MARINE MANAGEMENT SUPPORT:
NINGALOO

SALINITY-TEMPERATURE DATA AND CONTOUR PLOTS FROM SURVEYS CONDUCTED IN BILLS BAY ON 8 APRIL 1994 AND 29 MAY 1996.

Data Report: MMS/NIN/NIN-19/1999

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BACKGROUND

This data report presents the results of two opportunistic field surveys undertaken in Bills Bay, Western Australia on 8 April 1994 and 29 May 1996. During these field surveys salinity-temperature data were opportunistically collected from within and adjacent to Bills Bay.

DATA

The salinity-temperature data were recorded using a Yeo-Kal Electronics Hamon 602 Salinity-Temperature Bridge Mark II (Serial No. ST384). The calibrated data (for calibration details see *calibration*) is presented in Tables 1 and 2 for the 1994 and 1996 survey, respectively.

The location (for accuracy see *position fixing*) and names of the sites visited during the 1994 and 1996 surveys are represented in Figures 1 and 2, respectively. Figures 3-6 are hand-drawn contour plots of bottom temperature and salinity data, showing horizontal isotherms and isohalines of Bills Bay and the adjacent ocean.

POSITION FIXING

Position fixing during the 1994 survey was performed using a hand-held compass and line of sight with prominent landmarks. Hence, site positions on plot charts (Figures 1, 3 and 5) are approximate and the resulting salinity-temperature contours are therefore only indicative fields. It is estimated that the site locations on the plots have spatial errors of less than about 50m.

Position fixing during the 1996 survey was performed using lines of sight with prominent landmarks. Hence, site positions on plot charts (Figures 2, 4 and 6) are approximate and the resulting salinity-temperature contours are therefore only indicative fields, with limited spatial accuracy. It is estimated that site location on the plots have spatial errors of less than about 100m.

CALIBRATION

For each survey the salinity-temperature meter was calibrated using accurately analysed bottled salinity water samples and a scientific thermometer. In the field, water samples (in airtight bottles) were collected from a bucket of skimmed surface water. The salinity of the bucket water was measured with the meter and recorded on the field data sheets. The bottled salinity sample was subsequently sent to the CSIRO Marmion Laboratory for accurate analysis by an inductive salinometer. The salinometer reading was used to adjust the raw field salinity samples (Appendix I). The meter's temperature was checked using a scientific thermometer, which itself had an accuracy of +/- 0.05 C. Calibration data is presented in Appendix I of this data report.

Using the manufacturer's specifications and extensive experience in the use of the Yeo-Kal ST meter for coastal salinity-temperature surveys, the author submits that the calibrated data can be assumed to be accurate to within +/- 0.1 pss (practical salinity scale), which is equivalent to ppt (parts per thousand) in salinity and +/- 0.1 C in temperature. In the salinity contour plots the solid contours represent lines of high confidence, and the dashed lines indicate the inferred salinity between solid contours.

PRELIMINARY COMMENTS ON THE DATA AND RECOMMENDATIONS FOR FURTHER WORK

In both cases the data show that there was a horizontal stratification between the nearshore lagoonal waters and the waters further offshore. It is particularly noteworthy that the northeast and southeast regions of Bills Bay were both regions of localised salinity and/or temperature maxima or minima. This most likely represents the effects of differential heating, cooling and evaporation between the shallow (and possibly poorly flushed) offshore waters.

Researchers who have studied the effects of circulation patterns in the area point out the strong effects of wave pumping in driving oceanic water into the lagoon due to the breaking of waves over the barrier reef, with consequent compensating flows of water out strongly through the reef gaps (Dr Chris Simpson, Pers. Comm.). It may be that this mean circulation pattern somewhat bypasses the inner nearshore regions within the lagoons of the Ningaloo Reef area. Further conclusions on the hydrodynamics associated with the observed stratification are not possible based solely on the data presented herein. Further survey work of this nature, preferably complemented by measurements such as temperature logger deployments and in-situ flow measurements, and supplemented by 3D hydrodynamic modelling, would be required to help resolve the dynamics of this area.

Dr Cliff Hearn and colleagues conducted related hydrodynamic research on the Ningaloo Reef lagoons and adjacent oceanic waters during the 1980s. Currently, the Australian Institute of Marine Science are investing the hydrodynamics of the lagoons and adjacent shelf regions of the Ningaloo Reef.

