Figure 3-1: 1997 Wind Velocity and Water Level Records.

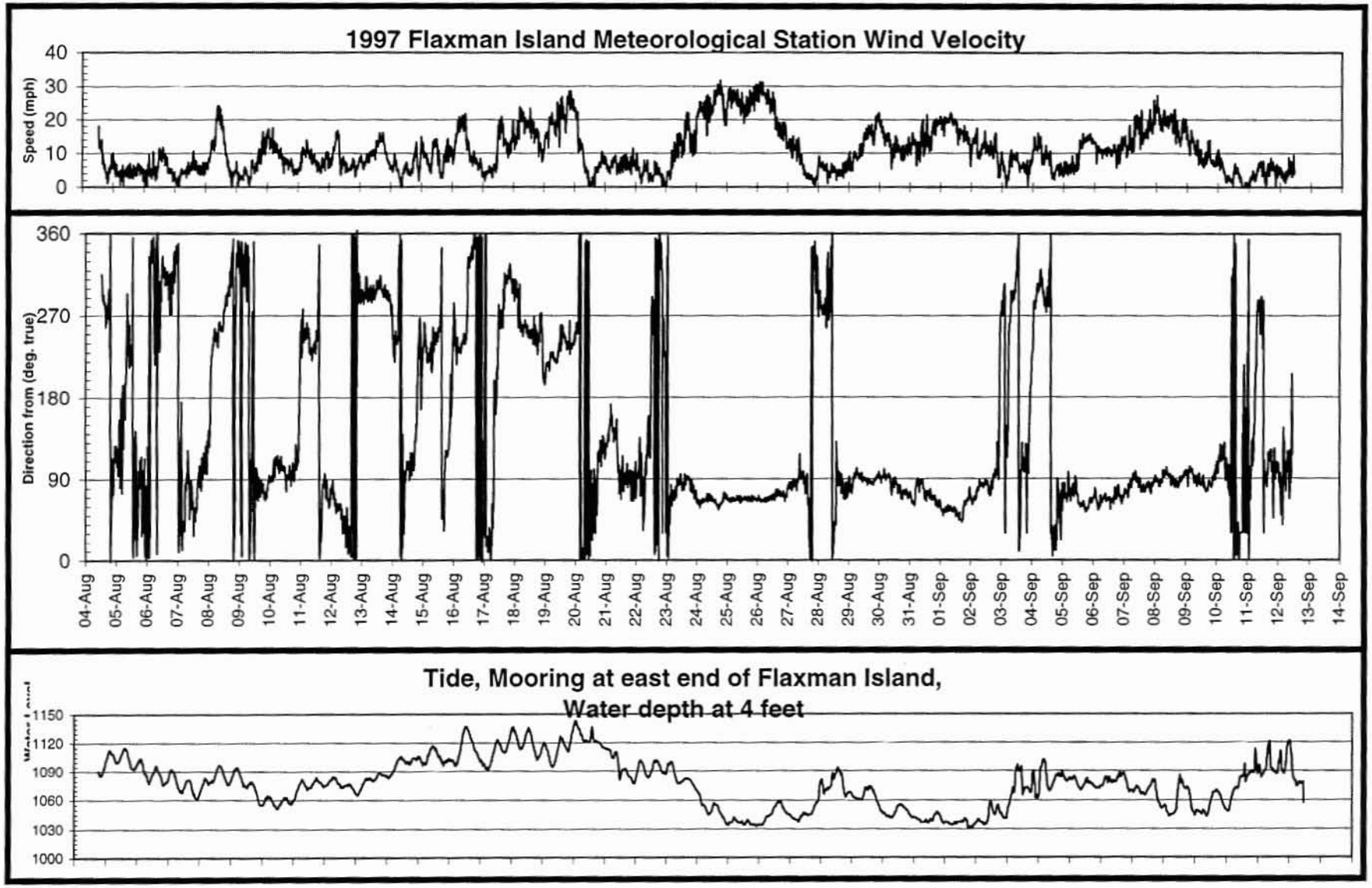


Figure 3-2: 1997 Current Meter Records.

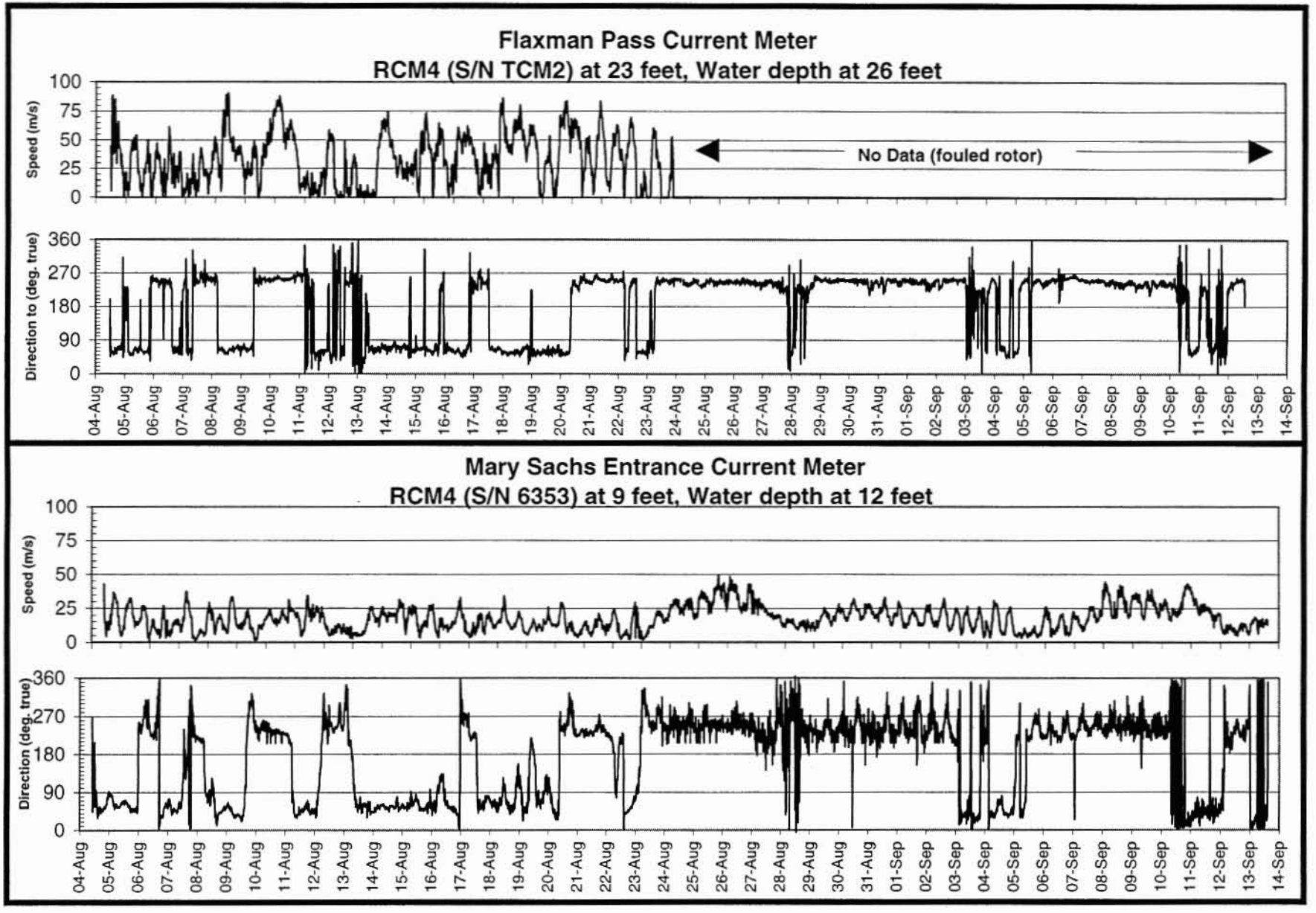
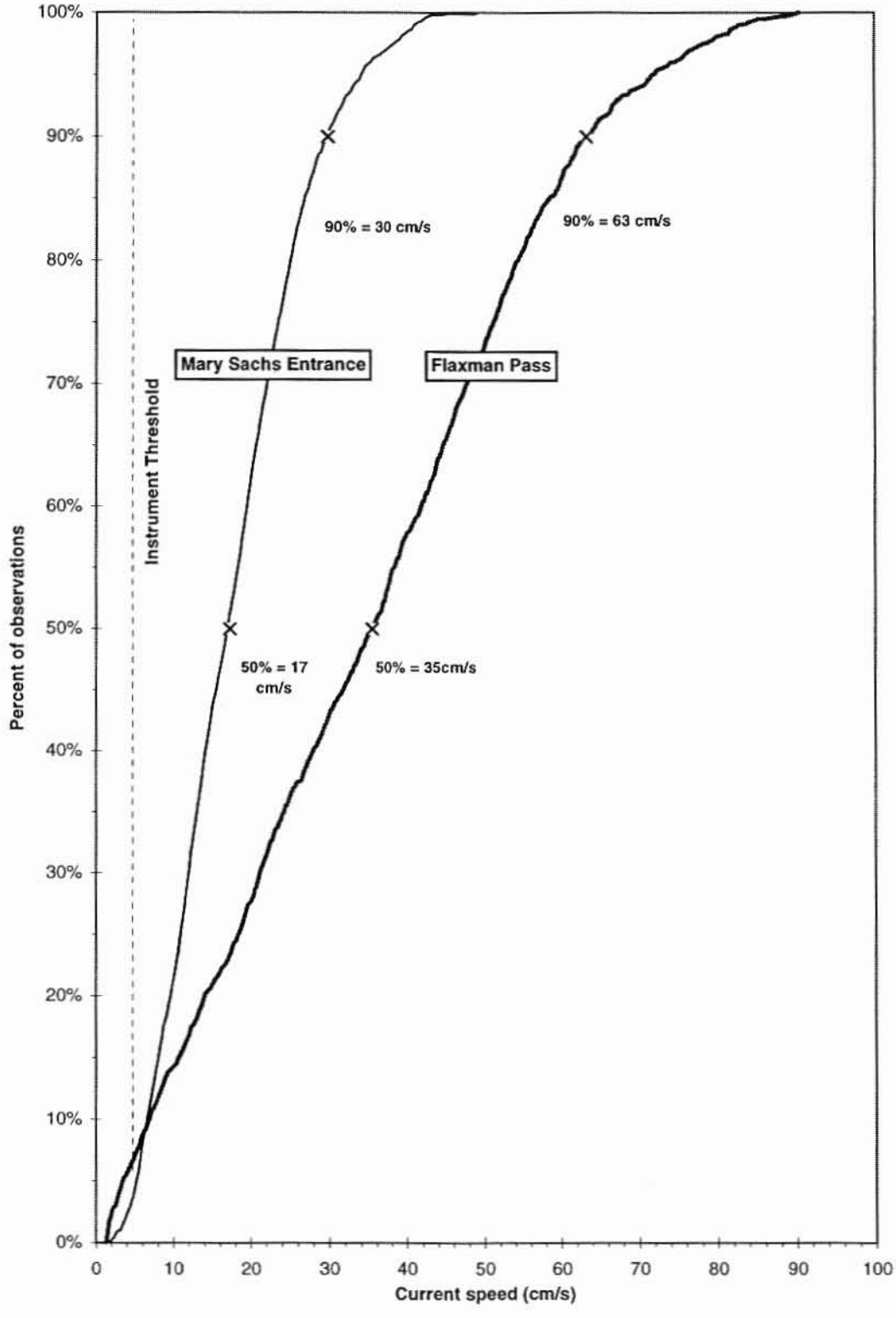


