Oceanographic Features of Saanich Inlet 9 May - 2 July, 1968

by R. H. Herlinveaux

FISHERIES RESEARCH BOARD OF CANADA
TECHNICAL REPORT NO. 300

FRB

1972

FISHERIES RESEARCH BOARD OF CANADA

Technical Reports

FRB Technical Reports are research documents that are of sufficient importance to be preserved, but which for some reason are not appropriate for scientific publication. No restriction is placed on subject matter and the series should reflect the broad research interests of FRB.

These Reports can be cited in publications, but care should be taken to indicate their manuscript status. Some of the material in these Reports will eventually appear in scientific publication.

Inquiries concerning any particular Report should be directed to the issuing FRB establishment which is indicated on the title page.

FISHERIES RESEARCH BOARD OF CANADA

Technical Report No. 300

Oceanographic Features of Saanich Inlet
9 May - 2 July, 1968

by

R.H. Herlinveaux
Pacific Environment Institute
4160 Marine Drive
West Vancouver, B.C.

February 1972

TABLE OF CONTENTS

Introduction

A biological program to assess the productivity of Saanich Inlet was carried out under the direction of Dr. T.R. Parsons during the spring-summer periods, 1966 through 1968. The biological, chemical and physical data collected for this study have been reported by Stephens et al. (MS, 1967) and Fulton et al. (MS, 1969). Results of additional physical oceanographic and meteorological observations undertaken by the author for the purpose of describing the temporal and spatial variability for the periods of the productivity measurements are presented here.

Program

A base laboratory was set up on the CNAV Deperm barge YBD3. The barge contained temporary laboratory and living accommodation, and was moored at Patricia Bay Naval Station Wharf (Fig. 1). Vessels of the Underwater Weapons Range (YSW220, "Wildwood") were made available by the Commanding Officer, Lt. Cdr., R. Newstead, for the oceanographic work. The vessel "Turbid" (DOT), "Decibar" (FRB) and "Tharybus" (FRB) were used also when available.

(a) Current observations:

In the central productivity-study area "A" (Fig. 1), continuous current observations were made at 2 m depth by suspending a current meter from a pontoon-type buoy anchored bow and stern. Three moorings were made utilizing a different current meter for each of the moorings. The first series of observations (May 14 - June 14) were obtained using a Geodyne "Savonius-rotor" type current meter. The next series of 14 days was missed because of malfunction of a Hydro-Product current meter. The third series of observations (July 2-18) was successfully recorded on a Neypric current meter. These data are presented in Appendix I.

Drift drogues, suspended at depths of 1, 10 and 30 m were released also periodically near the site of the moored array and were tracked for varying periods of time.

(b) Oceanographic and meteorological observations:

A series of oceanographic stations was taken weekly along the centre of the Inlet from Squally Reach to the sill, and through the productivity-study area (Fig. 1). Observations consisted of temperature and salinity profiles down to 70 m depth using an Industrial Products "in-situ" salinometer, considered to have an accuracy in temperature of ±0.1 C and in salinity of ±0.1‰. Turbidity profiles were also taken to 70 m depth with a 1-m path length turbidity meter equipped with red and blue-green filters. Temperatures at 1 m depth were recorded continuously in Patricia Bay from the barge.

Wind direction and velocity were recorded at two locations, Patricia Bay Wharf and Tozier Rock (Fig. 1).

Results

(a) Winds:

The dominant wind direction and total miles of wind for each day at Patricia Bay and Tozier Rock are presented in Table 1. At Patricia Bay Wharf, there was generally a reversal in wind direction in the afternoon from that recorded in the morning -- the predominant direction in the morning was westerly, in the afternoon, easterly. Wind directions at Tozier Rock also varied diurnally. However, in general, directions were different and speeds were greater (as much as three times) than those recorded at Patricia Bay Wharf.

(b) Temperatures at 1 m depth:

Temperatures at 1-m depth at Patricia Bay Wharf are shown in Fig. 2 and 3. A significant feature is the diurnal variation in temperature, considered to be associated with the diurnal variation in wind direction. Easterly (off the land) winds transport surface waters offshore which are replaced by cooler deeper waters, resulting in a decrease in surface water temperatures. In late spring-early summer, the decrease associated with this offshore transport was as great as 4°C; maximum rate of change was 2°C per hour (Fig. 2, May 25). When the winds decreased in strength or reversed, warm surface waters returned to Patricia Bay, and water temperatures increased. Under the influence of westerly winds, temperatures remained relatively constant.

(c) Current drogue observations:

Current drogue measurements were carried out at three depths (1 m, 10 m, and 30 m) with varying degrees of success; the results are shown in Fig. 4 to 13. On several occasions the 30-m drogue disappeared after being down for a short time. It is believed that the plywood drogue became water-logged, lost its buoyancy, and as a result, the whole drogue unit sank.

No general pattern of tidal flow was evident in the drogue observations at depth, that is, there was no flood inflow, ebb outflow. At times the water movement at all three depths would be in the same general direction. At other times, flows at each depth were in different directions. In the upper metre of water the speed was generally twice that observed at 10 m.

(d) Current meter results:

Three types of current meters were used with various degrees of success. Some of the data recorded were analysed and a polar coordinate histogram plot of direction and rotor speed was made on the first 28-day series (Fig. 14 and 15). These plots indicate that there was no prevailing direction of flow, instead a lobal pattern with intensification of movement in five general directions was present. The largest movements were generally in the direction 339°. The fastest single movement recorded was 0.8 knots to 271°.

The daily average flow components in the area for the observed periods are shown in Table II. The vector trajectory plots of water movement in the sampling area are illustrated in Fig. 16 for the period May 14 to June 14, and in Fig. 17 for the period July 3 to 17, 1968. For the first series, Fig. 16 shows the sequential vector plot for movement of an object at one location in Saanich Inlet over a 29-day period. There were periods of as much as 12 days when the net transport at the depth of sampling, was out of the inlet, and as long as 7 days with a net transport inward. The fastest transport per day was of the order of 10.06 miles per day. The average daily transport at 2 m depth for a 29-day period was an outflow of 0.30 nautical miles. These figures can be interpreted in many ways; for example, there are periods of several days when a particle in the sampling localities could remain in the general area (2 miles square), while there are other days when it could move right out of Saanich Inlet in part of a day.

(e) Longitudinal distributions of temperature (C), salinity (‰) and turbidity (% light transmission):

Longitudinal distributions of temperature, salinity and turbidity from Squally reach to the mouth of Saanich Inlet, as shown in Fig. 18 to 31. They clearly illustrate the variability in these parameters that occur over periods of less than a week. The temperature sections show that, at depth, most of the isotherms are continuous throughout the sampling area. The exceptions are those which define the temperature maxima and minima which are present at various depths (Fig. 27 and 29). They are not continuous or permanent, suggesting that they are formed by differential movement of water at depth. The near-surface gradients are a result of the processes of surface-induced heating and wind mixing. The clouds of warm surface water are believed to be a result of wind transport or of local heating of the slow-moving surface waters. From the sill inward, the isotherms below 20 m depth tend to slope upward.

The longitudinal section of salinity show that at depth the isohalines are continuous from Squally Reach to over the sill. In the surface layer, the presence of clouds of low-salinity water is considered to be evidence of lateral intrusion of brackish water. The isohalines may slope up or down, depending on the direction of water movements. Large changes in salinity below the halocline occurred from week to week.

The longitudinal sections of turbidity show the space and temporal variability in the distribution of suspended materials in Saanich Inlet. Generally there are lenses of suspended material in the upper 30 m. Below 30 m the % transmission increases (the waters become clear), below 50 m the % transmission decreases as more detrital material is encountered. Herlinveaux (1962) reported a turbid layer (low % transmission) associated with the bottom of the scattering layer which is always present in Saanich Inlet. Some of the turbid water observed around the sill could have been due to the exchange of the deep, relatively turbid water inside the sill or due to stirring up of bottom materials during the exchange of waters from Satellite Channel.

There were periods when many lenses of turbid water were present in the inlet (Fig. 25 and 27) but at other times, the waters were relatively clear, e.g. Fig. 21 indicating complete flushing of the system sometime during the period from May 27 to June 4 (Fig. 20 and 21). At other times a partial clearing occurred, e.g. June 14 (Fig. 24). These variations are readily apparent in the vertical profiles shown in Fig. 32 to 42.

A number of turbidity maximums (low % transmission) must have had life in them because the light signals received on the turbidity meter, while in the layers, fluctuated as though living organisms were entering and leaving the light path.

Discussion

The time series data presented suggest that the oceanographic environment in Saanich Inlet is highly variable; due to irregular water movements at various depths. Herlinveaux

(MS, 1968) noted that at the mouth of Saanich Inlet, the water movements at all depths over the sill can vary both in direction and speed. It is assumed that this differential movement at depth observed at the sill extends for some distance into Saanich Inlet. This conclusion is supported by the results of a few drogue measurements taken at 1, 10 and 30 m (Fig. 2 to 11) in the biological sampling area.

It is further evident that there are changes vertically as well as longitudinally in the properties of temperature, salinity and % transmission in the Inlet. They can only be explained by assuming that this region is a layered system and that the characteristics of these layers are dependent on their origin.

Summary

The principal oceanographic features of the biological sampling area for the period 9 May - 2 July, 1968 are:

1. At 2 m depth, an outflow was recorded from May 14 to 31; an inflow from May 15 to 28. The outflow was greatest on May 23 and least on May 17. An inflow was recorded from June 1 to 7, with the greatest inflow occurring on June 4. From June 8 to 11 (until the meter stopped) an outflow was recorded. No observations were recorded from June 12 to July 1. From July 2 to 6 a weak inflow was recorded. On July 9 a marked outflow was noted and persisted until July 15.

2. The longest periods during which a movement of less than 1 mile per day was observed were from May 14 to 18, from May 28 to June 1 and from July 2 to 8.

3. Generally, turbid layers were observed in the upper 10 to 15 m, although on several occasions a cloud of suspended material was observed immediately overlying the "sill".

4. The distribution of % transmission indicates that suspended materials in the water column vary both longitudinally and vertically. Generally, several layers or lenses are evident. However, there were occasions when very little suspended material was observed in the Inlet. At times, the layers of suspended material may have had their origin near the head of the Inlet, while at other times, outside the Inlet.

5. The average daily net movements at 2 m depth for the 29- and 15-day periods were 0.33 and 0.56 nautical miles out of the Inlet, respectively. Daily net movements as great as 10.06 miles out and 5.35 miles in were recorded. The average daily net movement is approximately one-tenth that observed in other B.C. inlets.

References

Fulton, J.D., O.D. Kennedy, H. Seki and K. Stephens. MS, 1962. Biological, chemical and physical observations in Saanich Inlet, Vancouver Island, British Columbia. Fish. Res. Bd. Canada, MS Rept. No. 1018, 109 p.

Herlinveaux, R.H. 1962. Oceanography of Saanich Inlet in Vancouver Island, British Columbia. J. Fish. Res. Bd. Canada, 19(1): 1-37.

1968. Features of water movement over the "sill" of Saanich Inlet, June-July, 1966. Fish. Res. Bd. Canada, Tech. Rept. No. 99, 34 p.

Stevens, K., J.D. Fulton, O.D. Kennedy and A.K. Pease. MS, 1967. Biological, chemical and physical observations in Saanich Inlet, Vancouver Island, British Columbia. Fish. Res. Bd. Canada, MS Rept. No. 912, 119 p.