TABLES AND FIGURES

Table 1: Calibrated salinity-temperature data collected at Bills Bay, Western Australian on 08/04/94.

SITE	TIME (HRS)	DEPTH (M)	TEMPERATURE (°C)	SALINITY (PPT)
CB5	1115	0.1	26.2	35.46
		2	26.15	35.46
		3.5	26.1	35.46
CB10	1120	0.1	26.3	35.48
		4	26.3	35.488
CB20	1125	0.1	26.3	35.5
		3.0	26.3	35.5
CB30	1130	0.1	26.6	35.42
		2.5	26.6	35.42
CB60	1145	0.1	26.8	35.43
		3	26.8	35.43
CB50	1150	0.1	26.3	35.43
		6	26.3	35.43
CB40	1155	0.1	26.3	35.5
		4	26.3	35.5
CB70	1200	0.1	26.15	35.6
		2	26.15	35.6
CB80	1208	0.1	26.3	35.5
		2	26.3	35.5
CB90	1215	0.1	26.5	35.45
		3	26.5	35.4
		7	26.3	35.4
CB120	1228	0.1	26.3	35.38
		2	26.3	35.38
		4.5	26.3	35.38
CB110	1230	0.1	26.05	35.5
		3	26	35.5
CB100	1235	0.1	26.25	35.5
		2	26.25	35.5
CB130	1250	0.1	25.55	35.6
		2.5	25.55	35.6
CB140	1305	0.1	26.35	35.4
		3	26.35	35.4
CB150	1325	0.1	26.8	35.35
		1.5	26.7	35.35
		3	26.7	35.35
CB180	1340	0.1	27	35.3
		2.25	27	35.3
CB170	1350	0.1	26.5	35.32
		2	26.5	35.35
		3	26.25	35.4
		4	25.9	35.5
CB100	1355	0.1	25.5	35.38
		0.5	25.6	35.38

		1	25.85	35.52
		2	25.85	35.52
		3	25.85	35.52

Table 2: Calibrated salinity-temperature data collected at Bills Bay, Western Australian on 29/05/96.

SITE	DEPTH (M)	TEMPERATURE (°C)	SALINITY (PPT)
1	0.1	25.25	35.65
	1	24.85	35.65
	2	24.65	35.63
2	0.1	25.35	35.55
	2	25.35	35.55
3	0.1	25.55	35.57
	2	25.55	35.57
4	0.1	25.7	35.53
	2	25.6	35.5
5	0.1	25.75	35.47
	2.5	25.75	35.47
6	0.1	25.8	35.43
	3.5	25.5	35.45
7	0.1	26.65	35.35
	3	26.65	35.35
8	0.1	26.85	35.32
	2	26.85	35.34
9	0.1	26.4	35.38
	3	26.05	35.41
10	0.1	26.75	35.33
	2.5	26.65	35.33
11	0.1	26.35	35.38
	5.5	25.95	35.45
12	0.1	26.6	35.34
	5	26.65	35.45
13	0.1	25.15	35.5
	1	25.15	35.5
	2	25.15	35.5
14	0.1	25.45	35.25
	1	25.45	35.25
	1.5	25.45	35.25
15	0.1	24.15	35.37
	1	24.15	35.37
16	0.1	24.3	35.57
	1	24.3	35.57
1N	0.1	25.15	35.53
	1	25.05	35.53
16N	0.1	23.9	35.41
17	0.1	23.8	35.45
	1	23.65	35.45
18	0.1	25.1	35.25

