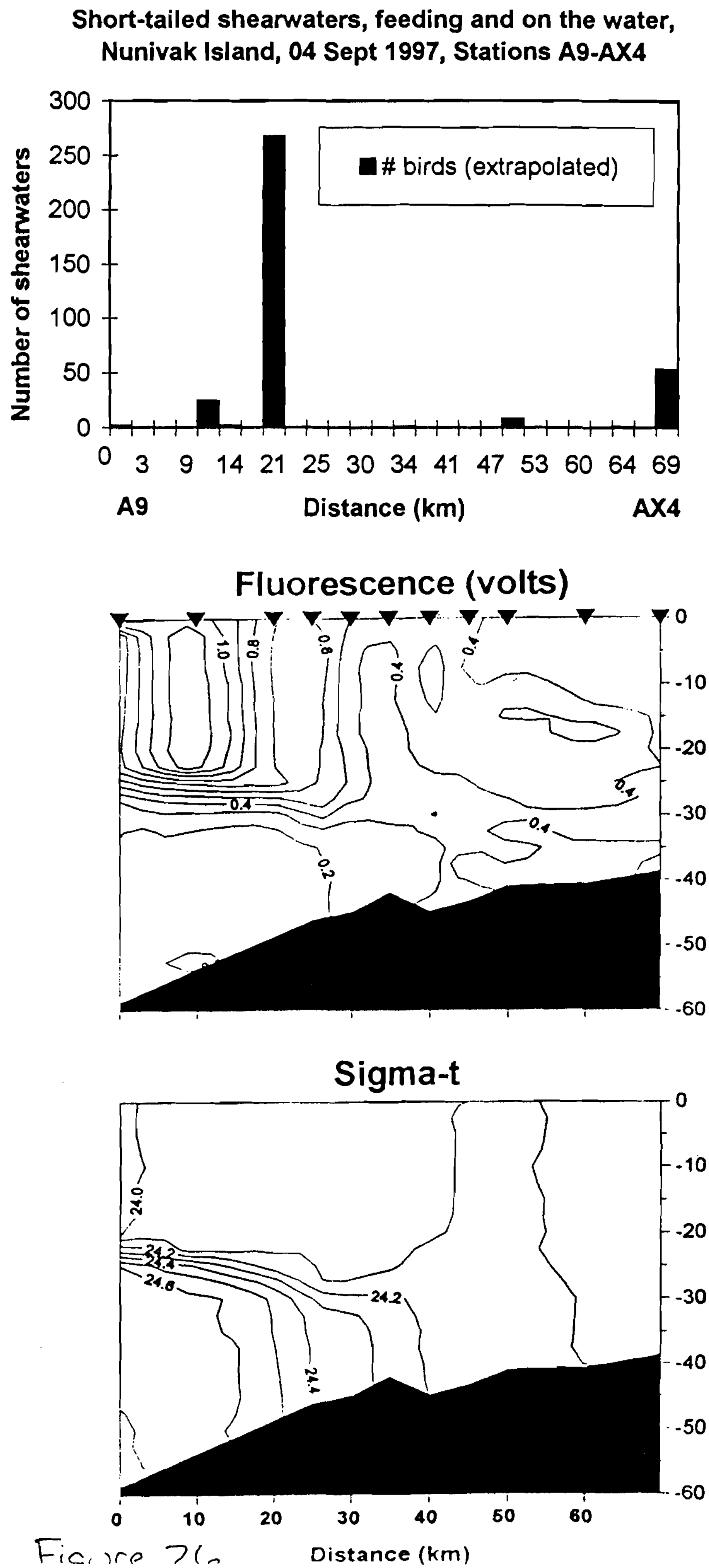

Short-tailed shearwaters, feeding and on the water,
Nunivak Island, 04 Sept 1997, Stations A9-AX4
Number of shearwaters
birds (extrapolated)
0 3 9 14 21 25 30 34 41 47 53 60 64 69
A9
Distance (km)
AX4
Fluorescence (volts)
Sigma-t
Distance (km)

Figure 7(a)

