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Kodiak Area Two Layer Hydrodynamical-Numerical (HN) Model

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by

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INTRODUCTION

Multiple layer Hydrodynamical-Numerical (HN) models of the Hansen type have been utilized in numerous studies to determine typical tidal current fields based on astronomical tide station components and mean wind fields (Hamilton 1982; Harding 1976; Bauer 1978; Callaway 1976; Laevastu 1974 a-d). These HN models generated the tidal current fields utilized in models of advection and diffusion of hypothetical pollutants and can be useful in fisheries models that attempt to reproduce observed migration patterns and dispersions of eggs and larvae from spawning grounds.

This document provides the overview of the sequence of programs installed on the Burroughs computers at NWAFC that produce and display the model results. File names and control card examples are provided. The detailed descriptions of the HN models are found in Laevastu (1974 a) and Bauer (1978) and are not reproduced in this document.

BACKGROUND

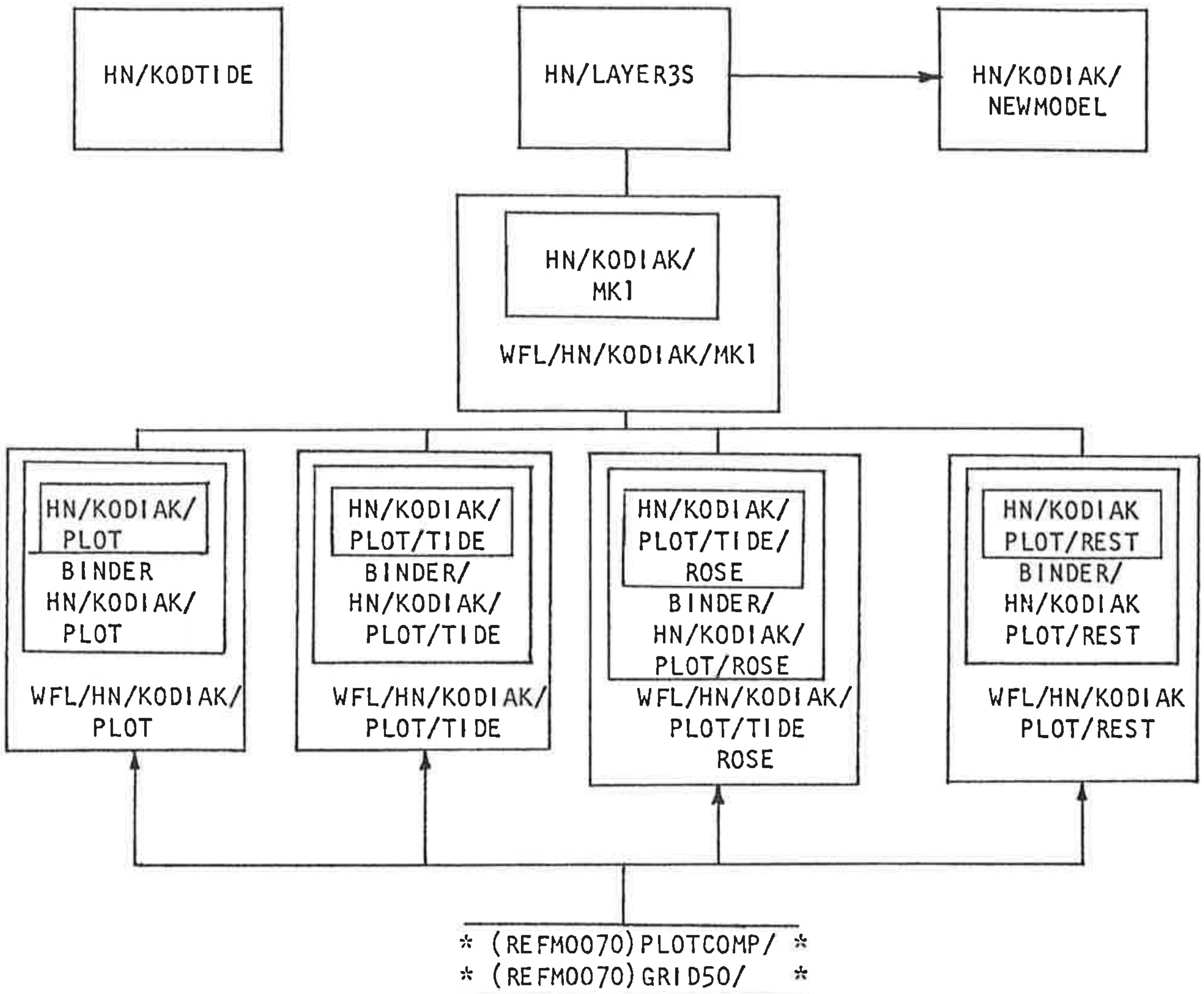
The optimized two layer HN model was installed on the University of Washington (UW) Control Data Corporation 6400 computer in 1977 and run on the Kodiak area grid using a test set up. This test model was not tuned with realistic tidal inputs. The installation of the HN model on the NWAFC Burroughs computer required a code conversion that was accomplished in three steps.

First, the optimized model programs LAYER3S and LAYER3 (Bauer 1978) were converted to the Burroughs and tests were made using the original Kodiak 42X31 grid until the results matched those saved from test runs made with the model in 1977 on the UW computer. Second, the MK1 program was created by converting the New York Bight model (Laevastu 1974 b) to the Burroughs and then adapting it to the Kodiak area. The LAYER3S program was used to convert the data fields from the 42X31 grid used in the LAYER3 model to the 44X33 grid configuration used in the MK1 model. The results from the LAYER3 and MK1 were compared to insure the converted and reconfigured MK1 model was functional. Third, the KODIAK area grid was extended to the southwest, creating a 50X31 grid that included the canyon south of the Shelikof Strait. This expanded grid was processed by the LAYER3S into the 52X33 grid format, and the CANDE editor was used to add the MK1 control cards to the beginning and ending of the LAYER3S output file.

The MK1 model was run and the output was used to test the three new display package programs. These three programs produce the horizontal water height and velocity vector plots, the tide cycle-velocity vector plots and the tidal ellipse plots. All three plot programs use the GRIDS package and together replace the LAYER3F program in the optimized HN model code, the foundation from which the GRIDS was developed (Pola, 1981; Pola Swan, 1982 and 1983).

OVERVIEW

The program sequence (Figure 1) involves seven programs identified by the file names shown in the innermost boxes. The outermost boxes show the Burroughs' Work Flow Language (WFL) files used to execute object or bound programs. Intermediate boxes, present for the plot jobs, show the binding step decks that are used to bind the compiled programs with the two REFM0070 files shown at the bottom of Figure 1 as a star-edged box. These files are the separately compiled GRIDS package and Tektronics set of plotting routines. These binding decks



Note: File WFL/HN/KODIAK/PLOT runs the bound file HN/KODIAK/PLOT/BOUND created by file BINDER/HN/KODIAK/PLOT. The same convention is followed for the TIDE, ROSE, and REST programs.

Figure 1. Source programs, binding decks, WFL and plotting software file names and their interrelationships.

create files with the same program name, ending with the name BOUND.

Programs HN/KODTIDE compute the tide heights at KODIAK tide stations from the astronomical tide components given on Monaco tide station sheet 420 for the K1, O1, M2 and S2 components.

Program HN/KODIAK/NEWMODEL, referred to by the last name NEWMODEL, is the optimized multilayer HN code described by Bauer (1978) and Stroud (1978) configured for two layers and boundary conditions that match the UW test results. NEWMODEL was only used during the installation of the MK1 model and is not configured for the extended KODIAK grid.

Program HN/KODIAK/MK1 is the converted New York Bight model configured for the expanded Kodiak grid with pollution and transport functions deactivated.

Program HN/KODIAK/PLOT is the program that plots hourly water height contours and velocity vectors on the grid with the land background and bathymetric contours as shown in Appendix A.

Program HN/KODIAK/PLOT/TIDE produces the plots of data saved at special points as tidal curves with superimposed velocity vectors as shown in Appendix B.

Program HN/KODIAK/PLOT/TIDE/ROSE produces a vector format tidal ellipse for each species point as shown in Appendix C.

Program HN/KODIAK/PLOT/REST produces a vector plot of rest currents beginning at 54,600 sec and ending at 144,000 sec as shown in Appendix D.

Figure 2 expands the sequence of programs by adding the linking input and output file names and the steps where the Burroughs system editor, CANDE, is used to modify the contents of the data files. The numbers to the right of the starred file boxes are the Burroughs file numbers associated with the input to the next program in the sequence. The numbers to the left are the output file numbers. For instance, in Figure 2 file HN/KODIAK/OLDMDATA is generated by

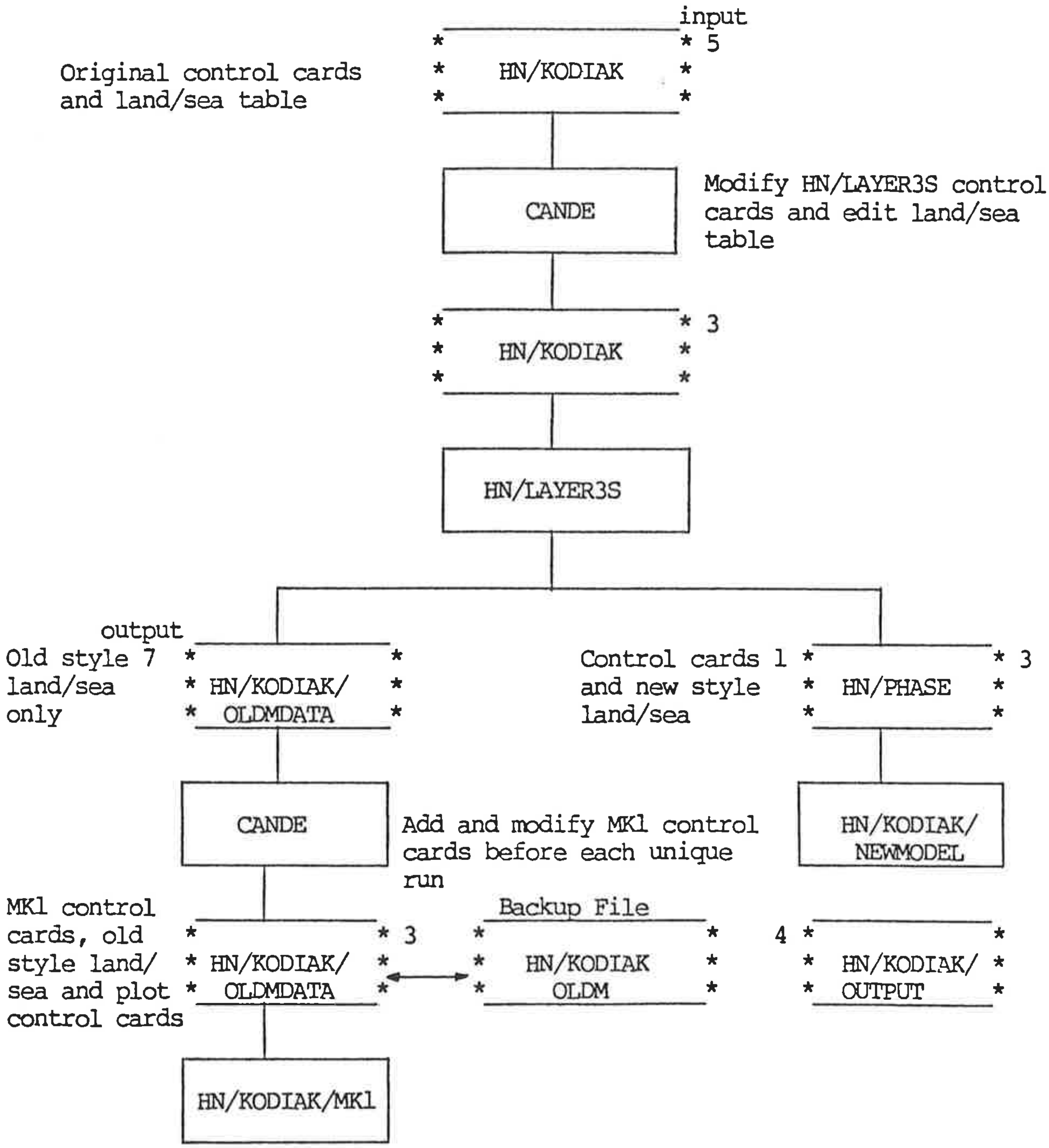


Figure 2. Data preparation program sequence with data and program file names.

program HN/LAYER3S as file 7 but is read by program HN/KODIAK/MK1 as file 3.

Figure 3 expands the program sequence used for production runs by showing additional input and output files. The primary control file for the MK1 model is the file HN/KODIAK/OLDMDATA, and CANDE is used to make changes to the run specification in this file. The file contains the initial control cards, the land/sea card decks and the plot control cards, which are described in the Run Instruction section that follows.

When the HN/KODIAK/MK1 model is run the output overwrites the previous run results unless the file names are altered. Separate files are created for the water height and velocity vector fields for each layer. These are the LAYER1 and LAYER2 files, which are read into the PLOT program. The special point velocity and tide heights are also stored in separate files for each layer. The special point plot programs TIDE and ROSE are run from either the SPECPT1 or the SPECPT2 file. The MK1 model can be restarted using the HN/KODIAK/SAVE file, which contains the final water height and velocity component fields.

By far the most complicated set up of files occurs in the use of the program HN/KODIAK/PLOT. PLOT draws both the horizontal contours and vector field plots. The PLOT program has two modes of operation, which complicates the file structure. In the first mode the program generates and saves a compact file of background topographic data for the area. In the second mode it accesses the saved background files.

All four plot programs, PLOT, TIDE, ROSE, and REST are configured to produce graphics using the Tektronics terminal.