	1	25.1	35.25
19	0.1	25.95	35.15
	4	25.9	35.15

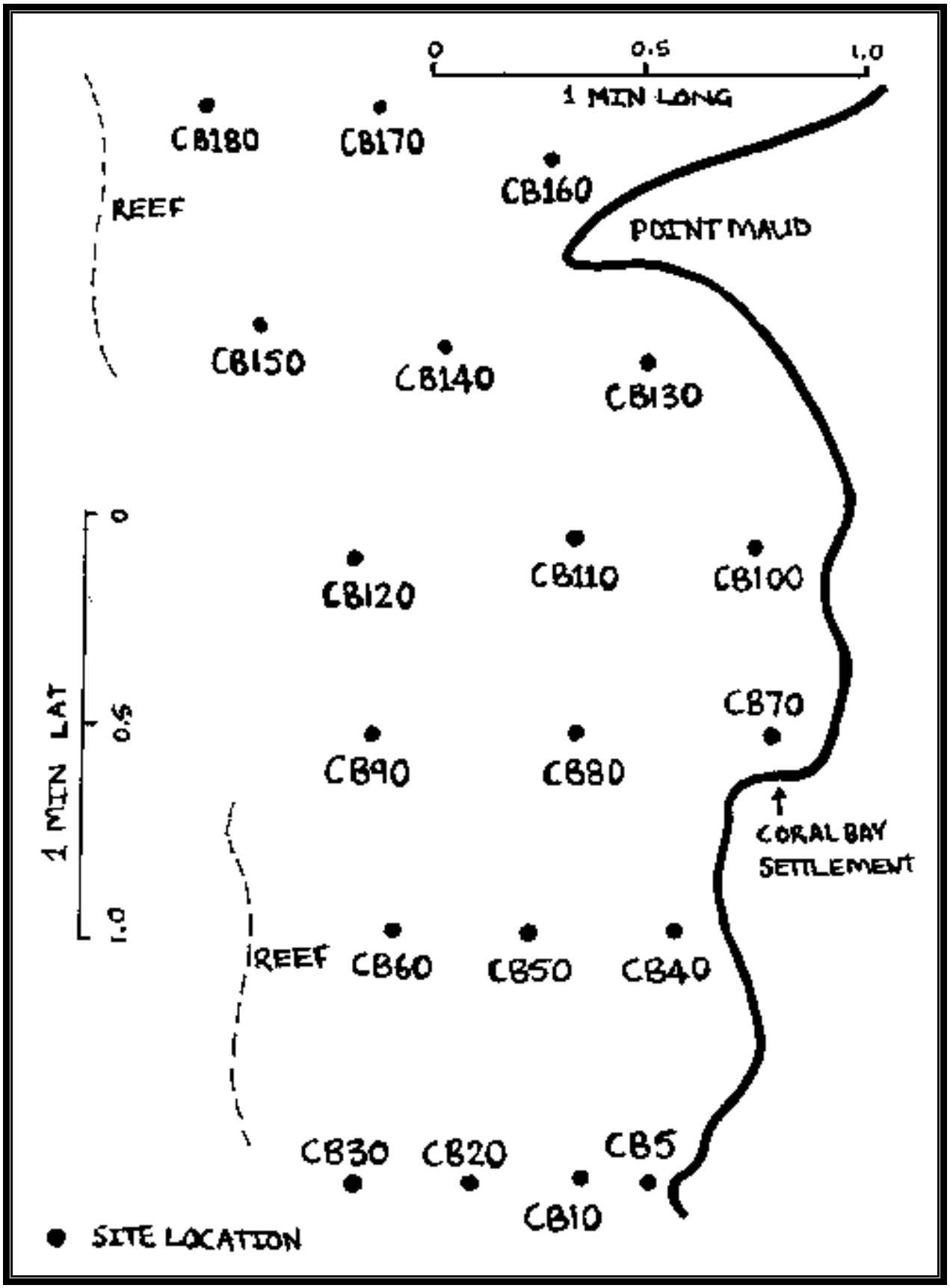

Figure 1: Sites sampled in Bills Bay, Western Australia on 08/04/94.

