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TEMPERATURE, DISSOLVED OXYGEN, TOTAL ALKALINITY, AND BIOCHEMICAL OXYGEN DEMAND IN THE COLUMBIA RIVER ESTUARY, 1966-1967

DATA REPORT 43

C. W. SIMS and C. J. CEDERHOLM

United States Fishe and Wildlife Service
Washington, D. C.

January 1970

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TEMPERATURE, DISSOLVED OXYGEN, TOTAL ALKALINITY, AND BIOCHEMICAL OXYGEN DEMAND IN THE COLUMBIA RIVER ESTUARY, 1966-67

By

CARL W. SIMS and CARL J. CEDERHOLM

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TEMPERATURE, DISSOLVED OXYGEN, TOTAL ALKALINITY, AND BIOCHEMICAL OXYGEN DEMAND IN THE COLUMBIA RIVER ESTUARY, 1966-67

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ABSTRACT

These data collected at 19 locations in the Columbia River estuary are presented as a reference for researchers in fisheries or in water quality.

INTRODUCTION

The Bureau of Commercial Fisheries has been studying juvenile Pacific salmon (genus Oncorhynchus) and steelhead trout (Salmo gairdneri) in the estuary of the Columbia River since March 1966. These studies have been concerned primarily with the timing and rates of migration, the distribution, and the behavior of juvenile fish in the estuary system. Certain characteristics of water quality have been measured since April 1966 as part of these studies.

This report presents data on water quality (collected in 1966-67) for use in research on fisheries or water quality in the Columbia River estuary. The estuary is a large and complex system. Increased industrial development and population growth along the lower river will bring about changes in water quality that could significantly affect the basic ecology of the system. A knowledge of pre-existing conditions is essential to planning for fisheries or for pollution control.

Data on water quality for the estuary are limited. Haertel and Osterberg (1967) presented profiles of temperature and oxygen concentration in the lower estuary for 1963-65. Additional information, for the most part, concerns the upper estuary and the river (Lincoln and Foster, 1943[1/]; Robeck, Henderson, and Palange, 1954[2/]; U.S. Public Health Service, 1957-62[3/] and 1962-65[4/]).

Data presented in this report cover measurements in the Columbia River estuary in 1966-67 of: (1) Temperature, (2) D.O. (dissolved oxygen), (3) T.A. (total alkalinity), and (4) B.O.D. (biochemical oxygen demand).

1/ Lincoln, John H., and Richard F. Foster. 1943. Report on investigation of pollution in the lower Columbia River. Wash. State Pollut. Comm. Oreg. State Sanit. Auth., 143 pp. (Processed.)

2/ Robeck, Gordon C., Croswell Henderson, and Ralph C. Palange. 1954. Water quality studies on the Columbia River. U.S. Public Health Serv., Bur. State Serv., Div. Sanit. Eng. Serv., Robert A. Taft Sanit. Eng. Center, Cincinnati, Ohio, 99 pp. text, App. A-52 pp., App. B-80 pp., App. C-35 pp., App. D-28 pp. (Processed.)

3/ U.S. Public Health Service, National Water Quality Network. 1957-62 Water Pollution Surveillance System Annual Compilation of data.

4/ U.S. Public Health Service, National Water Quality Network. 1962-65 Water Pollution Surveillance System Annual Compilation of data.

SAMPLING PROCEDURES

Temperatures and water samples were taken at depths of 0.5 m. below the surface and 0.5 m. above the bottom at all sites where the depth exceeded 2 m. Where the depth did not exceed 2 m., only surface samples and measurements were taken.

Nineteen sites in the Columbia River estuary were sampled intermittently in 1966-67 (fig. 1). Twelve of these sites were established in April 1966. Four sites were added in August 1966, below the outfall from the Crown Zellerbach pulp mill at Wauna, Oregon (Sites W1, W2, W3, and W4, fig. 1). The remaining three sites were added in July 1967, in the vicinity of a proposed aluminum plant in the lower estuary (Sites C1, C2, and C3, fig. 1).

ANALYTICAL METHODS

Temperature was measured in the field with an electronic hydrographic thermometer, accurate to 0.55° C.

Water samples were returned to the laboratory for determinations of dissolved oxygen, total alkalinity, and biochemical oxygen demand.

Dissolved oxygen concentration

The azide modification of the standard Winkler method as outlined in "Standard methods for the examination of water and wastewater" (American Public Health Association, 1965) was used for all determinations of oxygen concentration, but the method was modified slightly. In the titration, P.A.O. (phenylarsine oxide) was substituted for sodium thiosulfate. Samples were flocculated and acidified in the field and returned to the laboratory for titration.

Total alkalinity

Total alkalinity was determined by potentiometric titration as outlined in "American Public Health Association (1965).

B.O.D. (Biochemical oxygen demand)

B.O.D. throughout 1966 and most of 1967 was determined by incubation of the undiluted, oxygen-saturated samples in the dark for 5 days at 20° C. and by determination of the residual oxygen. The original oxygen concentration, less the residual oxygen of the incubated samples, is the 5-day B.O.D.

During the late summer, fall, and winter of 1967, a Hach manometric B.O.D. analyzer was used for most B.O.D. determinations. Tool (1967) described this method and the Hach apparatus.

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American Public Health Association.

1965. Standard methods for the examination of water and wastewater. 12th Ed., Amer. Public Health Ass. Press, New York, 769 pp.

Haertel, Lois, and Charles Osterberg.

1967. Ecology of zooplankton and fishes in the Columbia River estuary. Ecology 48: 459-472.

Tool, Raymond H.

1967. Manometric measurement of biological oxygen demand. Water Sewage Works, June 1967, pp. 211-218.

COLUMBIA RIVER ESTUARY

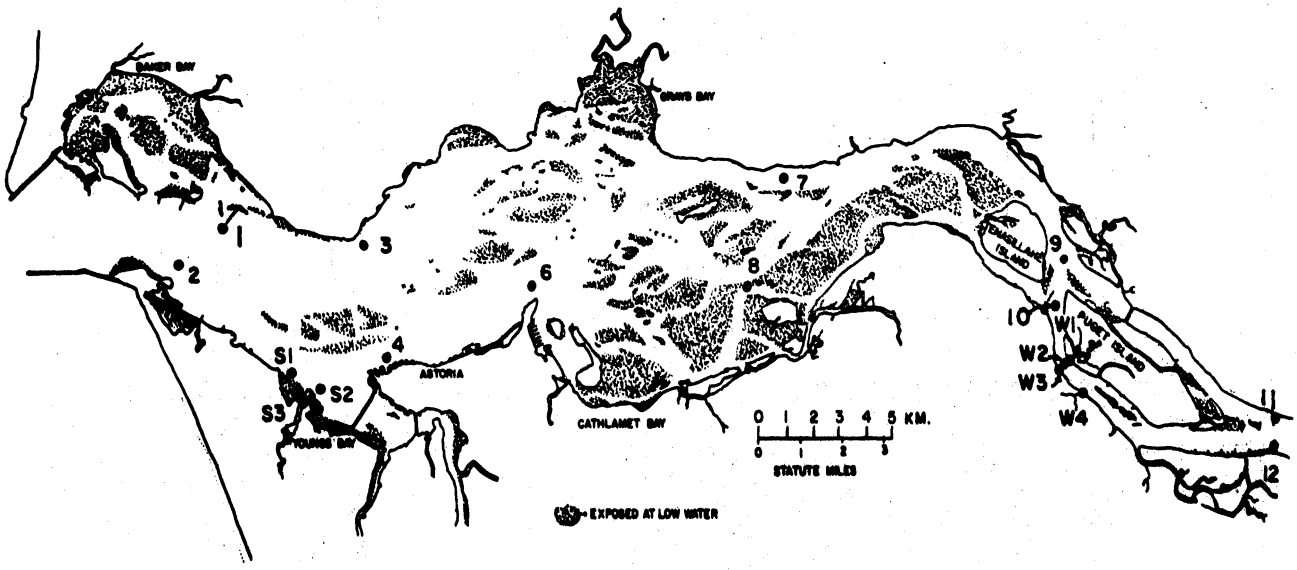

Figure 1.--Water sampling stations in the Columbia River estuary, 1966-67.