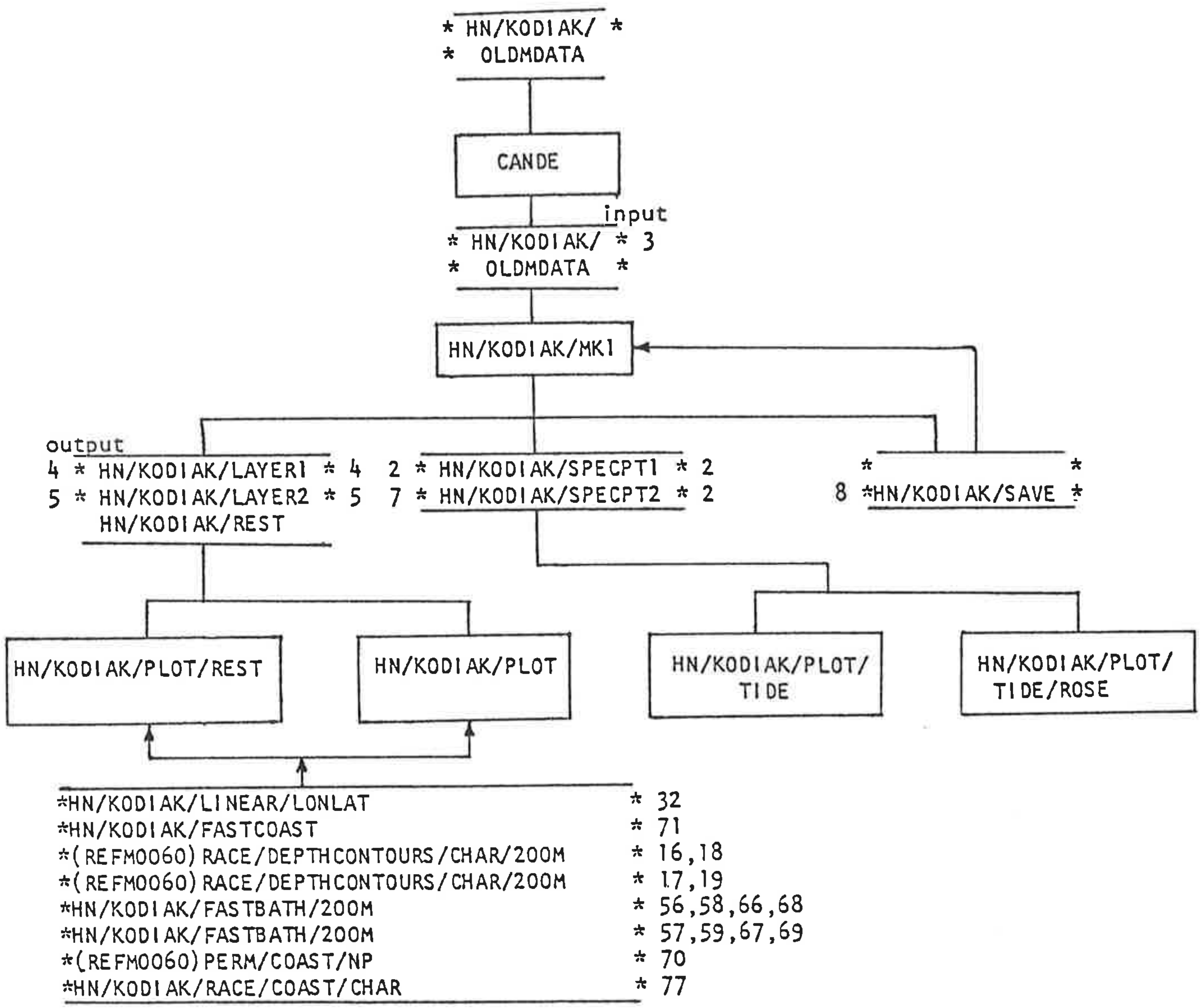


Figure 3. Model run and display sequence with data and program file names.

RUN INSTRUCTIONS

Program HN/KODTID.

There are no controls external for this program. The tidal components and the number of hours computed are compiled into the program.

Program HN/LAYER3S.

The instructions for setting up the control cards for this program are provided in Stroud (1978) and are reproduced in TABLES 1 and 2. The master control cards in TABLE 1 are common to both the LAYER3S and the NEWMODEL programs. The cards described in TABLE 2 are unique to the LAYER3S program.

As the HN/LAYER3S is set up, it overwrites the HN/KODIAK/OLDMDATA file with the converted land/sea and water depth table card sets. When this occurs CANDE must be used to reinsert the MK1 control cards at the beginning of the file and the plot control cards at the end of the file. The file HN/KODIAK/OLDM has been established to save a functional copy of OLDMDATA.

The input for HN/LAYER3S is on file HN/KODIAK. This file contains the control cards and the original land/sea and water depth tables.

The LAYER3S program was patched near statement 170 to allow continued use of SETU and SETV cards indexed to the original grid. This patch adds 8 to the NM and NP values read from the cards in the HN/KODIAK deck.

Program HN/KODIAK/NEWMODEL.

This program is controlled by the cards in the file HN/KODIAK and reads and writes model results from file HN/PHASE. The program is essentially as described by Bauer (1978) and Stroud (1978) with a rewritten input output format tape defined as HN/PHASE. Since it was not used after the initial comparison, the

TABLE 1. MASTER CONTROL CARD SET (page 1 of 3)

Card Type	Program Variable	Description
NAME Card		Format (20A4)
1-4		NAME
5-80		Comments or titles (any number of cards may be used to identify the output)
GRID Card		Format (A4,2I3,7E10.3)
1-4		GRID
5-7	NE	Number of rows
8-10	ME	Number of columns
11-20	DL	Distance between grid points (cm)
21-30	ROTANG	Counter-clockwise angles between north and the +Y axis of the computational grid (deg)
31-40	C	Wind drag coefficient
41-50	TK	Mid latitude of grid (deg)
51-60	R	Bottom friction coefficient
TIME Card		Format (A4,I6,7I10)
1-4		TIME
5-10	MODOUT	Number of seconds between saved results
11-20	ITO	Time of first output in seconds
21-30	ITS	Start time for computations in seconds. If this time is greater than zero, the HN/PHASE file is assumed to contain U,V and Z arrays for necessary levels at the time specified.
31-40	ITE	End time for computations in seconds
41-50	ITINC	Time step in seconds
51-60	IPO	Time of first printout
61-70	IPMOD	Number of seconds between printouts
FACT Card		Format (A4,6X,7E10.3)
1-4		FACT (when present must precede TIDE cards in Phase I)
5-10	Blank	
11-20	TIDSPD(1)	Speed of the tidal constituents
21-30	TIDSPD(2)	
31-40	TIDSPD(3)	(Match order of component phase angle and amplitude on TIDE card) K1 = 15.0410686 (deg/hr) O1 = 13.9430356 M2 = 28.9841042 S2 = 30.0000000 N2 = 28.4397295

TABLE 1 (Page 2 of 3)

Card Type	Program Variable	Description
TIDE Card		Format (A4,4I3,I6,4F7.2,4F6.2,2F3.2)
1-4		TIDE (0<J<4)
5-7	ITIDE(1,J)	Minimum row (N) index for tidal input
8-10	ITIDE(2,J)	Maximum row (N) index for tidal input
11-13	ITIDE(3,J)	Minimum column (M) index for tidal input
14-16	ITIDE(4,J)	Maximum column (M) index for tidal input
17-22	ITIDE(5,J)	Time offset between time of computations and time 0 tide phase angle (sec)
23-29	TIDE(1,J)	Tidal constituents 1 phase angle (deg)
30-36	TIDE(2,J)	2
37-43	TIDE(3,J)	3
44-50	TIDE(4,J)	4
51-56	TIDE(5,J)	Tidal constiuents 1 amplitude (cm)
57-62	TIDE(6,J)	2
63-68	TIDE(7,J)	3
69-74	TIDE(8,J)	4
75-77	TIDE(9,J)	Weight factor for second layer tide heights (no tide set in second layer if 0)
78-80	TIDE(10,J)	Weight factor for third layer tide heights (no tide set in third layer if 0)
WIND Card		Format (A4,4I3,4X4I10)
1-4		WIND (0≤J≤4)
5-7	IWIND(1,J)	Minimum row (N) index for wind field
8-10	IWIND(2,J)	Maximum row (N) index for wind field
11-13	IWIND(3,J)	Minimum column (M) index for wind field
14-16	IWIND(4,J)	Maximum column (M) index for wind field
17-20	Blank	
21-30	IWIND(5,J)	Wind start time (sec)
31-40	IWIND(6,J)	Wind end time (sec)
41-50	IWIND(7,J)	Wind direction (degs true from which wind blows)
51-60	IWIND(8,J)	Wind speed (m/sec) Note: This is the only measurement in the input given in meters rather than cm.
LAYS Card		Format (A4,I6,3F10.0,8F5.0)
1-4		LAYS
5-10		Number of layers
11-20	HL(1)	Maximum depth of layer 1 — If zero layer is ignored in computations. Acts to truncate bottommost layer.
21-30	HL(2)	2
31-40	HL(3)	3

TABLE 1 (Page 3 of 3)

Card Type	Program Variable	Description
41-45	ALPHA(1)	Smoothing parameters for layer 1
46-50	ALPHA(2)	2
51-55	ALPHA(3)	3
56-60	RHO(1)	Density for layer 1
61-65	RHO(2)	expressed as 2
66-70	RHO(3)	sigma-t values 3
		(Density -1.0)*1000
71-75	HMIN	Minimum allowable thickness of layer in Phase II
SORC Card		Format (A4,4I3,2I2,2I10,4E10.3)
1-4		SORC(0<J≤10)
5-7	ISORC(1,J)	Minimum row (N) index for source
8-10	ISORC(2,J)	Maximum row (N) index for source
11-13	ISORC(3,J)	Minimum column (M) index for source
14-16	ISORC(4,J)	Maximum column (M) index for source
17-18	ISORC(5,J)	Minimum layer (LM) index for source
19-20	ISORC(6,J)	Maximum layer (LP) index for source
21-30	ISORC(7,J)	Start time for source
31-40	ISORC(8,J)	End time for source
41-50	SORC(1,J)	Concentration introduced per time step
51-60	SORC(2,J)	Volume of water introduced per time step per level (cm^3)
FLOW Card		Format (A4,4I3,2I2,2I10,4E10.3)
1-4		FLOW (0≤J≤4)
5-40	IFLOW(,J)	Same as SORC card
41-50	FLOW(1,J)	Direction of flow (deg true)
51-60	FLOW(2,J)	Velocity increment (cm/sec/step)
61-70	FLOW(3,J)	Second layer factor
71-80	FLOW(4,J)	Third layer factor
COMP Card		Format (A4I6,7I10)
1-4		COMP This card is used to start the computations in the Phase II program. It is the last card read in the control card deck by the program Phase II.
5-10	MODEL	Model number used in record header on intermediate data set
11-20	IREF	Reference level above MSL (Phase I: used to construct relative depth fields; Phase II: used for proper display of fields)

TABLE 2. HN/LAYER3S CONTROL/DATA CARDS (page 1 of 3)

Card Type	Program Variable	Description
NEWT Card		Format (A4,F6.3,7F10.0)
1-4		NEWT Read in new format HTU and HTV tables that follow card
5-10	FAC	Conversion factor used to change depth units to cm. If blank assumed = 1.
11-20	SEALEV	Sea level adjustment to be added to water depths in cm. (No adjustment or conversion occurs until TAPE card processing).
21-30	ZINIT	Initial values to prescribed for initial time type two records on intermediate file.
31-40	UINIT	
41-50	VINIT	
51-60	AHTV	>0 No HTV table present. =0 HTV table present. <0 HTU augment table replaces HTV table. (Nonzero values in the augment table supercede any value in the HTU table.)
61-70	TINIT	Initial time (usually 0)
OLDT Card		Format (A4,F6.3,F10.0)
1-4		OLDT Read in old format HTZ, HTU and HTV tables that follow card
5-10	FAC	Conversion factor used to change depth units to cm. If blank assumed = 1.
11-20	SEALEV	Sea level adjustment to be added to water depths in cm. (No adjustment or conversion occurs until TAPE card processing.)
New Format HTU and HTV Tables		Format (12I6)
1-6 . . .	IU or IV	Follows NEWT card. Each row of the array is read with a separate READ statement. The array element (1,1) is punched on the first field of the first card and the last element in the row (1,ME) is the last value on the (ME-1)/12+1 card. The elements (2,1)...(NE,1) all begin new card sets. The IU array is read first followed by the IV array. Negative depth values are allowed referenced to MSL in the same units as positive depths whatever their reference. (SEALEV parameter on NEWT is expected to adjust depth reference to MSL.)
Old Format HTZ, HTU and HTV Tables		Format (12I6)
1-6 .	IZ, IU OR IV	Follows OLDT card. Each array is read using logic that duplicates an array READ using a double indexed implied DO loop with the column index varying faster.