Short-tailed shearwaters, all behaviors, Slime Bank, 10 Sep 1997, Stations A10-A2

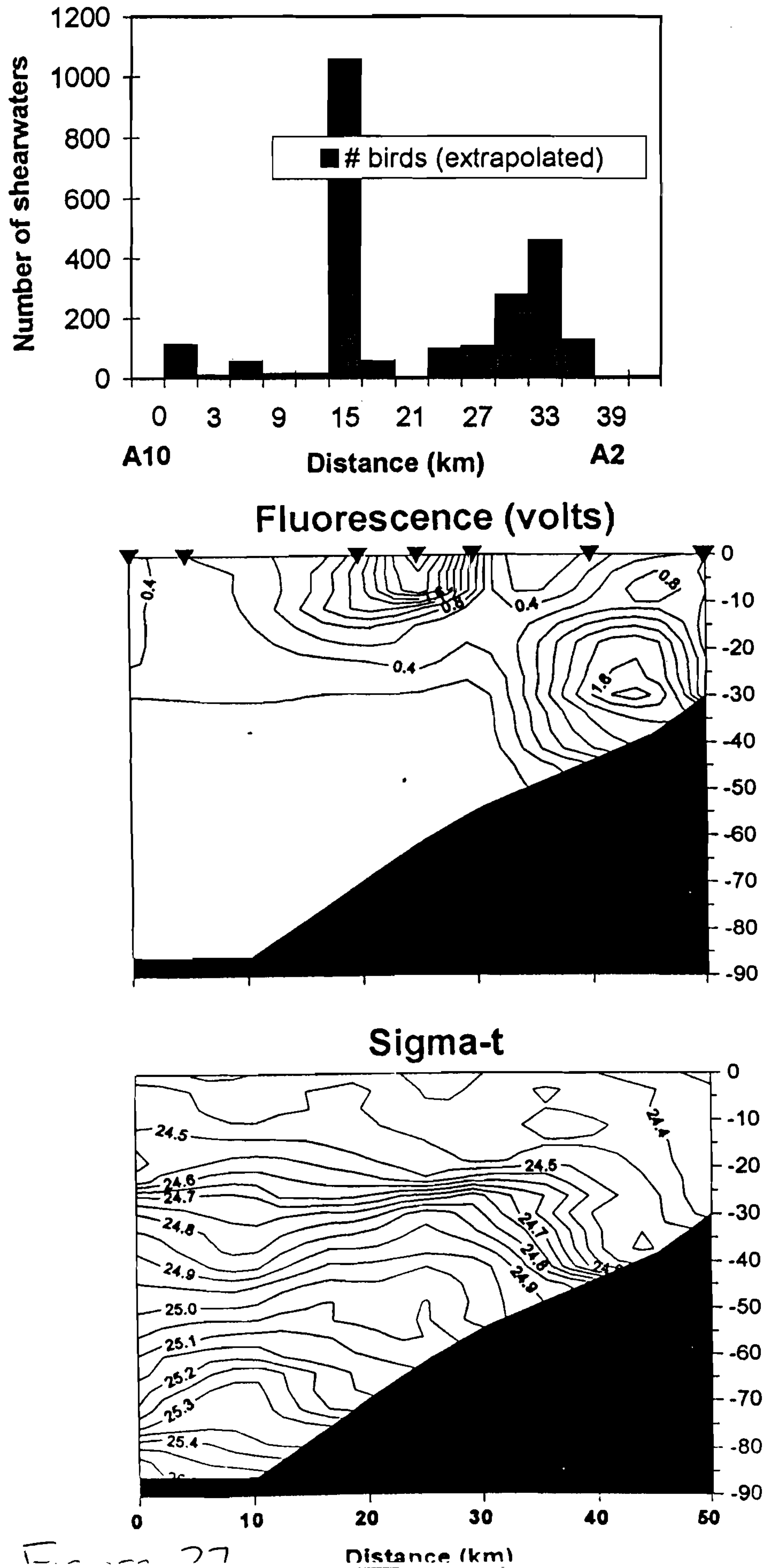


Figure 27

Short-tailed shearwaters, feeding and sitting on water, Slime Bank, 10 Sep 1997, Stations A10-A2