Table 1.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 1 (lat. 46°15'22" N., long. 123°58'52" W.), Columbia River estuary, 1966-67

Date	Surface Time*	Surface Temp. °C.	Surface D.O. P.p.m.	Surface T.A. P.p.m	Surface B.O.D. P.p.m.	Bottom Time*	Bottom Temp. °C.	Bottom D.O. P.p.m.	Bottom T.A. P.p.m.	Bottom B.O.D. P.p.m.
1966										
4/ 9	0945	8.3	10.1	-	-	1000	9.4	10.4	-	-
4/17	0920	11.1	10.1	-	-	0925	10.0	9.4	-	-
4/23	0955	11.1	10.1	-	-	0945	11.1	9.8	-	-
4/30	0840	10.0	9.6	-	-	0845	8.3	8.1	-	-
5/ 7	-	12.0	8.7	-	-	-	12.0	8.6	-	-
5/14	-	13.0	10.7	-	-	-	13.0	10.5	-	-
5/21	0840	12.8	10.2	-	-	0835	12.8	10.0	-	-
5/29	0935	12.8	9.4	-	3.0	0925	6.7	3.7	-	3.5
6/ 4	0845	13.3	10.5	-	-	0840	12.8	9.9	-	-
6/11	0805	14.4	9.6	42.0	1.1	0750	14.4	9.3	44.0	1.1
6/19	-	16.1	10.2	50.8	0.9	-	15.6	10.1	73.4	1.4
6/30	0815	16.1	10.5	49.6	-	0930	11.7	8.3	60.8	-
7/ 9	0835	15.6	-	48.0	-	0830	12.2	-	91.6	-
7/16	0830	17.8	-	54.0	-	0820	15.6	-	46.8	-
7/24	0810	16.7	-	58.6	0.9	0800	14.4	-	93.8	1.0
7/30	0905	18.3	8.8	57.0	1.8	0900	8.9	3.5	96.0	0.1
10/ 8	0910	12.2	9.2	-	1.4	0900	12.2	8.7	-	1.1
10/15	0910	14.4	8.0	-	-	0900	12.8	7.3	-	-
12/16	0855	8.3	11.4	-	-	0845	8.9	11.4	-	-
12/23	1540	8.3	11.4	-	2.7	1525	8.1	11.3	-	2.3
12/30	1110	8.6	10.8	-	-	1100	8.9	10.3	-	-
1967										
1/13	0840	6.7	11.4	-	-	0830	6.9	11.4	-	-
2/12	-	7.8	11.3	-	1.9	-	7.8	11.4	-	1.9
2/17	-	6.9	11.7	-	-	-	6.9	11.6	-	-
2/24	-	8.3	-	-	-	-	9.2	-	-	-
3/ 3	-	7.8	11.7	-	2.7	-	8.3	10.3	-	2.4
3/11	-	7.2	11.4	-	-	-	7.8	10.8	-	-
3/25	-	8.6	-	-	-	-	8.3	-	-	-
4/ 1	-	8.6	10.9	-	-	-	8.3	10.8	-	-
4/08	-	9.2	10.6	-	-	-	9.4	10.0	-	-
4/13	-	9.7	10.4	-	-	-	9.4	10.4	-	-
5/14	-	12.8	9.4	-	-	-	13.6	8.4	-	-
7/ 5	-	18.2	-	-	-	-	18.2	-	-	-
7/26	0720	18.0	9.0	-	-	0710	12.5	7.3	-	-
8/ 3	1020	17.8	7.4	-	1.9	1015	12.2	4.8	-	0.9
8/ 7	0815	17.5	7.2	57.3	1.3	0810	16.1	6.2	76.3	2.8
8/14	0910	17.2	6.4	80.8	1.5	0905	15.0	5.5	96.0	3.1
8/28	1015	18.9	8.4	70.3	-	1010	11.1	5.5	84.0	-
9/ 5	0950	20.0	8.0	64.6	-	0945	17.8	8.0	68.7	-
9/11	0600	18.5	8.9	-	-	0610	16.0	8.8	-	-
10/ 7	0820	16.1	8.1	-	-	0810	15.6	7.7	-	-
10/28	1000	13.9	9.4	-	-	0955	14.4	8.7	-	-
11/18	1525	12.2	10.0	-	-	1520	13.3	9.8	-	-

Table 2.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 2 (lat. 46°14'26" N., long. 123°59'12" W.), Columbia River estuary, 1966-67

Date	Surface Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	0930	10.0	10.5	-	-	-	-	-	-	-
4/ 9	1030	9.4	10.3	-	-	1040	7.8	10.3	-	-
4/17	0950	11.7	10.6	-	-	0955	10.0	9.6	-	-
4/23	1015	11.7	10.1	-	-	1010	11.1	9.8	-	-
4/30	0905	11.1	10.5	-	-	0915	8.3	8.2	-	-
5/ 7	-	12.0	9.06	-	-	-	12.0	8.9	-	-
5/14	-	13.0	10.7	-	-	-	13.0	6.2	-	-
5/21	0825	12.8	10.1	-	-	0815	12.8	9.9	-	-
5/29	0910	13.3	10.2	-	1.2	0900	6.7	3.5	-	2.0
6/ 4	0835	13.9	10.3	-	-	0820	13.3	10.3	-	-
6/11	0825	14.4	9.8	42.8	1.2	0815	9.4	7.2	96.4	1.5
6/19	-	16.1	10.0	52.4	1.2	-	15.6	10.0	51.6	1.6
6/30	0900	16.1	10.6	47.6	-	0850	10.0	9.1	56.2	-
7/ 9	0900	16.7	-	46.4	-	0850	10.0	-	91.2	-
7/16	0845	17.2	-	57.2	-	0840	11.7	-	82.0	-
7/24	0825	16.7	-	57.6	1.1	0820	14.4	-	71.0	0.6
7/30	0920	17.8	8.4	58.4	1.1	0915	13.3	5.9	78.4	0.8
10/ 8	0930	12.8	8.9	-	0.7	0920	10.6	9.5	-	1.3
10/15	0840	15.0	8.0	-	-	0830	13.3	7.6	-	-
11/19	-	11.7	-	-	-	-	11.7	-	-	-
12/16	0920	8.3	11.3	-	-	0920	8.6	10.9	-	-
12/23	1615	7.8	11.1	-	-	1600	7.8	10.2	-	1.8
12/30	1140	8.3	11.4	-	-	1130	9.4	10.1	-	-
1967										
1/13	0930	7.8	11.4	-	-	0915	8.9	10.2	-	-
2/ 3	-	7.8	11.7	-	2.4	-	8.9	11.0	-	2.2
2/11	-	7.2	11.3	-	2.1	-	7.8	10.9	-	2.0
2/17	-	6.7	11.8	-	-	-	6.7	10.8	-	-
2/24	-	8.3	-	-	-	-	9.2	-	-	-
3/ 3	-	7.8	11.6	-	2.6	-	9.2	9.3	-	1.3
3/11	-	7.2	11.5	-	-	-	7.2	10.8	-	-
3/25	-	8.3	-	-	-	-	8.3	-	-	-
4/ 1	-	8.3	11.4	-	-	-	8.3	10.7	-	-
4/ 8	-	9.4	10.6	-	-	-	9.4	9.6	-	-
4/13	-	10.0	10.4	-	-	-	9.7	10.0	-	-
5/14	-	12.8	9.3	-	-	-	12.8	8.4	-	-
7/26	0615	18.5	8.5	-	-	0625	12.5	7.9	-	-
8/ 3	0935	18.3	7.7	-	1.5	0930	10.6	4.7	-	1.3
8/ 7	0805	18.3	7.6	55.7	1.0	0800	17.2	7.5	68.9	2.2
8/14	0855	19.0	7.3	67.8	1.2	0850	10.6	4.0	106.4	2.4
8/28	1035	18.9	8.3	63.7	-	1030	10.6	5.8	81.2	-
9/15	0935	20.0	7.6	65.0	-	0930	18.3	8.0	67.3	-
9/11	0635	18.0	8.7	-	-	0640	16.0	8.7	-	-
10/ 7	0833	16.1	8.6	-	-	0825	15.0	8.5	-	-
10/28	1040	13.9	9.4	-	-	1035	13.9	9.1	-	-
11/18	1510	12.8	9.8	-	-	1500	13.3	8.9	-	-

* Pacific Standard time

Table 3.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 3 (lat. 46°14'26" N., long. 123°52'24" W.), Columbia River estuary, 1966-67

Date	Surface Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	1330	10.0	10.6	-	-	-	-	-	-	-
4/ 9	1230	8.9	11.1	-	-	1330	7.8	11.1	-	-
4/17	1140	11.1	9.9	-	-	1145	10.6	9.4	-	-
4/23	1105	11.7	10.7	-	-	1055	11.7	10.4	-	-
4/30	0945	11.1	10.3	-	-	0950	8.9	8.3	-	-
5/ 7	-	12.0	10.0	-	-	-	12.0	9.8	-	-
5/14	-	13.0	11.0	-	-	-	13.0	5.2	-	-
5/21	0935	12.8	11.5	-	-	0925	13.3	11.3	-	-
6/ 4	0915	13.3	-	-	-	0905	13.3	-	-	-
6/19	-	16.7	10.5	47.8	-	-	16.7	10.3	47.2	-
11/19	0740	11.7	10.2	31.6	-	0725	11.7	9.0	63.5	-
12/16	1025	8.9	11.7	-	-	1015	8.3	11.2	-	-
12/23	0915	9.2	11.5	-	2.3	0850	9.4	10.1	-	1.6
12/30	1330	7.5	11.5	-	1.9	1320	9.4	10.0	-	0.5
1967										
7/26	0820	19.0	8.3	-	2.6	0810	17.5	7.6	-	-
8/ 3	1100	20.0	8.2	-	2.2	1055	15.0	5.3	-	1.9
8/ 7	0900	19.7	7.7	56.7	2.5	0855	19.4	7.1	73.2	7.4
8/16	1050	18.9	-	61.2	2.4	1045	14.4	-	73.4	5.4
8/24	0735	20.0	7.8	64.4	1.4	0730	18.3	6.9	69.0	1.7
8/28	1330	20.3	8.9	58.2	-	1320	11.4	4.2	59.7	-
9/ 5	1010	20.8	8.1	63.8	-	1005	19.7	7.4	63.5	-
9/11	0850	20.0	8.9	-	-	0855	19.5	8.2	-	-