		Only the last card in each array set can contain unused fields. HTZ array is read first followed by the HTU and HTV arrays
SETU Card		Format (A4,4I3,4X,I10)
1-4		SETU Set the value ICC in HTU within the limits
5-7		Minimum row (N) dimension
8-10		Maximum row (N) dimension; if zero set to min value
11-13		Minimum column (M) dimension
14-16		Maximum column (M) dimension; if zero set to min value
17-20		Blank
21-30	ICC	Value to be placed in array (same units as HTU field prior to conversion)
SETV Card		Same as SETU. Modify HTV array.
SETZ Card		Same as SETV. Modify HTZ array.
VOLM Card		Format (A4,4I3,4X,I10)
1-4		VOLM
5-20		Same as SETU card
21-30		Reset flag 1 = volume to zero before computing volume 0 = add computed volume to previous volume
GRDZ Card		Format (A4,6XI10)
1-4		GRDZ Set HTZ and -1 values in HTU and HTV field; test boundary configuration; provide print option
5-10		Blank
11-20		Flag to bypass combined symbolic HTZ, HTU and HTV printout 0 = print 1 = bypass printout
OLDP Card		Format (A4,4I3)
1-4		OLDP Punch old format HTZ, HTU, and HTV cards
5-16		Same as SETU card, except if left blank limits set to 1, ME or NE as appropriate
NEWP Card		Format (A4,4I3)
1-4		NEWP Punch new format HTU and HTV table
5-16		Same as OLDP card

TAPE Card		Format (A4,I6,I10)
1-4		TAPE 1) Combine u,v depth print 2) Convert and adjust sea level as required 3) Print HTZ, HTU and HTV 4) Set HTZ, HTU and HTV values less than 0 to 0 and scale by 10 5) Write HTZ, HTU and HTV fields on tape 6) Set Z, U and V fields to 2 for all cells over water, -0 for all cells over land. Write on tape for layer 1. 7) Repeat 6 for layer 2 and then 3 if HL(2) and HL(3) are non-zero 8) Write double EOF on tape, backspace 1 EOF 9) Return to reset for next data set
5-10	ICC	Skip parameter >0 Print HTZ, HTU and HTV but do not write tape 0 Print and write tape
11-20	ICD	>0 Request U/V grid print of depth field ≤0 No print

run instructions are skipped in this document.

Program HN/KODIAK/MK1.

The control cards for this program are detailed by Laevastu (1974 b). As implemented at NWAFC, some of the control card values are not used and additional controls are compiled into the program. The NWAFC Kodiak model control cards are described in TABLE 3 and the control variables that are compiled into the program are listed in TABLE 4.

Short test runs can be made by running the HN/KODIAK/MK1 file, but longer jobs require the use of the WFL/HN/KODIAK/MK1, which places the job in the proper queue. The control cards are modified in file HN/KODIAK/OLDMDATA using CANDE.

The MK1 model for the Kodiak area has three open boundaries. The logic to define the water heights along these boundaries is compiled into the model as are many of the controls that were not defined for the original single layer HN model adapted to the New York Bight area, which now has been readapted for use in the KODIAK area by making the minimum changes possible.

Program HN/KODIAK/PLOT.

The PLOT program must be compiled, bound and then run from the bound file. There are no external controls, but the program contains a time control array which selects the fields to be plotted from the HN/KODIAK/LAYER1 or LAYER2 files. There are additional control variables compiled into the program that must be toggled to generate the fast coast line files. The control variables are listed in TABLE 5.

TABLE 3. DESCRIPTION OF MK1 MODEL INPUT PARAMETERS AND FORMATS CONTAINED IN FILE HN/KODIAK/OLDMDATA.

PARAMETER CARDS

CARD 1		FORMAT (24I3)
1-3	JA	Indicator, JA=1, read initial values; JA = 0 set, z = 0.2, u = 0.2, v = 0.2
4-6	NE,ME	Size of the computational grid (NE = number of rows, ME = number of columns)
7-9	IZE	Number of points on the open boundary where tidal heights are introduced. (Not used in this version. Set to 0.)
10-12	IUE	Twice the number of wind fields
13-15	KKE	Number of wind field characteristics (A(I))'s (= (IUE/2)*3)
16-18	NURU	Number of selected special points
19-21	NG	Number of points at the second open input boundary. (Not used in this version. Set to 0.)
22-24	NS	(Not used)
25-27	LI	Parameter for computation of dispersion and diffusion of pollutants: LI = 0 - No computation LI = 1 - Computation to be performed. (Not used)
CARD 2		FORMAT (9F8.3)
1-8	AFGN	Problem number
9-16	G	Acceleration of gravity. (Ignored. Computed from latitude after read in is complete.)
17-24	ALPHA	Smoothing parameter for the first layer (e.g., 0.099)
25-32	RBETA	Coefficient of geostrophic wind (e.g., 0.65). (Not used)
33-40	C1	Wind indicator: 0 - No wind 2 - Wind

CARD 3		FORMAT (9F8.0)
1-3	DT	One-half time step (sec)
9-16	TE	Length of computation (sec)
17-24	TW	Time when wind starts (sec)
25-32	T1	Time interval between printouts (sec)
33-40	T2	Field output counter (0 if outputs desired from the start of the computation; otherwise, any other delayed starting time)
41-48	S1	Time when wind stops (sec)
49-56	T	Time (initial = 0. If previous computations were made and z, u and v read from tape, give the time previous computation ended)
57-64	T3	If plot desired, time when fields are required for plotting. (Not used. See plot control cards.)

CARD 4		FORMAT (6E12.4)
1-12	DL	Half grid size in cm
13-24	F	Coriolis parameter (Ignored. Computed from latitude after value is read in)
25-36	SIGMA	Angular velocity of M_2 tide. (Not used)
37-48	R	Friction coefficient (0.003)
49-60	ROL	Density of the air. (Not used)
61-62	C	Drag coefficient (e.g., $3.2\text{x}10^{-6}$)

CARD 5		FORMAT (24I3) (one or more cards)
1-3, 4-6, etc.	NZ, MZ	N and M coordinates of the first open boundary. (Insert blank card)

CARD 6		FORMAT (24I3) (one or more cards)
1-3, 4-6	NZ, MZ	N and M coordinate pairs for the special points selected for time series output

PLOT CONTROL CARDS

CARD 1		FORMAT (3F10.0)
1-10	STV	Start time for velocity vector plots (sec)
11-20	ETV	End time for vector plots (sec)
21-30	TINCV	Time interval between plots (sec)
CARD 2		FORMAT (3F10.0)
1-10	STH	Start time for water height contour plots (sec)
11-20	ETH	End time for water height contour plots (sec)
21-30	TINCH	Time interval between plots (sec)

TABLE 4. CONTROL VARIABLES COMPILED INTO THE HN/KODIAK/MK1 PROGRAMS

ROUTINE/ TYPE	VARIABLE	DESCRIPTION
J02		
D	HTL1	Initial surface layer thickness (cm)
S	ALAT	Mid-latitude of the grid (deg + N, - S)
S	G	Gravity (computed from ALAT)
S	F	Coriolis (computed from ALAT)
S	-	Depth of false bottom (cm)
J03		
S	TRB	Rest current start time (sec)
S	TRE	Rest current end time (sec)
VECTOR		
S	ROT	Grid rotation angle used to convert local grid geometric angles to geographic degrees
J05		
D	RH01	Mean density of surface layer
D	RH02	Mean density of second layer
D	TIDSPD	Astronomical tidal components
D	TANG	
D	TAMP	
S	ALP	Second layer smoothing term
S	-	Calculations of tides at each point along 3 open boundaries

D = data statement

S = Executable statement

TABLE 5. HN/KODIAK/PLOT CONTROL VARIABLES.

TYPE	VARIABLE	DESCRIPTION
D	TPLTS	Times of selected plots in ascending order. Times must match a subset of the results saved on file HN/KODIAK/LAYER1 and LAYER2.
S	IFAST	Convert coastline file to fast format 0 = skip 1 = create fast files

Program HN/KODIAK/PLOT/TIDE.

The TIDE Program operates from either the HN/KODIAK/SPECPT1 or SPECPT2 file to produce the tide curve plot with superimposed velocity vectors. There are no control cards for this program, but there are compiled control variables as listed in TABLE 6.

Program HN/KODIAK/PLOT/TIDE/ROSE.

The ROSE program plots the tidal ellipse for a selected number of hours from the special points files HN/KODIAK/SPECPT1 or SPECPT2. The program has no control card, but the compiled controls are the same variables as are listed in TABLE 6.

Program HN/KODIAK/PLOT/REST.

The REST program plots the rest currents for the time period stated in the MK1 program under TRB and TRE for the beginning and ending times of the rest currents.

TABLE 6. HN/KODIAK/PLOT/TIDE AND HN/KODIAK/PLOT/TIDE/ROSE CONTROL VARIABLES

TYPE	VARIABLE	DESCRIPTION
S	NURU	Number of special points
S	HR	Start time of plot in hours
S	TS	End time of plot in hours

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APPENDIX A

Water Height Contours and Velocity Vector Plots

The 16 plots are examples for the two layer Kodiak area grid. Contour and water vector lines on the Kenai Peninsula are plotted from a sink used to account for the water volume in Cook inlet.

Heavy lines are plotted for the coast line; the dashed bathymetry line is the 200 M contour and the solid bathymetry line is the 2000 M contour.

Grid lines are drawn every 2 cells and are labeled every 5. The Y axis labels are inverted. The computation grid location 1,1 is the lower corner, which is labeled 33 on the Y axis. The GRID package used to produce the plot does not provide an option to invert the Y labels.

The outside two rows and columns are not plotted, as they are only used in the setting of the boundary conditions, which provides flow only in the direction perpendicular to the boundary.

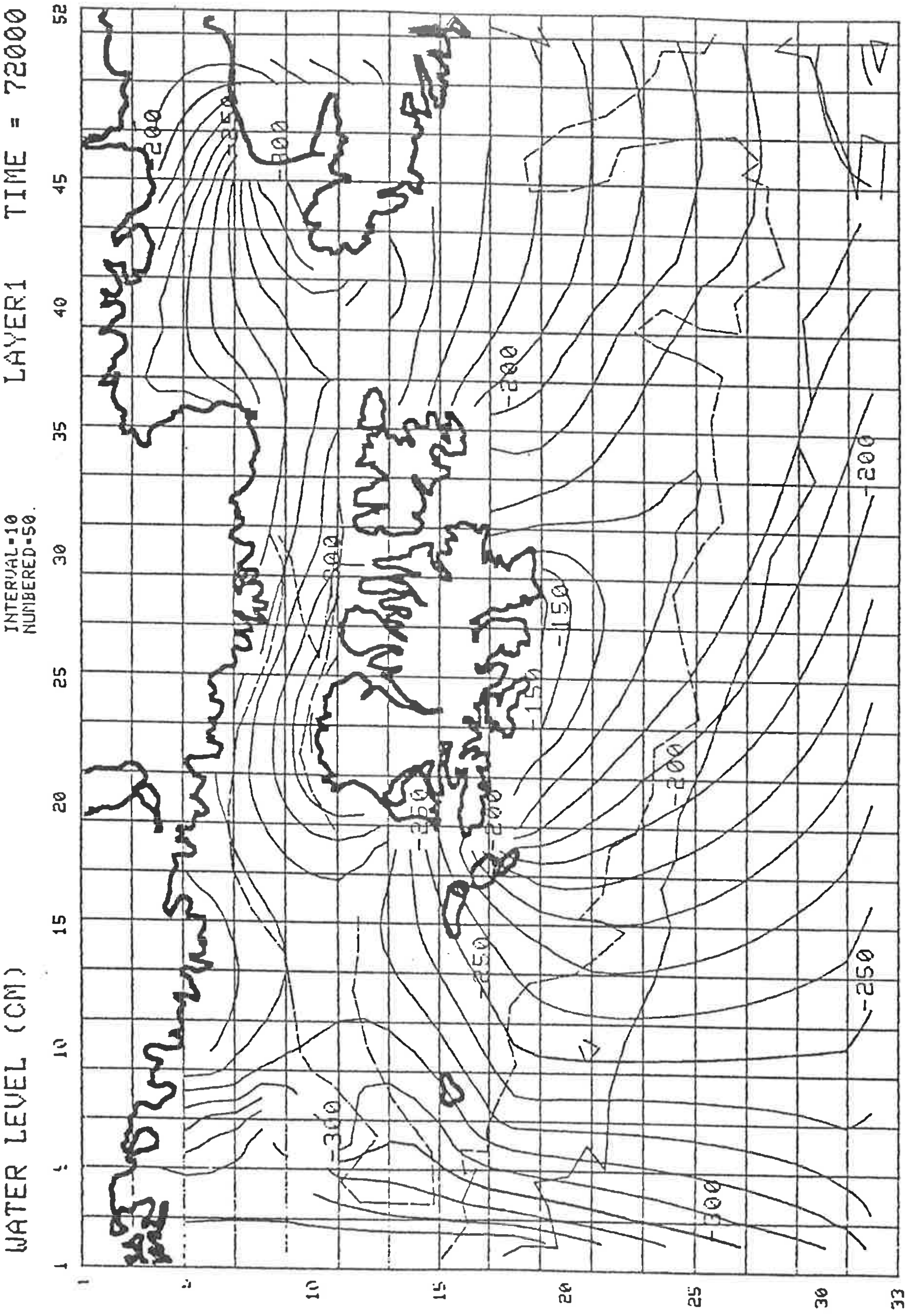

Figure 4.--Surface water deviation at primary low water off Kodiak.

