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THE EFFECTS OF MODIFIED BLEACHING OF PULP MILL EFFLUENT ON THE DISSOLVED OXYGEN LEVELS IN ALBERNI HARBOUR, BRITISH COLUMBIA 1974-1976

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ABSTRACT

The MacMillan Bloedel (Alberni) Limited pulp mill located at the head of Alberni Inlet, underwent a series of modified bleaching trials to reduce effluent colour from 1974-1976. The effectiveness of the colour removal trials was estimated by observing dissolved oxygen levels in Alberni Harbour and the Somass River, and the flow rate of the Somass River. This report presents an analysis of data supplied by the Technical Services laboratory at Alpulp from 1974 to 1976.

RÉSUMÉ

De 1974 à 1976, l'usine de pâte de la société MacMillan Bloedel Alberni Limited, située au fond de l'inlet Alberni, a fait l'objet d'une série d'épreuves de blanchiment modifié pour réduire la couleur de l'effluent. Pour juger de l'efficacité des essais de décoloration, on a noté les taux d'oxygène dissous dans le havre d'Alberni et la rivière Somass ainsi que le débit de cette rivière. Le présent rapport analyse les données provenant du laboratoire des services techniques de l'Alpulp pour la période s'étendant de 1974 à 1976.

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SUMMARY AND CONCLUSIONS

Parker and Sibert (2) showed that the humic stain in pulp mill effluent prevented oxygen production in the layer below the halocline by restricting light penetration and effectively blocking photosynthesis. The oxygen deficit is increased by the respiration of fauna and flora below the halocline. Water for entrainment into the halocline and to the upper mixed zone is therefore low in dissolved oxygen. A numerical model presented by Sibert and Parker (4) showed that primary productivity does not recover until the stain content of the effluent is reduced to 125 units and does not exhibit signs of "normality" until the level is dropped to 75 units, or approximately 90% stain removal. The modified bleaching trials conducted at Alpulp from 1974 - 1976 resulted in decreases of 20 - 68% of stain.

The measured levels of dissolved oxygen during the 1975 closure of the mill or 100% colour removal showed a definite increase over averages for previous years. The values in the upper layers were greater than 5 mg/l at a time when dissolved oxygen is generally lowest for the year. Although dissolved oxygen concentrations at the bottom remained well below 5 mg/l, they were improved from the levels prior to mill closure. In 1976, during the continuous modified bleaching sequence from July to December, slight improvements in dissolved oxygen levels were recorded despite the low Somass River flows occurring from September to December.

1 INTRODUCTION

The head of Alberni Inlet (Figure 1) is a highly stratified estuary having a large freshwater inflow, a strongly defined halocline, and an underlying layer of higher salinity seawater. The layer below the halocline is the immediate source of entrainment water to the halocline and the upper mixed zone (1).

Low dissolved oxygen levels are frequently recorded in the surface waters at the head of the inlet. The oxygen levels in the layer above the halocline are often below the 5 mg/l required in the Pollution Control Branch operating permit for the MacMillan Bloedel (Alberni) Limited pulp mill located at the head of the inlet. The pulp mill discharges into the surface waters of the inlet near the mouth of the Somass River.

In 1970, primary and secondary biological treatment facilities were constructed to remove 50% of the biochemical oxygen demand (BOD) of the effluent before discharge. However, even with this measure, dissolved oxygen in the upper mixed layer still dropped below 5 mg/l at certain times of the year.

Parker and Sibert (2) suggested that if the low dissolved oxygen could not be solely attributed to the removal by BOD from the effluent, then it followed that oxygen generation through photosynthetic activity below the halocline was reduced. Entrainment of pulp mill effluent in the surface waters would contribute to low dissolved oxygen in the upper zone. Phytotoxic components in mill effluent or the limiting effects of nutrients (3) could result in the inhibition of phytoplankton production. However, shading and high light attentuation caused by colour in the effluent appeared to be the most obvious factors in reducing phytoplankton production and thereby further lowering dissolved oxygen levels. Respiration by bacteria and other aquatic organisms would be expected to rapidly deplete the low initial dissolved oxygen in the upper layers.

In an attempt to reduce the detrimental effects of humic stain in the effluent, the pulp mill conducted three modified bleaching trials to reduce effluent colour (Table 1).

The purpose of this report was to examine the dissolved oxygen concentrations in Alberni Harbour during the periods of modified bleaching and to determine whether appreciable changes had occurred. All data used in this report was supplied by the Technical Services laboratory at Alpulp, Port Alberni, British Columbia.

2 RESULTS AND DISCUSSION

From 1970 to 1976, dissolved oxygen levels in Alberni harbour and the Somass River followed a similar annual pattern. Dissolved oxygen levels were lowest in September-October, began to increase and reached highest levels in December-January and then decreased through the summer to the fall minimums (Figures 2, 3, and 4). This pattern appears to be directly effected by the Somass River flow (Figures 5, 6, 7, 8, and overlays) and may be partially related to seasonal phytoplankton production cycles.

The first sequence of modified bleaching was in operation from June 20 to September 3, 1974 (Table 1), with the exception of the week of August 9 to 18, when the mill reverted to conventional bleaching.

The average colour value prior to bleach modification was 877 units. Colour during the modified bleaching operation was recorded in a range from 410 to 710 units (Table 2) or approximately 20 - 54% stain removal. During the week of August 9 to 18, 765 colour units were measured.

The change in dissolved oxygen at the surface and at 10 feet during the modified bleaching trial was insignificant compared to data from previous years. However, the values recorded at the bottom were higher than either the preceding two month period or the two months following the modified bleaching experiment. Because of the limited test period, the effect of the bleaching process on bottom dissolved oxygen levels cannot be stated with any certainty.

The second trial period of modified bleaching occurred during the period May 15 to July 16, 1975, at which time a labour dispute forced closure of the pulp mill (Table 1). When the mill resumed operations in October, the conventional bleaching process was reinstated.

During the modified bleaching experiment in 1975, colour was recorded in a range from 310 to 580 units. The average level prior to the modified bleaching was 940.5 colour units (Table 2). These values represent approximately 39 - 58% stain removal.

The dissolved oxygen concentrations measured at the surface and at 10 feet during the colour removal sequence were similar to 1974 levels. The levels at the bottom were well below 5 mg/l and did not appear to be affected by the modified bleaching. With essentially 100% colour removal when the mill was shut down, dissolved oxygen levels at the surface and at 10 feet were noticeably higher than for the same period in previous years. The values recorded at the bottom were still below 5 mg/l, but were higher than those levels recorded in the four months prior to the mill closure.

The 1976 colour removal operation was in effect from May 20 to June 23 and again from July 12 to December 14 (Table 1). This was the longest continuous sequence of modified bleaching for the three trial years. From an initial average level of 845 colour units, values during the modified bleaching were recorded from 310 to 914 units or approximately 36% colour removal (Table 2).