* * *

List of Figures

* * *

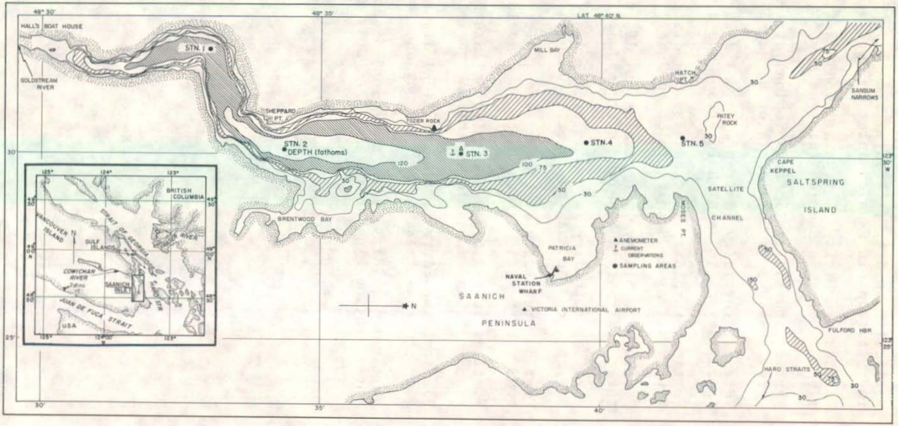

Figure 1 Saanich Inlet showing bottom contours, productivity study area (A) and oceanographic station positions.

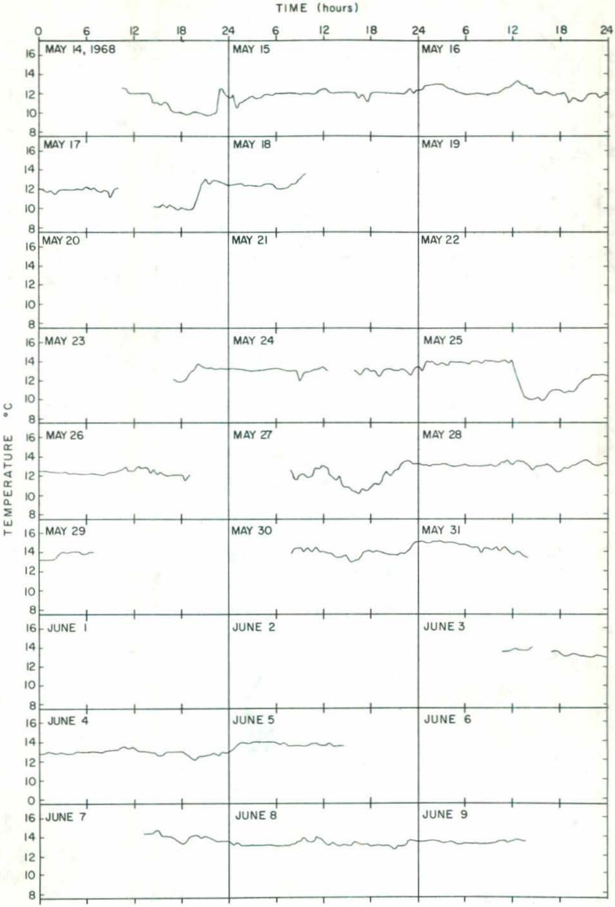

Figure 2 Temperatures (C) at 1 m depth at Patricia Bay Naval Station Wharf, May 14-June 9, 1968.

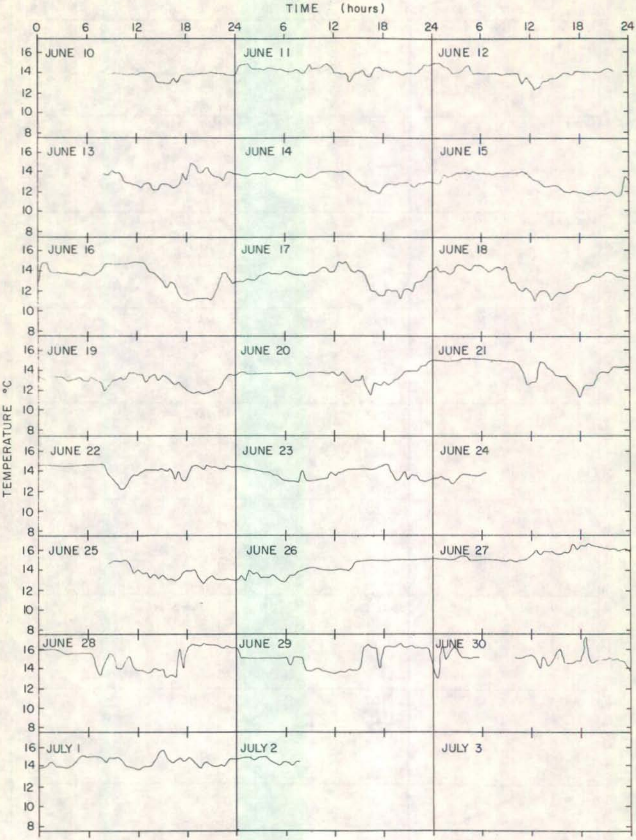

Figure 3 Temperatures (C) at 1 m depth at Patricia Bay Naval Station Wharf, June 10-July 2, 1968.

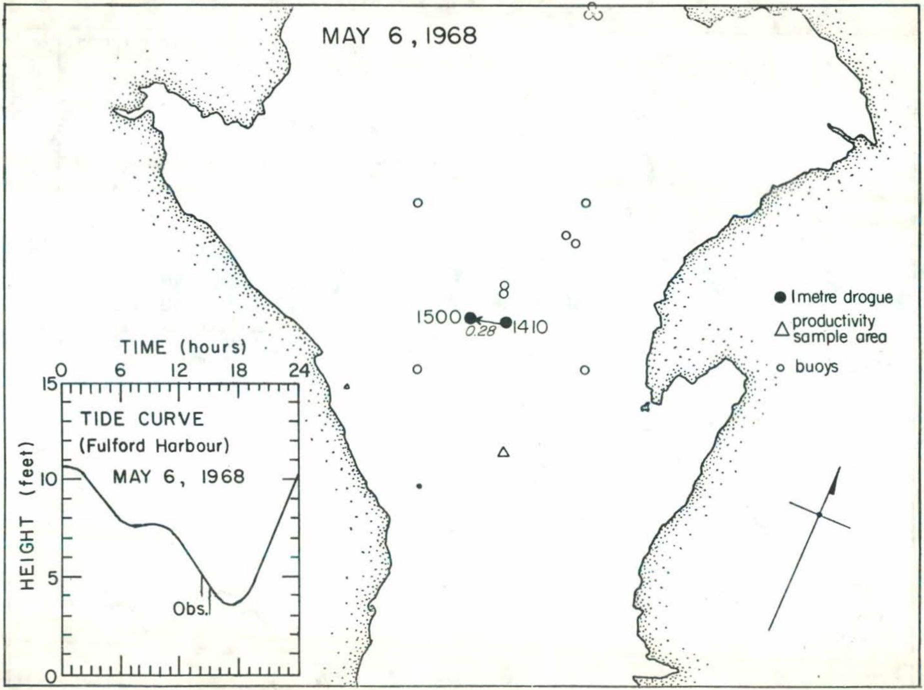

Figure 4 Drogue measurements at 1 metre depth on May 6, 1968.

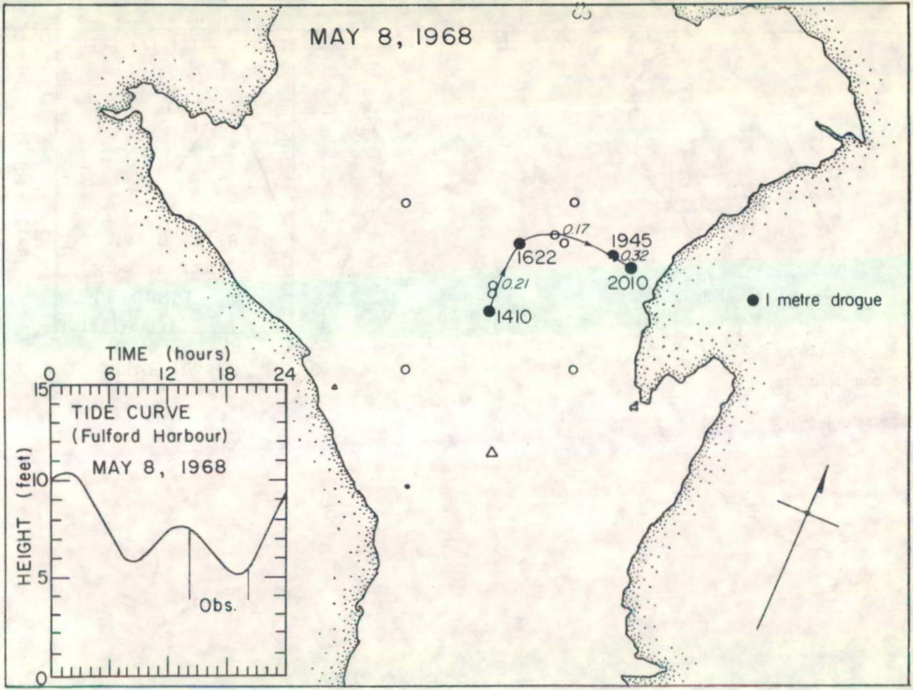

Figure 5 Drogue measurements at 1 metre depth on May 8, 1968.

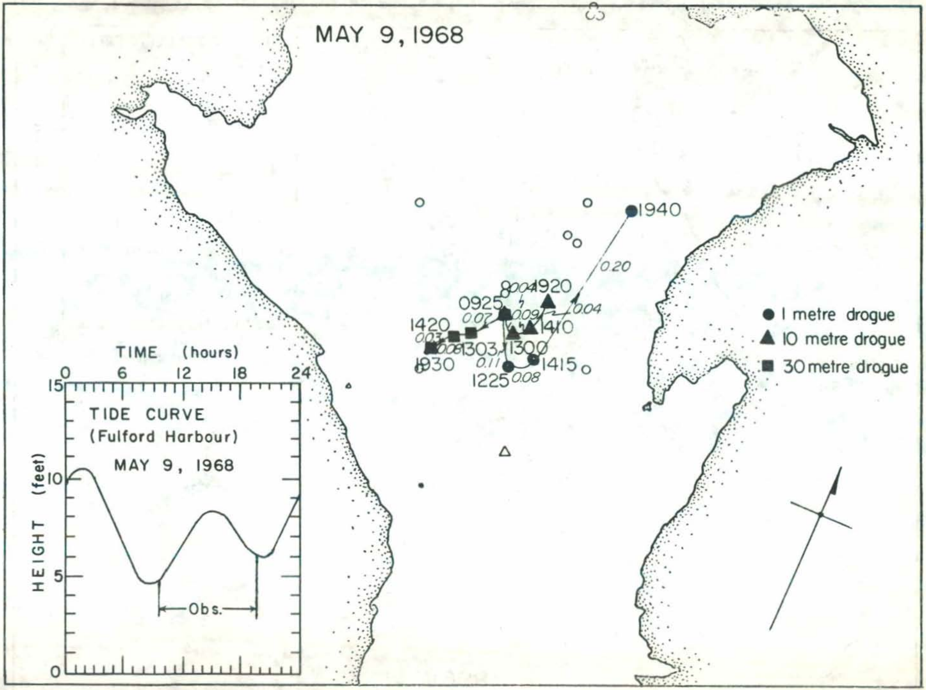

Figure 6 Drogue measurements at 1, 10 and 30 metres on May 9, 1968.