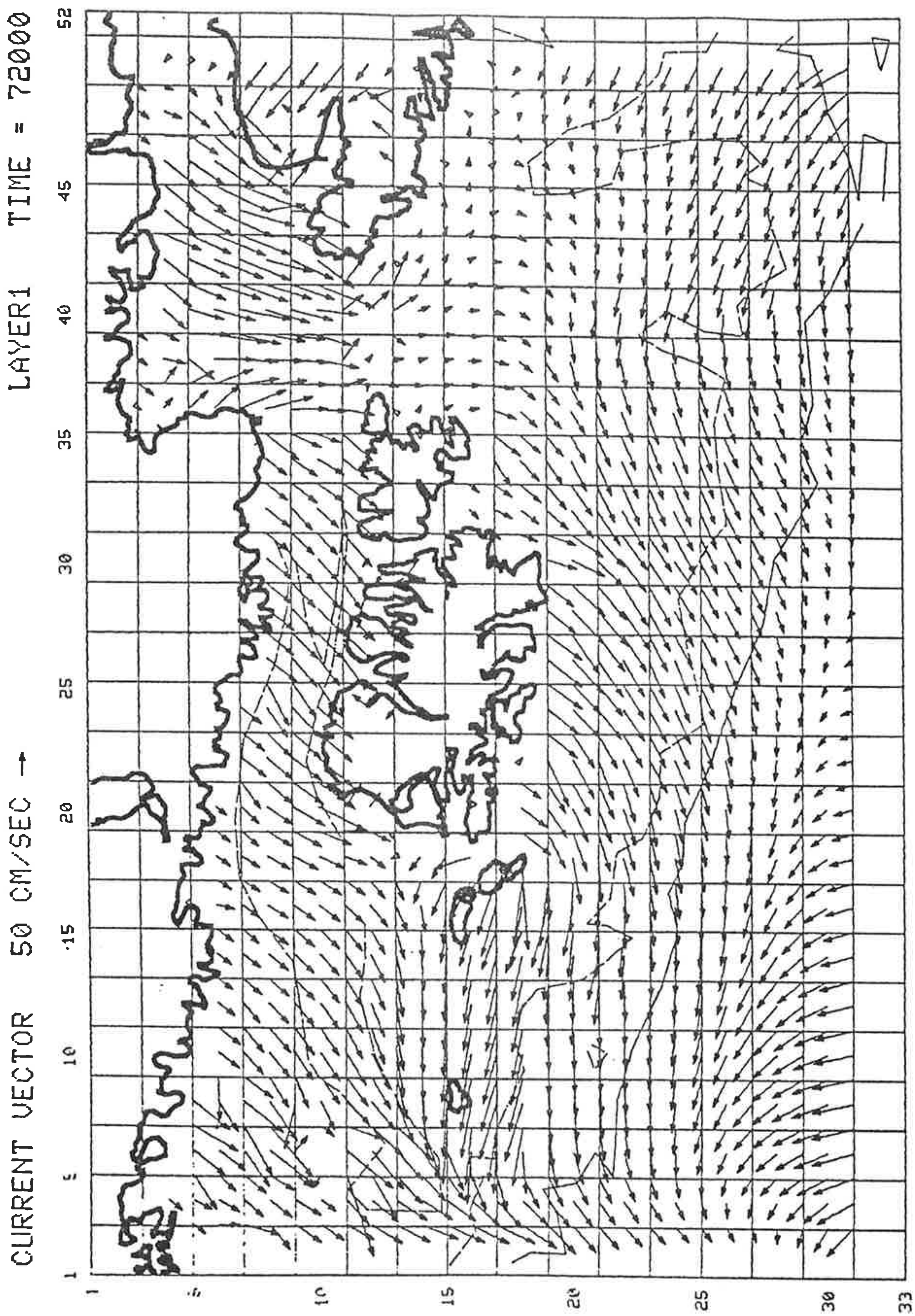

Figure 5.--Surface vector currents at primary low water off Kodiak.

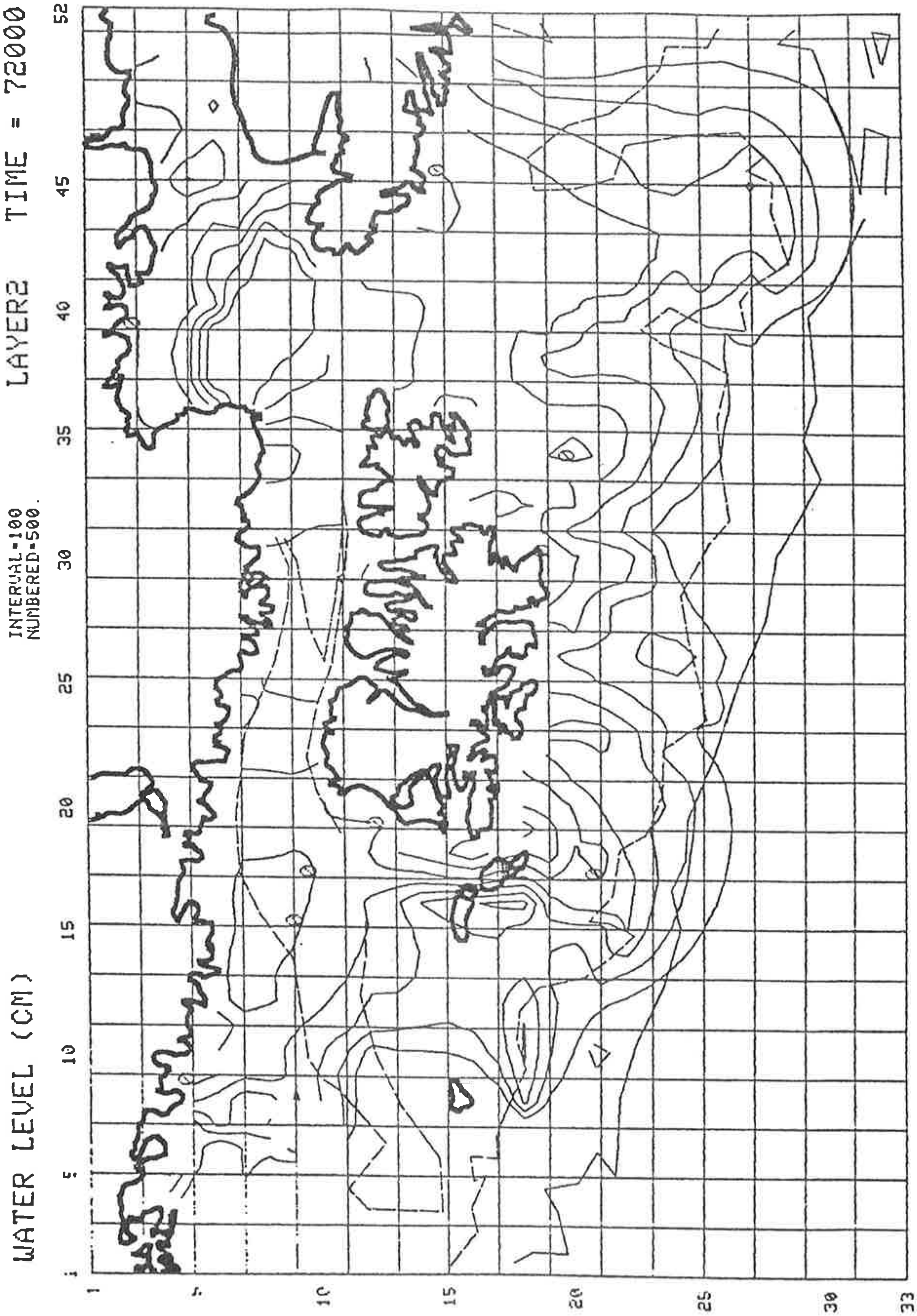

Figure 6.--Mixed layer depth (MLD) deviation at primary low water off Kodiak.

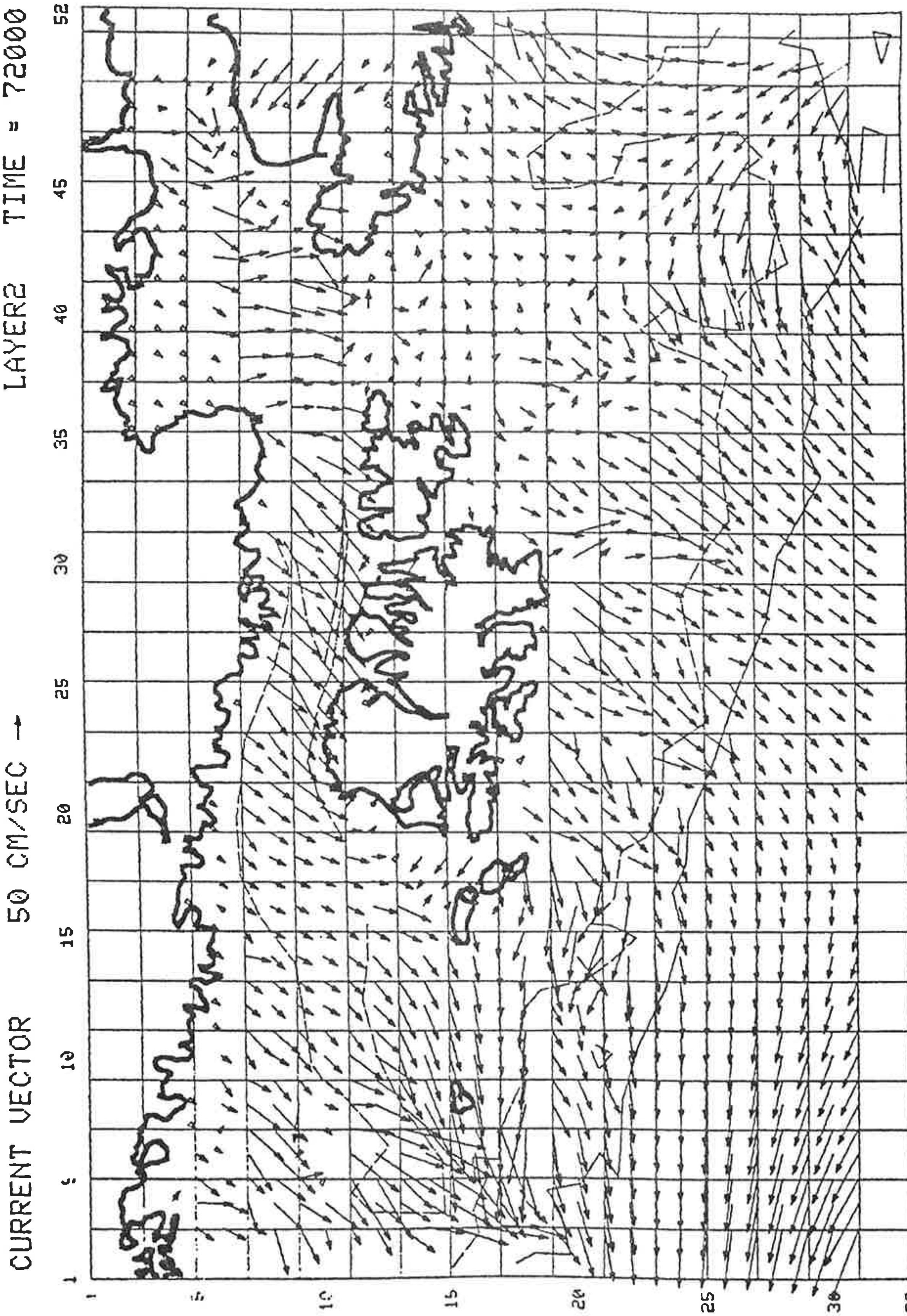

Figure 7.--Current vectors below MLD at primary low water off Kodiak.

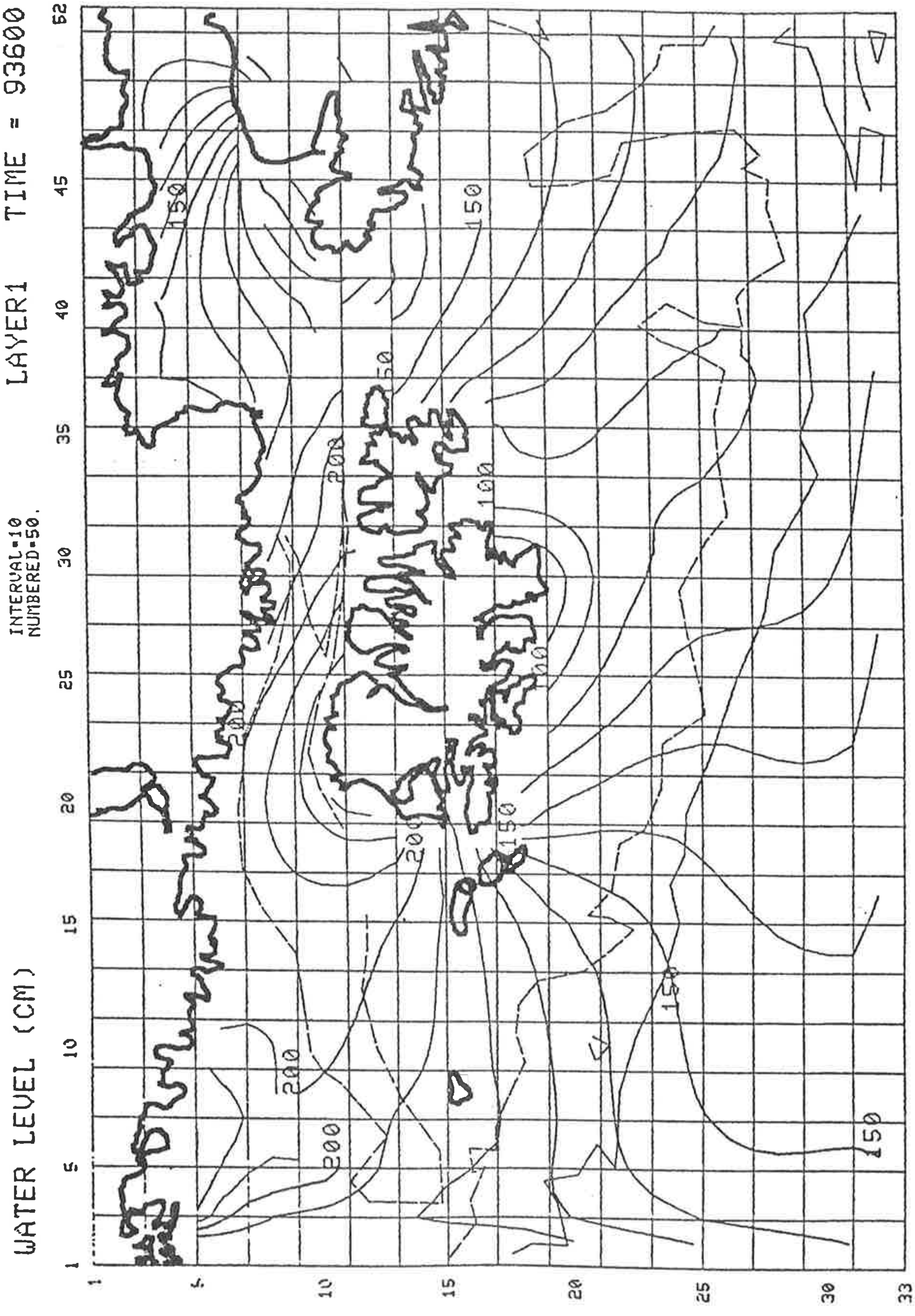

Figure 8.--Surface water deviation at secondary high water off Kodiak.