*Pacific Standard Time

Table 4.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 4 (lat. 46°11'35" N., long. 123°50'42" W.), Columbia River estuary, 1966-67

Date	Surface Time *	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	1100	9.4	-	-	-	-	-	-	-	-
4/ 9	1500	-	10.9	-	-	1515	-	11.0	-	-
4/17	1435	11.1	10.8	-	-	1445	10.6	10.5	-	-
4/23	1305	11.7	10.6	-	-	1300	11.7	10.6	-	-
4/30	1310	11.1	11.0	-	-	1315	9.4	8.4	-	-
5/ 7	-	12.0	9.9	-	-	-	12.0	9.7	-	-
5/14	-	13.0	10.9	-	-	-	13.0	8.0	-	-
5/21	1105	13.3	11.1	-	-	1055	13.3	10.9	-	-
6/19	-	17.2	10.3	47.2	-	-	16.7	10.2	46.6	-
11/19	1000	11.7	10.2	-	-	0945	11.7	9.3	-	-
12/16	1110	8.3	11.4	-	-	1055	8.3	11.0	-	-
12/23	0945	8.3	11.3	-	2.5	0935	9.2	10.3	-	2.0
12/30	1400	7.8	11.3	-	0.9	1350	9.4	10.2	-	-
1967										
7/ 5	0825	18.2	10.1	-	-	0830	18.2	-	45.0	-
8/ 3	1230	21.1	7.8	-	2.3	1225	17.8	6.5	-	2.0
8/ 7	0735	19.4	7.8	57.3	1.6	0630	19.4	7.6	77.8	1.9
8/15	0650	20.5	7.9	57.3	1.6	0645	18.8	6.9	67.8	1.7
8/24	0620	20.0	7.7	58.4	1.7	0615	15.0	5.4	56.6	1.5
9/ 5	0835	21.4	7.6	64.4	-	0830	21.1	7.6	62.0	-
9/11	1035	20.5	8.2	-	-	1045	18.5	8.1	-	-

*Pacific standard time

Table 5.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 5 (lat. 46°16'22" N., long. 123°45'58" W.), Columbia River estuary, 1966-67

Date	Surface Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	1415	10.0	10.9	-	-	-	-	-	-	-
4/ 9	1325	-	11.0	-	-	1330	-	11.1	-	-
4/17	1215	11.1	10.7	-	-	1220	11.1	10.7	-	-
4/23	1130	11.1	10.7	-	-	1120	11.1	10.9	-	-
4/30	1025	11.1	11.2	-	-	1020	11.1	9.5	-	-
5/ 7	-	12.0	10.1	-	-	-	12.0	10.1	-	-
5/14	-	13.0	12.3	-	-	-	13.0	12.2	-	-
5/21	1010	13.3	11.7	-	-	1000	13.3	11.9	-	-
5/29	1025	13.9	10.9	-	2.0	1015	13.9	10.7	-	2.5
6/ 4	0945	13.3	11.4	-	1.3	0935	13.3	11.3	-	1.2
6/11	0935	14.4	9.8	42.0	1.4	0925	14.4	9.9	42.0	1.1
6/19	-	16.7	10.7	46.0	-	-	16.1	10.7	45.2	1.8
6/30	1005	16.1	10.8	46.4	-	1000	16.1	10.6	50.4	-
7/ 9	0945	16.1	-	41.6	-	0940	16.1	-	47.2	-
7/16	0935	18.3	-	50.4	-	0930	17.8	-	50.0	-
7/24	0910	17.8	-	51.2	0.8	0900	17.8	-	52.4	0.9
7/30	1000	18.9	9.4	51.4	1.7	0955	19.4	9.4	49.2	1.6
10/ 8	1035	16.7	9.1	-	1.2	1015	16.1	8.1	-	1.9
10/15	1010	16.1	8.9	-	-	1000	16.1	8.5	-	-
11/19	0825	11.7	10.4	-	-	0815	11.7	10.0	-	-
1967										
2/11	-	7.2	11.5	-	1.8	-	6.7	11.3	-	1.5
2/17	-	6.7	11.7	-	-	-	6.7	11.7	-	-
2/24	-	7.2	-	-	-	-	7.2	-	-	-
3/ 3	-	7.8	11.8	-	3.2	-	7.5	11.7	-	3.1
3/11	-	7.2	11.9	-	-	-	6.7	11.9	-	-
3/25	-	8.3	-	-	-	-	8.3	-	-	-
4/ 1	-	8.3	11.7	-	-	-	8.3	11.4	-	-
4/ 8	-	9.2	11.5	-	-	-	9.4	11.4	-	-
4/13	-	9.4	11.6	-	-	-	9.4	11.5	-	-
5/14	-	14.4	10.5	-	-	-	13.3	10.1	-	-
7/26	0855	19.5	9.5	-	3.9	0845	19.5	9.4	-	3.7
8/ 3	0940	20.6	8.8	-	2.0	0935	20.0	8.7	-	1.9
8/ 7	0930	20.3	8.3	54.2	1.8	0925	20.0	8.2	67.6	1.7
8/16	1120	21.7	-	54.7	1.9	1115	19.4	-	58.9	1.9
8/24	0800	22.2	8.8	56.4	1.7	0755	21.4	8.3	56.0	1.7
9/ 5	1040	22.2	8.4	63.2	-	1035	21.7	8.0	61.8	-
9/11	0930	20.5	9.2	-	-	0940	20.0	8.9	-	-
9/18	1555	11.7	10.2	-	-	1550	12.2	9.6	-	-
10/ 7	0910	16.7	8.9	-	-	0905	16.7	8.7	-	-
10/28	1135	13.9	10.2	-	-	1130	13.9	10.0	-	-

*Pacific standard time

Table 6.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 6 (lat. 46°13'7" N., long. 123°45'19" W.), Columbia River estuary, 1966-67

Date	Surface Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	1145	10.0	11.3	-	-	-	-	-	-	-
4/ 9	1345	-	11.2	-	-	1355	-	11.1	-	-
4/17	1330	11.1	11.1	-	-	1340	11.1	11.0	-	-
4/23	1240	11.1	8.0	-	-	1225	11.7	10.8	-	-
4/30	1250	11.1	11.4	-	-	1240	11.1	11.3	-	-
5/ 7	-	12.0	10.5	-	-	-	12.0	10.3	-	-
5/14	-	13.0	11.2	-	-	-	13.0	9.9	-	-
5/21	1145	13.3	12.0	-	-	1145	13.3	11.9	-	-
5/29	1120	13.9	11.2	-	2.3	1110	13.9	10.8	-	2.5
6/ 4	1055	13.3	11.5	-	1.4	1045	13.3	11.4	-	1.3
6/11	1100	14.4	9.7	43.2	1.6	1050	14.4	9.6	43.6	1.7
6/19	-	16.7	11.1	45.8	1.3	-	16.1	10.7	45.6	1.1
6/30	1050	15.0	11.0	46.0	-	1045	16.1	10.7	45.6	-
7/ 9	1230	16.7	-	49.2	-	1225	16.7	-	46.0	-
7/16	1020	17.8	-	50.4	-	1015	17.8	-	51.0	-
7/24	0950	18.3	-	51.4	0.5	0940	17.8	-	51.8	1.9
7/30	1055	18.9	9.7	49.4	1.6	1050	19.4	9.68	48.2	1.3
10/ 8	1010	16.7	7.9	-	2.4	1055	15.6	9.4	-	1.4
10/15	1100	16.7	8.8	-	-	1050	13.3	8.5	-	-
11/19	0925	11.7	10.25	-	-	0915	11.7	9.4	-	-
1967										
2/11	-	6.7	11.5	-	1.8	-	6.7	11.6	-	2.1
2/17	-	7.2	11.9	-	-	-	6.7	12.0	-	-
2/24	-	7.2	-	-	-	-	7.2	-	-	-
3/ 3	-	7.8	12.1	-	2.8	-	7.5	11.9	-	3.0
3/11	-	6.7	12.0	-	-	-	6.7	11.8	-	-
3/25	-	8.3	-	-	-	-	8.3	-	-	-
4/ 1	-	8.3	11.7	-	-	-	8.3	11.7	-	-
4/18	-	9.4	11.6	-	-	-	9.4	11.6	-	-
4/13	-	9.7	11.7	-	-	-	8.9	11.6	-	-
5/14	-	13.1	10.1	-	-	-	12.8	10.0	-	-
7/ 5	-	18.2	-	-	-	0900	18.2	10.6	54.2	-
7/24	0920	19.2	10.1	-	-	0915	19.2	9.8	-	-
8/ 3	0805	20.5	9.1	-	1.9	0800	20.2	9.0	-	1.7
8/ 7	0615	19.7	8.4	56.3	2.2	0610	19.7	8.2	59.2	2.0
8/15	0635	21.2	7.4	55.2	2.3	0630	20.5	7.2	63.1	2.3
8/23	0810	22.2	7.9	56.2	3.3	0805	22.2	7.9	55.4	3.5
9/ 5	1230	22.2	-	60.3	-	1225	22.2	-	59.9	-
9/11	1130	21.0	8.4	-	-	1140	19.5	7.7	-	-
10/ 7	0707	16.7	8.2	-	-	0700	17.2	9.1	-	-
10/15	0735	15.5	8.9	61.5	-	0720	15.5	9.0	60.8	-
10/28	1250	13.3	10.0	-	-	1245	13.3	9.3	-	-
11/18	1310	11.7	10.6	-	-	1305	11.7	9.9	-	-