Figure 3-3: 1997 Current Speed Cumulative Frequency Diagram



S:\976026na\Data\Database\Excel\Goodcharts.xls, Fig 3-3

Figure 3-4: 1997 Salinity and Temperature Records.

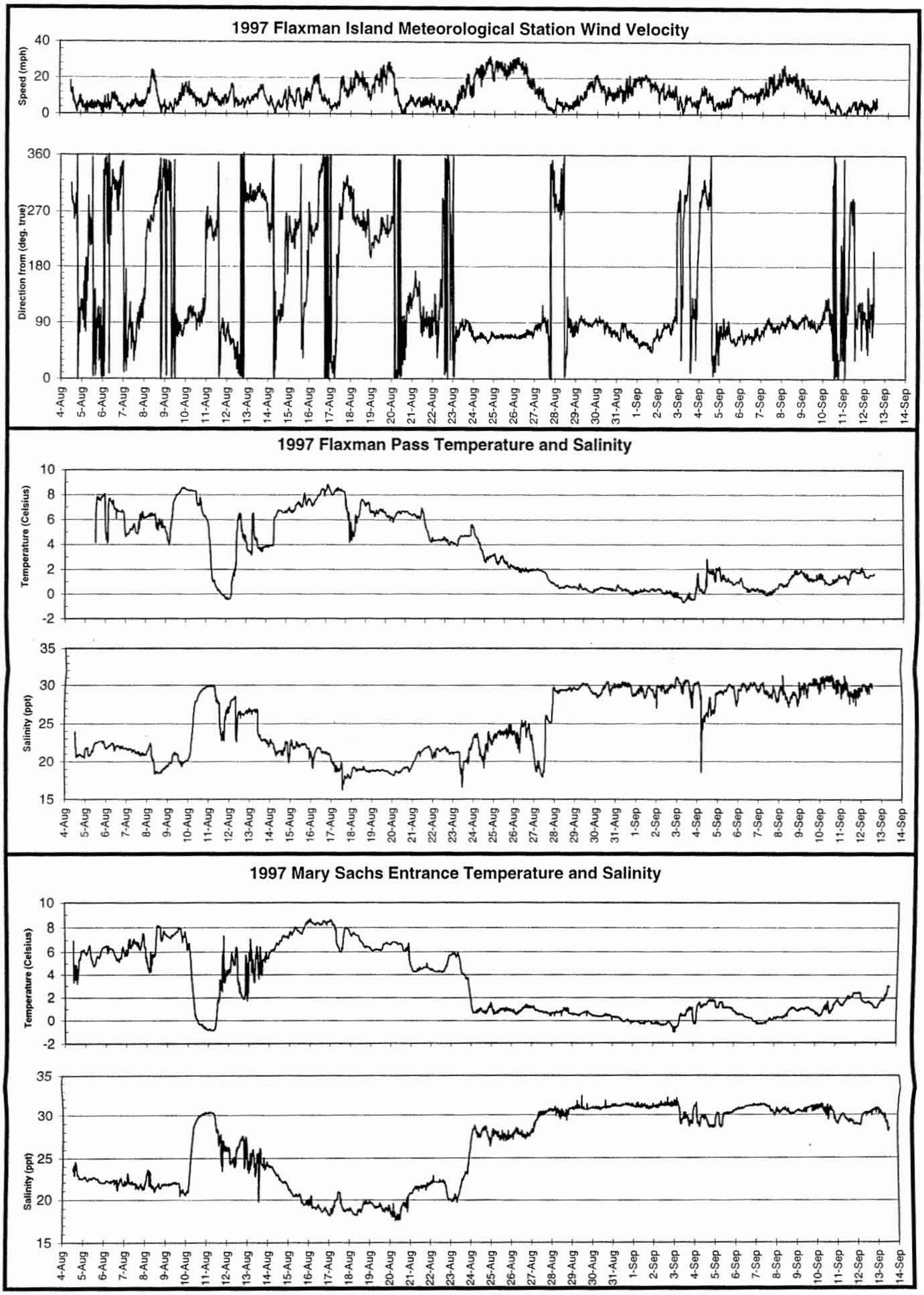
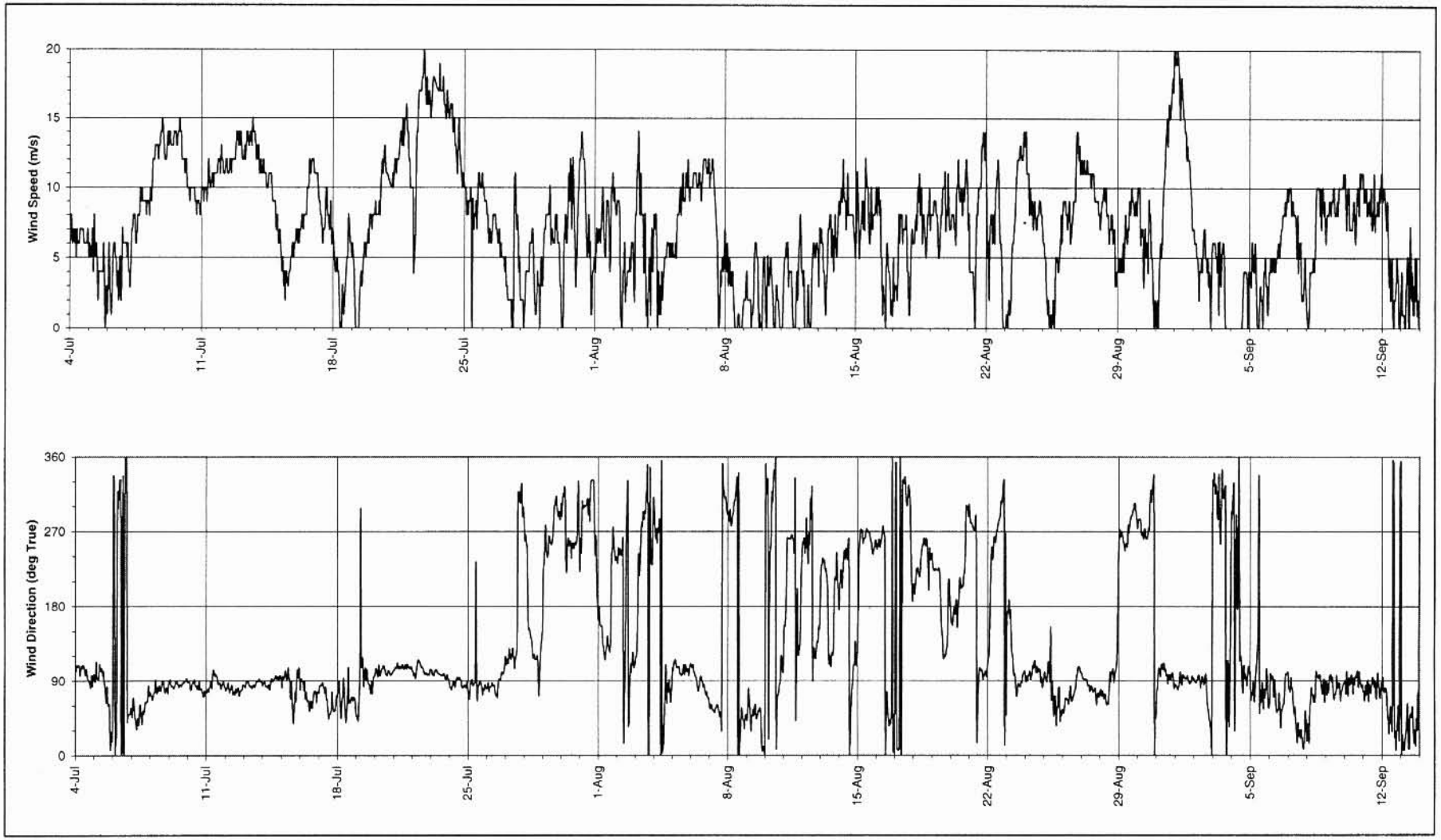
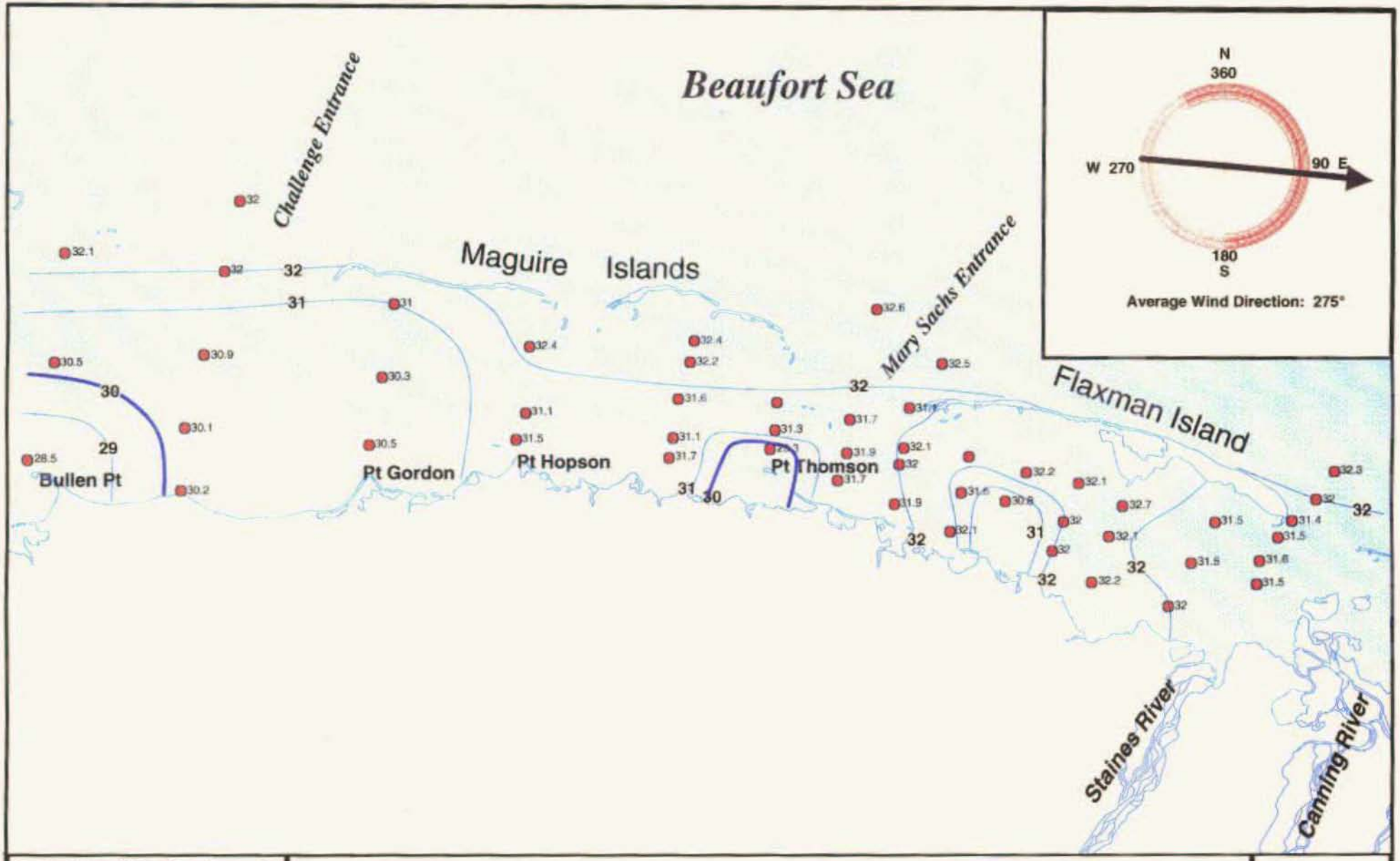