In 1976, the dissolved oxygen levels at the surface were similar to those recorded in 1974. The acceptable dissolved oxygen levels in the surface waters of Alberni harbour appeared to be a reflection of the high dissolved oxygen levels of the Somass River. At the 3 metre depth, dissolved oxygen levels dropped below 5 mg/l in October and November while the colour removal operation was being conducted. This was typical of the seasonal pattern of dissolved oxygen levels in that stratum, although it occurred slightly earlier in 1973 and 1974 (Table 3). The values recorded at the bottom were still below 5 mg/l most of the year; however, they were considerably higher during the period from July to September than the levels recorded during mill shutdown in 1975.

REFERENCES

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2. Parker, R.R. and John Sibert (1972). Effects of Pulpmill Effluent on the Dissolved Oxygen Supply in Alberni Inlet, British Columbia. Fisheries Research Board Technical Report No. 316.

3. Parker, R.R., J. Sibert, and T.J. Brown (1975). "Inhibition of Primary Production through Heterotrophic Competition for Nitrate in a Stratified Estuary." Journal, Fisheries Research Board of Canada, Vol. 32, No. 1.

4. Sibert, John, and R.R. Parker (1972). A Numerical Model to Demonstrate the Effect of Pulpmill Effluent on Oxygen Levels in a Stratified Estuary. Fisheries Research Board Technical Report No. 307.

ACKNOWLEDGEMENT

The author wishes to thank the Technical Services Laboratory at Alpulp, Port Alberni, B.C., for supplying the data used in the report.

TABLE 1 SEQUENCE OF MODIFIED BLEACHING - 1974, 1975, 1976

Date	Sequence
1974	
June 20	H (x) H bleaching started, Washer-15 overhaul (hypochlorite stages)
July 21	Washer-15 came on line
July 31	HHH bleaching started (hypochlorite stages)
August 2	HEH Bleaching started (hypochlorite stage, alkaline extraction, hypochlorite stage)
August 3	Semi-bleached kraft brightness increased to GE 67.5 (General Electric unit)
August 9	Switched back to conventional bleaching (CEH bleaching - chlorine, alkaline extraction, hypochlorite stage)
August 19	Switched back to modified bleaching (HEH bleaching)
September 3	Switched back to conventional bleaching
1975	
May 15	Modified bleaching trial commenced
July 16	Shutdown due to labour dispute
October	Resumed operation, conventional bleaching started
1976	
May 20	Modified bleaching trials commenced (HEH bleaching)
June 23	Switched to conventional bleaching (CEH bleaching)
July 12	Switched back to modified bleaching
December 14	Switched back to conventional bleaching

TABLE 2 COMBINED EFFLUENT COLOUR (units APHA)

Year	Date/Units	Date/Units	Date/Units	Date/Units	Date/Units	Date/Units
1974	January	February	March	April	May	June
	3 1000	7 1000	7 770	4 800	2 980	6 860
	10 1100	14 700	14 820	11 1220	9 -	13 820
	17 1000	21 1150	21 565	18 920	16 -	20 680
	24 800	28 800	28 700	24 880	23 -	27 460
	31 600				30 830	
	July	August	September	October	November	December
	4 510	1 620	5 540	3 580	7 1110	5 920
	11 565	8 710	12 615	10 730	14 940	12 920
	18 410	15 765	19 930	17 770	21 770	19 810
	25 569	22 695	26 920	24 1230	28 970	25 830
		29 550		31 1040		
1975	January	February	March	April	May	June
	1 -	5 -	5 965	2 1150	7 1080	4 540
	8 -	12 -	12 845	9 815	14 1090	11 485
	15 -	19 -	19 900	16 690	21 770	18 440
	22 -	26 885	26 815	23 750	28 580	25 380
	29 -			30 885		
	July	August	September	October	November	December
	7 310	6 -	3 -	1 -	5 660	3 770
	9 500	13 -	10 -	8 -	12 715	10 840
	16 420	20 -	17 -	15 760	19 670	17 890
	23 -	27 -	24 -	22 510	26 850	24 540
	30 -			29 710		31 720
1976	January	February	March	April	May	June
	7 825	4 750	3 780	7 760	5 850	2 600
	14 690	11 800	10 690	14 765	12 1010	9 640
	21 740	18 885	17 970	21 1010	19 1150	16 445
	28 840	25 790	24 825	28 860	26 850	23 485
			31 910			30 660
	July	August	September	October	November	December
	7 860	4 360	1 310	6 410	3 335	1 -
	14 780	11 417	8 580	13 365	10 335	8 330
	21 580	18 941	15 370	20 410	17 350	15 365
	28 440	25 335	22 520	27 450	24 410	22 430
			29 500			29 290

TABLE 3 SOMASS RIVER FLOW (cfs) AND DISSOLVED OXYGEN AVERAGES FROM SOMASS RIVER AND HOHM ISLAND, 1973 - 1974

		Somass River Flow (cfs)	Dissolved Oxygen (ppm)			
			Hohm Island			Somass River
			Surface	10 ft.	Bottom	Surface
1973	January	9585	12.74	10.94	6.76	13.53
	February	2863	11.23	6.31	5.03	13.56
	March	3619	11.31	6.96	5.68	13.01
	April	2389	9.36	7.09	1.86	11.49
	May	3597	9.26	7.22	3.71	10.63
	June	3403	8.79	7.15	4.71	10.53
	July	2261	8.70	6.45	3.95	10.18
	August	1706	6.99	6.25	3.55	9.35
	September	1563	6.13	3.91	3.40	9.07
	October	1951	7.31	3.92	3.02	10.07
	November	4530	9.84	6.70	4.80	11.66
	December	8833	11.01	8.93	6.47	12.03
1974	January	7802	11.1	9.4	4.8	12.1
	February	5149	11.2	10.5	7.2	11.8
	March	6276	11.3	8.3	5.0	12.1
	April	6339	10.9	9.7	6.1	11.8
	May	4775	11.0	7.6	2.7	11.9
	June	7051	9.4	9.1	2.9	10.8
	July	4426	9.2	8.9	5.3	10.1
	August	2784	8.1	6.3	4.2	9.2
	September	1973	6.9	4.9	2.9	9.2
	October	1903	6.9	2.9	2.4	9.8
	November	5178	9.0	5.4	3.8	10.8
	December	8643	10.3	9.4	5.5	10.8
1975	January	3095	10.0	6.3	3.4	11.2
	February	2517	8.7	5.8	4.7	10.7
	March	3624	9.4	7.8	5.6	10.1
	April	2578	9.4	6.8	2.5	11.5
	May	3790	9.8	7.5	2.8	10.6
	June	4181	9.2	8.0	2.2	10.0
	July	2179	8.1	8.0	2.2	9.3
	August	1393	8.7	8.8	3.7	9.0
	September	2491	9.1	6.9	3.7	9.4
	October	6444	9.7	8.4	3.2	10.6
	November	9115	10.9	9.5	5.5	12.0
	December	8051	10.7	7.7	4.1	12.1
1976	January	4192	10.6	8.8	6.2	11.8
	February	3956	10.9	8.3	3.9	12.3
	March	3281	10.6	8.1	4.0	12.1
	April	3450	10.2	6.4	2.7	11.9
	May	4052	9.4	8.2	0.9	11.2
	June	4224	9.3	8.1	2.8	10.1
	July	3663	8.1	7.1	5.7	9.8
	August	2039	7.6	7.1	5.2	9.5
	September	1738	7.3	5.5	4.0	9.6
	October	1753	6.8	3.9	2.7	9.6
	November	4260	9.1	4.8	2.7	11.3
	December	4718	10.1	5.6	3.9	12.4