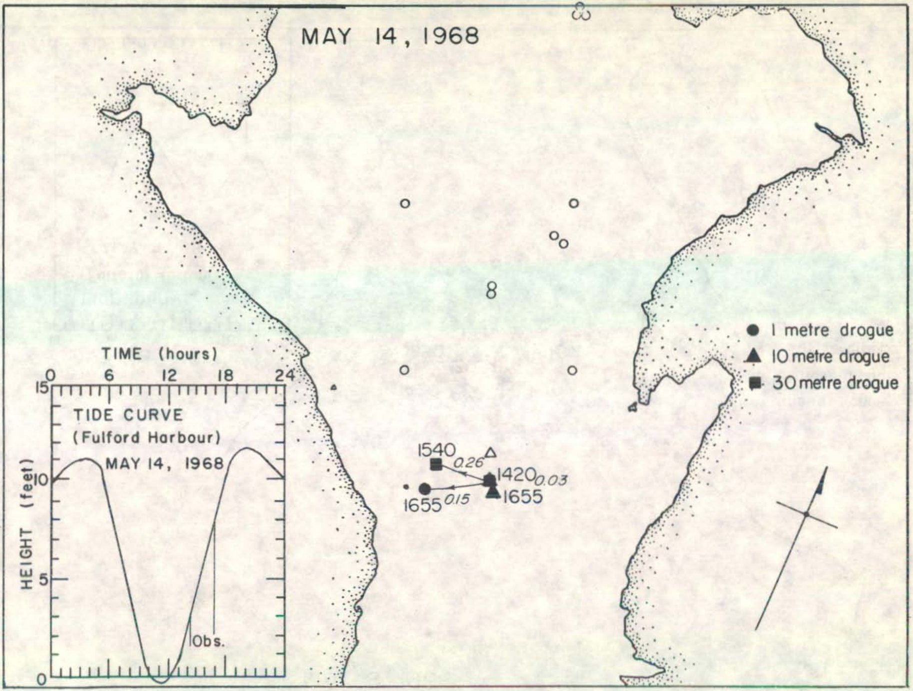

Figure 7   Drogue measurements at 1, 10 and 30 metres on May 14, 1968.

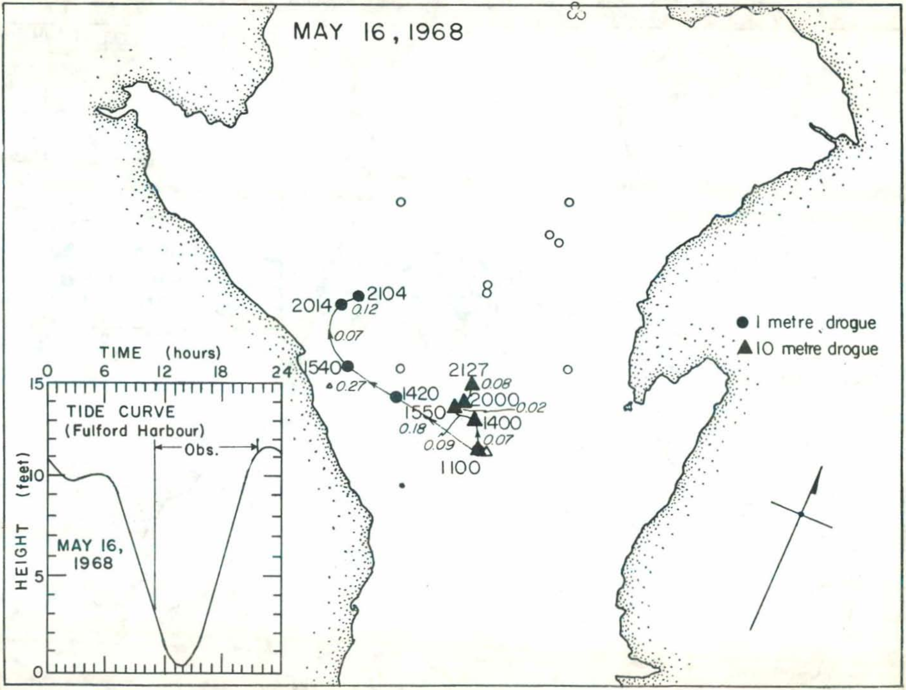

Figure 8 Drogue measurements at 1 and 10 metres on May 16, 1968.

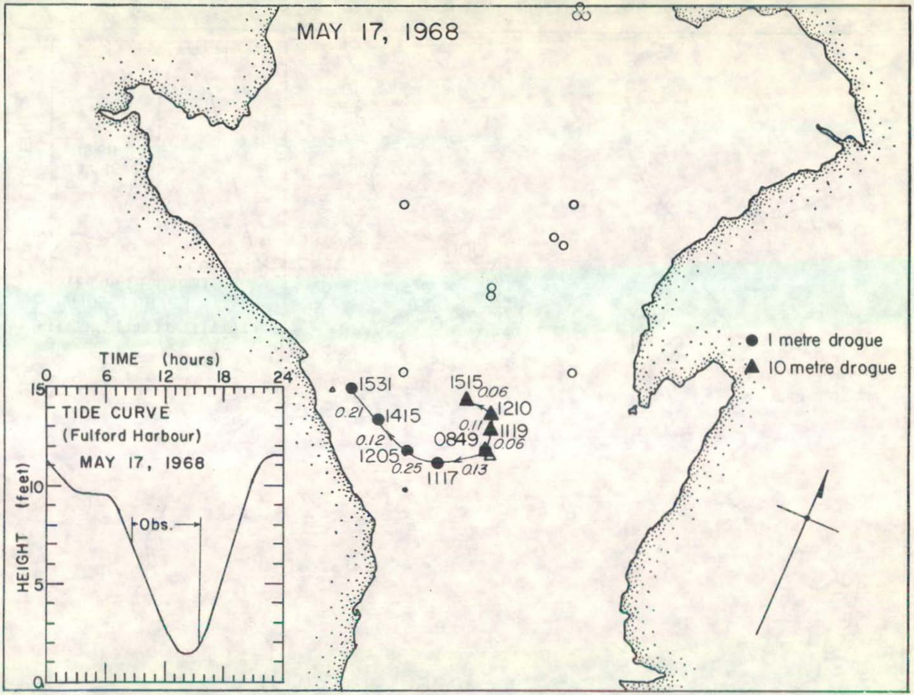

Figure 9 Drogue measurements at 1 and 10 metres on May 17, 1968.

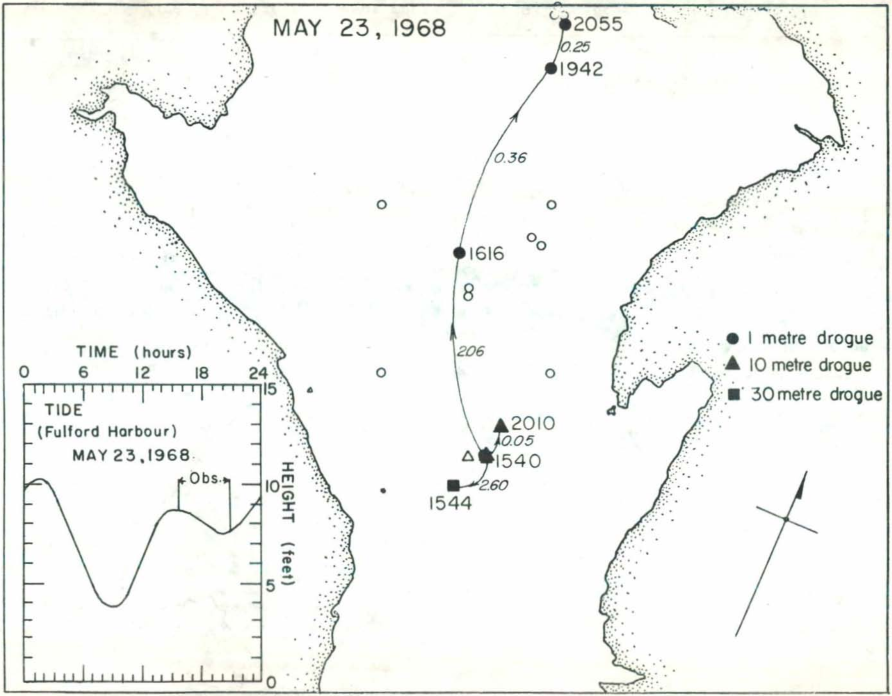

Figure 10 Drogue measurements at 1, 10, and 30 metres on May 23, 1968.

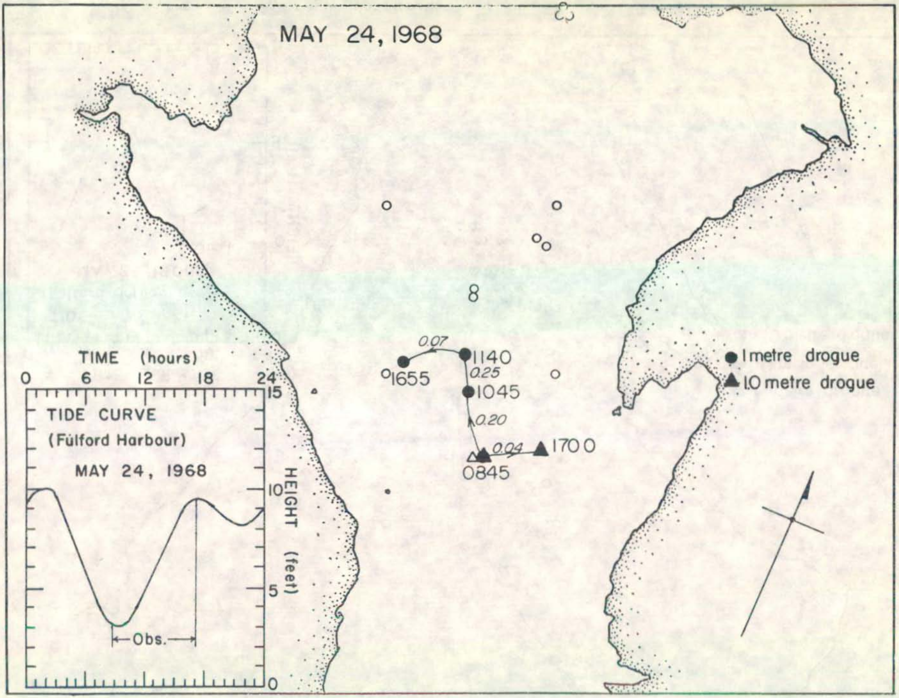

Figure 11 Drogue measurements at 1 and 10 metres on May 24, 1968.

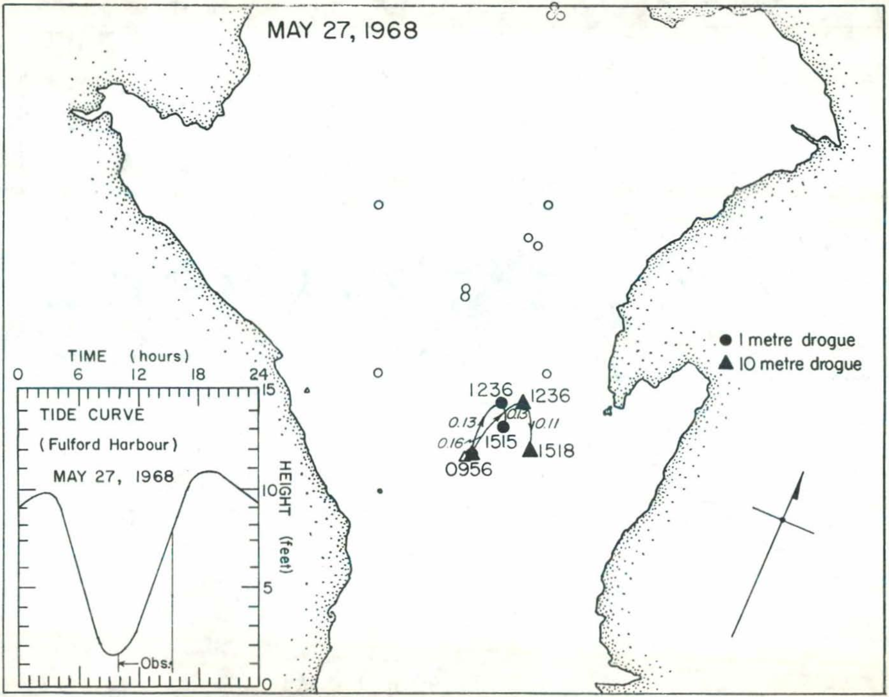

Figure 12 Drogue measurements at 1 and 10 metres on May 27, 1968.