*Pacific standard time

Table 7.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 7 (lat. 46°15'27" N., long. 123°35'10" W.), Columbia River estuary, 1966-67

Date	Surface Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface B.O.D.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom B.O.D.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	1545	10.0	10.7	-	-	-	-	-	-	-
4/ 9	1510	9.2	11.2	-	-	1500	9.7	11.3	-	-
4/23	1600	11.7	11.3	-	-	1545	11.7	11.2	-	-
4/30	1115	11.1	10.9	-	-	1120	11.1	10.9	-	-
5/ 7	-	12.0	10.6	-	-	-	12.0	10.5	-	-
5/14	-	13.0	11.5	-	-	-	13.0	11.1	-	-
5/21	1045	13.3	12.1	-	-	1035	13.3	12.0	-	-
6/ 4	1025	13.3	-	-	-	1015	13.3	-	-	-
1967										
1/ 6	1400	7.2	11.7	-	2.4	1410	6.7	11.7	-	1.0
1/20	1105	7.2	12.0	-	2.3	1055	7.2	12.0	-	2.5
7/ 5	0940	18.2	10.8	45.0	-	0950	18.2	-	46.7	-
7/24	0955	19.2	10.0	-	-	0950	19.8	9.9	-	-
8/ 3	1030	20.6	8.8	-	2.1	1025	20.6	8.8	-	2.0
8/ 7	1125	20.8	8.7	58.6	1.6	1120	20.8	8.8	59.3	1.7
8/14	1025	22.2	7.5	52.8	1.9	1020	21.8	7.8	59.7	1.8
8/23	0905	22.2	8.2	54.6	2.1	0900	22.2	8.6	55.2	3.6

*Pacific standard time

Table 8.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 8 (lat. 46°12'50" N., long. 123°37'22" W.), Columbia River estuary, 1966-67

Date	Surface Time *	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	1620	9.4	10.6	-	-	-	-	-	-	-
4/ 9	1610	10.0	11.1	-	-	1550	10.0	11.3	-	-
4/17	1900	11.1	10.9	-	-	1910	11.1	10.9	-	-
4/23	1510	11.1	11.0	-	-	1500	11.1	11.3	-	-
4/30	1150	11.1	11.7	-	-	1155	11.1	11.5	-	-
5/ 7	-	12.0	10.6	-	-	-	12.0	10.4	-	-
5/14	-	13.0	10.9	-	-	-	13.0	10.9	-	-
5/21	0935	12.8	11.8	-	-	0920	13.3	11.8	-	-
6/ 4	1100	13.9	11.7	-	-	1050	13.9	11.7	-	-
1967										
1/ 6	1330	7.2	11.5	-	2.2	1345	6.7	11.6	-	2.3
1/20	1030	7.6	11.8	-	2.1	1040	7.7	11.9	-	2.3
7/ 5	1010	18.2	10.7	45.8	-	1015	18.2	-	44.1	-
7/24	1120	19.9	10.0	-	-	1115	19.8	10.1	-	-
8/ 3	1115	20.6	9.0	-	1.9	1110	20.0	9.0	-	2.0
8/17	1200	21.1	8.7	55.4	1.5	1150	21.1	8.8	56.7	1.6
8/14	1105	22.2	8.0	49.3	2.3	1100	22.0	8.1	56.1	1.7
8/23	0925	22.2	8.1	55.1	2.6	0920	21.9	8.1	55.9	3.7

*Pacific standard time

Table 9.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 9 (lat. 46°13'10" N., long 123°25'18" W.), Columbia River estuary, 1966-67

Date	Surface Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 3	1100	8.9	11.0	-	-	-	-	-	-	-
4/10	1415	10.0	11.3	-	-	1400	10.6	11.2	-	-
4/18	1440	10.6	10.8	-	-	1450	11.1	10.7	-	-
4/24	1220	11.7	10.5	-	-	1215	11.7	10.5	-	-
4/30	0940	11.1	11.3	-	-	0950	11.1	10.9	-	-
5/ 8	-	-	11.2	-	-	-	-	11.0	-	-
5/15	-	-	11.8	-	-	-	-	11.9	-	-
5/22	1200	12.8	12.3	-	-	1140	13.3	12.2	-	-
5/30	0850	14.4	11.4	-	2.6	0900	13.9	11.1	-	2.2
6/ 5	1210	13.3	12.2	-	-	1205	13.3	11.6	-	0.4
6/12	0830	14.4	9.5	44.4	-	0825	14.4	9.6	44.4	-
6/20	-	17.2	11.4	46.2	1.7	-	16.7	11.9	46.8	1.5
6/30	1320	15.0	11.1	43.4	-	1310	15.6	11.1	48.0	-
7/10	1350	16.7	-	45.2	-	1345	16.7	-	45.6	-
7/17	1110	18.3	-	51.6	-	1100	18.3	-	51.6	-
7/24	1045	20.0	-	51.6	2.4	1040	20.0	-	51.6	2.3
7/31	0905	18.9	9.5	72.4	2.2	0900	18.9	9.6	52.4	2.5
8/ 6	1040	21.7	9.0	57.0	2.1	1030	21.1	9.0	52.0	1.8
8/12	1055	20.0	8.5	54.0	-	1050	20.0	8.4	55.6	-
8/12	1335	20.6	8.7	56.8	-	1330	20.0	8.4	54.4	-
8/23	1220	20.0	7.8	55.2	1.4	1215	20.6	7.8	55.2	1.6
8/29	1250	19.4	7.0	55.0	3.4	1240	18.9	6.9	54.4	2.7
9/ 9	1032	19.4	8.7	-	-	1028	19.4	8.4	-	-
10/ 9	1110	-	8.6	-	1.2	1050	-	8.3	-	1.3
10/15	0925	15.6	8.6	-	-	0915	16.7	8.5	-	-
10/23	0855	16.7	-	-	-	0840	18.3	-	-	-
11/20	1110	-	10.5	-	-	1100	-	10.7	-	-
12/ 4	1150	9.4	10.7	24.2	-	1140	9.4	10.7	25.0	-
12/10	1140	8.1	11.7	22.0	2.1	1125	7.8	11.6	22.1	2.5
12/17	1110	7.8	12.1	-	-	1100	8.3	12.2	-	-
12/24	1155	7.8	11.2	-	2.1	1145	7.8	11.3	-	2.5
12/30	0945	7.2	11.6	-	0.9	0930	6.7	-	-	-
1967										
1/ 6	1425	6.7	12.1	-	2.7	1420	6.7	11.9	-	2.7
1/13	1055	6.9	11.9	-	-	1050	6.7	11.7	-	-
1/20	1140	6.9	12.1	-	2.7	1130	6.9	11.8	-	2.4
1/27	0830	6.7	11.8	-	-	0820	6.7	11.9	-	-
2/ 3	-	7.2	12.4	-	3.0	-	7.2	12.3	-	2.9
2/11	-	6.9	11.5	-	-	-	6.7	11.6	-	-
2/17	-	6.7	11.5	-	-	-	6.9	11.6	-	-
2/24	-	6.7	12.0	-	-	-	6.7	12.0	-	-
3/ 3	-	7.2	11.6	-	2.7	-	7.2	11.8	-	2.2
3/11	-	7.2	11.9	-	-	-	7.2	11.9	-	-
3/25	-	8.3	-	-	-	-	8.3	-	-	-
4/ 1	-	8.3	11.4	-	-	-	8.3	11.50	-	-
4/ 8	-	8.9	11.3	-	-	-	9.4	11.4	-	-
4/13	-	10.0	11.5	-	-	-	10.0	11.5	-	-

*Pacific Standard time

Table 9.--Temperature, dissolved oxygen, total alkalintiy, and biochemical oxygen demand at station 9 (lat. 46°13'10" N., long. 123°25'18" W.), Columbia River estuary, 1966-67--Continued