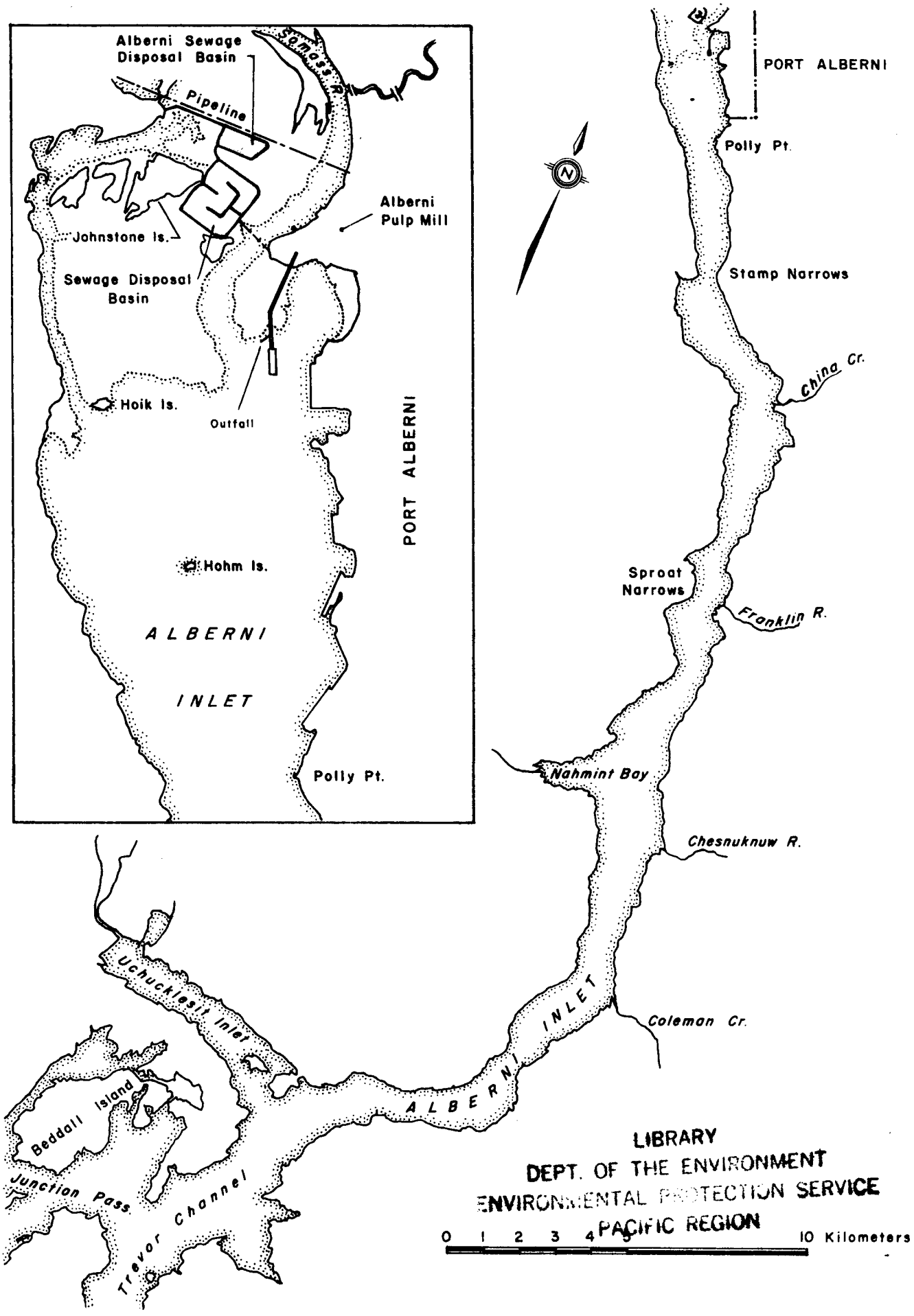


FIGURE 1 ALBERNI INLET

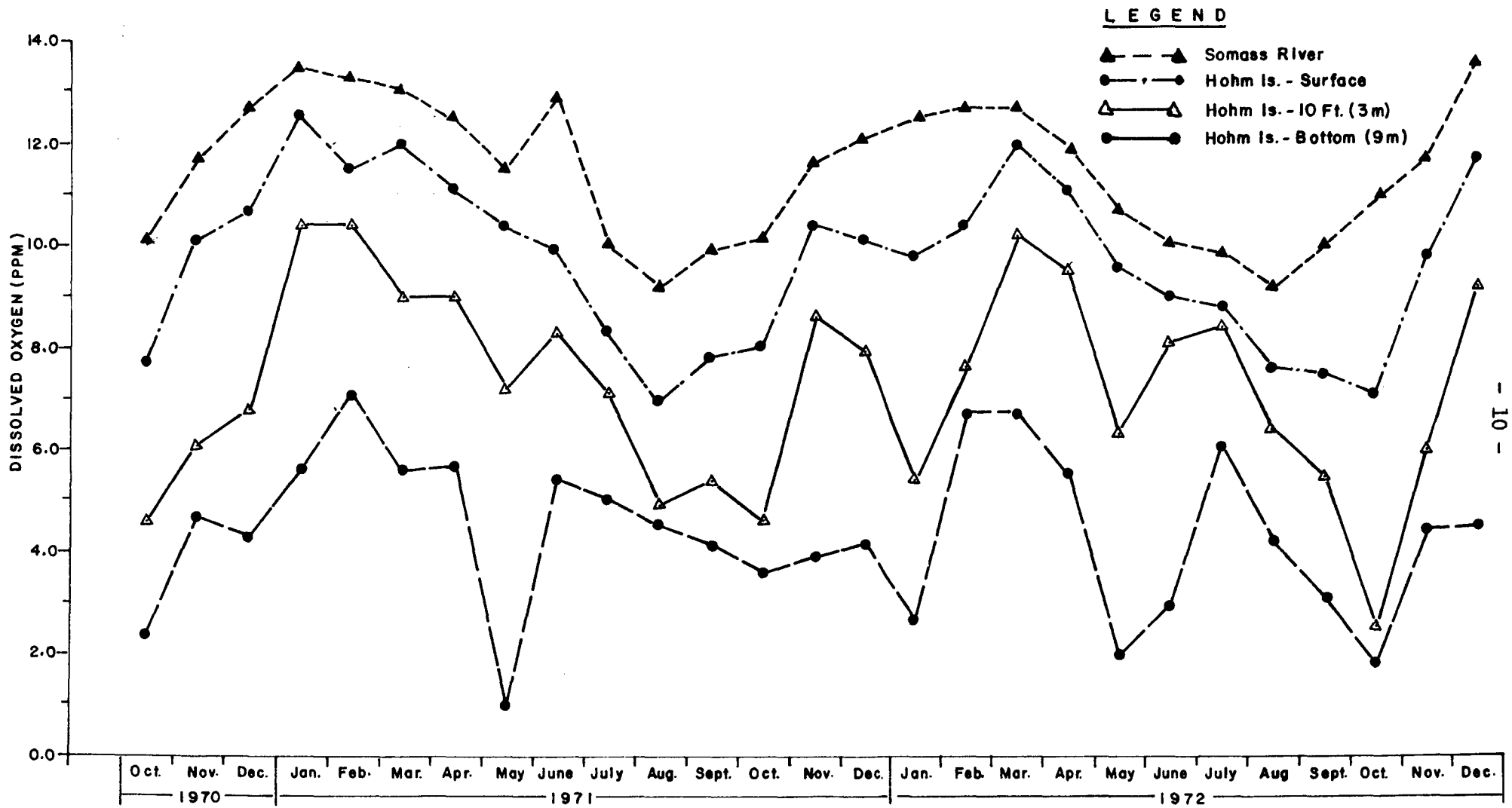


FIG. 2 MONTHLY DISSOLVED OXYGEN AVERAGES - HOHM ISLAND & SOMASS RIVER
ALBERNI INLET 1970 - 1972