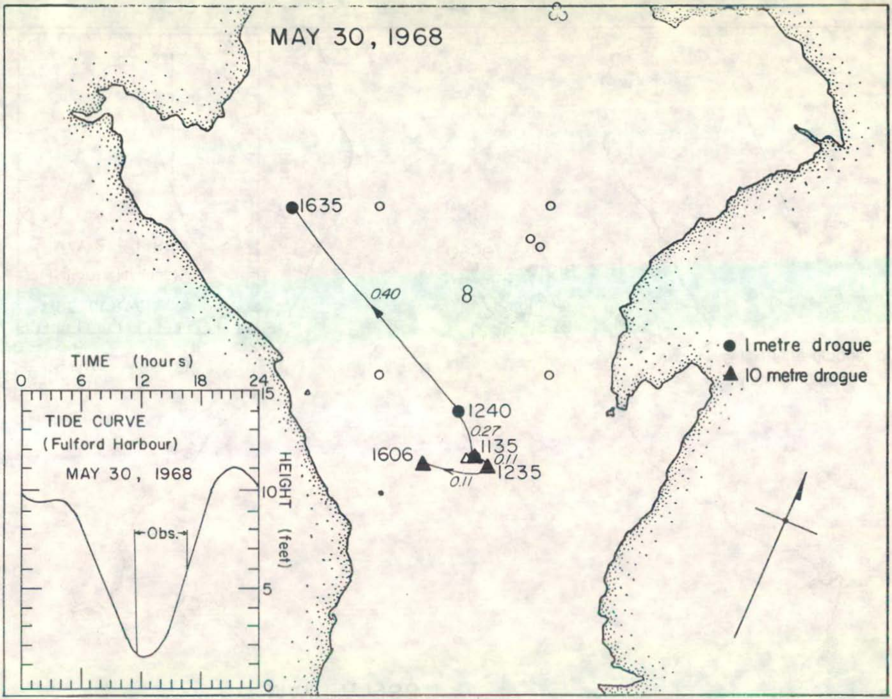

Figure 13 Drogue measurements at 1 and 10 metres on May 30, 1968.

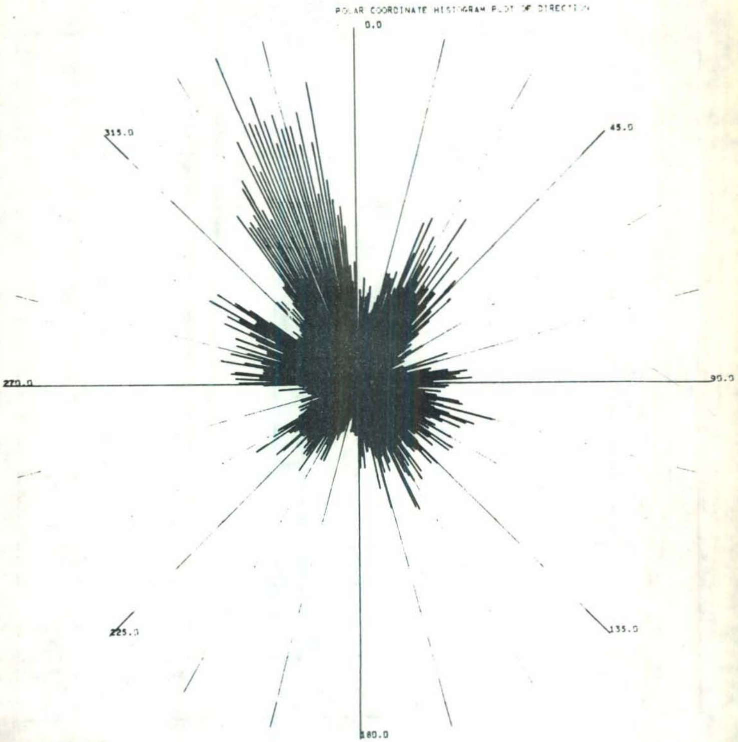

Figure 14 Polar Coordinate histogram plot of direction of the data collected over the period May 14-June 14, 1968.

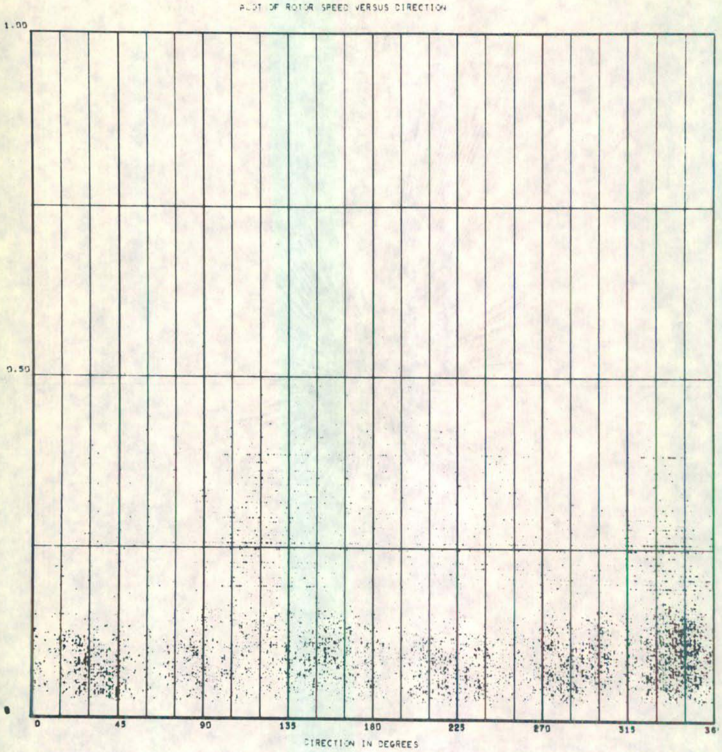

Figure 15 Plot of rotor speed versus direction for the period May 14-June 14, 1968.

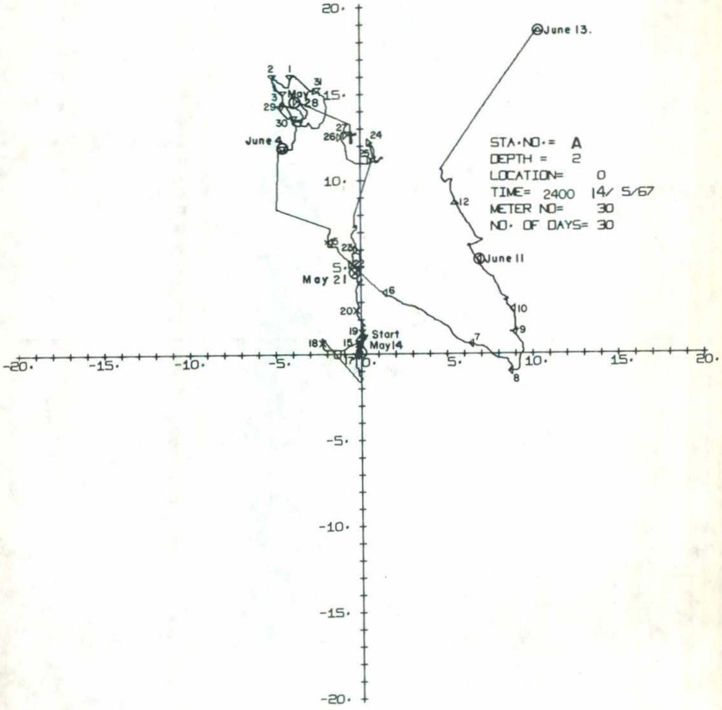

Figure 16 Vector trajectory plot of water movement at station A for the period May 15-June 13, 1968.

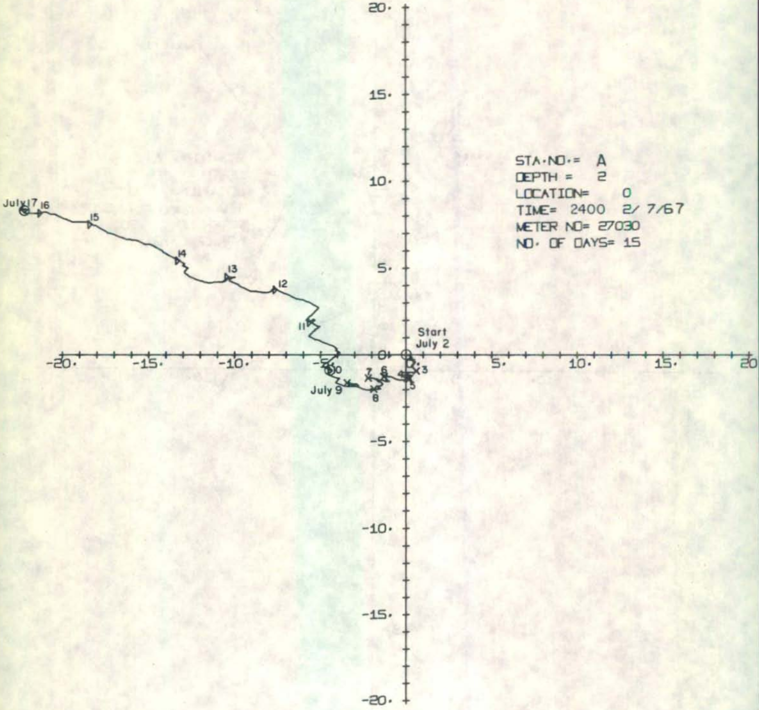

Figure 17 Vector trajectory plot of water movement at station A for the period July 3 to 17, 1968.

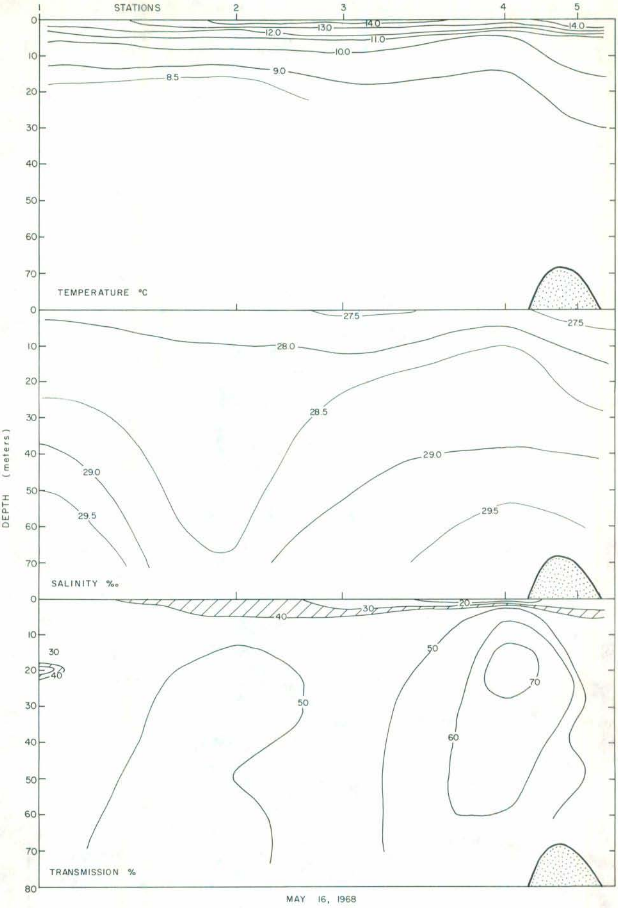

Figure 18 Longitudinal distribution of temperature (°C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on May 16, 1968.