Date	Surface Time*	Surface Temp. °C.	Surface D.O. P.p.m.	Surface T.A. P.p.m.	Surface BOD. P.p.m.	Bottom Time	Bottom Temp. °C.	Bottom D.O. P.p.m.	Bottom T.A. P.p.m.	Bottom BOD. P.p.m.
1967										
4/25	1355	11.1	12.2	-	-	-	-	-	-	-
6/14	-	12.8	10.9	-	-	-	12.8	10.9	-	-
7/ 5	1105	18.2	11.2	44.1	-	1115	18.2	-	42.5	-
7/13	1145	19.0	11.1	-	-	1135	19.0	-	-	-
7/21	1040	19.5	11.2	-	5.0	1325	21.1	9.7	-	1.8
7/28	1330	21.1	9.7	-	1.5	1325	21.1	9.7	-	1.8
8/ 7	1015	20.0	8.9	54.8	-	1000	20.0	8.7	55.0	-
8/14	0950	21.8	7.6	56.0	1.9	0945	21.8	7.4	55.4	0.6
8/22	0825	22.2	7.6	53.2	1.8	0820	21.9	7.5	54.8	3.4
8/28	1105	23.1	6.8	53.2	-	1100	22.8	7.3	53.9	-
9/ 5	0935	21.9	6.5	59.3	5.0	0930	21.7	6.4	58.9	5.0
9/11	1240	21.0	6.4	58.8	5.5	1235	21.0	6.5	59.2	5.5
9/21	0955	20.6	8.5	61.3	4.5	0950	20.6	8.3	61.2	4.5
9/30	1020	19.4	8.5	-	-	1010	19.4	8.3	-	-
10/22	0853	15.0	9.8	-	-	0803	15.0	9.6	-	-
11/ 4	0855	12.2	10.0	-	-	0850	12.2	9.9	-	-
11/18	1030	11.7	10.2	-	-	1025	11.1	10.4	-	-
12/15	1140	8.3	11.7	-	-	1132	7.5	11.8	-	-

*Pacific standard time

Table 10.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 10 (lat 46°12'05" N., long. 123°26'04" W.), Columbia River estuary, 1966-67

Date	Surface Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	1030	8.9	10.4	-	-	-	-	-	-	-
4/ 9	1330	10.6	11.0	-	-	1315	10.6	11.0	-	-
4/17	1400	10.6	10.6	-	-	1410	10.0	10.7	-	-
4/23	1245	11.1	10.4	-	-	1235	11.7	10.5	-	-
4/30	0925	11.7	11.3	-	-	0930	11.1	11.2	-	-
5/ 7	-	12.0	10.6	-	-	-	12.0	10.7	-	-
5/14	-	13.0	11.4	-	-	-	13.0	11.3	-	-
5/21	1230	13.3	12.0	-	-	1220	13.3	12.0	-	-
5/29	0920	14.4	11.1	-	2.1	0915	14.4	11.0	-	2.6
6/ 4	1145	13.3	11.6	-	-	1140	13.3	11.8	-	1.4
6/11	0850	14.4	9.4	45.2	-	0840	14.4	9.4	45.2	-
6/19	-	16.7	11.1	46.0	1.5	-	16.7	11.2	48.0	0.9
6/30	1255	15.0	10.9	46.6	-	1245	15.0	10.9	46.8	-
7/ 9	1335	16.7	-	46.8	-	1330	16.7	-	46.8	-
7/16	1130	17.8	-	51.0	-	1120	17.8	-	51.6	-
7/24	1110	20.0	-	51.4	2.5	1100	20.0	-	52.2	2.2
7/30	0925	17.8	9.6	53.0	2.5	0920	17.8	9.5	53.2	2.7
8/ 6	1020	21.7	9.0	50.8	2.0	1015	21.1	8.9	50.4	1.9
** 8/12	1110	20.0	8.8	59.2	-	1106	20.0	8.5	54.8	-
*** 8/12	1345	20.0	8.5	53.6	-	1340	20.0	8.5	54.6	-
8/23	1245	20.6	7.9	56.4	1.7	1235	20.6	8.1	52.0	2.2
8/29	1312	19.4	7.6	54.8	1.8	1305	19.4	7.6	48.8	1.8
9/ 9	1045	19.4	8.9	-	-	1125	20.0	8.8	-	-
10/ 8	1205	17.8	8.9	-	1.3	1150	17.8	8.6	-	1.4
10/15	0935	15.6	8.9	-	-	0935	16.7	8.9	-	-
10/22	0915	16.7	-	-	-	0905	17.2	-	-	-
11/19	1140	11.7	10.4	-	-	1130	11.7	10.3	-	-
12/ 3	1210	9.4	10.6	25.6	-	1200	8.9	10.7	25.6	-
12/10	1205	7.8	11.5	20.8	2.2	1155	7.8	11.6	20.6	2.3
12/16	1135	8.3	11.9	-	-	1125	7.8	11.8	-	-
12/23	1130	7.2	11.3	-	2.4	1125	7.8	11.2	-	1.9
12/30	1010	6.9	11.6	-	1.8	1000	7.2	11.9	-	2.7
1967										
1/ 6	1435	6.7	11.9	-	2.4	1430	6.7	11.8	-	2.4
1/13	1105	6.7	11.9	-	-	1100	6.7	11.7	-	-
1/20	1345	7.2	11.8	-	2.4	1340	7.2	12.0	-	2.3
1/27	0850	6.7	11.9	-	-	0840	7.2	11.8	-	-
2/ 3	-	7.2	12.4	-	3.4	-	7.2	12.5	-	3.3
2/11	-	6.7	11.6	-	-	-	6.7	11.5	-	-
2/17	-	7.2	11.4	-	-	-	6.7	11.3	-	-
2/24	-	6.7	12.1	-	-	-	6.7	12.0	-	-
3/ 3	-	7.2	12.0	-	3.0	-	7.2	11.7	-	2.5
3/11	-	7.2	12.0	-	-	-	7.2	11.9	-	-
3/25	-	8.3	-	-	-	-	8.3	-	-	-

**Ebb
***Flood

*Pacific standard time

Table 10.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 10 (lat. 46°12'05" N., long. 123°26'04" W.), Columbia River estuary, 1966-67--Continued

Date	Surface Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface B.O.D.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom B.O.D.
		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
1967										
4/ 1	-	8.3	11.4	-	-	-	8.3	11.3	-	-
4/ 8	-	9.4	11.5	-	-	-	9.4	11.3	-	-
4/13	-	8.9	11.4	-	-	-	8.9	11.4	-	-
4/25	1345	11.4	12.4	-	-	-	-	-	-	-
5/14	-	12.8	10.6	-	-	-	12.8	10.4	-	-
7/ 5	1130	18.2	10.6	39.2	-	1135	18.2	-	46.7	-
7/13	1100	18.8	10.8	-	-	1050	18.8	-	-	-
7/21	1000	19.5	10.4	-	19.0	0955	19.5	10.6	-	4.2
7/28	0920	20.0	10.0	-	2.2	0915	19.4	9.6	-	2.6
8/ 7	0935	20.0	7.8	49.3	-	0930	20.0	8.7	52.8	-
8/14	1225	22.5	7.7	54.8	1.4	1220	22.5	7.8	55.2	2.9
8/22	1105	23.3	7.9	52.6	4.4	1100	23.3	8.2	53.2	3.0
8/28	1125	23.1	7.2	52.9	-	1120	23.3	7.2	53.7	-
9/ 5	1310	22.8	7.1	59.0	10.0	1300	22.5	6.9	58.8	10.0
9/11	1210	21.0	6.4	59.4	6.0	1205	20.5	6.3	60.6	6.0
9/21	0930	20.6	8.6	60.8	5.0	0920	20.6	8.5	61.2	4.5
9/30	1004	19.4	8.9	-	-	0957	19.4	8.9	-	-
10/22	0737	15.0	10.0	-	2.0	0745	150.0	10.0	-	2.0
11/ 4	0835	12.2	10.6	-	-	0840	11.7	10.7	-	-
11/18	1015	11.1	10.9	-	3.0	1010	11.1	10.3	-	3.0
12/15	1120	6.7	11.7	-	-	1110	6.7	12.1	-	-

*Pacific standard time

Table 11.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 11 (lat. 46°9'25" N., long. 123°15'11" W.), Columbia River estuary, 1966-67