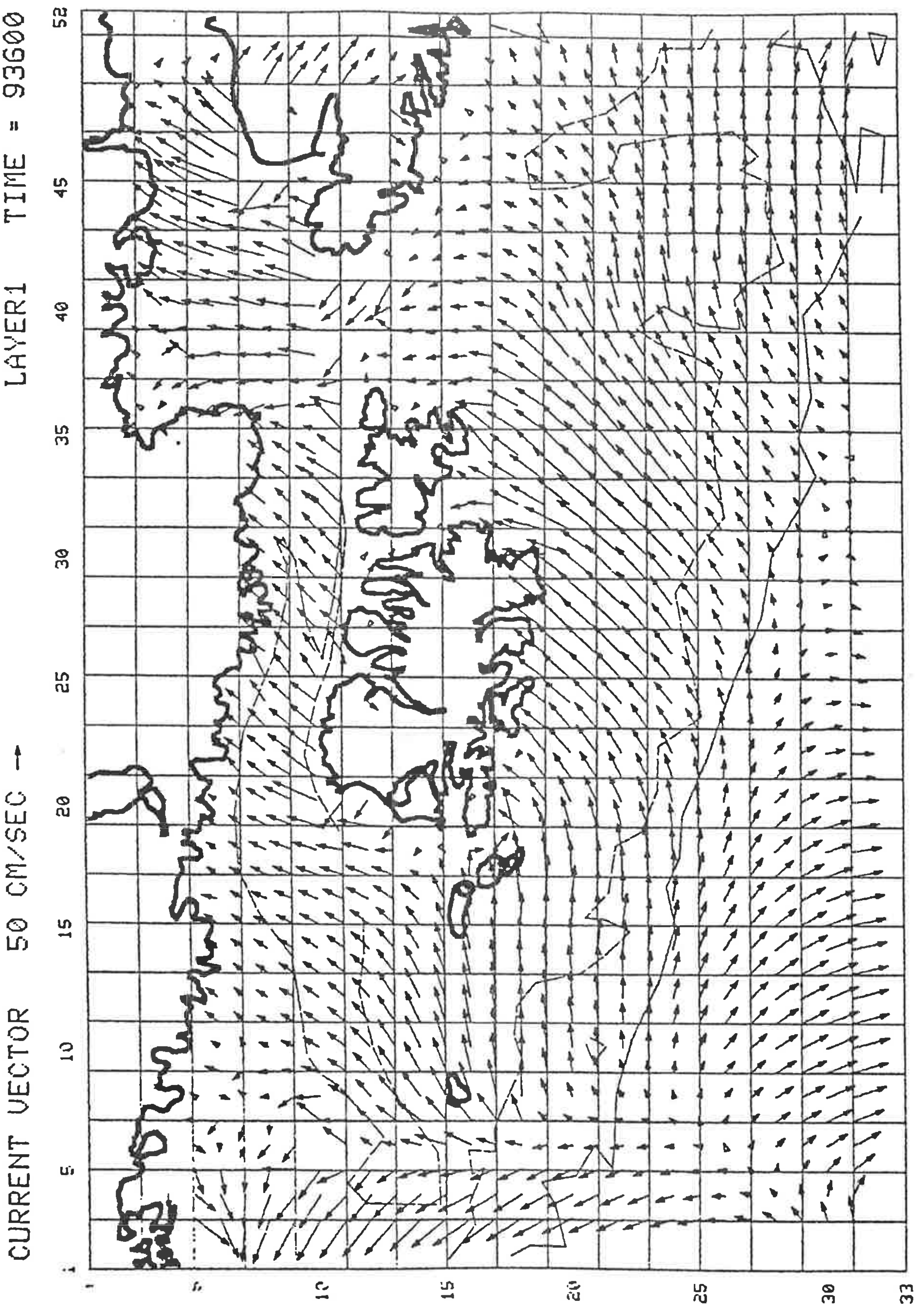

Figure 9.--Surface vector currents at secondary high water off Kodiak.

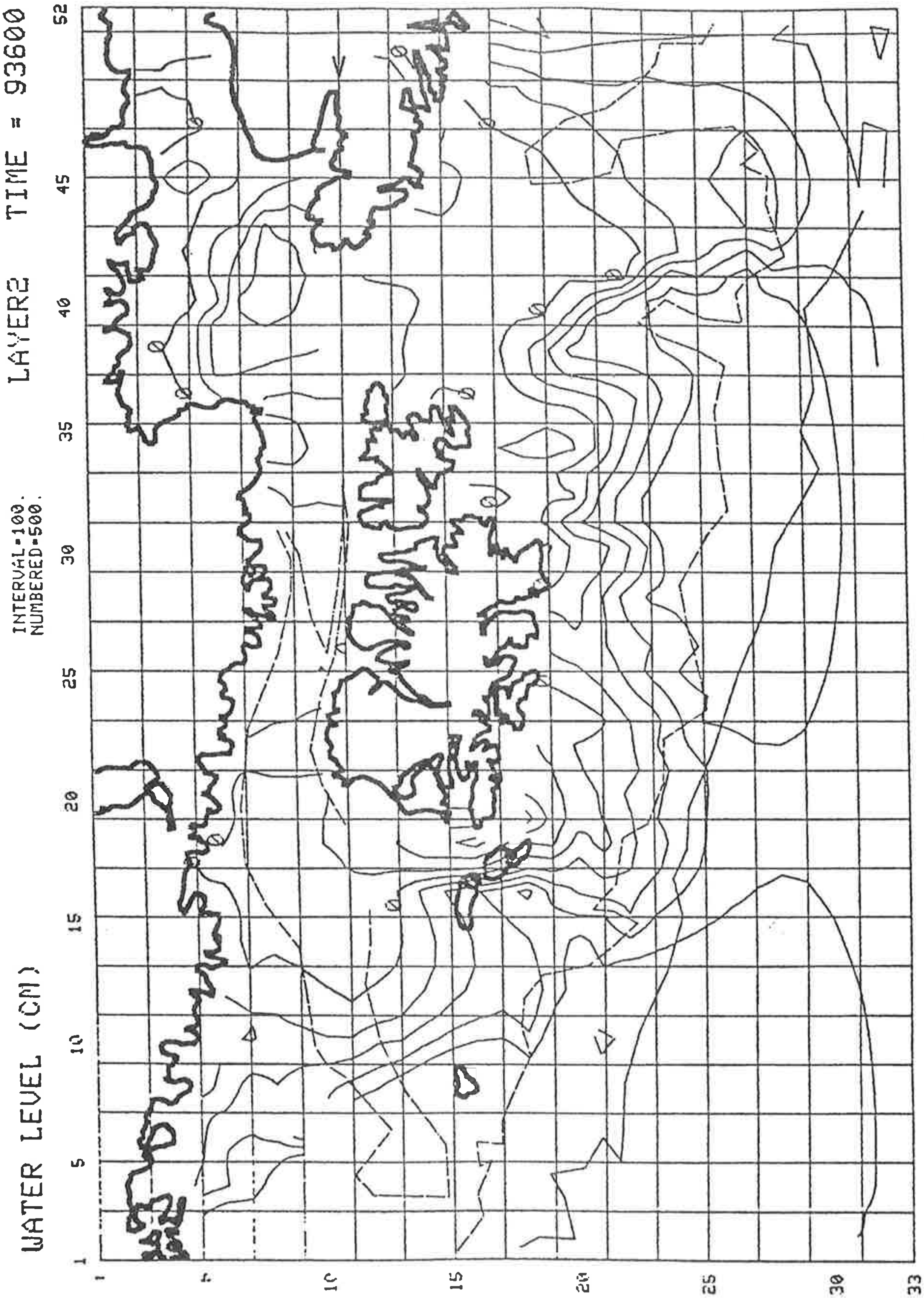

Figure 10.--MLD deviation at secondary high water off Kodiak.

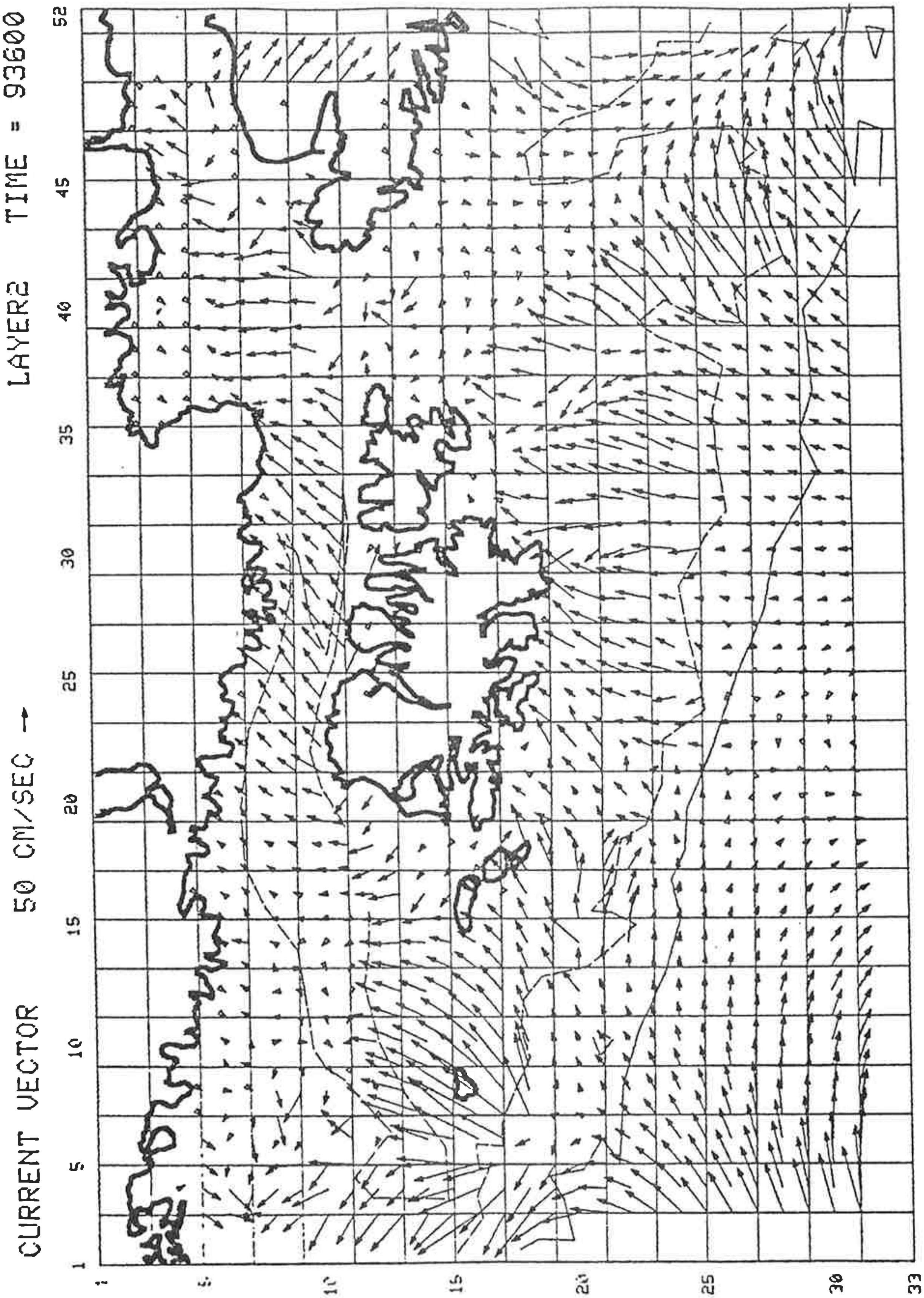

Figure 11.--Current vectors below MLD at secondary high water off Kodiak.