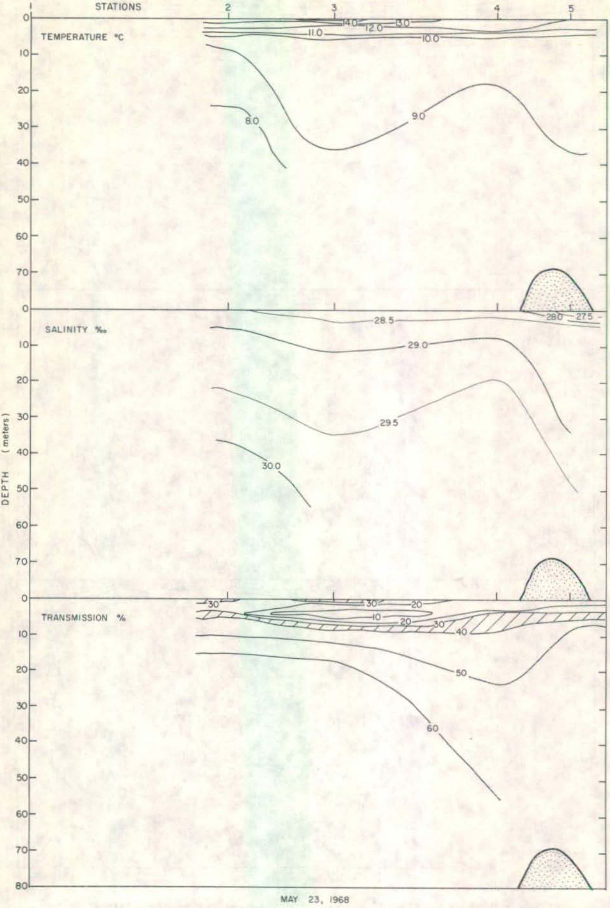

Figure 19 Longitudinal distribution of temperature (°C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on May 23, 1968.

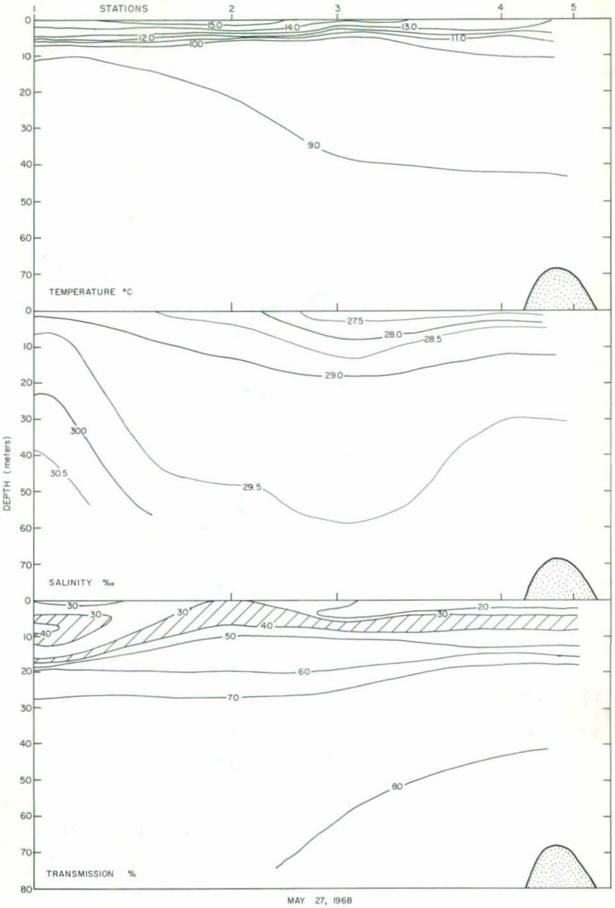

Figure 20 Longitudinal distribution of temperature (^{o}C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on May 27, 1968.

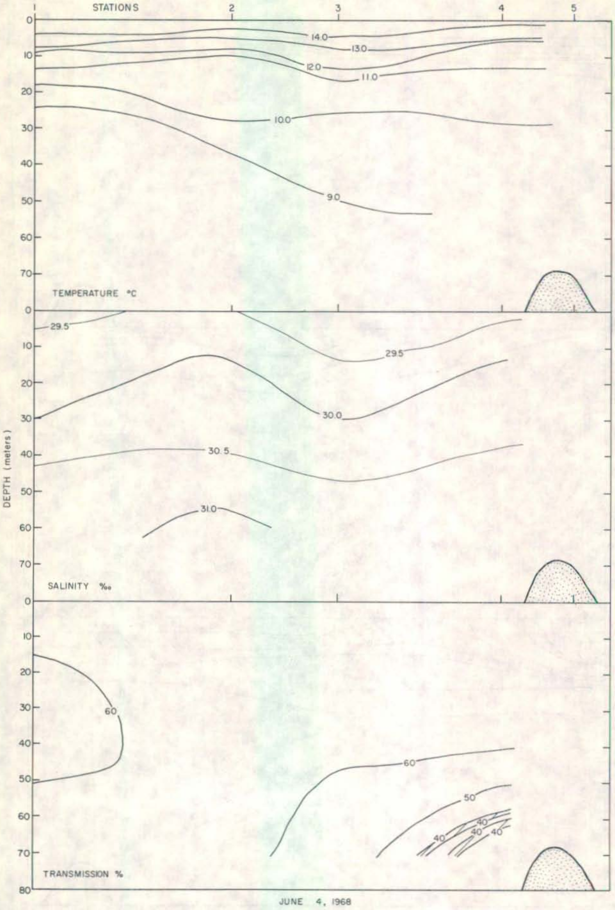

Figure 21 Longitudinal distribution of temperature (°C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on June 4, 1968.

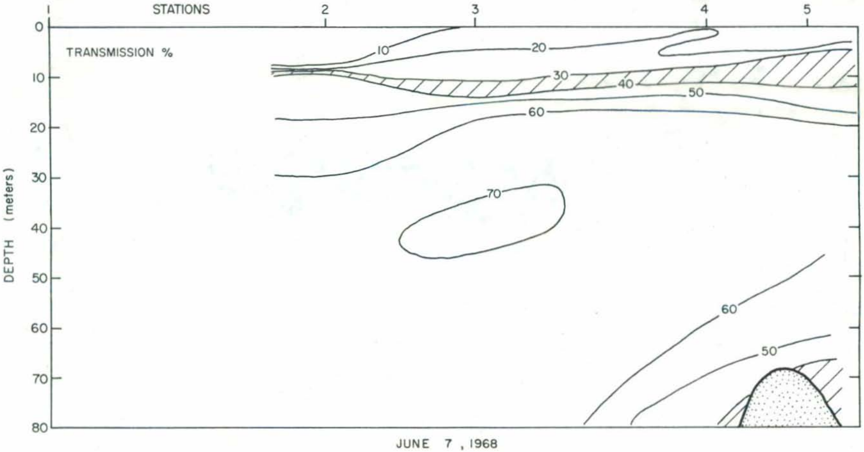

Figure 22 Longitudinal distribution of light transmission (%) down the middle of Saanich Inlet on June 7, 1968.

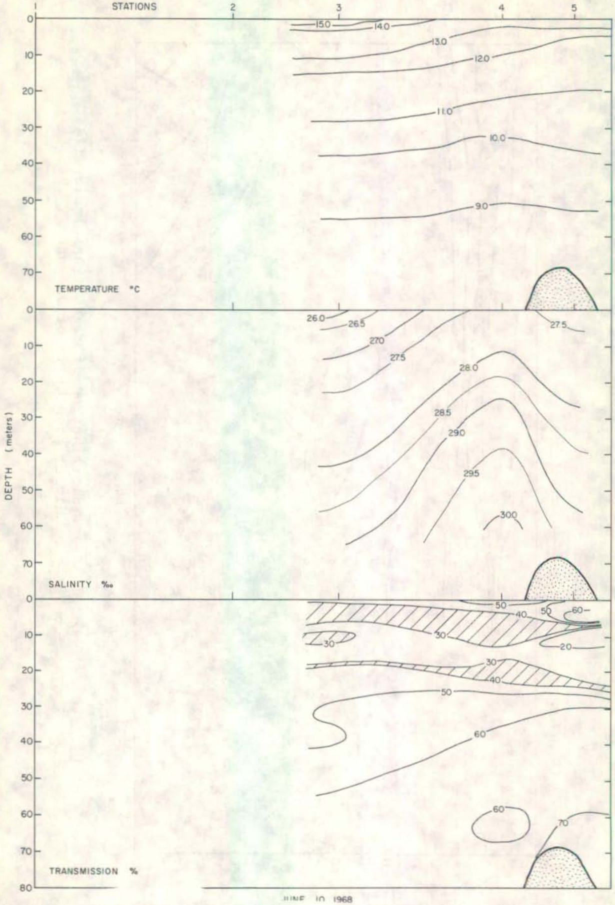

Figure 23 Longitudinal distribution of temperature (°C), salinity (‰), and light transmission (%) down the middle of Saanich Inlet on June 10, 1968.

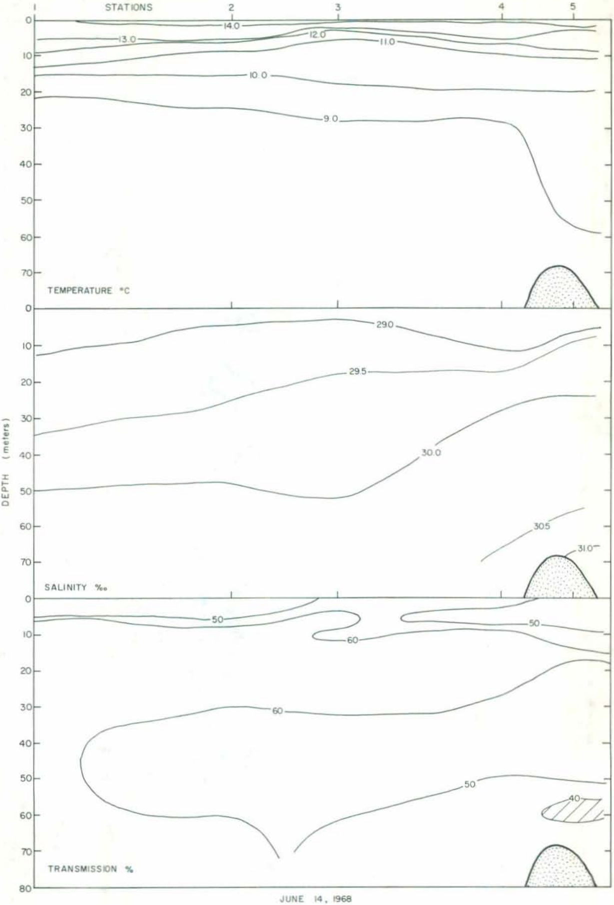

Figure 24 Longitudinal distribution of temperature (°C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on June 14, 1968.