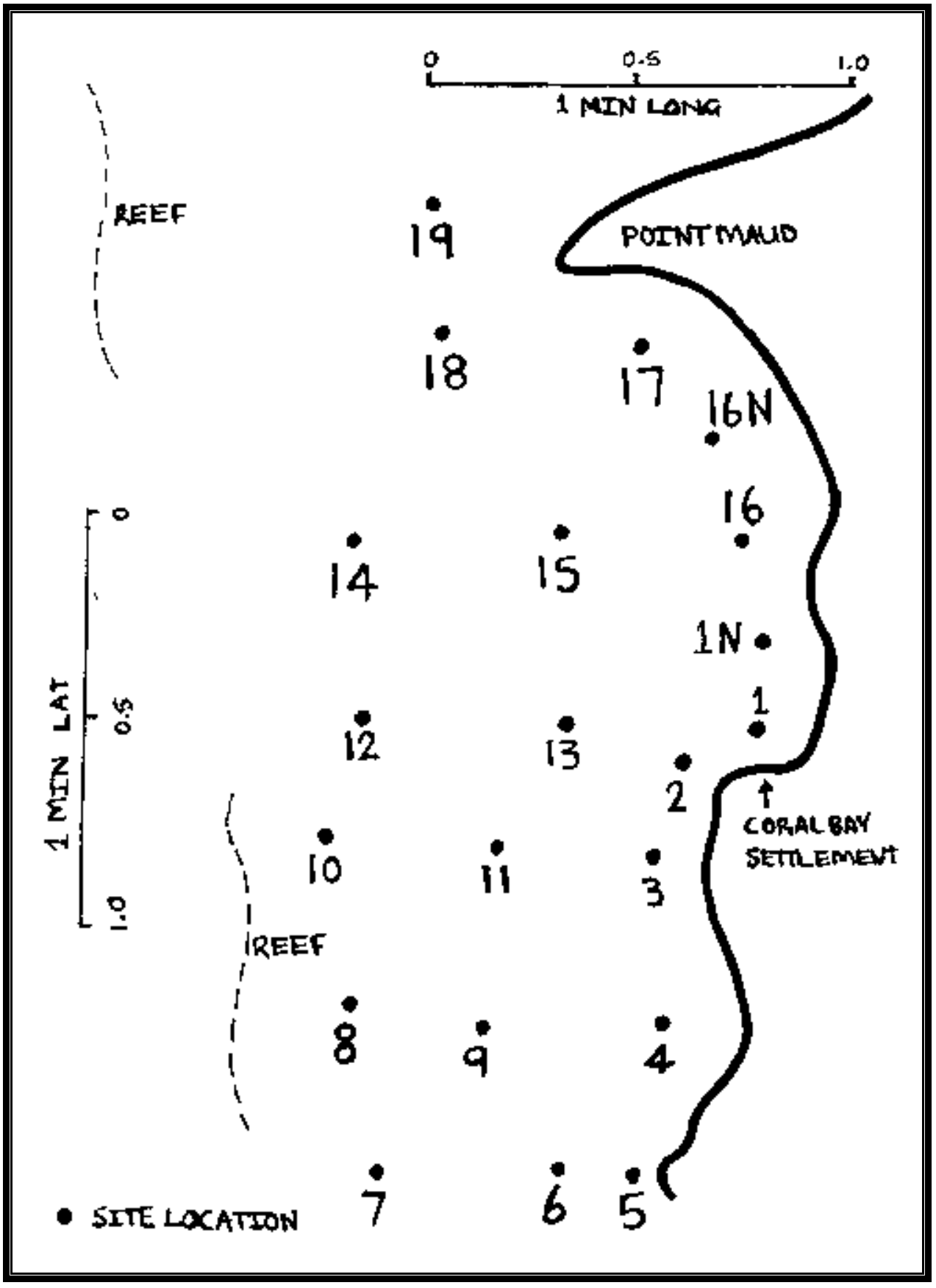

Figure 2: Sites sampled in Bills Bay, Western Australia on 29/05/96.