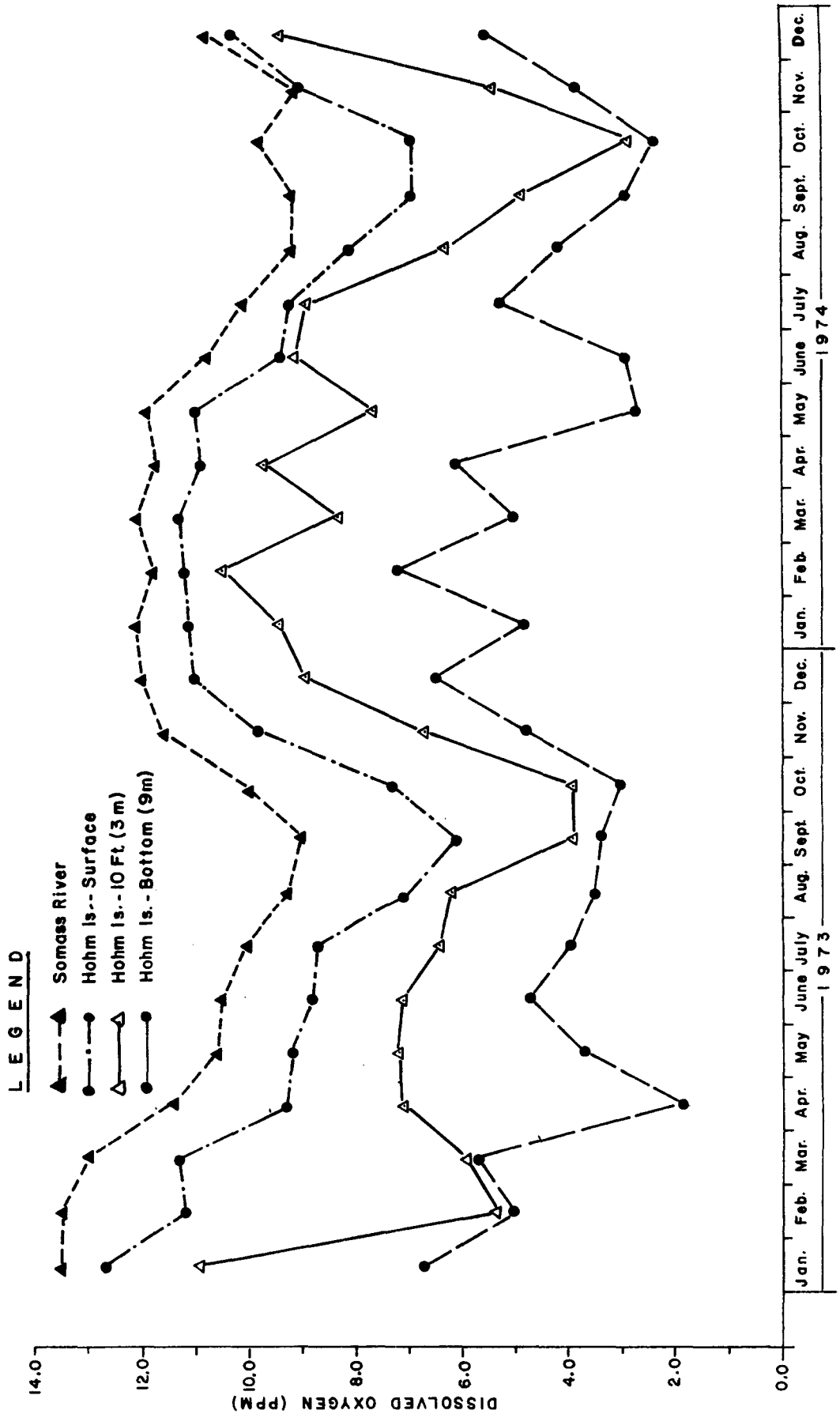


FIG. 3 MONTHLY DISSOLVED OXYGEN AVERAGES - SOMASS RIVER & HOHM ISLAND
ALBERNI INLET 1973 - 1974

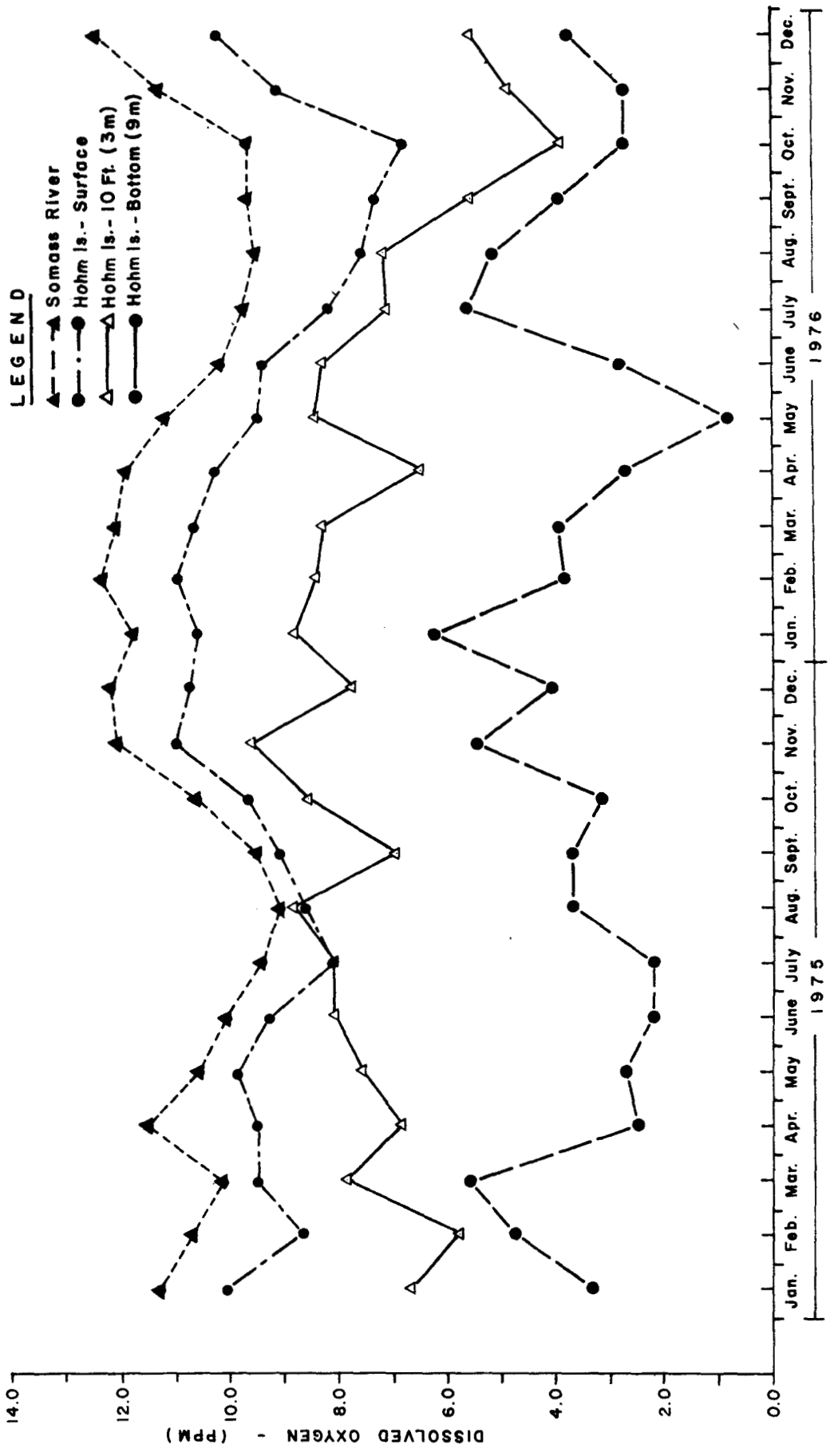
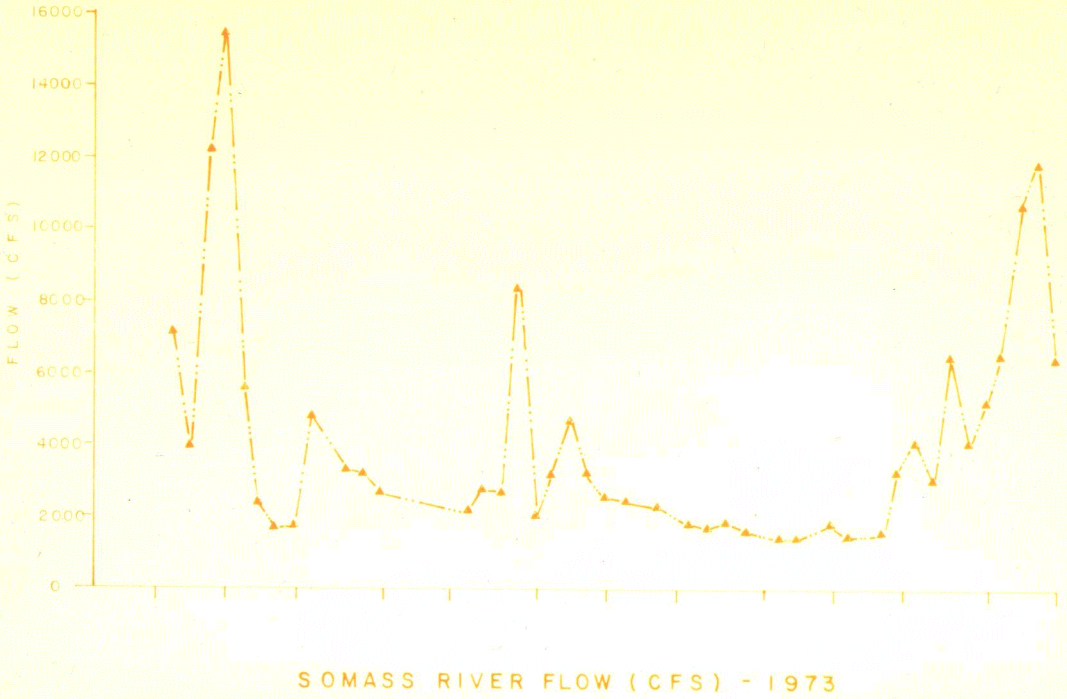