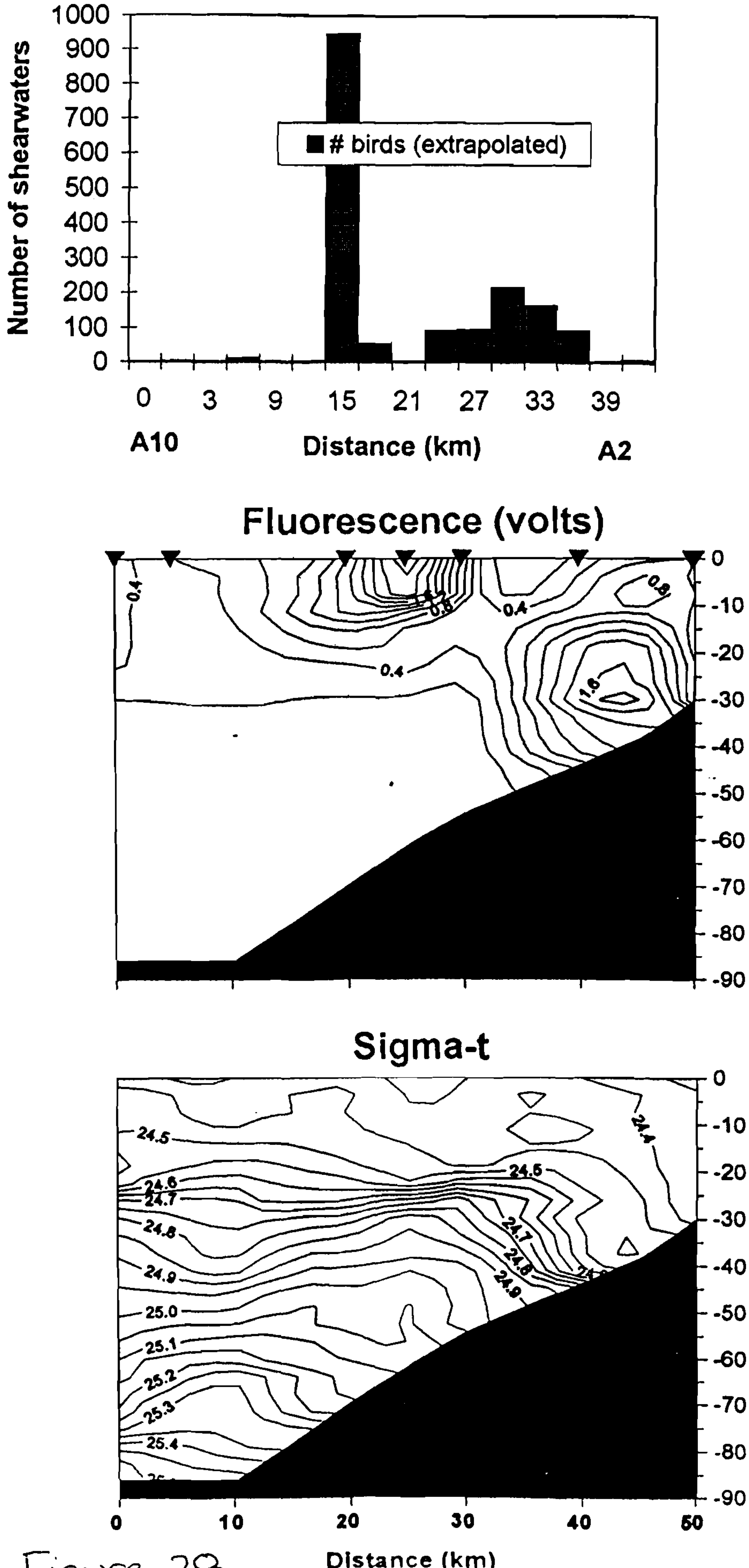


Figure 28

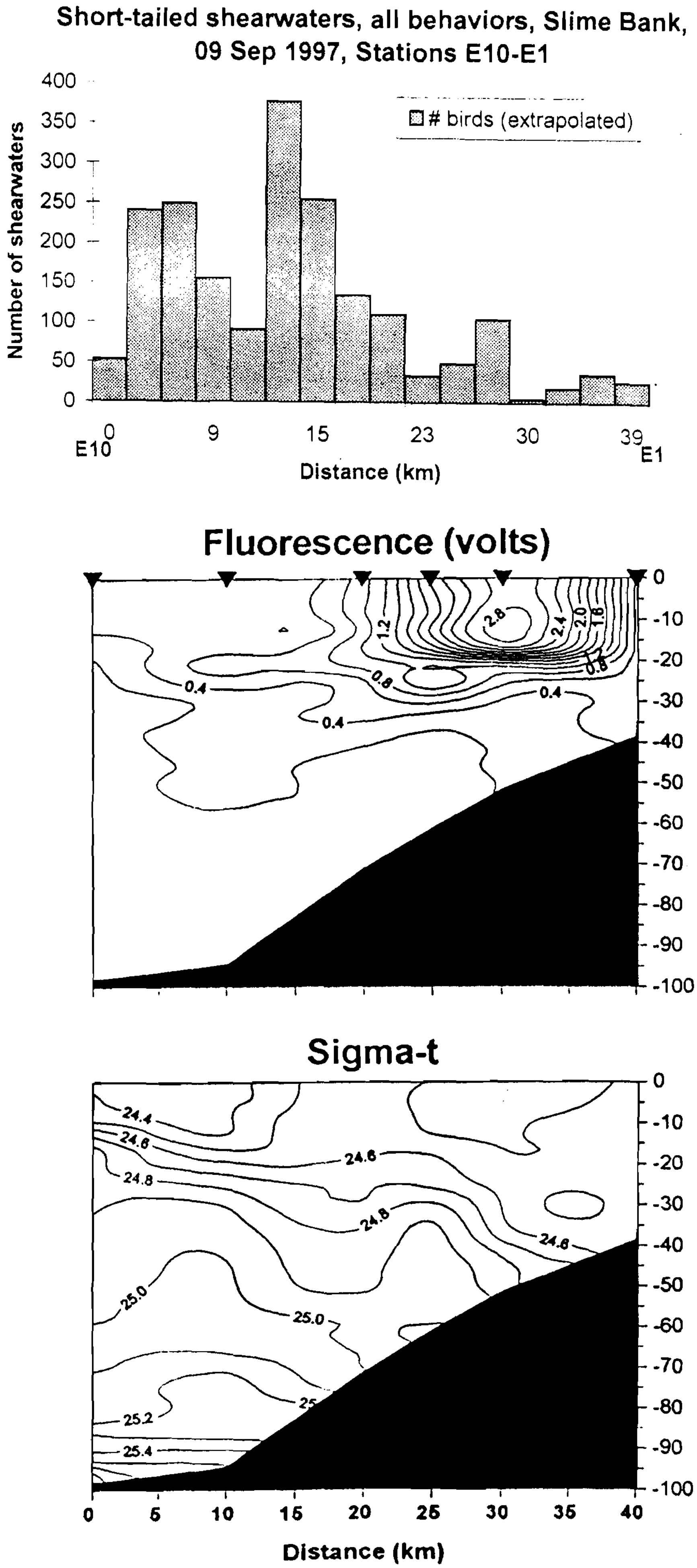

Short-tailed shearwaters, all behaviors, Slime Bank, 09 Sep 1997, Stations E10-E1
birds (extrapolated)
Number of shearwaters
0
50
100
150
200
250
300
350
400
0
9
15
23
30
39
E10
E1
Distance (km)
Fluorescence (volts)
0.4
0.8
1.2
2.8
2.4
2.0
1.6
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Sigma-t
24.4
24.6
24.8
25.0
25.2
25.4
0
5
10
15
20
25
30
35
40
Distance (km)