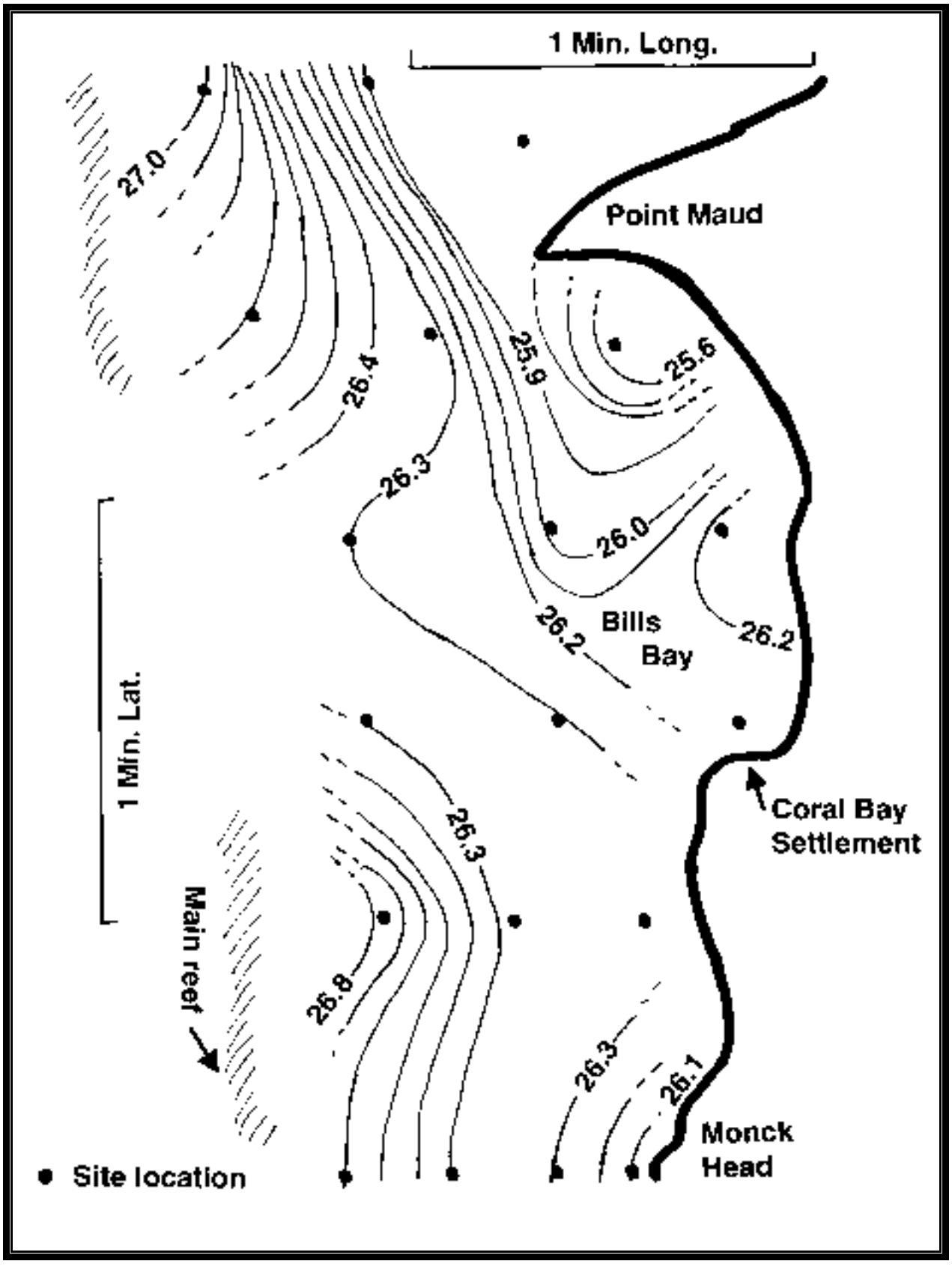

Figure 3: Horizontal temperature field for bottom temperatures at Bills Bay, Western Australia on 08/04/94.