FIG. 4 MONTHLY DISSOLVED OXYGEN AVERAGES - SOMASS RIVER & HOHM ISLAND
ALBERNI INLET 1975 - 1976



SOMASS RIVER FLOW (CFS) - 1973

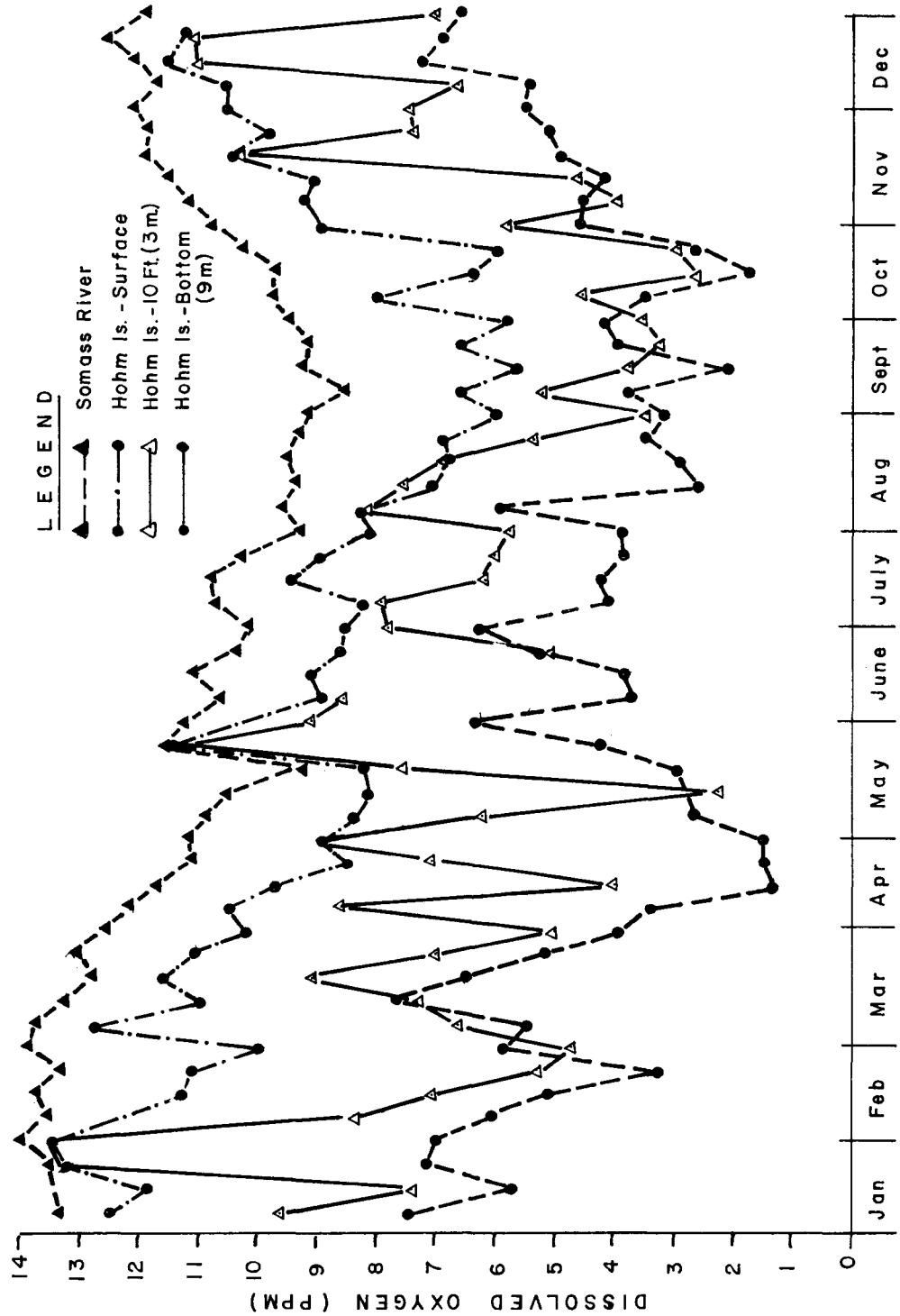
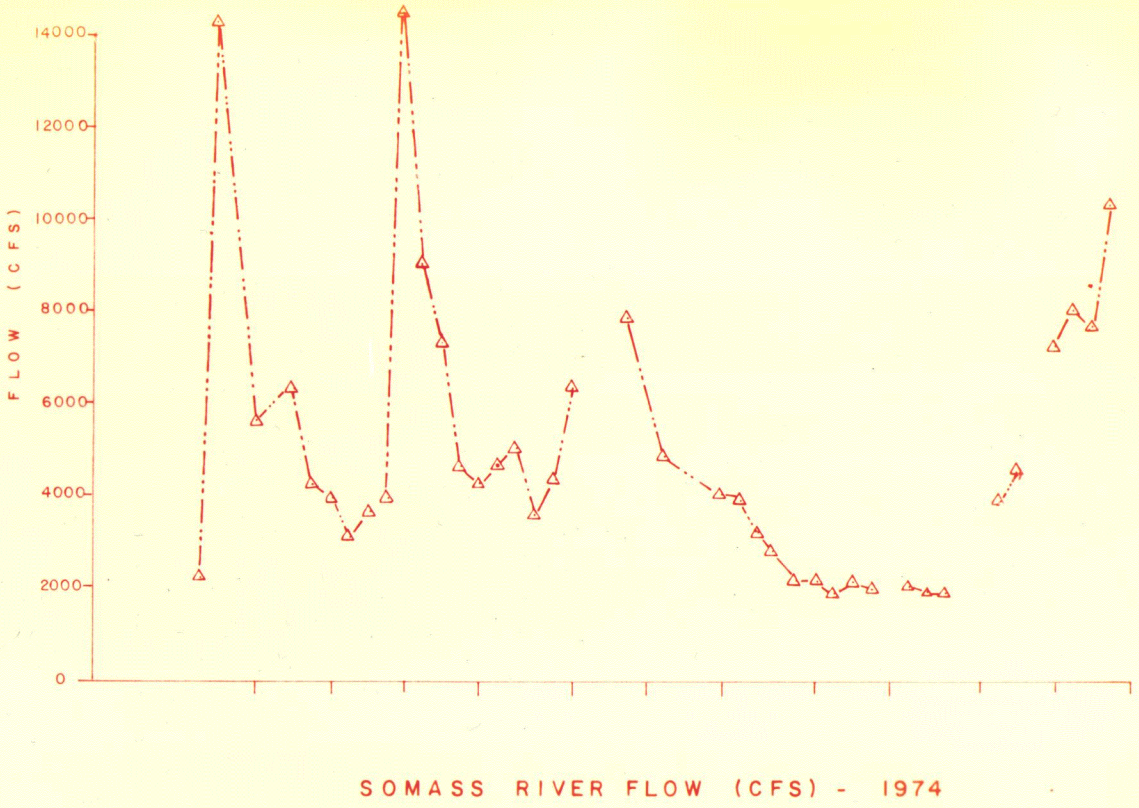