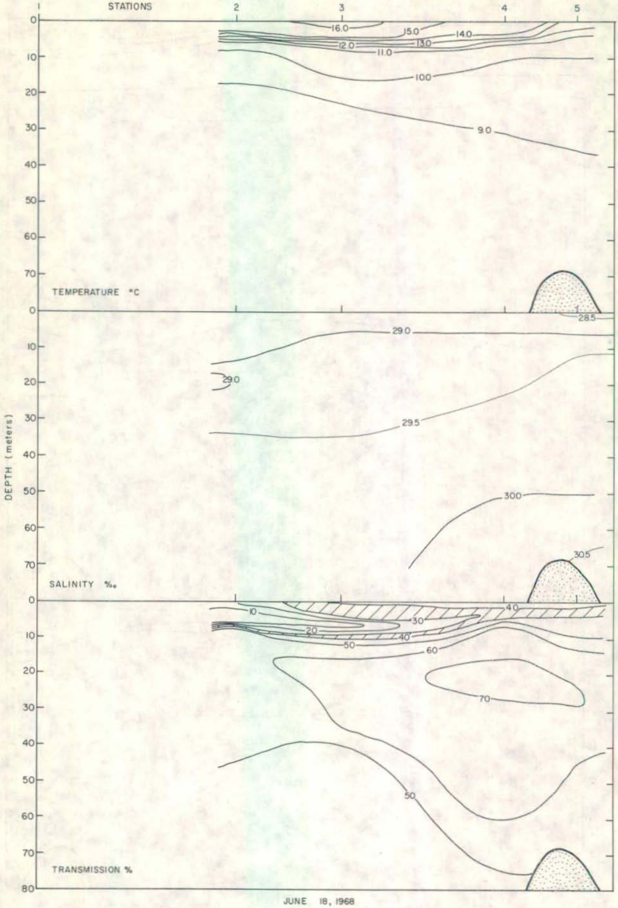

Figure 25 Longitudinal distribution of temperature (°C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on June 18, 1968.

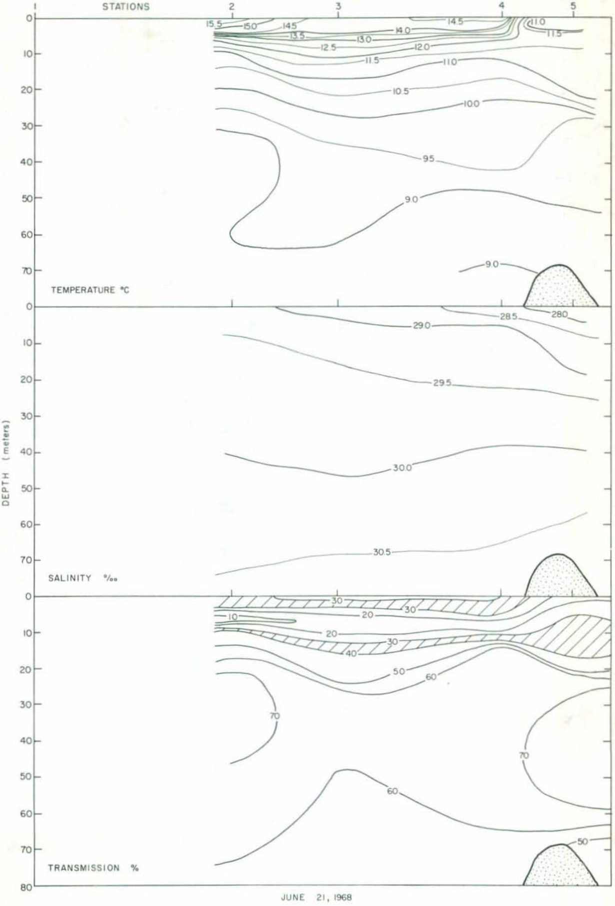

Figure 26 Longitudinal distribution of temperature (°C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on June 21, 1968.

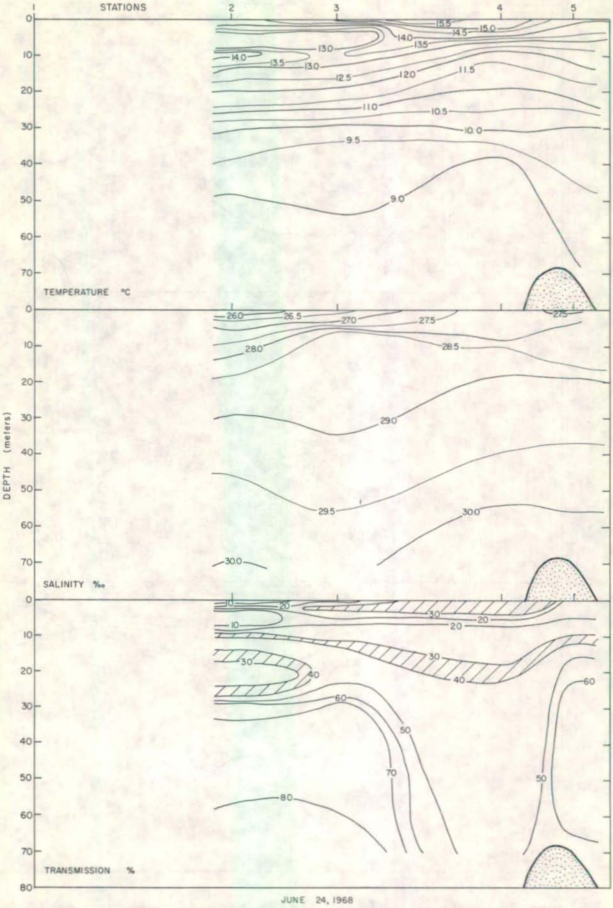

Figure 27 Longitudinal distribution of temperature (°C), salinity (‰), and light transmission (%) down the middle of Saanich Inlet on June 24, 1968.

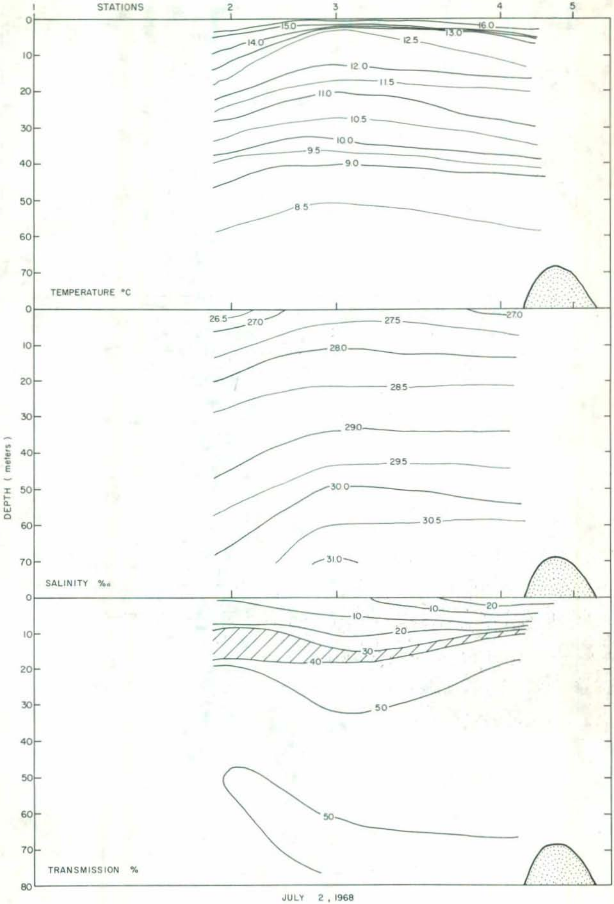

Figure 28 Longitudinal distribution of temperature (°C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on July 2, 1968.

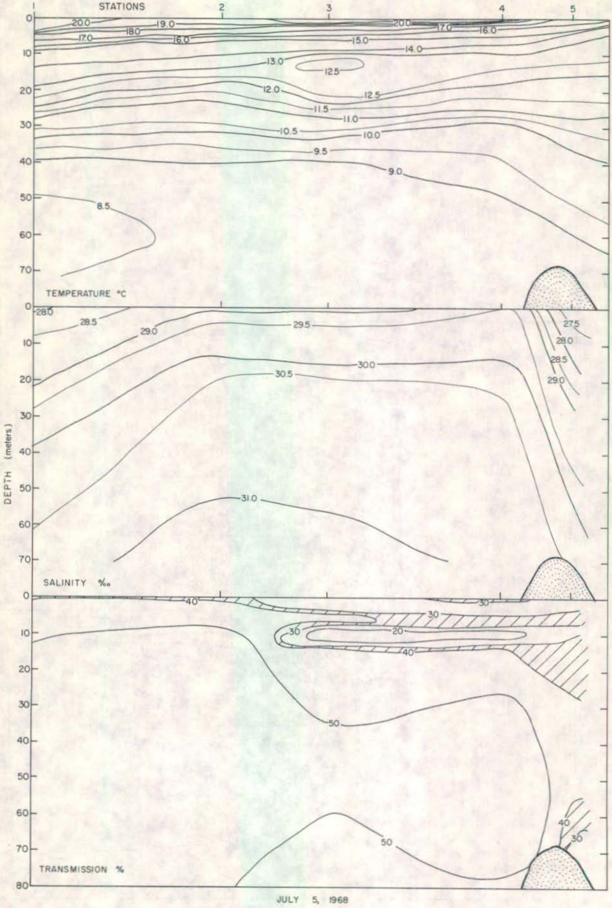

Figure 29 Longitudinal distribution of temperature (°C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on July 5, 1968.

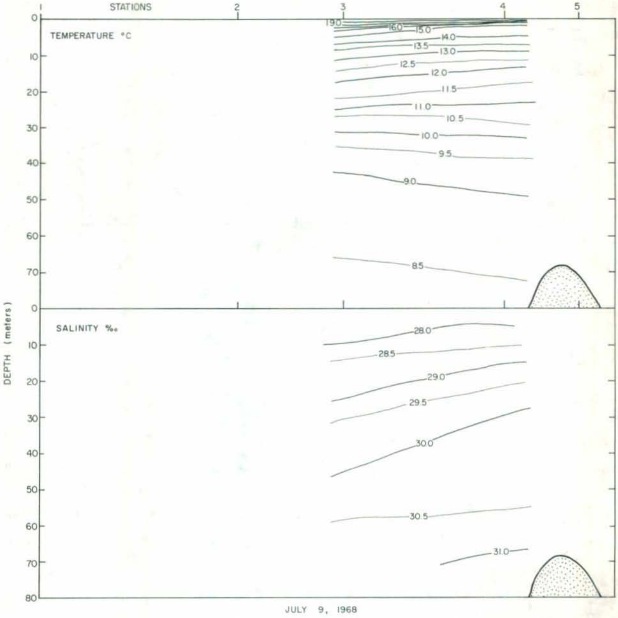

Figure 30 Longitudinal distribution of temperature (^{o}C), and salinity (‰) down the middle of Saanich Inlet on July 9, 1968.

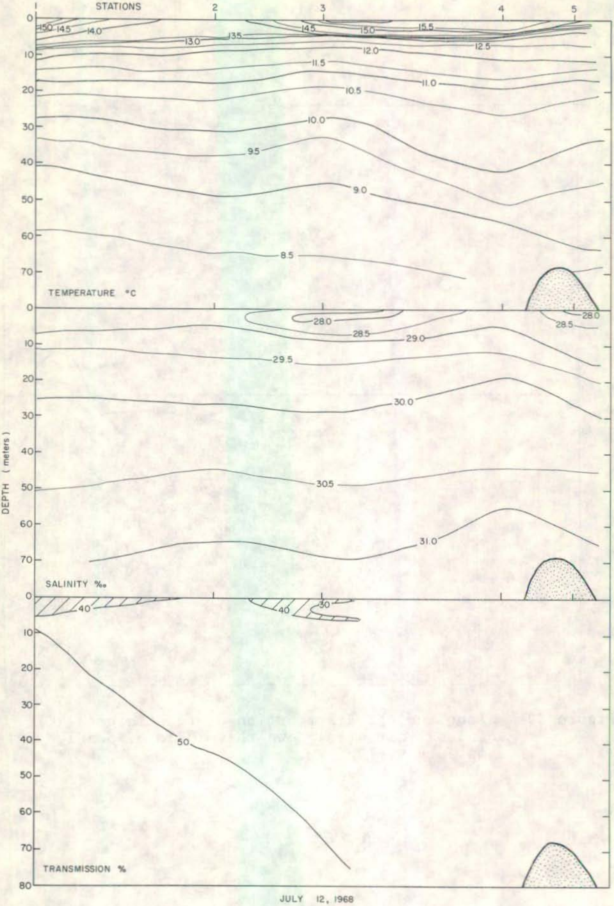

Figure 31 Longitudinal distribution of temperature (°C), salinity (‰) and light transmission (%) down the middle of Saanich Inlet on July 12, 1968.