Figure 3-5: 1998 Summer Meteorology Record, NOAA Station #9497645 1, Prudhoe Bay, Alaska



S:\Projects\WCC\986002na\Database\Met\METgraph, PTAC Fig3-5



Contour Interval: 1 part per thousand

URS Greiner Woodward Clyde

Surface Water Salinity Distribution
July 31, 1998

Figure 3-6

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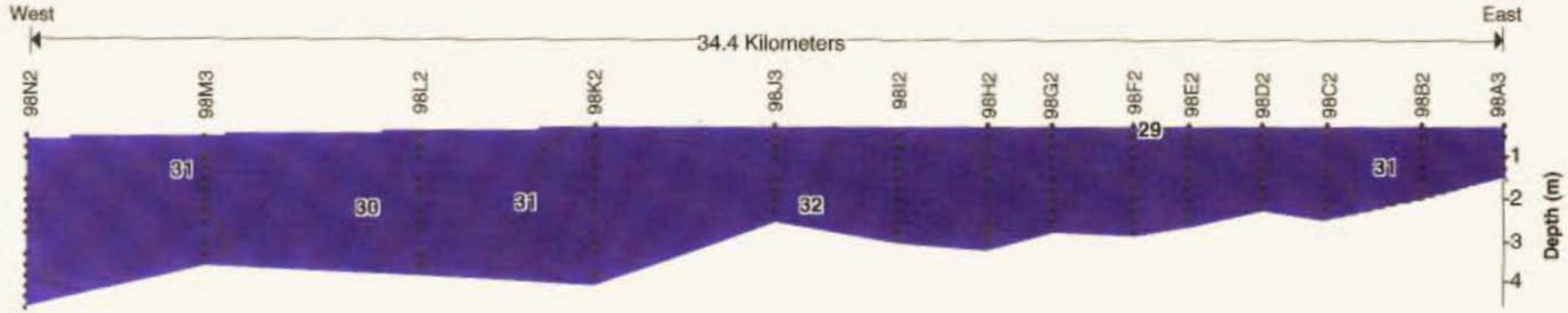
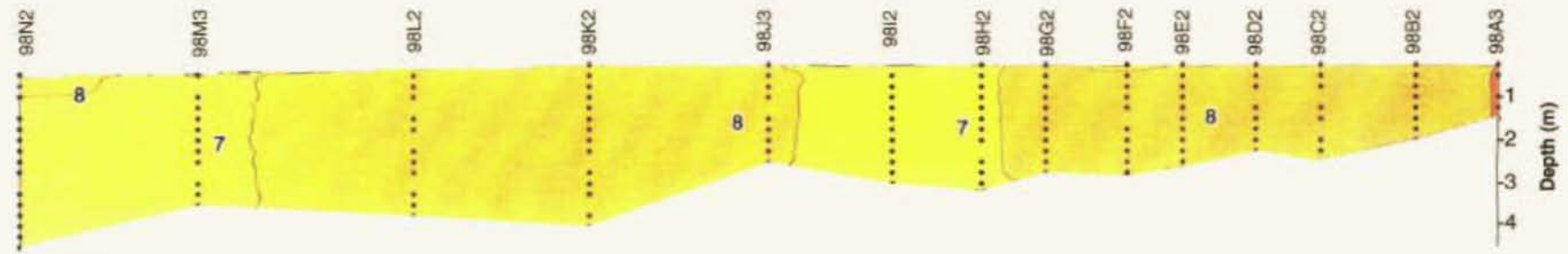
Cross Sectional Transect