FIG. 5 WEEKLY DISSOLVED OXYGEN VALUES - HOHM ISLAND & SOMASS RIVER 1973



SOMASS RIVER FLOW (CFS) - 1974

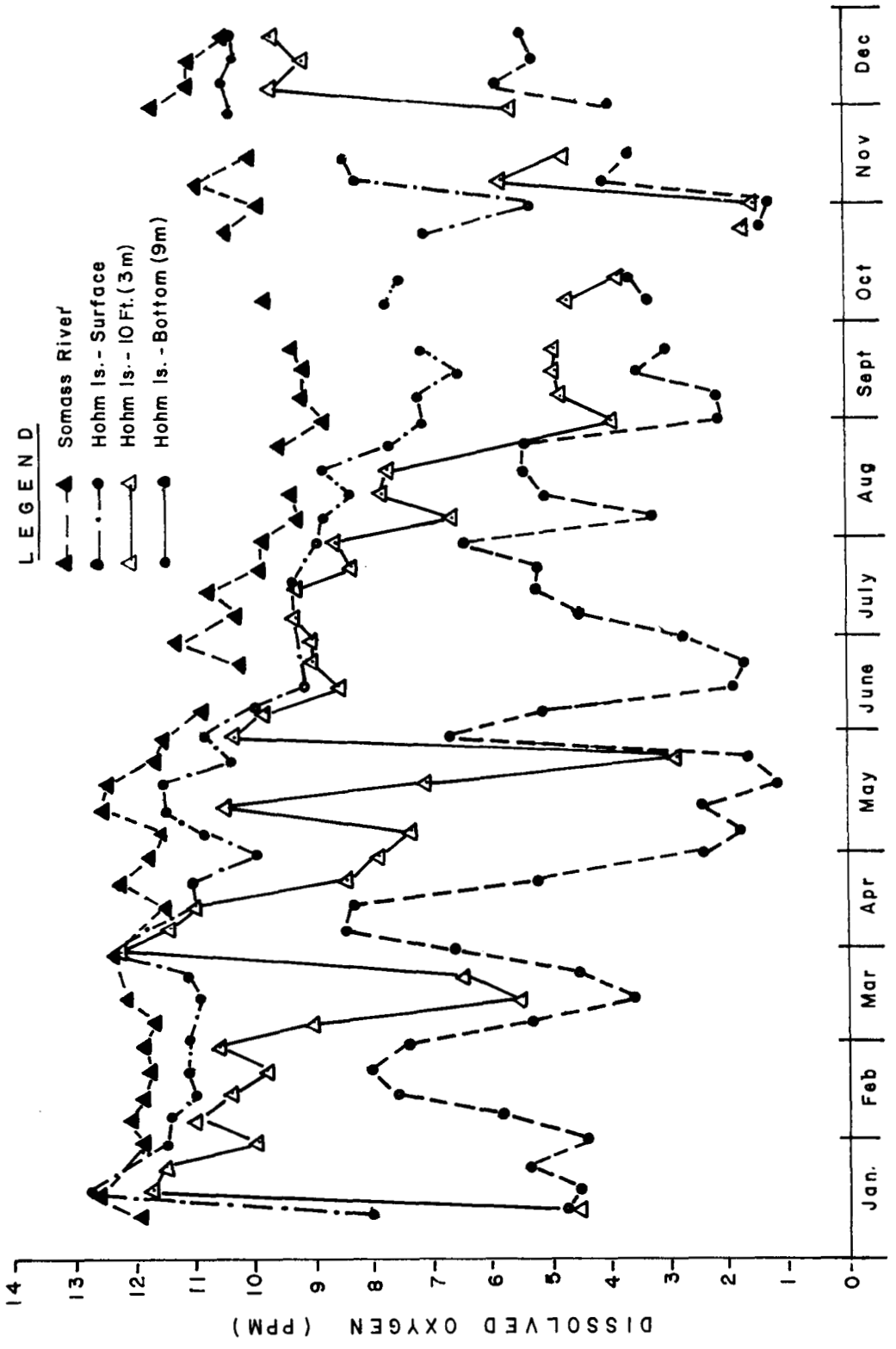
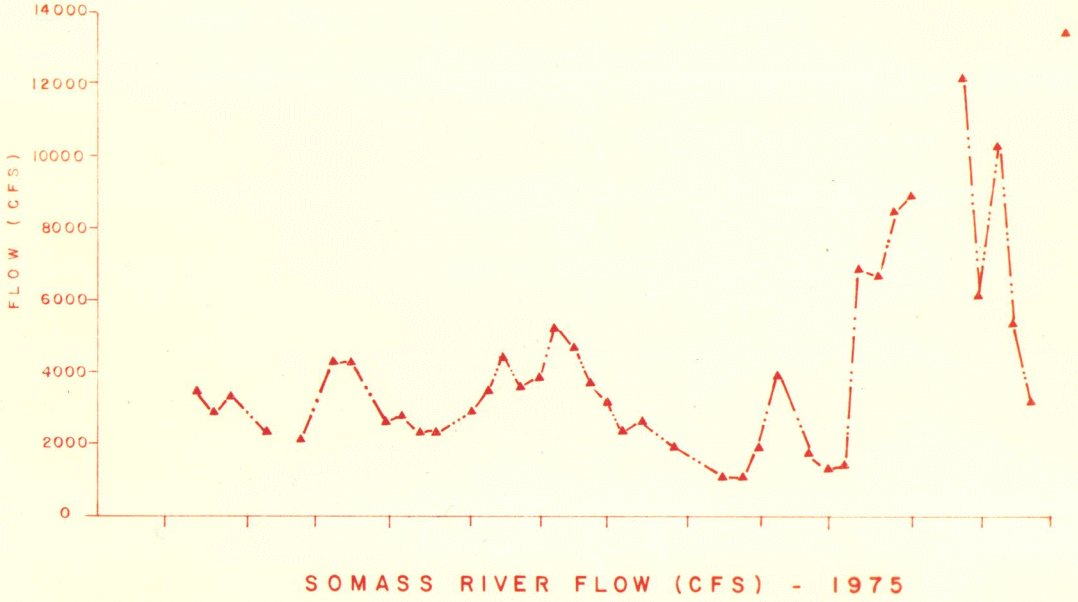