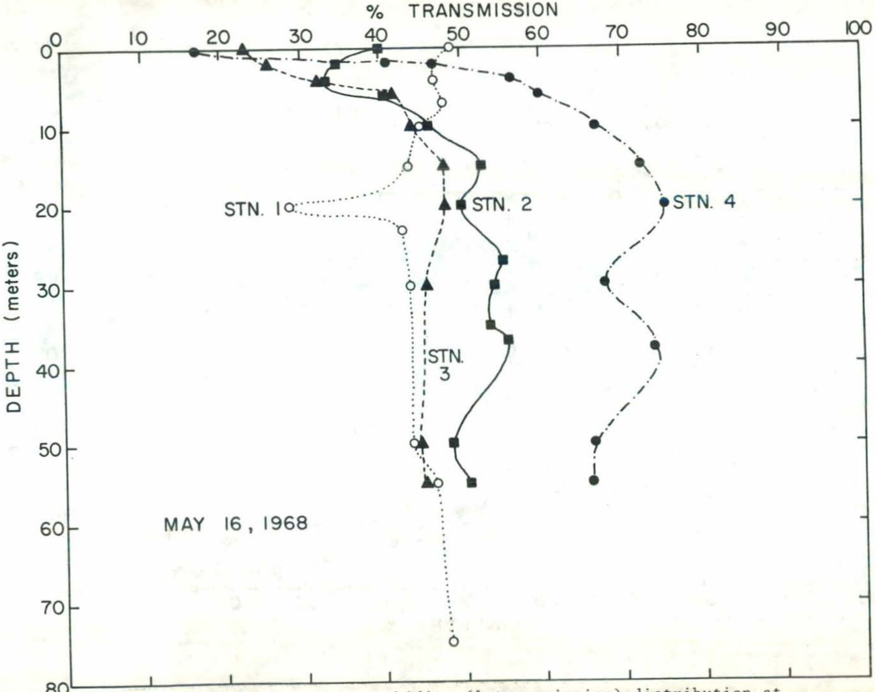

Figure 32 Vertical turbidity (% transmission) distribution at four stations in Saanich Inlet on May 16, 1968.

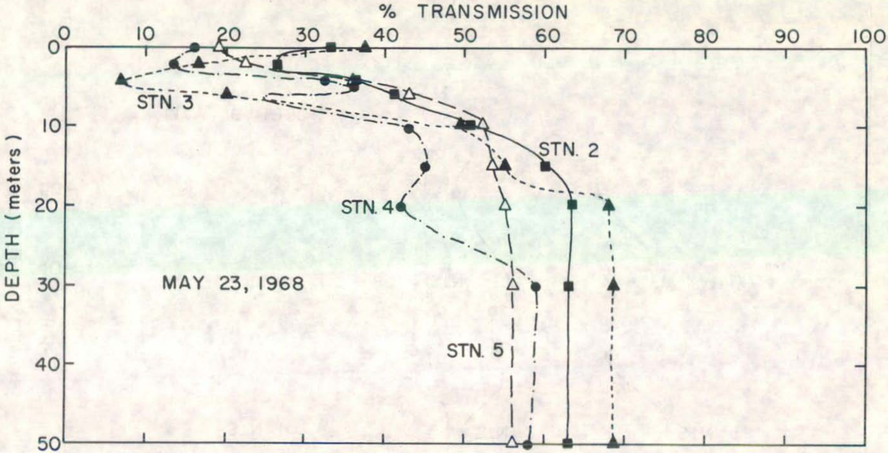

Figure 33 Vertical turbidity (% transmission) distribution at five stations in Saanich Inlet on May 23, 1968.

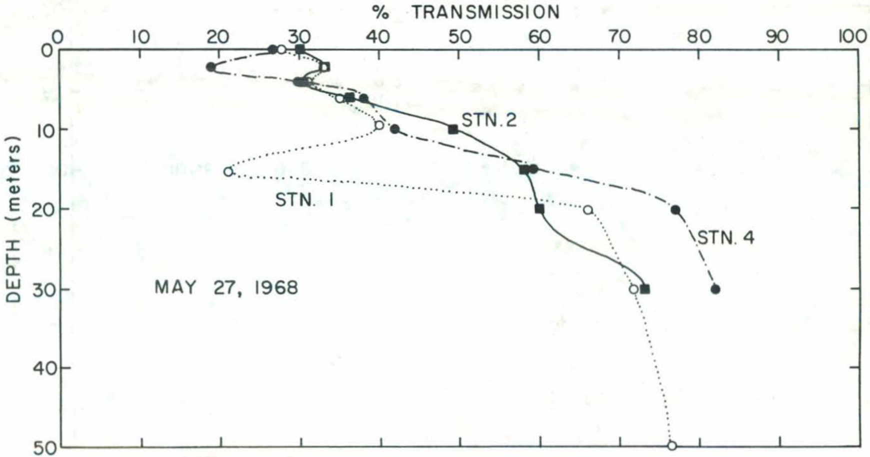

Figure 34 Vertical turbidity (% transmission) distribution at three stations in Saanich Inlet on May 27, 1968.

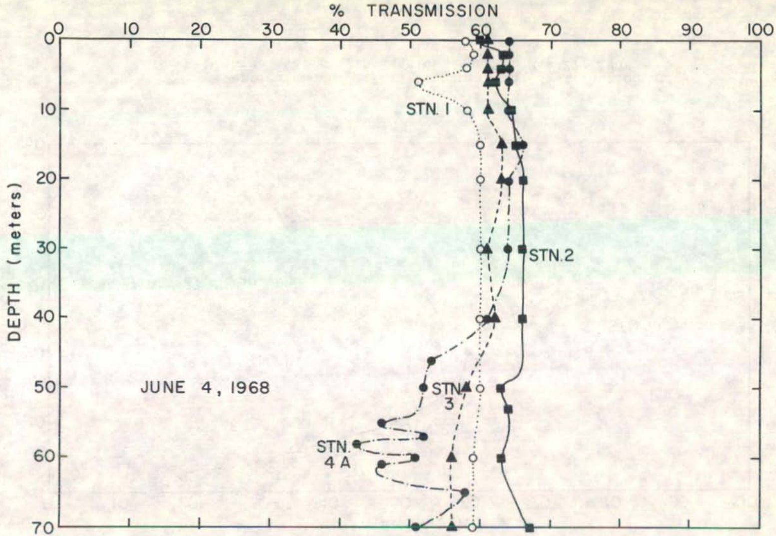

Figure 35 Vertical turbidity (% transmission) distribution at four stations in Saanich Inlet on June 4, 1968.

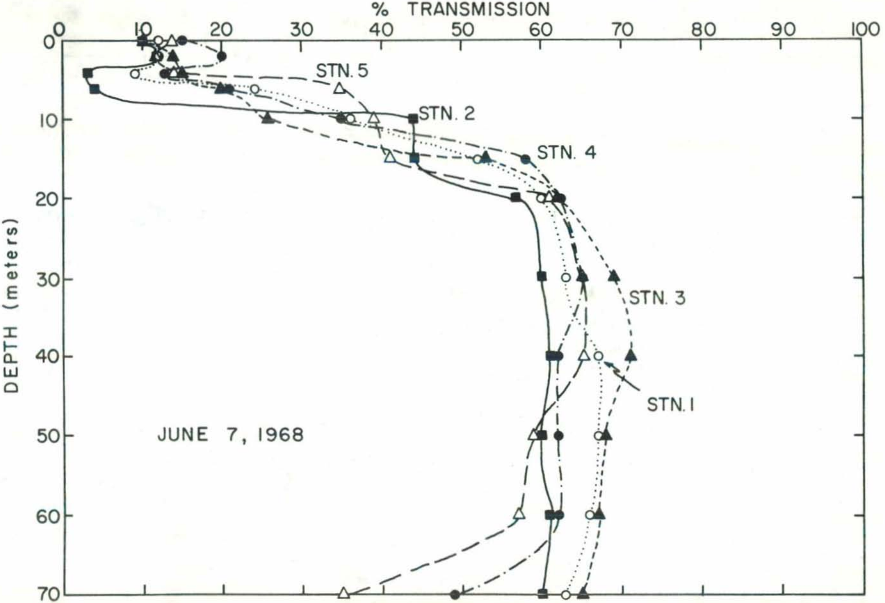

Figure 36 Vertical turbidity (% transmission) distribution at five stations in Saanich Inlet on June 7, 1968.

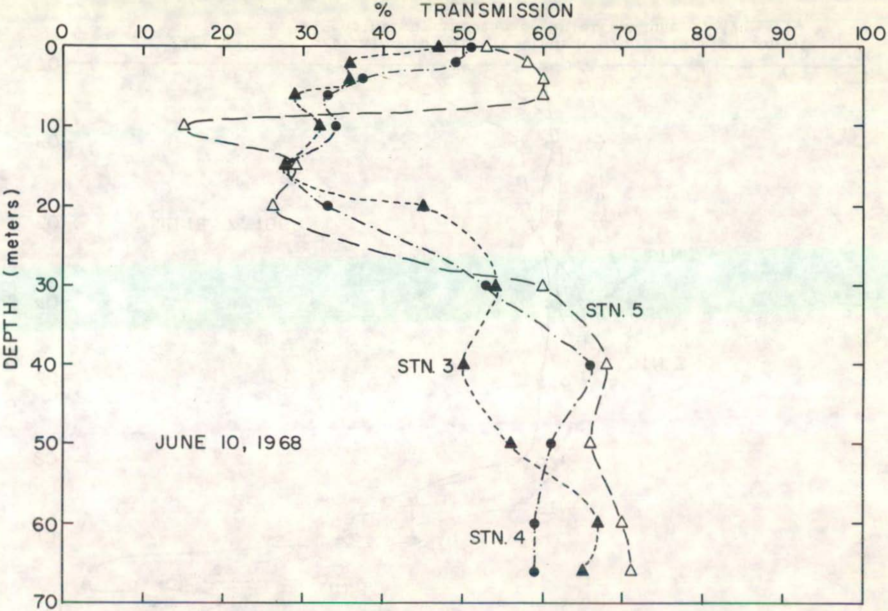

Figure 37 Vertical turbidity (% transmission) distribution at three stations in Saanich Inlet on June 10, 1968.