Salinity (ppt) Profile



Temperature (Celsius) Profile



Vertical Sample Interval: 0.25 m
Vertical Exaggeration: 1000:1

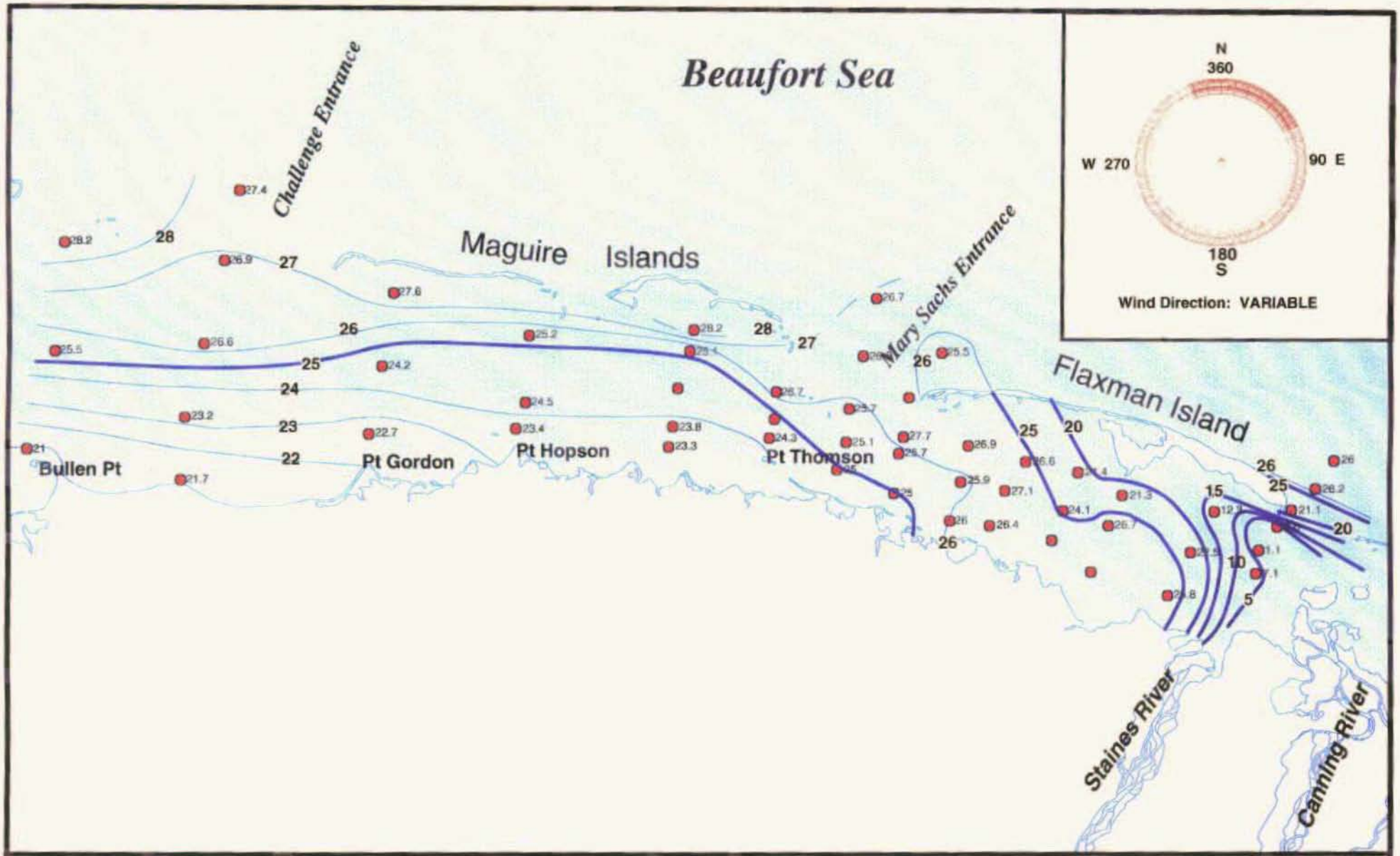
Temperature Contour Interval: 1° Celsius
Salinity Contour Interval: 1 part per thousand

URS Greiner Woodward Clyde

S:\projects\wcc\666002\nat\gis\fig3-7.wor

Temperature and Salinty Water Column Structure: Mid Channel Transect, July 31, 1998

Figure 3-7



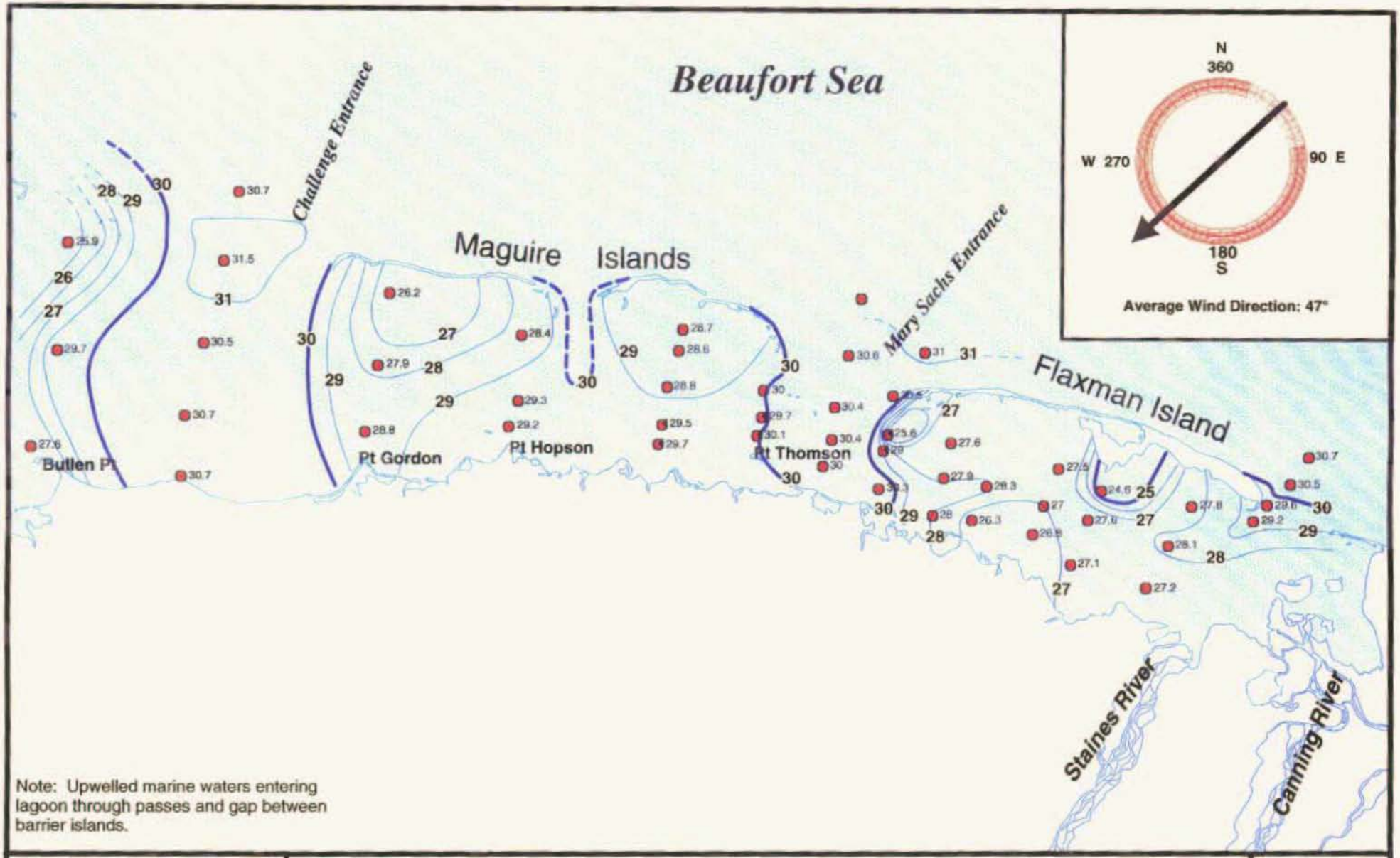
Contour Interval:
5 parts per thousand (ppt);
1 ppt interval above 25 ppt.