FIG. 6 WEEKLY DISSOLVED OXYGEN VALUES - HOHM ISLAND & SOMASS RIVER 1974



SOMASS RIVER FLOW (CFS) - 1975

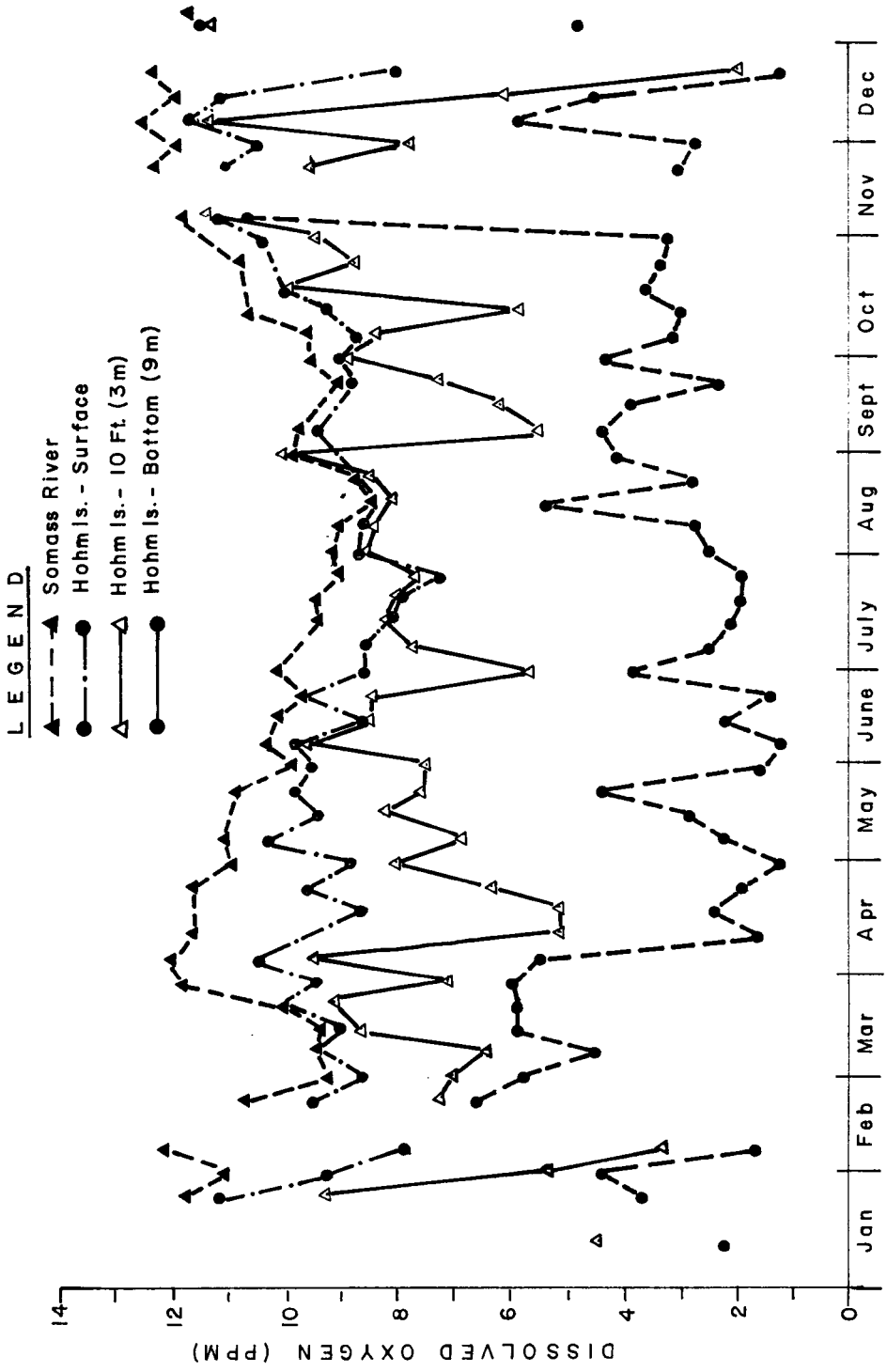
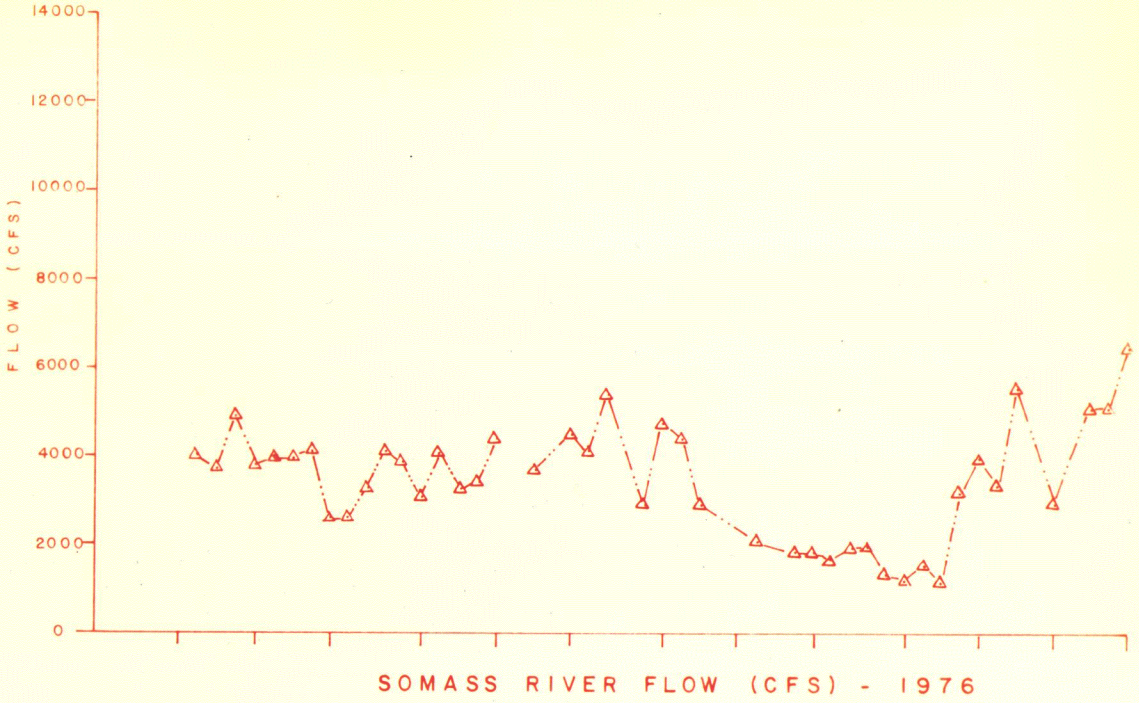