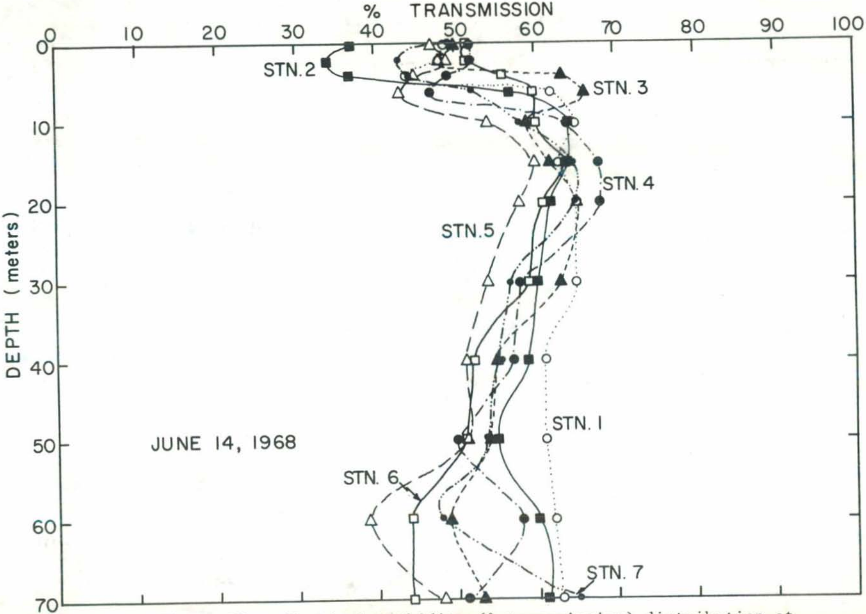

Figure 38 Vertical turbidity (% transmission) distribution at six stations on Saanich Inlet on June 14, 1968.

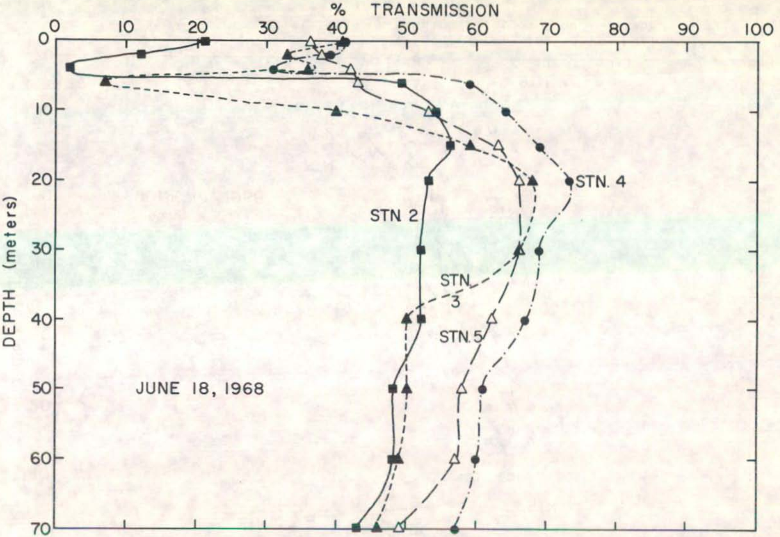

Figure 39 Vertical turbidity (% transmission) distribution at four stations in Saanich Inlet on June 18, 1968.

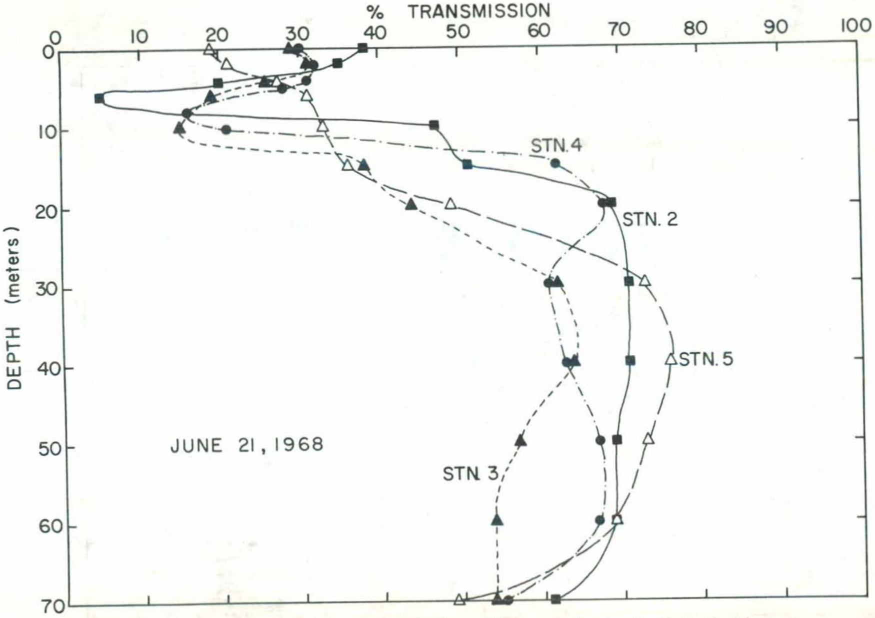

Figure 40 Vertical turbidity (% transmission) distribution at four stations in Saanich Inlet on June 21, 1968.

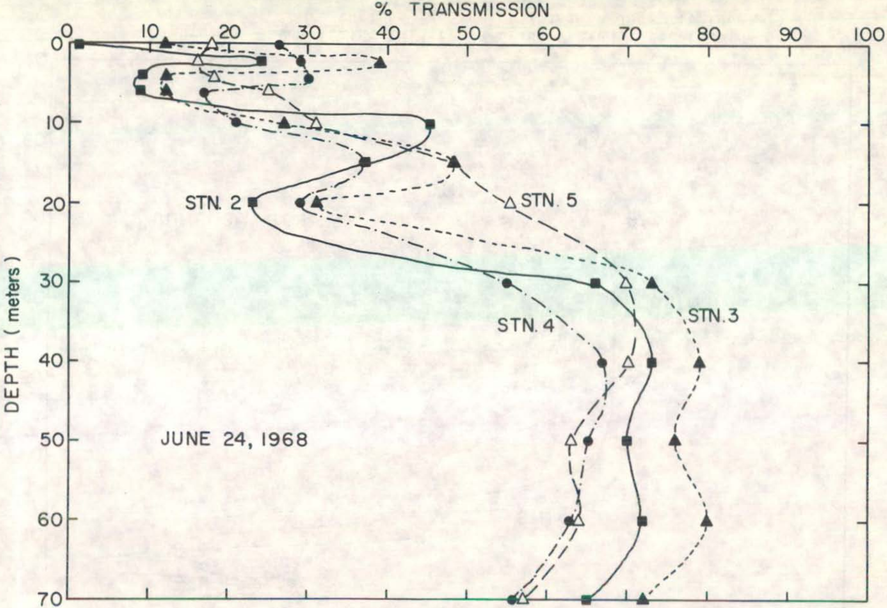

Figure 41 Vertical turbidity (% transmission) distribution at four stations in Saanich Inlet on June 24, 1968.

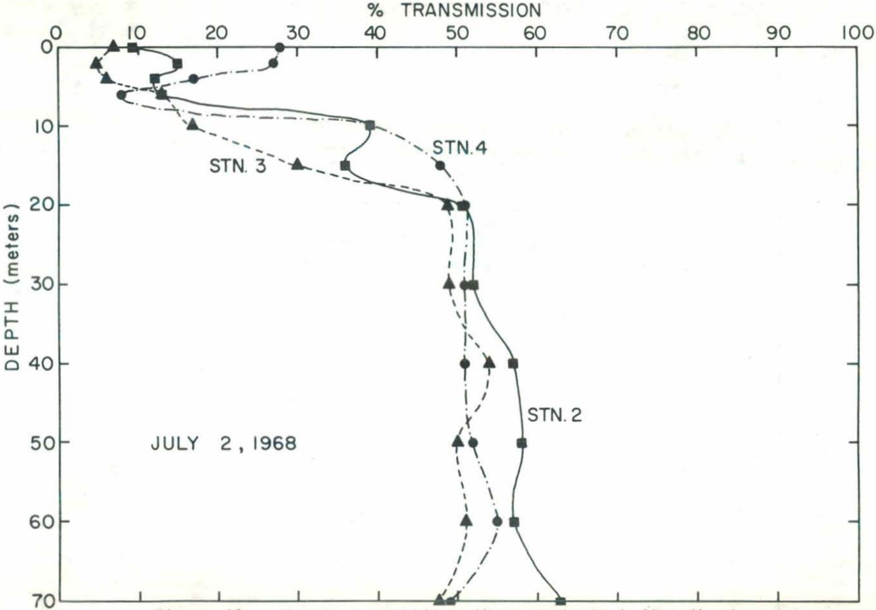

Figure 42 Vertical turbidity (% transmission) distribution at three stations in Saanich Inlet on July 2, 1968.

Table I: Dominant Wind Direction and Total Miles of Wind at Patricia Bay and Tozier Rock; May 2 - July 4, 1968

		Dominant Direction				Dominant Direction		
Patricia Bay	May	AM	PM	Total Miles	June	AM	PM	Total Miles
	2	--	N	25	7	W	E	62
	3	SW	N	58	8	W	E	64
	4	N	S	214	9	E	E	48
	5	SE	NE	125	10	E	E	56
	6	W	N	110	11	W	E	90
	7	SW	N	79	12	W	E	72
	8	S	NW	67	13	NW	E	38
	--				14	W	E	39
	17	--	--	--	15	SE	E	41
	18	W	W	23	16	W	E	35
	19	E	W	24	17	NW	E	55
	20	E	E	60	18	E	NW	41
	21	E	W	30	19	E	NW	45
	22	E	W	35	20	NW	E	70
	23	W	E	59	21	NW	E	59
	24	W	E	30	22	NW	NE	19
	25	W	E	87	23	W	E	46
	26	W	W	37	24	W	E	20
	27	W	E	40	25	W	E	25
	28	NW	E	65	26	E	S	92
	29	W	E	90	27	S	SW	127
	30	W	E	60	28	W	W	56
	31	W	E	37	29	W	E	70
	June				30	NW	E	33
	1	E	W	26	July			
	2	E	W	70	1	NW	E	22
	3	W	E	40	2	W	E	20
	4	W	E	36	3	W	E	21
	5	NW	E	31	4	W	E	30
	6	E	E	55				
Tozier Rock	May				May			
	17	W	N	70	30	NW	E	101
	18	W	N	63	31	W	NW	80
	19	N	E	80	June			
	20	NW	SE	155	1	NW	SW	89
	21	NW	NW	75	2	--	--	--
	22	SE	NW	115	3	--	--	--
	23	W	N	90	4	--	--	--
	24	SE	NW	85	5	W	W	64
	25	W	W	120	6	NW	SE	99
	26	W	NW	60	7	W	SE	100
	27	W	SE	97	8	W	SE	124
	28	W	NW	85	9	W	SE	104
	29	NW	NE	142	10	W	W	83
					11	W	W	112
					12	E	W	154
					13	W	[illegible]	[illegible]

Table II: Average Flow Components at Station A, Saanich Inlet May - July, 1968 (Miles/day).

Date	Direction North-South	Direction East-West
May 15, 1968	0.64	-2.16
16	-0.84	1.96
17	0.77	0.06
18	0.21	-0.02
19	0.61	0.14
20	1.64	-0.37
21	2.14	-0.07
22	0.62	-0.20
23	0.63	0.29
24	5.26	0.68
25	1.06	0.04
26	0.23	-1.75
27	0.17	0.32
28	2.03	-3.14
29	-0.37	-0.92
30	0.71	0.04
31	0.92	-0.49
June 1	0.06	1.30
2	-0.84	1.61
3	-1.57	-1.19
4	-1.67	-0.63
5	-5.35	2.48
6	-3.17	3.50
7	-2.90	5.09
8	-1.47	2.17
9	2.31	0.15
10	1.32	-0.35
11	2.82	-1.98
12	3.54	-1.16
13	10.06	4.96
July 3	-1.00	0.94
4	-0.53	-0.33
5	-0.23	0.09
6	0.07	-1.37
7	-0.05	-0.84
8	-0.49	0.29
9	0.55	-1.42
10	0.79	-0.92
11	2.70	-1.08
12	1.63	-2.11
13	1.00	-2.82
14	1.08	-2.95
15	2.09	-5.02
16	0.51	-2.69
17	0.04	-0.57