URS Greiner Woodward Clyde

Surface Water Salinity Distribution
August 12, 1998

Figure 3-8

S:\projects\wcc\986002\nal\gis\fig3-8.wor



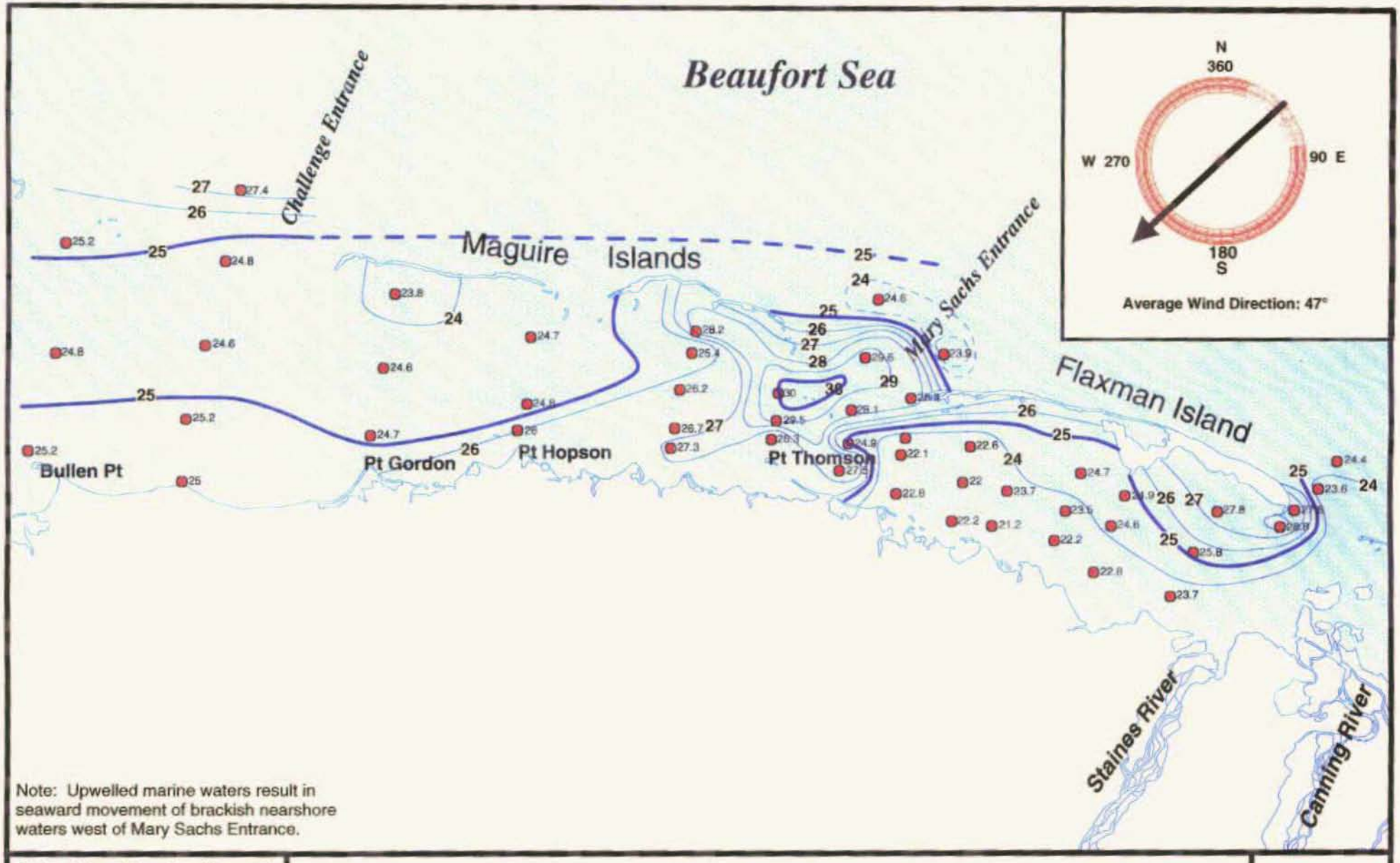
Contour Interval: 1 part per thousand

Bottom Water Salinity Distribution
August 25, 1998

Figure 3-9

URS Greiner Woodward Clyde

S:\projects\wcc\986000\reig\sf\fig3-9.wor



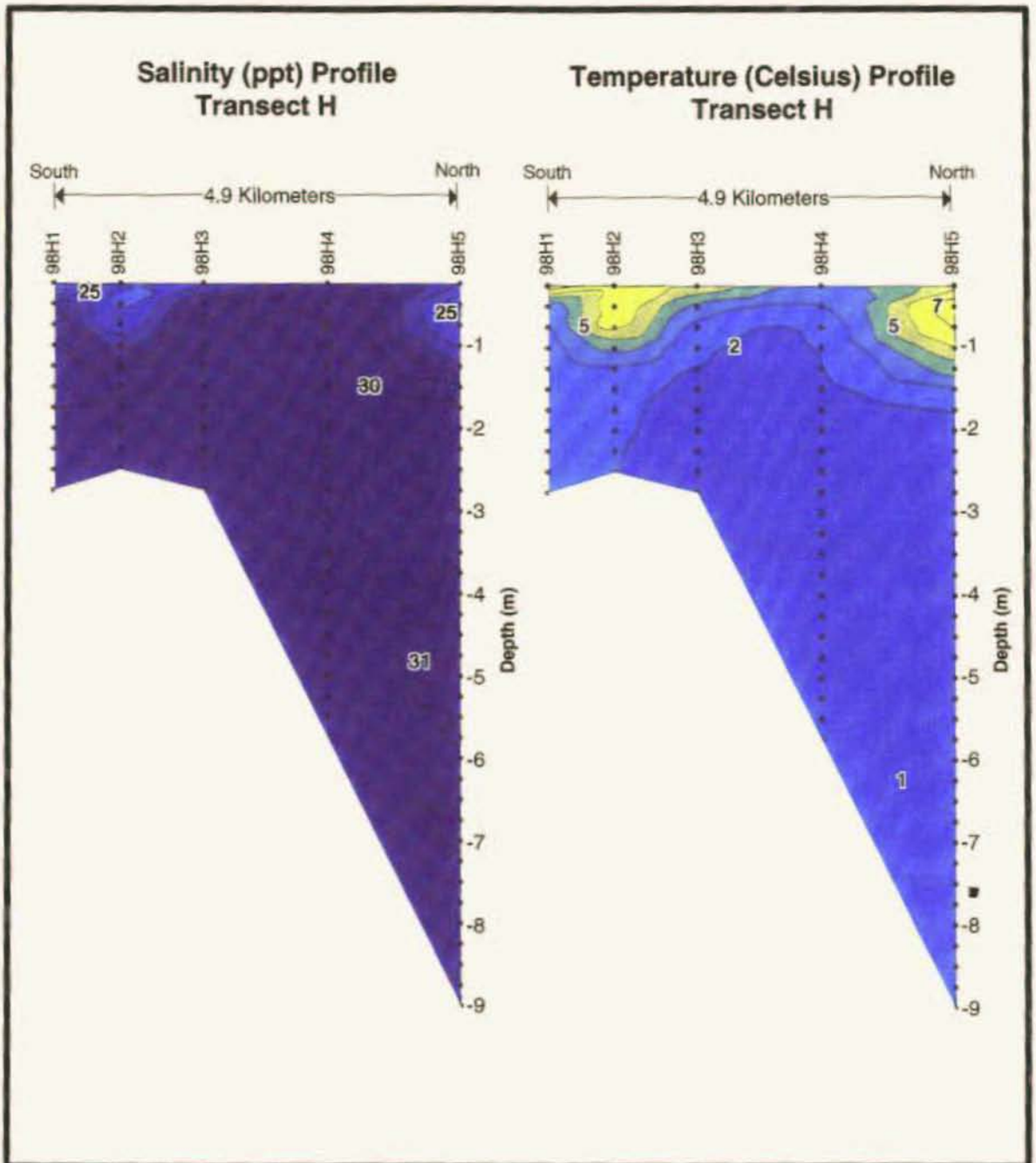
Contour Interval: 1 part per thousand

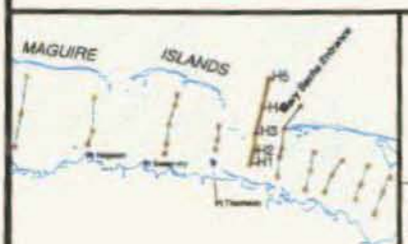
URS Greiner Woodward Clyde

Surface Water Salinity Distribution
August 25, 1998

Figure 3-10

S:\projects\wcc\666002\ai\gis\fig3-10.wor





URS Greiner Woodward Clyde

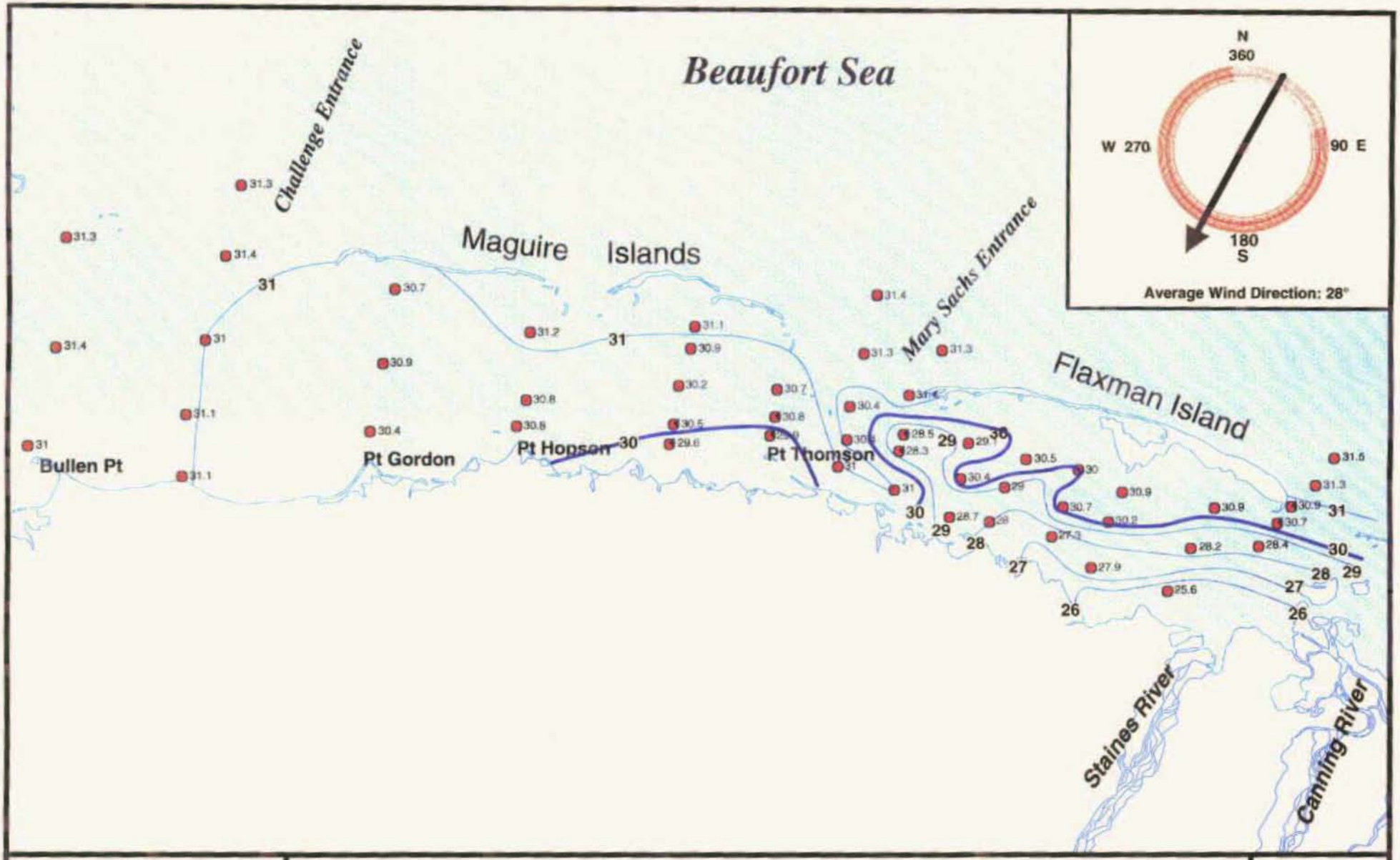
Temperature and Salinty Water Column Structure: Mid Channel Transect, July 31, 1998