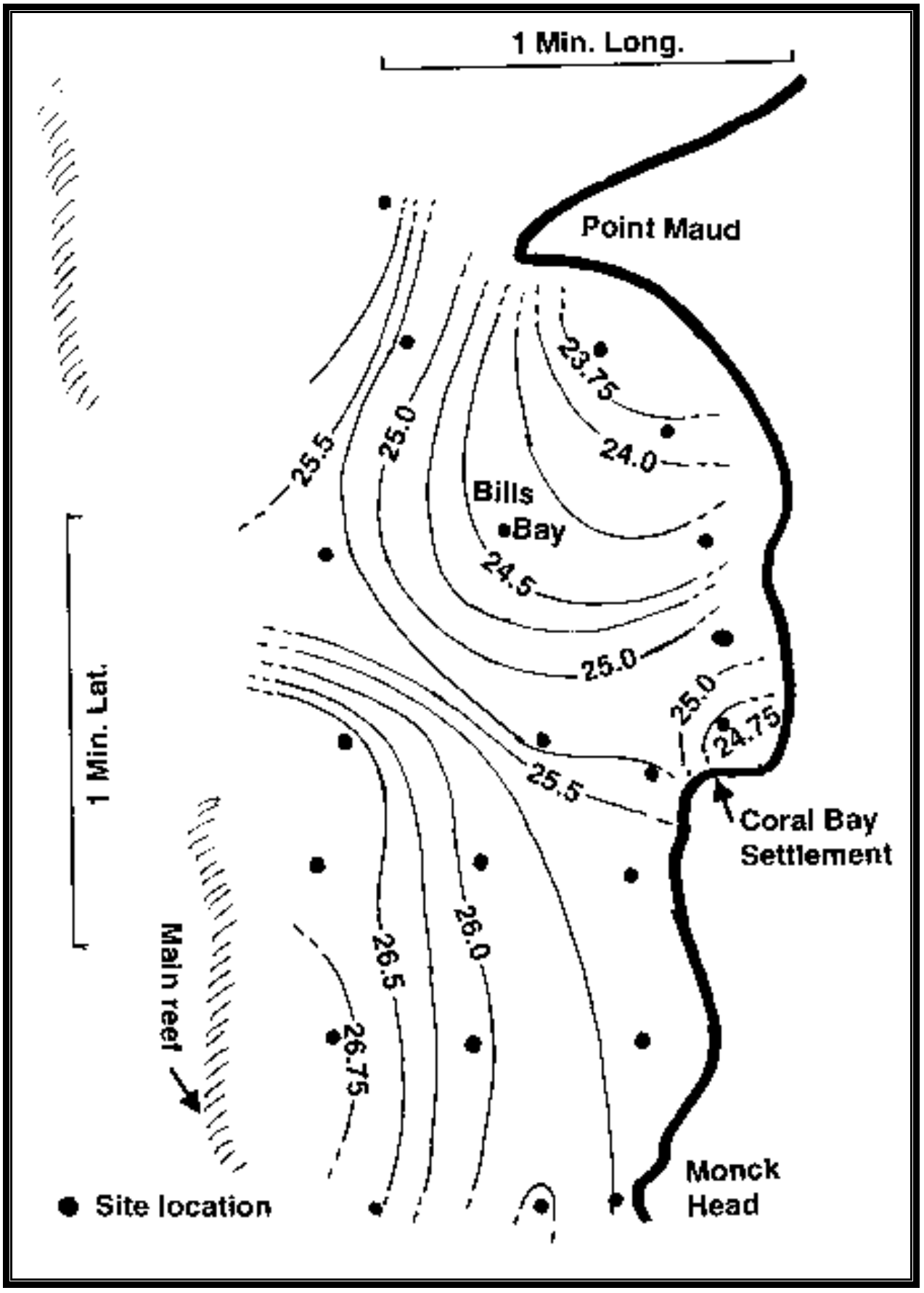

Figure 4: Horizontal temperature field for bottom temperatures at Bills Bay, Western Australia on 29/05/96.