FIG. 7 WEEKLY DISSOLVED OXYGEN VALUES - HOHM ISLAND & SOMASS RIVER 1975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12000
10000
8000
6000
4000
2000
0
FLOW (CFS)
SOMASS RIVER FLOW (CFS) - 1976

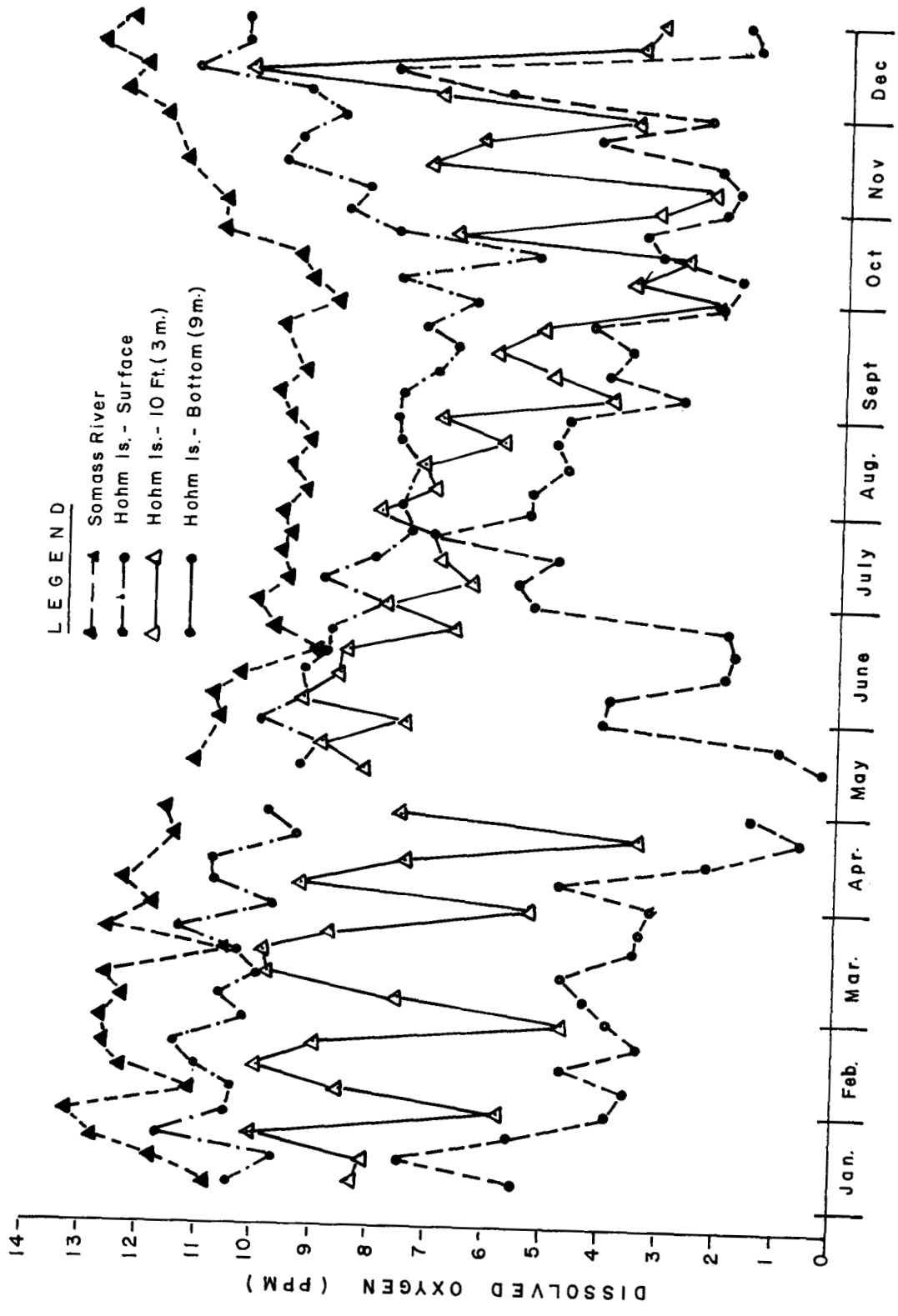

FIG. 8 WEEKLY DISSOLVED OXYGEN VALUES - HOHM ISLAND & SOMASS RIVER 1976