Vertical Sample Interval: 0.25 m
Vertical Exaggeration: 1000:1

Temperature Contour Interval: 1° Celsius
Salinity Contour Interval: 1 part per thousand

Figure 3-11

S:\projects\wcct986002na\gis\fig3-11.wor



Contour Interval: 1 part per thousand

Bottom Water Salinity Distribution
September 13, 1998

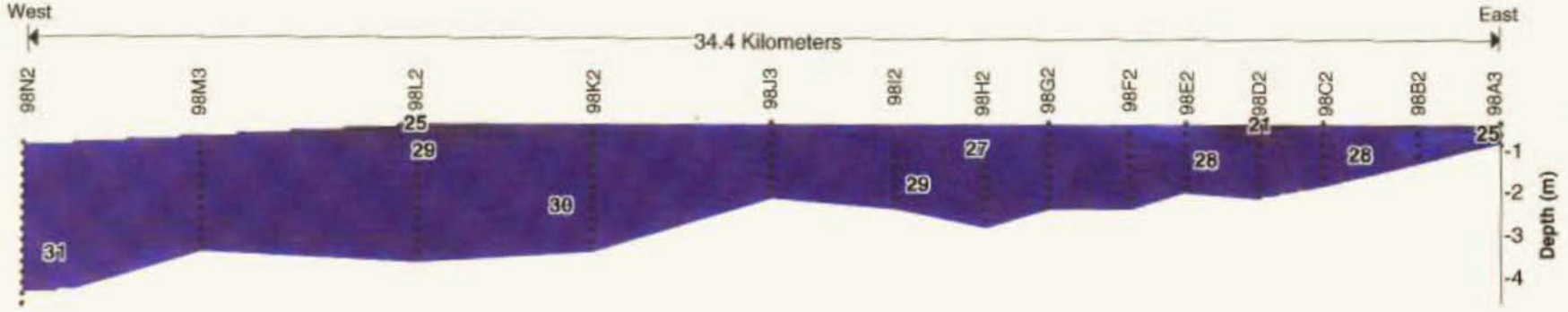
Figure 3-12

URS Greiner Woodward Clyde

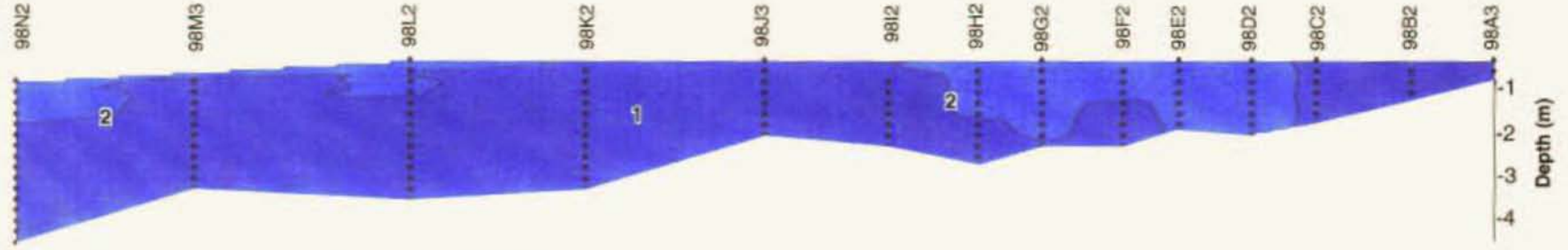
S:\projects\wcc\986002\wl\gis\fig3-12.wor

Cross Sectional Transect

Salinity (ppt) Profile



Temperature (Celsius) Profile



Vertical Sample Interval: 0.25 m
Vertical Exaggeration: 1000:1

Temperature Contour Interval: 1° Celsius
Salinity Contour Interval: 1 part per thousand

URS Greiner Woodward Clyde

S:\projects\wod\98502\sal\gis\fig3-13.wor

Temperature and Salinty Water Column Structure: Mid Channel Transect, September 13, 1998

Figure 3-13

The oceanographic environment within Lions Lagoon is a relatively shallow marine lagoon that is situated south of a barrier island complex with a width of approximately 3 to 4 miles, and water depths typically between 5 and 13 feet (ft). The other marine environment is the Beaufort Sea. The barrier island complex parallels the coast and extends approximately 18 miles from Challenge Island on the west to Flaxman Island on the east and serves as a boundary that separates the two marine environments. Channels or gaps between the barrier islands serve to connect the lagoon waters with the Beaufort Sea and are an important pathway for hydraulic communication. Thus, this coastal lagoon system serves as an interface between freshwater sources and the ocean.

4.1 LIONS LAGOON BATHYMETRY

The barrier island complex serves to shelter much of Lions Lagoon from exposure to storm waves generated in the Beaufort Sea during the open-water periods. The lagoon is divided by the Mary Sachs Entrance, a broad 2.25-mile pass between North Star and Flaxman islands. The lagoon east of the Mary Sachs Entrance is shallow and is protected by Flaxman Island, while west of the Mary Sachs Entrance is a deeper and wider lagoon that is open at the west end.

The eastern third of the lagoon is shallow, with depths generally less than 10 ft. Shoals are common near the mouth of the Staines River and western distributary of the Canning River and extend toward Point Brownlow. The channel between the east end of Flaxman Island and Point Brownlow (Flaxman Pass) is narrow (1,200 ft) and relatively deep (26 ft). Historical soundings obtained from NOAA Chart No. 16045, revised in 1996, suggest the lagoon is asymmetrical, with deeper waters near the mainland shore and a gentle slope from the mid-channel north to Flaxman Island (Figure 4-1). Water depths within the lagoon gently increase towards the west to a depth of 8 ft approximately mid-length of Flaxman Island and reach 11 ft immediately northeast of Point Thomson.

Mary Sachs Entrance is a broad and relatively deep channel, with a northeast/southwest oriented channel that extends toward Point Thomson. Water depths within the channel are typically 9 to 11 ft with the 10-ft isobath approximately 2,400 ft north of the mainland shore in the vicinity of Point Thomson (Figure 4-2). Mary Sachs Entrance provides a break in the protection offered by the barrier islands, exposing the shoreline adjacent to and east of Point Thomson to offshore storm events. The increased exposure to waves is evident by the well developed spit and bar formation along the mainland shore.

The western portion of the lagoon is protected by a group of barrier islands known as the Maguire Islands (Challenge, Alaska, Duchess and Northstar islands). This portion of the lagoon widens from 1.5 miles at Point Thomson to 3.5 miles near Challenge Island. Water depths adjacent to the mainland between Point Thomson and Point Hobson are typically 7 to 10 ft and gently increase to 16 ft at the west end of the lagoon.

4.2 REGIONAL PROCESSES

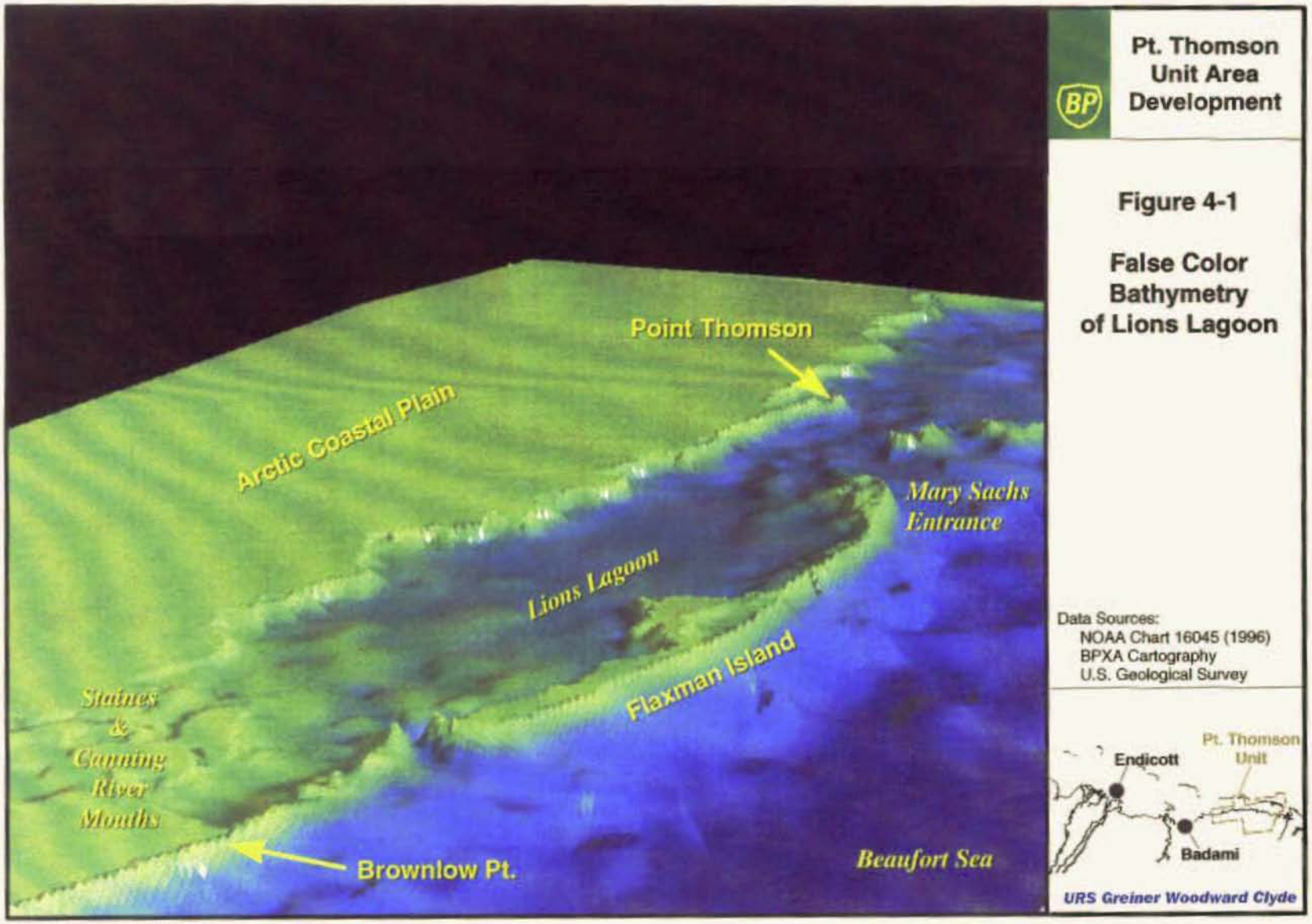
The size, shape, and orientation of Lions Lagoon is similar to the geometry of Simpson Lagoon. The prevailing wind direction, hydraulic communication with Beaufort Sea, location and size of freshwater source (east end) all make Lions Lagoon a nearly perfect analog of Simpson Lagoon,