Date	Time *	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	1345	9.4	11.2	-	-	-	-	-	-	-
4/ 9	1145	10.0	11.0	-	-	1130	10.0	11.1	-	-
4/17	1140	10.0	11.1	-	-	1150	10.0	11.2	-	-
4/23	1430	11.1	11.2	-	-	1420	11.1	11.3	-	-
4/30	0855	11.1	11.2	-	-	0900	11.1	11.2	-	-
5/ 7	-	12.0	11.04	-	-	-	12.0	11.1	-	-
5/14	-	13.0	11.2	-	-	-	13.0	11.2	-	-
5/21	1500	13.3	12.1	-	-	1440	13.9	12.2	-	-
5/29	1235	13.9	11.4	-	2.0	1225	13.9	11.1	-	2.2
6/ 4	1340	13.3	12.2	-	-	1325	13.3	12.2	-	-
6/11	0930	14.4	9.7	45.6	-	0925	14.4	9.5	44.8	-
6/19	-	17.2	11.4	45.8	1.9	-	16.7	11.3	46.2	1.9
6/30	1425	15.5	11.2	46.4	-	1415	15.0	11.2	46.8	-
7/ 9	1025	16.7	-	47.4	-	1015	16.7	-	49.6	-
7/16	1210	17.8	-	50.0	-	1200	17.8	-	50.6	-
7/24	1150	20.0	-	51.4	2.0	1140	20.0	-	51.4	2.1
7/30	1015	20.6	9.7	53.0	2.0	1010	20.0	9.7	53.0	2.5
8/ 6	0935	20.6	9.0	50.4	1.9	0930	20.0	8.8	50.8	2.4
** 8/12	1155	20.0	8.3	53.6	-	1150	20.0	8.2	53.0	-
**† 8/12	-	-	-	-	-	-	-	-	-	-
8/23	1035	20.0	7.9	53.8	1.8	1030	20.0	7.7	52.8	1.7
8/29	1040	18.9	6.8	51.6	1.8	1050	18.9	6.9	48.8	1.9
9/ 9	0940	19.4	8.3	-	-	0935	19.4	8.3	-	-
10/ 8	1255	17.2	8.2	-	1.5	1240	17.2	8.2	-	1.6
10/15	1245	14.4	8.4	-	-	1235	14.4	8.4	-	-
10/22	1045	16.7	-	-	-	1035	17.2	-	-	-
11/19	1600	11.7	10.2	-	-	1545	11.7	10.3	-	-
12/ 3	1335	9.4	10.8	24.5	-	1325	9.4	10.8	24.8	-
12/10	1340	7.8	11.3	23.4	2.8	1320	7.8	11.5	25.8	3.4
12/16	1325	8.6	12.3	-	-	1315	8.1	12.3	-	-
12/23	1010	6.7	11.5	-	2.6	1000	7.2	11.5	-	2.7
12/30	1205	7.0	11.7	-	2.2	1155	7.0	11.7	-	2.6
1967										
1/ 6	1025	6.7	12.0	-	3.8	1020	6.7	11.7	-	3.4
1/13	1305	6.7	11.8	-	-	1300	6.7	11.8	-	-
1/20	1300	6.9	11.9	-	2.2	1250	6.9	11.9	-	2.5
1/27	1010	6.7	11.8	-	-	1005	7.2	11.8	-	-
2/ 3	-	7.2	12.2	-	2.8	-	7.2	12.3	-	2.9
2/11	-	6.7	11.6	-	-	-	6.7	11.6	-	-
2/17	-	6.7	11.7	-	-	-	6.7	11.4	-	-
2/24	-	6.7	12.1	-	-	-	6.7	12.2	-	-
3/ 3	-	7.5	12.1	-	2.9	-	7.2	12.1	-	3.7
3/11	-	7.2	11.4	-	-	-	7.2	11.4	-	-

** Ebb
**† Flood

Table 11.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 11 (lat. 46°9'25" N., long. 123°15'11" W.), Columbia River estuary, 1966-67--Continued

Date	Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1967		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
3/25	-	8.9	-	-	-	-	8.6	-	-	-
4/ 1	-	8.9	11.7	-	-	-	8.6	11.8	-	-
4/ 8	-	9.4	11.0	-	-	-	9.4	11.0	-	-
4/13	-	9.4	11.3	-	-	-	9.4	11.4	-	-
4/25	1215	10.8	11.9	-	-	-	-	-	-	-
5/14	-	12.8	11.2	-	-	-	12.8	11.1	-	-
7/ 5	0730	18.2	10.8	45.8	-	0740	18.2	-	44.1	-
7/13	0825	18.5	10.9	-	-	0815	18.2	-	-	-
7/21	0745	19.0	10.7	-	4.0	0735	19.0	10.5	-	5.3
7/28	1220	21.2	9.8	-	2.3	1215	21.1	9.8	-	2.9
8/ 7	1100	20.3	9.0	50.2	2.0	1050	20.3	9.3	51.3	-
8/14	1025	22.2	8.1	51.2	2.7	1020	21.8	8.0	53.3	1.6
8/22	0910	22.8	8.0	54.2	1.4	0905	22.5	7.9	55.3	4.3
8/28	0940	22.5	6.8	52.5	-	0930	22.5	6.6	49.7	-
9/ 5	1020	22.5	8.0	59.2	6.0	1015	22.2	8.1	58.8	6.0
9/11	1025	20.5	7.1	58.6	5.5	1020	20.5	7.9	60.1	5.5
9/19	0810	21.1	8.2	61.5	4.0	0800	20.6	8.1	60.8	4.0
9/30	1120	19.4	8.6	-	-	1115	19.4	8.3	-	-
10/22	0910	15.0	8.5	-	4.0	0900	1500	9.0	-	4.0
11/ 4	1035	11.7	10.9	-	-	1030	12.2	10.3	-	-
11/18	0910	11.1	10.8	-	3.5	0900	11.1	10.2	-	3.5

*Pacific standard time

Table 12.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 12 (lat. 46°09'04" N., long. 123°15'22" W.), Columbia River estuary, 1966-67

Date	Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface BOD.	Bottom Time	Bottom Temp.	Bottom D.O.	Bottom T.A.	Bottom BOD.
1966		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
4/ 2	1400	10.0	10.9	-	-	-	-	-	-	-
4/ 9	1115	10.6	10.9	-	-	1100	10.6	11.0	-	-
4/17	1110	10.6	10.8	-	-	1120	10.0	10.8	-	-
4/23	1445	11.7	11.0	-	-	1435	11.7	11.0	-	-
4/30	0830	11.7	11.2	-	-	0840	11.1	11.1	-	-
5/ 7	-	12.0	10.7	-	-	-	12.0	10.7	-	-
5/14	-	13.0	11.6	-	-	-	13.0	11.6	-	-
5/21	1520	13.9	11.9	-	-	1510	14.4	11.9	-	-
5/29	1250	14.4	11.0	-	2.2	1245	14.4	10.8	-	2.7
6/ 4	1405	13.3	11.6	-	2.4	1355	13.3	11.6	-	2.4
6/11	0945	14.4	9.4	48.0	-	0940	14.4	9.6	44.8	-
6/19	-	17.8	11.9	46.4	0.5	-	17.8	11.9	45.4	0.2
6/30	1440	16.1	11.2	54.2	-	1430	15.6	11.2	47.2	-
7/ 9	1040	17.2	-	46.0	-	1030	16.7	-	48.4	-
7/16	1225	18.3	-	51.8	-	1220	18.3	-	52.4	-
7/24	1210	18.9	-	45.0	2.0	1200	18.9	-	51.6	2.3
7/30	1035	20.6	9.8	54.0	1.6	1030	20.6	9.6	53.2	1.5
8/ 6		21.1	9.1	52.8	2.1		21.7	8.9	52.4	1.6
** 8/12	0905	20.0	9.0	54.0	-	0900	20.0	8.6	54.0	-
8/23	1205	20.0	8.5	54.4	1.5	1200	20.0	8.4	55.2	1.4
8/29	1055	18.9	6.9	52.0	1.6	1042	19.4	7.0	52.6	1.9
9/ 9	1100	20.0	8.8	-	-	1105	18.9	8.8	-	-
10/ 8	0950	16.7	9.1	-	1.4	0945	17.8	9.1	-	1.4
10/15	1315	15.0	8.0	-	-	1305	15.0	8.1	-	-
10/22	1305	18.3	-	-	-	1315	17.2	-	-	-
11/19	1105	11.7	10.4	-	-	1055	11.7	10.3	-	-
12/ 3	1355	8.9	10.7	26.2	-	1345	9.4	10.6	26.2	-
12/10	1400	7.2	11.4	17.8	2.2	1350	7.5	11.5	17.9	2.4
12/16	1410	9.3	11.8	-	-	1345	8.9	11.7	-	-
12/23	1030	7.2	11.1	-	-	1020	7.2	11.3	-	2.6
12/30	1230	7.0	11.4	-	2.1	1220	7.0	11.5	-	2.3
**Ebb										
1967										
1/ 6	1010	6.7	11.8	-	2.9	1005	6.9	11.3	-	2.9
1/13	1315	6.7	11.7	-	-	1310	6.7	11.7	-	-
1/20	1315	6.9	11.8	-	2.5	1310	6.9	11.8	-	2.4
1/27	1025	6.7	11.6	-	-	1020	6.7	11.2	-	-
2/ 3	-	7.2	12.3	-	3.1	-	7.2	12.3	-	3.1
2/11	-	6.7	11.4	-	-	-	6.7	11.6	-	-
2/17	-	6.9	11.2	-	-	-	7.2	11.2	-	-
2/24	-	6.7	12.0	-	-	-	6.7	11.8	-	-
3/ 3	-	7.8	11.9	-	2.5	-	7.5	11.9	-	3.2
3/11	-	7.2	11.6	-	-	-	7.5	11.5	-	-
3/25	-	9.2	-	-	-	-	8.9	-	-	-

*Pacific standard time

Table 12.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station 12 (lat. 46°09'04" N., long. 123°15'22" W.), Columbia River estuary, 1966-67--Continued