Figure 29

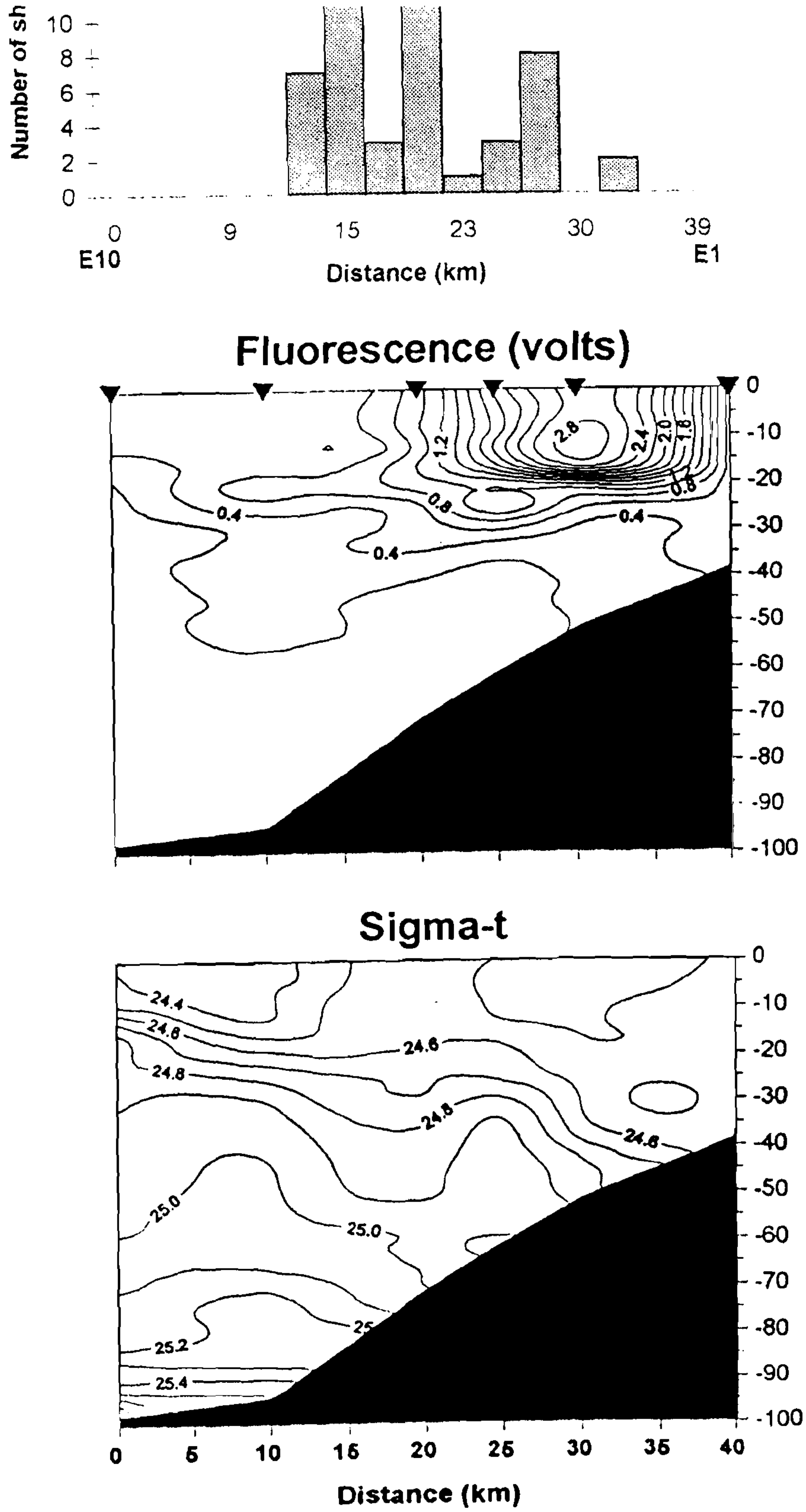

Number of sh
10
8
6
4
2
0
0
E10
9
15
23
30
39
E1
Distance (km)
Fluorescence (volts)
2.8
2.4
2.0
1.8
1.2
0.8
0.4
Sigma-t
24.4
24.6
24.8
25.0
25.2
25.4
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
5
10
15
20
25
30
35
40
Distance (km)

Figure 30