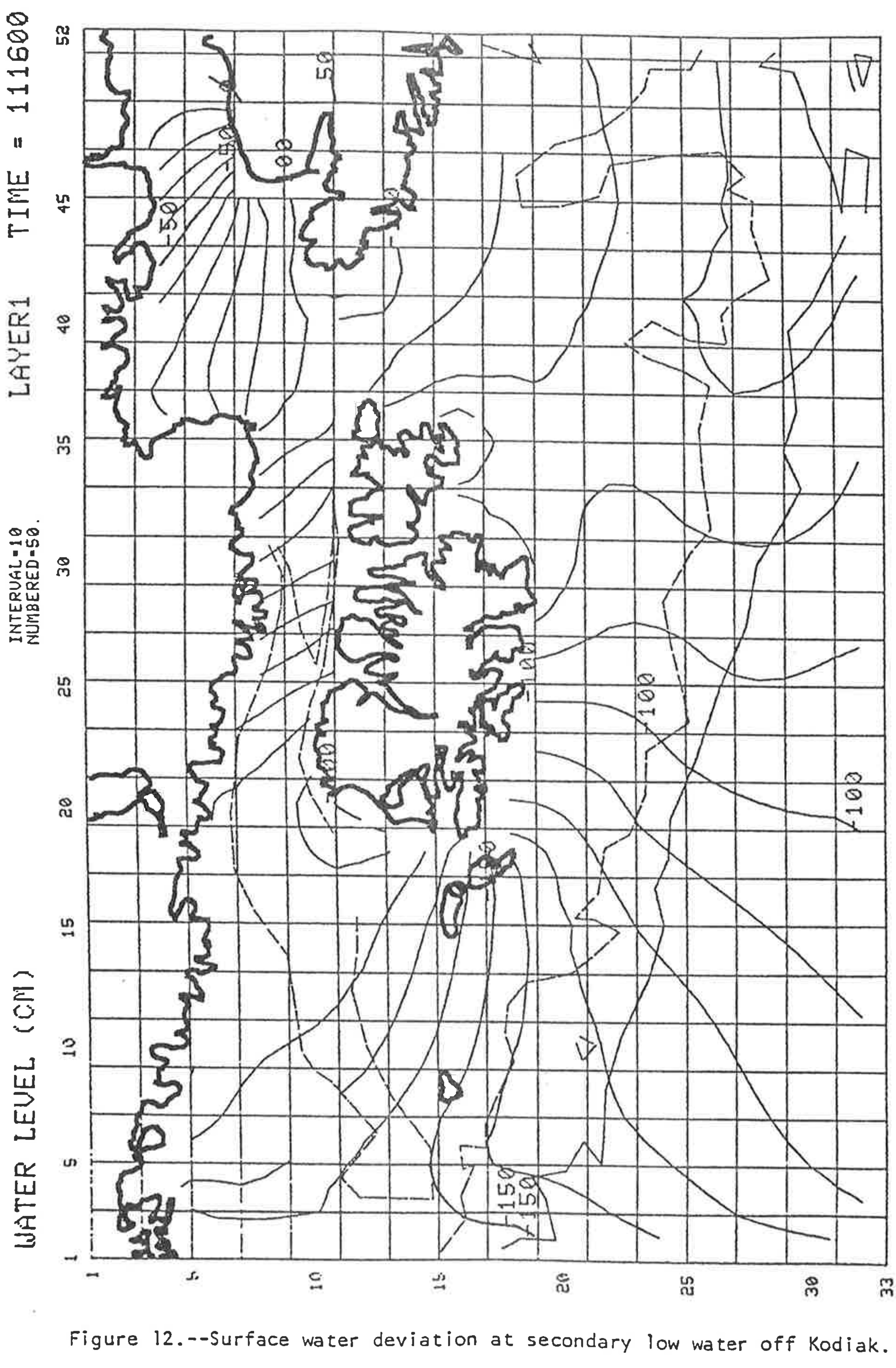

Figure 12.--Surface water deviation at secondary low water off Kodiak.

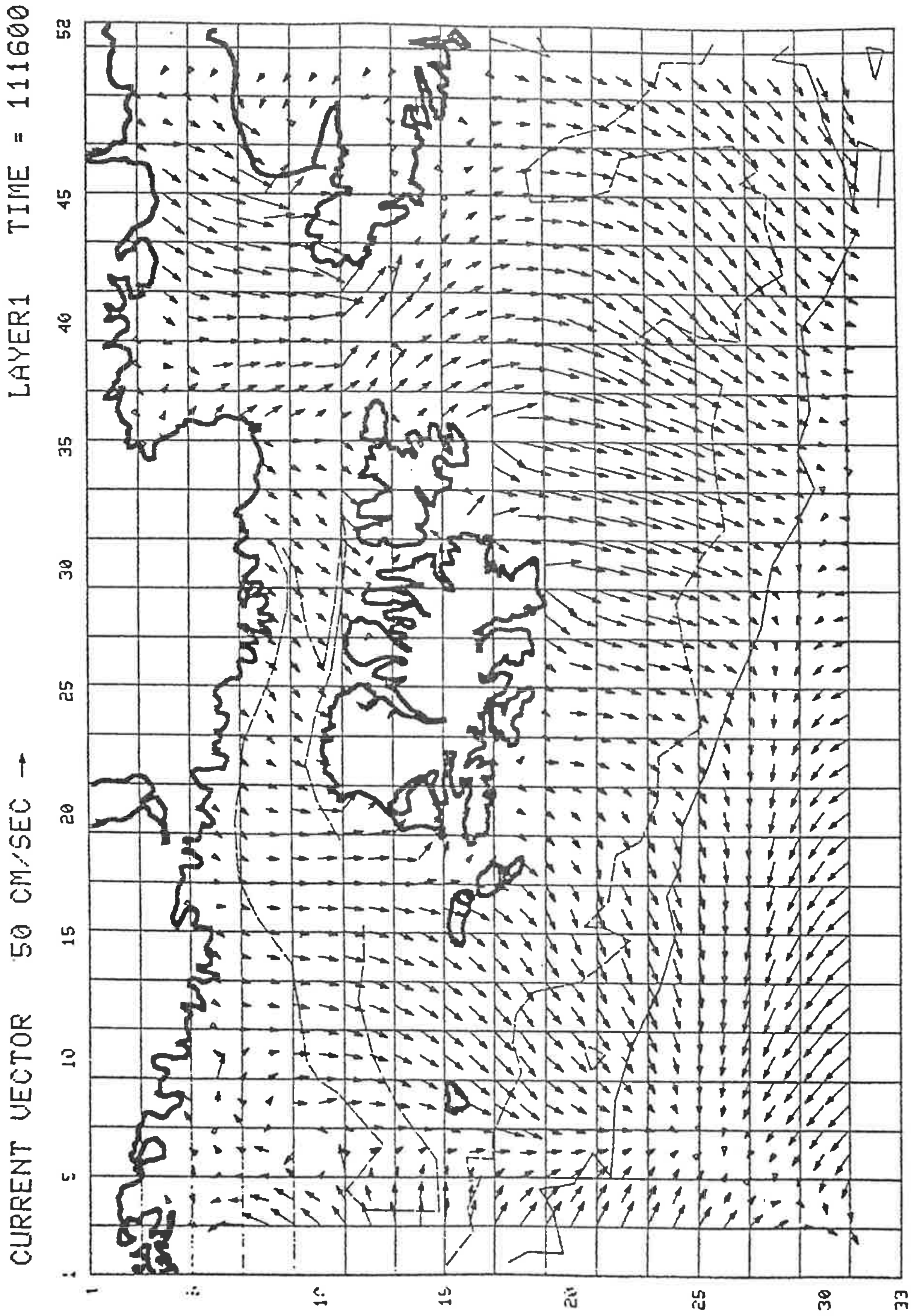

Figure 13.--Surface vector currents at secondary low water off Kodiak.

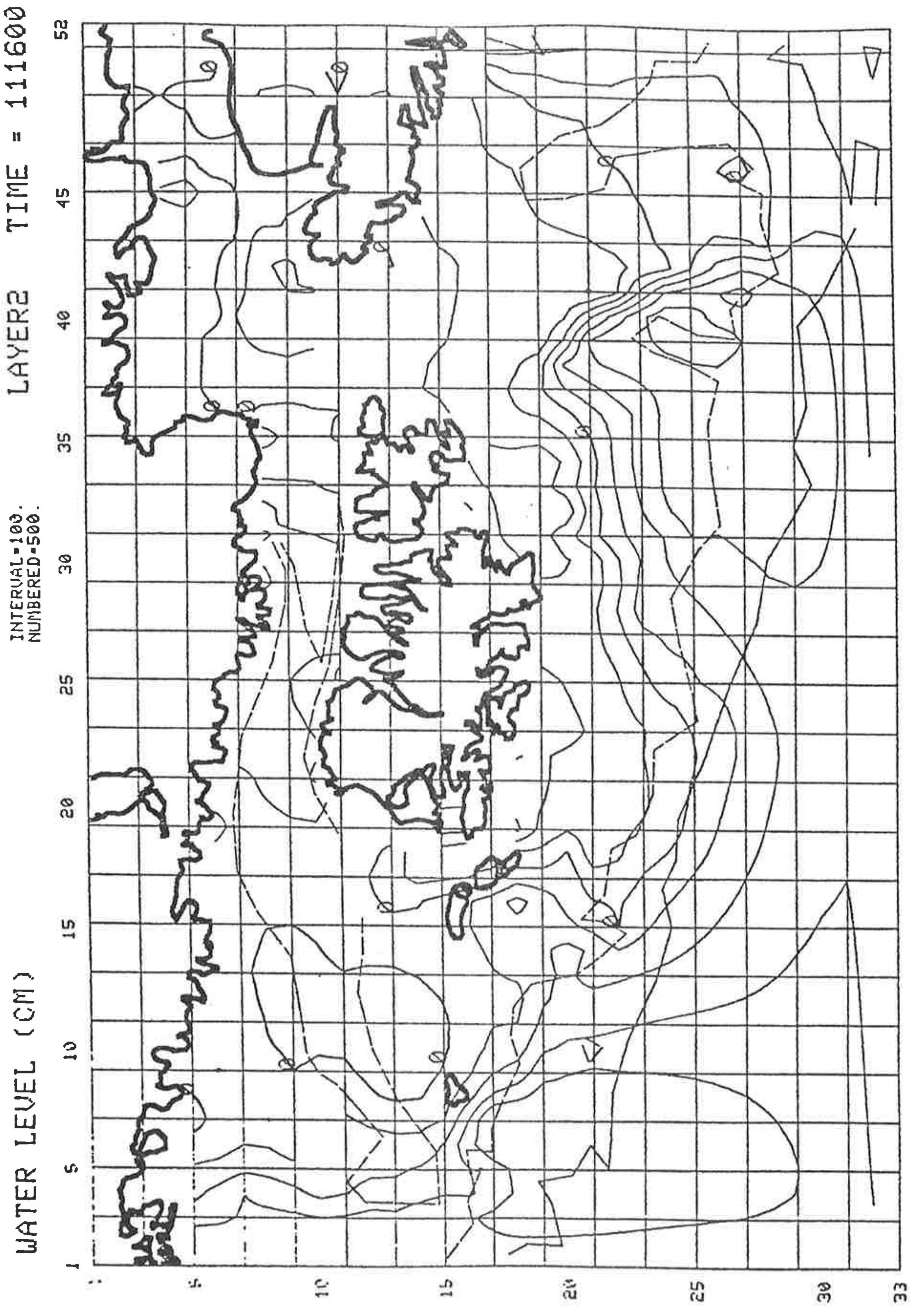

Figure 14.--MLD deviation at secondary low water off Kodiak.

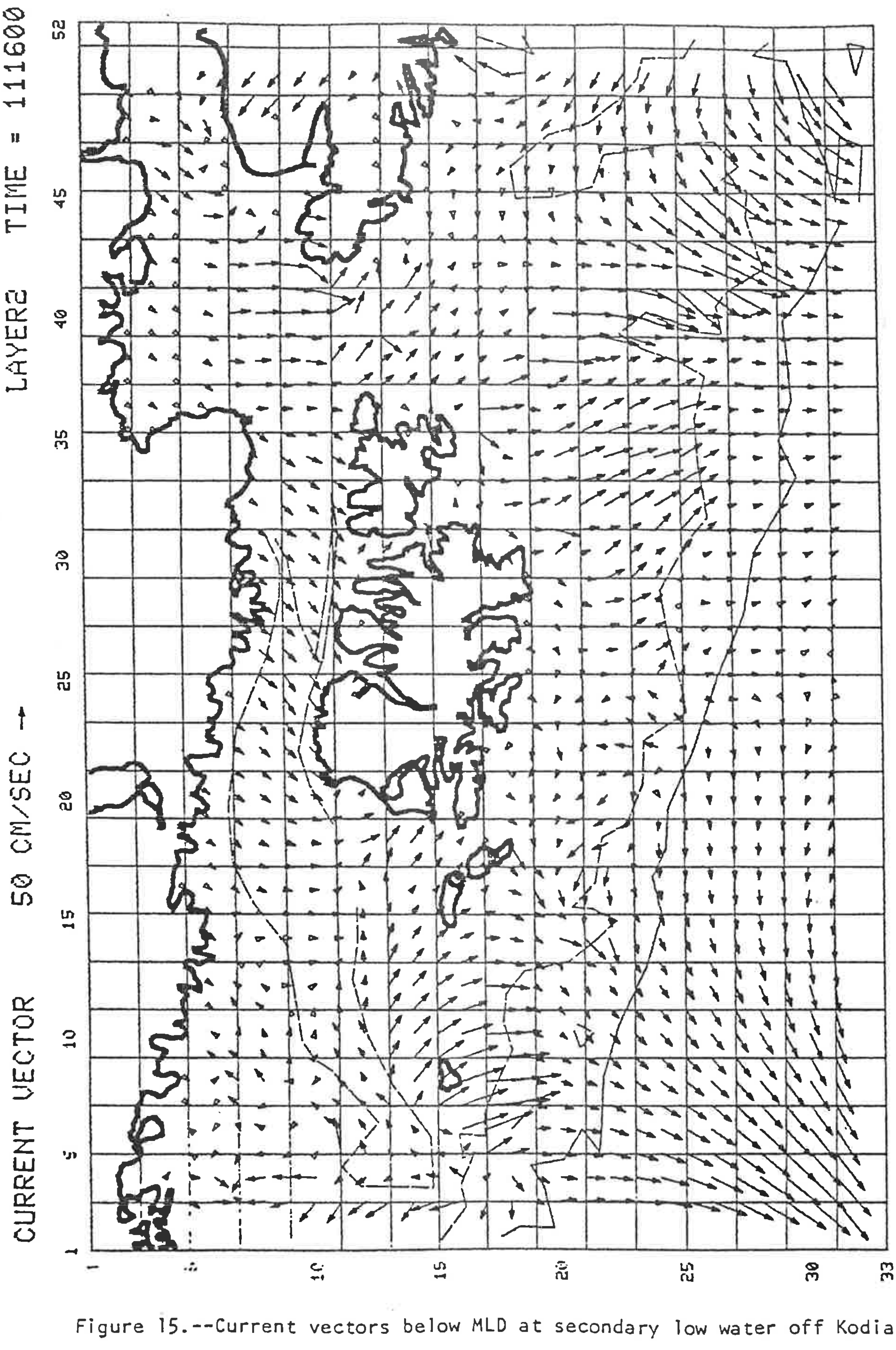

Figure 15.--Current vectors below MLD at secondary low water off Kodiak.