Date	Surface Time*	Surface Temp. °C.	Surface D.O. P.p.m.	Surface T.A. P.p.m.	Surface BOD P.p.m.	Bottom Time	Bottom Temp. °C.	Bottom D.O. P.p.m.	Bottom T.A. P.p.m.	Bottom BOD P.p.m.
1967										
4/ 1	-	9.2	11.41	-	-	-	8.9	11.50	-	-
4/ 8	-	9.4	11.3	-	-	-	9.4	11.4	-	-
4/13	-	9.7	11.3	-	-	-	9.7	11.2	-	-
4/25	1240	11.1	12.2	-	-	-	-	-	-	-
5/14	-	13.1	10.7	-	-	-	13.3	10.6	-	-
7/ 5	0750	18.2	10.6	44.1	-	0800	18.2	-	45.8	-
7/13	0840	18.8	10.5	-	-	0835	18.5	-	-	-
7/21	0755	19.2	10.4	-	1.7	0750	19.2	10.3	-	2.5
7/28	1230	21.7	9.8	-	1.4	1225	21.2	9.9	-	1.6
8/ 7	1115	20.3	9.0	49.7	1.4	1110	20.3	9.2	53.6	2.0
8/14	1035	22.2	8.0	52.4	1.7	1030	22.2	8.6	54.5	1.9
8/22	0925	22.8	8.1	51.6	1.4	0920	22.2	8.2	52.0	2.1
8/28	0955	22.8	7.2	50.6	-	0950	22.2	7.0	52.5	-
9/ 5	1035	22.8	7.8	59.0	6.5	1030	22.5	7.8	59.0	6.5
9/11	1000	21.0	7.1	59.2	4.5	0955	20.5	7.1	59.0	4.5
9/19	0820	21.1	8.6	61.6	4.0	0825	20.6	8.4	61.8	4.0
9/30	1100	19.4	8.5	-	-	1058	19.4	8.4	-	-
10/22	0920	15.0	8.9	-	2.5	0915	15.0	9.1	-	2.5
11/ 4	1050	12.2	10.2	-	-	1045	12.2	10.5	-	-
11/18	0850	11.1	10.4	-	3.0	0840	11.7	10.4	-	3.0

*Pacific standard time

Table 13.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station W1 (lat. 46°10'50" N., long. 123°25'26" W.), Columbia River estuary, 1966-67

Date	Time*	Temp.	Middle D.O.	T.A.	B.O.D.
1966		°C °C.	P.p.m.	P.p.m.	P.p.m.
** 8/12	1040	20.0	8.6	54.0	-
*** 8/12	1315	20.0	8.4	53.8	-
8/23	1340	20.6	7.9	53.8	1.4
8/29	1355	19.4	6.9	46.8	1.6
9/ 9	1117	19.4	9.0	-	-
10/ 8	1400	17.8	9.0	-	1.1
10/15	1010	15.0	8.8	-	-
10/22	1000	17.2	-	-	-
11/19	1510	11.7	10.3	-	-
12/ 3	1255	9.4	10.7	26.0	-
12/10	1240	7.8	11.6	20.8	2.3
12/16	1210	8.6	11.8	-	-
12/23	1115	7.2	11.2	-	2.7
12/30	1030	7.0	11.4	-	2.1
**Ebb					
***Flood					
1967					
1/ 6	1125	6.7	11.8	-	2.2
1/13	1130	6.9	11.5	-	-
1/20	1420	7.2	12.1	-	2.3
1/27	0925	6.7	11.8	-	-
2/ 3	-	7.2	12.1	-	2.7
2/11	-	6.7	11.6	-	-
2/17	-	6.7	11.4	-	-
2/24	-	6.7	12.0	-	-
3/ 3	-	7.8	11.8	-	3.0
3/11	-	6.9	11.9	-	-
3/25	-	8.6	-	-	-
4/ 1	-	8.6	11.2	-	-
4/ 8	-	9.4	11.3	-	-
4/13	-	9.7	11.5	-	-
4/25	1320	11.1	11.8	-	-
5/ 9	-	12.2	10.9	-	-
7/ 5	1200	18.2	11.4	40.2	-
7/13	1025	19.0	10.9	-	-
7/21	0925	19.3	10.6	-	4.0
7/28	0930	20.0	9.6	-	3.0
8/ 7	0900	20.3	8.7	51.7	-
8/14	1155	22.2	7.5	53.7	1.6
8/22	1020	22.2	7.9	56.2	3.5
8/28	1215	23.1	6.6	55.1	-
9/ 5	1215	22.5	6.6	58.6	6.0
9/11	1110	21.0	6.4	58.9	5.5
9/21	0910	20.6	8.5	61.8	4.0
9/30	0935	19.4	8.1	-	-
10/22	0810	15.0	9.4	-	1.5
11/ 4	0930	12.2	10.5	-	-
11/18	0940	11.1	10.4	-	4.5

*Pacific standard time

Table 14.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand, at station W2 (lat. 46°10'48" N., long. 123°25'37" W.), Columbia River estuary, 1966-67

Date	Surface Time*	Surface Temp. °C.	Surface D.O. P.p.m.	Surface T.A. P.p.m.	Surface BOD P.p.m.	Bottom Time	Bottom Temp. °C.	Bottom D.O. P.p.m.	Bottom T.A. P.p.m.	Bottom BOD P.p.m.
1966										
**8/12	1035	20.0	8.7	55.2	-	1030	20.0	8.4	53.6	-
***8/12	1310	20.6	9.0	54.8	-	1035	20.0	8.4	54.4	-
8/23	1330	20.6	8.2	54.0	1.8	1325	20.6	8.1	54.2	1.1
8/29	1350	19.4	7.3	52.0	1.7	1345	18.9	6.9	54.8	1.5
9/ 9	1113	19.4	8.9	-	-	1110	19.4	8.8	-	-
10/ 8	1420	17.8	8.5	-	1.0	1410	17.2	8.7	-	1.2
10/15	1000	15.0	8.4	-	-	0950	15.6	8.6	-	-
10/22	0945	17.8	-	-	-	0935	17.8	-	-	-
11/19	1500	11.7	10.5	-	-	1490	11.7	10.5	-	-
12/ 3	1245	9.4	10.9	25.0	-	1235	10.6	10.8	25.6	-
12/10	1300	7.8	11.5	19.8	2.1	1250	7.8	11.7	19.8	2.5
12/16	1205	8.1	12.1	-	-	1155	8.3	12.1	-	-
12/23	1105	7.8	11.2	-	1.4	1055	7.8	11.4	-	2.5
12/30	1050	7.0	11.5	-	3.2	1040	7.0	11.7	-	2.8
**Ebb										
***Flood										
1967										
1/ 6	1115	6.7	12.3	-	2.6	1110	6.7	12.0	-	2.5
1/13	1125	6.9	11.8	-	-	1120	6.7	11.8	-	-
1/20	1410	7.2	11.9	-	2.5	1400	7.2	11.9	-	2.0
1/27	0915	6.7	11.7	-	-	0910	6.7	11.4	-	-
2/ 3	-	7.2	12.3	-	2.8	-	7.2	12.4	-	2.8
2/11	-	6.7	11.6	-	-	-	6.7	11.4	-	-
2/17	-	7.2	11.0	-	-	-	9.4	11.5	-	-
2/24	-	6.7	12.0	-	-	-	6.7	12.1	-	-
3/ 3	-	7.2	11.8	-	2.9	-	7.2	12.0	-	3.3
3/11	-	7.2	11.8	-	-	-	7.2	11.8	-	-
3/25	-	8.9	-	-	-	-	8.6	-	-	-
4/ 1	-	8.9	11.4	-	-	-	8.6	11.5	-	-
4/ 8	-	9.4	11.2	-	-	-	9.4	11.3	-	-
4/13	-	9.7	11.2	-	-	-	9.4	11.3	-	-
4/25	1310	11.1	12.1	-	-	-	-	-	-	-
5/ 9	-	12.2	11.1	-	-	-	11.9	11.1	-	-
7/ 5	1220	18.2	11.3	46.7	-	1225	18.2	-	40.2	-
7/13	1035	19.0	11.4	-	-	1030	19.0	-	-	-
7/21	0935	19.8	10.5	-	3.8	0930	19.5	10.5	-	3.0
7/28	0945	20.0	9.6	-	3.0	0940	20.0	10.0	-	2.2
8/ 7	0910	20.0	8.9	53.6	-	0905	20.0	9.1	55.2	-
8/14	1205	22.2	7.9	55.6	2.1	1200	22.2	8.5	56.1	1.8
8/22	1030	22.8	7.9	56.8	4.2	1025	22.8	7.9	55.6	3.7
8/28	1200	23.5	6.6	54.7	-	1150	23.3	6.4	53.2	-
9/ 5	1230	22.2	7.1	59.0	3.0	1225	22.2	7.0	59.0	3.0
9/11	1115	21.0	6.5	59.4	4.0	1120	21.0	6.6	59.4	5.0
9/19	0855	20.6	8.6	61.6	3.0	0900	20.6	8.6	60.8	3.5
9/30	0942	19.4	8.32	-	-	0937	19.4	8.5	-	-
10/22	0820	15.6	10.2	-	1.5	0815	15.6	9.5	-	1.5
11/04	0940	12.2	10.0	-	-	0935	12.2	10.0	-	-
11/18	0950	11.1	10.3	-	5.0	0945	11.1	10.4	-	5.0
12/15	1207	6.1	12.0	-	-	1203	6.7	12.1	-	-