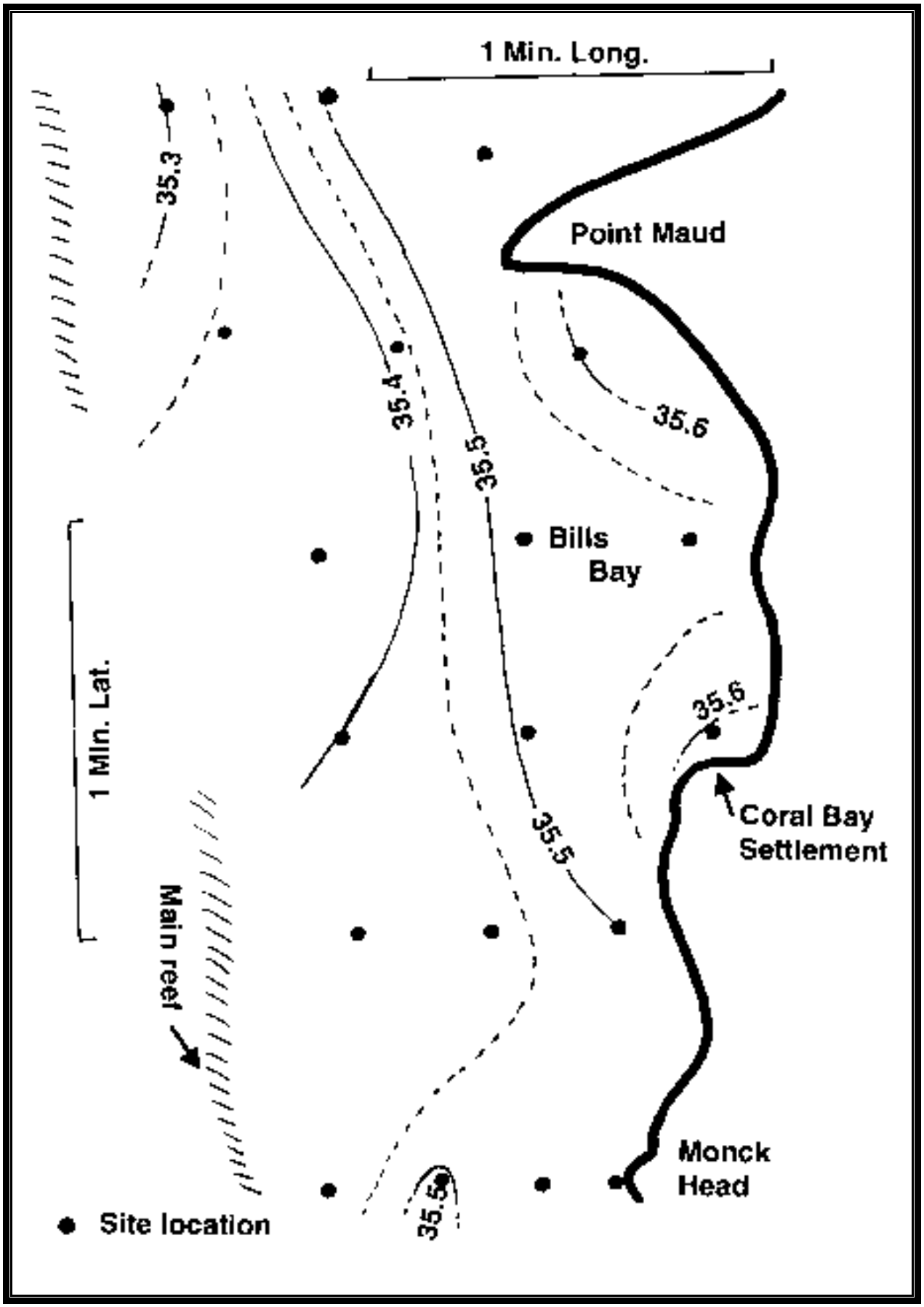

Figure 5: Horizontal salinity field for bottom salinities at Bills Bay, Western Australia on 08/04/94.