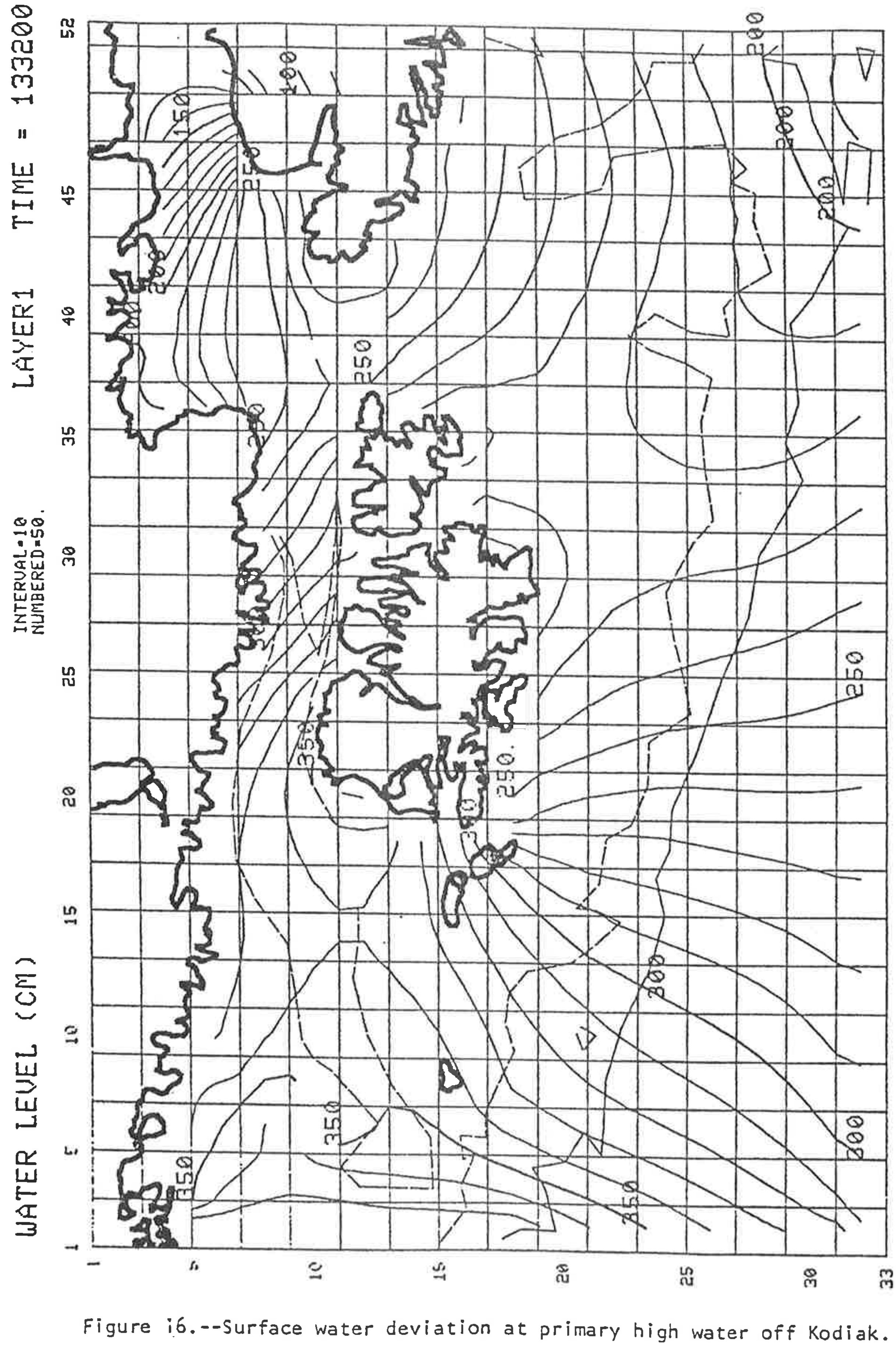

Figure 16.--Surface water deviation at primary high water off Kodiak.

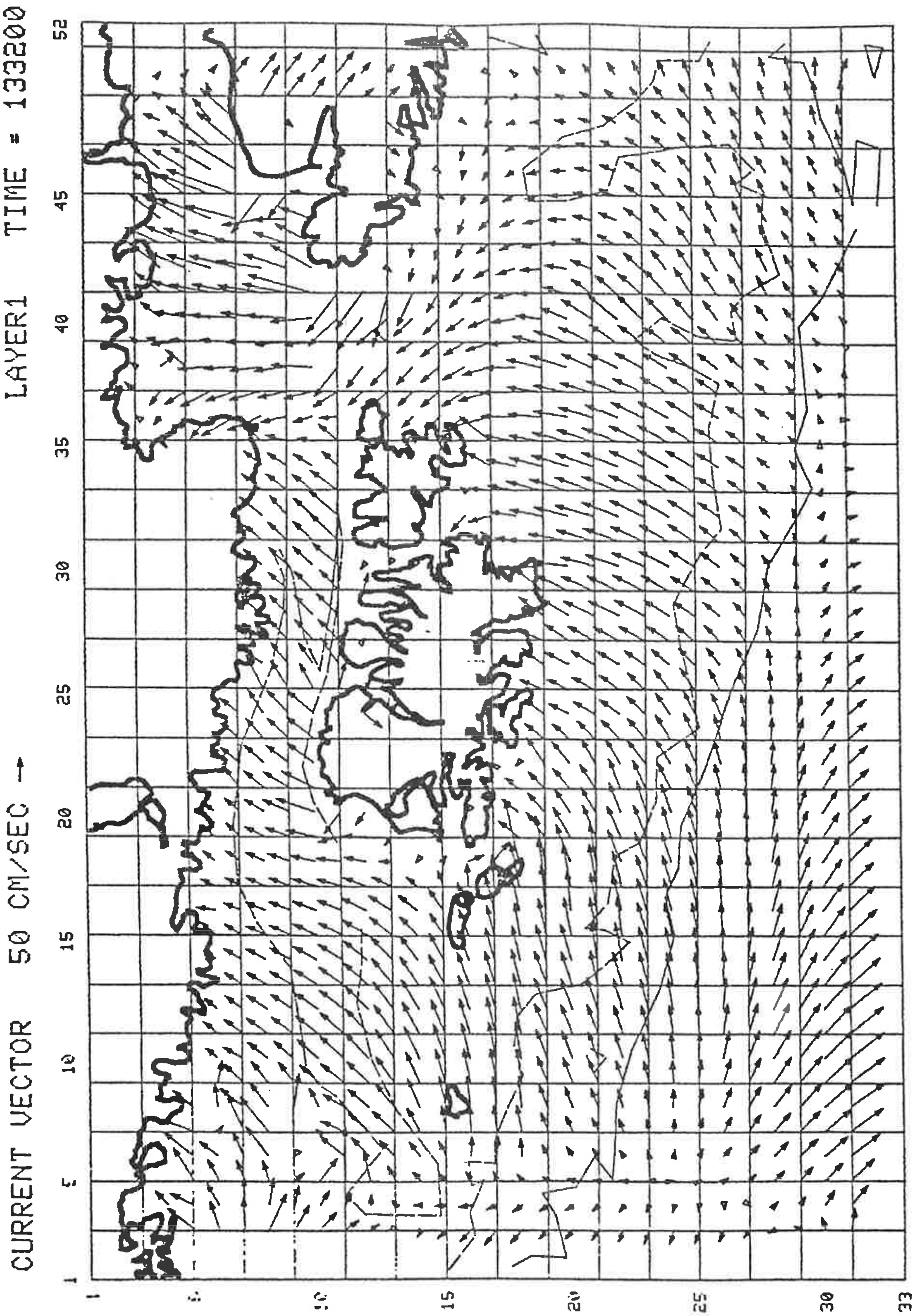

Figure 17.--Surface vector currents at primary high water off Kodiak.

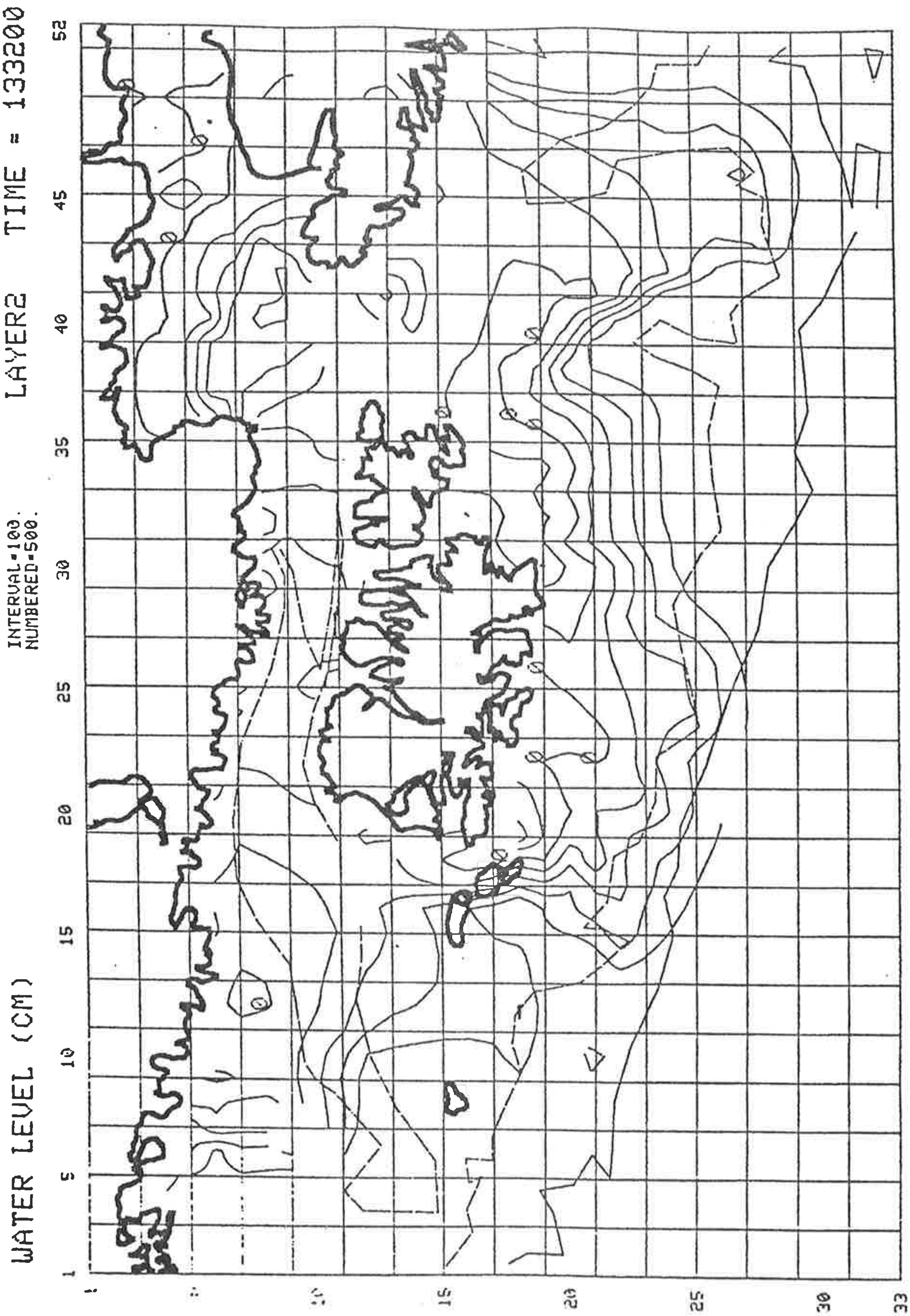

Figure 18.--MLD deviation at primary high water off Kodiak.