*Pacific standard time

Table 15.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station W3 (Lat. 46°10'45" N., long. 123°25'51" W.), Columbia River estuary, 1966-67

Date	Time *	Temp. °C.	Surface D.O. P.p.m.	T.A. P.p.m.	B.O.D. P.p.m.
1966					
** 8/12	1022	20.0	8.5	54.8	-
*** 8/12	1300	21.1	8.8	56.4	-
8/23	1310	20.6	8.0	54.0	1.4
8/29	1335	19.4	6.9	52.4	1.8
9/ 9	1105	19.4	9.2	-	-
10/ 8	1430	17.2	9.0	-	1.3
10/15	0945	15.6	8.8	-	-
10/22	0925	16.7	-	-	-
11/19	1200	11.7	10.4	-	-
12/ 3	1225	9.4	10.7	25.2	-
12/10	1310	7.8	11.6	22.2	2.5
12/16	1145	8.7	12.0	-	-
12/23	1050	7.2	11.4	-	2.3
12/30	1100	7.0	11.5	-	2.2
1967					
1/ 6	1100	6.7	12.1	-	2.3
1/13	1110	6.9	11.8	-	-
1/20	1355	7.2	11.9	-	2.4
1/27	0905	6.9	11.8	-	-
2/ 3	-	7.2	12.1	-	2.6
2/11	-	6.7	11.5	-	-
2/17	-	6.7	11.4	-	-
2/24	-	6.7	12.1	-	-
3/ 3	-	7.2	11.8	-	2.8
3/11	-	6.9	12.0	-	-
3/25	-	8.6	-	-	-
4/ 1	-	8.6	11.4	-	-
4/ 8	-	9.2	11.3	-	-
4/13	-	9.4	11.4	-	-
4/25	1300	11.1	12.2	-	-
5/ 9	-	12.2	11.0	-	-
7/ 5	1230	18.2	9.7	44.1	-
7/13	1045	19.0	10.5	-	-
7/21	0940	19.5	10.4	-	3.5
7/28	0950	20.0	9.4	-	5.2
8/ 7	0915	20.0	8.5	50.5	-
8/14	1210	22.2	8.3	54.3	2.4
8/22	1035	22.8	7.9	56.1	4.8
8/28	1145	23.3	7.6	52.6	-
9/ 5	1240	22.2	7.3	59.2	4.0
9/11	1130	21.0	6.7	59.0	6.0
9/21	0845	21.1	8.6	61.5	4.0
9/30	0946	19.4	8.5	-	-
10/22	0825	15.0	9.9	-	4.0

** Ebb
*** Flood

*Pacific standard time

Table 16.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station W4 (lat. 46°09'56" N., long. 123°24'54" W.), Columbia River estuary, 1967

Date	Time*	Surface Temp.	Surface D.O.	Surface T.A.	Surface B.O.D.
		°C.	P.p.m.	P.p.m.	P.p.m.
7/ 5	1250	18.2	9.7	54.2	-
7/13	1010	19.0	3.5	-	-
7/21	0915	19.2	9.9	-	11.4
7/28	1010	20.6	7.6	-	10.4
8/07	0850	20.6	9.2	58.8	-
8/14	1145	22.2	7.6	55.1	7.3
8/22	1005	22.8	7.7	58.6	5.8
8/28	1215	23.3	7.2	56.3	-
9/ 5	1200	22.5	7.1	59.4	4.0
9/11	1050	20.5	6.5	59.1	5.5
9/21	0830	21.1	8.6	61.8	4.0
9/30	0920	19.4	8.7	-	-
10/22	0833	15.0	9.0	-	5.0
11/ 4	0955	12.2	9.8	-	-
11/18	0935	11.7	10.0	-	5.0
12/15	1227	6.7	11.8	-	-

*Pacific standard time

Table 17.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station S1 (lat. 46°11'23" N., long 123°55'03" W.), Columbia River estuary, 1967

Date	Surface Time *	Surface Temp. °C.	Surface D.O. P.p.m.	Surface T.A. P.p.m.	Surface BOD. P.p.m.	Bottom Time	Bottom Temp. °C.	Bottom D.O. P.p.m.	Bottom T.A. P.p.m.	Bottom BOD. P.p.m.
7/26	1030	19.0	8.0	-	-	1025	19.0	8.0	-	-
8/ 3	1205	21.1	8.2	-	1.9	1200	15.6	6.0	-	1.6
8/ 7	0715	18.9	7.5	55.0	1.4	0710	18.3	7.0	63.8	1.4
8/15	0735	19.5	7.8	60.3	1.8	0730	19.8	7.8	98.6	1.5
8/24	0710	20.0	7.6	60.3	3.2	0705	18.9	6.7	61.2	1.9
8/28	1145	18.9	8.1	63.1	-	1140	11.4	4.8	59.7	-
9/ 5	0910	20.8	7.6	65.4	-	0905	20.8	7.5	64.6	-
9/11	0720	19.5	8.2	-	-	0730	19.0	8.0	-	-
10/ 7	0755	16.1	8.2	-	-	0750	16.1	8.2	-	-
10/15	0835	15.0	9.5	81.1	-	0830	15.0	8.9	76.9	-
10/28	0900	13.3	10.0	-	3.5	0850	13.3	9.3	-	3.5
11/18	1440	12.2	10.4	-	3.5	1430	12.2	9.7	-	3.5

*Pacific standard time

Table 18.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station S2 (lat. 46°11'6" N., long. 123°54'00" W.), Columbia River estuary, 1967

Date	Surface Time*	Surface Temp. °C.	Surface D.O. P.p.m.	Surface T.A. P.p.m.	Surface BOD. P.p.m.	Bottom Time	Bottom Temp. °C.	Bottom D.O. P.p.m.	Bottom T.A. P.p.m.	Bottom BOD. P.p.m.
7/26	1010	19.0	6.6	-	-	1005	19.0	5.7	-	-
8/ 3	1150	21.1	8.4	-	2.0	1145	18.9	7.2	-	1.8
8/ 7	0705	18.9	7.2	52.1	0.6	0700	17.8	6.1	65.2	1.9
8/14	0720	20.0	8.1	58.1	1.0	0715	20.0	8.0	89.8	2.0
8/24	0655	20.0	7.6	59.4	1.9	0650	20.0	6.5	63.4	1.6
8/28	1210	19.4	8.1	57.6	-	1200	16.1	5.2	61.0	-
9/ 5	0900	19.4	7.5	63.9	-	0855	18.9	7.3	65.2	-
9/11	0740	19.5	8.4	-	-	0750	19.0	7.8	-	-
10/ 7	0745	16.1	7.4	-	-	0740	15.6	8.3	-	-
10/15	0825	15.0	9.2	78.0	-	0815	15.0	7.4	70.3	-
10/28	0913	13.3	10.0	-	3.5	0907	13.3	9.3	-	3.5
11/18	1420	11.7	10.0	-	4.0	1410	12.2	9.9	-	4.0

*Pacific standard time

Table 19.--Temperature, dissolved oxygen, total alkalinity, and biochemical oxygen demand at station S3 (lat. 46°10'42" N., long. 123°58'52" W.), Columbia River estuary, 1967

Date	Surface					Bottom				
	Time *	Temp.	D.O.	T.A.	BOD.	Time	Temp.	D.O.	T.A.	BOD.
		°C.	P.p.m.	P.p.m.	P.p.m.		°C.	P.p.m.	P.p.m.	P.p.m.
7/26	0950	19.0	8.3	-	-	0945	18.5	7.3	-	-
8/ 3	1135	20.5	8.1	-	1.7	1130	18.9	7.5	-	1.5
8/ 7	0650	18.3	7.5	53.8	1.3	0645	18.1	7.2	63.7	1.2
8/14	0710	20.2	7.9	60.1	1.5	0705	19.5	7.4	88.4	1.2
8/24	0645	20.0	7.9	55.2	0.7	0640	19.4	7.0	58.2	1.7
8/28	1225	19.7	8.1	58.6	-	1220	18.9	6.9	57.3	-
9/ 5	0850	20.6	7.4	64.6	-	0845	20.6	7.2	64.4	-
9/11	0800	19.5	8.3	-	-	0810	19.5	-	-	-
10/ 7	0735	16.7	8.2	-	-	0730	16.1	9.6	-	-
10/15	0810	15.0	9.2	66.2	-	0800	15.0	8.7	70.9	-
10/28	0926	13.3	9.5	-	3.0	0920	13.3	9.4	-	3.0
11/18	1350	11.7	9.6	-	3.0	1345	12.2	9.6	-	3.0

*Pacific standard time

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