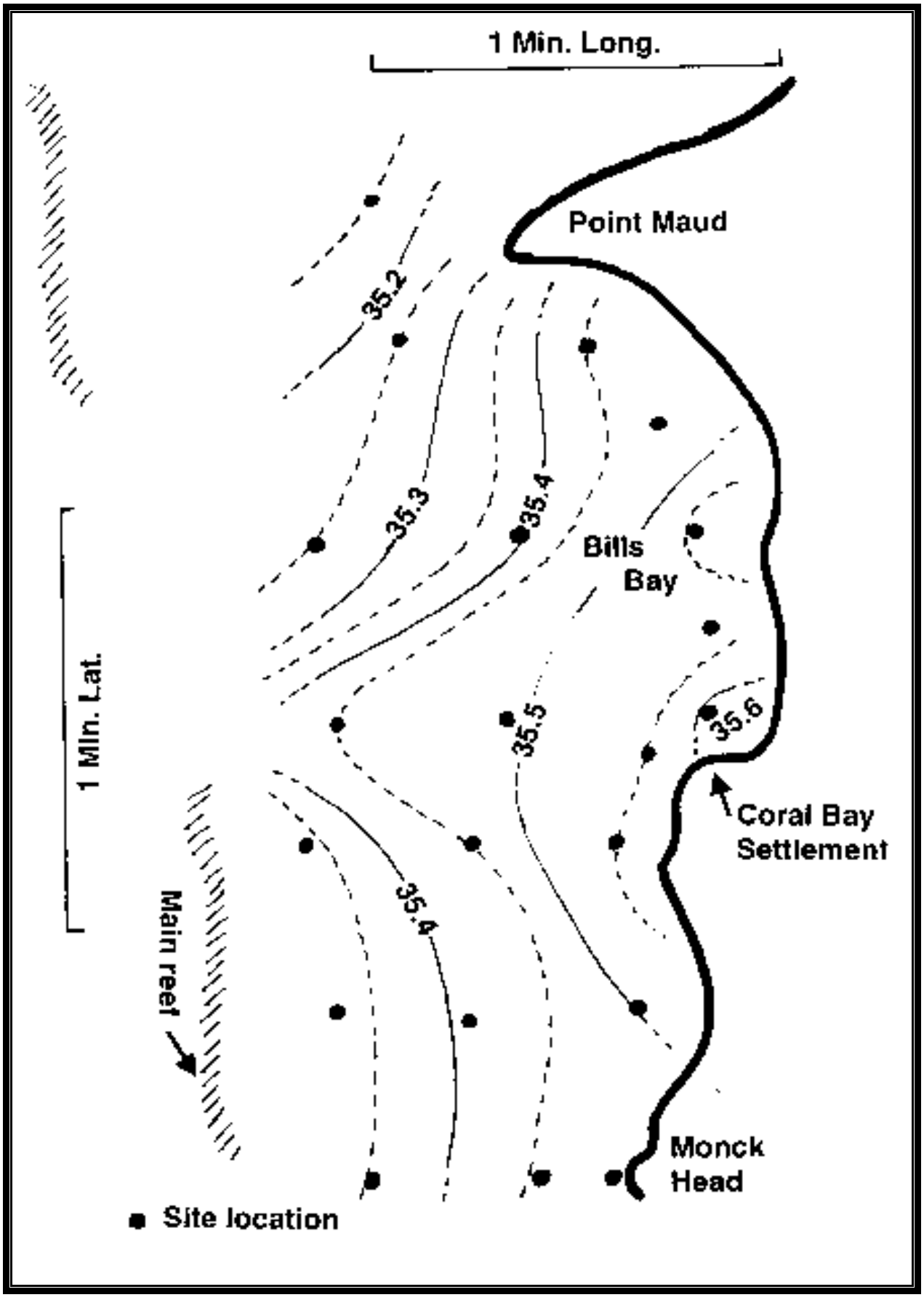

Figure 6: Horizontal salinity field for bottom salinities at Bills Bay, Western Australia on 29/05/96.

Appendix I: Calibration details for salinity-temperature data collected at Bills Bay, Western Australia on 08/04/94 and 29/05/96

SALINITY 08/04/94

Site	Salinity A (ppt)[1]	Salinity B (ppt)[2]	Adjustment made to raw salinity data (ppt)[3]
CB70	35.4	35.497	Add 0.097
CB130	35.4	35.614	Add 0.214
CB150	35.15	35.436	Add 0.285

[1]Salinity A: salinity recorded in the field using a salinity temperature meter.
[2]Salinity B: salinity of bottle sample measured by CSIRO inductive salinometer (ppt).
[3]Mean adjustment: Add 0.198 ppt.

TEMPERATURE 08/04/94

Sample	Temperature A (°C)[1]	Temperature B (°C)[2]	Adjustment made to raw salinity data (ppt)[3]
1	25.6	25.3	Deduct 0.3
2	27	26.8	Deduct 0.2
3	27.9	27.7	Deduct 0.2
4	28.95	28.8	Deduct 0.15
5	29.4	29.35	Deduct 0.05

[1]Temperature A: temperature recorded using a salinity temperature meter.
[2]Temperature B: temperature recorded using a scientific thermometer.
[3]Mean adjustment: Deduct 0.2 ppt.

SALINITY 29/05/96

Site	Salinity A (ppt)[1]	Salinity B (ppt)[2]	Adjustment made to raw salinity data (ppt)[3]
16N	34.96	35.42	Add 0.46

[1]Salinity A: salinity recorded in the field using a salinity temperature meter.
[2]Salinity B: salinity of bottle sample measured by CSIRO inductive salinometer (ppt).
[3]Mean adjustment: Add 0.46 ppt.

TEMPERATURE 29/05/96

Sample	Temperature A (°C)[1]	Temperature B (°C)[2]	Adjustment made to raw salinity data (ppt)[3]
1	26.8	26.8	0
2	26	26	0
3	23.05	23.72	Add 0.15

[1]Temperature A: temperature recorded using a salinity temperature meter.
[2]Temperature B: temperature recorded using a scientific thermometer.
[3]Mean adjustment: Add 0.05 ppt.