about which much is known and therefore transferable to understanding of physics and biology of Lions Lagoon. Our present understanding of the regional processes indicate that the hydrography of virtually any location along the Alaska Beaufort coast is governed primarily by proximity of a freshwater source and recent wind history, and secondarily by the occasional profound effects of regional upwelling and downwelling phenomena.

The 1998 study documented substantial freshwater input that resulted in brackish nearshore waters immediately adjacent to the Staines and Canning rivers. During persistent easterly winds, the river discharge is advected toward the west, and thus dominates the water column within lagoon system south of Flaxman Island. The remainder of Lions Lagoon is not adjacent to a notable freshwater source; however, tundra stream runoff serves to create a thin brackish band of nearshore waters within the protected western portion of the lagoon system.

Mary Sachs Entrance and to a lesser extent, Flaxman Pass, and the other channels between the barrier island complex serve as pathways that connect the lagoon system with Beaufort Sea shelf and bottom waters. Meteorological and current velocity records collected in 1997 show quite clearly the hydraulic responsiveness of Lions Lagoon to wind direction. East winds produce a westward stress on the surface of Lions Lagoon, causing Beaufort Sea waters to be drawn southward into the lagoon system through its various entrances. The opposite effect is produced by west winds, causing water to flow northward out of the lagoon and into the Beaufort Sea.

The interaction between the brackish nearshore waters and marine bottom waters was clearly observed in the 1997 salinity time-series records. Pulses of cold, saline marine waters flowed through the barrier island channels (Mary Sachs Entrance and Flaxman Pass) and into the lagoon during persistent easterly winds. These upwelling events coincided with depressed water levels within the lagoon. The 1998 CTD surveys confirmed that the marine bottom waters enter Lions Lagoon through all of the barrier island channels during persistent easterly winds. Thus, the regional upwelling process affects Lions Lagoon in the same manner along the Beaufort Sea coast that has been observed in Simpson Lagoon and elsewhere.



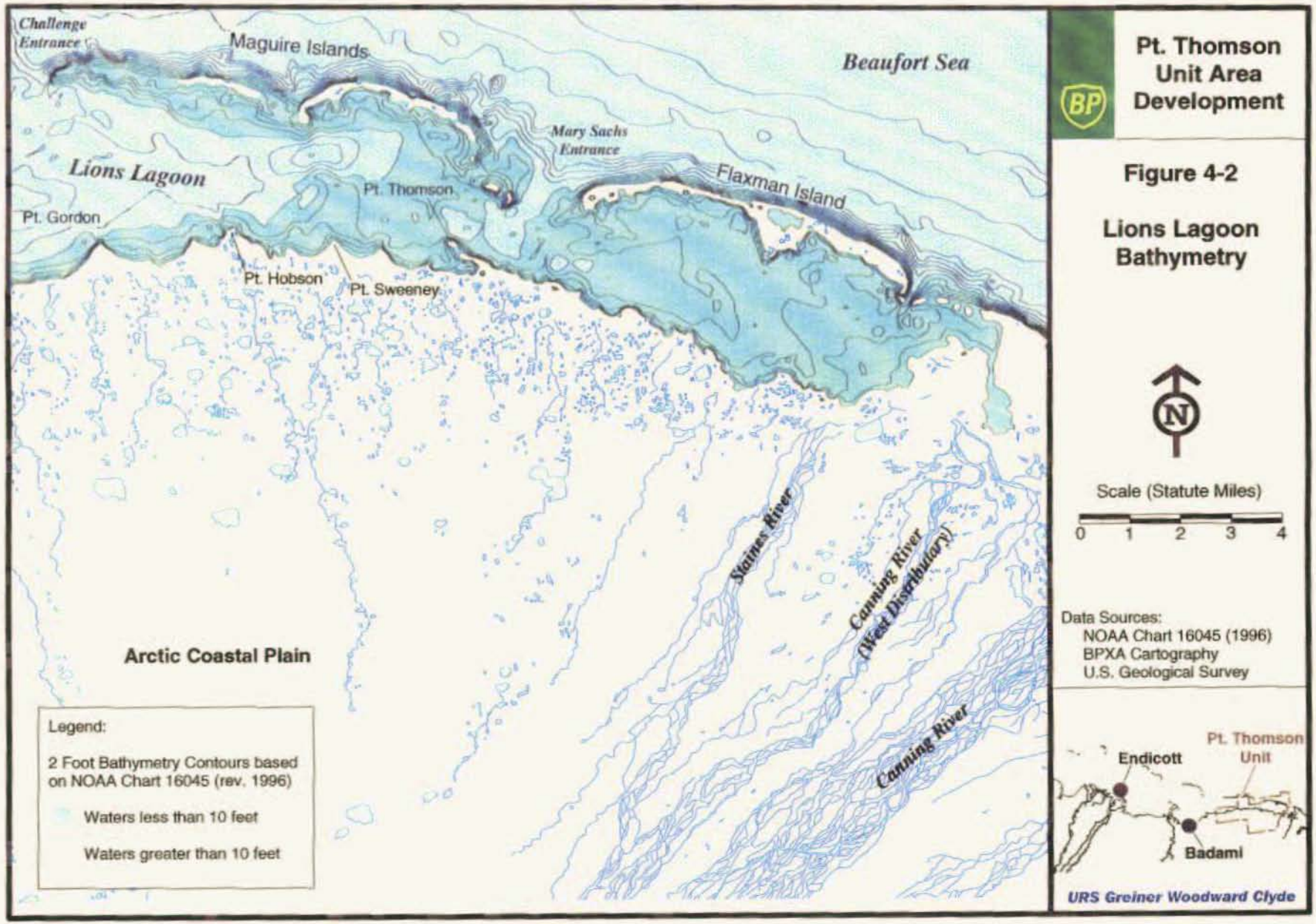
Pt. Thomson Unit Area Development

Figure 4-1

False Color Bathymetry of Lions Lagoon

Data Sources:
NOAA Chart 16045 (1996)
BPXA Cartography
U.S. Geological Survey

URS Greiner Woodward Clyde


Challenge Entrance
Maguire Islands
Beaufort Sea
Mary Sachs Entrance
Lions Lagoon
Pt. Thomson
Flaxman Island
Pt. Gordon
Pt. Hobson
Pt. Sweeney
Staines River
Canning River (West Distributary)
Canning River
Arctic Coastal Plain
Legend:
2 Foot Bathymetry Contours based on NOAA Chart 16045 (rev. 1996)
Waters less than 10 feet
Waters greater than 10 feet
Pt. Thomson Unit Area Development
Figure 4-2
Lions Lagoon Bathymetry
N
Scale (Statute Miles)
0 1 2 3 4
Data Sources:
NOAA Chart 16045 (1996)
BPXA Cartography
U.S. Geological Survey
Endicott
Pt. Thomson Unit
Badami
URS Greiner Woodward Clyde

The 1997 and 1998 physical oceanography studies confirmed that regional processes govern the water column structure, water movement, and water level within the lagoon system. Specific regional processes that were observed within Lions Lagoon include:

- Local freshwater input from the Staines and Canning rivers created brackish water conditions for lagoon waters south of Flaxman Island. The lack of notable fresh water was evident along the western portion of Lions Lagoon
- Upwelled marine bottom waters entered the lagoon system through the channels between the barrier islands during persistent easterly winds, that also depressed the water level
- Elevated water levels corresponded to persistent westerly winds and short (24 to 36 hour) periods of mixed easterly and westerly winds. Typically, uniform brackish ($\leq$25 part per thousand) conditions were observed throughout Lions Lagoon

The geometry of the lagoon system influenced water movement and water quality. Specific observations include:

- The channels between the barrier islands served as pathways for Beaufort Sea shelf and marine waters to enter Lions Lagoon during easterly winds
- Current direction within Mary Sachs Entrance and Flaxman Pass were parallel to the channel
- The barrier island complex effectively protected the lagoon waters. Turbidity and suspended sediment were elevated for waters adjacent to the Staines and Canning rivers, and in the channels between the barrier islands

The combination of regional and site-specific studies is necessary to meet U.S. Federal and State of Alaska regulatory requirements. As the conceptual engineering advances, the location and dimensions of the dock and other coastal structures will be established. At that time, physical environment studies will be designed to collect sufficient site-specific information to support the permitting process.