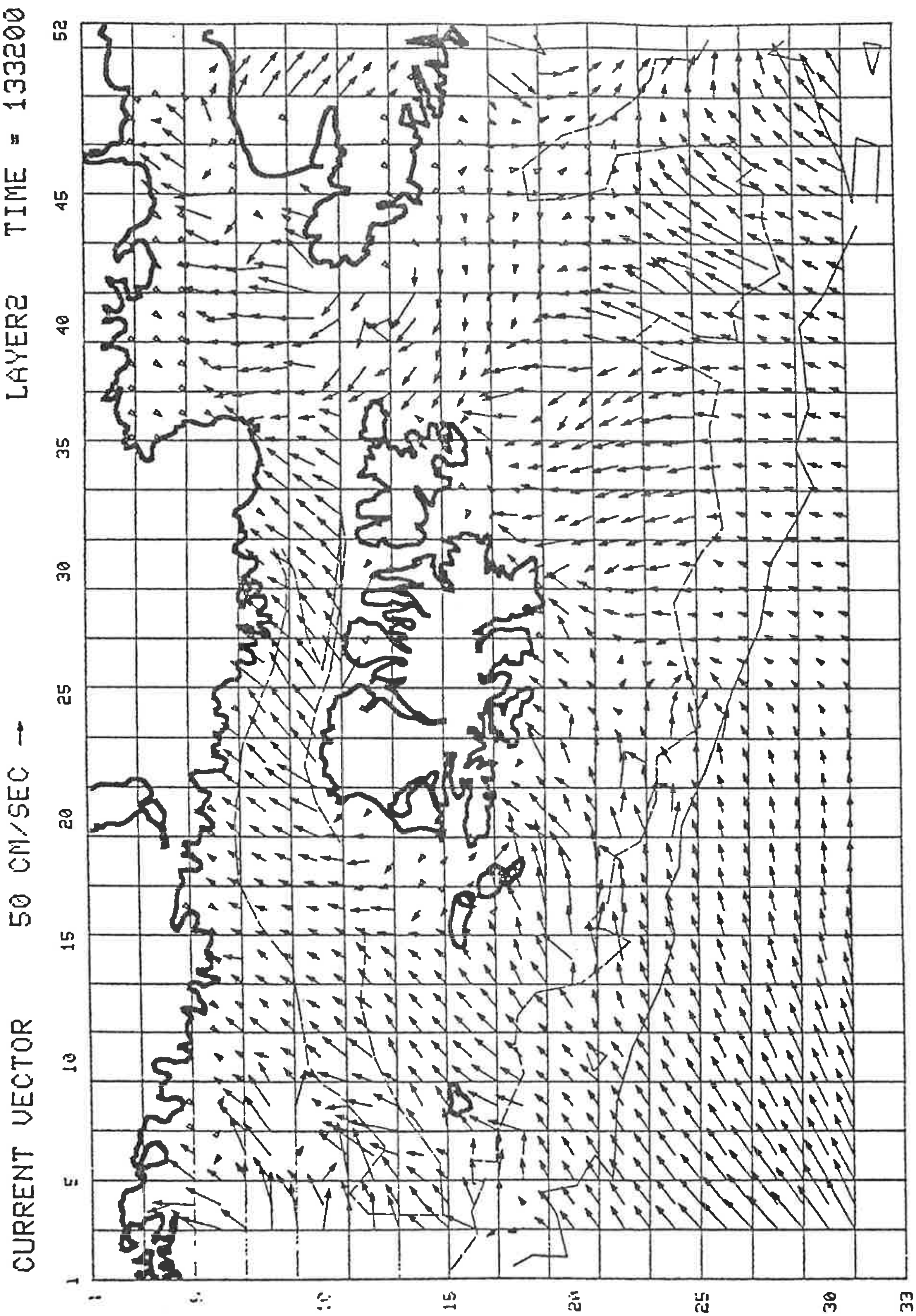

Figure 19.--Current vectors below MLD at primary high water off Kodiak.

APPENDIX B

Water Height Vector Plots.

The water height with superimposed velocity plot vector is at one of the special points selected during the MKl model run. The initial portion of the results generated during the spin up period are not plotted in this example.

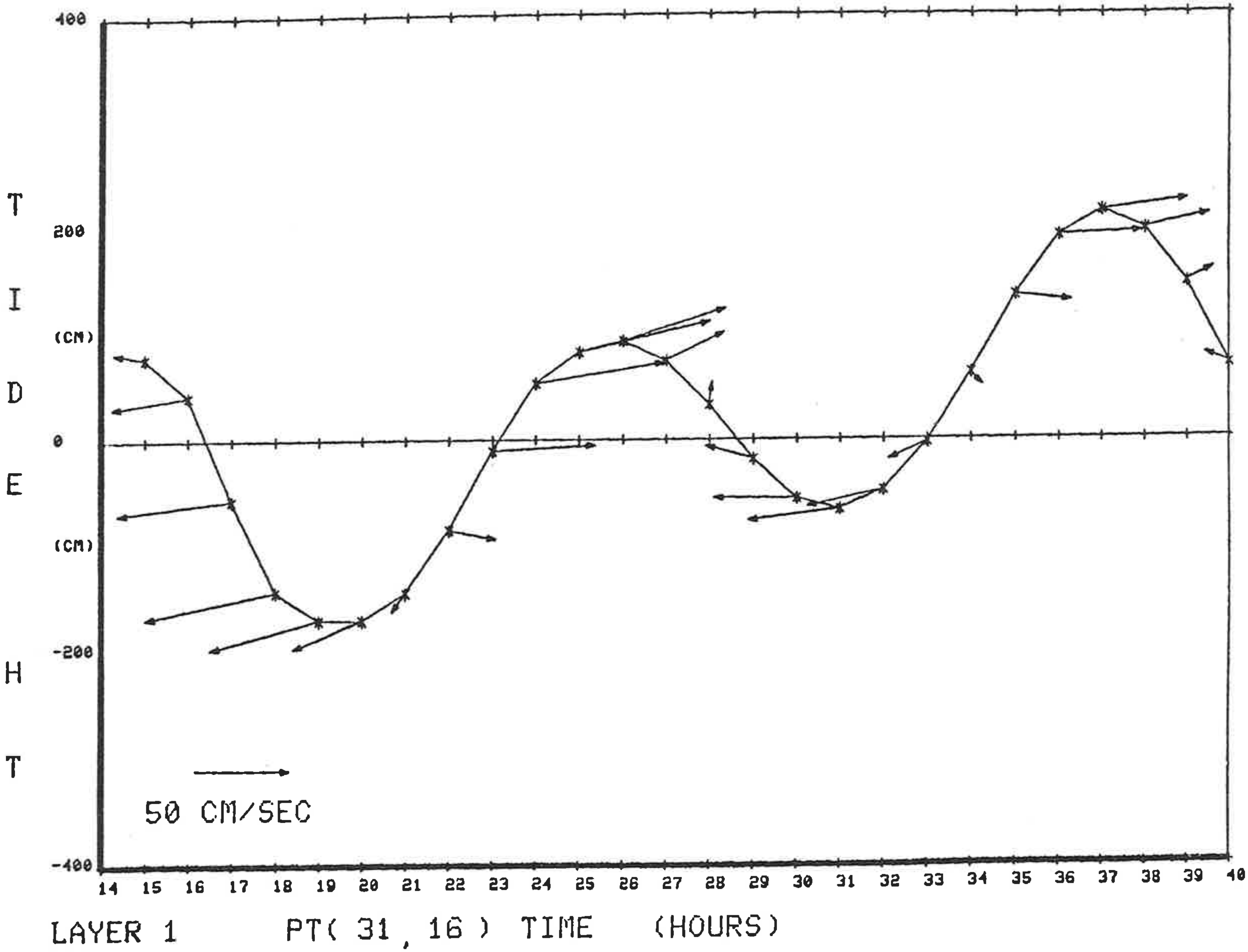

Figure 20.--Tide and resultant current off Kodiak (point 31, 16)

APPENDIX C

Tidal Ellipse Vector Plot.

The plots are produced from the file of special points created during the MK1 model run. The tidal ellipse represents a 25 hour period starting after the spin up period. The hours after start time are plotted at the ends of the vectors.

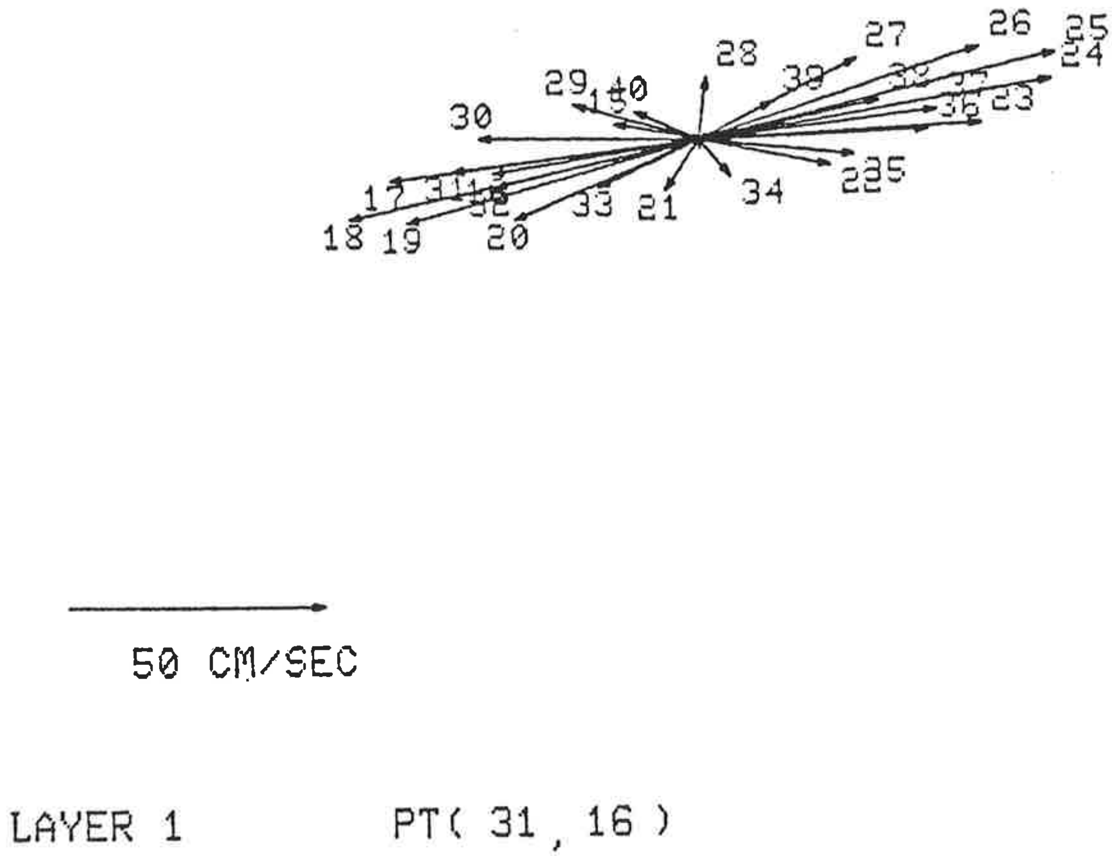

Figure 21.--Tidal ellipse vector plot off Kodiak (point 31, 16)

APPENDIX D

Rest Current Vector Plots

The rest current vector plot is the net difference of a 24 hour 50 minute time span ending at 40 hours (144,000 seconds) as shown.

The grid lines and the inversion on the Y axis is the same as the water height contours and velocity vector plots. Therefore the 1,1 point is the point next to the 33 point on the y axis.

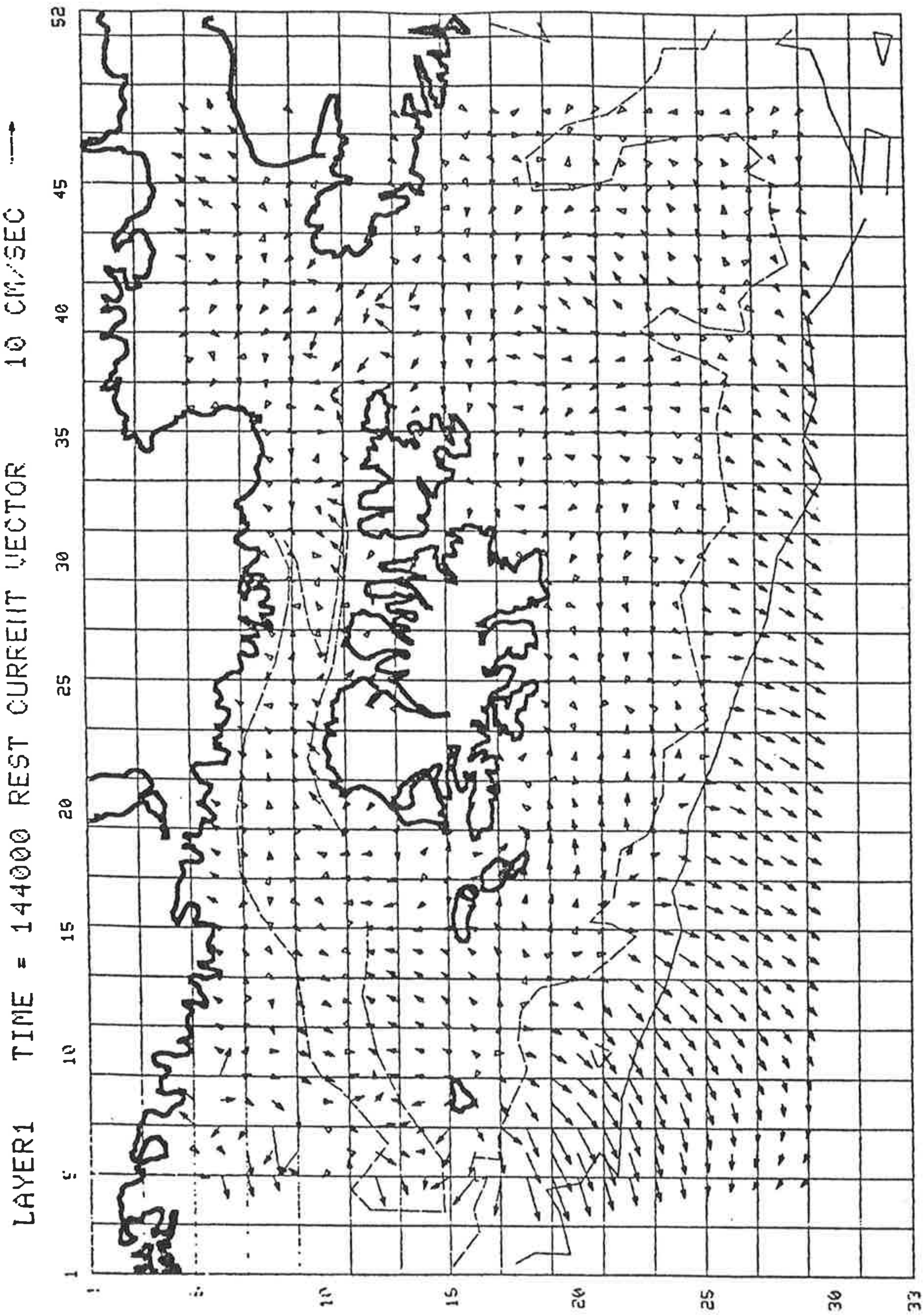

Figure 22.--Surface rest current vectors