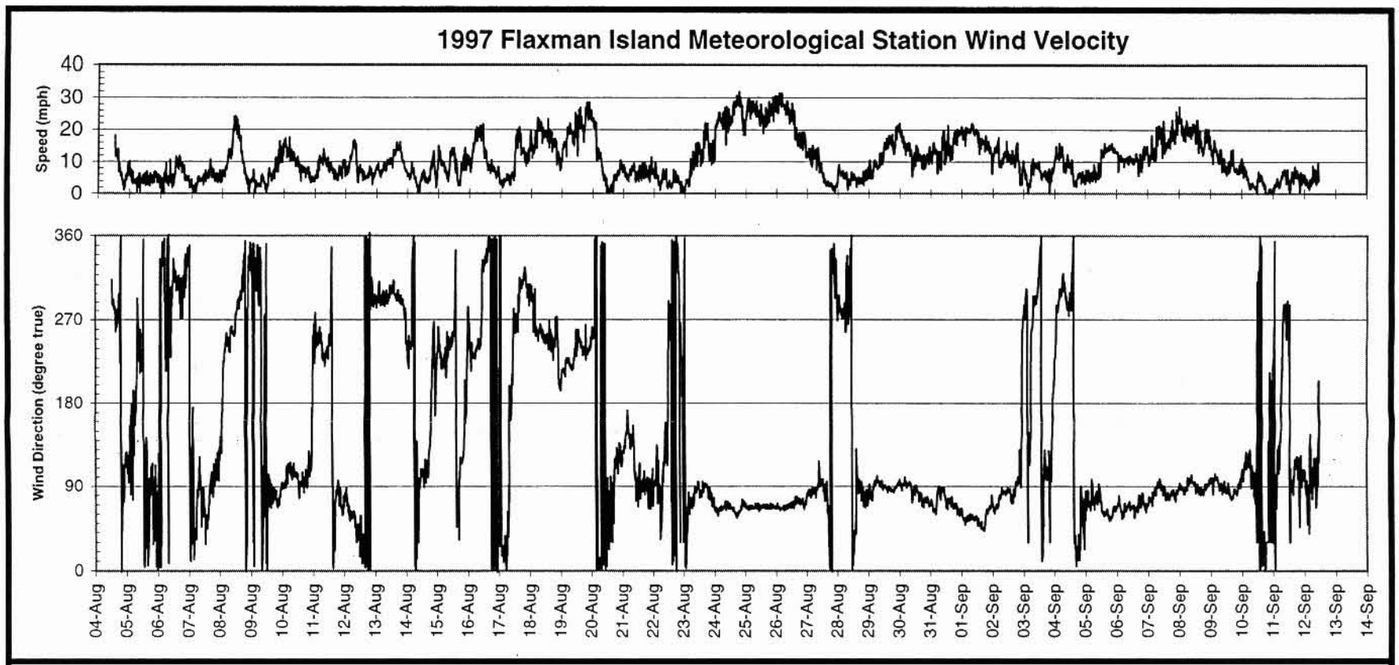
Colonell, J.M., and B.J. Gallaway (1990). An Assessment of Marine Environmental Impacts of West Dock Causeway. Report for the Prudhoe Bay Unit Owners represented by ARCO Alaska, Inc. prepared by LGL Alaska Research Associates, Inc. and Environmental Science and Engineering, Inc. Anchorage, Alaska. 132 pp. + appendices.

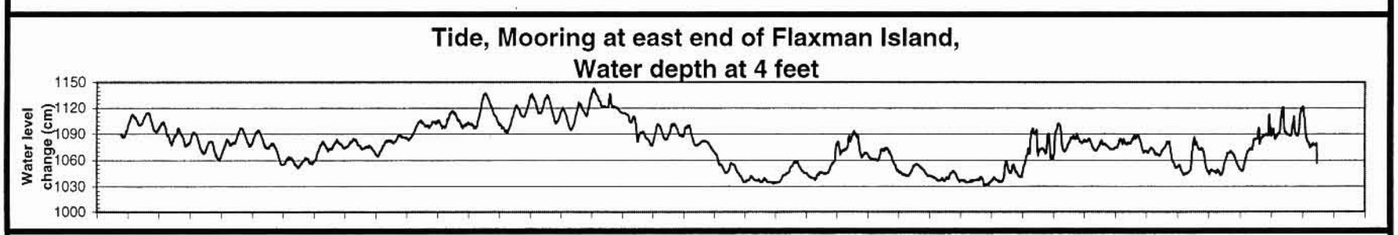
Kinnetic Laboratories, Inc. (1983). Oceanographic Engineering Services Point Thomson Development Project (Agreement Number PTD-8204). Prepared for EXXON Company U.S.A.. Volumes 1, 2A, and 2B.

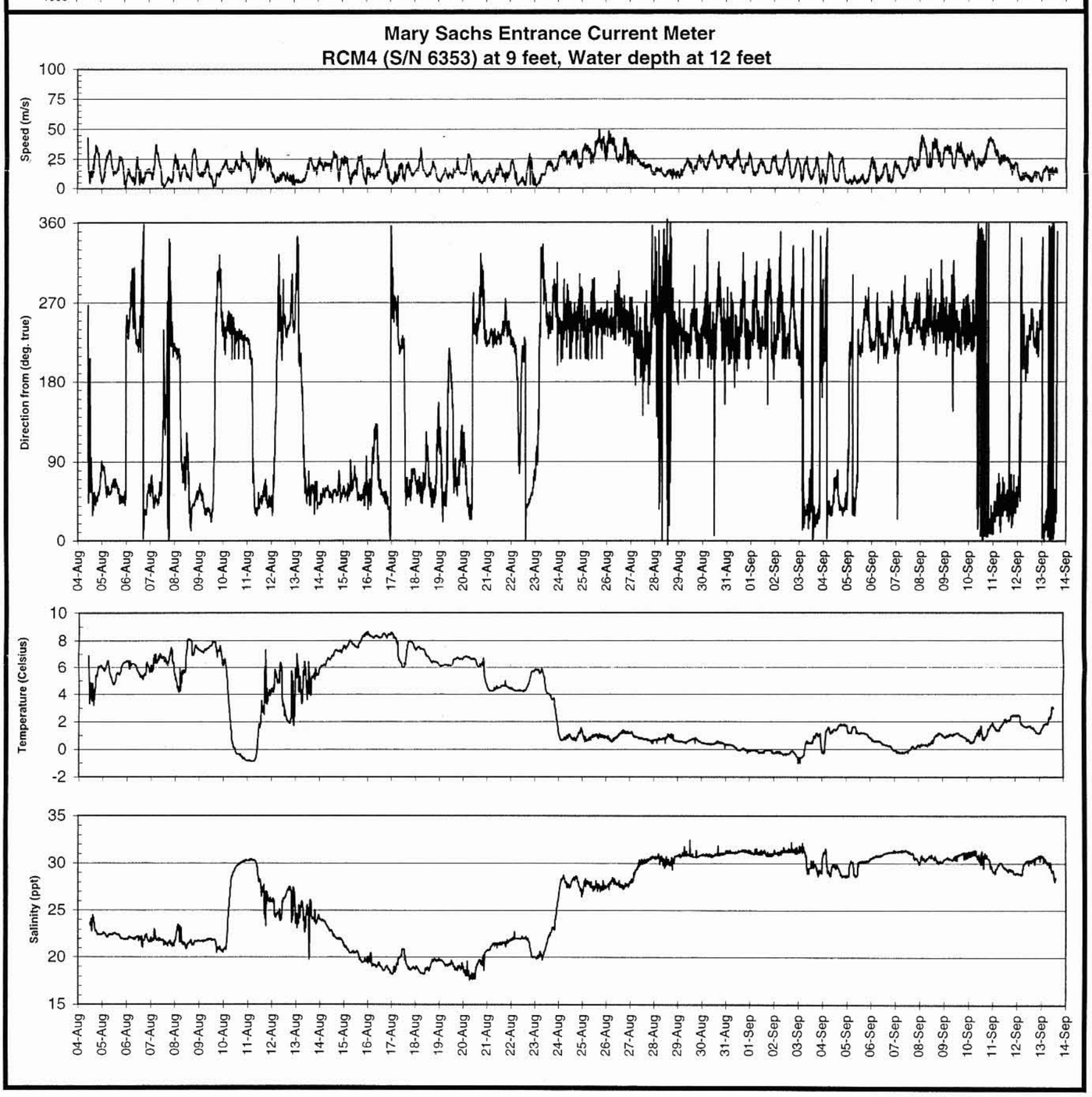
Appendix A

1997 Physical Oceanography And Meteorology Records

1997 Time Series of Flaxman Meteorology and Mary Sachs Entrance Current Meter RCM4 (S/N 6353)
04 Aug - 13 Sept 1997







1997 Time Series of Flaxman Island Meteorology and Flaxman Pass Current Meter RCM4 (S/N TCM2)
04 Aug - 13 Sept 1997